Saab Gripen

Sweden's 21st Century Multi-role Aircraft

Gerard Keijsper

AeroFax

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An imprint of
Ian Allan Publishing

www.zolder.ucoz.ru

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© 2003 Gerard Keijsper
ISBN 1 85780 137 7

Published by Midland Publishing
4 Watling Drive, Hinckley, LE10 3EY, England
Tel: 01455 254 490 Fax: 01455 254 495
E-mail: midlandbooks@compuserve.com

Midland Publishing is an imprint of
Ian Allan Publishing Ltd

Worldwide distribution (except North America):
Midland Counties Publications
4 Watling Drive, Hinckley, LE10 3EY, England
Telephone: 01455 254 450 Fax: 01455 233 737
E-mail: midlandbooks@compuserve.com
www.midlandcountiessuperstore.com

North American trade distribution:
Specialty Press Publishers & Wholesalers Inc.
39966 Grand Avenue, North Branch, MN 55056
Tel: 651 277 1400 Fax: 651 277 1203
Toll free telephone: 800 895 4585
www.specialtypress.com

Design concept and layout
© 2003 Midland Publishing
and Stephen Thompson Associates

Edited by Bob Munro

Printed in England by
Ian Allan Printing Ltd
Riverdene Business Park, Molesey Road,
Hersham, Surrey, KT12 4RG

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Contents

Title page: **Heavily armed F7 Wing JAS 39A Gripen 39134 over a typical Swedish landscape. The G at the top of the fin is for 'Gustaf', the radio callsign of F7 Wing.**

Below: **Eight Batch One JAS 39A Gripens at Malmen, home of TU-39 and the FMV FC units. The aircraft wear the original high-visibility Dayglo tactical codes and seven of the eight have the black nose radomes fitted to aircraft 39109 to 39127.**

Introduction

A quartet of Saab J 29 Tunnans (Flying Barrels), Sweden's first-generation jet fighter, operated by F3 Wing. The type served with the Swedish Air Force from 1951 to 1970.

Although Sweden has jealously guarded its neutrality for close to 200 years (it was last involved in conflict in 1814 when it gained Norway from Denmark), the largest of the countries in Scandinavia has long had a reputation for purposely maintaining a strong military capability to deter other nations, most recently the Soviet Union and its Warsaw Pact allies during the Cold War years, from seeking to gain a strategic advantage by way of invasion.

The principal element of this impressive defence capability has long been been the Svenska Flygvapnet (Swedish Air Force), which has traditionally relied almost exclusively on aircraft designed and built by another key element, namely Sweden's indigenous aerospace industry.

The roots of Sweden's modern-day aerospace industry can be traced back to 1930 and the establishment of the Aktiebolaget Svenska Jarnvagsverkstadernas Aeroplanavdelning at Linköping. Seven years later, with the clouds of war gathering across Europe, Svenska Aeroplan Aktie Bolaget (SAAB) was formed at Trollhättan and two years later these companies were merged.

In the 60-odd years since the merger, Saab has produced a series of successful and often innovative aircraft to meet very specific operational requirements bestowed upon the Swedish Air Force. Those requirements are reflected in the Swedish Air Force's policy of designating its aircraft by role. The designations, introduced after the First World War, are as follows:

J	Jakt (Fighter)
A	Attack
S	Spanning (Reconnaissance)
SF	Spanning Foto (Photographic Reconnaissance)
SH	Spanning Havsovervakning (Maritime Reconnaissance)
Sk	Skol (Trainer)
B	Bomber
Tp	Transport
Fpl	Flygplan (Aeroplane – used for light multi-role aircraft)
Hkp	Helikopter (Helicopter)

Saab's first military designs to enter service with the Swedish Air Force were the single-engined B 17/S 17 and twin-engined B 18/S 18 of 1940 and 1942 respectively. A clear indication of Saab's innovative approach to aircraft design came with the J 21A Falco, a twin-boom single-seat fighter first flown on 30th June 1943

and which featured a pusher propeller located at the rear of the central nacelle rather than a conventional nose-mounted tractor type. The J 21A was followed in 1947 by the J 21R which retained the twin-boom configuration but replaced the 12-cylinder piston engine with a jet engine; the first Saab aircraft to be so powered.

On 1st September 1948 the prototype of the Saab 29 Tunnan (Flying Barrel) undertook its maiden flight. This was the first original jet-powered aircraft to be designed by Saab and was followed by a quartet of outstanding types. Test pilot Bengt Olow took the prototype of the first of the four, the Saab 32 Lansen (Lance), on its first flight on 3rd November 1952; during October 1953 the Lansen became the first Saab aircraft to break the sound barrier, a step that made Sweden the fifth country to fly a supersonic aircraft. The Lansen proved to be a versatile platform and served primarily in the all-weather attack/night fighter roles and also as a reconnaissance, ECM and cloud-sampling platform.

The Saab J 32 Lansen was Sweden's second-generation jet fighter and attack aircraft. The type's versatility resulted in a service career with the Swedish Air Force of over 40 years.

This view of a Swedish Air Force J 35F Draken illustrates well the type's distinctive cranked delta wing. The armament comprises two Rb27 radar-guided and two Rb28 IR-guided Falcon air-to-air missiles. Bob Munro

As the Cold War escalated, Sweden's neutrality and policy of non-alignment became very western orientated. The main threat was now came from Warsaw Pact countries that had air bases within half an hour's flying time of Sweden and who's front-line strength was greater than that of the North Atlantic Treaty Organisation (NATO) forces of Norway and Denmark and non-aligned Finland. NATO calculated that in a conventional war Sweden would protect NATO's northern flank, so protection of the NATO countries could therefore be made implemented through West Germany and the Iceland-Greenland-UK gap.

Sweden calculated that, in a conventional war, both NATO and the Warsaw Pact would consider Swedish territory to be of high tactical value and on that basis the Swedish Air Force estimated what size of force would be needed to prevent an invasion. The base system that Sweden used assumed that, as Swedish Air Force bases would probably be the first targets for destruction, its combat aircraft had to be able to take off from runways shortened by damage or from short strips of road. Thus the Swedish Air Force's second-generation combat aircraft would have to be designed to operate from a network of dispersed road bases. (This requirement was expanded with each succeeding generation of combat aircraft to ensure that they would have enough roads available for landings. Eventually Sweden had 24 dispersed bases available, each with three runways, plus the country's additional well designed road infrastructure.)

A first-generation AJ 37 Viggen of F15 Wing. The Viggen was the aircraft against which the Gripen was measured and compared during and after the initial design stage.

Bengt Olow was also the pilot for the first flight of the Swedish Air Force's second-generation combat aircraft, the outstanding Saab 35 Draken (Dragon) Mach 2 all-weather interceptor. Whereas the Lansen was of conventional configuration, the Draken, first flown on 25th October 1955, featured an eye-catching and unusual double-delta wing with a cranked leading edge swept 80° on the inner section and 57° on the outer section.Saab had calculated that this wing configuration offered the best handling characteristics of both a delta and conventional wing.

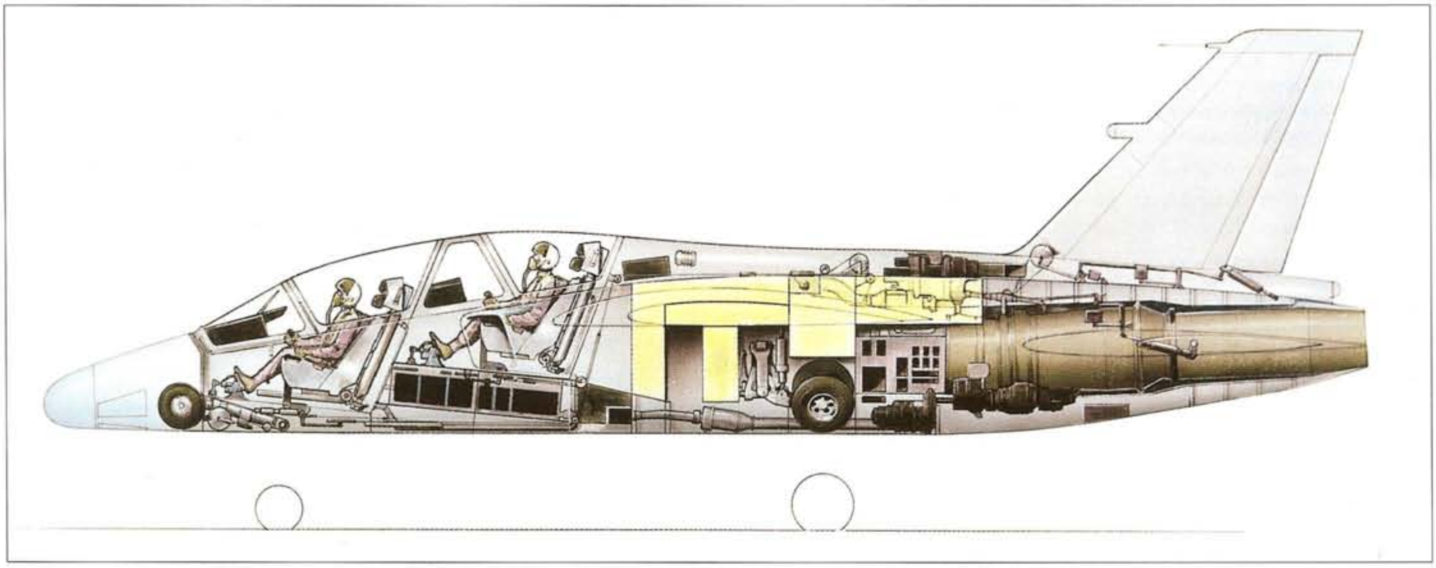
The Draken's good handling characteristics were enhanced by low drag thanks to the small frontal area, and an excellent rate of climb and high-speed performance thanks to the powerful RM6 engine with afterburner and a wing thickness-to-chord ratio of just 5%. These were important considerations given the Swedish Air Force's stipulation that the aircraft had to have the ability to operate from dispersed sites, to climb fast and high to intercept the enemy aircraft and then return and land safely within a short distance on the roadway site. The landing run was shortened by the Draken sitting back on a pair of small twin tailwheels to maximise aerodynamic drag.

The J 35A Draken interceptor entered Swedish Air Force service with F13 Wing in March 1960 and was followed over the years by modified and improved J 35 variants, the S 35E reconnaissance platform and the Sk 35C two-seat trainer. Drakens were also exported to Austria, Denmark and Finland.

Even before the Draken entered service, in the late 1950s the Swedish Air Force had turned its thoughts to the future need for a Draken replacement. The decision was taken to embrace the concept of a total weapon system in which design and development of the airframe would progress in parallel with that of onboard avionics and equipment, armament, the powerplant, and ground-based support equipment including simulators for pilot training. A prerequisite was that the resulting weapon system had to be fully integrated with Sweden's STRIL 60 air defence control system.

What emerged in response to the Swedish Air Force's requirements was System 37, at the heart of which was Flygplan 37 (Aircraft 37). Saab was once again entrusted with the design of the aircraft.

First flown on 8th February 1967, the Saab 37 featured mid-set delta foreplanes (canards) with trailing-edge flaps – the first modern fighter aircraft to incorporate canards – and a main delta wing with leading-edge compound sweep and trailing-edge elevons. This 'canard-delta' configuration and the power of the RM8 afterburning engine gave the Saab 37 the thrust and high lift necessary to take off from short stretches of roadway. The sturdy tandem twinwheel main landing gear units were designed to absorb the shock of no-flare land-



A computer-generated image of the B3LA. The design's similarity to the Italo-Brazilian AMX is clear to see.

Many of the suppliers involved in the abortive B3LA were subsequently invited to participate in the JAS programme; for example the French company Intertechnique, whose fuel system for the B3LA is illustrated.

ings at sink rates up to 5m (16ft) per second, thus enabling landings on short strips of roadway. Once on the roadway, deployment of a thrust-reverser and raising of the main wing elevons would restrict the landing run to an impressive 500m (1,640ft).

Big and powerful and able to carry an impressive array of ordnance and stores on seven underfuselage and underwing stations, the multi-role Saab 37 was given a name that reflected its strength and its ability to fly fast and hit hard: Viggen (Thunderbolt). First-generation Viggens comprised four variants, each with a primary and secondary operational role: the AJ 37 (attack, air defence), SF 37 (photo-reconnaissance, attack), SH 37 (maritime reconnaissance, anti-shipping strike) and the two-seater SK 37 (training, attack).

The Viggen entered Swedish Air Force service on 21st June 1971 and was progressively updated over the years. During the 1970s the second-generation JA 37 (air defence, attack) was developed and procured. Later, close to 100 surviving first-generation AJ/SF/SH 37s were upgraded to enable each aircraft to perform more than one operational role. This programme resulted in the AJS 37, AJSF 37 and AJSH 37; examples of the latter two are among the dwindling numbers of Viggens that remain in Swedish Air Force service at the time of writing. They serve alongside surviving JA 37s, some SK 37s (retained for proficiency training) and the youngest member of the Viggen family, the SK 37E Stör-Viggen (Jammer Viggen), which has replaced the J 32E Lansen in the EW training role.

Flygplan 80

From 1971 the Swedish Forsvarsmakten (FMV or Swedish Defence Material Administration) invested a substantial amount of money in a project called Flygplan 80 (Aircraft 80) which was intended to be a Viggen replacement that would enter production in the first half of the 1980s and reach service with the Swedish Air Force in the second half of the decade. Flygplan 80 was eventually retitled Project 85 and brought another proposal to life called the A-20, which was itself a ground attack derivative of the Viggen.

In the mid-1970s it was believed that the Viggen's service life would last around another 15 years. Consequently, it was suggested that when production of the Viggen fighter came to an end in 1985, a new enhanced-generation Viggen attack variant should be produced to replace the older, worn-out first-generation variants; this was to be Project A20. (In fact, Viggen production continued until 1990. Including the eight prototypes, a total of 337 Viggens were built).

By now the cost of new combat aircraft was starting to rise prohibitively. Norm Augustine of Lockheed Martin, in his book *Augustine Laws*, noted that this escalation in cost was due in no small part to their ever-increasing sophistication and the extra weight needed to house all of the state-of-the-art equipment. The table opposite illustrates this graphically.

It is often said that the weight of an aircraft multiplied by the price of gold will give the price of the aircraft and Swedish studies have confirmed this rule of thumb. Consequently the Swedish Air Force looked at some low-cost design proposals including the B3LA trainer and light attack aircraft.

The B3LA was seen as a replacement for the Sk 60 jet trainer (for which British Aerospace later offered the Hawk). Aermacchi of Italy cooperated on the B3LA's design and similarities can be seen with the shape of the AMX light attack aircraft which serves today with the Italian and Brazilian air forces. A further project given consideration was the A 38/Sk 38 dedicated attack aircraft and jet trainer.

According to Swedish government proposals in 1976 (Item 1976/77:74), the Swedish Air Force's front-line fighter capability should be modernised by upgrading the Viggen system to A-20 standard while the B3LA would replace the Sk 60, with full assessment of the B3LA to commence in spring 1977. The results of this inquiry were delivered in October 1977 and recommended that enough A-20s should be procured to equip six wings, plus 45 light trainer aircraft. Alternatively, two Swedish Air Force wings should receive AJ 37 Viggens and nine wings the B3LA.

In Government proposal 1977/78:95 it was decided that the final decision on force modernisation should be delayed and in January 1978 a FlygIndustry Kommite (FLIK or Aircraft Industry Committee) was formed to establish what was the best option for the Swedish Air Force. This committee reported to the Swedish government in October 1978 and recommended the acquisition of enough JA 37 Viggens and the new A-20 to equip eight wings and six wings respectively.

A report by the then Supreme Commander of the Swedish Armed Forces, General Lennart Ljung, noted a preference for the Sk 38/A 38 rather than the A-20, although it was acknowledged that the former would involve more design work and, therefore, a higher technical and financial risk.However, by the end of February 1979 Ljung's advice had been rejected by the Swedish parliament, which was to decide by 1st July 1979 on combat aircraft acquisitions for the next five-year period. When General Ljung initiated some studies to look at the available options, it soon became clear that a low-cost choice was desirable and both the British Hawk and Franco-German Alpha Jet were considered at this time to replace the Sk 60.

On 21st November 1978, both the B3LA and A 38 programmes were cancelled by Government proposition 1978/79:138 as being too expensive. Two months later, in February 1979, the A-20 programme also was cancelled. In November 1979 the Swedish government issued additional instructions to the Commander-in-Chief of Sweden's Armed Forces (the ÖB) to find an aircraft, possibly even from abroad, with a combined Jakt, Attack and Spanning (JAS: Fighter, Attack and Reconnaissance) capability of a level equivalent to the American General Dynamics F-16. Such an aircraft, if procured, would replace the Swedish Air Force's AJ/SF/SH 37 Viggens. At the same time, however, eight wings of JA 37 Viggens were to be acquired.

IG-JAS

In Sweden, realisation that an aircraft from an overseas manufacturer might be procured to meet the JAS requirement led to the formulation of Industrie Gruppen Jakt, Attack, Spanning (IG-JAS); five Swedish aerospace companies that would join forces to design, develop and manufacture a multi-role 'JAS combat aircraft'. The companies were Saab (airframe design, final assembly, digital fly-by-wire control system, marketing and sales); Volvo (development of the RM12 engine in co-operation with General Electric, it being a development of the GE404J); FFV (maintenance and the ODEN Helmet Mounted Sight); SRA (diffractive optics HUD and three head-down displays) and LM Ericsson (radar, FLIR, central computer system and IFF system).

IG-JAS was formed mainly for political reasons, to show that not only Saab but a broader Swedish industry base would profit from the development of the new fighter. One major change was that all of the other companies now became risk-taking partners, which had not been the case with previous Swedish fighter programmes; however, marketing of the complete aircraft would stay with Saab.

The Överbefälhaveren (ÖB or Supreme Commander of the Swedish Armed Forces) announced the results of his inquiry in February 1980 and recommended acquiring the JAS system to replace the entire fleet of Viggens, including the SF/SH 37 variants. In the summer of 1980 an official Request for Proposals (RFP) was sent to the US companies General Dynamics, McDonnell Douglas and Northrop, and to IG-JAS in Sweden. Shortly afterwards the Swedish parliament approved SKr 200 million to cover JAS design development from July 1980 until the end of 1981.

The RFP gave the three US companies until April 1981 to respond; IG-JAS was given a further two months because unlike its competitors, it did not have an actual aircraft available. Nevertheless, by November 1980, IG-JAS had received plenty of interest from overseas aerospace companies prepared to share the financial and technical risk of developing of their JAS proposal. Notable among these companies were British Aerospace, Messerschmitt-Bölkow-Blohm, and McDonnell Douglas and Rockwell (which offered its HiMAT technology).

Partners were to be selected before year's end so that IG-JAS could submit an offer to the Swedish Air Force. The Swedish government would then decide whether to develop an indigenous fighter or buy from overseas.

Year	Manufacturer	Type	Empty weight	Price (million US$)
1950	North American	F-86 Sabre	6,276kg (13,836 lb)	0.22
1958	Lockheed	F-104 Starfighter	6,760kg (14,903 lb)	1.4
1962	McDonnell Douglas	F-4 Phantom II	13,757kg (30,328 lb)	2.2
1968	General Dynamics	F-111	21,398kg (47,175 lb)	5.9
1978	McDonnell Douglas	F-15A Eagle	12,973kg (28,000 lb)	20
1990	McDonnell Douglas	F-15E Strike Eagle	14,379kg (31,700 lb)	40
1990	Lockheed-Martin	F-16C/D Fighting Falcon	8,663kg (19,100 lb)	25
1990	McDonnell Douglas	F/A-18C/D Hornet	10,455kg (23,050 lb)	30
2000	Eurofighter	Typhoon	9,750kg (21,495 lb)	≈ 50
2000	Dassault	Rafale		≈ 50
2000	Boeing	F/A-18E/F Super Hornet	13,880kg (30,600 lb)	≈ 60
2000	Gripen International	Gripen	6,622kg (14,599 lb)	≈ 30
≥ 2005	Lockheed-Martin	F/A-22 Raptor	+13,608kg (30,000 lb)	≈ 120*
≥ 2008	Lockheed-Martin	F-35		≈ 40*

* estimates for these perspective fighters for when they become available

Acknowledgements

I would like to thank the following people: Hans Brandtberg of Saab Avionics for his assistance with the chapters about displays and the Man-Machine Interface; Gerhard Dussler of BGT for his assistance with the section on IRIS-T; Corinna Wassner of Mauser-Werke for the information supplied about the BK27 cannon; Mike J Nipper of Lockheed-Martin for his assistance with auto AGCAS; Luther Craig of the AFFTC for his assistance and information about auto AGCAS and auto ACAS; Björn Johansson of FMV:prov for the information about test flying and the FMV unit patch; Owe Wagermark of Gripen International for allowing his staff to help me; Nils Göran Widh of Saab for all the photographs and other illustrations; Lt.General Kent Harrskog (Retired) for all the Swedish Air Force unit patches; Heidi Wendt of Saab for her help with Chapter Seven; Reino Lidvik, Saab test pilot; Yngve Kläth for his time, answers and solutions to problems; Sam Basch of Volvo Aero for his fact-checking of Chapter Four; Denel for information on their production of Gripen components; My friends who helped me with the translation of material for the text.

Lastly, I would like to thank Tony Buttler and Bob Munro for editing and proof-reading the material I supplied.

Gerard Keijsper
July 2003

Acronyms and Abbreviations

AAA	Anti- Aircraft Artillery
AADS	Advanced Air Data System
AAM	Air-to-Air Missile
AoA	Angle of Attack
ACTIVE	Advanced Control Technology for Integration Vehicle
ADC	Air Data Computer
AESA	Active Electronically Scanned Array
AFB	Air Force Base
AMRAAM	Advanced Medium-range Air-to-Air Missile
AMS	Audio Management System
APU	Auxiliary Power Unit
ASM	Anti-Ship Missile
ATE	Automatic Test Equipment
AVEN	Axi-symmetric Vectoring Exhaust Nozzle
BFM	Basic Fighter Manoeuvres
BITE	Built-In Test Equipment
BVR	Beyond Visual Range
BVRAAM	Beyond Visual Range Air-to-Air Missile
CCDU	Communication Control Display Unit
C-in-C	Commander-in-Chief
CPB	Centraal Plan Bureau (the Dutch economic analysis agency)
CRT	Cathode-Ray Tube
CSMU	Crash Survivable Memory Unit
CzAF	Czech Air Force
DASH	Display And Sight Helmet
DEXSA	Defence EXhibition South Africa
DFRC	Dryden Flight Research Center
DWS	Dispenser Weapon System
ECCM	Electronic Counter-Counter Measure
ECM	Electronic Counter Measure
ECS	Environmental Control System
EFA	European Fighter Aircraft (later Eurofighter Typhoon)
EFM	Enhanced Fighter Manoeuvrability
EGNP	Elektronisk Genererad Nöd Presentation (Electrically Generated Emergency Display)
ELINT	Electronic INTelligence
EMD	Engineering and Manufacturing Development
EO	Electro Optical
FACh	Fuerza Aérea Chilena (Chilean Air Force, ChAF)
FADEC	Full-Authority Digital Engine Control
FBW	Fly-By-Wire
FCS	Flight Control System
FETT	First Engine To Test
FLIR	Forward-Looking Infra-Red
FMRAAM	Future Medium-Range Air-to-Air Missile
FMS	Foreign Military Sales
FMS	Full Mission Simulator
FMV	Forsvarsmakten (the Swedish Defence Material Administration SDMA)
FOD	Foreign Object Damage
GECU	General systems Electronic Control Unit
GSE	Ground Support Equipment
HARV	High-Alpha Research Vehicle
HAS	Hardened Aircraft Shelter
HDD	Head-Down Display
HiMAT	Highly Manoeuvrable Aircraft Technology
HMD	Helmet-Mounted Display
HMS	Helmet-Mounted Sight
HOTAS	Hands On Throttle And Stick
HUD	Head-Up Display
IAF	Israeli Air Force
IAI	Israeli Aircraft Industries
IFF	Identification Friend or Foe
INS	Inertial Navigation System
IOC	Initial Operational Capability
IR	Infra-Red
IRST	Infra-Red Search and Track
ITB	Invitation To Bid
ITO	International Test Organisation
ITP	Industria de Turbo Propulsores
JAS	Jakt, Attack, Spanning
JSF	Joint Strike Fighter
KEPD	Kinetic Energie Penetration and Destruction
LCA	Light Combat Aircraft
LCC	Life Cycle Cost
LOA	Letter of Offer and Acceptance
LP	Low Pressure
LRIP	Low-Rate Initial Production
LRU	Line Replaceable Unit
MACS	Modular Airborne Computer System
MATV	Multi-Axis Thrust Vectoring
McDD	McDonnell Douglas
MDC	Miniature Detonating Cord
MDRS	Maintenance Data Recording System
MDS	Modular Weapon System
MES	Mission Evaluation System
MFD	Multi-Functional Display
MIDAS	Multi-function Integrated Defensive Avionics System
MIDIS	Multi-function Integrated Defensive Information System
MIL-STD	MILitary STanDard
MLU	Mid-Life Update
MMC	Mass Memory Cartridge
MMI	Man-Machine Interface
MMS	Multi-Mission Simulator
MoD	Ministry of Defence
MoU	Memorandum of Understanding
MRAAM	Medium-Range Air-to-Air Missile
MRP	Modular Reconnaissance Pod
MTBF	Mean Time Between Failures
MTVN	Multi-axis Thrust-Vectoring Nozzle
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NVG	Night Vision Goggles
OBOGS	On-Board Oxygen Generation System
PAF	Polish Air Force
PfP	Partnership for Peace
PGM	Precision Guided Munitions
PIO	Pilot-Induced Oscillation
PRF	Pulse Repetition Frequency
Rb	Robot (Swedish term for guided missile)
RCS	Radar Cross-Section
RFP	Request For Proposals
RFQ	Request For Quotation
RM	Reaktions Motor or Jet Engine
RRV	Riks Revisions Verket (State Revision Works)
RWR	Radar Warning Receiver
SAAF	South African Air Force
SANDF	South African National Defence Force
SDD	System Development and Demonstration
SETP	Society of Experimental Test Pilots
SHK	Statens Havari Kommission
SKr	Swedish Kroner
S/MTD	STOL/Manoeuvring Technology Demonstrator
SRU	Shop Replaceable Unit
SSE	Stockholm Stock Exchange
STOL	Short Take-Off and Landing
STOVL	Short Take-Off and Vertical Landing
SwAF	Swedish Air Force
TARAS	TActical RAdio System
TDD	Technology Development and Demonstration
TFR	Tactical Fighter Regiment
TIDLS	Tactical Information Datalink System
TRM	Transmitter Receiver Module
TU-39	Taktisk Utprovning 39 (Tactical Testing 39)
VECTOR	Vectoring, Extremely STOL, Control and Tailless Operation Research
VISTA	Variable In-flight Stability Test Aircraft
VoVC	Validerings-och Verifiering Centrum (Validation and Verification Centre)
VRD	Virtual Retinal Display™
VTAS	Visual Target Acquisition System

The Future Takes Shape

According to Maj Gen Staffan Näsström, Chief of Sweden's Air Force Material Command, you have to look at previous generations of fighters to realise just what is meant by the term 'fourth-generation fighter' and what it can do.

First-generation jet fighters include the MiG-15 *Fagot*, F-86 Sabre and de Havilland Vampire; Swedish members of this generation were the Saab J 29 Tunnan and J 32 Lansen. Second-generation jet fighters used analogue systems to integrate their weapons and avionics and speed was a major performance requirement. This generation comprised types like the F-5 Freedom Fighter, F-4 Phantom II, MiG-21 *Fishbed* and the J 35 Draken. The Draken was the first Swedish Air Force aircraft to be equipped with a datalink system and, with this fighter, the Service began to build up its experience in such systems and appreciate their value in combat.

Third-generation aircraft were designed to have numerous separate digital systems that performed their own dedicated tasks but relied on several computers to link them together. Within this category come the F-16 Fighting Falcon, F/A-18 Hornet, Mirage 2000-5, MiG-29 *Fulcrum* and the JA 37 Viggen.

Fourth-generation fighters – led by the Gripen and including the F/A-22 Raptor, Typhoon, Rafale and the F-35 – have been designed from the outset as a single digital unit with a fully integrated computerised infrastructure utilising a common database. This means that the sensors, weapons, control surfaces, input devices and display systems can be used as information carriers and as information providers in an endless number of combinations. A relatively simple way of updating these aircraft is through improved software.

All of these fourth-generation fighters, with the exception of the F/A-22 and F-35, have something else in common: a delta canard configuration. Getting rid of the tailplane saves drag and weight, but the canard does increase the RCS while also possibly obscuring the pilot's downwards view. General Dynamics (the F-16's original designer, before it was merged with Lockheed, and a partner in the F-22 programme) went so far as to say that the only location for a canard was on another aircraft, preferably the enemy's!

JAS Configurations

Design studies for what would eventually become the IG-JAS submission for the JAS requirement had begun in 1979. Work commenced under the designation NV-0, this title identifying what was basically a half-scale Viggen with 55° wing sweep. Later the NV-0 became the Type 2100, thus instituting the use of the 2100 series.

Two basic configurations researched in depth were the Type 2102 and the Type 2105. The 2102 was the more conventional of the two, sporting a mid-set swept wing and tail, LERXs, a single engine and air intakes on the fuselage sides. The 2105, also single-engined, had canards and a cropped-delta wing configuration. The air intakes were again on the sides of a noticeably smaller, sleeker fuselage.

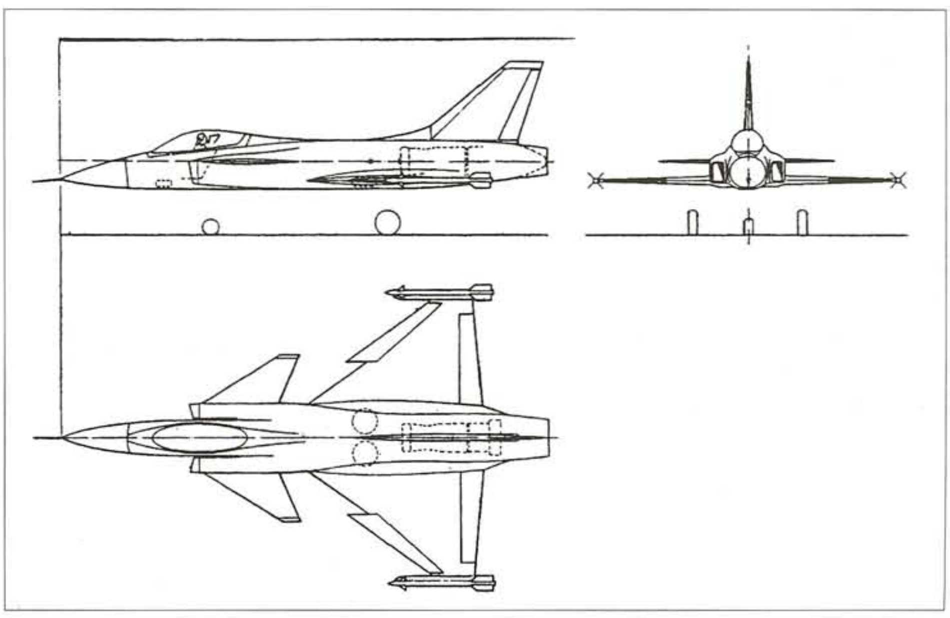
The delta canard wingplan was also tested with an air intake beneath the nose, rather like the F-16, but Saab concluded that this inlet was not really suitable for a small fighter because of the threat from foreign object damage. Additionally, it had a high head-on radar signature and the nose landing gear had to be placed behind the air inlet; this made the aircraft sit higher off the ground which did not help the maintenance aspect. The short wheelbase also placed restrictions on the size of the fuselage weapon load. (The engineers at Israeli Aircraft Industries did not feel that this was such a problem for their Lavi fighter, but that fighter's slightly larger airframe nullified the weapon load weakness.)

Another study was the Type 2107 fitted with a highly swept wing and a low-set tailplane. The 2107's most distinctive feature was a dorsal intake (similar to the North American YF-107A) giving a short and straight duct; more importantly, its engine was all but invisible to radar, giving the design better stealth characteristics.

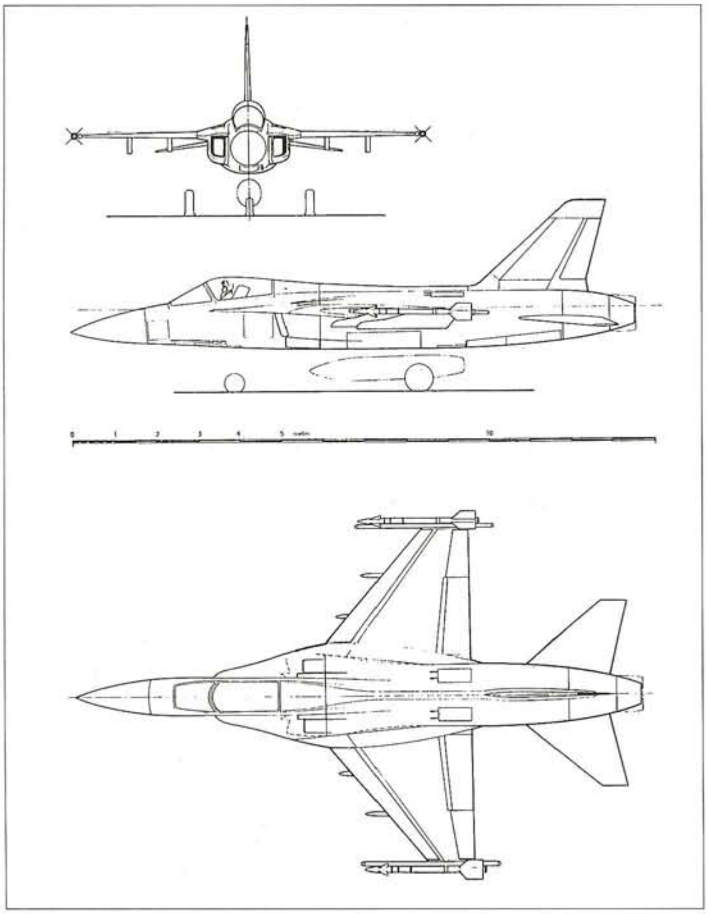
Wind-tunnel tests showed that the Type 2107 had a better turn rate than the 2105 and that it would perform well at high 'alpha' (angles of attack). However, adding a second seat would be difficult because of the intake position and there was concern with high 'alpha' and side slip.

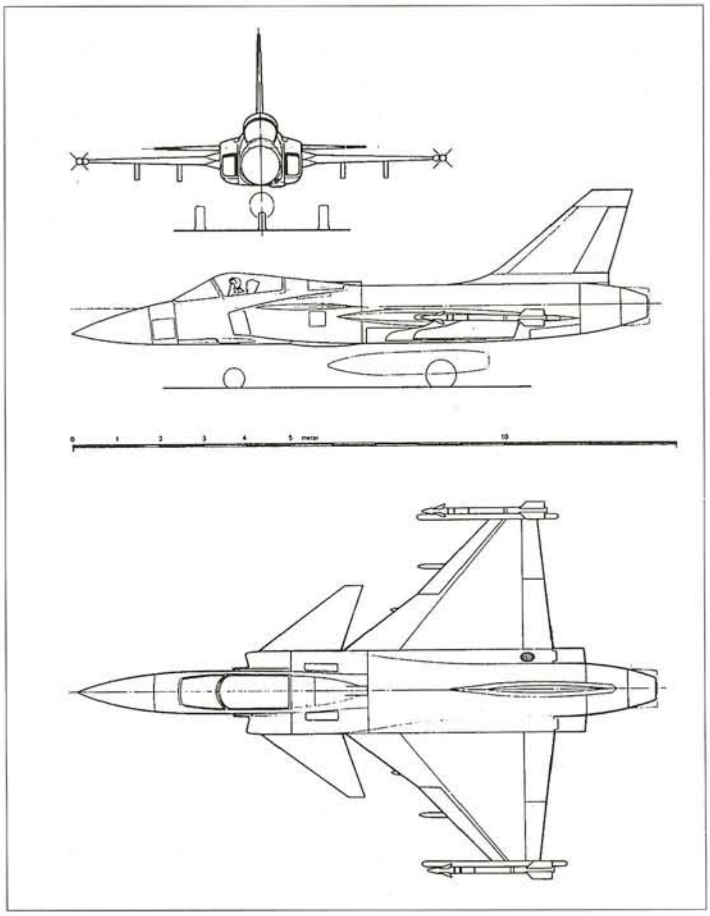
The Type 2108 was another canard design but with more of a swept wing than a delta, while the Type 2111-4 had a Rockwell-designed wing based on that company's Highly Maneuverable Aircraft Technology (HiMAT) research aircraft. The Type 2111-4's subsonic turn performance was improved thanks to the lower induced drag and the project's aero-elastic properties would not compromise performance in other flight regimes. Two remote-controlled HiMAT aircraft, each about half the size of the F-16, were test-flown between 1979 and January 1983 at NASA's Dryden Flight Research Center. The Type 2111-4's wing span was 9% greater than that of the Type 2105, sweepback was 10% less, wing area was 13% less but its weight was 3% greater.

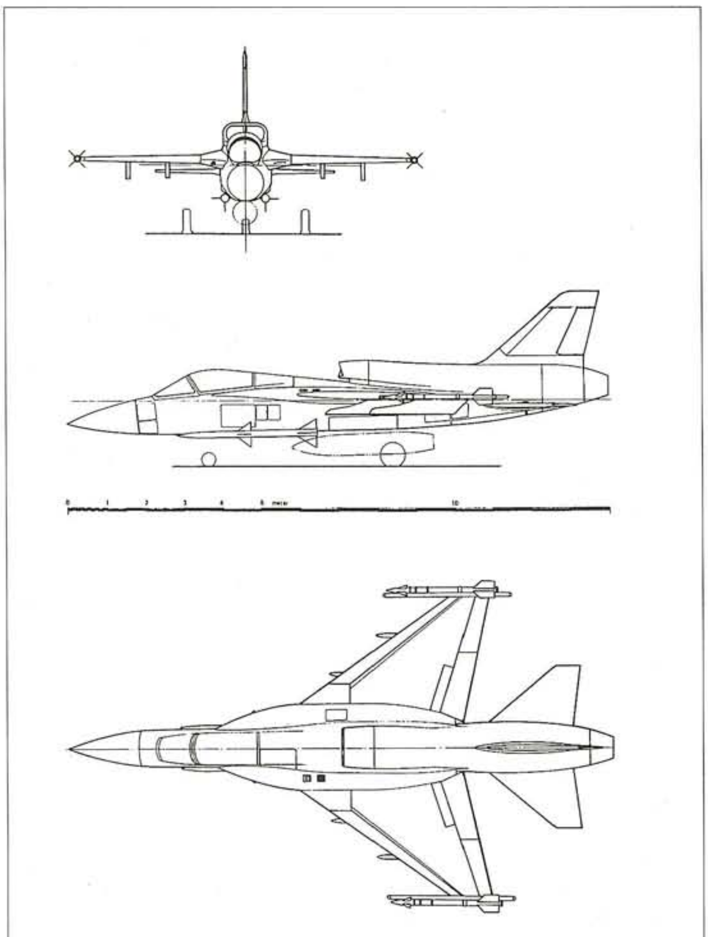
IG-JAS had until June 1981 to decide which of these designs was the most suitable to offer

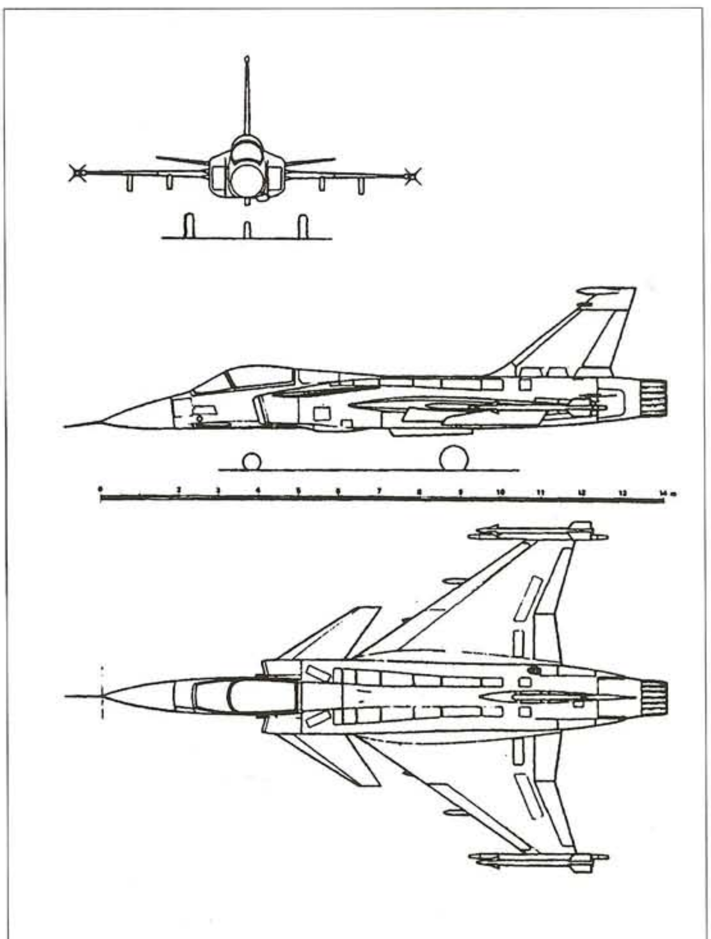


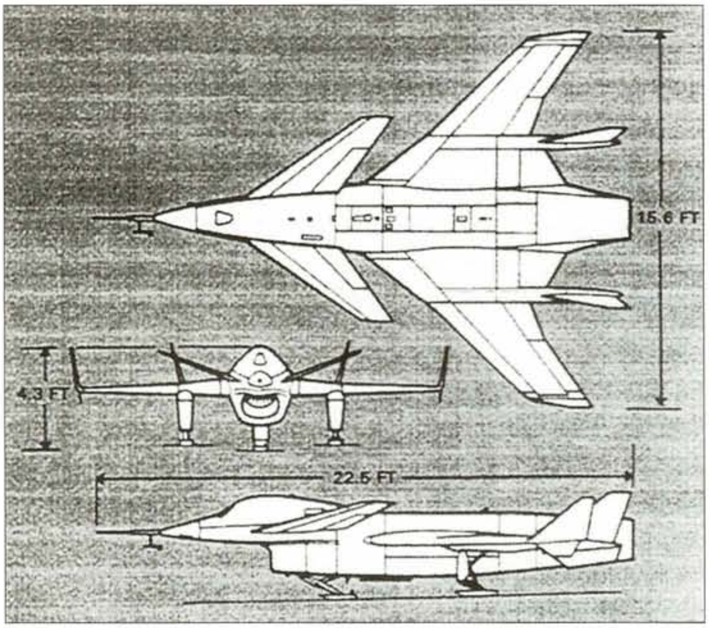
The NV-0 design – basically a half-scale Viggen with revised wing sweep – initiated the Project 2100 series which included designs that retained the canard foreplanes but otherwise looked quite different to the Viggen.



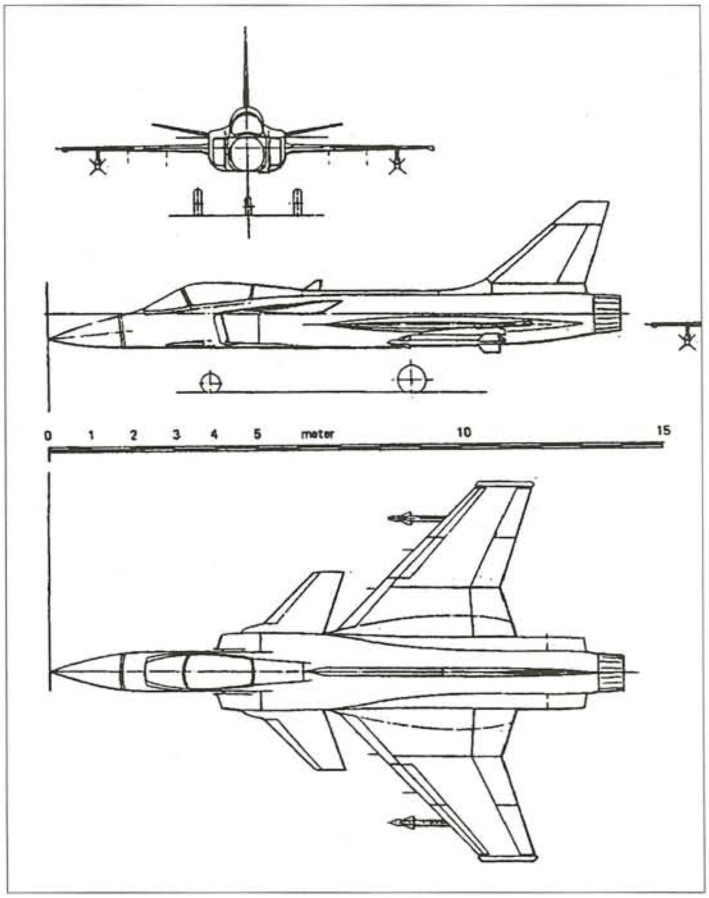








Project 2111-4 was the last alternative to Project 2105. The most obvious difference was the Rockwell HiMAT wing design.



Project 2111-4's canard foreplanes would have been fitted with prominent leading-edge root extensions (LERXs).

to the Swedish Air Force. Its assessment of each design was based on three phases – computer calculation, wind-tunnel testing and flight testing – but those designs showing the greatest disadvantages would be dropped after computer calculation. The two designs that survived the three-phase evaluation programme were the unstable Type 2105 (close-coupled canard delta) and the more conventional and stable Type 2102 (aft tail).

The Type 2105 and Type 2102 projects now passed through detailed aerodynamic design and structural testing while system integration studies were conducted. Computer calculation had become so advanced that wind-tunnel testing was more or less confirming the calculations, but tunnel work was far cheaper than flight testing and no flying model was available early on in the programme. Tunnel testing was undertaken in Sweden and in the best tunnels available in Canada, the Netherlands, Switzerland, the UK and the USA.

From a strike capability point of view the Type 2102 had good performance, but Saab could not sufficiently reduce the drag, so it was not as good in the supersonic regime as some other designs. Consequently, IG-JAS submitted the Type 2105 as its contender in the JAS competition.

Opposite page:

Top left: **A three-view of the Type 2102, of more conventional design than the Type 2105.**

Top right: **Further development of the Type 2100 included the Type 2105 with canards and a cropped-delta wing configuration.**

Bottom left: **The Type 2107 represented the biggest technological risk, due mainly to the unusual dorsal position of its engine air intake.**

Bottom right: **A three-view of one Project 2108 configuration; this project was also evaluated with the air intakes located behind the canards. Project 2108 was IG-JAS's first offer in response to the JAS requirement in 1981.**

Sweden Wins

On 17th September 1981 the Commander-in-Chief of the Swedish Air Force, Lt General Dick Stenberg, reported to the Supreme Commander that, after careful evaluation of the overseas contenders and the Type 2105, the Type 2105 would best meet the requirements of the Swedish Air Force, although it could cost slightly more than the most expensive existing aircraft then on offer. The extra cost would, however, be compensated for by the fact that Sweden would be able to maintain a strong industrial base to support the Swedish Air Force.

General Ljung duly confirmed Lt General Stenberg's findings by stating that the American and French options did not fulfil the Swedish Air Force's requirements. Evaluation of the F-16 had established that it did not meet the Swedish Air Force's strict take-off requirements: Swedish fighters had to be flying within one minute of an order to take-off whereas the F-16 needed around three minutes.

The F/A-18 Hornet was found to be better suited to the Swedish Air Force's needs; but it was also too expensive, partly because of the extra maintenance required for the type's twin engines (the Swedish Air Force had always used single-engined fighters).

The idea of joining an international programme to develop a fighter, though attractive financially in that the costs could be shared between the partner nations, was rejected because of the inevitable compromises inherent in the design and operational capabilities of a multi-nation aircraft. There also remained the unanswered question of whether or not such a programme could produce an aircraft able to meet the Swedish Air Force's operational requirements and thus replace the surviving Drakens and Viggens in service.

On 1st December 1981, the Swedish government voted in favour of the IG-JAS proposal and therefore gave the FMV an order to negotiate a contract with IG-JAS for a Draken/ Viggen replacement. The decision was made easier by reasons of employment, the nation's industrial technical base and, last but not least, Sweden's policy of neutrality. Also important was the fact that the Swedish Air Force was the only air arm actually using the Viggen and it would be dependent on Swedish industry for spare parts well past the year 2000. In fact the Swedish Air Force completed a study which revealed that if Sweden bought an aircraft 'off the shelf' there was be a real danger that existing indigenous aircraft then in service could soon only be maintained at extremely high cost.

An early publicity image of the Saab 2110. Of note are the longer, more slender nose and the smaller tail without an RWR receiver. The type's strike capability is evident in the shape of the RBS 15 ASM on the inboard pylon.

Type 2110

In January 1982 IG-JAS revealed the configuration of its JAS fighter. Refinement of the Type 2105, particularly in an attempt to keep weights down, had led to the Type 2110, intended by IG-JAS to be a real lightweight fighter in the class of the Northrop F-5E Tiger II. The 2210 was a close-coupled delta canard design with the wing tips clipped to enable the fitment of air-to-air missile rails. The canard was fully moveable and could be deflected downward on landing to provide aerodynamic braking. When the flight computer was operating the Type 2110 was unstable, but after a computer failure the canard would become 'free-floating' and return the aircraft to stability once again.

The wingplan was similar to that of the Viggen, with which Saab had by now gained a great deal of experience (a fact that undoubtedly had an influence on the final choice of wing configuration). Just behind the main wing were two airbrakes, one each side of the fuselage. The 2105's narrow fin with swept trailing edge was replaced by a thicker version with a straight edge.

In February 1982 the Swedish government presented to its parliament the plan to buy and develop the next-generation multi-purpose fighter and confirmed that it recommended

A scale model of the JAS 39 Gripen undergoing wind tunnel testing.

development of the indigenous JAS. Both the FMV and IG-JAS were required to complete their contract negotiations by 1st May 1982, to enable the Swedish parliament to make its final decision later that month.

On 30th April 1982, the FMV signed a preliminary contract with IG-JAS worth SKr 25,700 million and on 6th May the Swedish government approved the agreement; parliament followed suit on 4th June and on 30th June the full contract was signed by the FMV and IG-JAS. The contract covered the Type 2110 but with an option on the Type 2111 variant, which was to be researched by IG-JAS to see if the HiMAT technology was financially and technically worth introducing on the JAS. (The 2111 with HiMAT technology was very manoeuvrable with high turn rate, but its transonic and supersonic performance was significantly degraded and the project was eventually dropped.)

The contract between the FMV and IG-JAS was unusual because the development and production of five prototypes and 30 production aircraft was to be completed at a fixed price. In other words, an increase in development costs could not be clawed back by increasing the price of the first batch of production aircraft. There was also an option for a second batch of 110 aircraft at a not to be exceeded price.

Some of the requirements for stability and performance were outlined, including the functions which the aircraft had to achieve, but some technical detail was omitted because both parties wanted to keep their options open for any new technical innovations. Rollout and first flight were scheduled for 1987; deliveries of production aircraft were to begin in 1990. An Initial Operating Capability was to be achieved in 1992.

This contract differed from all previous contracts between the FMV and the Swedish aircraft industry in that, for the first time, it was the industry and the suppliers that carried the responsibility and not the procurement agency. Total value was SKr 10,000 million, but the ceiling price for the second batch (110 aircraft) has never been made public.

The FMV deliberately drove a hard bargain when it came to financing the development and production of the JAS 39. Over the years, the complexity and cost of each new generation of fighters had spiralled ever upwards. As costs increased, so the numbers of new fighters procured fell as air forces were forced to abandon 'one for one' replacement programmes. Keeping the cost of the JAS 39 down without sacrificing capability was therefore all the more important because the aircraft was intended to replace remaining second and third-generation fighters (Drakens and Viggens)still in Swedish Air Force service.

Keeping programme costs (and therefore unit price) down was a bigger problem for Saab than for other, larger aircraft manufacturers, for instance Dassault, General Dynamics and McDonnell Douglas, because Sweden's policy of neutrality and strict weapons export laws meant that the company did not have as broad a customer base on which to rely. Although the Draken had won orders from Austria, Denmark and Finland, the more capable Viggen failed to win a single export order. Outside Europe there was a different problem in that the Viggen's RM8 engine was a licence-built American design. When India. expressed an interest in possibly acquiring Viggens, the US State Department exercised its right to veto the transfer of engine technology and thus scuppered any chance of a deal.

When it came time to re-equip with third-generation fighters, the likes of Belgium, Denmark, the Netherlands and Norway all chose the F-16. Part of the explanation lay in the politics and practicality of Sweden's policy of neutrality. In short, if these NATO members procured the Viggen and then found themselves drawn into a war situation, could they rely on neutral Sweden to provide the essential spares and support for their Viggens? As for Austria and Finland, the increasingly open and competitive market meant that neither would be under any obligation to once again buy from Saab.

All of this meant that for Saab to stay profitable, it had to succeed in the domestic market. In 1982, when the decision was made to select and build the JAS 39, Saab worked on the basis that the Swedish Air Force would require 400 of what it claimed would be the first 'fourth-generation fighter' to enter service; any exports would be counted as extra. If the project failed on grounds of cost, the effect on Saab and the rest of the Swedish aerospace industry would be catastrophic.

First originally designed jet engine aircraft made by Saab, and probably the last one. The Tunnan and the Gripen.

Origination

As 1982 drew to a close, the Swedish Air Force's in-house magazine *FlygvapenNytt* published the results of a competition to name the JAS 39. By the end of the year the JAS 39 had been officially christened Gripen (Griffin); a fabulous creature of mythology with the head and wings of an eagle and the body of a lion. The Swedish Air Force's fourth-generation fighter would be a symbol of vigilance, patrolling the skies and ready to pounce.

The JAS 39 was the only fourth-generation fighter other than the IAI Lavi for which there was not a specially developed technology demonstrator – a decision taken with programme costs in mind. Instead, two Viggens were used to test some avionics and other equipment and help speed up development. On 14th September 1982 the first of the Viggens (37-52, the second prototype JA 37) took to the air in its new guise as the ESS (Elektriskt Styr System or Electric Control System) fly-by-wire testbed. The flight lasted one hour and 12 minutes and, according to the pilot Tord Grims, the system worked well. The ESS Viggen would go on to complete more than 250 flights before it was retired.

The Gripen's fighting prowess was clearly illustrated in two possible weapons loads on models displayed at the 1983 Paris Air Show. Both had two wing-tip AIM-9 Sidewinder short-range AAMs (F-16 style) but one carried three RBS-15 ASMs and the other four Sky Flash medium-range AAMs.

On 11th February 1985 Saab displayed for the first time a 1:1 scale mock-up of the Gripen and during the Paris Air Show in June the company announced that the first prototype Gripen, 39-1, would make its maiden flight during 1987 as planned. Later, Saab's Aircraft Division announced that the prototype would be rolled out on the company's 50th anniversary, 26th April 1987, making it a day for double celebration.

Gripen 39-1 was indeed rolled out on 26th April 1987 during the celebrations. Saab's Tommy Ivarsson reported a half-year delay in the programme, but noted that this was not expected to have any effect on the schedule for first deliveries to the Swedish Air Force. The prototype was not entirely complete, which explained why those attending the 50th anniversary celebrations were only allowed to see the starboard side of the aircraft.

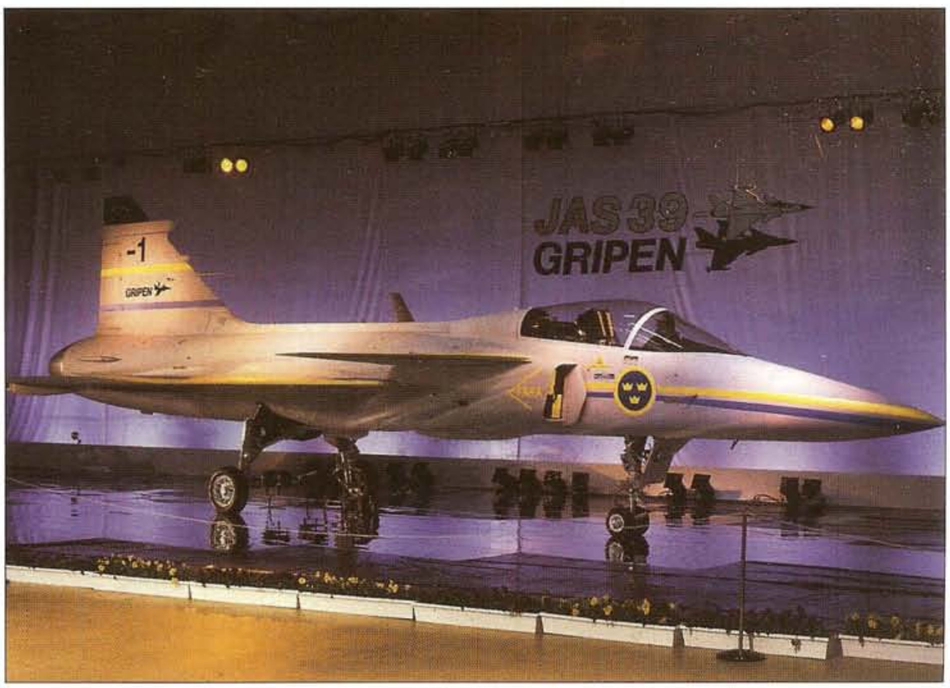
If everything stayed on schedule, 39-1 would make its maiden flight in the fourth quarter of 1987 with the other four prototypes following at six-monthly intervals. However, Saab was behind schedule and trying to catch up so that evening, shortly after the festivities finished, 39-1 was taken back to the testing hangar to allow work to resume straight away. The second Gripen prototype, 39-2, was already in final assembly.

Ejection Tests

Flight testing was not the only work needed to clear the aircraft for service. Saab built two forward fuselage/cockpit sections which were first used for birdstrike tests before one was sent to Martin-Baker in the UK for ejection seat testing. In addition, two single-seat fatigue test frames were built (39-51 and 39-52). The forward

Opposite page:

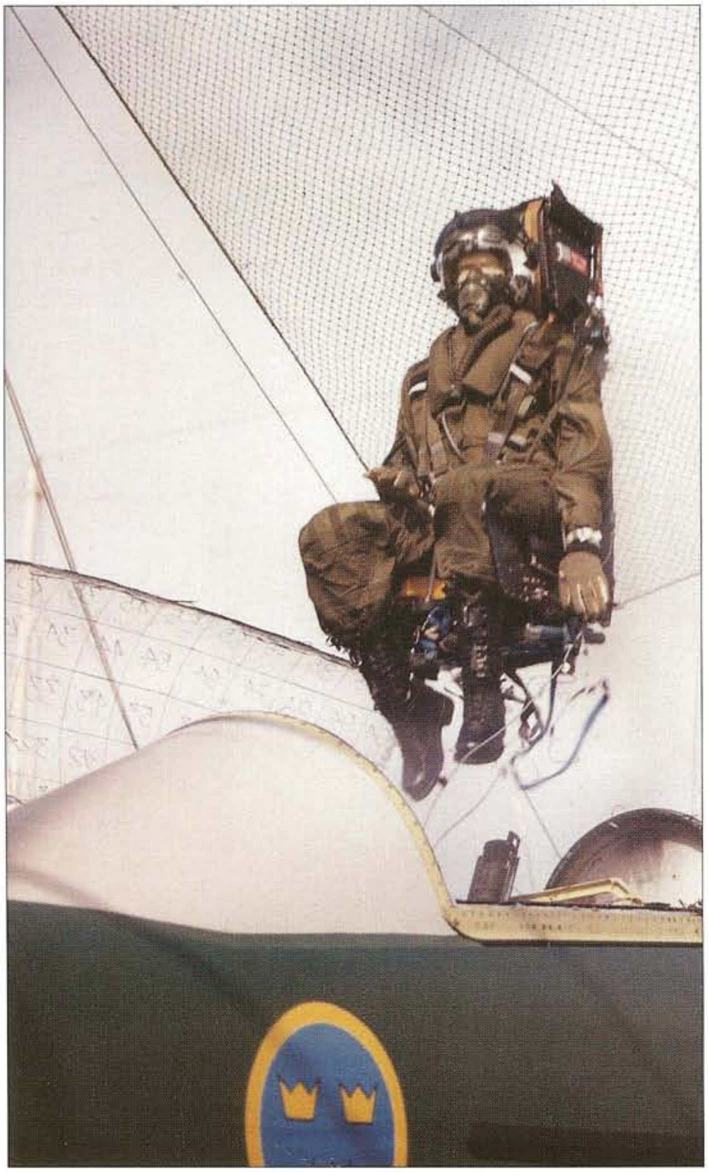
The ESS Viggen 37-51 in flight during 1982.



This page:

An early artist's impression depicting the JAS 39 in the Fighter version.

The highlight of the 50th anniversary of Saab was the roll out of the first Gripen prototype. Because work on the aircraft was far from complete, those in attendance were permitted to see only the starboard side of the aircraft.



Left: **A Martin Baker Mk.S10LS ejection seat undergoing a zero-zero test firing in June 1985.**

Above: **One of the two forward fuselage/cockpit sections used for test ejections.**

Below: **Gripen prototype 39-1 had a protracted ground testing period followed by a short-lived flying career of just six flights.**

fuselage/cockpit sections were nearly compete by October 1985 and birdstrike trials began shortly afterwards.

In March 1986 Martin-Baker took delivery of its test specimen for low-level, high-speed ejection qualification using a rocket sled, after which the two forward fuselage/cockpit sections were discarded. (Once its fatigue programme was completed, 39-51 was also disposed of but 39-52 did not begin its 16,000-hour test programme until 1993; in 1996 it had clocked up more than 8,000 hours of testing.)

The first Gripen prototype had entered final assembly by the end of 1986 and the forward fuselage and cockpit, centre fuselage and aft fuselage were mated together in January 1987. By the end of the year both the first and second prototypes had been built, but both were kept firmly on the ground while Saab tackled problems with the Flight Control System (FCS) software.

By the end of February 1988 Saab had completed its engine runs and 39-1 was scheduled to fly in June. A worrying occurrence at this time was the discovery that a dedicated group in Sweden was trying to learn some of the Gripen's secrets. Saab responded by arming its guards to protect its offices, workshops and hangars. A Bulgarian Embassy official was suspected of spying.

First Flight

On the evening of 8th December 1988 the FMV finally gave its approval for the first flight of the JAS 39 Gripen prototype. There had been many problems clearing the aircraft for flight, most of them concerning the FCS software which was the cause of an 18- month delay to the flight test programme. The programme was expected to include 2,500 flights and last until 1992, when initial deliveries of production Gripens were scheduled to begin. However the FMV, aware of the seriousness of the software problems, realised that the delivery timetable could be jeopardised as a consequence of the 18-month delay.

The first flight of JAS 39 Gripen 39-1 began at 12:22 on 9th December 1988 and lasted 51 minutes. The pilot was Stig Holmström who had joined the Swedish Air Force in 1965 and flown the J 29, J 35 and JA 37, and who had already made about 1,000 'flights' in the Gripen simulator. Before the flight the RM12 engine had also accumulated over 4,000 hours of ground running, of which more than 30 hours were in 39-1 itself.

During the flight, Holmström took the Gripen up to 21,000ft (6,400m) and a maximum speed of about Mach 0.8, pulled turns of 4g and achieved a maximum angle of attack of 12°. He found that the FCS was more sensitive than had been predicted in the ground simulator and noted that the control commands would probably need to be modified.

Saab and the FMV had intended that four Saab and two FMV test pilots would fly the Gripen. Arne Lindholm would be the second Saab test pilot and Lars Rådeström the third; the first FMV pilot was to be Major Mats Nilsson who was expected to fly the prototype's 9th flight. However, 39-1 flew just twice during December 1988, and six times altogether, before it was written off in a landing accident on 2nd February 1989.

The delay to the flight test programme because of FCS software problems was compounded by the unexpected early demise of 39-1. For the first time the planned delivery date for the first production Gripen was postponed by Saab from 1992 to early 1993.

During early April 1989 Saab still hoped to fly the second Gripen prototype before the end of the year. At this point the programme was a little over 35% over budget but to cancel it prematurely would, for the majority of the Swedish population, discredit their aviation industry and be seen as an admission of failure. A thorough investigation also concluded that the Gripen was still the cheapest option.

Nevertheless the Swedish government decided to postpone its decision on whether to continue funding the programme and to order a second batch of Gripens until 1991. General Lars-Erik Englund, Commander-in-Chief of the Swedish Air Force, subsequently maintained that the Gripen programme was not in danger of cancellation.

Milton Möberg has to 'force' Stig Holmström to get him into the cockpit before the first flight of Gripen prototype 39-1.

Gripen prototype 39-1 seen touching down at the end of one of the two test flights it undertook during 1988.

Following the loss of 39-1, the second Gripen prototype's flight test flight programme got off to a deliberately slow and cautious start.

Learning the Lessons

The programme's software design and engineering staff at Saab had been doubled by August 1989 in an effort to get the Gripen back in the air before year's end. The Statens Haverie Kommission (SHK or Swedish Board of Accident Investigation) stated that Saab should be more careful and could have prevented the crash of 39-1 if it had analysed the data from the aircraft's first two flights. Programme Manager Tommy Ivarsson agreed that they should have been more thorough.

Ivarsson also reported that the second prototype had finished its load calibration tests and was now awaiting the completion of changes to the FCS software to eliminate the oscillation problems encountered during 39-1's six flights The crash investigation had established that the oscillations were not due solely to bad weather and severe turbulence.

Saab reported at the end of February 1990 that 39-2 was ready to fly and the new FCS software was installed; however, the FMV had to thoroughly check 39-2's airworthiness, which Saab said would delay the flight until the first week of March. The FMV had followed the same procedure prior to 39-1's first flight, but after the second flight the FMV was no longer involved in the programme. The SHK blamed the FMV in part for the crash of 39-1, so it was hardly surprising that the FMV wanted to take the necessary action to avoid making the same mistake again.

On 28th March 1990, 39-2 was performing some high-speed taxying (the low-speed tests were done) when, at 74.5mph (120km/h), one of the nosewheel tyres burst. There was no damage to the aircraft but its first flight was delayed yet again.

At 19:49 on 4th May 1990, Arne Lindholm took to the skies in 39-2 on what was meant to be a 40-minute first flight. Lindholm had replaced Stig Holmström as chief test pilot and this was his third flight in the Gripen. It was to be a short flight, for Lindholm landed just 14 minutes after take-off.

The aircraft reached an altitude of 6,562ft (2,000m) and speeds of 173-288mph (278-463km/h) but a problem with the cooling system led ground control to decide to end the trip prematurely. The aircraft was expected to fly again within a couple of weeks.

The next prototype to fly would be 39-4, the fourth Gripen; 39-3, the third aircraft, would be used to ground test the radar system. The first production Gripen was also about to enter final assembly. Development work on the RM12 was also proving troublesome, a thrust loss problem when starting the engine cold and cracks in some compressor blades having been discovered.

At the Internationale Luftfahrt Austelling (ILA) held in Hanover in May 1990, Saab told the press that the FCS software changes which had been introduced were sufficient and that the Gripen was now very stable.

In September, at the SBAC Show at Farnborough, Per Pellebergs announced that the second prototype had made a total of just six flights. This was the result of a decision not to rush the test programme, but to advance it slowly and carefully in an attempt to avoid a second mishap.

Later in the SBAC Show, Arne Lindholm reported that 39-2 had now flown nine times, and that the flight test programme was gathering momentum. By mid-October all of the other prototypes were ready to fly and 39-2 had completed 22 flights. The next Gripen to fly (39-4) was expected to do so before the end of the year; 39-5 was being used to test the Mauser BK27 cannon and 39-3 was still involved in a series of ground tests.

Fears for the Future

At the end of November 1990 the Swedish government once again postponed its decision to buy a second batch of Gripens, this time until 1992, because of the delays experienced in the flight test programme. Saab feared that if this decision were to be postponed further still, the result would be a gap between the first and second production batches, which would mean the end of the project.

The first flight of Gripen prototype 39-4 gave Saab a much-needed boost to morale, and its arrival helped speed up the flight test programme.

Like the other Gripen prototypes, 39-5 was used for ground tests (including the Mauser BK27 cannon) as well as participating in the flight test programme.

The company's spirits were lifted somewhat when Arne Lindholm took 39-4, the first Gripen to be equipped with a complete avionics system and 'glass' cockpit, on its first flight on 20th December 1990. The flight lasted 43 minutes and included a systems check to see if 39-4 behaved in the same manner as the analogue-controlled 39-2. After two more flights to check that the systems were in sound working order, 39-4 moved on to engine testing. By the end of 1990 the three prototypes had between them accumulated a total of 33 flights.

The next Gripen to fly was 39-3 on 25th March 1991, again with Lindholm in the cockpit. This aircraft was the first to fly with the complete radar and its attendant system. At this point, the four Gripen prototypes had notched up 64 flights between them. Just over a month later, on 29th April, the FMV reported to the Swedish government on the Gripen's development programme to date. Some of the points noted by the FMV were:

- Tests on the aircraft's flying characteristics had so far produced the anticipated results.
- Initial tests on the avionics and data system were positive, as were the pilot's assessments.
- The performance requirements for the radar were likely to be achieved.

By the end of April the Gripens' flying time had risen to around 75 hours. By 13th May 1991, five pilots had flown the Gripen on a total of 83 flights which had revealed that the aircraft experienced less drag than predicted and, consequently, its performance was better than had been anticipated.

With the flight test programme now well under way, the Gripen was cleared to fly in formation and manoeuvre with its chase plane (a Viggen), which was unable to keep up! In the American journal *Aviation Week and Space Technology*, test pilot Jan Anger stated that the Gripen accelerates faster and manoeuvres better than the Viggen. The test programme used telemetry which made it possible to transmit data gathered in the aircraft back to the ground via a datalink so that it could be examined immediately. if necessary, further instructions could then be relayed back to the pilot.

Gripen prototypes 39-2 to 39-5. Note how only 39-2 is devoid of a black nose radome.

The first all-Gripen formation flight was made on 28th May 1991 and two days later the 100th Gripen test flight was completed. Completion of another milestone was announced the day before the start of that year's Paris Air Show when Saab announced that the Gripen had achieved sustained supersonic flight without afterburner.

Saab took the opportunity to also confirm that none of the Gripen prototypes would attend the show because they were all fully committed to the flight test programme. The company also stated that tests had shown that the Gripen produced less drag than expected.

Safety in Numbers

On 14th June 1991 the Supreme Commander of the Swedish Armed Forces gave his budgetary proposals to the Swedish government. The proposals comprised four alternative budget plans, three of which directly concerned the Gripen. The four plans were:

1. SKr 38.5 billion to pay for 21 squadrons of Gripens (JAS 39As and Bs) plus extra funds to complete the Gripen's development;
2. SKr 36.1 billion for 18 Gripen squadrons (JAS 39As and Bs);
3. SKr 32 billion for 16 squadrons but with no two-seaters (This option would make the Gripen more expensive, training and safety more problematic, and winning export orders that much more difficult.);
4. SKr 32 billion for the same number of aircraft as Option 1 but with a reduction in the number of conscripts to 1,200.

The FMV subsequently issued an RFP for a second production batch comprising 110 single-seater JAS 39As, and for an alternative proposal that included development of a two-seater JAS 39B. IG-JAS responded with offers that were submitted on 1st October 1991. The FMV was supposed to give its recommendation to the Swedish government and obtain from it a mandate to negotiate a contract with IG-JAS.

The IG-JAS offers were valid for a year, which gave Sweden's politicians time to make up their minds However, just a week later, in a Swedish daily newspaper, Minister of Defence Anders Bjorck spoke out in support of the two-seater Gripen, stating that he saw it as an essential part of the Gripen programme and a big help to the Gripen's chances of winning orders from overseas customers.

While IG-JAS and Swedish politicians considered future Gripen production and Sweden's defence requirements, the flight test programme continued apace. On 26th September, at the SETP annual symposium, Per Pellebergs, Director of Flight Operations, reported on progress made by the flight test team (the figures were actually 14 days old).

Aircraft	Flights
39-1	6
39-2	67
39-3	41
39-4	45
37-51*	207

* The ESS Viggen

He also stated that five Saab and two Swedish Air Force pilots were flying the aircraft and all three surviving prototypes had been fitted with modified engines. Three days later the first separation firing of an Rb74 Sidewinder air-to-air missile took place over Lapland.

On 19th June 1991 Ericsson Radar Electronics AB and SA Matra Defence of France signed an agreement at the Paris Air Show to jointly market the active radar MICA air-to-air missile (AAM) for the Gripen. The aim of the agreement was to secure the order for a medium-range radar missile for the Swedish Gripen programme and included a provision for further co-operation in other export markets. Other missiles in the competition were the American AMRAAM produced by Hughes Missiles Systems and Raytheon and the new Active Sky Flash produced by British Aerospace.

Double Century

The 200th Gripen flight took place on 16th October 1991, at which time there was some disagreement between Saab and the Swedish Air Force about the Gripen's flying qualities. After 200 flights the Gripen had revealed some of its strengths and weaknesses; Saab wanted to address the latter but felt that the Swedish Air Force should pay the extra cost. The Swedish Air Force, of course, felt otherwise and saw the Gripen's weak points as shortcomings in the design which, from a cost point of view, were the responsibility of Saab.

The 23rd of October saw test pilot Weikko Sunell make the maiden flight in 39-5. A total of 152 flying hours had now been accumulated in 216 flights. That figure rose to 278 flights by 9th December, by which time ten pilots (three of them from the FMV) were flying the Gripen. Load factors of up to 7g had been registered.

December 1991 proved significant in another way when the FMV was instructed by the Swedish government to start negotiations with IG-JAS for a second batch of Gripens, this to include up to 15 JAS 39B two-seaters. The subsequent negotiations resulted in a contract, announced on 2nd June 1992, for 110 Gripens; this figure to include 14 two-seaters, the prototype of which would be a modified production JAS 39A single-seater. The clear intention was to accelarate development of the JAS 39B and thus enhance the Gripen's chances of winning export orders (at the time the Gripen was competing for an order from Finland). An early export success might also help reduce the cost of further batches of Gripens for the Swedish Air Force.

German Interest

In January 1992 Per Pellebergs replaced Tore Forsström as Manager of the Flight and System Test Department. By March the Gripen fleet had made more than 350 flights, the ever-increasing number reflecting the availability of more prototypes. As flight testing progressed, Saab and the Swedish Ministry of Defence briefed German representatives on the aircraft (the German government was toying with the idea of buying a mix of Eurofighters and Gripens).

In the meantime Rediffusion, Loral, CAE and Link-Miles all submitted bids to the FMV in the hope of winning a contract to produce a Gripen flight simulator. Industry experts viewed this requirement as being very demanding. On 19th June 1992 Loral received a contract from the Swedish government to design and build two multi-mission Gripen simulators.

As of 20th May the five prototypes had flown 469 times. Per Pellebergs estimated that after 1,000 flights Saab would be ready to deliver the first production Gripens.

Batch Two

On 3rd June 1992 the Swedish parliament took the decision to place a second order for 110 Gripens. Known as Batch Two, the order included development of the JAS 39B two-seater; 14 of the 110 Batch Two Gripens would be of this variant. Firm orders for the Swedish Air Force now stood at 140.

Although the decision was welcome, for Saab it was too late to help it win what could have been an early export success. Had the Swedish parliament's decision been made before 10th March, it might have influenced the unit price in an offer to sell Gripens to the Finnish Air Force. The chance was gone. The Finnish Air Force subsequently placed an order for 64 McDonnell Douglas (later Boeing) F/A-18C/D Hornets, seven of which were to be the two-seater variant.

Per Pellebergs reported on 16th June 1992 that the five Gripen prototypes had made over 500 flights between them, totalling about 400 flying hours. By 25th June the Gripen airframe had been tested to 9g (the maximum *g* rating) and the first production aircraft, 39101, which had arrived in the test hangar back in the spring, had completed most of its ground tests and was expected to start flying in the early autumn.

Royal Approval

In September the Gripen made its debut at the 1992 Farnborough International Air Show. One of the Gripen pilots in attendance was Lars Rådeström, no stranger to Farnborough having flown the Viggen there as a Captain in the Swedish Air Force. King Carl Gustaf and Prime Minster Carl Bildt were present on 6th September to witness the Gripen's first Farnborough flight (and that of the Saab 2000 airliner).

Prototypes 39-3 and 39-4 were present which, by taking them away, delayed the flight test programme by a week. However, their presence allowed Saab to give a clear signal that it wanted (and expected to be allowed) to export the Gripen to countries outside the usual neutral boundaries.

Flight demonstrations were undertaken by 39-4; 39-3 was present in the static display on the trade days (it flew back to Sweden before the public days, fitted with external fuel tanks).

As if there was not a big enough Swedish VIP presence, Anders Björck, the Swedish Minister of Defence, flew in on 7th September in an Sk 37 Viggen, which was accompanied by another Viggen. Björck was there to promote the export of the Gripen and show that the Swedish government agreed with Saab's export ambitions. He said that the government-approved defence budget for the next five years meant a rise in military spending in real terms, making Sweden an exception to the fiscal cutbacks in defence expenditure in the rest of Europe. His statement was a clear message to Sweden's generals that they had nothing to complain about.

Björck also expressed the hope that there would be a decision in a year's time as to which medium-range AAM would be bought to arm the Gripen. He noted the French MICA, American AIM-120 AMRAAM and British Active Sky Flash as the options, and stressed that the French had a good chance of winning because they had already declared a willingness to give re-export rights for equipment sold as a part of the Gripen export package.

Germany, meanwhile, had caused some turmoil in the the EFA (Eurofighter) programme with a suggestion that it would not need an EFA-type fighter, but rather what was referred to as an 'EFA-lite'. Anders Björck reacted by stating that although 'EFA-lite' and the Gripen were not the same aircraft, they had the same concept and there was no doubt that others could learn from the Swedish approach.

On the first day of the show, the Gripen made an immediate and positive impression when 39-4 took off and performed in bad weather that kept most of the other fighters firmly on the ground. The demonstration ended with 39-4 showing off the Gripen's short landing run and its manoeuvrability on the ground by making 360° turns on the main runway.

A status report published by Saab put the case for a further order by reporting the following progress in the flight test programme:

- The flight envelope had been cleared to maximum speed and altitude for the basic aircraft.
- Further tests were now being performed with the heaviest external weapon load.
- Test flights had been carried out to a maximum load factor of 9g.
- In-flight firing of the 27mm cannon had given good results.

One of the prototype Gripens undergoing microwave testing in 1992.

Gripen prototypes 39-3 and 39-4 attended the Farnborough Air Show in 1992, the first and last time any of the prototypes participated. This view shows the aircraft in transit to the show. It would be another four years before a production Gripen attended the show.

An early publicity photograph of the Gripen's load-carrying capabilities. Note the white ECM jamming pod on the shoulder pylon.

- Sidewinder IR missiles had been fired in various flight conditions without problems.
- The first separation test with a DWS 39 dispenser weapon had taken place with good results.
- The introduction of updated software for the flight control and avionics systems in the test aircraft was under way (these aircraft were close to the planned version in its initial production standard).
- Results from both rig tests and flight verification of the engine were positive.
- The display system had been tested in both darkness and bright daylight (the basic display characteristics had been highly praised by the pilots).
- Further development of the displays was in progress, aimed at reducing pilot workload during complex missions.
- Radar function and performance had been verified with good results in the Gripen while more than 200 test flights had been made using a modified Viggen equipped with the Gripen's radar and displays.
- Development of an upgraded standard computer (the D80E) was in progress at Ericsson Radar Electronics.
- Series production was in progress with aircraft 39103 and 39104 in final assembly and 39105 through 39116 in various stages of construction.
- 39101 was in the final run-up stage prior to its first flight (it had been painted as a production aircraft in Swedish Air Force colours despite being a replacement for the lost first prototype 39-1).
- 39102 had left final assembly, preparations for final system tests were in progress and customer delivery was expected in the spring of the following year.

Gripen 39101 made its maiden flight on 10th September 1992; it lasted 44 minutes and was the 594th flight in the test programme.

Batch One Deliveries

When JAS 39A 39102 became the first Batch One Gripen to be delivered to the Swedish Air Force, on 8th June 1993, it led a special flypast of four generations of Saab fighters – Lansen, Draken, Viggen and, of course, Gripen – over Linköping to mark the event.

The very next day, the Gripen made its first road landing. This was a highly significant event because the Swedish Air Force was basing much of its future front-line operational capability on the new BAS90 system which used normal roads as dispersed bases to help the Swedish Air Force survive longer in a war. These dispersed bases would be very difficult to detect and destroy.

Progress Report

The Gripen did not attend the 1993 Paris Air Show but on 10th June Per Pellebergs revealed the following information at a Saab marketing department press conference.

Aircraft	Flights	Duration(hrs)
39-1	6	5
39-2	297	183
39-3	242	187
39-4	289	187
39-5	191	197
39101	66	57
39102	31	24
TOTAL	**1,122**	**840**

Note: Viggen 37-51 had also made 238 test flights with Gripen equipment.

Gripen 39-2 had been used to open up the complete speed, altitude and load factor flight envelope, flying with both light and heavy external loads; angles of attack up to 26° had been achieved. Gripen 39-3 was testing the radar, datalink, weapon and navigation systems, the basic functions of which were now covered; all that remained to be done was the interaction between these systems.

Gripen 39-4 was being used to clear the RM12, including restarting the engine in flight several times. Gripen 39-5 was being used to test the same systems as 39-3, but also the communication, hydraulic, reconnaissance and warning systems. The first production aircraft, 39101, in its role as a replacement for 39-1, was being used to test equipment not yet standard to Batch One production Gripens.

Pellebergs also announced that aircraft 39103 to 39108 were in final assembly, 39109 to 39122 were in various stages of assembly and the manufacture of parts for the first Batch Two aircraft was in progress. During June Lt Colonel Jan Andersson and Major Olle Eldh became the first operational pilots to fly the Gripen.

One of the prototypes with an array of the various weapon loads that the Gripen was projected to carry.

Gripen prototype 39-2 undertook a great deal of the weapon carriage tests during the flight test programme.

The Gripen's clean lines are evident in this view of the first production JAS 39A carrying nothing more than two wing-tip Rb74 Sidewinders.

JAS 39A 39102 leading a formation of older Saab products (Lansen, Viggen and Draken) in a celebratory flypast to mark the delivery of the first Batch One Gripen to the Swedish Air Force on 8th June 1993.

The first and the second production Gripens, 39101 and 39102, with '101' carrying an RBS 15F and an Rb75 Maverick on its port wing pylons.

The first and second production JAS 39A Gripens, 39101 (left) and 39102, in formation for the camera. Following the loss of prototype 39-1, Gripen 39101 was assigned to the flight test programme as a replacement.

A view of the Gripen assembly line. The aircraft are identifiable as Batch One Gripens thanks to their black nose radomes.

Second Loss

In August 1993 test pilot Mikael Seidl flew the Gripen for the first time but on the 8th of the month the second production aircraft, 39102, was lost in a crash. Four days later Bengt Gustavsson, Supreme Commander-in-Chief of the Swedish Armed Forces was requested to report on the operational and financial consequences of a possible delay in the Gripen programme. One difficulty was that it had been planned to deliver 39103 in October 1993 but deliveries would now be put on hold.

By the end of September 1993 around 200 FMV and IG-JAS personnel were working hard to get the Gripen back into the air and Saab hoped to fly the aircraft again in November. According to the Supreme Commander-in-Chief, the cost of the delay, excluding the value of the aircraft, was around SKr 93 million of which SKr 42 million would be carried by Saab and SKr 38 million by the FMV, with the rest compensated for by adjustments to the programme. Batch One production aircraft 39103 and 39104 would be delivered later than planned, but it was hoped that aircraft behind them on the production line would be delivered on time because their manufacture had continued uninterrupted.

During October 1993 the FMV submitted a status report for the Gripen test programme as of 30th June, little more than a month before the crash of 39102. The report stated that the fleet of test aircraft had made approximately 1,200 flights, the entire flight envelope without any external load had been explored and the RM12 engine was performing well. However, the report also noted that the Microturbo Auxiliary Power Unit (APU) continued to cause problems during flight.

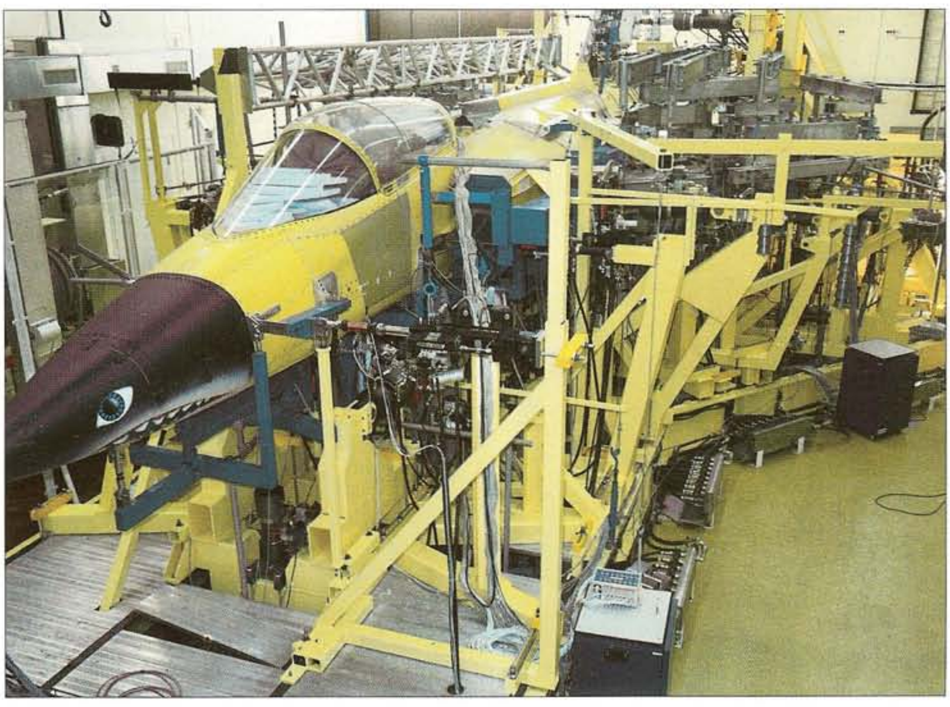
Gripen 39-2 resumed flying on 29th December 1993 when it made the first flight following the loss of 39102. Each of test aircraft was now adorned with an orange circle on each engine air intake, beneath the canard, to notify photographers that updated (post-crash) FCS software was being used.

A March 1994 status report on the Gripen programme gave the following information:

- Complete flight envelope (speed, altitude, load factor, angle of attack, external loads) had been explored, 60% of the total flight test programme was complete and 80% of the contractual verifications were complete.

Gripen prototype 39-2 takes off with a prominent orange disc visible under the canard to indicate that the aircraft has been fitted with improved FCS software following the 8th August 1993 loss of 39102.

Prototype 39-2 armed with ARAK 70 rocket pods.



One of the static test aircraft, and the only member of the Gripen family so far to have been adorned with sharkmouth artwork.

- Customer evaluation period successfully completed before first production delivery.
- Good engine function and performance in the aircraft; thrust as predicted.
- Drag lower than predicted.
- Acceleration, speed and range better than specification.
- Turn performance better than specification.
- Turn-around and service times better than specification.
- Testing of the internal gun in progress – mechanical environment within specification.
- Firing of the wing-tip Sidewinder AAM at load factor 6g achieved.
- Firing of Maverick ASM at load factor 3g achieved.
- Separation tests with ARAK 70 rocket pod, DWS 39 weapon dispenser and the RBS 15 anti-ship-missile carried out.
- Separation tests with external fuel tanks carried out.
- Flight testing up to design load factor of 9g; measured loads as predicted or lower.
- Comprehensive static, fatigue and damage tolerance testing performed on structural parts.
- Static testing of the complete airframe performed successfully to 230% of limit load.
- Full-scale fatigue testing of airframe in progress; the goal was to reach 6,000 hours in 1995 – so far 1,000 hours had been completed.
- Performance of the basic aircraft systems met specification – in many cases performance exceeded specification.
- High pilot ratings for flying qualities, even with heavy external loads; good landing qualities, even on narrow road bases.
- Flight control system back-up modes tested (digital as well as analogue).
- Good avionics system integration performance.
- Electronic display system given high pilot ratings for visibility, field of view and presentation.
- Good function and performance by radar in attack, fighter and reconnaissance modes.
- Aircraft 39103 to 39113 in checkout or final assembly; ten aircraft planned for delivery during 1994.
- Aircraft 39114 to 39128 in various stages of structural final assembly.

The outstanding flight testing to be completed covered high angles of attack, flight at extreme temperatures, continued weapon system testing and the optimisation of the flight control system and the avionics system.

The reason given for the Gripen's absence from the Farnborough Air Show in early September was that no display pilot was available, Lars Rådeström having retired from the test programme because he had passed the 50-year age limit specified in Saab's military department; he continued flying as a test pilot in Saab's civil aviation department.

Weapons Integration

The Gripen passed the 1,500 test flight mark on 16th November 1994 and, during that month, compatibility tests with the Rb75 Maverick ASM were completed. Following systems integration work an operational missile was test fired on the RFN firing range in northern Sweden to verify the results. Tests with the Rb74 Sidewinder air-to-air missile and the DWS 39 weapon dispenser were still in progress and included systems checks during complete missions.

The development of an Active Electronically Scanned Array (AESA) had also begun when the FMV placed a study contract with Ericsson for a radar with a thousand or more transmitter/receiver modules, which could be introduced on the Gripen after 2000.

Deliveries Resume

In early December 1994, production Gripens 39106 and 39107 made it into the air and by the 13th of the month 39103, 39104 and 39105 had been delivered. Aircraft 39108 to 39122 were in assorted stages of hangar preparation or final assembly and 39123 to 39139 in various stages of construction. About 70% of the flight testing had been completed and prototype 39-2 has been painted black to undertake some advanced high 'alpha' and spin tests scheduled for 1995.

The following breakdown by company/unit accounts for the 19 pilots who were (or had been) involved with the Gripen flight test programme at the end of 1994:

- Saab: 10 pilots, 3 of whom had retired from the programme or were no longer involved.
- FMV: 5 pilots, 1 of whom was no longer active.
- Swedish Air Force: 2 pilots, both still active.
- Valmet (Finland): the company chief test pilot, no longer involved because Finland had decided to buy the F/A-18C Hornet.
- Finnish Air Force: 1 pilot, no longer involved (a third Finnish pilot had evaluated the Gripen simulator).

Gripen prototype 39-2 with an impressive array of stores. Besides the Sidewinder air-to-air missile and the BK27 internal cannon, the initial weapons tested were air-to-surface and anti-shipping missiles.

During 1995, Saab contacted the Netherlands' Nationaal Lucht Ruimtevaart Laboratorium (NLR or National Aerospace Laboratory) for help following the two accidents. The need for outside help arose because Saab only had a fixed-base simulator (at Linköping) and the company needed to evaluate considerably more factors.

The NLR undertook the study in its National Simulator Facility with the motion system on active and non-active. With the motion system switched off the results were similar to Saab's simulator tests; however, when the motion system was switched on, the results were remarkably close or comparable to actual flight tests under the same circumstances. Co-operation between Saab and the NLR on this study continued until at least October 1996 and the software was evaluated for both the single and two-seat Gripen.

On 9th March 1995 the Swedish government asked the Riks Revisions Verket (RRV or State Revision Works) to examine the financing of the Gripen programme. Also in March, the FMV began flight operations using production aircraft from a base at Malmslätt outside Linköping.

Software Changes

The 22nd of March saw the first flight of a new version of the flight software called P11 which had received a lot of attention because of its electronic filter. The title P11 was derived from the 11 electronic filters used to prevent Pilot-Induced Oscillation, the cause of the two previous crashes. Saab undertook some 30 test flights before installing the new software in all of the test Gripen. (Installaton of the software in production Gripens began that autumn.) The new software's biggest advantage was that it allowed the Gripen to be evaluated through the entire flight envelope.

Gripen 39108 made its first flight on 11th April 1995 and introduced, at the request of the pilots, a low-pivot control stick with a new grip design; the old stick could be a strain on the pilot's arm and hand muscles during formation flying or in high g manoeuvres. By 28th April a total of 1,825 flights had been made, 1,726 of them test flights of which 18 involved the new P11 software.

Saab test pilot Reino Lidvik took 39109 on its first flight on 4th May 1995; this aircraft featured a black radome, the first of 19 aircraft to be so equipped. Mid-May saw the proportion of of the contractual flight requirements verified by Saab rise to 90%; only 264 points remained of which 219 were to be completed at Saab and the rest by the other IG-JAS partners. The total number of proof tests that had to be completed was 3,500; just a couple of those completed were:

- A rejected take-off at maximum weight up to full power and then braking during the take-off with full armament and weapons load.
- Operation from a road strip 800m (2,625ft) long and 9m (30ft) wide.

The entire Gripen fleet had made a total of 1,869 flights by 30th May 1995 of which 1,759 were test flights (the 1,772nd test flight saw the completion of 1,500 hours of test flying). Production Gripens 39105 to 39109 had been delivered to the Swedish Air Force (the last pair during May) and 39110 to 39111 were being used by Saab but were to be delivered during June.

From 11-14th June 1995 a Gripen (39-4) took part in the static display at the Paris Air Show at Le Bourget, its debut at the show.

Three Batch One JAS 39A Gripens undergoing final preparations in a hangar before delivery to the Swedish Air Force.

Gripen prototype 39-2 in its *Black Beauty* colour scheme for high 'alpha' trials in 1995.

This close-up view of JAS 39A 39108 on take-off illustrates the width of the foreplane canards. The aircraft was the first to fly with a new low-pivot control stick.

Mikael Seidl flew prototype 39-4 to Paris on 11th June and on the following day the aircraft was present for the signing of a new marketing contract between British Aerospace and Saab. This move gave Saab access to British Aerospace's bigger support system which would give the aircraft a better chance of being exported; an official handshake was given for the press by BAe's John Weston and Saab's Bengt Halse.

Acquiring the Gripen also gave British Aerospace an excellent aircraft portfolio, the Swedish aircraft complementing the Hawk trainer and Eurofighter because it was lighter and less expensive than the latter and filled the gap between the two superbly. This joint venture was not intended to avoid Sweden's strict export regulations concerning arms, rather that Gripen exports would now be subject to the regulations of both nations. In return for its marketing effort, BAe received 45% of export Gripen production work.

The follow-on order for the Swedish Air Force was now expected to be between 75 and 110 aircraft rather than the previously planned 160. The Gripen was to be marketed internationally with a different logo from that used to date in Sweden, although the latter would still be carried in its own country.

Jan Andersson, who flew the Gripen twice before the crash of 39102, was present at the Paris Air Show as part of the marketing effort. Andersson remarked that the Gripen now flew better than before and was safer. Later in the month the Chief of the Swedish Air Force, Lt Gen Kent Harrskog, flew the Gripen for the first time.

The Gripen Status Report produced in December 1995 noted the following:

- 95% of all contractual requirements had been verified.
- Flight testing of the fully operational P11 FCS software had been completed with excellent results.
- Flight testing with the production version of the E12 avionics software was under way and so far results were good.
- The APU for Batch Two aircraft was currently being flight tested.
- Flight performance was generally better than specification.
- Tests still to be done included optimising the avionic systems for tactical operations and the high angle of attack programme.

On 22nd December 1995 Clas Jensen took off in 39-4 from Linköping to make the 2,000th flight by a Saab Gripen – he had also performed the 1,000th flight 20 months earlier and on this trip he had to test the APU; everything went well.

First British Pilot

Twelve production Gripens had been delivered by the end of 1995: 39102 to 39112 and 39120; 39121 to 39123 were in the final clearance phase prior to delivery. Paul Hopkins, a BAe test pilot, flew a Gripen in the first week of February 1996, the first British pilot to fly the type and the third overseas pilot following the pair from Finland who had evaluated the aircraft. Hopkins would also be the last overseas pilot to make a first flight in a single-seat Gripen.

Meanwhile on 12th March, the FMV placed an order with Rockwell for the development of a new radio system known as Ra 90 that was to become part of Tactical Radio System (TARAS). Ra 90 was to be a new digital 'frequency hopping' communication system that would route voice and data between the Gripen and Tactical Air Command Centres. A production option could be exercised at the end of the development period and naval applications were envisaged to allow joint operations with the Swedish Navy.

By mid-year the Gripen had flown 2,180 test flights and over 600 more on production aircraft. A decision regarding which equipment upgrades were to be financed was to be taken at the end of the year. The Supreme Commander-in-Chief of the Swedish Armed Forces estimated that the budget cuts could be as high as 25% and so the required modifications were prioritised in order of importance:

- Helmet-Mounted Sight.
- In-flight refuelling.
- Infra-Red Search and Track (IRST).
- EP-17 display update.
- New engine.

The engine would be the most likely victim of budget constraints because it did not offer enough extra performance to justify the cost of its installation; more important were those modifications that would improve the chances of exporting the Gripen and, at the same time, lower its cost to the Swedish Air Force.

Batch Two PP12

The first Batch Two Gripen, 39131 piloted by Saab test pilot Reino Lidvik, took to the air for the first time on 20th August 1996 for a flight that lasted just over an hour. This was the first production aircraft not equipped with the two Ericsson PP1 and PP2 processors, but instead the PP12 processor which gave increased capability and saved space and weight.

On 24th and 25th August the Swedish Air Force celebrated its 70th anniversary with an airshow at Ljungbyhed. The Gripen was represented by 39113 in the static arena while the flying display included a four-ship formation made up of 39104, 39121, 39124 and 39126. Finally, Major Ken Lindberg performed his solo Gripen display for the first time in public, in 39120.

Gripen versus JSF

Thanks to the Saab/BAe agreement, the Farnborough Air Show required a big marketing effort at the highest level. Stig Holmström and three other Saab test pilots were present plus Ken Lindberg as the Swedish Air Force display pilot. At this time Saab announced that it visualised a Gripen technology demonstrator flying by 2002 and equipped with thrust-vectoring which would ensure future competition for the JSF and maintain air superiority until 2030 (ie, throughout the planned life cycle of the Gripen in Swedish Air Force service). Other planned upgrades also had to ensure that the Gripen would be of comparable quality to the JSF. One option, according to a Volvo official, was to reduce the Multi-Axis Thrust-Vectoring Control nozzle (being tested on the bigger General Electric F110 engine) to a size suitable for the Gripen.

As Christmas approached, on 13th December the Swedish parliament decided in favour of an additional four squadrons of Gripens, bringing the number of aircraft on order to around 200. In future the Swedish Air Force would operate 13 squadrons, rather than the original plan of 16; of these, 12 would be equipped with Gripens.

The exact number of Batch Three Gripens would depend on the agreed price and on the mix between single and two-seaters, and whether there were to be any upgrades (such as a different engine). The final Gripen from the first batch had been delivered to the Swedish Air Force and it was announced that the next bases to receive the type would be Ängelholm (F10 Wing) and then Uppsala (F16 Wing).

In an interview, General Owe Wiktorin, the Supreme Commander of Sweden's Armed Forces, said that the Forces had taken the responsibility to create the funds necessary for future investment in new defence material by reducing the number of military units and achieving an overall reduction in the military organisation of about 25%.

In future, around 48% of the budget would go towards the development and procurement of new equipment. He added that 'from the mili-

Four early-production JAS 39As (39103 to 39106) with prototype 39-4 in the background.

Batch One JAS 39A 39120 at the moment of rotation. Note the number 7 just behind the nose radome, indicating that the aircraft is (or would be) assigned to F7 Wing.

The high-visibility two-digit tactical code carried on the tails of production Gripens up to and including 39127 shows up well in this flashlit shot of F7 Wing JAS 39A 39116 as it flies over some wintry Swedish landscape territory.

tary side, we have tried to take care of our industrial base, not for the sake of the companies, but because it is in the interest of the armed forces to know that we can rely on a competent defence industry both today and in the future'.

Just over three months after the first Batch Two Gripen, 39128, had made its maiden flight, the aircraft was delivered to the Swedish Air Force on 19th December. Batch Two aircraft were easily recognisable because of their then experimental low-visibility air defence grey colour scheme and toned-down markings. Batch One Gripens had a black 7 just behind the nose radome (which was black on Gripens 39109 to 39127), identifying them as from F7 Wing at Såtenäs. Large Dayglo red/orange two-digit tactical codes adorned the fin. Batch Two aircraft (and the last pair from Batch One) were delivered in the new low-visibility scheme with all numbers, lettering and the national insignia in a darker grey.

New Faces

The first half of 1997 saw some staff changes at Saab. Arne Lindholm was promoted from Saab Military Aircraft chief test pilot to chief of the flight test department, while the new chief test pilot was the former deputy chief test pilot, Clas Jensen. Because of the 50-year age limit, Arne Lindholm retired from active test flying.

During May 1997 work began on Gripen cold weather trials. Sweden has some very cold winters, but the engineers wanted to confirm the results obtained in Swedish conditions. For two weeks a Gripen was exposed to the environmental test facilities at the British Defence Test and Evaluation Organisation at Boscombe Down. The Gripen was left for 24 hours in the environmental chamber, the temperature of which was set at -40°C. When the aircraft's temperature had stabilised the various items of equipment on board were tested to see if they would work in such conditions.

The normal Gripen start-up procedure was used: first the APU, then the engine. During the cold weather trial the onboard computers ran their test programme to ensure that nothing was wrong, while the engineers verified that the hydraulic power to the control surfaces also worked in spite of the temperature. The Gripen was expected to return to DTEO Boscombe Down at a later date to undertake similar high temperature trials.

JAS 39A 39127 (nearest) was the final Batch One Gripens to receive a black nose radome. Both these Gripens are armed with AKAR 70 rocket pods.

Export Gripen

At the Paris Show on 16th June 1997, Saab and BAe announced that the export Gripen was now more clearly defined. One of the options was a retractable air-to-air refuelling probe that would fit on the starboard side of the cockpit. To keep the cost of the export Gripen as low as possible, Swedish Air Force Gripens would have as much commonality as possible with the export version.

Again it was stressed that the Gripen was the first fourth-generation fighter in service; BAe's John Weston noted that Lockheed Martin was advertising its F-16 with the slogan 'a fourth-generation aircraft with a generation of experience', which he felt was a polite way of saying a third-generation aircraft with an updated avionics suite.

Ericsson displayed the first AESA (Active Electronically Scanned Array) antenna and ground testing of a model with 100 transmitter/receiver modules began shortly after the

JAS 39A Gripen 39132, an early Batch Two aircraft, illustrates the change from Dayglo tactical codes and full colour national insignia to more subdued lettering, numbering and insignia on a low-visibility colour scheme.

Low-level training over a frozen lake and mountains can be an exhilarating experience. The low-visibility two-tone grey scheme worn by F7 Wing JAS 39A 39149 helps the aircraft blend into its surroundings, but the white weapons are somewhat conspicuous.

The fact that Saab had to send the Gripen to Boscombe Down in May 1997 to test the aircraft in temperatures as low as -40°C is quite ironic given Sweden's proximity to the North Pole.

show ended. The main features of the AESA were to be:

- Instantaneous change of beam direction.
- Rapid flexible beam focusing.
- Increased detection range.
- Improved tracking performance.
- Effective jamming suppression.
- Flexible active/passive radar usage.
- Improved air combat manoeuvring.
- Data communication and datalinking.

On 26th June 1997 a third batch of 64 Gripens was ordered, this to include another 14 two-seaters; the Swedish Air Force order now stood at 204 including 28 two-seaters. The contract document confirmed that only 12 Swedish Air Force squadrons would be equipped with the Gripen while aircraft from the first two batches, all of them JAS 39As and Bs, were to receive a total of 23 updates including:

- Larger colour Multi-functional Displays (MFD).
- Enhanced warning and counter measure systems.
- A reduced radar signature.
- An imaging IR sensor.
- A further developed PS-05/A radar.
- Upgraded computers and databus.
- A new data cartridge.
- A helmet-mounted sight.
- Improvements to the RM12 engine including a new turbine, improved flameholder and new FADEC from Lockheed Martin, General Electric and Volvo Aero respectively.
- A new navigation and landing system.

The new Batch Three aircraft would also receive:

- Further signature management measures.
- A stronger landing gear for take-offs at higher weights.
- Two new, dedicated missile stations under the fuselage, closely spaced and staggered, in place of the centreline external tank.
- Preparations for in-flight refuelling gear and an onboard oxygen generating system.
- An upgraded rear seat position.

Saab at 60

Saab celebrated its 60th anniversary on 6th and 7th September 1997. Among the company's products on static display were Gripens 39144, 39801 (the first production JAS 39B) and several older aircraft. Six more Gripens flew in the air display, 39120 as the solo aircraft and 39113, 39121, 39134 and 39123 as a four-ship; then 39135 took part in a fly-by with examples of most of the jet aircraft designed and built by Saab: the J 29, J 32, J 35, JA 37 and Sk 60.

The first Swedish Defence Minister to fly the Gripen was Björn von Sydow, on 29th November, with Clas Jensen in the front seat. That month, Saab Dynamics delivered the Infra-Red Search and Tracking (IRST) system to the Swedish Defence facilities; named IR-OTIS, it was installed in Viggen 37301 for flight testing.

Gripens in Berlin

The ILA Show held in Berlin from 18th to 24th May 1998 was to have seen the international debut of the Gripen two-seater but, due to the arrival at short notice of a Philippine evaluation team, the aircraft was not available. The Gripens that went to Berlin were 39135 flown by Saab test pilot Frederik Müchler in the flying display and 39149 on static. During a press conference it was announced that 53 Gripens had been delivered while Saab and BAe were marketing the fighter to Brazil, Chile, the Czech Republic, Hungary, Philippines, Poland and South Africa. In August the United States cleared Saab/BAe to export the Gripen's American technology to South Africa.

After high expectations at the beginning of the year, 1998 proved to be a disappointment from an export sales point of view. Three countries had been expected to choose new fighters but Chile had postponed its requirement indefinitely, Hungary decided to delay its decision for three to five years depending on the economic situation and the Philippines had also postponed, if not entirely shelved, its requirement.

Batch Three GECU

The Swedish Air Force announced in April 1999 that the third batch of Gripens would be equipped with a single system for managing the air, fuel and hydraulic systems and the in-flight refuelling probe, and that it would replace three independent systems delivered by different manufacturers. This new General systems Electronic Control Unit (GECU) was produced by Ericsson-Saab Avionics and was to be installed from aircraft 39207 onwards; 39207 was a Batch Two aircraft that was expected to function as a sixth prototype for new technologies and to make its maiden flight in 2001.

Saab-BAe exhibited just a single Gripen, 39166, at the 1999 Paris Show of 12th to 20th June, the aircraft flying every day without support and spare parts to indicate the confidence the manufacturers now had in the aircraft. It was flown by Saab display pilot Frederik Müchler

Piloted by Ken Lindberg, JAS 39A 39120 performed a solo display during celebrations to mark the 60th anniversary of Saab.

This four-ship of Batch One and Batch Two Gripens was part of the air show to celebrate Saab's 60th anniversary on 6th and 7th September 1997. Batch Two Gripens had entered service without major testing as the differences between aircraft from the two batches were not significant.

From left to right:

Major Ken Lindberg, the first Swedish Air Force display pilot.

Frederik Müchler, the second Saab display pilot.

Martin Birkfeldt, the second Swedish Air Force display pilot.

(the new Swedish Air Force Gripen display pilot was Captain Martin Birkfeldt who had replaced Ken Lindberg after he retired in late 1998). The Swedish Air Force had by now received over 70 Gripens but still had more aircraft available than pilots; 50 pilots had converted to the Gripen and another 30 were undergoing conversion.

Prince Carl Philip became the first member of the Swedish Royal Family to fly the Gripen when he was given an hour-long flight in a two-seater on 17th June as a graduation present; Lt Colonel Bjorn Johansson was the pilot of 39803 on this occasion. In the meantime, from July Batch One Gripens were repainted at F17 Wing's base at Ronneby in the stealthier colour scheme of Batch Two aircraft.

Up to 31st August 1999 the Gripen had flown 11,054 times, this figure excluding all flights made by the prototypes and during test trials at Saab.

ETPS Evaluation

During the last two weeks of September, delegates from the world's oldest test pilot school, the Empire Test Pilots School at Boscombe Down, visited Linköping. After familiarising themselves with the aircraft in the Full Mission Simulator at Linköping, all of the ETPS visitors, including pilots from France, the USA and the UK, were allowed to fly in the Gripen.

Further evaluation of the Gripen by overseas pilots came when an International Air Power symposium was held in Sweden during November 1999 and an Israeli who attended, retired Major General Avihu Ben-Nun, got the chance to fly the Gripen from the back seat.

Ben-Nun was a former commander of the Israeli Defence Force and had flown in a wide range of aircraft, of which the most modern was the IAI Lavi. He was the first Israeli to fly the Gripen and could therefore make an informed comparison between the Swedish fighter and its Israeli counterpart, but what impressed him most about the Gripen was the TIDLS. In this field the Gripen was at the leading edge of information technology implementation.

On 10th December 1999 Ericsson Saab Avionics placed an order with CelsiusTech Electronics for radar warning receivers as part of a new second-generation warning and countermeasures system, the EWS-39 (Electronic Warfare System). The value of the contract was SKr 600 million.

By the end of the year two of the Gripen prototypes, 39-2 and 39-4, had been withdrawn from service, the latter aircraft being transferred to Halmstad where it was to be used for training technicians assigned to the type.

21st Century Radio

In early February 2000 the FMV ordered some new tactical radio equipment which would form part of TARAS, the Swedish Defence Forces' new communication system. The radio, called Communication and Datalink 39 (CDL 39), has a much improved capability, one of the most important aspects being that the Gripen could now communicate with foreign aircraft during exercises and peacekeeping missions. CDL 39 was to be introduced in the last 20 Batch Two aircraft and in the entire third batch; the order was valued at US $32 million.

During February 2000 *Flight International* published an article by the first pilot to fly the Eurofighter Typhoon, Dassault Rafale and the Gripen. In his summary he reported: 'The Gripen was easy and very pleasant to fly, it has a good performance and provides a comfortable working environment. The high level of utility systems automation has been well thought through and frees the pilot to get on with operational tasks. During my flight the aircraft and engine functioned faultlessly. Although the tests of the operational systems were of necessity superficial, they served to show that the aircraft has a logically organised, competent and sophisticated weapon system that will allow use in fighter, attack and reconnaissance roles. In particular, the datalinks are fully integrated into the weapon system and multiply the effectiveness of the aircraft. No aircraft is fault-free, but faults are either personal preference or can be easily corrected'.

Customer Reaction

A press conference held at FIDAE 2000 by General Jan Jonsson, Chief of Staff of the Swedish Air Force, was designed to give the customer's point of view. Jonsson believed that no air force would find it a problem to switch from a second-generation fighter to a fourth-generation fighter because the simplicity of the new type would cut the maintenance staff's workload and make life less work-intensive for the pilot; this in turn would cut overall costs.

The simplicity of the Gripen was once again proved by the fact that foreign pilots could fly the aircraft, complete with its Swedish-language cockpit, almost by intuition. Chief of the South African Air Force, Lt General Roelf Beukes was also present at the press conference and told the press how pleased he was that the South African government had chosen the Gripen.

On 10th April 2000, IG JAS obtained a SKr 650 million contract from FMV to upgrade the propulsion, air, fuel, and hydraulic systems on Batch One and Two Gripens. The contract was to be completed by 2007. At the end of May, Ericsson Saab Avionics received an order to upgrade the two first batches of Gripens (140 Swedish Air Force aircraft) with the GECU already selected for Batch Three machines.

At July's Farnborough International Air Show, Saab was able to push its claim that the Gripen was cheaper than any other fighter currently in service; a statement that could now be supported by accurate figures. Present in the static display was 39166 and 39174 performed flight demonstrations.

Today, testing continues with a new addition to the family of Gripen prototypes. On 29th January 2003 Gripen 39207, by now reconfigured as prototype 39-6, undertook its maiden flight. At the controls was Saab Test Pilot Johan Sjostrand. This, the seventh Gripen prototype, is used mainly for the testing and evaluation of new technologies.

Improving the Breed

When IG-JAS stated confidently that it could produce a fourth-generation multi-role/swing-role fighter that would be significantly smaller and lighter than the Viggen, less expensive but able to pack the same hefty punch, there were many who doubted that it was possible from a technological point of view. Also, the Swedish Air Force had compiled a series of stringent and demanding operational requirements for any Viggen replacement:

- One basic version only to perform fighter, attack, and reconnaissance missions.
- High reliability.
- Low maintenance and fuel costs.
- Low pilot workload.
- Half the loss rate of the Viggen during the type's operational life.
- The ability to operate from dispersed bases using V-90 strips (road strips dispersed around the country to allow aircraft to land on roads for refuelling and rearming).
- An ability to operate in harsh weather conditions.
- High initial sortie rate.
- Ten-minute turnaround in the intercept role and 20 minutes in the attack role using the logistics network connected with the V-90 strips.
- Low radar, infra-red and noise signatures (in short good stealth characteristics).
- Real time datalink with other aircraft and with other tactical officers on the ground or in the air.
- To break the cost curve the Life Cycle Cost was set at 60% of the Viggen LCC.

That such an aircraft was feasible thanks to the tremendous technical advances made in composite materials, the availability of more powerful and fuel-efficient engines, computers that were physically smaller yet with faster and greater processing power, and continuing advances in state-of-the-art avionics.

In terms of physical size, the Gripen is about 30% smaller than the Viggen and 40% smaller than the F/A-22 Raptor. The smaller the aircraft, the smaller the radar cross-section (RCS) and the smaller the target for enemy defences, which means it is harder to acquire, track and hit.

JA 37 Viggen	Single-seater
Wingspan	10.6m (34ft 9in)
Length (inc probe)	16.4m (53ft 9½in)
Height	5.9m (19ft 4in)
Wing Area	40.6m² (436.5ft²)
Wheeltrack	4.76m (15ft 7½in)
Wheelbase	5.6m (18ft 4½in)

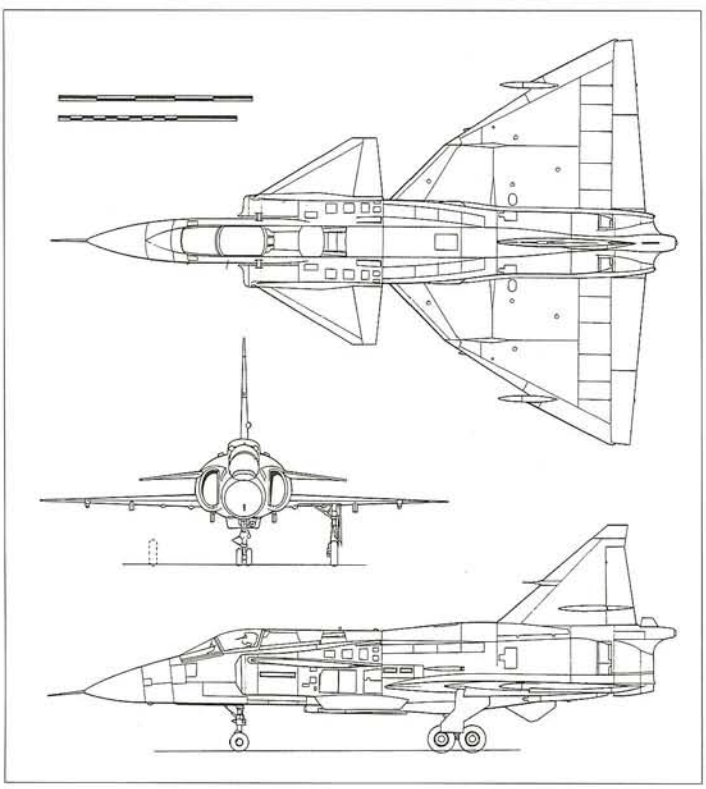
Gripen	Single-seater	Two-seater
Wingspan (inc launchers)	8.4m (27ft 6in)	8.4m (27ft 6in)
Length (excl pitot tube)	14.1m (46ft 3in)	14.8m (48ft 6in)
Height Overall	4.5m (14ft 9in)	4.5m (14ft 9in)
Wheeltrack	2.4m (7ft 10in)	2.4m (7ft 10in)
Wheelbase	5.2m (17ft)	5.9m (19ft 4in)

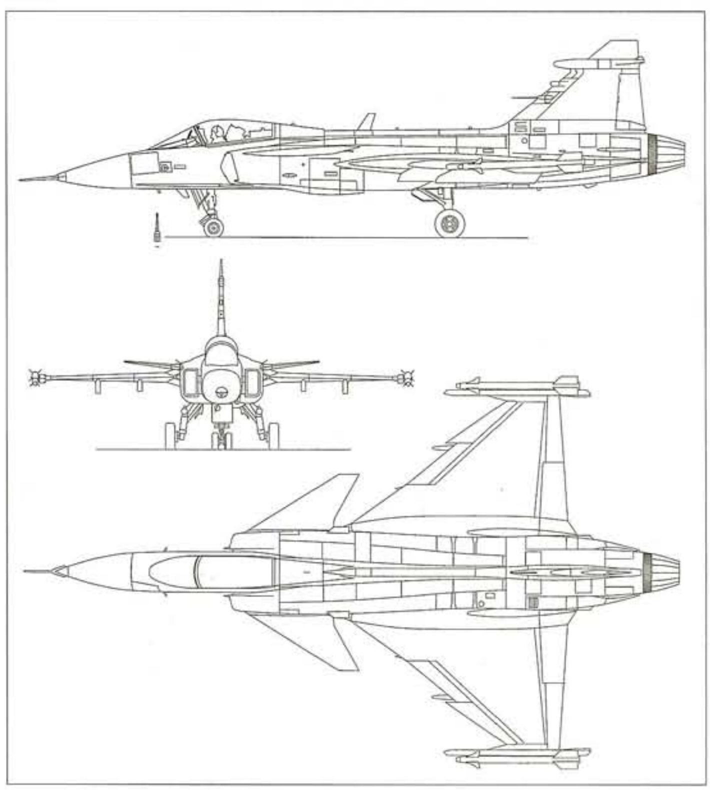
The in-house FMV magazine, *FMV-Aktuellt*, has for the first time publicly compared and published figures for the Gripen and Viggen systems. The list was made by Major General Staffan Nässtrom and included the following:

- The Gripen's fuel consumption is 50% lower than the Viggen.
- Scheduled maintenance is 40% lower.
- Gripen has a 28% better take-off performance than the specified limit.
- In slippery conditions the Gripen's landing performance is 17% better than specified.
- The accuracy of the Gripen's radar is 50% better than its predecessor.

Below left: **A three-view of the JA 37 Viggen, the principal version that the Gripen had to replace in the Swedish Air Force for air defence duties.**

Below right: **A three-view of the JAS 39A Gripen.**





This view of a JAS 39A shows well the aircraft's near-rectangular air intakes, cropped-delta wing and the slender rear fuselage.

The Gripen's airframe is made up of about 60% aluminium alloy by weight, 6% titanium alloy and 5% of other metals. The biggest change over the Viggen, however, comes from the fact that most of the remainder of the airframe – the wing skins and spars, fin, canards, elevons, undercarriage doors and some access panels – is made up of carbon-fibre composites.

Using carbon-fibre composites also helped reduce the Gripen's RCS, as did applying a special gold coating to the cockpit canopy and designing the engine duct arrangement to make it impossible for any infra-red or radar system to look directly at the hot engine.

Supplier Base

Given the involvement of overseas suppliers in supplying components for the Viggen, it was no surprise when IG-JAS decided early on to find suppliers around the world who could offer technology applicable to the Gripen that was not available in Sweden and which would otherwise take a lot of money to develop.

The most important criteria for choosing an overseas supplier was that it should do the job better, or at least as well as any of the Swedish companies within IG-JAS, and for a better price; the second point was important because the contract was very strict regarding price increases.

Agreements between IG-JAS and overseas suppliers would also include a certain level of offset work, mainly on the civil side. IG-JAS was indeed reasonably successful in gaining the required offsets from American and European suppliers.

Just how much importance IG-JAS placed on overseas suppliers can be gauged from the fact that 40% of the Gripen's components are supplied from abroad; double the proportion found in the Viggen. Overseas companies which have delivered products for the Gripen are listed in the table on the right:

One of the major suppliers of components for the Gripen was the UK, deals having been concluded with various of its aerospace companies to provide items such as the pilot ejection system, environmental control system, airframe (Anglo-Swedish), landing gear units, hydraulic system (in co-operation with Germany) and the secondary power system (in co-operation with France).

British Aerospace (BAe, later BAE Systems) was involved in the Gripen programme from the start because it was given responsibility for designing the wing after shaking off competition from MMB and Rockwell (the latter with its HiMAT technology wing the extra cost of which which negated the increase in performance).

BAe won the contract to build and deliver the Gripen prototype's wings in November 1982. When the contract was signed the wing choice was left open between the Type 2110 design and the Type 2111's increased-span, aeroelastically tailored surface based on the experimental HiMAT demonstrator. The Rockwell-developed wing offered improved transonic turning performance through controlled twisting of the aerofoil under load, the technology for which had been successfully proved by the remotely piloted HiMAT research vehicle. This aircraft achieved 8g at Mach 0.9; contemporary fighters could only reach 6g in the same conditions.

The Swedish authorities allocated SKr 28 million for the evaluation Rockwell's design but, according to the Swedish Air Force, its adoption would have increased by 50% the cost of the Gripen's wing compared to that of the 2110. Such an increase in costs was unacceptable. If Rockwell had won the contract, the company would have delivered a total of six wings, each less complete than the previous example, thereby gradually transferring production and technology to Saab.

Following a delay caused by a strike in the UK, BAe delivered the first Gripen wing in June 1986. Even BAe had a contract to transfer its technology to Saab and full production of the wings gradually moved to Saab after 3½ sets had been built for the Gripen prototypes.

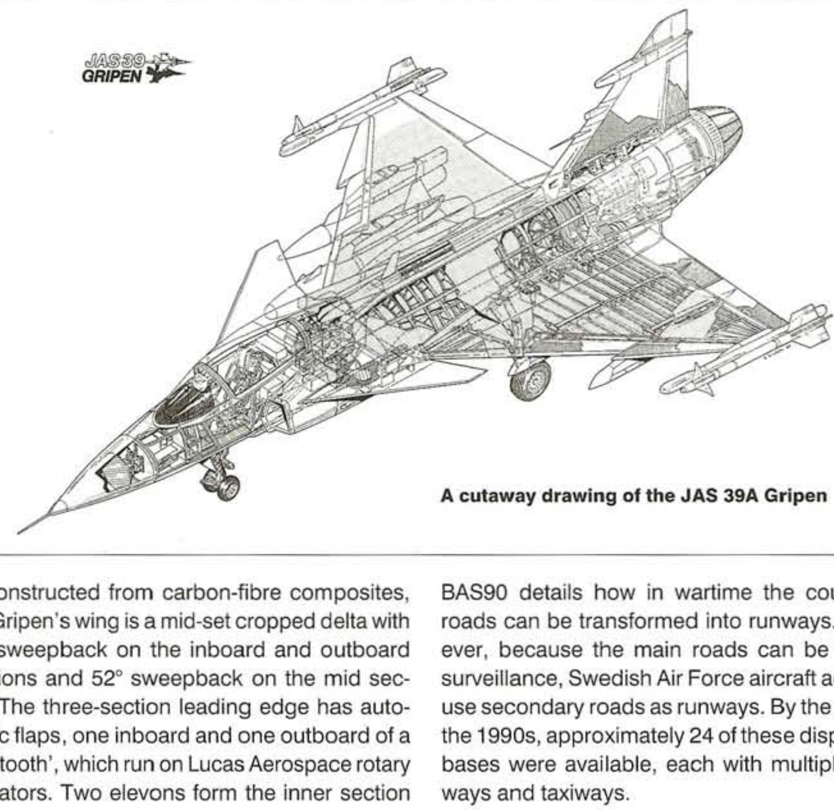
Companies who have delivered products for Gripen

General Electric	USA	Engine (in co-operation with Volvo in Sweden)
Kaiser Electronics	USA	Head Up Display (in co-operation with SRA)
Hamilton Sundstrand	USA	Electrical generator, third APU
Lear Astronics	USA	Flight Control System (FCS) computer hardware, Batch One
Martin-Marietta	USA	Flight Control System (FCS) computer hardware, Batch Two
AP Precision Hydraulics	UK	Landing gear
Dowty Group	UK	Hydraulic supply system and airbrake valve assembly, power transmission slats
Lucas Group	UK	Secondary power system, (AEPA), leading-edge flap control system, reserve gearbox
Martin-Baker	UK	Pilot ejection system
L-3 Display Systems	USA	Display Actiview 104P (display in the EP-17 Mk.3)
Honeywell	USA	Inertial Navigation System (INS) H-423, radar altimeter HG7705
Mauser-Werke	Germany	27mm cannon
Page		Hands On Throttle And Stick system (HOTAS)
Ferranti Defence systems		HUD video camera
Cobham Group	USA	Environmental Control System (Hymatic Engineering)
Microturbo	France	Auxiliary Power Unit (APU) and engine starter unit
Intertechnique	France	Fuel system
Aircraft Braking Systems	USA	Braking system
Thomson-CSF Communications		Identification Friend or Foe (IFF) system
Nobel Plastics		Radome
Dunlop Precision Rubber		Inflatable fabric-reinforced electrically conductive silicone rubber seals for the canopy.

Once offset work came into the picture, the list of companies producing equipment for the Gripen increased and was spread further around the world. Countries that received orders were the Czech Republic, Austria, Hungary, Poland, and South Africa; companies that got to deliver parts either from a pre-contract offset or after a Gripen order was signed were:

Denel	South Africa	Weapon pylon (NATO standard)
Grintek	South Africa	Communication unit
Danubian	Hungary	Tail cones
Jihlavan	Czech Rep	
Böhler Schmiede Technik	Austria	Undercarriage components.

The Gripen's 'swing-role' capability is shown in the form of two Rb75 Maverick air-to-surface missiles, two RBS 15F anti-ship missiles and two Rb74 Sidewinder air-to-air missiles.



A cutaway drawing of the JAS 39A Gripen

Constructed from carbon-fibre composites, the Gripen's wing is a mid-set cropped delta with 55° sweepback on the inboard and outboard sections and 52° sweepback on the mid section.The three-section leading edge has automatic flaps, one inboard and one outboard of a 'dogtooth', which run on Lucas Aerospace rotary actuators. Two elevons form the inner section of the wing trailing edge. The wings are cropped at the tips to enable AAM launch rails to be fitted; and each wing houses an integral fuel tank.

STOL Performance

Sweden is a relatively small country but it has an excellent infrastructure, including its road network. For some time this has been a key factor in Swedish tactical planning but in the 1990s it was updated in the form of the BAS90 system. BAS90 details how in wartime the country's roads can be transformed into runways. However, because the main roads can be under surveillance, Swedish Air Force aircraft actually use secondary roads as runways. By the end of the 1990s, approximately 24 of these dispersed bases were available, each with multiple runways and taxiways.

The specified runway performance for the Gripen requested that it should be able to operate from runways or roads 2,625ft (800m) long which means, thanks to the need for a safety margin, the actual take-off and landing run must be even less. Early in the test programme the prototype operated from a 30ft x 2,625ft (9m x 800m) strip of runway.

The Viggen was able to take off and land in 1,312ft (400m) and, since the Gripen has better acceleration than the Viggen, it should have a least the same runway performance. Howeve the Gripen was never fitted with the Viggen' thrust reverser because that piece of equip ment weighs one ton and would have put a enormous burden on the new aircraft's smalle airframe. Instead, the Gripen uses its canard and other forms of aerodynamic braking t bring it to a halt in the proscribed distance.

The canards also are constructed from ca bon-fibre composites. These have a leading edge sweep back of 58° and are independentl movable. The canards' greatest degree o deflection comes immediately after the Gripe lands, when they are deflected down to th maximum drag position to aid to ensure that landing within the Viggen's parameters is n problem at all.

The Gripen's landing gear also plays a important part in meeting the landing distanc requirements. AP Precision Hydraulics (APPH another British company, was responsible fo the Gripen's tricycle landing gear whic included some new features such as nose wheel braking, an important facility because o the short landing requirement.

As the Gripen's weapon load increased Saab asked APPH to supply a strengthene version of the landing gear. The new versio had to be about the same size and weight bu capable of carrying higher take-off and landin weights, the most important factor being that should have the strength to allow the Gripen to return and land with a heavier load.

The size of the new landing gear was not changed; instead its greater strength came from the fact that some parts were manufactured from stronger materials. This also allowed a change in the production process – instead of producing two items and fitting them together, they were manufactured as one piece which removed the weakness caused by the joint. The braking system was also improved to keep the braking distance the same and, according to Gripen test pilot Magnus Olsson, this was under test during the first half of 2002.

The main landing gear units each have a single Goodyear wheel fitted with a 25.5x8.0-14 (16 ply) tyre, ABS anti-skid units and carbon-disc brakes. Each unit retracts forward into the fuselage. The nose gear is of twin-wheel configuration and has a steering actuator with an automatic disconnect-reconnect facility for ground handling. Goodyear wheels are fitted with 14x5.5-6 (8 ply) tyres. Carbon-fibre disc brakes and an ABS anti-skid unit are also fitted and the whole unit retracts rearward.

Production of the main landing gear unit at BAe's Brough site began in January 1996 after a manufacturing jig had been installed. The landing gear was scheduled to be delivered during the spring and, to get some familiarisation experience and to smooth the start of production at Brough, some BAe production staff worked for a period at Linköping. According to Saab's Lars Jannson, Gripen 39149 was the first aircraft to fly with a BAe-manufactured main landing gear unit. Production of the main landing gear unit was later transferred to Denel of South Africa as part of an offset deal.

Operational Independence

Because Gripens have to operate from dispersed sites without the full range of support fund back at base, the aircraft must be easy to maintain and operate without much assistance from the 'outside'. In fact, the only support it should need is a fuel and weapon supply. Ease of maintenance factor is all the more important given that each ground support team comprises five conscripts and one officer/technician. The conscripts will serve only a short time in the Air Force, thus precluding any long-term training to gain expertise.

For the Gripen to function independently, conscripts have to achieve a complete turnaround, refuelling and rearming under the guidance of the officer/technician. Because conscripts do this work, the rearmament operation has to be simple so that each team can be trained in the shortest possible time.

Like any other military aircraft, the Gripen is at its most vulnerable on the ground. In a war situation, its stay on the ground would be for the minimum amount of time. One way to help achieve this is to refuel the aircraft when the RM12 engine is still running, the so-called 'hot' refuelling operation.

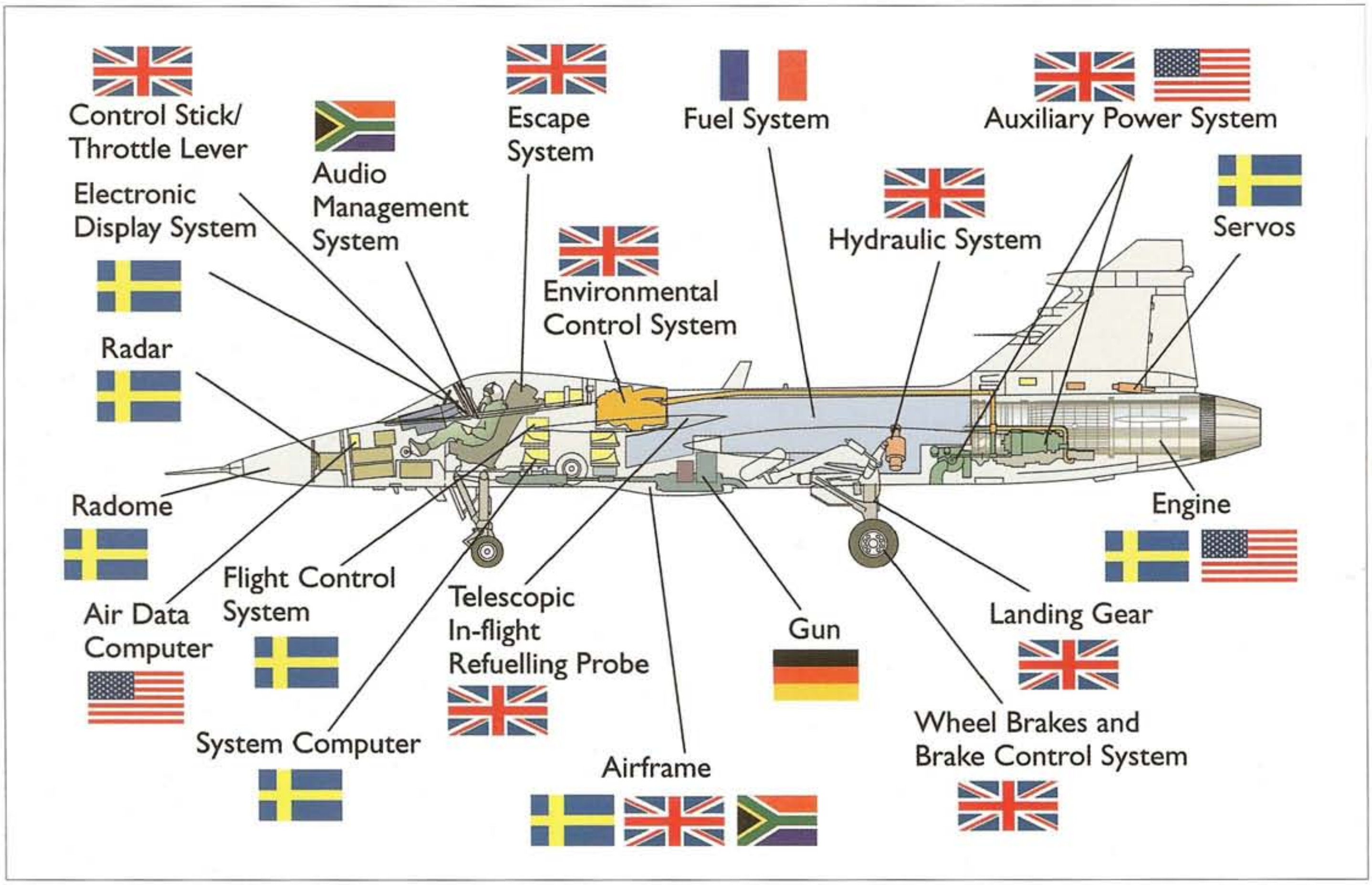
Auxiliary Power

The Gripen's Auxiliary Power Unit (APU) improves the aircraft's ability to operate from dispersed and remote air bases but it also acts as the main source of electric power for the aircraft on the ground, doing away with the need for separate electrical or starter units. Previous generations of Swedish combat aircraft had had to use extensive ground-support equipment to clear them for their next mission but with its APU the Gripen needs less ground crew and equipment which saves time and money and reduces the flyaway cost. Turnaround time is also reduced which allows the aircraft to return to the battle more quickly.

Microturbo was a French company specialising in APUs and starter systems and was responsible for almost all of the equipment fitted in French fighters like the Mirage 2000-5 and Rafale. For Gripen, Microturbo designed and produced a combined starter and APU system called TGA15-090.

The areas coloured blue identify those parts of the Gripen that are made from carbon-fibre composites. All of the Gripen's carbon-fibre parts are manufactured by Saab.

Lucas Aerospace produces the one-piece windscreen and the canopy. As can be seen, egressing the aircraft is facilitated by the sideways-hinged canopy.



The multi-national supplier base for the JAS 39C has changed considerably from that of the JAS 39A.

British Aerospace produced the first 3½ sets of Gripen wings, after which the relevant technology was transferred to Saab. All subsequent wing production has taken place at the company's Linköping plant.

To reduce aerodynamic drag the APU had to fit in a small space on the port side of the rear fuselage, next to the engine.One of the problems encountered during the flight test programme was that the time between failures was too short; this made the TGA15-090 APU more expensive to maintain. Another problem was that it failed to meet Swedish Air Force noise requirements.

Since the TGA15-090 had serious problems from the start, Microturbo got a second chance and updated the APU as the TGA15-328 which was flight tested during December 1995. The 2000th Gripen test flight, on 22nd December 1995, was dedicated to testing the new APU. The TGA15-328 was installed as new in aircraft from 39141 onwards and retrofitted to all previous Batch Two aircraft and nearly all Batch One aircraft.

According to officials, one of the main advantages for using Microturbo (and why Saab chose their company) was that, in export terms, they were much more flexible than their American rivals. This opinion was later proved incorrect when Saab switched to the American company Hamilton Sundstrand to supply APUs for late Batch Two Gripens, mainly because of the noise problems and Microturbo's inability to solve them. The Microturbo unit had also left some exhaust residue on the Gripen's port topside.

Saab began discussions with Hamilton Sundstrand in the early 1990s and gave a development contract for an updated TGA15-328 in September 1997. The first example was deliv-

As the background shows, the apparent remoteness of some of Sweden's road bases belies their close proximity to urban areas.

The location of the near-rectangular air intakes prevents any objects being ingested by the engine. This is especially important on stretches of public roads where cleanliness of the surface and the surrounding area is not so strictly controlled.

ered for testing in 1998 while the first flight-test unit was delivered to Saab in 1999 and installed in prototype 39-3. A production order was placed in late 1999 and the first examples were expected to arrive in early 2001 for fitting in new aircraft from 39207 onwards, and retrofitting to aircraft already in service.

New environmental laws could force the Swedish Air Force to retrofit all Gripens with this APU while the lower noise level might be favourably looked upon by future export countries such as Austria, where groups had protested against the Draken deal in 1985 because of the expected high levels of noise pollution.

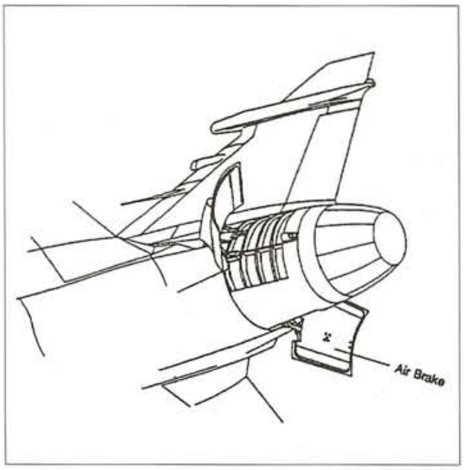
Flight Control System

Whereas the older Viggen was designed as a stable aircraft throughout, the Gripen is an unstable aircraft and uses a digital fly-by-wire (FBW) system. In the case of a system malfunction, the canards are disconnected and become free-floating which makes the Gripen become stable and allows it to be flown using the back up analogue flight control system.

One advantage of choosing an unstable design is that the engine can be placed well behind the centre of gravity, making space in the main body of the aircraft for fuel and other systems. Both the Draken and the Viggen had the engine positioned further forward than is the case with the Gripen.

The US company Lear Astronics, formerly Lear Siegler, was responsible for the Flight Control System (FCS) computer for the Gripen which had a triplex fly-by-wire FCS. The Swedes wanted a simple system and felt that the triplex type was safe enough.

By September 1985 it was clear that Lear Siegler would be late delivering the Gripen FCS and according to Brig General Sven Hökberg, the head of FMV, first flight was likely to be delayed from early until late 1987; Saab, however, felt at this point that the delay would



After touchdown, the Gripen uses all kinds of aerodynamic braking to reduce its landing distance, including downward deflection of the large-area canards and the two-section leading-edge flaps and the deployment of the airbrakes at the rear of the fuselage.

The Gripen's airbrakes are located at the very rear of the fuselage and contribute to the aircraft's short landing run.

only be a couple of months. Stig Holmström reported that the FCS felt super-sensitive following the Gripen's first flight; the problem was mainly software related.

Lear Siegler's FCS hardware was replaced in the second batch of Gripens by SA11 hardware from Martin Marietta (now Lockheed Martin).

Air-to-Air Refuelling

When IG-JAS made its initial JAS 39 proposals, both the internal and external fuel capacity were felt to be insufficient and were increased to meet Swedish Air Force requirements. The Gripen fuel system was developed and produced by Intertechnique of France which received its development contract in April 1983. Intertechnique and Saab were no strangers to one another because in 1972 Saab had approached the French company with a commercial inquiry that eventually developed into co-operation on the abortive B3LA programme.

The Gripen's internal fuel tanks are divided between the wings and fuselage and total 5,291 lb (2,400kg) or 660gal (3,000 litres). From the outset the Gripen's range could be increased by the use of jettisonable external fuel tanks carried on two wing pylons and on the centreline pylon beneath the fuselage. These external tanks hold 1,940 lb (880kg) or 242gal (1,100 litres) each, enabling the Gripen to carry an additional 726gal (3,300 litres) above its internal fuel capacity. The two-seat JAS 39B Gripen has a 5% lower internal fuel capacity than the single-seater to make room for the second cockpit and totals 5,026 lb (2,280kg) or 627gal (2,850 litres).

In the early stages of development the designed-in fuel capacity was thought to be sufficient. The relatively short operating distances over Swedish territory meant there was little need for prolonged use of the afterburner, thus reducing fuel consumption and increasing patrol time. What was not clear at the time was how much the political map of Europe would change, nor how widely marketed the Gripen would become. At a presentation of the Society of Experimental Test Pilots, Saab chief test pilot Arne Lindholm noted that during the first 15 Gripen test flights, Intertechnique's fuel system had worked without failure; however, the fuel measuring system had revealed some problems and had to be modified.

No serious problems were encountered with the Intertechnique fuel system until 28th January 2003 when, after a flight, a Gripen (39.144/144) was refuelled at the Vidsel test range in preparation for another flight. A couple of days later, on 30th January 2003, during a pre-flight check, it was noticed that the aircraft was deformed and some rivets had become loose. An over pressure in the fuel tank had been caused by too small a clearance between an overflow pipe and a bulkhead. A secondary cause was the fact that the refuelling was executed at a higher pressure than the limit set in the manual. The aircraft returned to service after repairs had been carried out.

The Gripen was first designed to be part of Sweden's invasion defences but since then the Swedish armed forces have slowly developed from an independent defence force into a service structured for international co-operation. However, Gripen's fuel tanks were not made to NATO standards and so the US company Sargent Fletcher received a development contract for a new 242gal (1,100 litre) tank for export Gripens that would be NATO-compatible; these were test flown in early 2003.

In the cockpit, the pilot does not see the exact amount of fuel that he has available; instead the figure is indicated as a percentage. With full internal tanks the pilot has 100% fuel; the external tanks then add the specific amount that they carry. During a symposium on the Fourth-Generation Air Force, Col Jan Jonsson from the Swedish Air Warfare Centre stated that the unrefuelled ferry range of the Gripen was 2,175 miles (3,500km).

A press conference held at the 1997 Paris Air Show by Saab and BAe announced that an air-to-air refuelling (AAR) capability was to be introduced on export Gripens. However, to keep the cost down the Swedish Air Force would help fund the programme because this capability might also be needed in the future by the Service as Sweden's policy of neutrality slowly changed. A couple of days later, when the contract was signed for the third batch of Swedish Air Force Gripens, it was stated that these aircraft should have the AAR capability installed.

A strengthened landing gear helps the Gripen to operate from Sweden's road strips. The aircraft can now return and land with heavier loads of unused ordnance.

The Gripen's smaller size (when compared to the Viggen) and steerable nosewheel facilitate its ability to use narrow and not always straight taxiways that form part of the BAS90 network of road bases.

The Gripen's undercarriage is fitted with carbon-fibre disc brakes and ABS anti-skid units to help the aircraft come to a controlled stop in a short distance on what can often be, during winter, very wet and slippery runways or sections of road.

The announcement reflected the Swedish Air Force's increasing realisation that, in the future, it would likely need to operate outside Sweden and might therefore need such a facility.

The introduction of in-flight refuelling on Batch Three Gripens forced the Swedish Air Force to consider acquiring its own aerial tankers. The service had eight Tp 84 Hercules on strength and at least one of the aircraft (one of the three earlier C-130Es) was to be adapted to an aerial tanker configuration as a possible solution. This capability was seen primarily as a necessity for peace-keeping missions but, during such operations, partner air forces could also support Swedish Air Force Gripens via their own aerial tankers.

During the press conference, Saab and BAe showed a computer-generated photograph of a Gripen equipped with an in-flight refuelling boom. However, it was inaccurate in only one detail – the boom was illustrated on the starboard side (the wrong side) of the aircraft. Nothing had to be removed in the Gripen to fit the probe and because it is retractable it will not disrupt the Gripen's clean aerodynamic configuration. What was required was a larger oxygen supply for the pilot if he was to be able to fly longer-lasting missions, and an On-Board Oxygen Generation System (OBOGS) is now installed.

In early November 1998, almost ten years after the first flight of the Gripen, the first in-flight refuelling trials took place using a mock-up of the refuelling probe. Five flights were carried out from British Aerospace's airfield at Warton, which is close to a designated AAR area over the Irish Sea, by test pilots Paul Hopkins (BAe chief test pilot) and Ola Rignell and Magnus Ljüngdahl (of Saab). The aircraft used was the fourth prototype, 39-4, which linked up with a Royal Air Force VC10 K.4 (ZD241) flown by a crew from the UK's Defence Evaluation and Research Agency (DERA). Paul Hopkins flew the first trip because he had more experience with in-flight refuelling and he tried several different approaches before finding the best method and hooking up successfully. This was a major step forward for the export Gripen.

The Gripen is the first Swedish fighter to have an in-flight refuelling system although previous Swedish aircraft were not intended to have such a capability. A second set of tests was held using a probeless JAS 39B to confirm whether or not the two-seater would behave the same behind the tanker as the single-seat JAS 39A.

During the first half of 2001, a photograph was released of the first production Gripen to be equipped with the probe, 39207, which was supposed to function as test aircraft 39-6. The then Commander-in-Chief of the Swedish Air Force, Lt General Mats Nilsson, reported that older Gripens were unlikely to be retrofitted with the AAR capability in the future because it would effectively constitute a rebuild of the airframe and its systems and would thus be too expensive. It was unclear at the time whether late Batch Two aircraft would receive the capability.

In March 2002 a photo was released of 39208 sporting a retractable in-flight refuelling probe. The accompanying press release stated that aircraft with this capability were to be tested by Saab and the FMV. Saab also took the opportunity to finally confirm what had until then been a well-kept secret – that many more Batch Two aircraft (from 39207 onwards) were to be fitted with the retractable probe This decision made sense as it meant that more of the Swedish Air Force Gripens would have the capability, and that was better for standardisation. This in turn meant that if export customers wished to receive Gripens with this capability earlier than Saab could deliver new-build examples, Swedish Air Force aircraft could go to the customer in the interim.

To increase its operational flexibility the Gripen will be qualified to refuel from four different aerial tanker aircraft types, and from almost any aircraft in the current NATO inventory. The four tanker types that will be involved in the testing are the KC-10 Extender, KC-135 Stratotanker, KC-130 Hercules and VC10. Although the first production Gripen capable of undertaking in-flight refuelling (39208) flew for the first time on 14th August 2002 and the prototype 39-6 (39207) on 29th January 2003, in-flight refuelling tests are not planned to start before autumn 2003.

Conformal Fuel tanks

An AAR capability was not enough to satisfy some potential Gripen customers, a fact confirmed by measures taken by other manufacturers to improve the range of their aircraft; the F-16 proved to be the toughest competitor. Lockheed Martin said that sales of the F-16 were based on the qualities of the aircraft and the experience of users, but that the company was looking into ways of extending its range. The F-16 thus became the second aircraft, after the F-15E Strike Eagle, to be equipped with additional conformal fuel tanks (CFT) to improve its range, in a variant developed for the United Arab Emirates (UAE).

Delays to the JSF programme were seen as good for business for the F-16 but they improved the chances of the Gripen as well. Since the US Air Force was not going to invest any more money in updating its F-16s, the UAE had to pay an awful lot of money for its new Block 60 F-16C/D, for which they were at the time the only customer. Sweden and South Africa had both committed to the Gripen and so were more likely to invest in upgrades.

The new F-16 variant beat the French Dassault Rafale to the UAE order; Dassault responded by deciding to develop a Rafale with CFTs. Saab reacted quite slowly to this trend but in April 2001 released a computer-simulated image of a Gripen with CFTs. At least the company was reacting to ideas coming from potential future customers who required a new fighter with greater range.

One such potential customer was Brazil. Saab felt that it had answered their requirement by developing an in-flight refuelling capability, but this was not the case because Brazilian Air Force planners were actually looking at fairing over the two-seat Gripen's rear cockpit and filling the space with an extra fuel tank. They felt that IFR probe-equipped Gripens would be too expensive to acquire and very vulnerable in a high-threat environment.

Will Saab-BAE introduce the CFT improvement onto the Gripen quickly enough to make it available for any future export customers? The answer to that might lie in the fact that the computer-generated photograph of the CFT-equipped Gripen was presented as the Gripen for the year 2010.

JAS 39B

As far back as 1985, the head of the FMV, Sven Olof Hokborg, stated that if a two-seat variant of the JAS 39 was rejected, Sweden would have to acquire a separate advanced trainer. Saab, however, had already been studying the possibility of such a variant, the intention being to add a 19.7in (0.5m) plug into the fuselage to make space for a second cockpit while retaining all of the weapon systems bar the internal cannon. In fact design work was already under way so that construction could be accelerated if or when the Swedish Air Force ordered the new variant.

Problems with the FCS software for the single-seater led to a postponement of any decision to develop a two-seat JAS 39B. A decision still had not been made when the first single-seat prototype finally got airborne on 9th December 1988. This delay plus the need to replace the Sk 60 trainer in the near future, renewed the Swedish Air Force's interest in the BAe Hawk, the manufacturer having briefed the

Photographs on the opposite page:

Top: **The ability to operate from Sweden's BAS90 road base system was an essential prerequisite for the Gripen. This view also illustrates well the aircraft's wing trailing-edge flaps.**

Bottom: **Working on the understanding that, in the event of war, all of its fixed bases would come under attack, the Swedish Air Force relies on the fact that its Gripens can operate from rudimentary dispersed sites with minimal maintenance and servicing by the small support teams.**

This page, right: **The Gripen has a proven track record of being able to operate from road bases in adverse weather conditions.**

Not only the aircraft but also the ground crew have to be able to work under harsh circumstances. Here, two conscripts are rearming the Gripen's BK27 internal cannon.

Air Force on the aircraft just three years earlier. Saab was unhappy about the delay in funding for the JAS 39B, realising that the lack of a two-seat trainer variant could adversely affect export potential.

In July 1989 the Swedish Ministry of Defence finally gave Saab a contract to undertake a design study for a two-seat version. This would last until early 1991 so that the variant could be included in the second batch of production Gripens, the decision for which was expected by June 1991. The allocation of funds for the design study came as something of a surprise given the programme's cost overruns up to that point, but it was in part an acknowledgement that a two-seat Gripen was the obvious line of development.

Negotiation for a second batch of Gripens included development of a two-seater, up to 15 of which were to be produced. Finally, on 2nd June 1992, development of the JAS 39B was confirmed when the Swedish government agreed to procure 110 Gripens including 14 two-seaters. The prototype JAS 39B would be a modified JAS 39A. This would speed up the development programme and enhance the Gripen's export potential.

By mid-1993, structural design work for the JAS 39B was 90% complete and 70% of all of the sub-contracting has been signed up. The two-seat programme was on schedule and within cost estimates while the weight of the JAS 39B would not differ too much from that of the JAS 39A because it would have a reduced fuel capacity and the BK27 taken out to make space for the second cockpit.

While the two-seat Sk 37 Viggen trainer had the same dimensions as the single-seater (because Saab simply deleted the forward fuselage tank and revised the internal avionics), the JAS 39B is 25¾in (65cm) longer than the JAS 39A. That extra length combined with the aircraft's weight also make it slightly less unstable than the JAS 39A and this feature has slightly reduced the two-seater's flight performance.

The fact that the JAS 39B was developed nearly ten years after the JAS 39A made it possible to include more modern technology. For example, the cockpits' EP-17 display system was improved to Mk.2 standard; this equipment was not standard on Batch One Gripens. The front cockpit was to be equipped with a Head-Up Display (HUD) but the information from it was to be presented on one of the Head-Down Displays (HDD) because the HUD was not installed in the rear cockpit.

Development of the JAS 39B proceeded without any of the problems experienced by the JAS 39A. To save money the two-seater was built without a mock-up although 5,200 different parts were needed for this variant; even 70% of the systems needed some changes. The prototype, 39800, entered final assembly on 1st September 1994 with rollout planned for autumn 1995 and first flight about six months later.

Development work went so smoothly that 39800 was rolled out on 29th September 1995; on 29th April 1996 it took to the air on its maiden flight with pilots Clas Jensen (in the front) and Ola Rignell (in the back). The trip lasted 41 minutes and the chase plane was 39108. By 7th June the aircraft has completed nine flights and the first production two-seater, 39801, was undergoing pre-flight checks.

After leaving final assembly in an official ceremony at Linköping on 29th February 1996, 39801 was handed over to the general project manager Goran Berseus.It was agreed that it too would be as part of the flight test programme. Thus, having made its first flight on 22nd November 1996 and been delivered to the Swedish Air Force in December, 39801 was duly leased back to Saab. The flight test programme would take about 200 flights and first deliveries of production JAS 39Bs were planned for 1998. One JAS 39B fatigue test frame was also built, 39-71, which began testing in February 1996.

The JAS 39B was never given the normal Swedish prefix Sk for trainer, from which one may conclude that the combat-capable two-seater will mostly be used for other duties with training a secondary role. In connection with this role definition, on 29th April 2002 (the sixth anniversary of 39800's very first flight) the prototype two-seater flew for the first time after having been updated to JAS 39D standard. At the controls were Frederick Müchler and Magnus Ljungdahl.

Among the improvements built into the JAS 39D are a new APU from Hamilton Sundstrand, FADEC and a new navigation system called NINS. The cockpit has been updated with the full-colour displays that had previously been flight tested in single-seat Gripen prototype 39-5. Air-to-air refuelling will be possible thanks to an in-flight refuelling probe. To date, plans call for the 14 two-seaters that form part of the 64-aircraft Batch Three to be built as JAS 39Ds to be built for the Swedish Air Force.

JAS 39C

The JAS 39C or JAS 39X or the Gripen EBL (Export Base Line), or just Gripen as Gripen International would like to have it, is from the outside just the same as the original JAS 39A; all of the changes made are beneath the skin. It was originally intended that all of the Batch Three Gripens for the Swedish Air Force would be built to JAS 39C standard. However it was soon realised that the greater the number of Gripens produced to the same equipment standard, the lower (and thus more affordable) the unit cost would be for the Swedish Air Force and export customers. Thus it was decided to build the last 20 Batch Two Gripens to Batch Three standards.

The JAS 39C has reinforced wings and landing gear units so that a heavier weapon load can be carried, which makes the Gripen's hefty punch even greater. Another feature that has a significant effect on the JAS 39C's operational capabilities is the inclusion of a retractable in-fight refuelling probe which, together with the On-Board Oxygen Generation System (OBOGS), theoretically extends the range of the JAS 39C Gripen indefinitely.

Some of the changes are less visible; for example, the pilot's 'office' has received a major upgrade. In fact, the JAS 39C is the first fighter not to rely on any analogue back-up instruments. The HDD area has been increased and upgraded from monochrome to colour while the information it presents is displayed in English and not, as previously, in Swedish; and in Imperial rather than Metric, thus making it more adaptable to other air forces.

The data entry panel has been removed and integrated into the main mode selector and status indicator and a new display, the Communication Control and Display Unit, has been introduced on the pilot's left-hand side. The new Communication Datalink 39 (CDL 39) radio system is included as part of the Swedish Defence Forces' TARAS communication system and, to increase its survivability, the JAS 39C is also equipped with a new Electronic Warfare System (EWS 39).

Since the internal changes needed more computer power than was then available, the on-board computers were replaced by new examples with ten times the capacity. To maintain the Gripen's growth capacity the JAS 39C is equipped with five databuses instead of the previous three (less than 50% of the capacity of which was actually used). A more reliable and precise navigation system has been installed so that an Auto Ground Collision Avoidance System can be integrated without difficulty; a new landing system was also included as part of this change.

A new Electronic Control Unit has been installed to replace the three separate units that had monitored the air, hydraulic and fuel systems (originally developed for the JAS 39C, the new unit has since been retrofitted in JAS 39As).

Replacing the existing RM12 engine was considered too expensive so only the turbine, flameholder and FADEC were upgraded to improve durability and reduce cost. (The new flameholder was such a success that the original model was taken out of production immediately and replaced across the board.) A new APU was also introduced that can be retrofitted to older Gripens if it is deemed to be a financially viable improvement. Software was also changed together with the facility to integrate new or upgraded systems in the future.

L-3 Communications received contracts for displays in late Batch Two plus Batch Three Gripens and, on 9th May 2002, a contract was also received for a Crash Survivable Memory Unit for Batch Three machines that should be capable of communicating through the MIL-STD 1553B databuses. Deliveries were to start during November 2002.

An Rb75 Maverick ASM being loaded onto a Gripen by Swedish conscripts; the inner pylon has a DWS 39 dispenser in place. Making the Gripen 'user friendly' for conscripts was an important factor in the aircraft's design.

Rearming a Gripen should take no more than 10-20 minutes, depending on the specific mission requirements.

The first JAS 39C, 39208, was handed over by Saab to the FMV during a ceremony held in Linköping on 6th September 2002; the aircraft had been flying since 14th August when it took to the air for a 55-minute first flight. The pilot during this flight was Saab test pilot Mats Thorbjörnson, who was previously test flying the Gripen for the FMV. The prototype, 39207, had yet to fly, which meant that the Swedish Air Force could not use some of the new equipment, such as the air-to-air refuelling probe, until the clearance trials were completed. Flight tests with 39208 started in autumn 2002.

Gripen 2010

The Swedish Air Force and FMV now released a computer-generated image which represented a possible Gripen to be produced after the year 2010. New features included thrust vectoring, AESA radar, a new engine (options were the GE F414 and the EJ200) and extra internal fuel (options to be studied were conformal fuel tanks or deleting the two-seater's rear seat and replacing it with a fuel tank; the latter was initiated by a demand from the Brazilian Air Force which had indicated a need for longer range). The picture also showed the modified Gripen streaming two towed decoys. Previously, some smaller 'Future Gripen' studies had been paid for by the FMV and had included IRST and electronic warfare systems.

Future Gripens

Finally, a department called Saab Future Products, which is independent of Gripen International, is tasked with maintaining Saab's capability to design complete aircraft. The technology it has produced has, in a large part, been destined for integration in the Gripen but the department has also researched and tested various design models beginning with some derivatives of Gripen. An example of technology that has been successfully implemented on the Gripen production line was the assembly of the APU. A simulation was tried on the production line and the whole process, as developed by Saab Future Products, was found to be more effective.

Technology under development also includes studies in co-operation with Saab Avionics to improve the man-machine interface. One system that will find its way into the Gripen cockpit will display the pathway in the HUD and give height presentations on an HDD. This will improve the pilot's situational awareness and help him to fly his planned attack mission while reducing the risk of crashing when at low level.

Other areas where Saab Future Products is active include Uninhabited Air Vehicles (UAV) and Uninhabited Combat Air Vehicles (UCAV), both of which are seen as a key element of the future Network Centric Warfare Defence. Saab foresees that the Gripen will in the future work side-by-side with UAVs capable of undertaking bombing missions. This study, which has been ongoing for some time, was revealed by Saab on 2nd June 1999.

The centreline station is mostly used for the carriage of an external fuel tank, increasing the Gripen's range without greatly diminishing the aircraft's weapon-carrying abilities.

The in-flight refuelling probe as it was first presented, on the starboard (wrong) side.

The in-flight refuelling flight trials were successful and the JAS 39B returned at a later stage to establish whether the longer two-seater would behave in the same way behind the tanker aircraft as the single-seater.

Photographs on the opposite page:

Refuelling is a simple task as everything is within easy reach of the turn-around team.

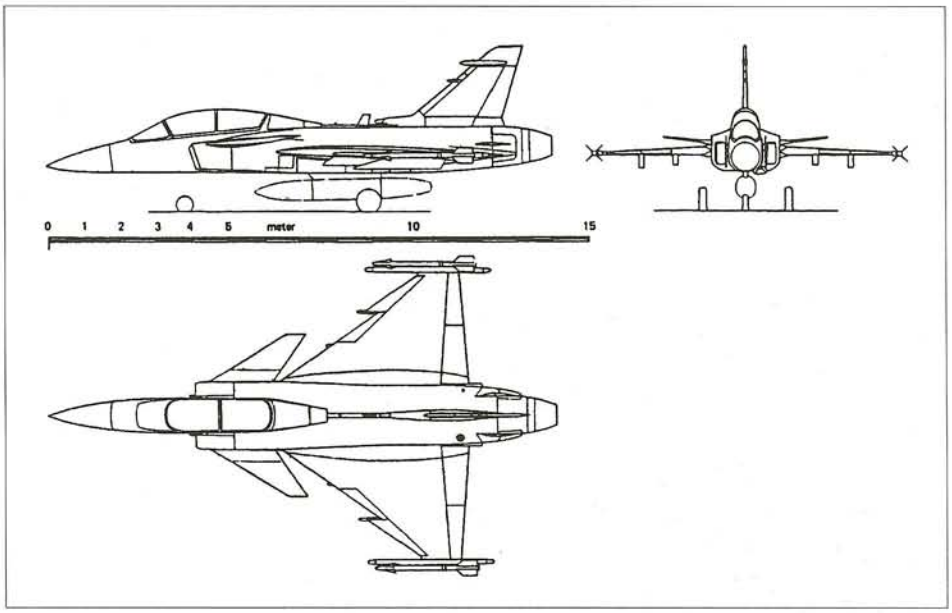
While this view of JAS 39A 39150 shows to good effect the Gripen's canards and cropped-delta wing, it also reveals the prominent staining on the rear fuselage caused by exhaust from the Microturbo TGA-15-090 APU. The -090 model was superseded by the TGA-15-328 but that has been replaced by a Hamilton Sundstrand APU.

Above: **Prototype 39-4 was used for the initial in-flight refuelling in November 1998 with a VC10 K.4 tanker over the Irish Sea.**

Left: **A close-up view of the production-standard in-flight refuelling probe, developed and manufactured by Flight Refuelling Ltd.**

Below: **At the time 39208 was ordered, the decision to fit the last 20 Batch Two aircraft with an in-flight refuelling probe when on the assembly line had yet to be made.**

Above: **Large conformal fuel tanks were one of the obvious physical additions to the next-generation Gripen proposed for 2010.**



Right: **Design of a two-seater variant (originally the same length as the single-seater) was under way from the moment the Project 2110 configuration was frozen. In 1983 the programme was put on hold but three years later, in expectation of the Batch Two order, the design studies were restarted.**

Right: **The first JAS 39B two-seater, 39800 after its rollout on 29th September 1995.**

Left: **A close-up of the JAS 39B's nose section when the aircraft was rolled out on 29th September 1995. Note the high-visibility markings on the low-visibility colour scheme.**

Below: **The one and only JAS 39B two-seater prototype took to the air and did not encounter any of the early programme problems experienced by the single-seat JAS 39A.**

Bottom: **JAS 39B Gripen two-seat prototype 39800 seen on its maiden flight.**

Photographs on the opposite page:

Top: **JAS 39A 39108 was used as chase plane during the first few flights, but most of the new technology had been previously flight tested in the single-seat prototypes.**

Centre: **The JAS 39B is by no means just a two-seat trainer, as illustrated by 39802 armed with an Rb74 Sidewinder 'six-pack' for close-in air defence. The fact that the JAS 39B has never been allocated an Sk (training) designation signals that it and the JAS 39B will be used in more combat-orientated roles.**

Bottom: **JAS 39B 39802 breaks formation to reveal the two-seater's most obvious and distinctive features: the second cockpit and the lengthened canopy.**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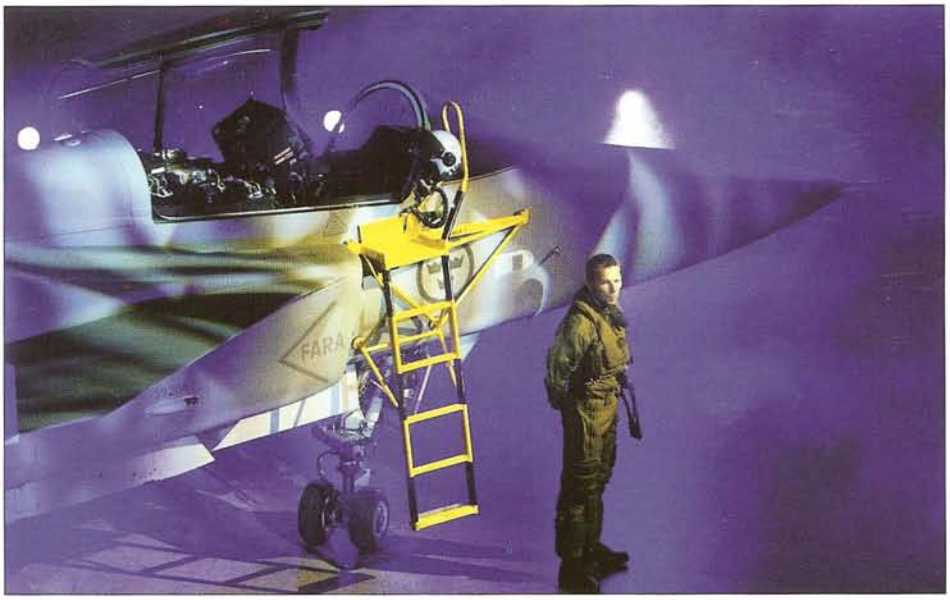


Left: **Mats Thorbjörnson took part in the handover ceremony for the first JAS 39C. On this occasion he was representing Saab when he handed over the aircraft to the FMV, to which he had previously been assigned.**

Below: **The first production JAS 39C Gripen to roll off the production line was 39208, in the first quarter of 2002. The aircraft is seen here with the in-flight refuelling probe extended.**

Bottom: **Saab's view of the ECM and increased survivability of the Gripen. Note the decoys being streamed aft of the wing-tips and the large CFTs either side of the fuselage.**

Roar of the Gripen

One of the partners in the IG-JAS consortium, Volvo Flygmotor, was responsible for the engines used in previous Swedish-built fighters that served with the Swedish Air Force. Volvo Flygmotor's history can be traced back to 1930 when a company called Nohab Flygmotorfabriker AB began operations in Trollhättan. In 1941 Volvo became the majority shareholder and in the same year the name of the company was changed to Svenska Flygmotor Aktie Bolaget. The company functioned under that name for almost 30 years until it was changed to Volvo Flygmotor in 1970.

Prior to the Gripen programme the most recent military engine produced by Volvo Flygmotor was the RM8 (RM = Reaktions Motor = Jet Engine) for the Viggen family. In the early 1960s Sweden had concluded that it was more cost-effective to adapt an existing design and in 1962 Volvo Flygmotor signed an agreement with US engine manufacturer Pratt & Whitney to produce their JT8D as the RM8; the agreement ran until the last RM8 was delivered in 1988.

Because keeping costs down was such an important factor in the Gripen programme, it was always the case that the engine requirement would be met by once again selecting an existing design and concluding an agreement to build it under licence. However, because the Gripen needed to be significantly smaller and lighter than the Viggen, the engine likewise had to be smaller. Consequently IG-JAS looked at the Rolls-Royce Turbo Union RB199, Pratt & Whitney PW1120 and General Electric F404J.

When engine installation was first considered, in 1980 in Project 2100, the F404J was chosen as a reference unit to aid size calculations. A thrust-reverser in combination with a two-dimensional nozzle were under consideration, the thrust-reverser primarily because the Viggen was equipped with one and the landing distance requirements for its replacement would be at least as demanding.

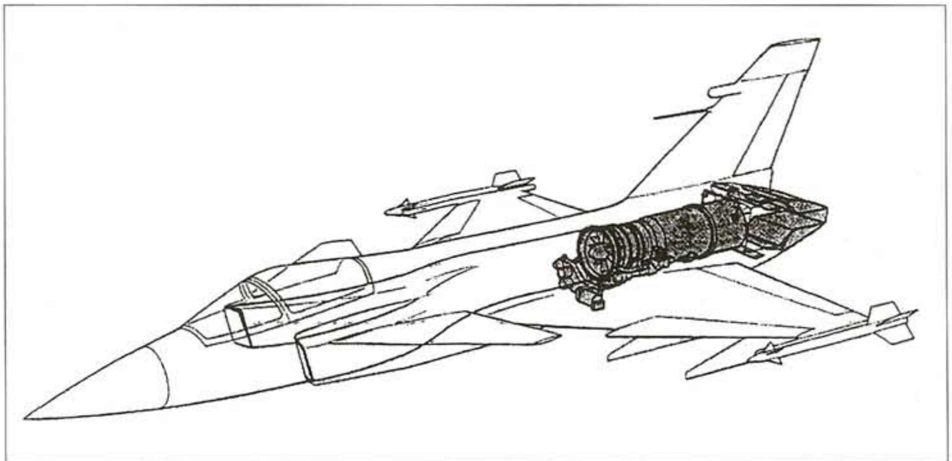
The RB199 was used in the multi-role Panavia Tornado and the F404J in the McDonnell Douglas (later Boeing) F/A-18 Hornet fighter. The Pratt & Whitney PW1120 was specially developed under a US Foreign Military Sales programme for the IAI Lavi and IAI's updated McDonnell Douglas F-4 Super Phantom/Kurnass 2000.

The PW1120 had its initial flight in the starboard nacelle of the Super Phantom on 30th July 1986 and the same aircraft flew with two PW1120s from 24th April 1987. Two PW1120s reduced the Super Phantom's take-off run by 20% compared to that for the same aircraft powered by the original General Electric J79s.

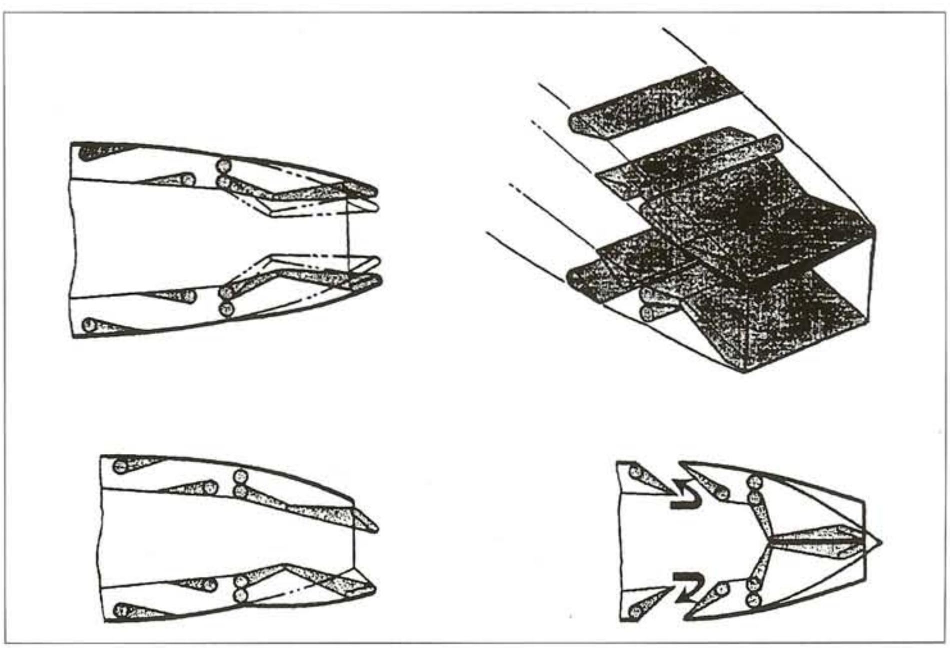
According to some sources, the PW1120 was so powerful that the Super Phantom could fly supersonically without using the afterburner. However, since it was a new engine developed for export, there would most likely be problems with the transfer of the advanced technology.

	RM8B	GE404J	RB199	PW1120	RM12
Power output, dry, lb	16,200	11,000	9,100		1,2141
with afterburner, lb	28,110	16,000	16,000	20,600	18,105
Length, mm	6,223	4,034	3,200	4,045	4,040
Width, mm	1,030	884	940		850
Height, mm	1,260			1,005	1,100
Dry Weight, lb (kg)	4,895 (2,220)	4,763 (2,161)	2,103* (945)*	2,848 (1,292)	2,325 (1,055)

* without thrust reverser



A little-known fact about the Gripen is that in the early stages of its design, it was actually considered with a two-dimensional thrust-vectoring and reversing nozzle. Illustrated is the Type 2100 with this engine installation. It was soon confirmed that the JAS 39 would fulfil the required take-off and landing requirements without the two-dimensional nozzle.



A close-up of the nozzle that was considered for the F404J engine in the early stages of the Gripen's design phase. The design of the nozzle is very similar to that tested on the F-15 S/MTD.

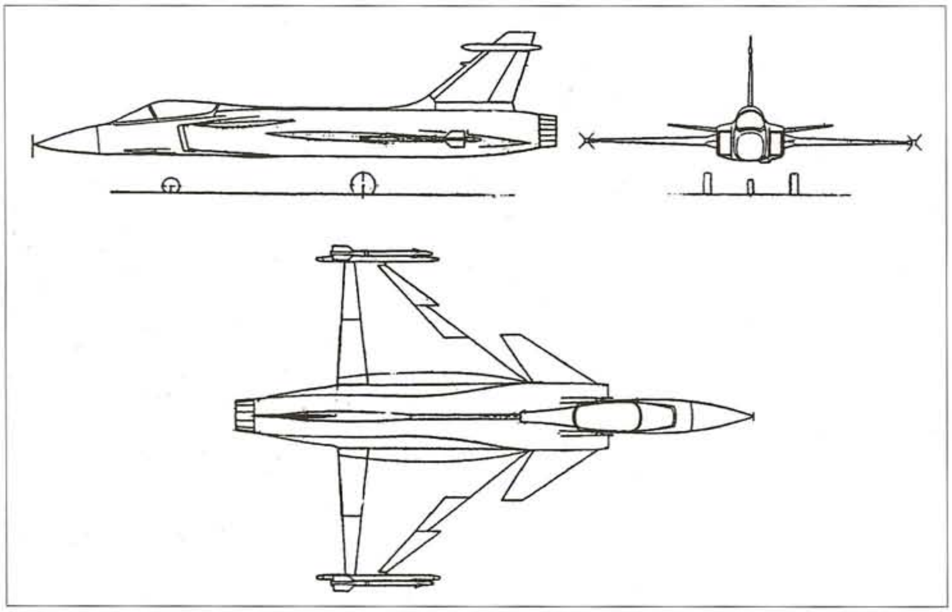
Both the RB199 and the F404J had the advantage of being proven and reliable service engines, having entered service in July 1980 and February 1981 respectively; The F404J had the added attraction of being simple in terms of its construction, which made it easier to maintain. The PW1120 was heavier and needed a higher thrust to give the same performance, which negated some of its advantages, but it did have 70% commonality with the same manufacturer's F100 engine used in the McDonnell Douglas (later Boeing) F-15 Eagle. The larger size of the PW1120 was also important because it would require a bigger airframe

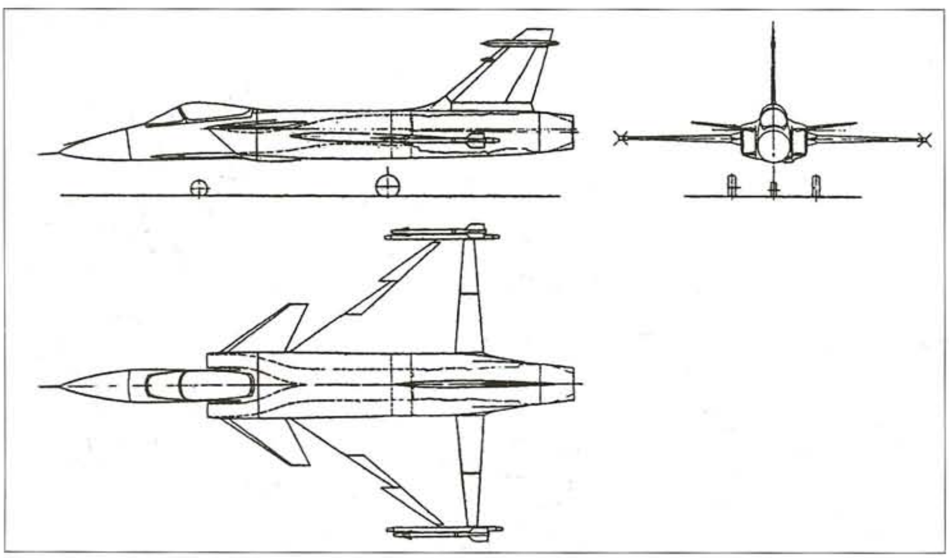
F404J Selection

When the first provisional drawings of the Type 2105 project were shown to the public at the 1981 Paris Air Show, it was stated that the F404J had been chosen for the JAS 39. The engine was thought to have real growth possibilities and was already in production for the F/A-18 Hornet. Despite the earlier co-operation between Volvo Flygmotor and Pratt & Whitney on the JT8D/RM8 for the Viggen, it had been concluded that the PW1120 did not offer the advantages offered by the F404J.

The F404J first needed to be optimised for the Swedish Air Force's requirements which were:

- Increased sea level static performance from the F/A-18's 16,000 lb (71.1kN) thrust class up to 18,000lb (80kN), the extra power coming from improved turbine alloys to allow higher temperatures and an increased fan flow.
- The introduction of redundant control system features to meet the single-engine requirements and changes to the hydro-mechanical and electronic control systems to improve redundancy from 50% to 90%. (At the time, hydro-mechanical systems were used up to intermediate throttle settings with engine control to full power achieved electronically. In its new form the engine would be 90% controllable by either system.)
- The incorporation of an improved birdstrike capability – particularly important given that the JAS 39 was to be a single-engined fighter when the F404J had, at the time, only been flown in twin-engined.





The licence-built F404J was designated RM12 for Swedish use. Smaller than the RM8, its weight was only 47% that of its predecessor but it delivered 62% of its power. Volvo Flygmotor was to produce just 35 components for the new engine, which does not seem much, but the company received a separate contract to produce for General Electric 23 different parts for all other F404 engines intended for installation in single-engined aircraft, thereby securing the 100% offset required by the Swedish company

In April 1984 General Electric reported that it was testing on a normal F404 a new fan developed for the RM12 which could handle 10% more airflow. It was planned that the JAS 39's engine would first run in June with flight clearance following in September 1985 and qualification in 1987.

Volvo Flygmotor tested the RM12 at Trollhättan for the first time on 23rd January 1985; the engine having already undergone some testing at General Electric in 1984. A total of 11 development engines were built, four of them for bench-test work and the others for flight testing. In 1986 Volvo Flygmotor proposed a further development of the engine and after the so-called Development Phase 2 in 1991 the RM12 was expected to give a thrust of 20,025 lb (89kN), a 10% increase over the original without any increase in the engine's size.

In March 1987 Volvo Flygmotor delivered the first of seven RM12s to Saab which were destined to participate in airworthiness tests for both the engine and the Gripen. A year later the test programme was still going according to plan, the bench-test units having accumulated over 4,000 hours of running time. Around the same time the initial flight engine was tested for the first time in the Gripen prototype 39-1 and by early September 1988 one RM12 had run for more than 20 hours in the same aircraft.

Photographs on this page:

Project 2112, a variant of the final Project 2110, with the PW1120 engine the most obvious difference. This engine option was liked more by some of those involved in the JAS 39 project as it offered better performance than the GE F404. The latter won out because it was the lower-risk option.

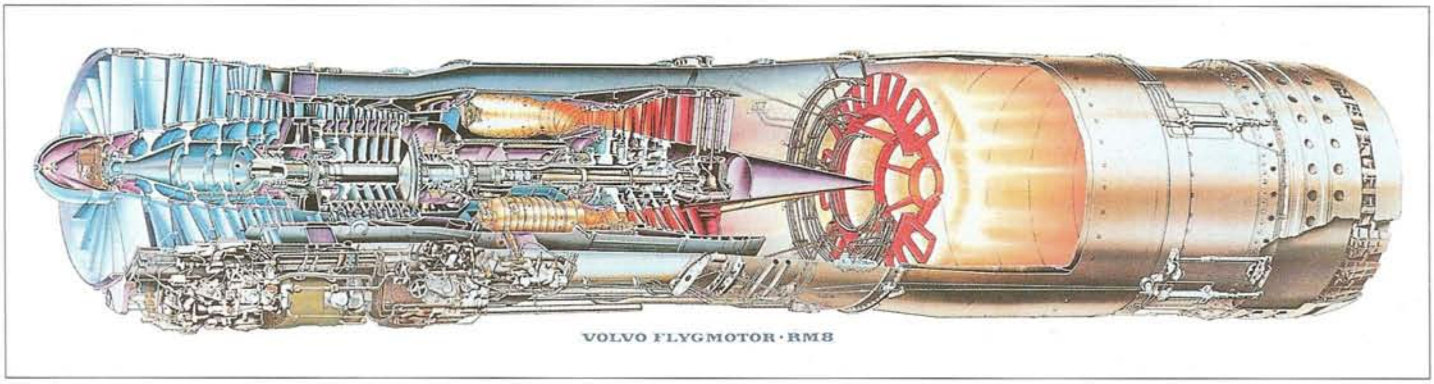
Project 2113, another variant of the final Project 2110, powered by a Pratt & Whitney F100.

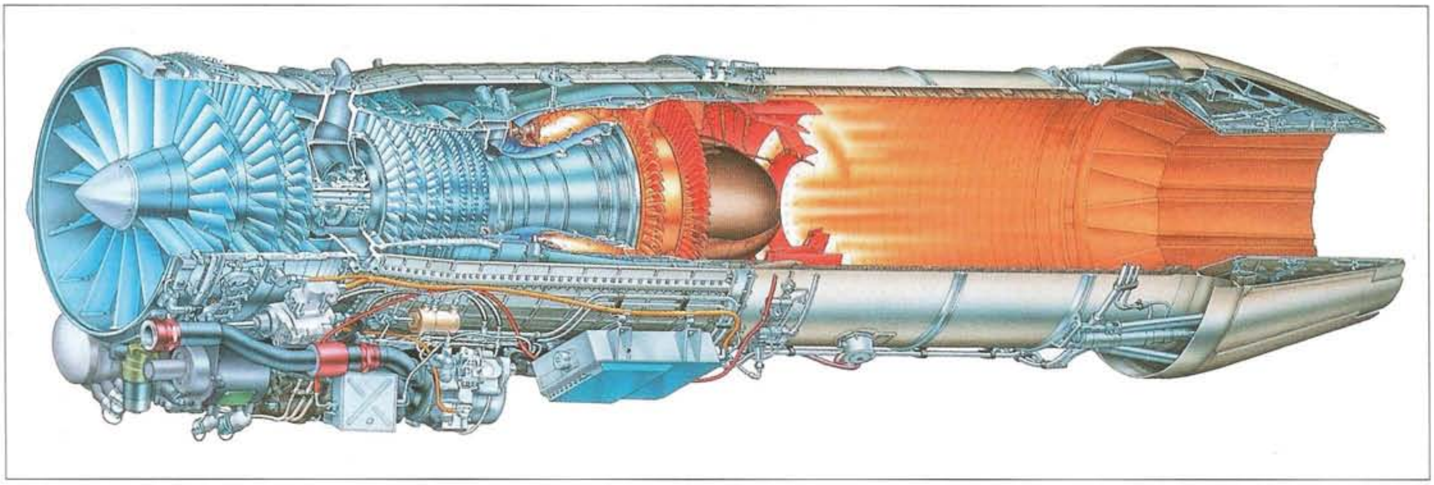
Photographs on the opposite page:

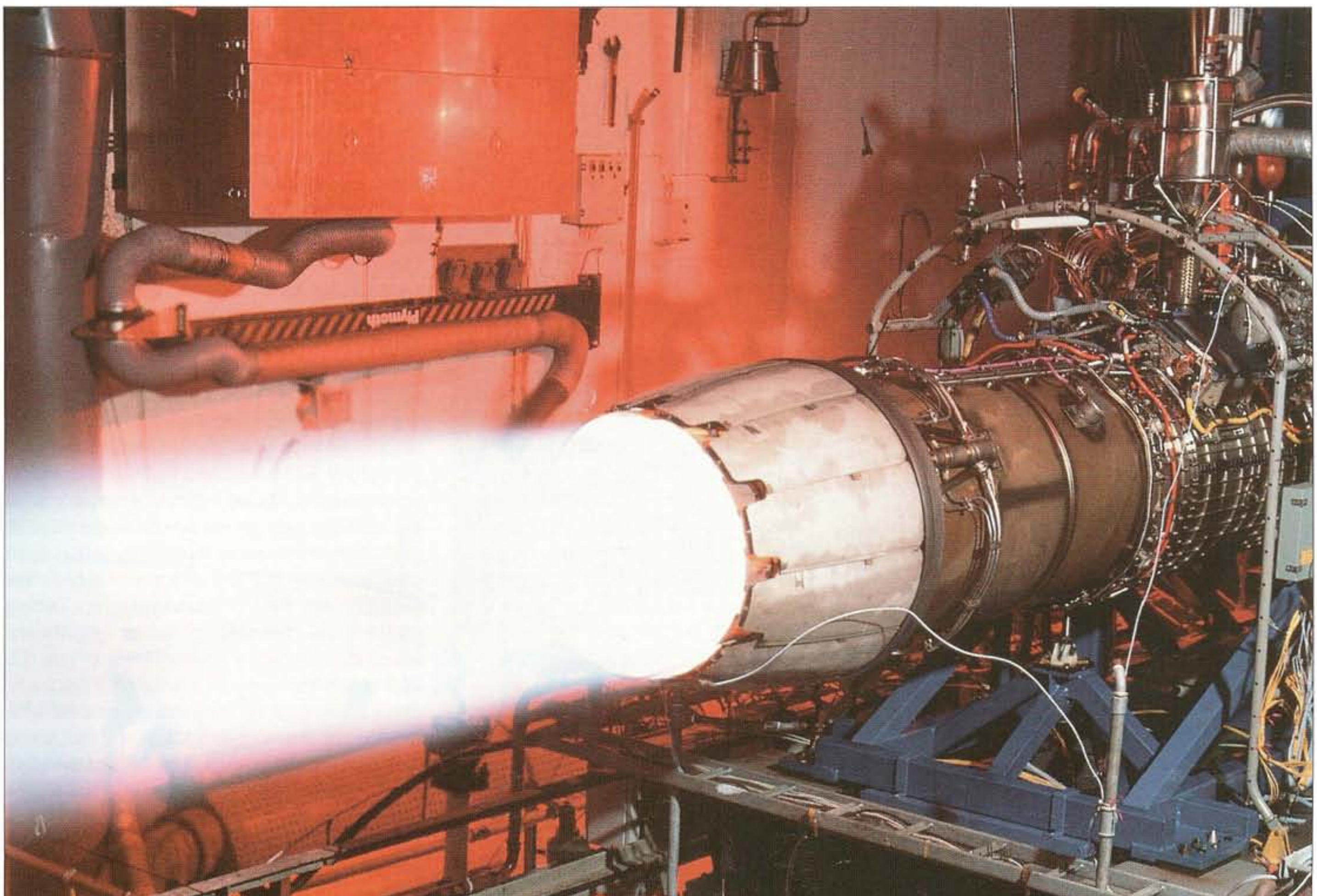
Cutaway drawing of the RM8 engine as used in the Viggen.

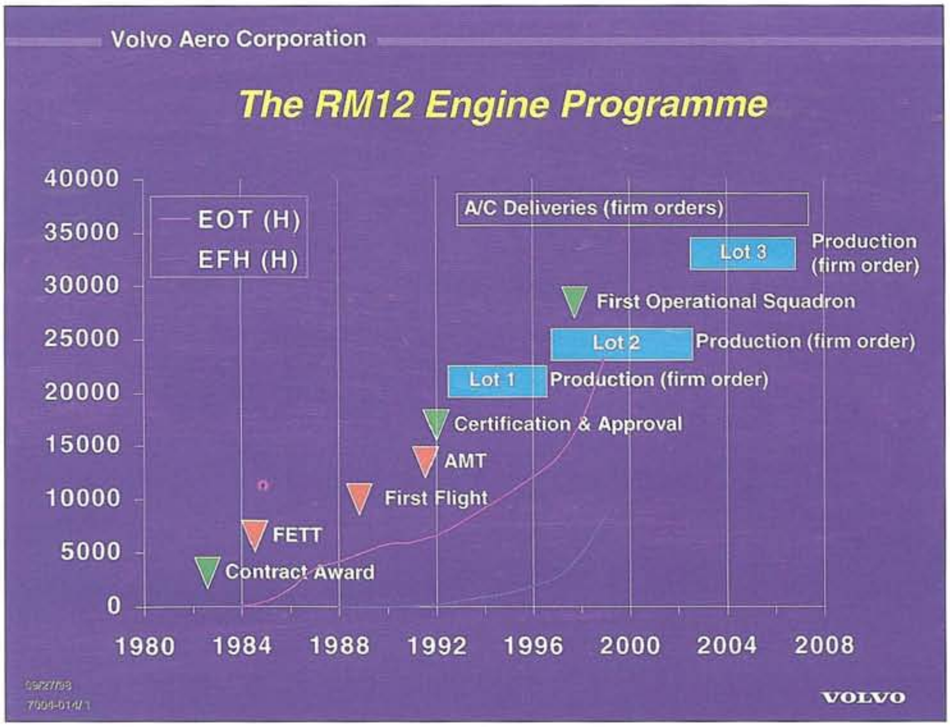
Cutaway drawing of the RM12 engine as used in the Gripen.

An RM12 in full afterburner during the exhaustive ground testing programme. Before the first flight, RM12 testbed engines were run for approximately 5,000 hours.


VOLVO FLYGMOTOR · RM8







An overview of the development and production of the RM12 engine.

FETT	**First Engine To Test**
AMT	**Accelerated Mission Test**
EOT (H)	**Engine On Test (Hours)**
EFH (H)	**Engine Flight Hours (Hours)**

Birdstrike Resistance

The RM12's intake has 15 reinforced struts (compared to the original F404's 18 struts) to help the engine withstand a strike by a 1.1-lb (0.5-kg) bird. This should make the Gripen less vulnerable to damage and loss as a result of birdstrikes – all the more important because reducing peacetime losses was one of the Swedish Air Force's Gripen requirements.

The results of the RM12's birdstrike tests were so positive that Volvo Flygmotor stated that, after a birdstrike with a 1.1-lb (0.5-kg) bird, the Gripen should still be able to return to base; better than the requirement set by the Swedish Air Force. The higher birdstrike-resistant fan runs at a 5% greater airflow than the original F404 from which it is derived, while the RM12 has a redesigned fan to increase flow capacity by about 10% to give 15% more thrust than the original.

RM12 fuel consumption at full throttle is 9.3 lb/sec (4.2kg/sec) compared to 18.1 lb/sec (8.2kg/sec) for the RM8. The Swedish Air Force has confirmed that the engine's fuel consumption is around 50% that of the Viggen's RM8 engine. The Gripen fuel system has two backup systems, one electrical (DEC) and one mechanical (AMOT).

Given the operational demands placed on the RM12, it has to be checked regularly. To facilitate this it has 13 ports through which it can be inspected using the boroscope technique. Twelve of these ports are accessible by the technician when the engine is still in the aircraft, which makes engine inspection easier and cheaper.

A condition monitoring system registers the flight data, which is downloaded after every fifth flight, and the results and trends are displayed on computer graphs. This has helped to cut maintenance costs because, prior to this, rather more preventive maintenance had to be undertaken. The engine technicians did not know, for example, how long the afterburner had been used.

Another feature that makes maintenance cheaper is the fact that the RM12 is made in seven sections or modules, each of which can be changed separately. These are the fan, high-pressure compressor, combustor, high-pressure turbine, low-pressure turbine, afterburner and accessory gearbox. The entire engine still has to be removed from the Gripen to allow the removal of one section, but if the aircraft is operating from remote areas it is easier to supply a section of an engine rather than an entire unit.

Back-up Power

It is never good to have an engine failure, especially if happens in a single-engined aircraft. If this occurs in the Gripen, power is provided by the APU. There are also two types of back-up battery, with a respective duration of around ten minutes and half an hour. In an emergency these two power sources should make it possible for the Gripen pilot to glide to a nearby airfield.

After the loss of the first prototype, the accident investigation report published in June 1989 noted that, at the time of the crash, 39-1 had just 5.3 hours' flying time. RM12 production engine NR.755046-2G had run in the aircraft for 38 hours, during which time its afterburner had been used for 33 minutes.

The Gripen has a total of 40 computers of which two are used to monitor the engine. The Engine Condition Monitoring System records 20 parameters using 20 sensors inside the engine and the specific information provided can, for example, be used to keep the engine in the aircraft for a longer period than planned.

FADEC

One big difference between the F404J and RM12 arose from the fact that the US Department of Defense did not wish to transfer the Full Authority Digital Engine Control (FADEC) system technology to Sweden. Therefore Volvo Flygmotor had to look for a new FADEC system for the RM12, but in fact another system was wanted anyway since the F404's FADEC was designed for a twin-engined aircraft and did not need the security features required for the single-engine Gripen. The RM12 is thus equipped with a Swedish-developed Digital Engine Control instead of a FADEC.

Development Problems

Shortly before the maiden flight of the second Gripen prototype in 1990, problems were noted with the RM12's afterburner and a loss of thrust was registered; the build-up of thrust was just too slow. This was serious because it extended the aircraft's take-off time and thus its operational reaction time – and the longer time needed by the F-16 was one of the reasons why that aircraft was not felt to be suitable for the Swedish Air Force. Changes introduced to help cure the problem included some different engine materials and an increase in the turbine temperature at take-off. According to the manufacturer, the two problems were connected.

Another problem appeared a month later when cracks were found in some blade roots in the fan compressor's third stage on three of the ten test engines, which had all run between 500 and 800 hours (the others had not been run for so long). The blades had resonated when the engine was running within its normal envelope, which in turn created surface cracks; the cause was either vibration or fatigue. This meant that Gripen prototype 39-2's maiden flight had to be performed within a limited flight envelope This was, however, not too much of a problem since the software had also to be checked out.

By May 1991 all of test Gripens had been equipped with modified engines, by which time only 39-5 and 39101 had not yet flown. Testing of the RM12 had now exceeded 8,000 hours.

Flameholder

On 13th August 1991 Volvo Flygmotor concluded the Accelerated Mission Test during which an RM12 completed a series of tests that corresponded to 1,000 flight hours. The engine flameholder was the main worry but it passed the test, although some development work remained. A flameholder is basically a sort of wind brake in the afterburner chamber which shields the combustion from flame-out; the

The Gripen can reach supersonic speeds without having to light the RM12's afterburner.

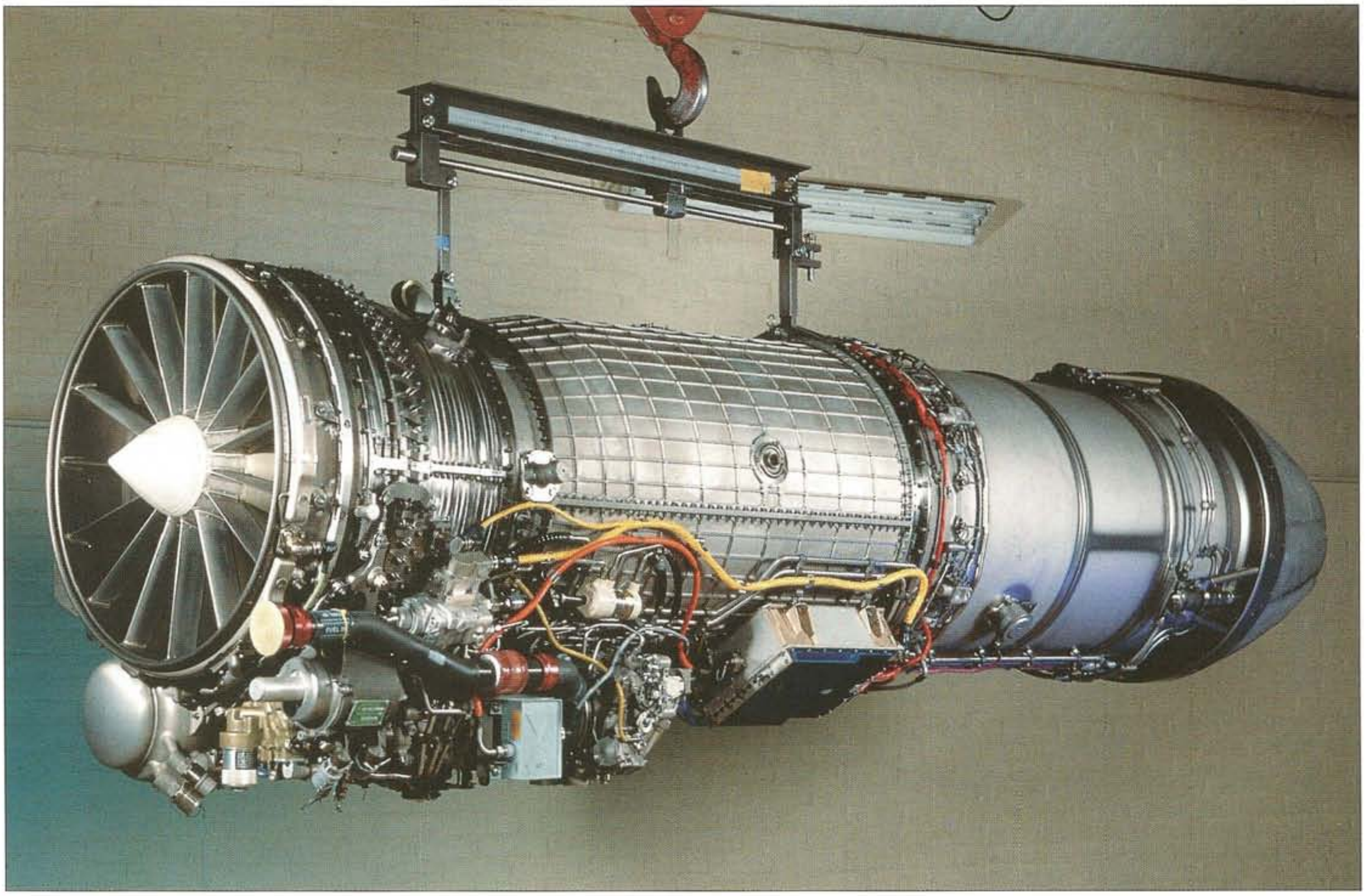
Engine assembly at Volvo Aero in Trollhättan is carried out underground as a result of precautions taken during the Second World War to protect against the ravages of bombing.

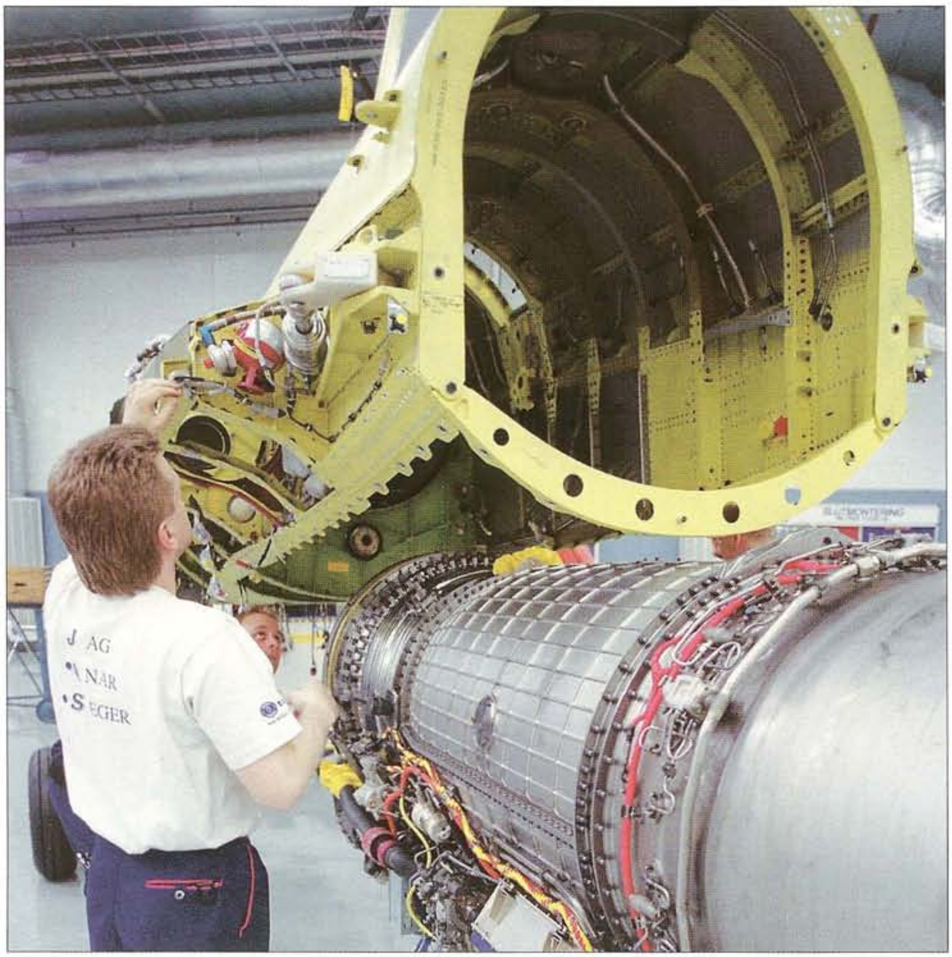
speed of the gases leaving the engine are so high that they would otherwise extinguish the flame. Very high temperatures are experienced in the afterburner which means the requirements on the material are also exceptionally great; the temperature can reach nearly 2,000°C.

Towards the end of February 1992, General Electric announced that the transfer of the design authority for the RM12 to Volvo Flygmotor would be complete within six months. At the 1993 Paris Air Show it was reported that in-flight engine shutdown and restarting had been successfully tested in Gripen 39-4, the engine test prototype.

Blade Failure

Soon after the flight-test programme had resumed following the crash of 39102, the second production aircraft, in 1993, after just five more flights, Saab had to cease flying from 14th January to 15th February 1994, again because of engine problems. Once again, blade failure was the cause, this time in the single-stage low-pressure turbine in the 15th production RM12. The blade failed after 58 minutes of a 10-hour bench test at the Volvo Flygmotor complex in Trollhättan. The company later found that a faulty fuel nozzle valve was the cause, the offending item having failed to open during the test. This nozzle valve was manufactured by Parker Hannifin, a sub-contractor to General





Above: **An RM12 engine on a transport belt, ready for delivery to Saab.**

Left: **An RM12 engine is 'introduced' to the Gripen's engine bay during the final assembly phase.**

Photographs on the opposite page:

Top: **The RM12 in its original form offered 80.5kN (18,000 lb st) with afterburning, enabling the Gripen to meet the Swedish Air Force's demanding payload/take-off distance requirements for road operations.**

Bottom: **Engine reliability is all the more important as important when it comes to Gripen operations from short stretches of road within the Swedish Air Force's BAS90 sites.**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Electric, and all RM12s were now checked for faulty valves to clear the aircraft to fly.

During Gripen test flights the RM12 achieved Mach 1.08 without reheat; in other words, the Gripen can fly supersonically without afterburning – something the F/A-18C/D Hornet is incapable of doing with two F404J engines.

RM12+

A new powerplant was proposed for a future Gripen development, the JAS 39C (which was generally taken to be the Batch Three aircraft, though neither Saab or the the Swedish Air Force ever acknowledged this). Options for the study were:

- RM12+ (an improved version of the RM12).
- Snecma M88-3.
- Eurojet EJ200.
- General Electric F414.

The fact that so early in the Gripen programme, discussions had begun regarding an engine change led to speculation that the thrust-to-weight ratio of the RM12 was insufficient. However, this was countered by the fact that the Swedish Air Force's requirement that the Gripen should be able to take off with a full load from 2,600-ft (800-m) stretches of road was not only met but exceeded.

At this time the RM12+ was being proposed by Volvo Flygmotor as the logical option but, whichever engine was chosen, the company would be partly involved in its development as per the F404J/RM12. The RM12+ had the best chance of success and the lowest cost but, on the other hand, it did not have so much capacity for growth compared to the others. This was important since the JAS 39C was expected to be able to carry a bigger payload, therefore an increase in power was needed. Nevertheless, because the cost of maintaining two engines was not financially or logistically viable, the RM12+ stood the best chance.

The Snecma M88-3 was a development of the M88-2 installed in the Dassault Rafale but, during this study, it was still only at the planning stage and was not being tested. The other engines were already under test or even notching up hours of flight experience, which was why the M88-3 was the first to be dropped from the study. The M88-2 itself was not considered.

The EJ200, designed and built by the Eurojet consortium for the Eurofighter Typhoon, flew for the first time in the third prototype Eurofighter on 4th June 1995 and was the most developed engine of all the available options. When the Swedish study was initiated the other engines had not been flown whereas the EJ200 had a secure future with four Eurofighter customers, which made it one of the main options. An important and favourable factor was that it was designed and built in Europe, so the United States could not make life difficult when it came to potential exports.

The new flameholder offers better performance for less weight, which allows the Gripen to lift heavier payloads for attack missions and offers enhanced high-speed performance when operating in the air defence role.

The General Electric F414 was, from 1993, the last of the contenders to be considered. In essence it was a bigger F404, but it incorporated part of the technology developed for the F412 originally planned for the US Navy's A-12 attack aircraft cancelled in 1991. Some of the technology developed for the YF120 (the losing contender for the USAF's Advanced Tactical Fighter) was also incorporated.

Compared to the F404J, the F414 would have a higher airflow, an increased overall pressure ratio and a higher thrust-to-weight ratio; yet, despite these improvements, the F414 had the same length and diameter as the RM12. The RM12 had improved birdstrike resistance which was also incorporated in the

Technical Engine Data

	RM8	RM12	RM12+	GE404	GE414	EJ200	M88-3
Total length, m	6.22	4.1		4.03	4.03	3.988	3.606
Inlet diameter, m (in)		0.709 (31)		0.703 (27.7)	0.777 (30.6)		0.660 (26)
By-pass ratio		0.28		0.34		0.40	0.30
Total compression ratio	16.5:1	27.5:1		25:1	30:1		
Max rating with afterburner, lb	28,110	18,105		16,000	22,000	20,250	19,555
Thrust, lb	16,200	12,141		11,000	14,770	13,500	16,782
Airflow, lb/sec		150		142	170	170	159
Weight, lb	4,895	2,325		2,185	2,445	2,182	2,170
Max diameter, m (in)		0.884 (35)		0.876 (34.5)		0.740 (29)	0.787 (31)
Pressure ratio		27:1		25:1	30:1		27:1

F414, and necessary changes to the engine would be minimal.

In May 1993 the First Engine To Test was ahead of schedule and on 26th May 1995 General Electric announced that it had delivered the first two F414 test engines, which made their first flight in the Boeing F/A-18E Super Hornet's on the type's maiden flight on 29th November 1995.

The EJ200 and F414 were the frontrunners to meet the JAS 39C's engine requirement. If the F414 was chosen, one of the questions that would arise again was whether or not the United States would veto the export of certain aspects of the F414's technology to countries from which other US companies hoped to win orders.

In 1994 Volvo Flygmotor changed its name for a third time to Volvo Aero, the new name giving a more international image which was important to the company since it now had more business abroad than in Sweden.

Testing to Extremes

The Gripen's RM12 engine was, of course, tested in extreme conditions and performed outstandingly during high angle of attack flights and spins. FMV test pilot Björn Johansson took the Gripen into a deep stall and moved the power level continuously between flight idle and military power without any stall stagnation problems. Johansson also stated that the engine had operated well at 160° angle of attack and 90° of sideslip.

In 1996 the new Swedish defence budget cancelled all of the new engine studies because they were too expensive; only a few improvements to the existing RM12 engine were to be financed. An increase in performance had to be balanced against the attendant cost, and thus the engine modernisation programme was the first victim. In modified form it included a new FADEC system, a new turbine and a retrofittable flameholder. The first upgraded engine was expected in 1999.

Initial studies were made in 1995 and 1996 to replace the DEC and AMOT systems (AMOT is a Swedish abbreviation which can be translated as 'engine adapter'). Volvo Aero, in co-operation with General Electric and Lockheed Martin Control Systems, began development work in June 1997 and an engine equipped with the new FADEC was delivered to Saab by the end of June 1999. Since then it has undergone a series of tests to obtain FMV airworthiness approval, given on 22nd October 1999.

The first flight with the new FADEC-equipped RM12 was made on 3rd November 1999 in Gripen 39101, Saab's test aircraft at Linköping. The trip lasted for 45 minutes and was the first in a 25-flight programme. The switch to the new FADEC system has saved 17.6 lb (8kg) of weight and will cut maintenance costs. Communication between the engine and the aircraft was changed from analogue to digital, thus bringing the interface between the two more up to date and closer to fourth-generation standards. Gripen 39193 was the first production aircraft to receive the new FADEC.

New Flameholder

The RM12's original flameholder did not meet its service life requirements which meant that the level of maintenance required was very heavy, hence the new study initiated in 1997. The results of the study proved so promising that a contract for a full-scale prototype was soon awarded by the FMV. The main difference was that the old flameholder was not cooled whereas the new type received air cooling, which extended its service life to three times that of the original.

Gripen prototype 39-4 first tested the new installation in September 1998. A second advantage was that it was not necessary to remove the entire RM12 engine to replace the new flameholder, which had been the case when replacing the original flameholder. It was also not necessary to replace the entire flameholder, but rather only the worn-out parts, which in turn saved money and reduced turn-around and maintenance times.

Because it is cooled, the new flameholder's heat signature is reduced, which means an overall reduction in IR radiation and so makes the Gripen more stealthy. In terms of weight, the new installation was 6.6 to 8.8 lb (3 to 4kg) lighter. Delivery of the first RM12 equipped with the new flameholder was expected during autumn 2001.

These updates, plus the new turbine design, made the difference between the RM12 and the RM12+ and, before the first half of 2001 was over, Switzerland and Finland (both FA-18C/D Hornet users) had ordered the new flameholder. Test flights were conducted during April 2001 in conjunction with Saab in Linköping and the first engine equipped for production aircraft was to be 12-254. All older in-service engines were to be retrofitted.

Thrust Vectoring

At the end of September 1997 the FMV asked Saab to begin a study on behalf of the Swedish Air Force for a Gripen equipped with a more powerful engine and thrust vectoring. The advantages offered by thrust-vectoring nozzles are:

- Better manoeuvrability, including post-stall manoeuvring.
- Better performance such as a shorter take-off run and pointing the aircraft's nose in a different direction to its flight line.
- Better stealth characteristics.

Since 1988, more and more fighters have been equipped experimentally with thrust-vectoring nozzles, There have been several technology demonstrators built for the purpose of gaining experience with thrust vectoring. The main examples have been the:

- X-31 Enhanced Fighter Manoeuvrability Demonstrator (the only one considered for use in the Gripen research effort).
- F-18 HARV (High Alfa Research Vehicle).
- F-15B S/MTD (STOL/Manoeuvring Technology Demonstrator).
- F-16 VISTA (Variable In-flight Stability Test Aircraft) and MATV (Multi-Axis Thrust Vectoring).
- F-15B ACTIVE (Advanced Control Technology for Integrated VEhicles).

Due to the fact that the Lockheed Martin FA-22A Raptor has thrust vectoring installed, and also because that the Russians have been busy experimenting with thrust vectoring technology, Saab also has had to show an interest. At the ILA96 Show in Berlin, Swedish government and industry officials sat around the table with the two original X-31 partners, Germany and the United States. A proposed follow-on programme, using the surviving Rockwell/MBB X-31, was called VECTOR and Sweden was added as a programme manager. It was to be funded equally, with the United States taking system leadership; go-ahead was expected in late 1998. However, budget constraints in Sweden resulted in severe delays and by June 1999 it was the only one of the three partners not to have signed the Memorandum of Understanding development agreement. At the end of that year it looked as if Sweden could not fulfil its commitment and Germany and the United States would go ahead on their own.

Eventually, thanks to heavy budget cuts, Sweden had to choose which Gripen improvements it should invest in. Thrust vectoring was not considered to be sufficiently important (the cost/gain margin was not good enough and the technology could always be bought 'off the shelf'), therefore it was deleted from the short-term programme. The X-31 continued as a US-Germany project.

Bird of Prey

Weapon Systems

Guns

Analyses conducted at the beginning of the 1990s of manned air combat simulation and actual conflicts showed that more than 30% of all air-to-air encounters, no matter how far apart the aircraft were when contact was first made, ended with close-in combat. The evidence showed that a fighter's cannon and Short-Range Air-to-Air Missile (SRAAM) could still supply the decisive punch.

An internal cannon features as standard equipment in every fourth-generation fighter. A harsh lesson learnt by the United States during the Vietnam War was that no matter how good its air-to-air missiles were, a pilot who had expended all his missiles needed an internal gun to defend himself. Before Vietnam the internal cannon was thought to be obsolete and, consequently, American fighter pilots were often powerless to shoot down their opponents or were shot down themselves.

The Gripen was designed to have the same weapons capability as the Viggen and, after the lessons of Vietnam, this included an internal cannon. The choice was between the Swiss Oerlikon KCA 30mm, as used in the Viggen, and the German Mauser-Werke BK27 27mm, already in use on the Panavia Tornado and the DBD Alpha Jet and later selected for the Eurofighter.

The BK27, based on the revolver principle, was the smaller and lighter of the two (it was in fact the most compact light power revolving gun) and therefore better suited to the Gripen's smaller airframe and the need to keep the aircraft's weight down. In September 1983, Mauser Werke announced that the BK27 had been chosen to arm the Gripen.

The 'clean' weight of the BK27 is 220 lb (100kg) including a barrel that weighs 37lb (17kg). It uses 27mm high-explosive shells each of which weighs 9oz (260g), and has a maximum rate of fire of some 1,700 rounds per minute; however, the weapon does have a variable rate of fire down to as low as 1,000 rounds per minute. Muzzle velocity of this high-energy cannon is 3.36ft/sec (1.025m/sec) and it can operate in an automatic radar-guided mode to increase the hit probability.

Gripen prototype 39-5 was used to ground-test the BK27 before it participated in the flight test programme; according to some sources, the number of rounds carried in the Gripen is 120. The cannon is fitted on left-hand side of the single-seat Gripen's fuselage; the two-seater is not armed with the cannon, space and weight having had to be saved to allow for the second cockpit and its pilot.

Short-Range Air-to-Air Missiles

The other option for the air-to-air battle is the air-to-air missile (AAM) which exists in three different forms, each classified by its guidance system and range. These are active radar guidance, semi-active radar guidance and infra-red guidance.

Left: **One of the first two production JAS 39A Gripens with a display of the armament that could be carried at that time.**

Photogrpahs on the opposite page:

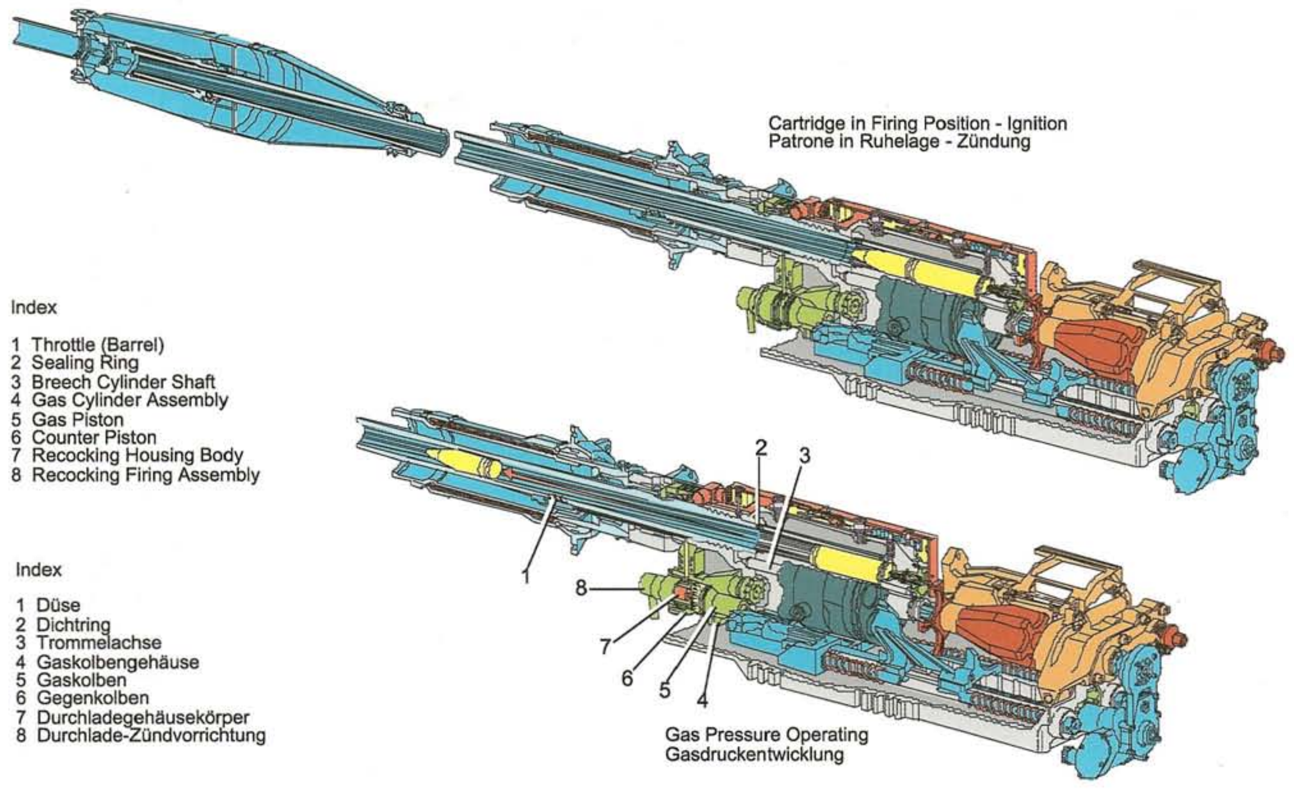
Top: **A schematic drawing of the BK27: throttle, gas cylinder assembly, gas piston, pyrotechnic recocking housing and front slide.**

Bottom: **The fired 27mm round is carried into position, ready for ejection. The empty cartridge case will be ejected during the forward movement of the front slide.**
A cartridge fires;
A cartridge is fully rammed and engaged by the cartridge retainer;
A cartridge is partly rammed;
This cartridge case is empty and ready to be loaded.

Bordkanone 27mm x 145

Table 3.1

Funktion der Bordkanone
und der Durchladevorrichtung



Index

1 Throttle (Barrel)
2 Sealing Ring
3 Breech Cylinder Shaft
4 Gas Cylinder Assembly
5 Gas Piston
6 Counter Piston
7 Recocking Housing Body
8 Recocking Firing Assembly

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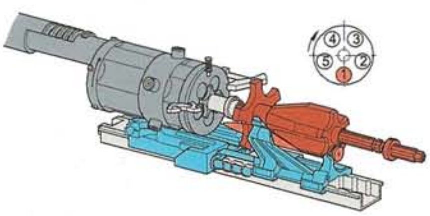
1 Düse
2 Dichtring
3 Trommelachse
4 Gaskolbengehäuse
5 Gaskolben
6 Gegenkolben
7 Durchladegehäusekörper
8 Durchlade-Zündvorrichtung

Gun Assembly 27mm x 145

Bordkanone 27mm x 145

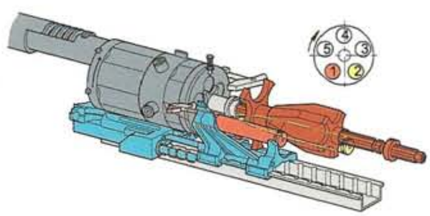
Table 4.1

Patronenzuführung
und Hülsenauswurf



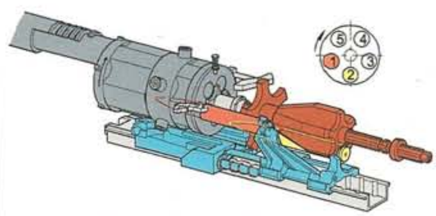
Cycle 1 Begin of First Feeding Action
Stellung 1 Anfang des ersten Taktes

The primary rammer strikes the base of the first round (red) on the loading platform.
Der hintere Ausstosser greift am Boden der ersten Patrone (rot) auf der Führungsplatte an.



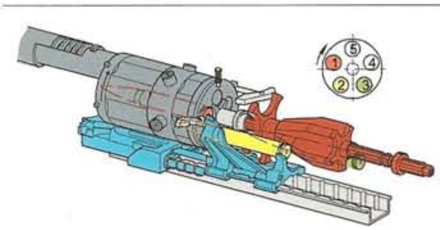
Cycle 2 End of First Feeding Action
Stellung 2 Ende des ersten Taktes

The primary rammer drives partly the first round (red) into chamber of breech cylinder.
Der hintere Ausstosser schiebt die erste Patrone (rot) zur Hälfte in das Trommelpatronenlager hinein.



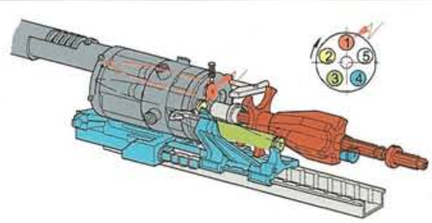
Cycle 3 Begin of Second Feeding Action
Stellung 3 Anfang des zweiten Taktes

The secondary rammer strikes the base of the cartridge case of the first round (red), while the primary rammer strikes the second round (yellow).
Der vordere Ausstosser greift am Boden der ersten Patrone (rot) an, und der hintere Ausstosser greift am Boden der zweiten Patrone (gelb) an.



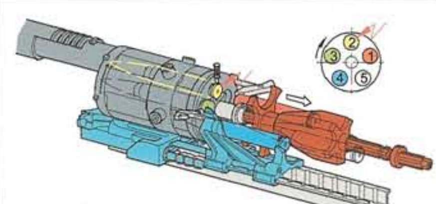
Cycle 4 End of Second Feeding Action
Stellung 4 Ende des zweiten Taktes

The first round (red) is fully rammed and engaged by the cartridge retainer. The second round (yellow) ist partly rammed. Third round (green) is placed on loading platform.
Die erste Patrone (rot) ist ganz zugeführt und wird von der Rückprallsperre gehalten. Die zweite Patrone (gelb) ist halb zugeführt. Die dritte Patrone (grün) liegt auf der Führungsplatte.



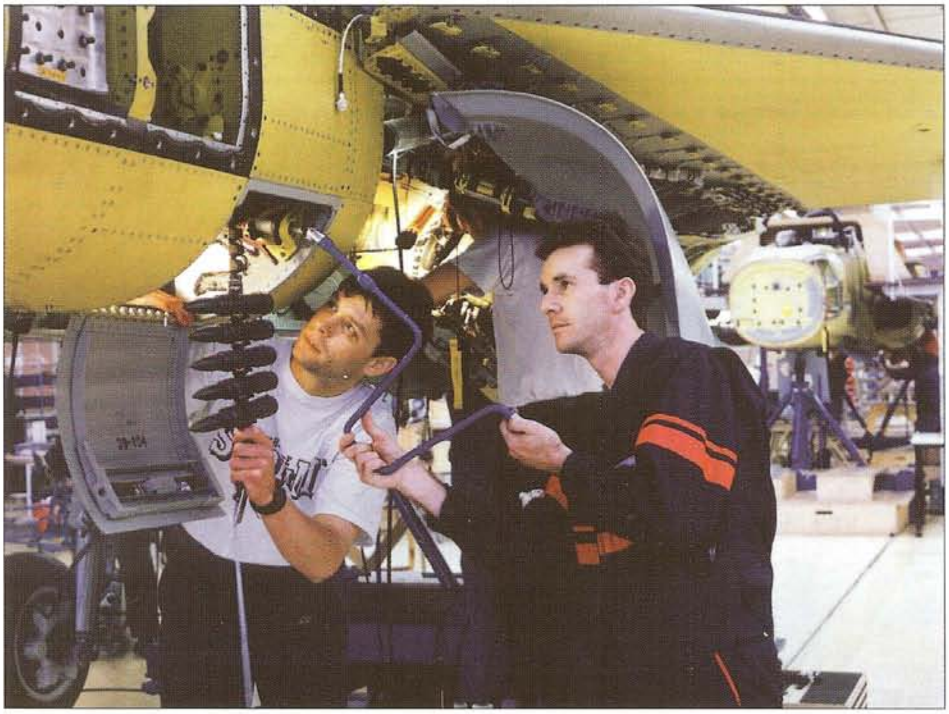
Cycle 6 End of Third Feeding Action
Stellung 6 Ende des dritten Taktes

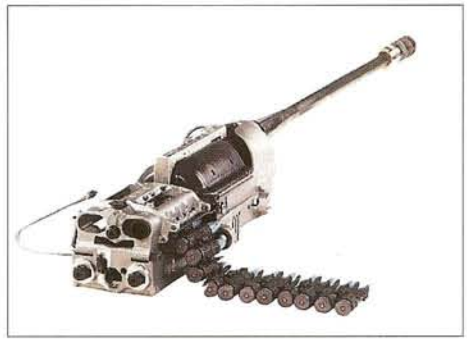
The first round (red) is in firing position and fires. Second round (yellow) is fully rammed. The third round (green) ist partly rammed. Fourth round (blue) is placed on loading platform.
Die erste Patrone (rot) ist in Schussstellung. Der Schuss bricht. Die zweite Patrone (gelb) ist ganz zugeführt. Die dritte Patrone (grün) ist halb zugeführt. Die vierte Patrone (blau) liegt auf der Führungsplatte.



Cycle 8 End of Fourth Feeding Action
Stellung 8 Ende des vierten Taktes

The fired round (red) is carried into position ready for ejection. The empty cartridge will eject during forward movement of the front slide. The second cartridge (yellow) fires. The third cartridge (green) is fully rammed and engaged by the cartridge retainer. The fourth cartridge (blue) is partly rammed.
Die leere Hülse (rot) wird in Auswerferstellung gebracht und ausgeworfen, wenn der Schaltschieber wieder nach vorne kommt. Der zweite Schuss (gelb) bricht. Die dritte Patrone (grün) ist ganz zugeführt und wird von der Rückprallsperre gehalten. Die vierte Patrone (blau) ist halb zugeführt.





Above: **The Mauser-Werke BK27 cannon as it would be installed in the Gripen.**

Left: **Testing the Gripen's gun-loading mechanism on the production line.**

Below: **Besides acting as a 'battlefield manager' the JAS 39B two-seater can actually take an active part in any conflict, as illustrated by 39802 and its weapon load of six Rb99 Sidewinder AAMs for close-in air combat.**

The most expensive of the three is active radar guidance because the missile has its own radar and is therefore self-sufficient. Such missiles are known as 'fire-and-forget' weapons, a good example being the AIM-54 Phoenix carried by the Grumman F-14 Tomcat.

An example of a semi-active radar guided missile is the AIM-7 Sparrow which needs assistance from the launch aircraft after release to help guide it to its target, an action that gives the parent aircraft away to the enemy and, thus, a chance for him to counter-attack or perform some evasive action.

An infra-red guided missile is another 'fire-and-forget' weapon, but one that does not need an expensive radar. Instead it uses the heat emitted by the enemy aircraft to guide it towards its target. After release the launch aircraft can take evasive action, thus avoiding having to give itself away.

The infra-red AIM-9 Sidewinder AAM was first developed in the 1950s and has served well on the Viggen for the last three decades, on many other western aircraft and now also on the Gripen. In Swedish service Nevertheless, and despite numerous upgrades, in a few years the Sidewinder will be outdated.

Europe's defence industry, having tired of American domination in the AAM field (with the possible exception of the German company BGT, responsible for European Sidewinder production), launched SRAAM projects to counter the threat posed by the Russian Vympel R-73/AA-11 *Archer* and the Israeli Rafael Python 4. The latter was proclaimed to be the most advanced SRAAM in the world.

British Aerospace and BGT (Bodenseewerk Gerate Technik) began to develop the ASRAAM (Advanced SRAAM) for the Eurofighter but, following a revision of its requirements, the Luftwaffe and also German industry became dissatisfied with the British-led programme. BGT responded by beginning its own study which it dubbed Infra-Red Imaging System – Thrust vector (IRIS-T) and the following companies joined the German firm – Allied Signal (Canada), Hellenic Aerospace, Intracom and Pyrkal (Greece), Alenia-OTO, Fiatavio and Litton (Italy), Raufoss (Norway) and Saab Dynamics (Sweden). The Italian companies have altogether a 20% responsibility in the project, the Greek companies 8%, Allied Signal 4%, Raufoss 3%, Saab Dynamics 18% and BGT 47%. At the start it was foreseen that Greek F-16C/Ds, Canadian CF-18A/Bs, German and Italian Tornados and Eurofighters and Swedish Gripens would be armed with the IRIS-T missile.

The change to a new missile was cost and capability-related – it was felt that the added cost should make the additional advantages that such a new system had to offer worthwhile. To make sure that the IRIS-T missile was superior, all of the vital components were tested individually – for example, the heat seeker was tested simultaneously against the seeker from an AA-11 *Archer* and an AIM-9 Sidewinder. The results were very pleasing, but no Python 3 or 4 seeker was available to help clarify just how much better than the opposition the IRIS-T was. It was clear however that the real threat still came from an unstable Russia and thus the AA-11 *Archer* was seen to be the missile that had to be beaten.

To simplify the integration of the IRIS-T, it had to have similar dimensions to those of its predecessor. IRIS-T combined an aerodynamic and thrust vector tail control with an Imaging Infra-Red (IIR) seeker head.

On 9th August 1996 Greece, Italy, Canada, Norway, Sweden, and Germany validated the contract for the Project Definition Phase (worth DM28 million) and signed an agreement. This phase was successfully completed in March 1997 and in January 1998 the six countries then launched the 55-month-long Development Phase which, it was planned, would lead to first production deliveries in late 2002.

In April 1998 target-cueing test flights with the IRIS-T seeker and various Helmet-Mounted Displays were performed successfully. Belgian, Danish, Dutch and Norwegian Air Force pilots flying a Dutch F-16 MLU fighter acquired and tracked targets at +/-90° lock angles at up to 0.9 Mach, 40,000ft (12,192m) altitude and 7g. The Greek Air Force used its F-16s to test IRIS-T from 17th to 23rd October 2000 and test-fired three missiles during this period. The three unguided launches were all made in different environments (subsonic, supersonic and high-*g* conditions) and represented the first occasions on which the IRIS-T missile was launched from an aircraft.

Compatibility tests with other aircraft are ongoing but, as a result of a US-dictated integration schedule of the IRIS-T onto Canadian CF-18s, the Canadian MoD left the programme by the end of 2001.

The first Swedish trial of IRIS-T was conducted during September 2000 by Gripen 39104 in unison with the Guardian Helmet-Mounted Display. The first separation test from the Gripen was performed at the Vidsel test range the following November but, although the separation itself was satisfactory and declared safe, shortly afterwards some parts were lost from the missile; an unfortunate setback to the programme. The test programme is still ongoing at the time of writing.

The competition has not sat on its laurels, the US Navy and Air Force having initiated a joint programme with the Raytheon AIM-9X, the latest model of Sidewinder. Full-scale development began in early 1997 and to give it an edge over older Sidewinders, it was to be equipped with thrust-vectoring control. The first live test firing was made from an F/A-18C on 18th March 1999 and the first production AIM-9Xs were to be delivered from 2001.

Contracts for the integration of IRIS-T on the Typhoon and F-16 were awarded in December 2001. On 14th March 2002 an F-4F Phantom II from WTD-61 fired an IRIS-T at a drone over an Italian test range and scored a direct hit. A few days later this test was repeated and again the IRIS-T scored a direct hit.

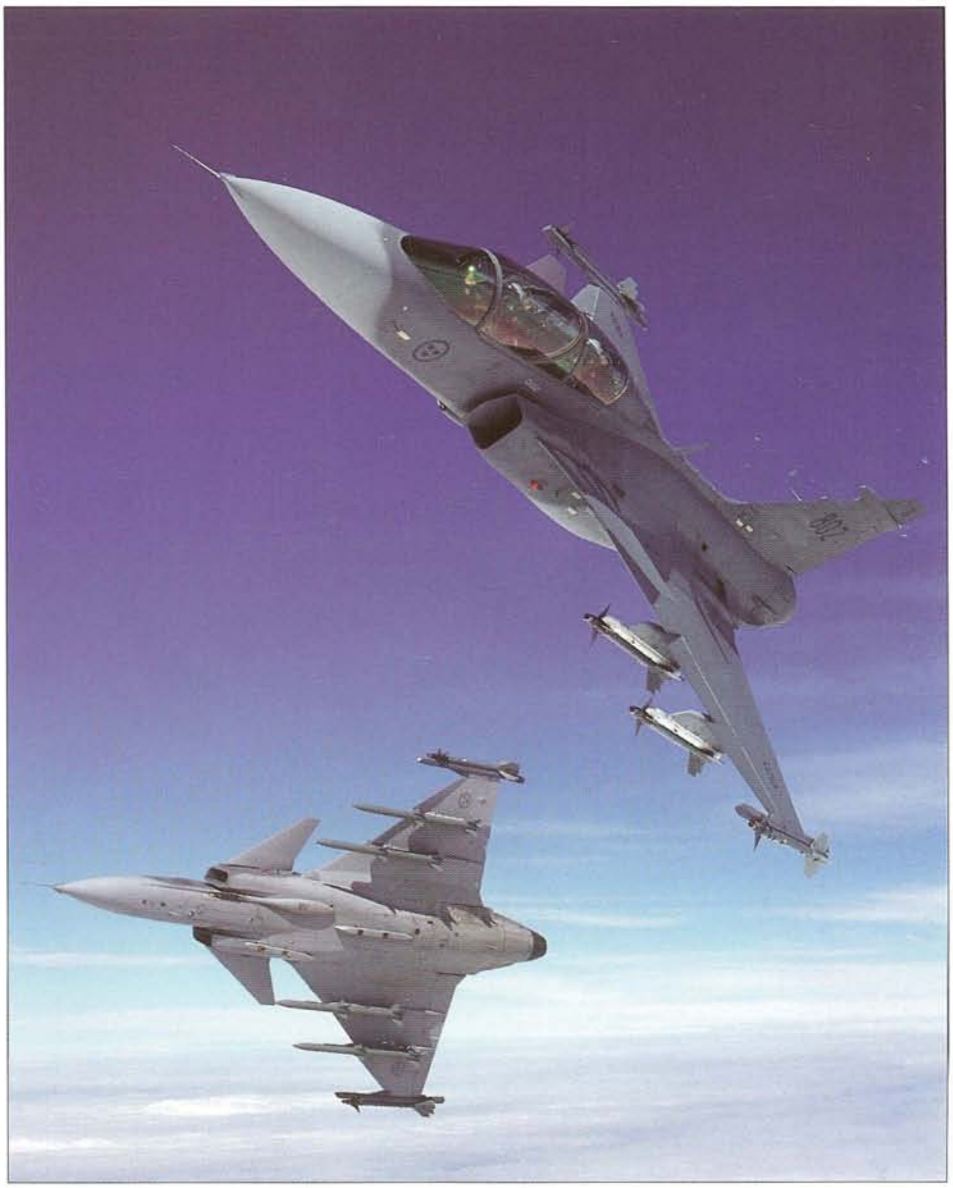
After these successful trials the next target was a drone that that was commanded to take evasive action. The drone also released flares, but that did not stop the IRIS-T from scoring another direct hit. The seeker-guided Validation Test Round firings were successfully completed in June 2002 followed by a series of performance demonstration firings to mark the completion of the development work. Production of IRIS-T is now due to start in 2004.

Short-Range Air-to-Air Missiles

	AIM-9L Sidewinder	Python 4	Python 5	AA-11 *Archer*	IRIS-T
Max length	287cm	294cm	310cm	290cm	300cm
Max span	63cm	48.9cm	64cm	50.1cm	45cm
Body diameter	12.7cm	15cm	16cm	17cm	13cm
Total weight	86.6kg	105kg		110kg	87kg
Range	8km	15km		90km	12km

At the Paris Air Show in June 2003 the Python 5 AAM made its public debut and was offered as an option for the Gripen. Although integration work could commence almost immediately, discussions with Israel to facilitate this work have not yet taken place.

In terms of its diameter, the Python 5 is in the AMRAAM size range, but it has Lock On After Launch (LOAL) and the normal Lock On Before Launch (LOBL) capabilities. LOAL gives the pilot the option to launch the missile which will then lock on to the target during its flight phase. This capability gives the Python 5 full-sphere, 360° effectiveness. Another advantage of the Python 5 is that it is effective in the Beyond Visual Range area as well as at short range.



JAS 39A 39145 banks away to reveal the offset BK27 cannon pod and four Rb99 AMRAAMs on the underwing pylons, while JAS 39B 39802 displays an alternative AAM configuration of six Rb99 Sidewinders.

Medium-Range Air-to-Air Missiles

If more than 30% of aerial engagements ends with close-in combat, it follows that more than 60% concludes with Beyond Visual Range (BVR) combat. Raytheon completed production qualification for the AIM-120 Advanced Medium-Range AAM (AMRAAM) in January 1989, the weapon being the intended replacement for the AIM-7 Sparrow in the US Air Force. AMRAAM is 143.7in (365cm) long, spans 25in (63.5cm) and has a body diameter of 7in (17.8cm). Launch weight is 345 lb (156.5kg).

AMRAAM became an automatic competitor for the Gripen BVR requirement. Because Swedish Air Force Viggens had been equipped with the BAe Sky Flash (Rb 71 in Swedish service), Saab Dynamics began working with BAe on the privately funded Improved Active Sky Flash programme and marketed the missile for integration on the Gripen. Active Sky Flash was to have been an improvement over the standard Sky Flash missile and used active radar guidance.

The US Department of Defense refused to let Saab conduct the integration work for the Gripen/AMRAAM combination, stating that all American weapon systems must be tested in the United States. This refusal meant that Saab could not offer AMRAAM-armed Gripens to Finland – arguably a major reason why Finland was lost as a customer. (Finland subsequently procured US F/A-18C/Ds.) Nevertheless, in 1992 Saab still wanted to perform the integration work in Sweden. The US response was that, unless a waiver was granted, the work could not be undertaken in Sweden or any other country.

March 1994 was the deadline set by Sweden for final bids for its medium-range AAM requirement. The FMV, which had to recommend to the Swedish government which missile to purchase, said that it would only give a recommendation based on the best available information. The missing data covered the AIM-120 AMRAAM missile, supposedly the most modern AAM in its class.

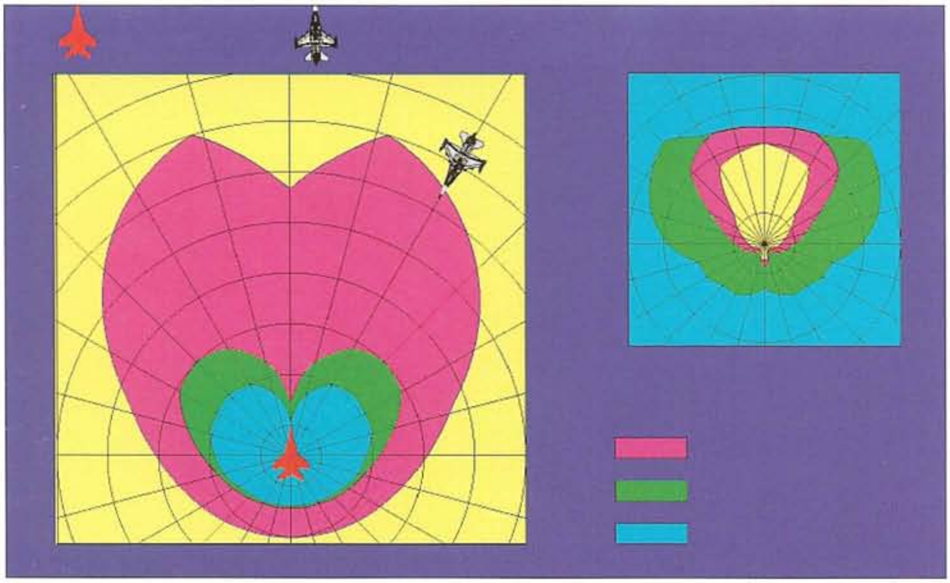
Given the US Department of Defense refusal to allow integration work in Sweden and hence the lack of relevant data when it came time for Saab to submit final bids, it was therefore quite a surprise when, on 1st September 1994, the FMV signed a Letter of Offer and Acceptance with the United States to purchase 100 Hughes AIM-120 AMRAAMs to equip Swedish Air Force Gripens.

The number of missiles bought was not high because the order was seen as more of a stopgap until a next-generation missile became available. Anders Björck, the then Swedish Minister of Defence, stated clearly that the decision to buy more would depend on the USA and on other technical developments (ie, new projects). If the USA caused problems with resale rights for the export versions of the Gripen, including all associated weaponry, Sweden would be forced to choose an alternative missile system.

The necessary integration work was eventually eventually carried out in Sweden and the AMRAAM (Rb99 in Swedish service) was test-fired from a Gripen for the first time on a Gripen in mid-April 1998. The missile was fired from Gripen prototype 39-5 over the FMV's Vidsel test range and was the first such missile to be test-fired outside the United States

Batch One Gripens can carry four Rb99 AMRAAMs on underwing pylons and two Rb74 Sidewinders on the wing-tip rails; a capability which matches that of the the Viggen. Improvements foreseen for Batch Three Gripens are the addition of two shoulder pylons under the fuselage which will carry one Rb99 AMRAAM each for the air-superiority role. This exceeds the capability both of the Viggen and the original JAS 39 requirement set by the FMV which specified the ability to carry two medium-range air-to-air missiles for air-superiority duties.

On 27th December 1992 AMRAAM achieved its first operational success when two F-16D fighters attacked two Iraqi MiG-25 *Foxbats* which had entered a no-fly zone protected by an international force. One F-16D fired an AMRAAM at one of the MiG-25s and achieved a confirmed kill. Less than a month later an F-16C used an AMRAAM to down an Iraqi MiG-23 *Flogger* in the Iraqi no-fly zone and these results immediately made AMRAAM a more marketable product. However, at some point over Iraq, six more AMRAAMs were fired at two MiG-25s but all missed.



The IRIS-T firing envelope:
left graph = 'outer firing range'
right graph = 'inner firing range'
red aircraft = target
grey aircraft = shooter
red area = IRIS-T firing envelope
green area = AA-11 *Archer* firing envelope
blue area = Rb74 Sidewinder firing envelope

IRIS-T integration work on the Gripen started about the same time as that with the Meteor BVRAAM. Meteor is expected to enter service in approximately five years.

An artist's impression of a Gripen firing an IRIS-T SRAAM.

Test firing of the IRIS-T from a German F-4F Phantom II was a major milestone for the programme. Development of the IRIS-T has progressed apace since then; introduction into service is expected in 2004 or 2005.

Over Yugoslavia, several coalition fighters shot down more enemy targets, all of which improved AMRAAM's reputation. The first non-US air-to-air victory was made by a Dutch F-16A which used an AMRAAM to down a Serbian MiG-29 *Fulcrum*, the first air-to-air kill by the Royal Netherlands Air Force since the Second World War.

A rival to AMRAAM is the Meteor Beyond Visual Range Air-to-Air Missile (BVRAAM), the product of another international missile programme includes Saab Dynamics. This Matra/BAe Dynamics-led programme included partners from the four Eurofighter-producing countries; Saab Dynamics was an exception but gave the project extra strength because of the export potential of the Gripen and the fact that AMRAAM was seen as a stop-gap solution on the Gripen.

The Meteor partners are Alenia Difesa (Italy), CASA (Spain), GEC-Marconi (UK), LFK (Germany), Matra/BAe Dynamics and Saab Dynamics. The missile itself has a multi-target engagement capability, shoot-up and shoot-down performance, a mid-course datalink capability and a high resistance to sophisticated ECM environments.

Just as the IRIS-T had a near perfect customer base, the Eurofighter countries did not want to be dependent on US weapons and, therefore, developed their own missile so they can export it to whom they see fit. Both Eurofighter and Gripen automatically become more attractive to foreign customers who do not wish to be dependent on the US for spare parts.

The Swedish Air Force cancelled its financial support for the Meteor development programme in June 1999 because of financial problems but, if parliament agreed to support it, money would come from other sources and development could proceed. The Swedish Air Force acknowledged that although it could not afford to share in the Meteor development costs, it was still interested in the missile.

Industry partners reacted calmly to this news and waited to see what the political reaction would be. At the Paris Air Show the French government stated that if Meteor was chosen by the UK, it would support the programme and was willing to fund up to 20% of the development costs. Apart from the financial aspect, France would invest its technology and expertise in the programme so that Meteor could be installed on the Rafale and possibly the Mirage 2000-5.

On 20th October 1999 the European Meteor consortium teamed up with Boeing to create the opportunity to export Meteor to countries that used Boeing (ex-McDonnell Douglas) fighters and to compete in the US market against AMRAAM and/or its successors.

In May 2000 Meteor won the competition to arm British Eurofighters and so increased the BVRAAM's foothold in Europe. Whether Meteor will be carried by Gripens remains to be seen.

At the Paris Air Show in June 2003, the head of the FMV test centre at Malmen, Colonel Per Olof Eldh announced that the Gripen had been chosen to undertake the important flight testing of the Meteor missile. The aircraft had proved itself to be better suited than Eurofighter as it is more mature system.

The Israeli Derby BVR missile was in the market not only in an attempt to pick up sales from South Africa, but also from Brazil where a third missile option was desired. The Derby has both LOAL and LOBL capabilities. Compared with AMRAAM, Derby is smaller (length 362cm; body diameter 16cm; span 6.4cm) and lighter (launch weight 118kg), but for a BVR missile it is also effective at short (visual) range.

Opposite page:

Top: **Sweden was the first country outside the United States to be allowed to undertake integration of the AIM-120 AMRAAM. Illustrated is the first test-firing of the missile from Gripen prototype 39-5 over the Vidsel.**

Bottom: **Armed with Rb99 AMRAAMS and Rb74 Sidewinders, this Gripen is optimised for the air superiority role.**

This page:

This low-angle view of JAS 39B 39150 shows the underwing pylon configuration and the two shoulder-mounted pylons. The latter can be used to carry another pair of AAMs.

Air-to-Surface Weapons

Air-to-surface weapons (ASMs) used by the Swedish Air Force's Viggens were also integrated with the Gripen. For example, integration of the ARAK 70 rocket pod and the AGM-65 Maverick missile was initiated in 1992 and 1993 respectively.

Maverick, a battle-proven missile (in Operation 'Desert Storm' it achieved a 92% strike rate) and known as the Rb75 in Swedish Air Force service, was test-fired from Gripen 39-2 and can be used against a variety of targets such as field fortifications, bunkers, HASs, tanks, APCs and AFVs, parked aircraft and radar or missile sites. Integration of the ARAK 70 and Maverick was completed in 1996 and 1997 respectively.

One of the most successful Saab Dynamics missiles has been the RBS 15 anti-ship weapon. The RBS 15 was derived from the earlier RB 04 anti-ship missile and was first developed in the 1970s for land- and ship-based launches. It was later adapted for air launch as the RBS 15F and entered service with the Swedish Air Force in 1989.

The RBS 15 Mk.3, developed for the Gripen, has a range in excess of 124 miles (200km). This enables the Swedish Air Force to flood an enemy's defences by sending multiple missiles from different directions, thereby securing a higher chance of mission success. Other missiles in this class are the Norwegian developed Penguin Mk.3 and the French Exocet; both, however, are older than the RBS 15F.

The original RBS 15 was designed from the beginning to be capable of:

- Selecting one specific target within a group of targets.
- Discriminating a ship surrounded by islands or land.
- Detecting and hitting a ship in port.
- Finding and hitting land targets such as large buildings, port facilities and defence sites.

The Meteor BVRAAM underwent captive-carriage tests on JAS 39A Gripen 39150 for the first time in 1998, in conjunction with the IRIS-T missile and the IR-OTIS system.

A computer-generated image of a Meteor BVRAAM being fired from a Gripen.

Photographs on the opposite page:

JAS 39A 39116 with a load of four Rb75 Mavericks and two Rb74 Sidewinders, a weapon configuration that gives the Gripen a highly effective attack capability against the likes of enemy armour while also providing a degree of self-defence.

Testing of the ARAK 70 rocket pod got under way during 1992, mostly due to the fact that it was already in the inventory of the Swedish Air Force. The Gripen may be designed to carry and use more high-tech 'smart' weapons, but equipped with up to four ARAK 70s it can still do a lot of damage.

Air-to-Ship Missiles

	RBS-15F	Penguin	Exocet	RBS-15F Mk.3
Length	4.45m (14ft 7in)	3.18m (9ft 11in)	4.68m (15ft 5in)	4.35m (14ft 3in)
Fuselage diameter	0.5m (1ft 8in)	0.28m (0ft 11in)	0.35m (1ft 2in)	0.5m (1ft 8in)
Wingspan	1.40m (4ft 7in)	1.4m (4ft 7in)	1m (3ft 4in)	1.4m (4ft 7in)
Weight warhead	300kg	120kg	165kg	
Total weight	600kg	385kg	660kg	800kg
Range	90km	55km	50km	200km

The Dispenser Weapon System 39 (DWS 39), derived from the captive carriage Modular Dispenser System which was being developed for German Air Force F-4F Phantom IIs, is the first series-produced autonomous free flight dispenser in the world. The Swedish government completed a contract with Germany's MBB (later DASA-LFK) in November 1986 to develop a DWS for the Gripen, hence the designation DWS 39. The dispenser was to be produced 50% in Germany and 50% in Sweden.

The DWS 39 is capable of carrying various submunitions and after deployment it flies to the specified target area. Known as the BK-90 in Swedish Air Force service, it became operational on AJ 37 Viggens in 1992, a year before the first Batch One production Gripen was delivered; it was operational on the Gripen from the moment the new fighter entered service.

A lot of companies subcontract to DASA-LFK on the DWS 39; components are produced by: Daimler-Benz Aerospace, TDA/TDW, Celsius Tech, FFV Aerotech, Bofors Missiles, BOREALIS, Saab Dynamics, Saab Military Aircraft, FFA Aeronautical Research Institute of Sweden, Thyssen Feinguss, Otto Fuchs Metallwerke, SPEKON Sachsische Spezial konfektion, Helmut Bauer KG and MSA (Britain) Ltd.

Based on experience from the DWS 39, further developments resulted in a family of stand-off missiles. Bofors and DASA-LFK formed a joint company on 8th October 1998 called TAURUS Systems GmbH in which Bofors has a 33% stake and DASA-LFK 67%.

The TAURUS family was developed from the standard TAURUS 350, which got its name from its range of 218 miles (350km), and is equipped with an IIR seeker, a Global Positioning System/Inertial Navigation System (GPS/INS) and (Terrain Navigation (TERNAV). This family of weapons uses a modular system and thus can be manufactured according to the specific requirements of a customer.

TAURUS Comparison Table

	TAURUS KEPD-350	TAURUS KEPD-150
Weight	1,400kg	1,060kg
Length	5.00m	4.50m
Range	350km	150km
Engine	1,500 lb turbo jet	1,300 lb turbojet

(KEPD = Kinetic Energy Penetration and Destruction)

The role for both weapons is strike against high-value targets and their superior operational concept is based on:

- High accuracy performance under all weather circumstances.
- Low collateral damage (which proved to be very important during NATO strikes against Yugoslavia).
- Long-range capability, depending on the type chosen, which provides a certain stand-off capability and means the launch aircraft can avoid danger and high-threat zones.
- High penetration at low level which is made possible by the TERNAV, GPS/INS and IIR systems, a high subsonic cruising speed and a low RCS.

On 27th August 1998 the FMV's Malmen Air Base flight tested the TAURUS KEPD-150 on one of its Gripens; two examples were carried by 39145 on the inner wing pylons.

In early 1999 the German government agreed to the development of the TAURUS


16
7


65
60


32
FARA

KEPD-350. The planned free-flight test programme was completed on 4th October 1999 but a further programme followed the next year before the first successful free flight of a KEPD-350 was made on 30th September 2000 over the test range at Vidsel.

On 11th April 2001 another milestone was passed when the Image-Assisted Navigation system, developed specifically for the TAURUS and installed on a German Tornado, flew its first test mission; during the trip the system's infrared seeker recognised 19 out of 20 pre-programmed sites on the ground.

Since one of the Gripen's future tasks will very likely include operations with the new European quick-reaction force, there is an identified need to have laser-guided bombs (LGB) integrated with the aircraft. Such a capability and operational option is also necessary for the export market.

In September 1998 the Swedish Air Force further announced that it intended to delay making a final decision concerning acquisition of a new BVR missile in favour of precision guided munitions (PGM) because, in the future, Sweden would likely be participating in peacekeeping missions where the rules of engagement were very complex and there was little opportunity to use BVR weapons.

On 8th October 2001 the FMV awarded Saab a contract to cover this work and, at the same time, noted that the weapons would be procured by the FMV. The contract also covered the pylons but, because the aircraft were to be used for international duties, it was clear that these would also have to be adapted to take weapons from other countries; in short, they had to be NATO standard. Denel of South Africa had received the pylon contract for export Gripens a few years earlier and they would now deliver them for the Swedish Air Force.

An impressive weapon load for any aircraft: DWS 39 munitions dispenser (inner pylons), Rb75 Maverick ASMs (outer pylons) and Rb74 Sidewinder AAMs (wing-tip rails); plus an auxiliary fuel tank (centreline).

JAS 39A Gripen 39145 was used for the first captive-carriage flight tests of the TAURUS KEPD-150 stand-off missile.

Photographs on the opposite page:

Like most fighter aircraft, Gripens operate in pairs, each differently armed so that they can meet any threat instantly. The enemy does not know what to expect. Note how the pilot of 39165 has partially deployed the aircraft's rear fuselage airbrakes.

The Gripen's weapon load has been improved and increased over the years and weapon testing and integration continues to this day. F7 Wing JAS 39A 39132 carries RBS 15F anti-ship missiles (inboard pylons) and Rb75 Maverick air-to-surface missiles for attack, Rb74 Sidewinder AAMs (wing-tips) for self-defence, and an external fuel tank on the centreline station to extend range or patrol time. This type of weapon load gives the Gripen its 'swing-role' capability.

The result of any tender could depend solely on political issues and therefore Gripen International looked at other options besides NATO-compatible air-to-ground weapons. One such was a guidance kit produced by Rafael of Israel and to be fitted to Mk.83 and Mk.84 iron bombs used by the Israel Defence Force/Air Force.

The Smart, Precise Impact and Cost-Effective (SPICE) guidance kit turns the bombs into PGMs with a stand-off range well in excess of 31 miles (50km). It has an electro-optical (EO) seeker that identifies the target and gives pinpoint accuracy. The EO seeker image can be followed in the cockpit on one of the displays. SPICE is navigated by the GPS/INS and was first shown in conjunction with the Gripen at the Paris Air Show in 2003.

In June 2003 the Gripen executed the first separation tests with NATO bombs on the Vidsel test range. South African Chief Test Pilot Johannes Joubert dropped the Mk.83 bomb to verify the safe separation of the weapon load from the aircraft. Other NATO loads such as the Mk.82 and the GBU-10 (Guided Bomb Unit) were tested by Saab test pilot Magnus Ljungdahl. Approximately another ten NATO weapons are planned to undergo these tests in the near future for export customers.

The SEAD Mission

Suppression of Enemy Air Defences (SEAD) is something that has grown in importance since the Vietnam War. During both Gulf Wars the initial Allied missions were flown against Iraqi radar installations, thus enabling the remaining strike aircraft to pass undisturbed. The value of SEAD-dedicated aircraft was confirmed again during the conflicts in the Balkans. The two anti-radiation missiles in service at the time were the American AGM-88 High-speed Anti-Radiation Missile (HARM) and Britain's Air-Launched Anti-Radiation Missile (ALARM).

The Swedish Air Force does not have special dedicated SEAD mission aircraft or missiles and some experts argue that an LGB is ultimately still the best SEAD solution. For Gripen exports, however, Saab has stated that if a customer wants SEAD weapons they could be easily integrated into the fighter, but that the company would do this only if there was a sufficient demand for this capability in the marketplace.

Reconnaissance Systems

Vicon 70 Series 72C

At the 1998 Farnborough Show another milestone was reached when it was announced that the Vicon 70 Series 72C EO/IR Tactical Reconnaissance Pod, manufactured by W Vinten Ltd, was the preferred option for the export Gripen. Vinten had a long history of making reconnaissance pods, countermeasures dispensing systems and video recording systems and the Vicon 70 series had been developed over the previous ten years for aircraft such as the BAe Harrier and Hawk, Panavia Tornado, McDonnell-Douglas A-4 Skyhawk, Dassault Mirage and a range of helicopters. The pods had been used in various configurations, conditions and speeds, sometimes well in excess of Mach 2.

The Vicon 72C is especially developed to be carried on the Gripen centreline and/or shoulder stations. The principal features are:

- Lightweight, low-drag pod structure.
- High-performance day/night Infra-Red Line Scan (IRLS) sensor.
- Choice of high-performance day Electro-Optical (EO) sensors.
- Sensors endorsed by major European air forces.
- Sensors fully flight tested on high-performance combat aircraft.
- On-board waterfall display of EO or IR imagery.
- Imagery recorded and replayed on the ground from S-VHS tape.
- Automatic reconnaissance mission planning system.
- Signal interface to the aircraft enabled datalinking of imagery via the Gripen's TIDLS communication system.

In addition, the expectation was that the Swedish Air Force would soon order the pod because the recce-configured SF 37 Viggen would need replacing within a few years. However, the Farnborough announcement was significant from an export point of view because it signalled that the Gripen was now a complete system.

MRP 39

In December 2000 the FMV issued a request for quotations for a reconnaissance system to be carried on Swedish Air Force Gripens and received proposals the following summer. On 21st December 2001 it gave Saab Avionics a contract worth SKr 600 million to develop its MRP 39 modular pod which was specially equipped for peace-keeping missions. This did not mean that the Vicon 70 was not up to the Swedish Air Force's requirements; the reason for this decision was primarily to support national industry and increase the options available to potential export customers.

Saab Avionics had won following stiff competition from Vinten, Lockheed Martin and Raytheon, among others, and the order covered eight pods for the Gripen with first delivery expected in 2004. The order came just in time because the SF 37 Viggen wing was already in the process of transitioning to the Gripen.

The MRP 39 pod will be a modified version of Terma's Modular Reconnaissance Pod (MRP); Terma is the major subcontractor to Saab Avionics. The structure will be more aerodynamically advanced than the original MRP used on the F-16 which had a faceted surface – the MRP 39 will certainly have a circular shape for the lower 180°. Because the system has a modular design, it can be adapted to the needs of the mission.

On 6th June 2002 it was announced that an L-3 data recording system, the Strategic/Tactical Airborne Recorder (STAR) RM-8000R, had been chosen for the MRP 39 to give it a simultaneous record/play capability, high MTBF and a small size and weight. The STAR system was flight tested on a Draken at Edwards AFB on 18th and 19th November 1999, but this had nothing to do with the tender for recorders from Saab Avionics.

Litening

The ability to operate around the clock can be a big problem because of weather and the visual conditions at night. This was most noticeable during the two Gulf Wars when different operating procedures had to be used to make round-the-clock missions possible; for example, aircraft being used to designate targets for other aircraft carrying LGBs.

At FIDAE 2000 the JAS 39B Gripen in attendance was exhibited with, for the first time, a Litening pod beneath the fuselage. Saab and BAe had formally agreed with Rafael of Israel to integrate a Litening pod with the Gripen and a deal was expected to be signed three months later with Zeiss, a European partner of Rafael.

At the July 2000 Farnborough Air Show it was officially announced that the Litening pod had been chosen for export Gripens and possibly also for the Swedish Air Force. The pod was already in service with air forces around the world and was proven in combat.

The Litening pod is an airborne targeting and navigation system designed to help the pilot find his target and, once an attack has been made, to then follow the target to see and record the results. It has a head that is capable of turning through 400° to allow the FLIR, laser and TV sensors to follow the target while the fighter is flying at low level, at night and in all-weather conditions, even if the pilot has to perform high g combat manoeuvres or take evasive action. The recording is used to give a better assessment of battle damage. The pod offers:

- Day and night precision strike capability in adverse weather conditions.
- Reduced pilot workload during targeting and tracking.
- Targeting and navigation capability in one system.
- Reduced operational limitations.
- Simple maintenance and support and low Life Cycle Cost (a result of the system's modular format).
- Growth potential.

The Litening system is based on the following systems: FLIR, INS, a narrow field of view CCD camera/laser spot detector/range finder/tracker and a wide field of view CCD camera and laser marker for co-operative missions. These sensors are all integrated in the module and the pod can be used for different types of mission. The Litening system can even be utilised by aircraft that are not actually carrying the pod if they are connected via the datalink system.

The pod is supposed to be carried on the Gripen's shoulder wing pylon, which also takes the reconnaissance pod, and, according to Saab, has the advantage that it will not reduce the Gripen's effective weapon load.

As part of Gripen International's export obligations towards Hungary and South Africa, Gripen 39101 flew with the Zeiss Optronics Litening Laser Designator Pod (LDP) for the first time on 7th February 2003; ground trials had been initiated shortly before Christmas 2002. This paved the way for the testing of precision guided munitions (PGM). The Gripen involved was chosen because it was also the test aircraft equipped with NATO-compatible pylons produced by Denel.

Radar

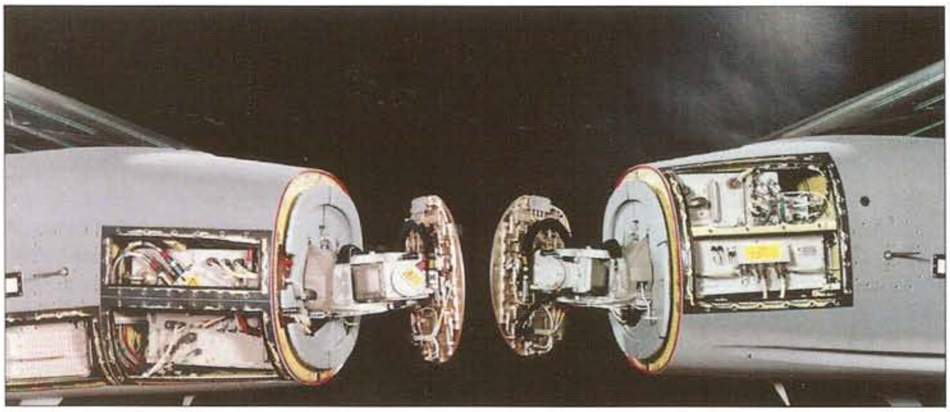
As IG-JAS was formed, and the contract for the first batch of Gripens was placed, LM Ericsson began working on the Gripen's new radar, called the PS-05/A. Ericsson has a rich history of producing and developing radar systems. It first acquired experience in radars when it licence-produced the system for the J 32 Lansen jet fighter and attack aircraft. Ericsson began co-operation with Thomson-CSF in early 1950 and licence production of the Lansen radar started two years later.

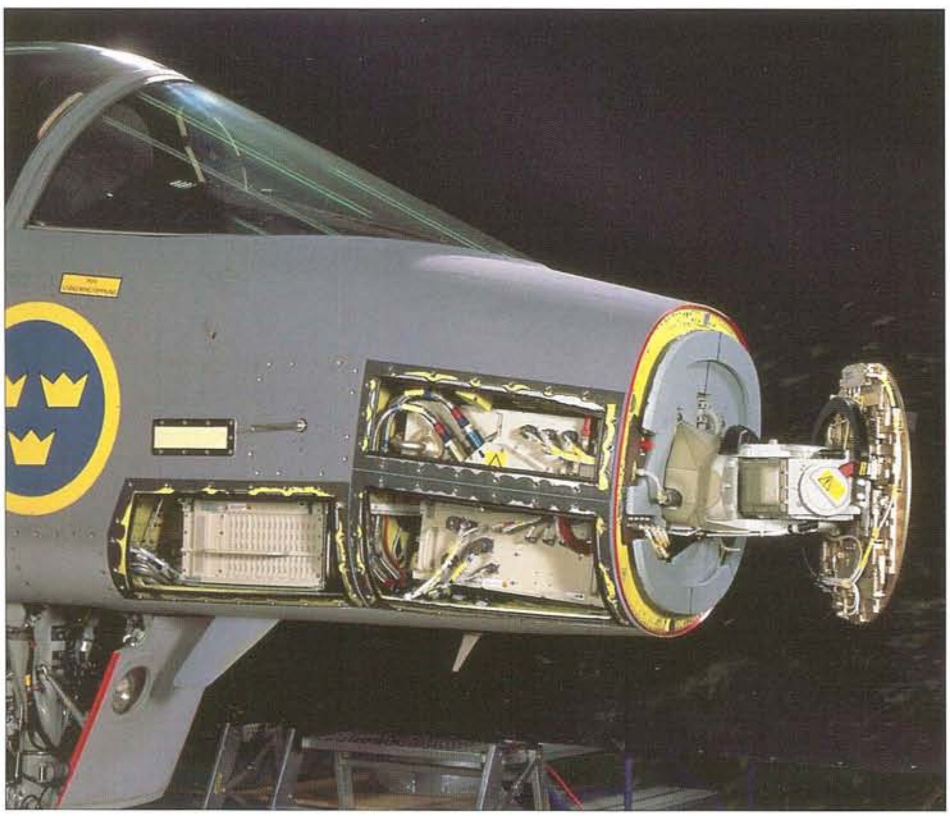
The PS-05/A radar was tested in Viggen 37-51 which was fitted with a special Gripen nose. The aircraft is shown here with Saab test pilot Lars Radeström in the foreground.

Photographs on the opposite page:

The shape of things to come? This doctored image of JAS 39A 39150 has had artwork of future weapons added to the underwing pylons. A Gripen fully armed will take the same load as the bigger Viggen. This Gripen is a Batch Two aircraft; Batch Three Gripens will be even more capable and thus superior to the Viggen.

A JAS 39B Gripen with a Vinten reconnaissance pod on the starboard shoulder pylon.





The first production JAS 39A Gripen, 39101, was of course equipped with the PS-05/A radar and was therefore used to test the equipment.

The PS-05/A multi-mode pulse Doppler target search and acquisition (lookdown/shootdown) radar and all its LRUs.

Upgrades that have been made to the PS-05/A radar so far are invisible from the outside.

Saab's next aircraft, the J 35 Draken supersonic fighter, carried the first pure Ericsson-designed radar, development of which had begun in 1956, and since then Ericsson has been responsible for the radar systems in all Swedish combat aircraft. This tradition was retained with the new multi-mode pulse Doppler Gripen radar, development of which began in 1982 and which was expected to supply three times the capacity of its predecessor.

This radar was first test flown in Viggen 37-51 by Bernt Weimer during September 1987. By the time Gripen prototype 39-4 had made its maiden flight, the prototype radar had flown over 160 flights in the Viggen. The radar eventually completed 238 flights in the Viggen technology demonstrator before 37-51 was retired from the programme in December 1991.

The first production-standard PS-05/A was delivered in 1989 for installation in prototype 39-3 and made its first flight in that aircraft, but it was also test-flown in 39-5 and 39101. Type testing of the radar system was complete by June 1993.

In general, radar is an active search system that can be jammed by electronic warfare; in fact the development of radar or any other active search system will eventually receive a counter-action or Electronic Counter Measure (ECM) system as an antidote; any ECM system may itself need an Electronic Counter-Counter Measure (ECCM) system. As a result, aircraft become bigger and heavier to ensure they have enough space to carry all of these sophisticated systems, which in turn makes the aircraft more expensive. Hence, it is important to find a mix of systems that gives the pilot an active and passive advantage over the enemy.

The development of the PS-05/A started around the same period as the Blue Vixen radar was developed for the British Sea Harrier F/A.2 and Ericsson was proud to point out that some of the electronics developed for the PS-05/A were also used in Blue Vixen. In return, Blue Vixen's antenna platform was used for the PS-05/A. As Ericsson noted in one of its advertising folders, the mythical Gripen has the body of a lion and the head of an eagle and Ericsson provided the eagle's eyesight in the form of the PS-05/A.

The PS-05/A presented a most challenging project for Ericsson. It consists of six LRUs, each of which can be replaced in about 30 minutes provided the technician has access to the radar on the flight line. The LRUs are the antenna, power amplifier, auxiliary transmitter, the high-frequency unit, signal and data processor and the waveguide unit.

The antenna unit has lightweight slotted waveguides, a guard antenna and low sidelobe levels. Low side-lobe levels are important to reduce the effects of jamming and clutter – the smaller the side lobes, the brighter the image the pilot gets on his screen, the better the picture offered by the data processor, and the better the resistance of the radar to ECM systems.

The weight of the antenna and its platform is 55 lb (25kg). Compared to the Viggen's PS-46/A radar, the PS-05/A has a 1kW output instead of PS-46/A's 0.5kW, its weight is approximately 60% that of its predecessor (342 lb to 573 lb [155kg to 260kg]) and it takes only 60% of the volume. The PS-05/A also has an antenna diameter of 23.6in (60cm) against the PS-46/A's 27.6in (70cm).

The pilot can choose different modes of radar, all of them software-driven and dependent on the type of mission being performed. For the radar there are two types of mission, air-to-air and air-to-ground. The different modes for the air-to-air sortie are:

- Long-range search.
- Multiple target track while search.
- Multiple-priority target tracking.
- Short-range, wide-angle search and track for air combat.
- Single-target tracking.
- Raid assessment.

The different modes for the air-to-ground missions are:

- Long-range search.
- Ground and sea priority target tracking.
- Mapping.
- Air-to-surface ranging.

The antenna platform is supplied by GEC-Marconi, which was later bought by BAE Systems and is the biggest subcontractor for the PS-05/A. The radar was fitted in the first three batches of Gripens but upgrades in the programme may mean that the PS-05/A is replaced by an Active Electronically Scanned Array (AESA) radar system. AESA is a next-generation fighter radar but before it can be introduced into Gripen the PS-05/A has to be upgraded. One of the upgrades will involve new computers, the D80E computer being replaced by the Modular Airborne Computer System (MACS). The latter's greater capacity will improve the Gripen's capability in a high-level ECM environment because MACS supplies Gripen with 50% more performance and reliability than the D80E.

Another improvement planned for the Gripen's radar in Batch Three aircraft is the introduction of an International Identification Friend or Foe (IFF) system so that the aircraft will be able to participate in future international peace enforcement operations.

The PS-05/A was the first radar to use 'off-the-shelf' components because they were cheaper and kept development costs to a minimum. According to the FMV magazine *FMV Aktuelt*, the PS-05/A performs better than specification, which was set at three times the capacity of the Viggen radar. Taking the specified levels as 100% (set in 1982 when the JAS 39 contract was signed) the target range in the air-to-air mode was between 115% and 140%, for air-to-surface the figure was 120% while the overall accuracy was 150%. The improvements achieved over the previous-generation radar were very impressive.

Despite the fact that the PS-05/A was relatively new, in November 1994 Ericsson Radar Electronics began developing a next-generation radar to an FMV agreement that covered the study of new technology for nose-mounted radar systems. The unique feature of this technology was that the search lobe could be moved without moving the antenna and the aim of the study was to research the potential of AESA systems and their introduction on the Gripen.

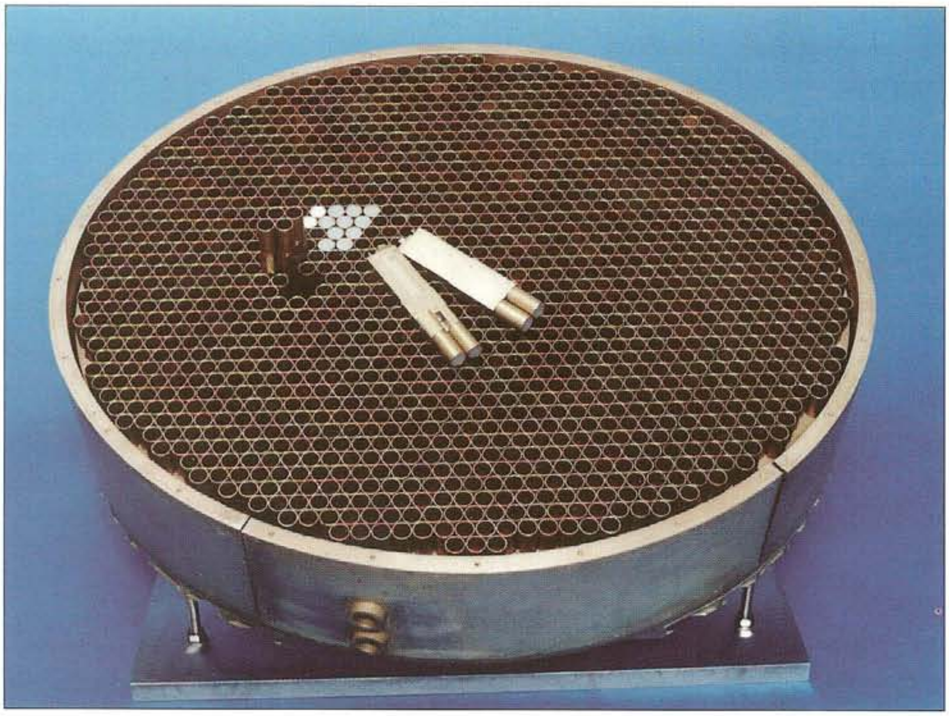
The AESA is a new type of radar based on transmitter/receiver modules (TRM) and can perform different tasks simultaneously; the development programme is named NORA (Not Only RAdar). The TRMs form the core component of an AESA radar and a development programme named ARON (NORA in reverse) was started in 1994.

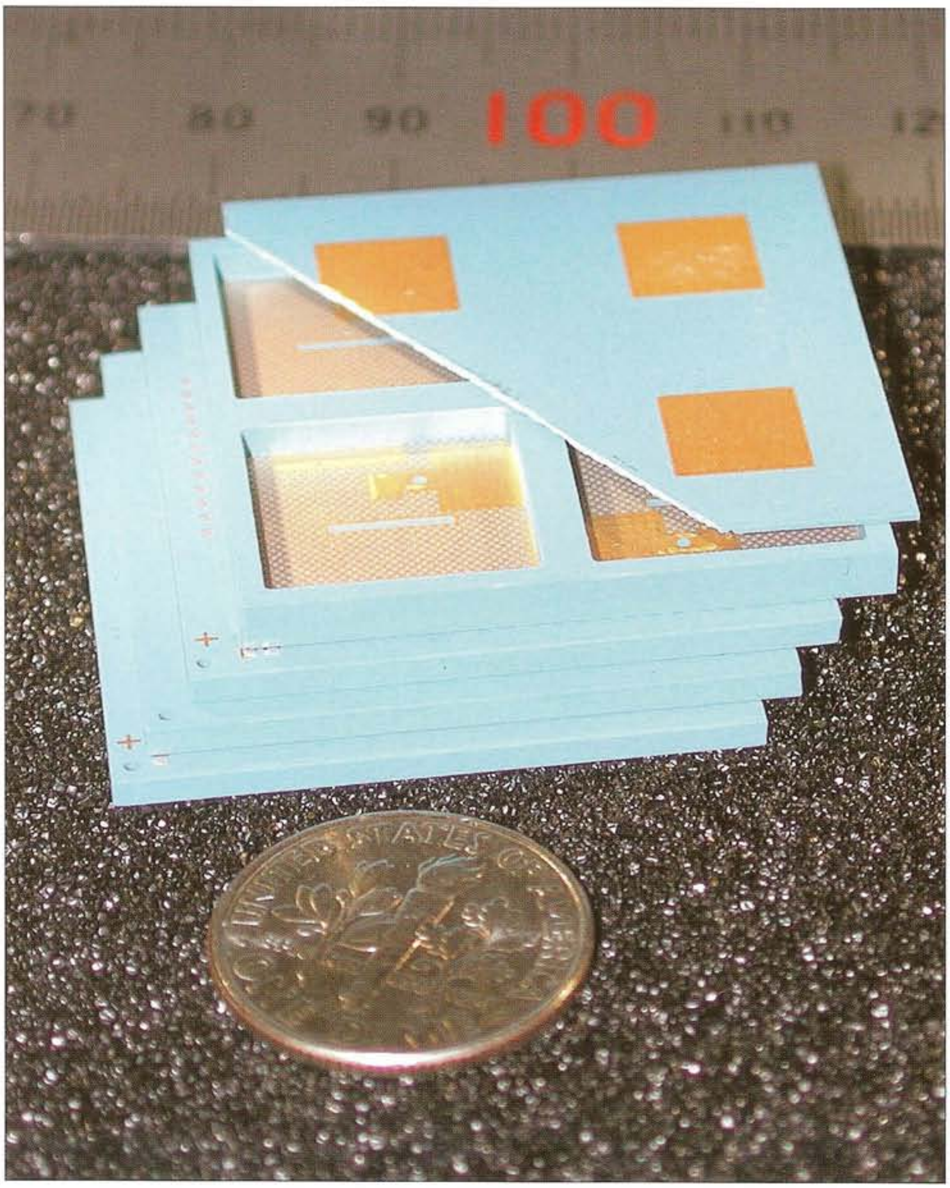
The passage of time brought swift changes to the TRMs' size and capability, in fact the size changed so fast that the European competition was surprised by the qualitative improvements made by Ericsson alone in the development stage. The first-generation TRM was approximately 6.3in (16cm) long; the second-generation was 3.15in (8cm) although this was still too big to be accommodated in the space currently taken in the Gripen's nose by the PS-05/A. The objective was to reduce the TRM's size so that the new radar would fit into the Gripen and by the end of 1998 the transceiver's size had been reduced to 1.57in (4cm), but it was still too big.

On 26th June 1997 the contract was signed for Batch Three Gripens, which also meant Ericsson received continued FMV support to develop its AESA technology. Ericsson planned to actively introduce AESA to the market by 2001. AESA should be capable of working passively and actively and, to give it extended coverage, the antenna will be placed on a moveable platform. Since the search lobe can be steered electronically, the moveable platform will give the radar a wider range than current systems. In addition, one of the big advantages of this new kind of radar is that it will have low side lobes, which are very difficult to jam.

The main features of this new radar should provide a Gripen pilot with improved air combat situational awareness. Ericsson has been looking for a development partner but how quickly it finds one will not alleviate AESA's dependency on Swedish government funding to get it integrated into the Gripen after 2010.

Flight testing of NORA (Not Only RAdar) in the Gripen is scheduled to start in 2004; installation in production Gripens will begin 2010.





The transceiver/transmitter units were originally assembled in a 'brick' system, formed by many TRM's stacked as bricks on top of one another, but during development Ericsson switched to the 'tile' system which the company felt would have a better future because it was cheaper to manufacture and would fit more easily into the Gripen.

The United States was slightly ahead in this field and had put its first AESA technology-based radar into service by 2000. The retrofit of APG-63(V)2 radars in F-15C/D Eagles, giving them a next-generation radar capability, was initiated by December 1999. Based on the AN/APG-63(V)1, the AN/APG-63(V)2 has the antenna replaced by an AESA unit. The retrofit programme was also intended to help prepare the USAF for the F/A-22 and F-35 JSF, both of which will carry AESA technology.

By FIDAE 2000 Ericsson had still not found a partner but, despite this, the AESA programme had progressed well and there were plans to fly a demonstration radar in a Viggen. At the 2001 Paris Air Show, Ericsson announced that it had agreed with Raytheon to buy an antenna system from them which would be delivered early in 2004. According to General Manager Lars Karlén, this will make it possible to demonstrate the AESA's capabilities to the Swedish forces on time and on schedule. The antenna was specially built to fit into the Ericsson AESA demonstration system but, to prevent the transfer of sensitive US technology, it will remain sealed.

Raytheon will deliver just the one antenna but the demonstrator should establish all of the advantages of an AESA and give Ericsson experience to build a system to be integrated into the Gripen by 2010. The complete AESA Radar System Demonstrator should be ready to fly in 2004 and will have an antenna comprising approximately 1,000 TRMs.

Infra-Red Search and Track Systems

A radar cannot always be used in combat situations because it makes the aircraft itself more detectable and the information generated can be denied by heavy jamming, so a fighter has to have other systems that can provide the data. These are Forward-Looking Infra-Red (FLIR) and Infra-Red Search and Track (IRST). However, IRST systems are not as new as they seem – some US jets and even Swedish aircraft were equipped with IRST equipment by the time the MiG-29 *Fulcrum* and the Su-27 *Flanker* displayed their systems at Farnborough (1988) and Paris (1989) respectively.

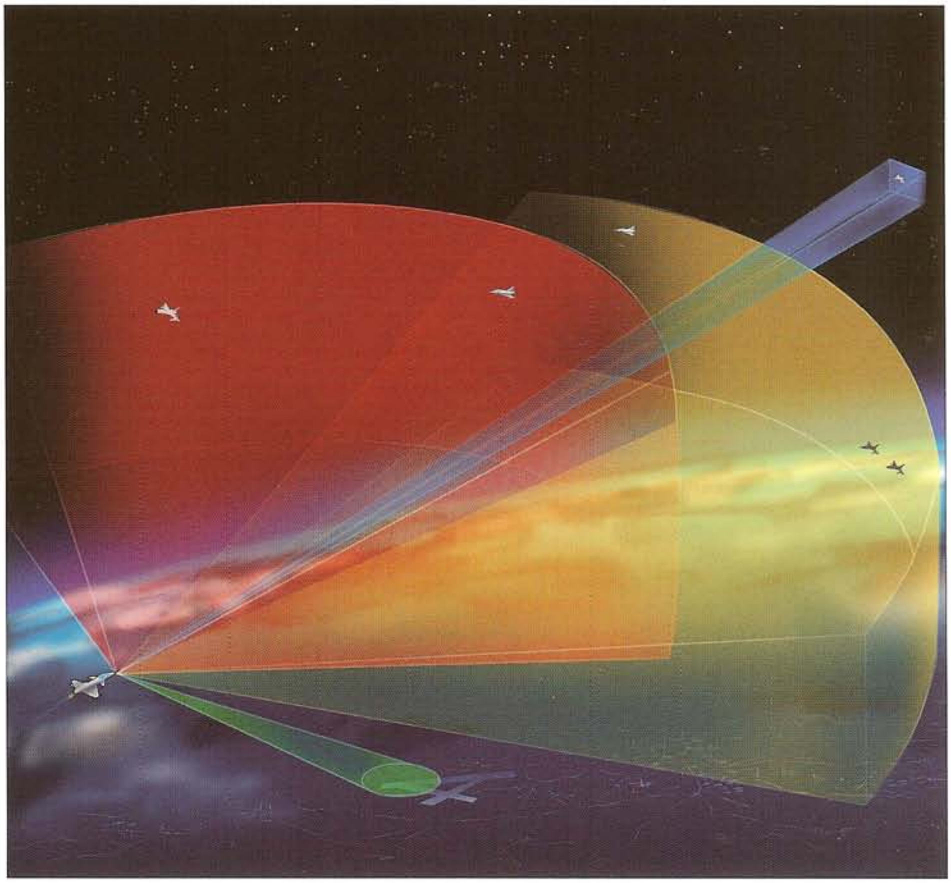
The efficiency of the western equipment, however, had not been particularly good and so it was replaced by TV systems or even abolished altogether. The Russian systems brought this

The 'brick' technology adopted in the early stages of NORA development.

The new 'tiles' system that is now being developed for the NORA system.

Viggen 37301 was used to test the IR-OTIS system, located just ahead of the windscreen.

An illustration of the IR-OTIS system's area of search.



equipment back into the picture, although they arrangements similar to those carried by some Swedish Drakens.

The main advantage of the IRST system is that it is silent and an opponent is not aware that he is being tracked. At a time when stealth technology was growing in importance, the value of so-called silent systems was also increasing. Saab Dynamics is responsible for one of the options, the Infra-Red – Optronic Tracking and Identification System, or IR-OTIS, which is a combined FLIR and IRST. Test flying of the IR-OTIS was under way by the end of 1997 in Viggen 37301.This particular Viggen made its first flight on 4th November 1979 and was retired on 6th April 2000 and, in between, flew just 1,166 hours, most of them for Saab because it served with the manufacturer from 1983 until 26th June 1990.

Saab Dynamics also developed an aircraft optronic system, TV-OTIS, which was flight tested aboard a Viggen from December 1992 to spring 1994.

The FMV awarded a contract to Saab Dynamics to develop prototypes of its infra-red search and track system, primarily for the Gripen though it might also be included in the last few Viggens. The IR-OTIS consists of a sensor unit and a signal-processing unit. The sensor is mounted in front of the canopy and, when not in use, can be turned rearwards to protect the lens (for example, during take-off and landing when foreign objects may cause damage). The signal-processing unit is placed several metres away from the sensor to make integration easier and communication between the two is accomplished through a pair of fibre-optic cables.

At FIDAE 2000 the Chief of Staff of the Swedish Air Force, General Jan Jonsson, said that it had not yet been decided if the Air Force would acquire IR-OTIS because its advantages compared to other options had to be examined carefully – the money could only be spent once. However, one interesting feature was that the IR-OTIS was capable of tracking ballistic missiles, while the system itself had been trial-fitted in production Gripen 39150. During that year's Farnborough Air Show a Saab Dynamics representative reported that the system's software was now being updated to make it more reliable and effective.

IR-OTIS is also connected to the aircraft's central computer so that it can receive data from or provide data to other aircraft. This allows the aircraft's electronic presentation system to also display the sensor image in FLIR mode and the results from the search process in IRST mode (for instance, the volume of tracked and scanned targets). The weight of the sensor unit is about 66 lb (30kg) and the signal processing unit 22 lb (10kg). To date the FMV has only placed a small order, in 1997, for a feasibility study.

The information war, as Saab calls it, could be won by just one aircraft using all or part of its sensors and linking the information through a secure datalink to a command station and to other aircraft in the air or on the ground. This provides information in real time and supplies other pilots in the air with the information they need without having to use their own radar or other active detection systems, and it gives the ground armourers the chance to put together the right mix of weapons needed for the next mission. This is all done by the Tactical Information Datalink System (TIDLS) which offers the Gripen pilot a 'near stealth' capability. The TIDLS, and the PS-05/A radar, were standard systems on Batch One Gripens; IR-OTIS went into testing when the Batch Two Gripens came onto the production line.

The radar, TIDLS, IR-OTIS and other internal information-providers pass their data to the pilot on three Head-Down Displays (HDD) and one Head-Up Display (HUD). At the moment when the HUD information can be presented on a Helmet-Mounted Sight (HMS), the HUD will become obsolete, but this stage had not been reached at the beginning of the Gripen's operational career. An HMS was developed during production of the first and the second batches of Gripens and ensures that the pilot will always have the most important information right in front of his eyes.

JAS 39A Gripen 39150 was used to test-fit the IR-OTIS on the production Gripen. The tests were completed satisfactorily and the IR-OTIS was subsequently removed from the aircraft.

The LRUs of the IR-OTIS. The system could be installed in all Swedish Air Force Gripens.

In the Cockpit

Man-Machine Interface (MMI)

The Gripen's performance depends on a lot of factors. Some of these are affected by the pilot and can be divided into physical and systems/information-related performance. Both categories are limited by the human input – the pilot's physical performance is limited to 9g with a g-suit and breathing aid while the systems/information-related performance (in other words the mental performance) varies from pilot to pilot but can be helped by the way information is supplied. Thanks to improved and new information-providers the supply of information in the cockpit is increasing all the time.

The cockpit is the most important information provider for the pilot so it is therefore important that all of its systems are in the right place and used to the optimum. Moving clockwise from the left-hand side, the Gripen cockpit has the following control panels:

- Radar panel.
- Combined throttle and system controls (part of the HOTAS system).
- Communication control unit (later replaced by the CCDU).
- Flight data display (left HDD – part of the EP-17 display system).
- Control stick (part of the HOTAS system).
- HUD (part of the EP-17 display system).
- Main mode selector and status indicator.
- Horizontal situation display (middle HDD – part of the EP-17 display system).
- Multi-sensor display (right HDD – part of the EP-17 display system).
- Caution panel.
- Data panel.
- Data transfer unit.
- Ejection seat.

The main information provider, the EP-17 display, was found by some pilots to be too cramped and so the displays were enlarged. The original cockpit layout had a display area, without the HUD, of 84in² (540cm²). The new EP-17 Mk.3 and Mk.4 display systems have a display area of 154in² (994cm²) without the HUD and surpass most competing aircraft display systems in size except for the Dassault Rafale and the Lockheed Martin F/A-22 Raptor (the latter has more than 213in² [1,375cm²]).

The MMI was much improved and for such a small aircraft it was something of a surprise to see that it it has a bigger display area than that of the twin-engined Eurofighter.

HOTAS

The HOTAS (Hands On Throttle And Stick) system provides all of the important functions that the pilot will need during combat. This means that during an engagement he will not need to look inside the cockpit to see whether his hands and fingers have reached the right button. The buttons on the control stick are placed so that they can be operated without actually looking at them, which means the pilot can focus all of his attention on the enemy and what is happening outside the cockpit. Training should make these functions totally automatic movements and, according to Saab test pilots, the movements are intuitive to every pilot.

During the Gripen's development the aircraft crashed twice and on both occasions the cause was attributed to Pilot-Induced Oscillations. Flight testing is important because it can eliminate the flaws in a system, improve the combination of the FCS and the control stick and calibrate the two systems so that they work in harmony. The original Gripen control stick was pretty small and, compared to previous Swedish designs, introduced some novel features. The control stick originally had two kinds of sensitivity:

- Normal sensitivity at large stick movements.
- Low sensitivity at small stick motions producing high-precision fine control.

Furthermore, a torque motor would dampen the motions of the control stick when the pilot was operating a different system and could, by accident, disturb the stick and throw the aircraft off course – a situation that could be very dangerous during formation flying.

Shortly before the Gripen prototype's first flight, it was noticed that the torque motor was not airworthy and it was therefore disconnected. During rig tests prior to the first flight the control stick worked smoothly even without the torque motor, but the crash investigation report for the loss of the first prototype revealed that the control stick had played a minor role in the accident. As a result Saab began to research the whole concept of the control stick.

Gripen test pilots told Saab that the stick was not as comfortable as they would have liked and tiredness in the arm and hand was a recurring problem after a period of manoeuvring or formation flying. The original rather straightforward control stick had a low pivot point and was not shaped around the pilot's hand; the new version was shaped to the hand, had a higher pivot point and an adjusted hand-resting surface. Other changes included a system that mechanically dampened the stick movement.

All of these improvements were test flown during 1993. However, production aircraft 39102 still had the old stick when it was lost during a flying display over Stockholm.

Research by Saab concluded that a new control stick, torque motor or any other system would not have prevented the second crash, but the new stick was introduced in the eighth Batch One production Gripen (39108) and later retrofitted to earlier aircraft. The new stick can be moved approximately 9° forward, 13° aft and 7° to left and right.

The communications control panel is situated right below the EP-17 display system to the left of the pilot's knee and is important for voice and data communications because both the datalink and radio are controlled by it. This panel was part of the communication system produced by Celsius Tech and the system can simultaneously receive and transmit voice and data communications. The pilot uses it to set and select radio modes and frequencies.

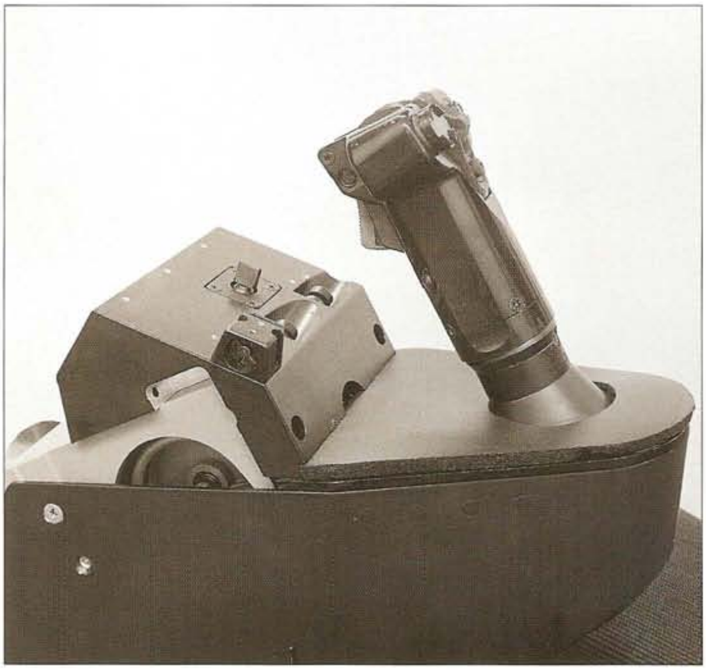
The communications control panel is to be replaced by the Communications Control and Display Unit (CCDU) developed by Grintek Communication Systems in South Africa as a part of the offset programme linked to South Africa's purchase of Gripens (Grintek is now part of a joint group with Saab). The CCDU was mainly developed for the export market but it could also be introduced in Swedish Gripens if the Swedish Air Force can obtain sufficient finance.

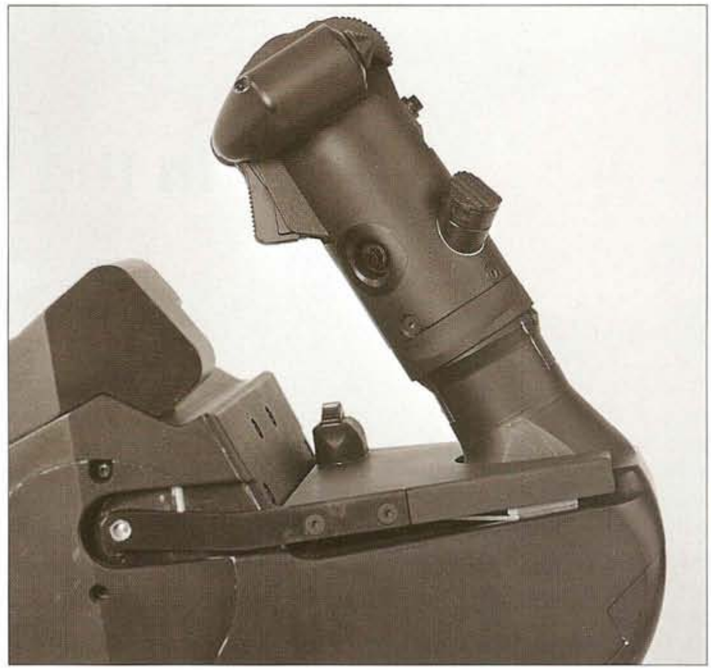
The CCDU has a 5in (12.7cm) active LCD matrix colour display and is a customised product specially developed for the Gripen to reduce pilot workload. To make it capable of communicating with more than 40 other systems on board the aircraft, the CCDU is connected through one of the five MIL-STD-1553B databuses.

On 18th June 2001 it was announced that the CCDU developed by Grintek was to be installed in 14 two-seat and 70 single-seat Swedish Air Force Gripens, in other words the final 20 Batch Two single-seaters and all 64 Batch Three Gripens. The first CCDU was to be delivered a month later and it is very probable that the unit will be ordered for the SAAF.

Main Mode Selector and Status Indicator

This is the system which allows the pilot, at the touch of a button, to change the configuration of the Gripen to fighter, attack or reconnais-





Control stick technology and design evolved from 1982 (left) to 1985 (right).

sance mode. In fact three touch-buttons on the left are marked (from top to bottom) J, A and S, but the panel is also equipped with other controls to specify the function in more detail.

During 1999 Saab conducted more research into improving the man-machine interface and covered the following points:

- Decision support for pilots.
- Display design and information allocation.
- Design of auditory environment including three-dimensional audio displays and direct voice input (which was a standard feature in the Eurofighter).
- Cognitive complexity.
- Methodology for the assessment of mental and physical workload/performance and situation awareness.
- Visual interaction and human effectiveness in the cockpit.
- Helmet-Mounted Display using Virtual Retinal Display (VRD) technology from the American company Microvision.

The Direct Voice Input (DVI) system was a Saab in-house programme funded by the FMV. The system is dependent on speech recognition; difficult enough under normal circumstances but even more so when the voice changes under stress, ie, under high g-forces, and is also disturbed by the outside environment. The greatest disturbance in the cockpit comes from the engine but, to overcome its influence on speech recognition, all outside noise had to be filtered out.

It was found easier to have the system recognise a certain voice from a template which could be either software- or hardware-based, although the latter would either be on permanent basis or would need the replacement of an LRU if a new pilot was to be added to the selection. Software-based templates can be downloaded to the aircraft at the same time as its mission details. Another software option might be, at the start of a mission, to have every pilot insert a personal magnetic card with his template on it.

There is no known time schedule for the Gripen HOTAS to be replaced by a Voice Throttle And Stick system, similar to that fitted in the Eurofighter from the outset.

The DVI was tested in conjunction with a three-dimensional audio system that allowed the pilot to know from which direction or location a sound had originated, either another pilot speaking to him or, for example, a radar warning signal.

The three-dimensional audio system, a colour flat panel HMD and the DVI system were flight tested seven times in an Sk 60 aircraft in June 2002. These tests were considered successful but, at this stage, no further flight trials are planned and a timetable for the integration of these systems is not yet available. The Saab-developed DVI is not based solely on pilot-specific software.

Flight Combat Suit

As noted previously, the physical performance of the pilot is limited to 9g, which is made possible primarily by a Swedish-developed flight combat suit. Development of a flight combat suit specifically for the Gripen began in 1985 and was optimised to protect the pilot against high g-forces and the extreme temperatures of fire (in the cockpit and during ejection) and water. The latter was particularly important because Sweden has a huge coastline and many lakes and the pilot needs special protection in case the water temperature is (or will fall) below 12°C.

Another cockpit system to help prevent the pilot from blacking out during the application of high g-forces is the breathing regulator. The FFV Aerotech FFV116 helmet has an oxygen mask connected to the breathing regulator and the regulator forces the pilot under pressure to continue to breath. The new flight suit was flight tested between 1994 and 1997 in the Sk 60, Draken, Viggen, Gripen and F-16. The F-16 was used because it has a better sustained rate of turn than the Gripen which meant that the strain on the pilot could be better monitored. The Gripen has a better instantaneous turn rate than the F-16 – important when trying getting the first chance to aim and shoot since close air-to-air combat has been proven to be usually of a very short duration.

One problem discovered by Gripen pilots when their training got under way at F7 Wing, was that during high g-loads they experienced intense pain in the upper left arm which could affect their mission. This pain had been experienced during centrifuge tests and when flying older aircraft but never to such a severe level that it affected the pilot's ability to fly the sortie. The cause of this pain was unknown but it was suggested that it was due to the swelling of blood as a result of blood massing in the upper arm.

F7 Wing immediately went to work and found a solution in the form of an elastic arm cover kept in place by two non elastic straps. On the inside there was a compression pad which was placed over the upper arm blood vessels.

Onboard Computers

The choice for the Gripen's computer system fell on the Ericsson-developed D80, which was intended to be a general-purpose computer covering most of the systems in the aircraft. No specific funding was allocated to this system because the civil market or private sector had already pushed computer research and development so fast, and to its limits, that it would have been a waste to invest money directly from a Swedish military budget that was getting smaller year by year. However, the D80's memory and calculation capacities were found to be insufficient for the future and the need for greater capacity generated a new version called the D80E. The D80 system did not last long enough to reach Initial Operational Capability while the processing power of the D80E increased capacity by a factor of three. No size or weight reductions were achieved.

During the first two months of 1993, Ericsson delivered the first computer modules for the D80E. Modules for the display and radar system were delivered for verification and then, during the spring, a complete D80E was received from Ericsson for testing.

At the time of delivery the first flight of the D80E in a Gripen was expected in late 1993; the D80E computer itself entered production in August 1994. Gripen 39108 was the first production aircraft to receive the D80E but those aircraft already delivered were soon refurbished with the new equipment.

Soon afterwards, Ericsson started working on a different system altogether to upgrade the Gripen and give it more growth capability. The new system was called the Modular Airborne Computer System (MACS) and was first advertised at FIDAE 98 where it was presented as one of the future Gripen upgrades to be introduced in late Batch Two aircraft.

As per the D80 and D80E, the Ericsson MACS is installed in three aircraft systems: the radar, flight display and the mission computer. However, since the system is of modular construction, for each operational application its modules differ in their use of Shop Replaceable Units (SRU), eg processors, I/O units and mass memory units. Used modules can be changed or replaced or even improved, depending on the technological advances available. MACS not only brought an improvement in capacity but also reduced the effects of radiation on the avionics system.

MACS's processing power is ten times that of the D80E. It is also known as the D96 and is 11.8 x 7.9 x 21.7in (30 x 20 x 55cm) in size without the handle and weighs 44.3 lb (13.5kg). The box is painted in red and white stripes to make it easier to find at a crash site.

From the outset, MACS was intended to have a high real time performance, high reliability and a low weight, volume and consumption of power. According to Ericsson Microwave, it was installed in a production Gripen (39193) for the first time for the 2001 Paris Air Show. It was, however, only installed in the mission computer – the MACS for the radar and display systems was installed in 39227 onwards.

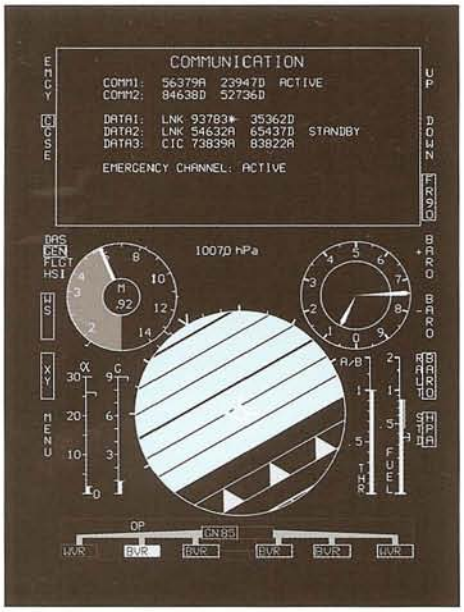
The Display System

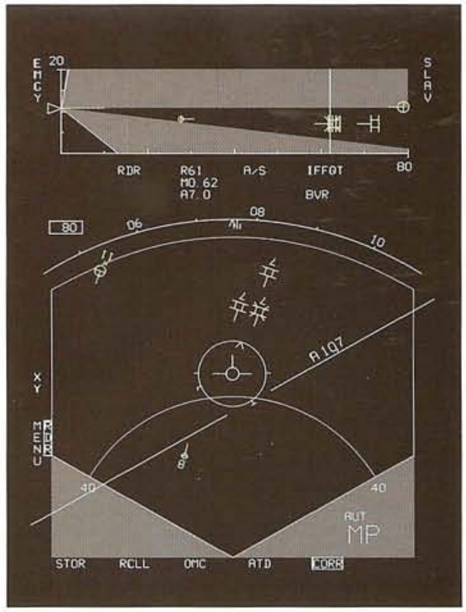
When IG-JAS first made its JAS 39 development proposals to the Swedish Air Force, a company called SRA was to be responsible for the display system including the Head Down Display (HDD), the Head Up Display (HUD), the display processor and the recorder. This company was already part-owned by Ericsson Microwave Systems AB and was shortly afterwards bought up entirely by Ericsson. In fact on 1st January 1983, SRA became a wholly-owned subsidiary of LM Ericsson after Marconi sold its 29% share.

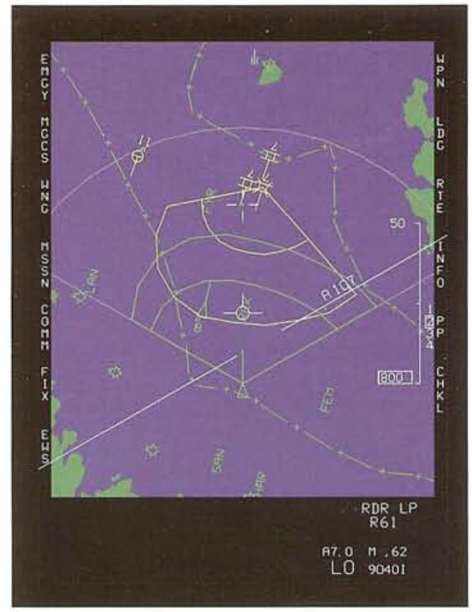
During the upgrading of the display system a joint venture was set up between Saab and Ericsson in January 1997, each with a 50% share of ownership. The joint venture went under the name of Ericsson Saab Avionics and, although physically the same organisation, it took over the responsibility for the display and some other systems. On 7th May 2001 Saab used an option to buy Ericsson's share of the joint venture for SKr 225million.

The display system is basically the only way that the Gripen's pilot can receive information

The MMI should be good enough that the pilot can look out of his cockpit continuously during close-in air combat. His field of view has to be as unobstructed as possible; ideally 360°. As this picture illustrates, the pilot has a good view of what is happening around him.







Above from left to right: **Flight Data Display; Multi-Sensor Display; Horizontal Situation Display.**

about his aircraft. How this information is presented is a key feature; the pilot should only get the information that is important at the time it is presented.

The display system developed for the Gripen was the EP-17 which uses four displays split into two groups – one HUD and three digital HDDs; four more back-up analogue HDDs were not considered to be part of EP-17.

Head-Up Display

The Gripen became the first aircraft to be equipped with a diffractive optics HUD which was developed by Hughes and Ericsson. However, very early on, production of the HUD was taken over by Kaiser Electronics who delivered the first example on schedule in June 1994. The HUD, like the HDDs, is connected to the display processor and a video cassette recorder. It provides the pilot with information for flying, navigating, take-off and landing, aiming and weapon firing – all functions a pilot might need in flight or combat.

The HUD was flight tested in Viggen 37-51 from February 1987, almost two years before the first flight of the first Gripen prototype (nine months later this Viggen was fitted with the JAS 39 radar). The HUD first flew in a Gripen in prototype 39-4 – the first two Gripen prototypes did not have the EP-17 digital display installed and, therefore, lacked the HUD as well. According to Gripen test pilots the HUD had a negative side-effect – in direct sunlight it gave a green reflection which meant the Gripen could be spotted by an opponent.

The Helmet-Mounted Sight (HMS) or Helmet-Mounted Display (HMD) would render the HUD obsolete – in its place would be a simpler and smaller HUD that functioned as an aiming device for the internal BK27 cannon and gave information for a precision landing.

A HUD camera is placed in front of the combiner (a glass viewer onto which all of the information is projected). This camera, the FD 5040, was developed for the Gripen in co-operation with Ferranti Defence Systems and was derived from the FD 5000 monochrome video camera. It has an automatic aperture and an exchangeable lens. A new camera has been developed by Kaiser Electronics.

The three HDD systems are also multi-functional displays and so are interchangeable, which means that their maintenance is cheaper and easier; it also means that if one display breaks down, data can be displayed on one of the others. All were monochrome cathode-ray tube displays, ie, green only (in comparison, for the Lavi IAI chose one monochrome and two colour displays supplied by Elbit).

Although both the Lavi and Gripen were developed at the same time, the Lavi system was integrated with advanced colour displays. The designers of the Gripen cockpit display system were concerned with redundancy and cost, but the main reason for not choosing colour displays was that they simply did not fulfil the stated requirements. At the time, colour displays were still considered to be something of a novelty and those that were available during the 1980s were lacking in visibility (brightness) and image quality (resolution).

The Gripen's three digital HDDs were placed as follows:

Left:	Flight Data Display (FDD)	H 120mm x W 150mm
Centre:	Horizontal Situation Display (HSD)	H 150mm x W 120mm
Right:	Multi-Sensor Display (MSD)	H 120mm x W 150mm

The FDD presents the pilot with all the data needed to fly the aircraft such as speed, altitude and attitude plus fuel levels, engine rpm and engine temperature. The HSD can supply digital mapping information to the pilot in the direction he is flying; in other words, when the aircraft makes a turn the digital map changes direction with it. The MSD shows the information from the radar, depending on which radar mode is being used, or the other tracking equipment (the IRST system).

The various pieces information from the sensors – the radar, HUD camera, missile/FLIR, TIDLS, TV/IR missile images and, later on, the IRST – provide data which has to be processed before it can be supplied to the pilot. Therefore the EP-17 is equipped with a display processor which includes in its memory a map installed by the customer (in Sweden's case the Air Force) giving details of high objects and so on. The job of the display processor is to process this information into understandable symbols on the correct part of the map (the EP-17 has a symbol for each display). The processor not only conveys the data to the displays, but also to the video recorder and to the TIDLS which can send the information to other aircraft that are not using their sensors.

The video recorder can be used to evaluate a mission and for training purposes because it can record the entire cockpit conversation between ATC and the pilot; it employs the same video cassette used by the general public in video cameras and recorders and this is removed after every mission for evaluation by a technician.

In early-production Gripens the original analogue video recorder was placed behind the pilot's seat; it was subsequently replaced with a new digital recorder called DiRECT which was expected to record all of the information from all of the information-providers, including all of the data downloaded through the datalink system.

Thanks to the TIDLS, anyone in the Full Mission Simulator or the Multi-Mission Simulator can join in during exercises – although they are nowhere near to where the exercise is taking place, they can see everything that the pilot sees, which makes ground training very realistic for a trainee and the post-exercise evaluation more valuable. During the evaluation, the pilot learns to make tactical decisions on the unique Gripen Mission Evaluation System developed by Celsius Aerotech.

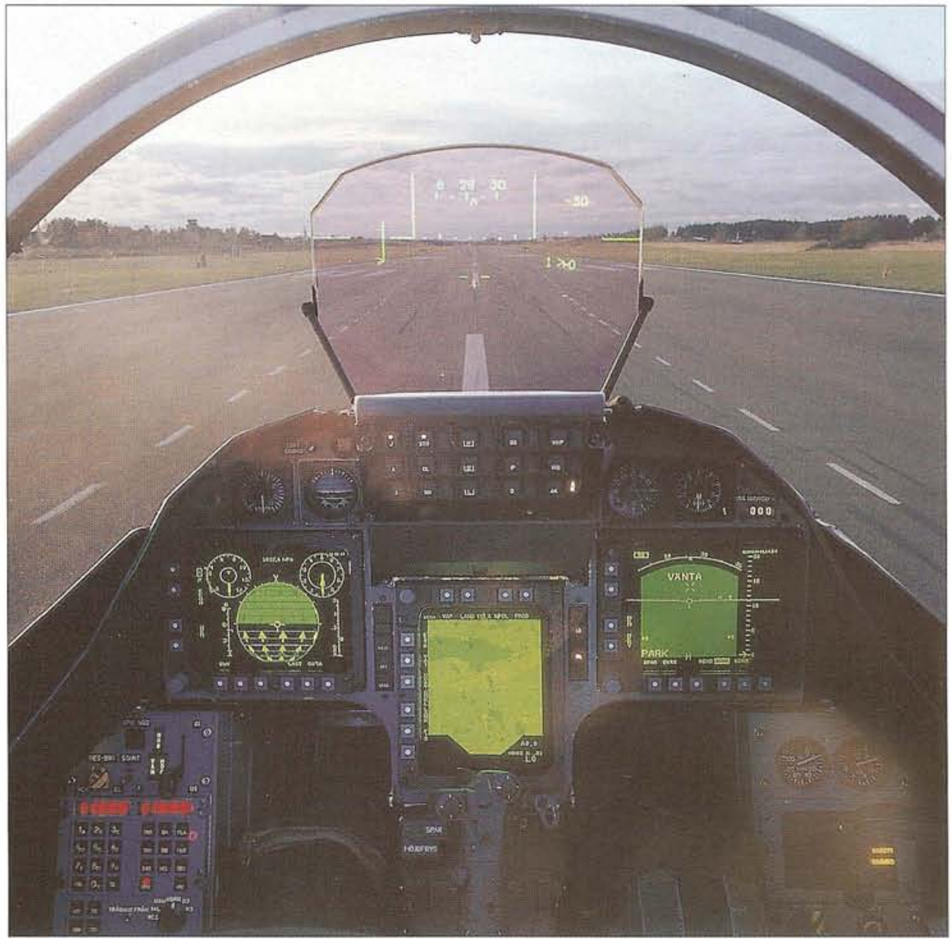
The EP-17 has six LRUs, the three HDDs, one HUD and two data display processors. Testing in both darkness and daylight was completed in September 1992 but subsequent testing was based primarily on reducing pilot workload and by 1998 the EP-17 had been the subject of several updates. The first of these saw two data processors, PP1 and PP2, replaced by a single PP12 processor.

Development of the PP12 was initiated in 1992 with the aim of improving capability and performance and reducing size and cost. By the end of 1994 the FMV had ordered some PP12s for evaluation in test rigs and test aircraft. The processor's development moved so quickly that by June 1995, at the Paris Air Show, it was reported that the PP12 was ready for flight testing and was awaiting approval for this to begin.

The PP12 processor flew for the first time in a Gripen prototype in the last week of August 1995. It still has two different processors, each one representing the functions of the PP1 and PP2; these duplicates are there to facilitate the redundancy of the new PP12 system and to assure flight safety. The big difference came in weight and volume which for the PP1 and PP2 was 90 lb (40.8kg) and 1.5cu.ft (42.6 litres); the figures for the PP12 are 52 lb (23.5kg) and 0.86cu.ft (24.3 litres) respectively – a considerable saving which also enabled a reduction in the number of LRUs needed.

The PP12 can be used in combination with multi-colour displays, which helped with the development of future display systems. The new processor was installed in Batch Two Gripens, the first to receive it being 39131 which made its first flight on 20th August 1996. In May 1996 the FMV had awarded Ericsson Microwave Systems a contract to update Batch One aircraft with the new data processor, thereby bringing the display systems in these aircraft up to Mk.2 standards.

The three original MFDs in the Gripen each had a 5 x 6in (12.7 x 15.2cm) monochrome screen, but eventually these were to be replaced by 6 x 8in (15.2 x 20.3cm) MFD colour displays. The fact that the replacements were larger meant that the four analogue back-up displays had to be removed to make space. These changes marked the EP-17 upgrade from Mk.2 to Mk.3 standard and the develop-



The EP-17 Mk.1 display system in a Gripen cockpit; note the analogue displays above the digital displays. The analogue displays are not part of the EP-17 system.

The Gripen's cockpit interior and display system has been upgraded several times during the aircraft's life. The latest display size was introduced only nine years after delivery of the first Gripen.

ment phase for the Mk.3's colour displays began when the order for the third batch of Gripens was signed in June 1997.

Thanks to previous research, it was already known that colour displays would improve the man-machine interface and Saab, in co-operation with the FOA, had been studying what effect colour displays might have. The difference between monochrome, one-colour and multiple-colour displays was examined together with the effect of g-forces on the pilot's eyesight. The colours used had to be recognised by the pilot under high g-forces.

Saab initially planned to replace the existing displays with colour alternatives of the same size and Ericsson-Saab Avionics therefore produced the EP-17 display system with same-size colour displays. However, the Gripen test pilots had noted in their evaluations that the display system was cramped and a bigger display area would be favourable, so the total HDD space was increased by around 90%. The specifications for the new Multi-function Integrated Display were:

- Active display area 6.2 x 8.3in (158 x 211mm).
- Overall size – width 7.4in (188mm), height 9.5in (242mm), length 15.7in (398mm).
- Weight 22 to 29 lb (10 to 13kg) dependent on the configuration.
- Resolution 600 x 800 pixels.

The displays were developed by a company called Avionics Display Corporation which in 2000 was bought by L-3 Communications. The displays were no longer CRTs but Active Matrix Liquid Crystal Displays (AMLCD). CRT displays had a shorter Mean Time Between Failures (MTBF) compared to AMLCDs – the industry MTBF average given for CRTs was 200 to 1,000 hours, for LCDs it was over 5,000 hours and L-3 stated that the figure for the Actiview 104P display (P = portrait mode) was an impressive 7,000 hours.

The displays are equipped with light sensors so that the computer can assist any adjustment made to the brightness of the displays, which prevents the pilot from having to stare at the displays to see an item (even in direct sunlight) or having to adjust the brightness with a button or switch during flight.

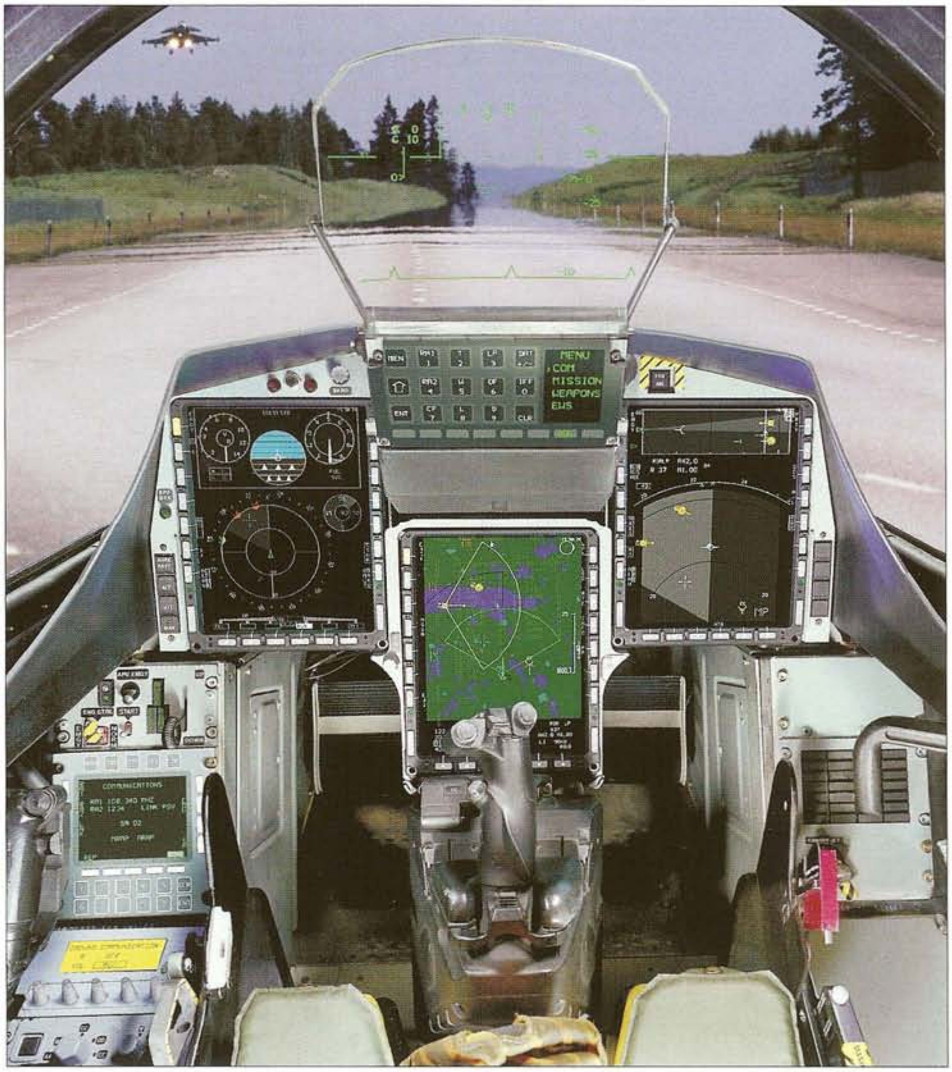
Emergency Power

The Elektronisk Genererad Nöd Presentation (EGNP or Electric Generated Emergency Display) was the new back-up system integrated into the displays. The likelihood that all three display systems would fail at the same time was very small but even in such a case the pilot would still have available to him all of the important data because the built-in mini-processors

In the original, less drastic upgrade plans, the EP-17 Mk.3's colour displays would have remained the same size.

The Gripen's cockpit layout with the EP-17 Mk.3 display system in place.

The EP-17 Mk.4 display system is only planned to be fitted in production Gripens from 39227 onwards and retrofitted in Gripens up to and including 39207. Note that the cover above the middle display is there from Mk.1 through Mk.4.



would present enough basic flight information for him to fly and land the Gripen. Another feature of the new EP-17 displays was that they were compatible with Night Vision Goggles (NVG), thus making the Gripen truly a 24-hour fighter.

The EP-17 Mk.3 was introduced on the last 20 Batch Two Gripens. On 12th February 1999 Ericsson Saab delivered the first Gripen EP-17 colour displays, including the Mk.3 processor, for testing in various rigs and simulators and in a Viggen.

The first Viggen test flight with this display took place on 9th March 1999 and in this aircraft it performed as a tactical indicator, displaying tactical information superimposed on a moving map. Such an expensive update a relatively short time before the Viggen was due for retirement (in 2004) was only possible because each display would be removed for recycling in a Gripen before the Viggen was scrapped.

Two of the new displays were first tested in a Gripen during May 2001 together with some back-up CRT screens, the work being carried out by Saab test pilot Frederik Muchler. The most important part of the testing was the validation of the back-up system.

The Air Data Computer and the Synthetic Attitude and Heading Reference System (S-AHR) were two other systems under test simultaneously with the new displays in Gripen 39-5. As the tests were considered high risk another Gripen acted as a chase plane during the test flights.

After completion of the testing in 39-5, the displays would also be tested for about 20 flights in the JAS 39B prototype in combination with the GECU. After the new displays had successfully passed these tests a production contract was signed with the supplier on 7th November 2001.

EP-17 Mk.4

Software changes incorporated into the EP-17 Mk.4 included updates to the computer, radar and recording functions. The analogue video recorder had been replaced in Batch Three Gripens by a digital system but in the EP-17 Mk.4 the DiRECT system replaced the video recorder and instead recorded the information on a Mass Memory Cartridge (MMC). The MMC does not have any moving parts, which makes it more rugged and less maintenance-sensitive. All of the information (video, audio, IR and electro-optical) is recorded synchronically and can therefore be replayed synchronically as well.

After being taken out of the aircraft the MMC can be inserted into a Ground Replay Station (a personal computer with the MMC adapter replaced by a CD-ROM), or the Mission Evaluation System, which makes any assessment of a mission easier.

The DiRECT system was not planned to replace the 'black box' flight recorder although it could transmit its data through the TIDLS even if the pilot had ejected from the aircraft. However, DiRECT is not crash-resistant; nor is it equipped with an underwater location beacon which activates and transmits after a crash.

The EP-17 Mk.4 was also the standard offered on export Gripens and was to be integrated (or at least connected to) the HMS or HMD required for the export market; however, the Swedish Air Force felt that an HMD system was only useful if it was combined with off-bore capable missiles.

As things stand, the EP-17 Mk.4 system for Swedish Air Force Batch Three Gripens and the export market is not considered to be the final stage of improvement. Further improvements will see the unit's capacity increased and the three main displays replaced by a single big screen. This technology is currently being designed as a long-term development for the Gripen.

The DiRECT system is due for introduction in Gripen 39227, after which it will be retrofitted to all other JAS 39Cs from 39207 onwards. This might change as the SHK recommended to the FMV that it replace the video recorder fitted in earlier (Batch One and Two) Gripens. The reason for the recommendation was the problems encountered during the investigation into the crash of Gripen 39156 on 20th September 1999, the video tape having been damaged by its immersion in water. As naval and marine forces have found to their cost, humidity from any source is a source of corrosion on video tapes. The DiRECT system is encapsulated in a metal case that protects it from water, dust, fog and any other form of humidity.

Helmet-Mounted Sights and Displays

The last major improvements introduced to cut pilot workload were the HOTAS and the glass cockpit. During combat the pilot has to look at his controls and at his enemy but, as long as the enemy is in front of him, this is not such a problem. However, the difficult part of air-to-air combat is to get the opponent in front of your own aircraft and then get a lock-on for a missile or cannon.

It is ridiculous that a fighter aircraft, which is capable of a maximum 9g, has to do all the difficult manoeuvring when the air-to-air missiles it carries have the capability to make up to 35g turns. The idea of the Helmet-Mounted Sight (HMS) is to give the pilot the capability to fire a

Display pilot Frederick Müchler removes the tape after each display so that he can evaluate his display. The tape from 39156 was recovered but was found to be unusable because of saltwater corrosion.

missile even if the target is outside the missile seeker's field of view; after launch the missile, with the aid of datalinking, can be guided until its seeker acquires the target, or it can be pre-programmed by the weapon-aiming computer shortly before launch.

The next stage was to make real the idea that if the pilot could have a targeting system mounted on his helmet, which would cue the radar where to look, this helmet-mounted system would be connected to the HUD navigation systems and weapon systems. Thus, HUD information can be projected onto the pilot's visor if he is looking off boresight (in short, a HUD on the head of the fighter pilot). This idea was not entirely new. The first system was the US Navy's Visual Target Acquisition System (VTAS) used by F-4 Phantom II squadrons in large-scale trials.

The VTAS was equipped with an optical tracker and a receptacle on the visor, the former measuring the position of the pilot's head and the latter ensuring that he was looking straight ahead. The biggest problem was encountered during high g manoeuvring because the system added 1.1 lb (0.5kg) to the helmet weight and this was amplified during high g manoeuvres – at 9g the helmet had an effective weight of 9.9 lb (4.5kg). This was too heavy for the pilot's neck and made the system unsuitable for fast, highly manoeuvrable fighter aircraft. The helmet's weight has to be balanced as well, otherwise during high g manoeuvres or an ejection it will pull the pilot's neck to the side with the most weight, which could seriously injure the pilot.

The Russian MiG-29 and Su-27 were both equipped with an HMS system and Israel has extensive experience with such equipment. The Israeli Display And Sight Helmet (DASH) system, developed by Elbit, was in operational service from at least 1986 and since then has been extensively upgraded and improved. In fact the systems that have now been developed for fourth-generation fighters can more accurately be described as Helmet-Mounted Displays (HMD). Whatever its title, it is clear that such technology not only gives an edge to an already capable aircraft, it can give a decisive advantage.

HMS ODEN

FFV Aerotech, part of IG-JAS and which later became Celsius Aerotech, specially developed an HMS system, the HMS ODEN, for the Gripen. It was intended to integrate this equipment in Batch Two and Three Gripens, but this was dependent on the success of the development phase and the availability of sufficient funding.

FFV updated the original Helmet 116 system which it had produced as the standard helmet for the Swedish Air Force. The new HMS ODEN helmet achieved a faster lock-on by directing the sensor in the right direction and then the normal search programme, which functions with the HUD, would locate the target. FFV Aerotech concluded from its own tests that an HMS would save several seconds in attacking a target, while the possibility of locking-on to multiple targets within a short period of time was also noted.

HMS ODEN is most effective when working with a high-manoeuvrability SRAAM fitted with off-bore capability, which is why the IRIS-T (or any other fourth-generation SRAAM) is important. The HMS ODEN's range is dependent on the weather and which search system it is connected to, either the radar, IR-OTIS, FLIR, any camera system or, of course, the missiles.

In addition to plans to include an HMS in the Gripen from the third batch onwards, thought has been given to maybe retrofitting older Gripens but again this is dependent on the finances being available. The Swedish Air Force, however, would prefer to wait until a complete HMD system is available but, according to FMV test pilot Björn Johansson, the FMV did perform some HMS ODEN flight tests from 1992. The HMS ODEN was an LED-based system and used four arrows on its display; the arrows would light up in the direction of the target and cue the pilot onto it.

HMS ODEN Technical Data

Operating range	
Yaw	± 180°
Pitch	± 90°
Roll	± 180°
Head motion box	
X (Front-Rear)	± 406mm (16in)
Y (Left-Right)	± 254mm (10in)
Z (Up-Down)	± 152mm (6in)
Resolution	
Angular	1.75 mrad, 0.1°
Translation	2.54mm (0.1in)
Accuracy	'HUD' box 2 mrad (RMS) Others 4-10 mrad
Power supply	115V AC, 0.7A, 400Hz 28V DC, 0.1A.
Transmission visor	83% (blue-green light)
Reflection visor	83% (red light)
Weight	1,350g (0.3 lb)
Field of view	6°
Exit pupil	18mm (7.1in)
Accuracy system	less than 1°

On 22nd May 1997, Saab and Ericsson Saab Avionics entered into an agreement with Seattle-based Microvision to develop a next-generation high-resolution HMD. Microvision was the company that had developed a Virtual Retinal Display™ (VRD) and the reason for the agreement was to see if it was possible to develop an HMD with this technology, and to test the safety and durability of VRD technology in a military aviation environment.

Ericsson Saab Avionics formed part of the agreement because of its experience in cockpit display technology. Microvision was to develop and deliver some high-resolution HMD technology demonstrators which would then be tested and used in advanced aircraft simulators. The resultant quality was so overwhelming that all three partners agreed to try to achieve TV-quality HMD resolution.

The first monochrome prototype was received from Microvision on 21st October 1997 while the second prototype, a full colour, high-resolution system for evaluation in Saab and Ericsson Saab's flight simulators, arrived on 10th August 1998. The second prototype used Microvision's patented VRD technology in an attempt to realise unprecedented image fidelity for a fighter pilot.

This system has more chance of success than the HMS ODEN because, as an HMD system, it would render the HUD as we know it obsolete. If the tests proved successful, the partner companies agreed to find other commercial uses for this technology and market it together.

In the meantime, on 17th March 1998, Microvision and Saab announced that they would accelerate the research and test the safety and durability of the system in a military cockpit environment – if the system was acceptable then integration into fighter aircraft would be the next step.

VRD technology takes advantage of the human visual system and projects the information, with the help of a laser, through the pupil and on to the retina of the eye. The pilot sees the virtual reality information that he needs an 'arm's length away' while also having an unlimited view of what is in front of him. The VRD works on four subsystems – the drive electronics, light sources, scanners and optics. The drive electronics basically comprise the system processor and the acquisition of information from a computer, video or video camera. The number of colours that can be used is almost unlimited.

The VRD uses a very low power light source to create and convey one pixel at a time through the pupil to the retina. Colour images need three light sources (red, green and blue) which are intensified separately and then merged to give the right colour – these light sources are not a health risk to the pilot's eyes. On the prototype, the light sources for red and green were rather small, but the blue light source was too large to handle.

A raster pattern was used to steer the light source over the retina via a scanner, which shaped the correct image; the scanner had to be very fast for the human eye to see the entire picture or superimposed information.

The helmet's visor will have the refractive and reflective optical elements built into it to project the rapidly scanning beam of light into the pilot's eye through the pupil and on to the retina. The optics create a large virtual superimposed image.

The big advantage of this HMD system is that there is no need for any flat-panel display of the old kind – no CRTs or LCDs which can be made unreadable due to outside light (usually direct sunlight) and are very expensive compared to the VRD technology. In short, all of the inefficiencies are eliminated and much of the cost as well. The problem of the extra weight on the pilot's helmet has not yet been resolved and, since the VRD unit is still too bulky, so far it has only been tested in the Gripen simulator at Linköping.

The belief that it would take some time to introduce VRD technology into the Gripen or any other fighter aircraft was confirmed at FIDAE 2000 but, like most other systems, in due course this technology will be miniaturised; how long this takes will affect when it is introduced on the Gripen. General Jonsson has stated that HMD systems will come more into their own with the next generation of off-boresight-capable missiles such as IRIS-T.

General Jonsson's comments reflected the opinion of the Swedish Air Force, but the FMV was looking at systems that were already available and the type they seemed to prefer was a monocular system made by Pilkington Optronics in co-operation with Cumulus of South Africa, one of Denel's business divisions. In autumn 1998 the FMV awarded Pilkington Optronics a contract for two Guardian monocular HMD systems, the first of which was delivered by Pilkington in June 1999 to the Försök Centralen (the FMV Test Directorate).

Cumulus has much experience in producing helmets and Guardian was produced for fixed-wing types like the South African Air Force's Atlas Cheetah and later the Gripen. Cumulus joined with Pilkington Optronics in 1995. (The question remains as to whether or not this choice was influenced by the South African offset requirements announced at about the same time as part of the Gripen sales bid.)

The HMD includes a monocular helmet with an integral colour camera, a display electronics unit and an optical head tracker. Test results in areas such as steering and tracking symbology were all satisfactory; in fact, the only problem was the inner helmet comfort for the pilot – it was vital that the helmet followed every movement of the pilot's head exactly. The HMD and IRIS-T missile were also tested together on Gripen 39104 and again the results were very promising.

On 7th February 2001 Saab tested the Pilkington HMD for the first time as part of the preparations for integrating the system into SAAF Gripens. The FMV had already tested the system in the simulator and in flight, but the Swedish Air Force had still not made its final choice and used this work to gain more experience with the Guardian HMD and to save on research expenditure.

At the end of 2001, Cumulus decided to stop working with Pilkington and began looking for a new partner – the partner it found was Saab Avionics.

Striker HMD

At the Paris Air Show on 17th June 2003, BAE Systems and Saab announced that they had signed an agreement for a new Integrated Helmet-Mounted Display (IHMD), to be based on the Striker HMD developed by BAE Systems for the Eurofighter Typhoon.

On each side of the Striker HMD there are two image-intensified tube CCD cameras that provide an integrated NVG capability. The system operates on a click-on basis, so the pilot can remove the cameras if there is no need for the NVG capability (for example, when a mission that commenced during the night continues on into daylight), thus reducing the weight of the HMD.

Striker offers full binocular overlap, allowing each of the pilot's eyes to see the same 40° field of view. The HMD display is a raster caligraphic, meaning that the system superimposes the symbology on the pilot's NVG image. Striker is switched off automatically if the pilot looks down at his HDDs in the cockpit. Should the pilot have to initiate an ejection sequence, the camera will detach automatically.

Christened Cobra, the new IHMD will retain the excellent tracking unit from Cumulus of South Africa that had been tested previously in conjunction with the Pilkington HMD. Another difference from Striker will be Cobra's size; smaller, because the Gripen and its cockpit are both smaller in size. Like Striker, Cobra will provide a night-and-day, all-weather, all-altitude capability over the full combat flight envelope.

South Africa has become the first country to order the Cobra IHMD; Sweden is evaluating the system and a decision on whether to procure it is expected during 2003.

TIDLS

The Tactical Information Datalink System (TIDLS) was not new to the Swedish Air Force, the service having already used datalink systems in the J 35 Draken. Since then the equipment has been updated and improved and much of the Swedish Defence Forces' operational capability has been built around it. For export countries this means that the Gripen can only be fully effective if they update their systems to enable them to communicate via the datalink system.

The Gripen TIDLS is a third-generation system in the sense that it was first introduced in a second-generation aircraft, the Draken, to overcome problems of radar and other forms of jamming. The datalink was used one way only, from the ground controller to the pilot, but this nevertheless enabled the pilot to be guided to

The VRD helmet worn by a Saab test pilot; it is clearly too big and still in prototype form.

The VRD on test st in the Gripen simulator at Saab's Linköping facility during 1999.

a target or interception point. The possibility of datalinking between aircraft was introduced in the Viggen.

The TIDLS is a Swedish idea and it is quite a surprise that other countries have paid little attention to it or tried to develop such a system themselves. Datalink began to be introduced in the F-16's MLU and users soon appreciated the unprecedented capabilities that it offered them, but it was not until the system was introduced in the Gripen that it was recognised internationally as a system for the future.

In the Gripen, data from up to eight other aircraft is transferred through pre-programmed radio channels and can be displayed on one of the cockpit MFDs without providing too much information for the pilot to control. A limited number of aircraft can transmit on this channel but the number that can receive the information is unlimited.

The information can be supplied from the Saab 100B Argus AEW&C aircraft, from ground stations or from the recce system carried on another Gripen. TIDLS gives the pilot all the important tactical information he needs and can make him a tactical decision-maker or a battlefield commander. A secondary peacetime option is the ability to transfer information to a Full Mission Simulator on the ground, thus giving the trainee Gripen pilot a first-class and highly realistic training device.

The datalink can also be used for other operational needs, for example if a unit malfunctions in the aircraft the Built-In Test Equipment (BITE) knows which part needs to be replaced and can transfer this information to technicians on the ground.

It was planned to improve the capabilities of the TIDLS from the last 20 Batch Two Gripens onwards by introducing the Communication and Datalink 39 (CDL 39). This system is connected with the Ra 90 radio terminal developed by Rockwell-Collins and should make the Gripen capable of communicating with aircraft from NATO and any other air forces that it may have to work with.

The equipment was ordered for Swedish Air Force Gripens but export aircraft will use a similar system from Grintek of South Africa, the company having developed and produced an Audio Management System and a Communication Control Display Unit. Both of these should be compatible with the Datalink 16 used by NATO MLU F-16s thereby adding to the capability of the already tremendous datalink capability and making it NATO-compatible. This CCDU unit has also been ordered for Swedish Air Force aircraft.

Advantage: Gripen

New technology such as TIDLS and other information-providers should give each Gripen pilot superior situational awareness and the battle commander unsurpassed battlespace awareness. In the future, it is planned to add to the current narrowband datalink a broadband datalink that would make it even more capable of receiving and transmitting information from all the available sources on the battlefield. This would form a part of the network-centric defence idea based on the internet. Something similar is being developed in the USA; called Co-operative Engagement Capability, the idea grew from lessons learned during the conflicts in the Gulf and the former Yugoslavia where the transfer of important data was often found to be too slow.

FV2000

The Gripen was presented to NATO officials for the first time on 9th November 2000 at F7 Wing at Sätenas and, at the same time, the FV2000 (Air Force 2000) system was also displayed. A demonstration was performed by two single-seat Gripens, 39142 and 39181, which took off with simulated weapon loads. Each was 'equipped' with two Sidewinders and two AMRAAMs; the leader also had one RBS 15F anti-ship missile and one DWS 39 stand-off dispenser weapon, the Number Two had two DWS 39 munitions dispensers.

The Gripens intercepted a ship off the west coast of Sweden and then immediately moved on to an interception mission over Lake Vanern. Afterwards they displayed the capability of the three remaining DWS 39 dispensers with a simulated attack on a Swedish road dispersal base and then returned home to demonstrate the aircraft's fast turnaround time. Both Gripens were refuelled and rearmed (this time not simulated) with defensive and offensive weaponry and exactly 20 minutes after landing they took off with two different pilots at the controls.

The demonstration could be followed on the ground because a third Gripen, sitting outside the presentation hangar, was hooked up to 1m (3.2ft) high screens in the hangar which gave every official the chance to view what the pilots themselves could see. All of the information from the two Gripens was downloaded via the secure datalink to the third aircraft. A Saab 100B Argus AEW aircraft was included in the exercise and also transmitted information to the hangar. Most impressive of all, however, was the fact that throughout the entire exercise there was absolutely no voice communication between the pilots; nor was it necessary.

The new NetDefence system was to be tested on a Swedish island with sensors and information providers linked to it. New systems or information-providers should be integrated quite easily into the system, thereby making it readily adaptable to any air force. As the Net-Defence is based on the internet, it would not be difficult to share it with coalition partners. Smaller countries could use it independently without the need to make huge investments in a new system.

Landing System

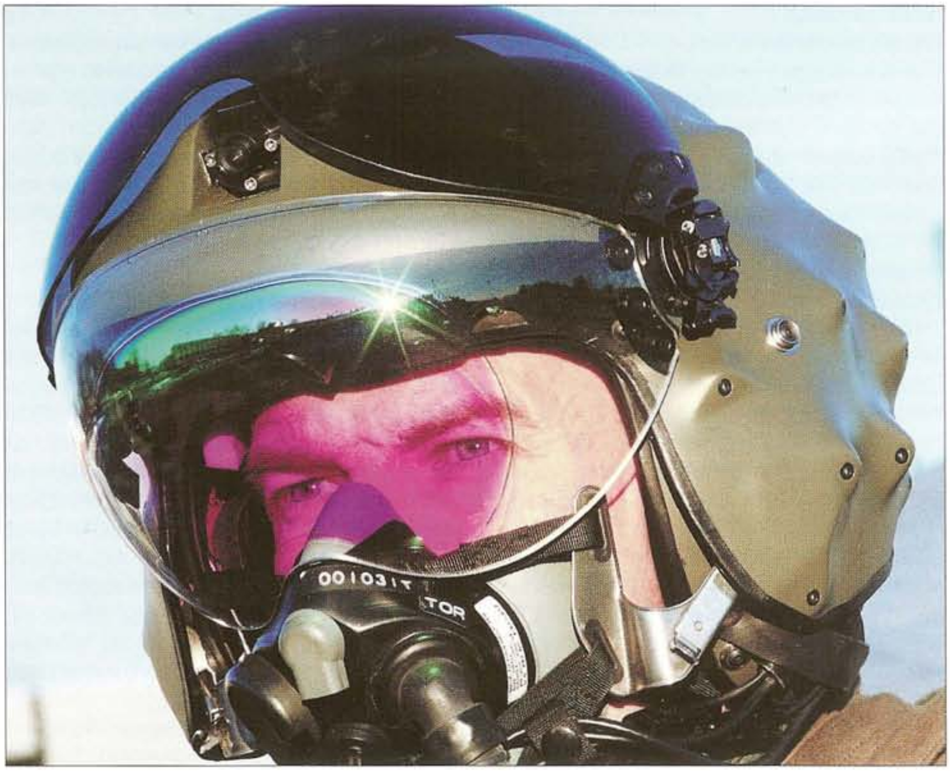
Since the Swedish Air Force needs its aircraft to operate autonomously (ie, without help from the outside), Saab AB and Saab Dynamics developed a new system to give the Gripen the capability to make automatic landings. The system employed by the Viggen was comparable to those used on US Navy aircraft carriers. Its Tactical Instrument Landing System (TILS) was used at Swedish air bases but was old and expensive to operate and, because it was bulky, it could not be transported easily to the dispersed roads that were in use as alternative runways.

The basis of the new landing system was a new navigation system which had to be accurate for safety reasons, especially when the Gripen operates from dispersed air bases. The Gripen was equipped from the outset with INS, a radar altimeter, an air data computer and sensors that provide basic barometric altitude and air temperature. Together these gave the pilot his bearings, telling him where he was and thus giving him the ability to navigate.

The Gripen's speed on finals is 174mph to 186mph (280km/h to 300km/h) and, depending on the AoA, the speed on touchdown is about 168mph (270km/h) at 12° AoA or 146mph (235km/h) at 14°. Although the Gripen is capable of stopping after touchdown within 1,148ft to 1,312ft (350m to 400m), even when it operates from fields with 2,625ft (800m) long runways the navigation accuracy still has to be very high.

The basic objective was to develop a system that would make TILS obsolete. Although English test pilot Dan Griffiths was much impressed with this system when he flew the Gripen for the first time in early 2000, the aim to make the Gripen more autonomous than before was more in line with its design philosophy and fourth-generation fighter technology.

If an aircraft is to perform an autonomous landing then it has to rely on its onboard systems and sensors, but due to the fact that the Gripen was a small aircraft there was insufficient room to install bulky equipment. Saab and Saab Dynamics therefore developed two new systems for the Gripen that would use many of the sensors and much of the information currently available in the aircraft, thereby keeping the equipment small.



The Cumulus Pilkington HMD worn by a Saab test pilot.

This Swedish Air Force test pilot is wearing the Pilkington/Cumulus HMD, used in conjunction with the IRIS-T SRAAM on the wing-tip.

NINS and NILS

The two new systems were called the New Integrated Navigation System (NINS) and the New Integrated Landing System (NILS). NINS uses the Gripen's built-in navigation suite and a high-precision sophisticated digital terrain database. The fact that the database is digital means that it takes up minimal space and it will be possible to miniaturise this further with development. NILS relies heavily on the NINS system's accuracy.

NINS was tested in an Sk 60 during 1998 and 1999 and the results validated the concept. NINS also brings something new to the aircraft, Terrain Navigation (TERNAV), which incorporates geographical information in a digital database that gives data on ground elevations and high obstacles such as electricity pylons and churches. The new system allows the Gripen to perform a CAT 1 landing on almost any runway, which means that the pilot can see the surface from 197ft (60m) up and 3,937ft (1,200m) away and perform a landing, and also to make an autonomous landing in bad weather.

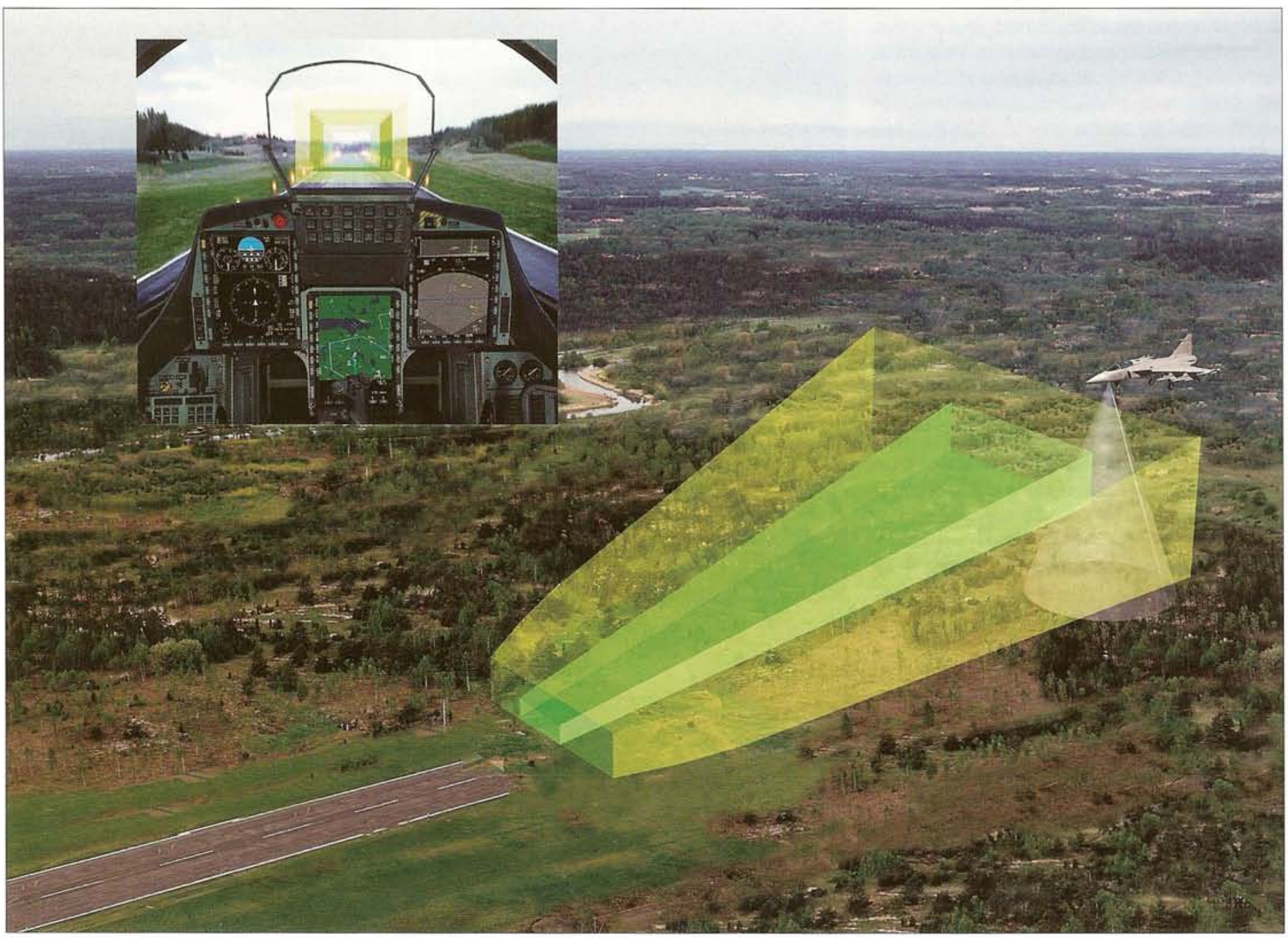
The NINS/NILS equipment was tested in the third Gripen prototype. A Czech author writing for a military magazine flew in a Gripen in the spring of 2001 and thought he had landed the aircraft using the NINS/NILS system, proving that it was indeed so easy to use that even non-pilots such as he could land with it; however, he was actually operating the old landing equipment. The NINS/NILS was expected to offer an improvement over the existing system and, according to John Neilson from Gripen International, it was installed in an operational Gripen for the first time in November 2001; Gripen test pilot Berndt Weimer, however, reported that the system was installed but not yet in use.

Maintenance and Reliability

A low Life Cycle Cost (LCC) is a key feature of the Gripen and to achieve it there are two levels of maintenance: line and shop maintenance. The aircraft has installed in it LRUs and SRUs. LRUs are the most common and Gripen has about 250 of them, so every dispersed base or unit that operates the fighter must hold some LRUs. However, since the Swedish Air Force operates from dispersed bases the aircraft's maintenance equipment must be mobile and, because it is impossible for a small unit to hold all of the LRUs, those that they do have are based on their MTBF. In addition, many LRUs are used by more than one system.

Even before a mission begins, when the APU starts up the aircraft the safety checks start immediately as well. The results of the checks are shown in the cockpit on one of the MFDs and 25 main sub-systems are tested first. If a faulty system is reported, the pilot or technician can use the Fault Location button to trace were the problem is. The Built-In Test Equipment or BITE also shortens the time the Gripen spends on the ground and saves money on the LCC while the performance and function of every system is carefully recorded when the fighter is airborne. After landing the pilot can use one of the MFDs to read what the BITE says needs to be fixed. The pilot can inform the maintenance team during taxying what equipment is malfunctioning or requires a check-up or replacing; even quicker, during flight this information can be transferred to the maintenance staff by datalink. The data recorded during the flight is downloaded to an external memory that empties the Gripen's computers of the relevant information and transfers it to an evaluation computer. The analyses can also warn, or be used to teach, maintenance technicians about certain problems or conditions.

Here the trajectory that the NINS/NILS has calculated for the pilot can be seen. The light green area is the safety margin; outside that area the pilot should try for another approach. The dark green area means that the pilot is lined up for a perfect landing. The inset image shows what the pilot sees on his HUD during the landing approach.



Each Swedish Air Force wing will be equipped with a Maintenance Data Recording System onto which will be loaded all of the information from every system in every aircraft belonging to the wing. Thanks to this system the technician can see how long a certain piece of equipment has operated in the aircraft and if any parts or LRUs are not working properly or need servicing; this applies to every system in the aircraft and engine. For the engine the technician is even informed about what kind of actions it has been asked to perform by the pilot, full military power, certain manoeuvres, etc, so again the technician knows when the engine does or does not need servicing which reduces costs and increases aircraft availability. Computerisation is used to monitor and control all of the systems so that most major breakdowns or accidents can be prevented before they occur which again cuts costs and losses.

Minor problems that will not interfere with the pilot during his work are not reported to him during flight. Major problems though, and which systems are affected, are immediately reported so that he can take the necessary action to land safely. After pushing the right buttons he can even request flight instructions; all of these measures do much to reduce the pilot's workload.

On 17th May 2000, during an engine start at the FMV test base at Malmen, three thermo batteries in the emergency power system unexpectedly activated when they were not required. The examination showed that the onboard fault locating equipment had reported that there was insufficient power, which was why the batteries had activated, and this knowledge allowed the staff to call the American manufacturer to report that the batteries were not working properly.

As a result the entire Gripen fleet was grounded by the Swedish Air Force's Air Safety Inspection. During the grounding two other defective batteries were discovered and all five were found to come from the same manufacturing batch. A study made in conjunction with technical staff from the American supplier checked to see if any improvements to the batteries were needed, the BITE software was modified and maintenance regulations adapted accordingly, and from 29th May the Gripen fleet's flight ban was lifted.

If the BITE declares one of the 250 LRUs to be faulty, the technician (an officer) or one of his five team members (who are all conscripts) replaces the faulty LRU which means the aircraft is ready within ten minutes to resume action. The faulty LRU goes to a depot where some Automatic Test Equipment or ATE is used to isolate the malfunctioning part, once again making maintenance cheaper. There are 250 different ATE systems for the 250 LRUs and these are grouped into the ATE 31, ATE 35 and ATE 37; ATE 31 is used to test specific LRUs in their frequency range. LRU accessibility must be excellent and so, with the Gripen being a small aircraft, every panel had to be easily accessible for the maintenance team. One update ordered in 1997 and confirmed at the Paris Air Show was that the third batch of aircraft had to have even better availability and LCC, making the Gripen even more marketable and future operation costs even lower than before.

The engine is also divided into modules and each is an LRU. While it is in the aircraft the engine can be inspected through 12 portholes but if a module needs changing then the complete engine can be removed. All that is needed to replace the engine module within an hour are three conscripts, three mini-hoists and a dolly for the engine. The Gripen's update programmes were aimed at reducing equipment maintenance and volume so that more systems could be integrated. The EP-17 is a good example – the Mk.1 was equipped with PP1 and PP2 data processors which were replaced by the PP12 – replacing two LRUs with one. LRU Mean Time Between Failure figures have been kept classified.

Gripen reliability is also much increased by the Flight Control System's (FCS) back-up system which ensures in an emergency or malfunction that the aircraft can return to base. Power for the FCS comes from five sources – the FCS generator or one of four back-up power supplies. If they all fail Gripen has an analogue back-up system which disconnects the canards and makes them free floating so that the aircraft becomes stable again.

The Swedish Air Force has four so-called priority or PRI aircraft which are used more intensively than any other aircraft in service to see what the future cost curve will be for the rest of the fleet and to test the durability of newly introduced technology. A PRI aircraft has been used by the Swedish Air Force to test every new system. 39131 is one of the PRI Gripens and on 17th January 2001 was the first example to reach 800 flight hours. The others are 39121, 39122 and 39142 and at the end of July only 39142 had flown less than 800 hours.

During the cost curve investigation of up to 800 flight hours nothing was found that needed major alteration (as had been the case with the Viggen according to Major Hakan Brandt of F7 Wing). On 1st October it was decided to extend the cost curve investigation to a new limit of 1,600 hours to ensure the reliability of the systems and the aircraft as a whole. Because the standard of each batch was different, and the difference from Batch Two to Batch Three was greater than the difference between Batch One and Two aircraft, it was decided that two Batch Three machines would be added to the PRI inventory as soon as the mark was introduced into Swedish Air Force service.

The first operational Gripen to fly 1,000 hours was the 39131 (one of the four PRI aircraft) on the 21st October 2002. The second Batch Two PRI aircraft, 39142, reached the same landmark in mid-November 2002.

Gripen Survivability

Good maintenance, system redundancy and reliability are not the only measures used to increase the survivability of the latest aircraft. Stealth, Electronic Warfare (EW), Electronic Counter Measure (ECM) systems and others are necessary although some of this equipment was available to earlier generations of fighters. From the outset of a new aircraft's design, stealth or signature reduction and improved detecting sensors are an important part. The Gripen's size is definitely an advantage in close air combat since a small aircraft is harder to detect and harder to hit, particularly if it is not flying straight and level. A golden rule for dogfighting is small is beautiful but Gripen also had to be more manoeuvrable and possess greater acceleration than its predecessor. Besides its systems, the aircraft also has to depend on the pilot's training and the physical and mental limits.

Although attention was paid to it, stealth was not such an important design factor as it was for American fighters such as the F-22 and JSF. During the Gulf War the F-117 was a major success and the advantage seemed clear that the F-117 did not need any fighter escort but a few years later the advantage held by stealth aircraft received a big blow when one was shot down over the former Yugoslavia and the remains disappeared to reappear again in Russia. These two conflicts spurred companies to design less expensive stealth detection technology and the advances in this equipment was one reason for Sweden to question the sense of investing in expensive technology like stealth. On many fighters the engine air inlet is normally a good radar detection source but, on the Gripen, the engine is rather small and placed in the rear of the fuselage which reduces the radar signature.

A system that warns the pilot of enemy radar detection is the RWR or Radar Warning Receiver and if a lock-on is made he can then take action to avoid enemy fire. The RWR is basically a passive ELINT (ELectronic INTElligence) system and Swedish Air Force aircraft have been equipped with RWR since the J-29 in the 1950s. The capability of new radars make the old RWR systems totally useless because now the equipment has to be able to filter the information to give the pilot warnings of the threats that really matter. The company responsible for Swedish combat aircraft RWR was Celsius Tech.

RWR is a passive system that gives no signals for detection, which means that it does not warn the enemy that the pilot knows he is there and, unlike radar, it cannot be jammed. Each type of radar has its own 'fingerprint' which is shaped by, among other factors, the Pulse Repetition Frequency; this means it can be recognised. The RWR can define what kind of aircraft is shaping the threat because the pilot's 'radar database' will tell him what kind of radar he is up against. During the Gulf War F-14 Tomcat pilots complained that they did not see any action because when they switched on their radars the Iraqi pilots turned and ran before the Tomcats could lock-on. The database is assembled by using the RWR to collect information from various radars and recording it in a library which can easily be updated to accommodate any new types of radar that appear.

The RWR does not take much space, weight or electrical power and is thus always fitted in small fighters. Analogue RWR systems were used in earlier generation aircraft but the Gripen has a digital RWR that is more capable of filtering information and recognising important threats. To give all-round coverage the RWR must be mounted where it can look in every direction or the aircraft must be equipped with more than one system, in fact combat aircraft usually have multiple RWR systems. The Viggen was equipped with one on each wing at the wing tooth, although on the Viggen they also perform a secondary role because they were positioned to generate enhanced vortices. The Gripen has five RWR systems – one placed on the front side of the vertical fin in between the Flight Control System dynamic pressure sensor and the ECM equipment fairing and two more on each wing-tip missile rail, one at the front and one at the back. These provide all-round RWR coverage against any radar threat.

During its service life the Gripen RWR has been continuously updated. The first-generation RWR which used wideband receivers was produced until 1999 when it was replaced by the second-generation system that added a narrow band receiver. In addition the hardware was updated to make it faster and more compact than in the earlier generation. Thanks to a change of Swedish political policy, for the first time it was possible to export this kind of product and the second-generation RWR interested Germany as a replacement for the existing system in the Panavia Tornado.

The RWR was an integral part of the Ericsson-Saab EWS-39 fitted initially in export Gripens but also selected, at the end of 1999, for the Swedish Air Force. This system consists of five LRUs – four RWRs (called the wing-tip units) and one Electric Warfare Central Unit (EWCU). Basic RWR coverage is in the E to J-band and the EWS-39 communicates with the aircraft's other internal and external systems through Mil-Std-1553B data busses. The other onboard systems help it to make an evaluation of the threat and accordingly apply countermeasures. Options to enhance the EWCU are a Digital Radio Frequency Memory, a noise modulator, repeater noise modulator and an output stage module.

At the 1999 Paris Air Show Ericsson presented for the first time a new electronic warfare suite called MIDAS or Multi-function Integrated Defensive Avionics System. As well as RWR, MIDAS uses Electronic Intelligence (ELINT), Electronic Support Measures (ESM), Electronic Counter Measures (ECM) and a high capability datalink. To perfect the system it should be combined with a Low Probability of Intercept (LPI) radar that is also under development at Ericsson (although MIDAS can be used with any other LPI radar). The MIDAS development programme was initiated in 1995 by Ericsson as the replacement or enhancement of the EWS-39 but, during its development, the system was evaluated so much that its role became a lot broader and the name was changed from MIDAS to MIDIS (Multi-function Integrated Defensive Information System). MIDIS is seen by Ericsson as a system that should be integrated in the Gripen by 2010.

Beside these warning systems Gripen has a more active system to help the pilot avoid missiles. Celsius has developed a dispenser for infra-red countermeasure flares which are dispensed one packet at a time, the vortex behind the aircraft helping to disperse the flares and generate a large enough alternative target for an enemy missile to lock-on to. The dispensers can be built into the missile launchers so that they take up a minimum of space.

Opposite page, top: **A heavily armed JAS 39A at one of the Swedish Air Force's dispersed sites.**

Opposite page, bottom: **Reliability, even in remote locations, is very important as the amount of spare parts that can be transported by a small team is limited.**

Below: **The turnaround crew downloads all the flight data immediately after each flight to help them establish the wear and tear on the aircraft.**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7

The GCAS programme badge with American and Swedish flags and the warning chevrons in green that would show in the HUD in the case of system activation.

AFTI F-16D 83-1176 was the aircraft used for the joint US-Swedish Auto GCAS test flying programme.

AGCAS (Du Kan Inte Flyga Lagre)

To increase safety and reduce peacetime losses the monitoring and endurance of aircraft systems compared to previous generation aircraft was increased and pilot safety improved. There was, however, still room for improvement. Combat aircraft and pilots were being lost during exercises because the pilot could, as a result of high g manoeuvres, lose consciousness and if he was flying at low level this would mean a crash. This problem is called G-induced Loss Of Consciousness and has been responsible for the loss of many experienced pilots. Another scenario capable of producing a similar result is the high speed low altitude flight typical of a fast jet mission. Pilot errors during such flights often have a lethal ending and such accidents are called Controlled Flight Into Terrain (CFIT).

From September 1995 Saab worked with Lockheed Martin Tactical Aircraft Systems to produce equipment that could prevent 95% of these accidents, its development being paid for by the USAF and FMV. For each party the reason for co-operation was to cut costs – both the US and Sweden had the technology to develop such a system alone. An obstacle for co-operation was the F-16 competing against the Gripen on the export market but this was overcome. The programme was initiated in autumn 1996 and followed some previous ground collision avoidance research carried out in 1985 to 1988 and 1989 to 1991. It was led by the USAF Research Laboratory, with the help of the FMV, at Edwards AFB and the Swedes called the programme Du Kan Inte Flyga Lagre (You Can't Fly Any Lower). In the ten year period between 1987 and 1996, the USAF lost 98 aircraft to CFIT.

The new system, called Automatic Ground Collision Avoidance System (AGCAS), was designed to stop the pilot from flying into the ground. It was test flown in the AFTI (Advanced Fighter Technology Integration) F-16 but was not to interfere with normal flying when there was no immediate danger; this was the difficult part of the job. The system was designed to reset the aeroplane onto level flight and then do a 5g pull up. To warn the pilot that it was activated and about to take action, a signal would be shown on the HUD (two chevrons or arrows on the outer edge of the HUD moving to the centre) so that the pilot could take corrective action or prepare for the manoeuvre. At the moment the two chevrons made contact in the centre of the HUD a flash on the HUD combined with an aural warning in his helmet warned the pilot that the AGCAS was about to make a maximum AoA recovery. After recovery the AGCAS gave the pilot an aural 'you've got it' to tell him that he was back in control.

The computer takes information from the GPS, terrain database, altimeter radar and speed recorder to predict the moment when the aircraft will need to take corrective action to avoid crashing. The operational version should limit height to something between 50ft and 150ft (15m and 46m) and points for the AGCAS to take into account are AoA, angle of bank, speed, altitude, the terrain and other obstacles in the immediate vicinity (on the Gripen most of this data is collected by the new NINS landing system). In 1997 the AFTI/F-16 team initiated research into 'nuisance' warnings where the AGCAS might give a warning when, in fact, there was no immediate danger. The pilot might then wish to switch off the system during low-level flight which would make AGCAS useless, so the criteria for nuisance warnings were set and from there the AGCAS designers could work further. The nuisance testing was done by AFTI/F-16 75-0750 until the beginning of November when it was replaced by F-16DS/N 83-1176.

Thirty AGCAS test flights were flown from Edwards Air force base between 8th July and 5th November 1998, a total of 38.3 flight hours, during which more than 350 test manoeuvres were flown by Swedish and US pilots. The Swedish pilots that participated in this testing were Bjorn Johansson from the FMV and Ola Rignell, Saab Chief test pilot, while the US pilots came from Lockheed Martin and 416th Flight Test Squadron. The system was near nuisance-free and those nuisance warnings that did come up were mainly due to errors by the terrain reference navigation system, GPS system coverage blanks and discrepancies in the Inertial Navigation. GPS coverage blanks happen mostly during heavy manoeuvring where the aircraft's antenna loses contact with its GPS satellites.

Auto AGCAS will be implemented as a software function in the Flight Control System and system computer so all the aircraft can be updated. The system is supposed to be ready for operational test and evaluation in 2003. It is not clear if the system will be introduced in all 202 remaining aircraft as 40 have been made available for sale or lease, this system might increase their value considerably.

During a conference called Technology versus Terrorism, the US Dept of Defense's James O'Bryon recalled being at Edwards when the AGCAS was test flown. It was performing so well that the pilots tried 14 times to deliberately crash the aircraft but on each occasion the system took over and saved the plane and the pilot. After the US-based test programme was finished it was reported that AGCAS was 95% ready. AGCAS was tested in Gripen 39-5 at Linköping from May 2002. After the joint project was completed the American 412th Flight Test Squadron received funding to further improve the system.

The programme had been so successful that a complementary project was initiated to deal with mid-air collisions, the third-largest cause of loss for military aircraft, which is reason enough to do something about it. This time, Boeing was also included in the programme for what would eventually become the Air-to-air Collision Avoidance System (ACAS).

The agreement between the parties was signed in October 2000. Sweden was to pay half of the cost and the technology software would be government property. The first phase of the programme, the conceptual study, was completed in May 2001. Boeing and Saab each had the responsibility of designing the system algorithms according to eleven pre-set requirements:

1. The system should prevent air collisions between all aircraft (military and civil) and UAV's. This was essentially because UAV's and military aircraft will have to operate alongside each other in any future missions.
2. The system should operate with both manned and unmanned air vehicles. In a manned vehicle the system will not interfere with normal pilot control of the vehicle except to prevent aircraft loss (ie, it will be nuisance free). In an uninhabited vehicle the system will not interfere with the normal operator control of the vehicle except to prevent its loss.
3. The system had to provide, as a last resort, an emergency manoeuvre to prevent collision with all other air vehicles. For a manned military aircraft the expected ACAS initiation time is between 0.5 and 1.5 seconds time-to-escape prior to a collision.
4. The system should provide a predictable response to avoid a collision; for example, one similar to that of an aware pilot or UAV operator.
5. The system should not cause a collision with the ground during execution of an escape manoeuvre. ACAS should also be able to communicate with or be connected to AGCAS.
6. The escape manoeuvre should be commanded only long enough to avoid the collision and must release control of the aircraft to the pilot immediately following clearance of the threat aircraft.
7. The system should protect against unforeseen events that cause collisions.
8. The system had to provide safe vehicle operation and be fully verified, validated, and tested with redundant elements as required. It was to make extensive use of distributed integrity monitoring to insure fail-safe operation without the use of brute force redundancy.
9. The system had to able to force a UAV to execute a collision avoidance manoeuvre prior to a manned aircraft.
10. The system should have redundant elements to provide the necessary protection against failures.
11. ACAS system should be designed for modularity and portability to enhance its implementation onto multiple aircraft and UAV types, including military, civilian and commercial aircraft.

The second phase, the system design and flight test, started in August 2001. The best parts of each algorithm were to to be further developed in a generic algorithm. Lockheed Martin was responsible for system integration into the VISTA F-16. The integration work was initiated during the autumn of 2002 and, according to Saab test pilot Magnus Olsson, ACAS was tested in the Gripen simulator in Linköping by Swedish and US pilots.

The system will allow formation flying but the aircraft will have an invisible safety area calculated by the computer surrounding it, the size depending on the aircraft's speed and direction. For example if the respective 'safety' areas of two aircraft approaching each other are going to touch, the ACAS will activate and initiate a high g-manoeuvre to prevent a collision. The system was intended to be based on datalinked information but was not to be limited to just that; other information sources would include radar, FLIR and IRST. Test flying in the United States is proposed for June and July 2003 under the lead of the Air Force Research Laboratory.

On 7th August 2003 the VISTA F-16 flown by USAF Major James Less and the Swedish Air Force Major Richard Ljungberg tested the ACAS system for the first time on another F-16 flown by Major Scott Wierzbanowski. According to Steve Markman, the flight test director at the Air Force Research Laboratory, the two aircraft approached each other and the auto ACAS activated every time to separate them without pilot input. For the first test flight against a real aircraft the miss distance was set intentionally high so that the pilots could react if the system did not work. The miss distance will be gradually decreased as both the pilots and the engineers gain confidence in the system.

The Escape System

Any combat pilot must have a feeling of security so that if things do go wrong in battle or in an exercise, he knows that he has every possibility of getting out of the aircraft. The solution for modern jet-powered combat aircraft is the ejection seat where the pilot and his seat are fired directly upwards and out of the aircraft. The most famous of all ejection seat designers has to be the British Martin-Baker company but, during the Second World War, Germany and then Sweden became the first countries to put ejection seats into service.

The first Swedish indigenously designed ejection seat was developed for the Saab J 21. This piston-engined fighter had a pusher propeller at the back of the fuselage pod which prevented the pilot from baling out safely because of the risk of hitting the still-turning propeller blades. Hence the need for an ejection seat to propel the pilot (and his seat) clear of the aircraft.

After the war, Sweden continued to develop its own ejection seats for all of its fighters. The J 29 Tunnan used an updated seat from the J-21 because it was a faster aircraft, the later Mk.2 seat having two firing guns rather than the one used in older versions. The Mk.3 seat was installed in the J 32 Lansen and had a central gun replacing the two-gun arrangement.

The ejection seats used in the J 35 Draken incorporated more updates and improvements than any of the earlier models. The first rocket-powered seat, the Saab RS-35 Generation 1, was installed in the J 35D while the later RS-35 Generation 2 was equipped with a more powerful cartridge, more powerful rocket engine, stabilisers and other improvements.

The RS-37 was developed for the Viggen and again had more safety improvements but the seats designed for each new generation of fighter had become more and more bulky and, therefore, could not be used in the Gripen. It was thus decided to modify an already existing ejection seat, which would also be cheaper, and Swedish and Martin-Baker engineers began working together in 1982 to adapt the Martin-Baker Mk.10 to Swedish requirements. The Gripen was the first Swedish aircraft to be equipped with a foreign-designed and produced ejection seat, a lightweight version of the Mk.10.

The Mk.10 was developed from the Martin-Baker Mk.9. The latter had featured a new faster-action position for the seat-firing handle between the legs of the occupant in front of the seat pan; it was also much more comfortable than previous seat, which made longer flights less of an ordeal. Changes made for the Mk.10 included:

- The extension of the gas-operated firing system introduced on the Mk.9 to include the release of the drogue and to operate the harness release system.
- The combination of the drogue and the parachute as a complete assembly stowed in one quickly detachable container at the top of the seat structure.
- A simplified two point combined harness.
- The introduction of arm restraints.

The Mk.S10LS lightweight version was specially adapted to a Swedish Air Force specification and one of the important reasons for choosing it was its low LCC and longer periods between maintenance. According to Martin-Baker, the cost of ownership of the Mk.10L system was almost certainly the lowest, in regard to manpower and cost, of any modern crew escape system. Seat testing commenced in June 1985; in March 1986 Saab delivered to the UK one of two special forward fuselage/cockpit sections for further trials.

The decision to build a two-seat Gripen with a new cockpit introduced a further round of ejection seat development. The single-seat forward fuselage section was returned to Saab who rebuilt it as a two-seater and then sent it back to Martin-Baker. The first two-seat test was carried out in July 1993 – the pilots were ejected in sequence but there was a problem in that, after detonation, the canopy glass re-entered the cockpit and struck the rear pilot as the front-seat pilot departed. Martin-Baker solved this by introducing an airbag that inflated for a second to protect the rear pilot before deflating again to allow him to eject safely.

Another problem that had to be solved was how to ensure that there was no collision between the two pilots either during or after ejection. To minimise the chances of this happening, the procedure is to have the front seat move slightly to the left during the ejection sequence and the rear seat to the right. In the event of a zero-zero ejection (zero speed and zero altitude) from a two-seat Gripen, the left-right movement will position the pilots 65ft (20m) apart at the highest point after departure.

The ACAS programme patch illustrates that this was another joint American/Swedish project. In the centre of the patch two aircraft can be seen just missing each other!

Top and left: **ACAS should not interfere with normal Gripen formation flying.**

The Mk.S10LS ejection seat differs from the standard Mk.10L in various ways. Most of the changes introduced by way of improvement have been developed or suggested by Saab and include the following:

- Further improved seat comfort.
- Gas-operated drogue gun and seat timer.
- Redundant gas system.
- Leg restraint system.
- Increased head rest.
- Canopy breaker on the seat pan.
- Rocket initiator safety device.
- Locator beacon and safety handle with electrical indication.
- Extended seat beam for taller Swedish pilots.

Saab's work on the seat itself was minimal and only covered the wiring looms and connectors for the leg restraint system.

The Mk.S10LS is a fully automatic, cartridge-operated, rocket-assisted ejection seat. It provides a safe escape for most combinations of aircraft altitude, speed, attitude and flight path within the flight envelope of zero speed/zero altitude to the maximum speed range of the Gripen between zero altitude and 50,000ft (15,240m).

The seat is installed at a 27° angle to optimise the pilot's resistance against g-forces and the speed of the parachute's deployment depends on the altitude of the aircraft; the seat recognises three different flight levels: low altitudes up to 7,000ft (2,134m), medium altitudes above 7,000ft and high altitudes above 10,000ft (3,048m).

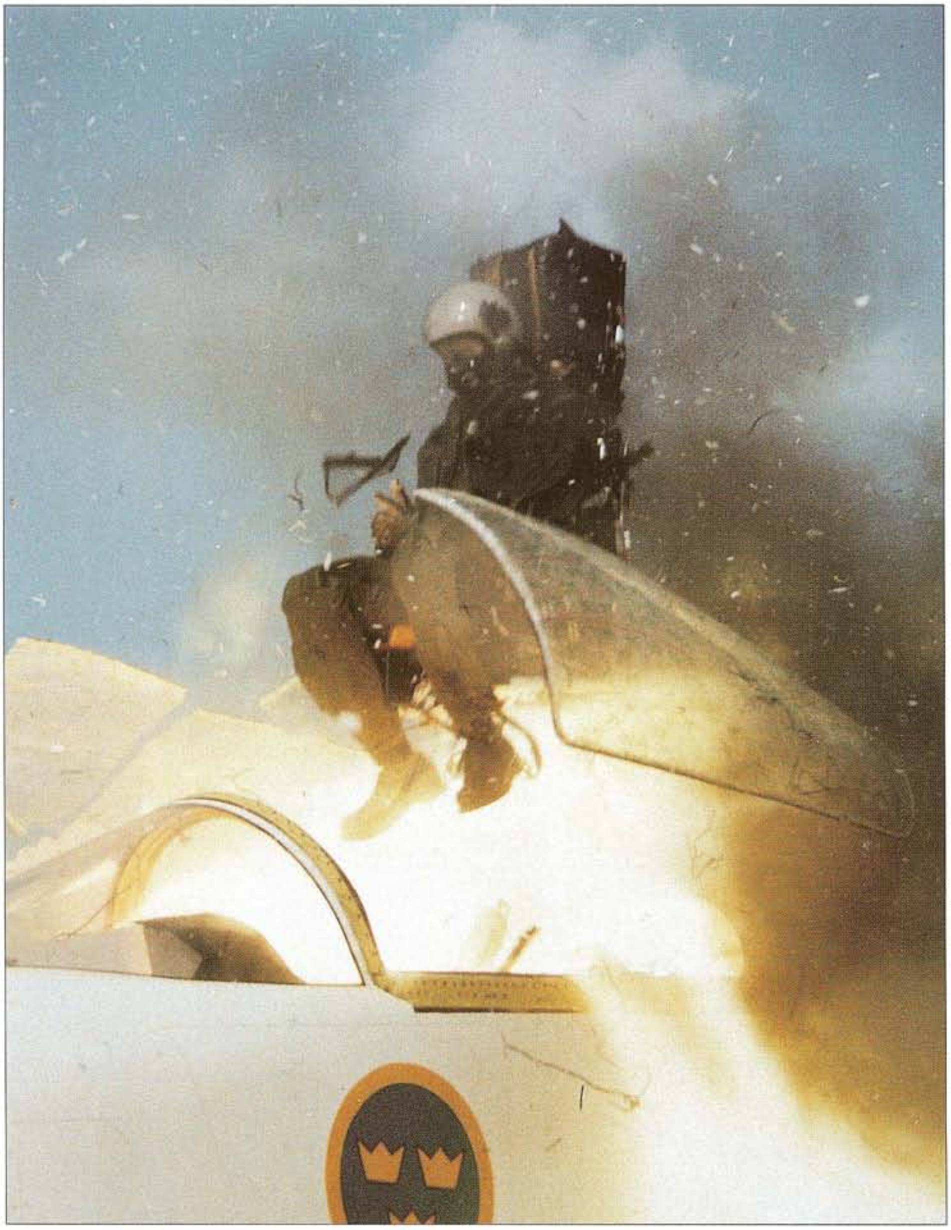
Ejection is initiated by pulling the seat-firing handle placed between the pilot's knees on the front of the seat pan. There are three ways of getting rid of the canopy for an ejection: jettisoning it by operating the firing handle, fragmentation by a Miniature Detonating Cord (MDC) or penetration by the ejection seat itself. The Gripen's canopy is fitted with an MDC system so if the firing handle is pulled the MDC is ignited and the seat passes through the fractured canopy.

The MDC is installed around the edges and through the middle of the canopy and the wire is so thin it does not impair the pilot's view. The canopy is 0.35in (9mm) thick but the windscreen is 1.04in (26.5mm) thick because it has to resist bird impacts during flight. The windscreen has been tested for 2.2 lb (1kg) birdstrikes up to 622mph (1,000km/h) – if the bird

The airbag for the rear cockpit of the JAS 39B/D Gripen undergoing test inflations in 1995.

A Gripen forward fuselage ready for tests and mounted on a Martin-Baker sled fitted with a pusher rocket.

The two-seater cockpit/forward fuselage during a test ejection in 1995. Note how the pusher rockets are in full burn to propel the sled down the track at speed.



is heavier, or the speed higher, or if the windscreen gives way sooner than the margin allows, the bird's remains are deflected away from the pilot's face.

After ejection, man/seat separation and parachute deployment are automatic. A manual override system will restart the separation sequence in the unlikely event of automatic system failure.

In the 'low altitude' range, parachute deployment is completed within 3 seconds of the pilot initiating the ejection system. At medium altitude this is delayed by a barostatically controlled g-limiter which senses the seat's deceleration by the drogues and delays the time-release operation by approximately 1 second until the required parachute deployment speed is attained. This makes the occupant's transition smoother and reduces the chance of damage to the spinal vertebrae.

At high altitude the occupant remains in the seat and is supplied with oxygen while descending to a safe height pre-set by the barostat. The seat is stabilised by the deployed drogue and when the pre-set height is reached the parachute opens automatically. After deployment, the seat and its occupant separate; this method reduces the risk of a mid-air collision.

The parachute has a drift speed of 9.8ft/sec (3m/sec) but it cannot be steered, which means that the pilot cannot get out of the way of any obstacles that might cause injury on landing. Because of this, the Swedish Air Force started to replace this parachute in Batch Two Gripens with a new version that is steerable. The steerable parachute also has a drift speed of 9.8ft/sec (3m/sec) when it is controlled by the pilot, but if the steering capability is not used it has a drift speed of just 1.6ft/sec (0.5m/sec); this reduces the risk of injury because the landing is not so rough. This is particularly important for pilots who are wounded or otherwise incapable of controlling their landing.

On 8th August 1993 the Gripen's Mk.S10LS ejection seat was fully proven when Lars Radeström survived an ejection at very low altitude during an air display in Gripen 39102. It was the 6,335th known successful ejection from a Martin-Baker seat (although a book on Martin-Baker states that it was the 6,320th) but the first time ever that the system had been used to exit a Swedish Air Force aircraft – a dubious honour. The second occasion came just over six years later when, on 20th September 1999, Gripen 39156 was lost over Lake Vänern; according to Martin-Baker's database this was the 6,746th successful ejection using a Martin-Baker seat.

Ejection from the Gripen is preceded by the detonation of the Miniature Detonating Cord, the results of which can be seen as the ejection seat passes through the broken canopy.

The Miniature Detonating Cord does not obstruct the pilot's view in any way.

Extreme High Alpha Test Flying

The preparations for high angle of attack ('alpha') test flying began in 1993. The test aircraft was intended to be 39-4 but its displays were something of a problem because, despite being close to production standards, the glass cockpit would stop working if the direct current electric supply was broken. In such a high-risk test this was a risk not worth taking, so 39-2 was chosen instead because it had a conventional cockpit.

However, although 39-2's analogue displays were less vulnerable to power failure, the older cockpit layout was still unsuitable for high 'alpha' flight and the test group had to study layouts that had been used in the United States for this type of work before adapting 39-2's cockpit accordingly.

The Gripen had already reached an angle of attack of 26°. In December 1994, in preparation for these tests, Saab painted 39-2 in black and dubbed the aircraft *Black Beauty* after the famous children's novel. Later a drag 'chute was added to effect a recovery if the AoA limit was exceeded and the aircraft went into a spin.

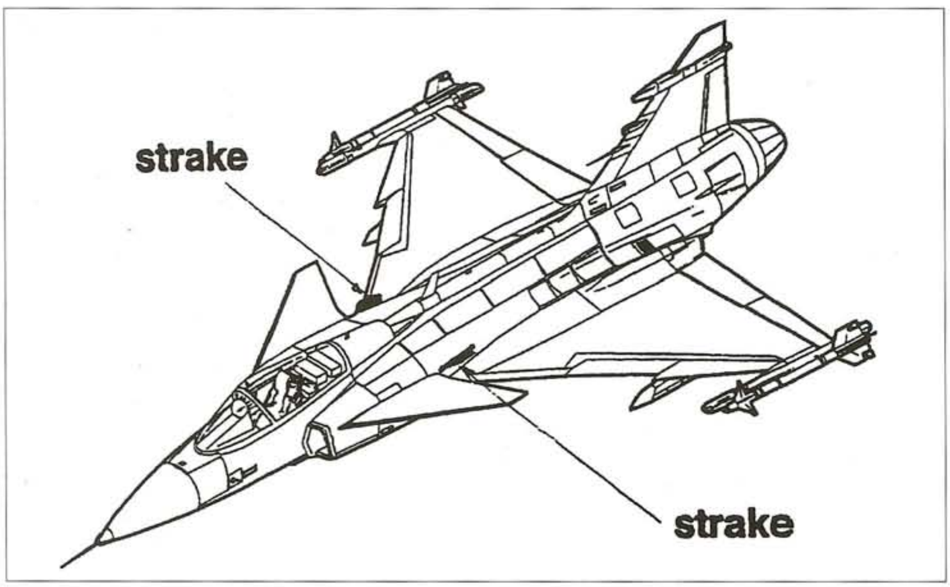
The position where the recovery 'chute was mounted prevented the airbrakes on the aircraft's side from functioning properly so these were removed to make the fitting more solid and reliable; the 'chute would itself function as a brake. Some parts of the aircraft were later painted white for better visibility and the test flying commenced in 1995.

High 'alpha' testing was vital to ensure that Swedish Air Force pilots would enjoy carefree handling in the extreme parts of the flight envelope. The flight test programme comprised over 1,900 flights but the highest-risk sorties were not performed until the end, when all of the 'low-risk' testing was complete. Most of the flights were made by Saab test pilot Clas Jensen and FMV test pilot Björn Johansson, both of whom were specialists in this area, but Mikael Seidl also helped with some of the flying.

The flight test programme with prototype 39-2 lasted until 1999, after which the aircraft was retired and transferred to Halmstad. Testing to obtain final clearance for production aircraft then had to continue using 39101 and 39104 because 39-2 was not equipped to production standards. During this part around 150 departures from controlled flight were made with an average of six to eight per sortie; up to three flights were required for each stores configuration. As a consequence of the positive results obtained with 39-2, neither 39101 or 39104 were equipped with an anti-spin 'chute.

The high 'alpha' tests had to be repeated on the two-seater because this was a longer aircraft and had a different centre of gravity. The aircraft chosen for the task was the second production JAS 39B, 39802, which received only minor modifications; it was equipped with an anti-spin 'chute on 10th January 2001 and two days later it was tested in flight. Later on, just before spin testing began in June 2001, two analogue instruments were added to the cockpit, one to measure the angle of attack and the other the rate of yaw. The spinning tests were completed in September 2001.

All kinds of stores were carried to test the Manoeuvre Load Limiter before the actual high 'alpha' testing was initiated.



Top: **During high 'alpha' flight testing, some parts of Gripen 39-2 were painted white to increase visibility for the observers.**

Left: **The design of the Gripen was considered a success by Saab as there were no major upgrades necessary to the shape or structure of the aircraft. The only upgrade that was noticeable was the addition of strakes just behind the canards, to improve control in the high 'alpha' region. The strakes were added early on in the programme and were introduced quickly on the first few production aircraft.**

Above: **The high 'alpha' flight control laws are divided into three different regions: Region I is the normal flight envelope; Region II is divided into two separate AoA segments (the aircraft is still statically unstable in this region and a non-linear prediction of AoA (via alpha-dot) and an increasing feedback are used to bring the aircraft back into Region I); and Region III in which the aircraft is statically stable and the control laws include an auto-recovery function back to Region I.**

Left: **Production JAS 39B 39802 was used for high 'alpha' flight testing. This rare photograph of the aircraft during the trials shows the spin 'chute installed.**

Into Service

The Swedish defence budget has traditionally been evenly divided between the three services that comprise the country's armed forces – the Air Force, the Army and the Navy. Each Service was given more or less a free hand on how to spend its budget allocation and the Swedish Air Force adopted a system whereby 60% of its allocation went into new material and 40% into staff and other costs. That meant that whenever there were defence cuts, which have been continuous since 1965, the Swedish Air Force did not suffer as badly as the Army and Navy who spent more of their budgets on operations and staff and, consequently, were harder hit.

When the decision was made to build the Gripen, it was seen purely as a 400-aircraft requirement intended solely for the defence of Sweden, a neutral country independent of any major defence alliance.

In 1989 the Warsaw Pact disintegrated and soon major cutbacks in defence expenditure were being implemented across Europe and in the United States. Sweden, however, was very careful in not reducing its forces too much because of the apparent instability in Russia; on 29th June 1990 the last of 329 Viggens was delivered to the Air Force, the intention being that the type would serve for another 20 years, much of that time alongside the Gripen. During the 1990s, however, the Swedish government was increasingly of the opinion that any future conflict would not be fought alone and that Sweden could therefore now afford to reap the benefits of the so-called 'peace dividend'.

When the contract for the second batch of 110 Gripens was announced on 2nd June 1992, the Swedish Air Force was still counting on receiving a third batch of approximately 160 aircraft. When added to the 140 already on order, this would give enough Gripens to equip some two-thirds of a 23-squadron Swedish Air Force; the rest would have Viggens.

Almost five years later, when the contract for a third batch was finally agreed on 27th June 1997, things had changed dramatically. The order was for only 64 aircraft, reflecting the further contraction of the Swedish Air Force in the intervening time. The trend had been downward for some three decades: 50 squadrons in 1965, 38 in 1971, 26 in 1988 and 16 in 1996.

Plans drawn up in 1997 foresaw just 13 squadrons in service in 2006, 12 with Gripens and one with AJS 37 Viggens; another two squadrons of Viggens would be held in reserve. The Viggen was an ageing aircraft, and there were two possible options for the future:

i. Due to ever-diminishing defence budgets the Viggen squadrons could be retired entirely.
ii. There could be an order for a fourth batch of Gripens.

The first was the more likely outcome and by the end of 1997 it was clear that the Swedish Air Force would be retiring its remaining Viggens. Compared to the Gripen, keeping the Viggen system would be very expensive and so the Swedish Air Force tried to speed up the conversion process but, in the meantime, the Swedish government had begun to shape a less neutral policy. Sweden began to participate in NATO's Partnership for Peace exercises and also joined United Nations peacekeeping forces (as it had done previously in the Belgian Congo), a move which put a heavier burden on the available forces and staff.

Planned force reductions and a date when an operational squadron for international duties would be ready were both set for 2003. In the first year this was intended to use AJS 37 Viggens from F21 Wing before being replaced the next year by the Gripen.

The next wing to be re-equip with the Gripen was to be F10 at Ängelholm, after which F16 Wing at Uppsala would receive the aircraft. However, on 19th May 1999 a Swedish defence review revealed that the number of planned Gripen squadrons was to be cut from 12 to 8 although the number of aircraft in each would be increased. One of the wings chosen for disbandment was F16.

Defence plans for 2000 changed the situation again. F10 Wing at Ängelholm was now expected to close with F16 Wing becoming the home of the flying and tactical schools. General Jan Jonsson, Chief of Staff of the Swedish Air Force, went on record as saying that, if possible, he would speed up conversion to the Gripen to save money on operations and retire the remaining Viggens earlier than expected to release money to invest in other equipment.

A new round of budget cuts would show a 30% reduction in funds for the Swedish Air Force and were to be achieved by both base closures and the early retirement of older equipment. Both F10 Wing and F16 Wing were to be abolished by 2003; the conversion of F10 Wing to the Gripen would continue for the time being but the pilots would later transfer to F4 Wing and F17 Wing. The reduction in units was to be countered by increasing the number of Gripens per squadron from 17 to 25, which meant about 50 Gripens per wing.

Finally it was decided that F10 Wing would not be split between the remaining wings but instead transfer to F17 at Ronneby where it would replace two squadrons of JA 37 Viggens. After that, F4 Wing would be the next to receive

The Swedish Air Force has participated in several Partnership for Peace exercises to show that the Gripen is NATO-compatible. Among the exercises was *Baltic Link* which saw Gripens operating alongside Finnish Air Force F/A-18C Hornets.

the Gripen to replace another two JA 37 squadrons. F21 Wing would be the last to get the Gripen because this wing had a reconnaissance capability and the Swedish Air Force had yet to commit to buying a reconnaissance pod for the Gripen.

A major change in defence policy was now announced by Defence Minister Björn von Sydow. According to Von Sydow the most important point was that the structure of Sweden's defences should switch from protection against invasion to an organisation that would uphold the country's territorial integrity. In line with this switch in emphasis, the defence budget was to be cut by 10% yearly from 2002 to 2004, which proved a very unpopular decision within the defence industry. Saab was not so badly hurt by this because the Swedish Air Force would still have to take delivery of the 204 Gripens it had on order since there was no clause allowing for cancellation.

On 1st March 2001 the new Supreme Commander of the Swedish Armed Forces, Johan Hederstedt, made a resolute and bold decision in announcing that the Swedish Air Force would not need all the Gripens it had ordered. He stated that the first 40 production aircraft could either be sold or leased (although 39102 had been written off in a crash and 39101 was still serving with Saab).

Hederstedt's rationale was that the Swedish Air Force needed to reduce its ambitions to a certain extent in order to achieve a greater capability. The Gripens in question were initially expected to remain as a reserve for the Swedish Air Force but, according to Hederstedt, the Swedish Air Force did not need that reserve; also, the fact that these aircraft would not remain in service rendered any updates to them obsolete.

Hederstedt's decision meant that the number of Gripens per squadron would not be increased as was previously planned. Björn von Sydow's reaction was realistic; he described Hederstedt's decision as logical.

On 17th April 2001 Hederstedt said that, if his proposals were accepted in parliament, not only would F10 Wing disband on 31st December 2002 but F4 Wing would close as well. He felt that implementing these proposals would make the long-term future of the Swedish Air Force more cost-effective, rational and environmentally friendly. The proposal saw the Swedish Air Force based on four wings comprising eight Gripen squadrons:

i. F16 with one squadron of Gripens integrated with the flying school at Uppsala.
ii. F21 at Luleå with three Gripen squadrons.
iii. F7 at Såtenäs with two squadrons.
iv. F17 at Ronneby with two squadrons.

A defence committee was convened to review Hederstedt's proposals from 19th April 2001 and it was hoped that parliament could make its decision by 16th May. However, it did seem that Uppsala would get its Gripen squadron.

In fact the politicians did not agree that the bases should close and they decided on a different approach that had not been recommended by Johan Hederstedt. It was decided that F4 Wing would remain open but that F16 Wing at Uppsala would be closed by the same date as F10 Wing, thereby closing the country's two largest air force bases at the same time.

Saab Test Department

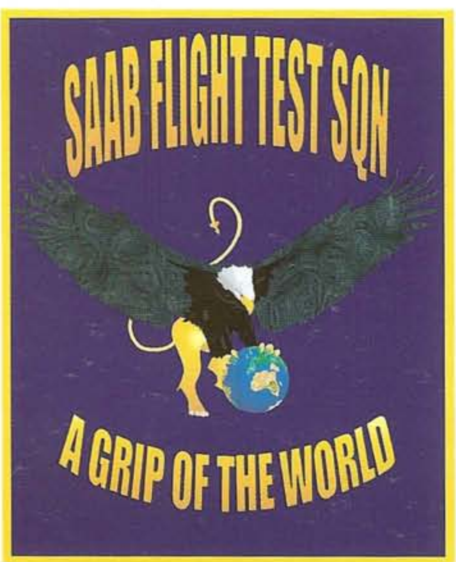
The first unit to fly the Gripen was, of course, Saab's test department at Linköping which was responsible for flight testing from day one until the type was introduced into squadron service. Saab was also responsible for the testing of new software and hardware and had to perform the airworthiness test flying for every production Gripen before it was handed over to the FMV (which usually required three flights). The Chief Test Pilots of this unit were:

- Stig Holmström from September 1984
- Per Pelleberg from 1989
- Arne Lindholm from July 1990
- Class Jensen from 1996
- Ola Rignell from 1999.

The Saab flight test department was also responsible for the flight demonstrations that were held all around the world and the first pilot to be employed on these duties was Lars Rådeström. On 6th June 1991 Rådeström flew prototype 39-3 over Skansen Open Air Museum in Stockholm and made two passes at 656ft (200m). Lars Rådeström retired in 1994 and was replaced a few years later by Frederick Müchler.

FMV or Försök Centralen

The FMV or Forsvarsmakten is the Swedish Defence Material Administration and Gripens delivered to the FMV are operated by the Försök Centralen or Test Directorate. The FMV's test department is based at Malmen Air Base near Linköping, in fact on the opposite site of Linköping to the Saab test airfield. It has an evaluation, test and controlling function and was involved in Gripen test flying from the start.



Top left: **The new Saab Flight Test department badge with the mythical Gripen on top of the world.**

Bottom left: **The badge previously worn by Saab's Gripen test pilots.**

Top right: **The unit badge of the FMV test and evaluation unit. Semper Comperiemus translates as 'Always Comparing'.**

Bottom right: **The badge of the TU-39 test and evaluation unit, basically the third unit to fly the Gripen before the aircraft was assigned to front-line units.**

Björn Johansson (right) in post-flight discussion with some of his TU-39 colleagues.

The Gripen was evaluated using test pilots from Saab and the Försök Centralen and then an independent report for the customer was produced covering the development of the aircraft and its systems. Every production fighter delivered by Saab also goes to the FMV where the test department puts it through some more tests before it is delivered to a unit. The slogan on the badge of the FMV test department, *Semper Comperiemus*, roughly translates to 'Always Comparing'.

The first FMV pilot to fly the Gripen was Mats Nilsson; he was the fourth pilot to fly the aircraft and was later to become the Inspector General, or Commander-in-Chief, of the Swedish Air Force. Nilsson made his first Gripen flight in September 1990 and for some time worked with Arne Lindholm as the two main pilots in the Gripen programme. Since Swedish Air Force units had a number, and later a letter, on the aircraft's nose to identify the wing to which the aircraft belonged, the test department had the letters 'FC' painted on the nose.

The FMV also tests new technology, mainly against requests from the Swedish Air Force; for example, in 1999 some man-machine interface products (three-dimensional sound control, HMD and voice control) were tested for their suitability to be integrated into the Gripen.

The Chief FMV test pilots during the full Gripen test phase included Lt Col P O Almstedt and Lt Col Björn Johansson.

There was talk of moving the FMV to Uppsala to prevent that base from being closed, but the move never happened. Malmen Air Base was closer to Saab, which had its advantages when the two organisations were co-operating on a project.

During the first half of 2002 the unit was renamed the Validering och Verifiering Centrum (VoVC or, in English, the Validation and Verification Centre); the unit markings were also changed with 'FC' on the aircraft's nose being replaced by 'VoVC'.

TU-39

Lieutenant Colonel Jan Jonsson, later to become Commander-in-Chief of the Swedish Air Force, was given the job of setting up a JAS department that would be responsible for the development of JAS tactics and the training and integration of other systems. Between 1987 and 1989 Jonsson converted from the JA 37 to the SF 37 (photo reconnaissance) Viggen so that he could get acquainted with the problems involved; this made him the ideal person to set up the establishment that would act as the Swedish Air Force's Gripen operational test and evaluation unit and plan and prepare for the type's introduction into service. Jonsson received this commission in autumn 1989 and the unit was called TU-39 for Taktisk Utprovning 39 (or Operational Test and Evaluation).

On 1st November 1989 TU-39 became the first active Swedish Air Force Gripen unit and one of its tasks was to write the textbooks for Gripen pilot and maintenance instructors. In the summer of 1993 Jan Jonsson moved on and handed the responsibility for TU-39 to one of the first operational pilots to fly the Gripen, Lt Col Jan Andersson.

TU-39 was based at Malmen near Linköping so that it could easily communicate with the staff at Saab and the first Gripens to be delivered were based at Malmen from October 1995 until March 1997, when they and TU-39 were moved to Såtenäs.

During March 1997 the first F7 Wing pilots began converting to the Gripen while in 1998 Jan Andersson was promoted to become the wing commander of F7 Wing and was replaced at TU-39 by Major Hakan. TU-39 was responsible for the conversion duties at Såtenäs until the summer of 1999 when the two squadrons of F7 Wing took over this task. The first Gripen display pilot, Ken Lindberg, also worked for TU-39. The unit was transferred back to Malmen from Såtenäs in late 2000 and early 2001.

The Swedish Air Force has requested that by 2004 a wing of Gripens should be available for international operations and from May 2000 TU-39 was tasked with developing the systems required for these missions. The new overseas unit would be equipped with the AJS 37 Viggen from 2003 until it converts to the Gripen.

The badge of F7 Wing's Red Squadron. The letter G (for Gustaf) forms part of the badge design.

Not much different from the Red Squadron badge, that of F7 Wing's Blue Squadron differs only in its colour and motto.

Inauguration of the Gripen training centre on 9th June 1996 was considered important enough that King Carl Gustaf XVI attended.

Skaraborg Flygflottilj F7

F7 Wing came into existence in 1940 and is also called the Gustaf wing (G is the seventh letter of the alphabet and Gustaf is the Swedish phonetic spelling). The callsigns for F7 Wing are either Gustaf Röd (Red) or Gustaf Blå (Blue), depending on which squadron is concerned.

In late December 1987, before Gripen test flying began, the Commander-in-Chief of the Swedish Air Force, Lt General Sven-Olov Olson, decided that F7 Wing at Såtenäs would be the first unit to receive the Gripen. In February 1988 he announced that Såtenäs would also undertake all Gripen type conversion flight and simulator training. This would be the third time that F7 Wing had been the first to receive a new aircraft type; the first occasion involved the J 21R, the second was the AJ 37 Viggen in 1973. It would also require a lot of planning and many changes to the base's infrastructure.

Såtenäs Air Force Base is situated in an area that has few inhabitants, which makes it ideal from an environmental point of view (no broken windows or noise-related complaints during exercises). Flanked on two sides by the waters of Lake Vänern, it also presents no problems for low flying.

Besides its two fighter squadrons, F7 Wing also has a transport squadron equipped with the Lockheed Tp 84 Hercules. Såtenäs has two runways 6,562ft and 8,202ft (2,000m and 2,500m) long respectively, which is more than enough for the Gripen and satisfactory for Hercules operations.

Because the decision to introduce the Gripen to replace F7's two squadrons of Viggens had been made so early, the base's infrastructure was adapted for the aircraft long before the first Gripen arrived. (The first Gripen to visit the base was prototype 39-2, in May 1992.) Såtenäs was to be the main Gripen training base and a 'Gripen Centre' was built for every future Gripen pilot to pass through before being cleared to fly the aircraft; in addition, a maintenance training facility for F7's technical staff was set up in Linköping in May 1994.

Although F7 was the first operational Gripen wing and received its first aircraft on 8th June 1993, it was not until March 1997 that the type was declared fully operational at Såtenäs.

On 9th June 1996 the Swedish Air Force held the inauguration ceremony for the Gripen training centre at Såtenäs, which was opened by King Carl Gustaf XVI. In reality this was the introduction of the Gripen to service, although the test flying programme was not yet complete.

TU-39 had compiled the various books and documents needed by Gripen instructors and the first unit to begin training was F7 Gustaf blue squadron. Six days later, 39122 was seen in the static display at Östersund-Frösön and by 17th June F7 Wing had received 18 of its 22 Gripens with two more due shortly.

The Swedish Air Force held a Gripen Combat Exercise from 8th until 27th September 1997 which involved calling up conscripts to give them experience working on the fighter. After the exercise was completed the first Gripen squadron was officially declared operational on 1st October. F7 Wing, the Skaraborg Flygflottilj, comprised at this point three squadrons: one JAS 39A Gripen, one AJS 37 Viggen and one Tp 84 Hercules. The second Gripen squadron was intended to be operational in early 1998, also within F7.

As noted, the two Gripen squadrons belonging to F7 are called Röd (Red) and Blå (Blue). Blå squadron (2 Div/flygflottilj) was the first to become operational following an exercise held in the autumn of 1997 and it carries the Latin motto *Audaciter Tenaciter,* (Courageous Tenacious).

In December 1997 19 pilots got together in the Malmen officers' mess and initiated the latest step of a long tradition, which already existed among Draken and Viggen pilots, to initiate The Order of the Gripen Knights. This was to be a society of warriors who had been declared suitable to control the Gripen in the noble art of aerial warfare. The group comprised 18 pilots from the first operational squadron together with Kent Harrskog who was the current Chief of the Swedish Air Force and the highest ranking officer present.

The Order of the Gripen Knights has its home at F7 Wing and once a year 'knightings' are carried out under the supervision of the Riksriddare (the Gripen pilot with the highest military rank in the Kingdom).

According to the knight order there are eleven patches that a pilot can obtain in his career as an air force pilot, which are the following:

1. Less than 250 flight hours – A blue patch with the Gripen silhouetted in silver.
2. More than 250 flight hours – A blue patch with the Gripen silhouetted in silver plus the shorter upper edges also in silver.
3. More than 500 flight hours – A blue patch with the Gripen silhouetted in silver and a silver frame.
4. More than 750 flight hours – A blue patch with the Gripen silhouetted in silver and a bright yellow frame.
5. More than 1,000 flight hours – A blue patch with the Gripen silhouetted in bright yellow and a bright yellow frame.
6. Gripmästere or qualified Gripen instructor – A blue patch with the Gripen silhouetted in silver and a silver star above the Gripen.
7. Ordens Riddare or pilot with the most Gripen flight time within the Kingdom – A blue patch with the Gripen silhouetted in bright yellow, a bright yellow frame and a yellow star on each wing-tip of the Gripen silhouette.
8. Ordensmästare or Chief of Flying Operations at every wing – A blue patch with the Gripen silhouette in silver plus the shorter upper edges in silver and three silver stars around the Gripen silhouette, one on the top and one on each wing-tip.
9. Stormästare or the Gripen pilot with the highest military ranking in the region – A blue patch with the Gripen silhouetted in silver, a bright yellow frame and in each corner a star around the Gripen silhouette.
10. Riddarna Runt Skölden or the Knights around the Shield (the Gripen pilots from the first operational squadron and the founder of the Gripen order) – A blue patch with the Gripen silhouette in bright yellow, a thin bright yellow frame and 18 stars around the Gripen silhouette.
11. Riksriddare or Gripen pilot with the highest military rank in the Kingdom (the first person to obtain this badge was Kent Harrskog) – A blue patch with the Gripen silhouette in bright yellow, a big silver star in the middle of the silhouette, a thin bright yellow frame and a star in each corner around the Gripen silhouette.

F7 Wing JAS 39A Gripen 39120 and another Batch One aircraft take to the air. Thanks to defence budget cuts, Gripens from the first production batch would become obsolete sooner than was originally planned.

Early-production Gripens had the figure 7 painted on the forward fuselage even though F7 Wing pilots did not transfer to the Gripen until March 1997.

Shortly before F7 Wing became operational, the skies were flooded with Gripens when the unit took part in a major exercise. Fourteen aircraft can be seen in this view.

F7 Wing JAS 39As 39153 and 39157 armed with DWS 39 dispensers, Rb75 Maverick ASMs and Rb74 AAMs patrolling over Sweden.

Carrying an impressive array of ordnance for the fighter and attack roles, F7 Wing JAS 39As 39140 and 39170 both wear the Gripen's low-visibility colour scheme.

F7 Wing JAS 39A Gripens 39155 and 39187 on patrol along Sweden's picturesque coastline.

Lt General Kent Harrskog announced at the 2001 Paris Air Show that in August 2002 he would hand over the title that he had held since that December night in 1997 to the current Commander-in-Chief of the Swedish Air Force, Inspector General Mats Nilsson.

The last of the F7 Wing Viggens was retired in October 1998. The second F7 squadron, Röd squadron (1 Div/flygflottilj), has the Latin motto *Primus Interpares* (First Among Equals) and became operational on 1st January 1999.

Up to the beginning of 2000 the training of new pilots was dependent on simulators and single-seat Gripens, but from that point deliveries of two-seater JAS 39Bs to F7 began. F7 Wing was required to train all future Gripen pilots and was thus equipped with the expensive MMS and FMS simulators; the increasing cost of training equipment was the main reason for choosing centralised training. F7 Wing was also the first wing to lose a Gripen in operational service.

Skånska Flygflottilj F10

On 5th August 1995 F10 Wing at Ängelholm celebrated its 50th anniversary while, at the same time, the Draken was near to celebrating the 40th anniversary of its first flight. A major air show was staged at which Gripen 39101 was present in the static arena; test aircraft are no longer allowed to do flying displays in Sweden so the Gripen had to stay on the ground.

Once the decision had been made to make F10 Wing at Ängelholm Air Base the second to convert to the Gripen, the infrastructure there also had to be adapted for the new type. Preparations began in 1996 and on 25th June 1998 the Swedish government agreed to invest another SKr 190 million in the infrastructure, including new hangars and workshops and changes to the flight ramp.

The last operational Swedish Air Force J 35J Drakens were retired from the F10 Ängelholm Wing in December 1998 and from this point the wing was made ready for the arrival of the Gripen. The last of the Drakens had been in service with Johan Blå squadron which automatically became the third operational Gripen squadron. Pilot training commenced from 11th March 1999.

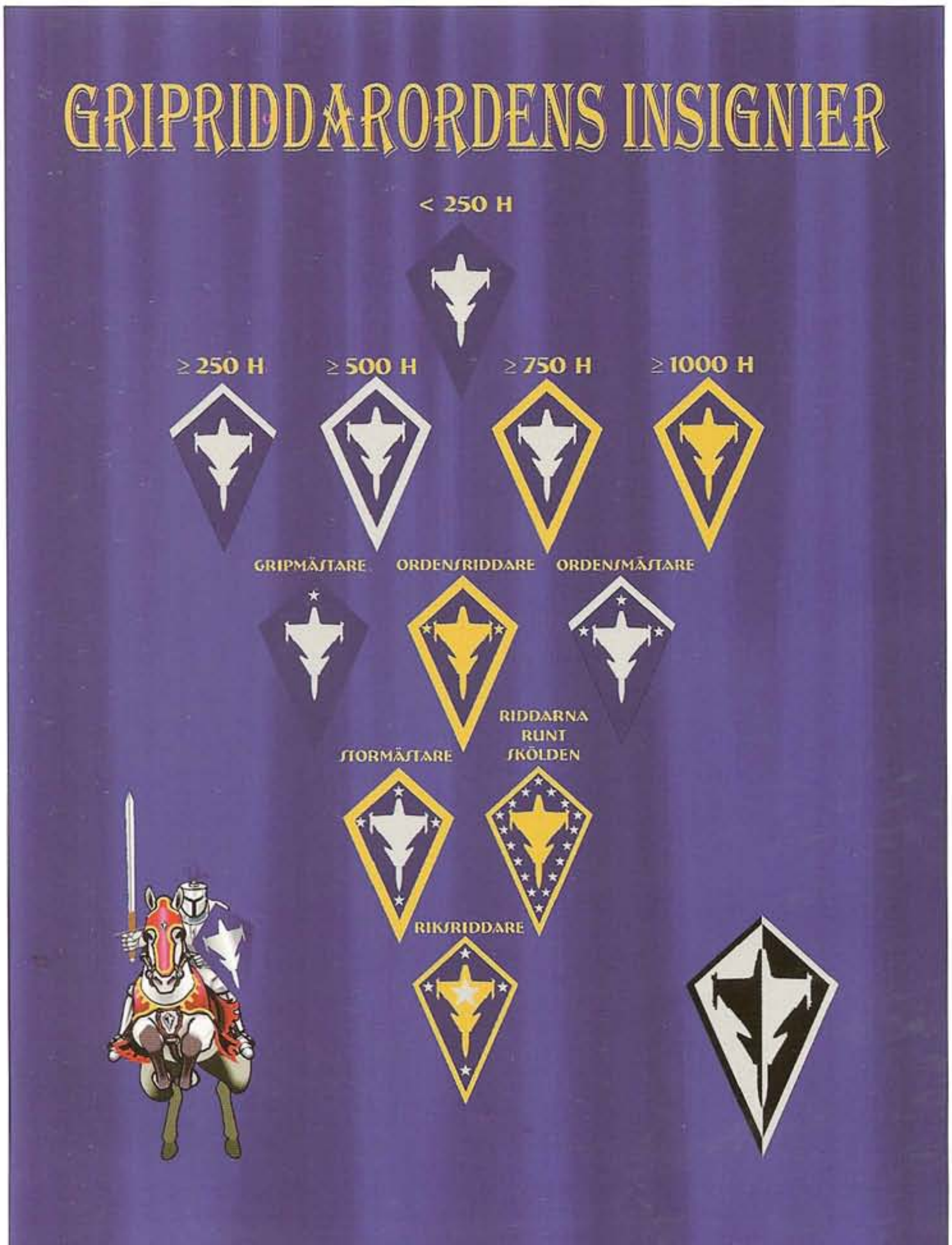
The first two Gripens for F10 Wing were formally handed over on 30th September when the two pilots who delivered the fighters, Christer Westerlund and André Brannstrom, formally handed over the logbooks of their respective aircraft to the wing commander Kjell Ofverberg. Both aircraft were single-seaters (39134 and 39165) which had previously served with F7 Wing at Såtenäs.

The planned reorganisation of the Swedish Air Force made it uncertain just how long these and other Gripens would stay at Ängelholm because the base itself was to close. The decision to close Ängelholm was made because the base was in the south of the country, where the level of civil air traffic was increasing and the military had to compete with airlines for airspace. This was not the case in the north which also had a much smaller population compared to the south, a factor that reduced environmental problems caused by exercises that involved low flying.

The final decision made sense because each side of the country was now evenly defended; two wings covered the north, two the south, two the west and two the east with each wing facing in two directions.

Responsibility for the technical airworthiness of the Gripen lay with F10 Wing. Air safety and security were still the responsibility of F7 Wing until 15th May 2000, but on that day F10 Wing became the second qualified Gripen wing as required by the *Regler Militar Luftfart* (Rules of Military Aviation).

During February 2000 the first eight pilots from Johan Blå squadron arrived back at F10 from their initial Gripen training with F7 to begin another 12 months of instruction and conversion at their home base under the supervision of F7 instructors. Shortly afterwards, on 30th March, the Swedish parliament decided to close F10 Wing in 2003, which meant that it would be the shortest-lived Gripen user. This decision was not taken lightly because of the huge government investments that had been made on the base's infrastructure (in excess of SKr 357 million) since funds were first allocated in 1996.



Left: **All the different badges that a Gripen pilot can earn during his/her career.**

Photographs on the opposite page:

F7 Wing Gripens return from a multiple-aircraft training sortie over Sweden.

Two As and a B: two-seater 39802 holds station with single-seaters 39152 and 39166 from F7 Wing. Because the JAS 39B was a relative latecomer, most pilots converting to the Gripen had their first flight in a JAS 39A.


G
66
G
52

Top left: **F10 Wing's Blue Squadron was the last Swedish Air Force squadron to fly the J 35 Draken and the third operational unit to transfer to the Gripen.**

Top right: **F10 Wing's Red Squadron will likely go down as the operational unit that operated the Gripen for the shortest period.**

Centre left: **The small red Q (for Quintus) identifies this as the badge of F17 Wing's Red Squadron.**

Centre right: **F17 Wing's Blue Squadron manages to use the letter Q twice, once in blue and again when the shape of the badge was slightly altered.**

Bottom left: **F21 Wing's Red Squadron has a wolf in its badge, which makes a change from the birds that feature in several other unit badges.**

Bottom right: **F4 Wing's Red Squadron has a fire-breathing black dragon in its badge, This squadron is slated to become operational on the Gripen around 2004/2005.**

Johan Blå squadron was operational on the Gripen by the start of 2001 and Johan Röd squadron was to be the next unit to reach this status later in the year when its AJS 37 Viggens had been replaced. Johan Röd, however, was to transfer its aircraft to F21 Wing at Luleå and in autumn 2000 F21 was preparing to start its conversion programme at F7. But the plans were changed and the Gripens of the Skånska Flygflottiljen were transferred to F17 Ronneby-Kallinge Wing from autumn 2002,

Ängelholm was expected to finally close its doors on 30th June 2003. Before F10 Wing was to become extinct however, six Gripens from F10 Blå squadron had the chance to make an exchange visit to the German airfield at Laage, the home of the German Air Force's 731 Staffel and its MiG-29s. This exchange formed part of the preparations for the Gripen Swafrap (the Swedish Air Force's rapid reaction unit which, in an international crisis, is to be capable of going anywhere at any time). This was the first time that a Gripen squadron had trained with a foreign unit.

Blekinge Flygflottilj F17

F17 Wing dates back to 1946 and is currently based at Ronneby. The Swedish phonetic word for Q, the 17th letter in the alphabet, is Quintus and so the radio call signs for F17 Wing's squadrons are Quintus Röd and Quintus Blå. On 14th June 2002 the first Gripens arrived at F17 Wing; most of the aircraft and personnel came from F10 Wing. The first operational Gripen flights by an all-new F17 crew took place on 19th June 2002; by this time flights by ex-F10 Wing crews were already under way.

Norrbottens Flygflottilj F21

The first Gripens for this unit arrived in January 2001 but, since the pilot training for the second squadron at F10 Wing was still to be completed, the aircraft were to be used for training ground crews and technicians.

The first operational Gripens for the unit, two single-seaters (39165 and 39190), landed at Luleå on 17th January 2002 and both were destined to serve with the Urban Blå squadron (F21 Wing has as its callsign Urban which corresponds to the 21st letter in the Swedish phonetic alphabet). Gripen 39165 had already served with both F7 Wing and F10 Wing and indeed had also been one of the first two aircraft to join F10 Wing.

The arrival of the two Gripens made the third Gripen wing a reality and the following week it was expected that the first squadron would start operations from F21's base. F21 Wing was also serving as the base for Austrian pilots to train on the Viggen. (Note: F16 Wing at Uppsala was originally supposed to replace its JA 37 Viggens with Gripens in 2000 and 2001.)

Urban Röd squadron was the Swedish Air Force Rapid Reaction Force (SWFRAP), and also the unit where the Austrian pilots flew on the Viggen. The squadron will convert probably when the SWAFRAP function has been taken over by the Gripen, but this could change if export customers are offered or obtain Gripens that would have originally been destined to enter service with the Swedish Air Force. The Swedish Air Force has to support the country's aerospace industry, and that may mean having to take delivery of Gripens later than planned.

Jamtlands Flygflottilj F4

F4 Wing, one of the remaining four wings, was preparing itself for the introduction of the Gripen (hangars were ready by 2002), but it too could be affected by future export successes. The F4 Röd and Blå squadron pilots would have to wait and see when they would get their hands on the new aircraft.

The old and the new: F7 Wing JAS 39A 39131 flies alongside an F10 Wing J 35J Draken during the type's swansong in Swedish Air Force service. The Dayglo 50 on the Draken's fin and wings were applied to mark F10 Wing's 50th anniversary on 5th August 1995.

A Gripen on QRA taxies out of a HAS. The ability to operate from austere sites will be of benefit when the aircraft joins the SWFRAP.

JAS 39A Gripens 39165, 39169 and 39173 on the flightline at F10 Wing's Ängelholm base. The infrastructure of the base had to be upgraded and extended prior to the arrival of the Gripen, but the base has since been closed.

Fallen Gripens

The Gripen lost one prototype and one production aircraft during its development. At the time of the second crash only seven aircraft had flown, five single-seat prototypes and the first two production aircraft (one of which was serving as a replacement for the lost first prototype to speed up the already delayed programme). In 1999 the Gripen suffered its first in-service loss; an unfortunate incident since the type would otherwise have had a very impressive safety record of five years without loss.

Comparing these figures to the service life and number of crashes of other Swedish fighter designs makes interesting reading. The J 29 served from 1951 until 1970 and 190 examples were lost in 19 years. The J 32 served from 1955 to 1997 (a small number did continue flying with the FMV until 1999) and 118 were lost in 42 years. The Draken entered service in 1960 and the last squadron was retired at the end of 1998 – 118 lost in 38 years. The Viggen entered Swedish Air Force service in 1971 and will serve until 2003/4 when it will be finally replaced by the Gripen; to date 43 have been lost in 30 years. So far the Gripen compares well with these figures which, apart from the human element, means good value for money.

Gripen Accidents

Loss of the First Prototype

Before prototype 39-1 had flown, false emergency signals from the fuel-burning system had been recorded during ground testing. This problem was to be examined in the air and since Lars Rådeström was responsible for this system, he became the third test pilot to fly the Gripen.

Pressure testing of the fuel system was originally planned for 12th January 1989 with some other tests to be carried out on the 24th. The sixth flight was planned for 1st February 1989 but, because of bad weather, it was postponed until the next day. There would be two chase aircraft flying with the prototype, a J 32 piloted by Arne Lindholm, who had flown the Gripen twice, and an SH 37 piloted by Jård Gisselman.

At 11:27 on 2nd February 1989, during Flight Six, Lars Rådeström crash-landed in 39-1 during his first Gripen flight. Rådeström, who was 44 years old, experienced severe pitching on the approach and so lit the afterburner and tried to go around again. However, the aircraft impacted, broke its left main gear and lost its radome, then bounced, skidded and cartwheeled across the runway.

Fortunately Rådeström was only slightly injured – apart from a broken arm and a severe shaking, he was fine. He had made an attempt to eject but the Gripen had ended up inverted. It was the first crash in Rådeström's entire flying career; to this point he had recorded 4,032 flying hours on various types of aircraft.

It was hoped that the cause of the crash could be found quickly because the on-board recorders were recovered intact, the ground telemetry recordings were also available and there was film material from both Saab and a television station who were filming the landing.

On all of the Gripen'sprevious flights the pilot had experienced problems with lateral oscillations, but on this last trip oscillation in pitch was also noticed.

Saab's test department received some criticism from the Statens Haverie Kommission (Swedish Board of Accident Investigation or SHK) and the FMV because they felt one pilot alone should have built up some experience with the aircraft. Instead, this sixth flight was Rådeström's first; two other pilots had flown 39-1: Stig Holmström (the first three flights) and Arne Lindholm (the fourth and the fifth flights).

On Flight Six the Gripen was carrying dummy wing-tip Sidewinder AAMs and, for the first time, a centreline camera pod which made it more vulnerable to the heavy crosswinds which probably exceeded the limit that Saab had already imposed on the aircraft because of handling difficulties. Indeed the accident investigation commission believed that the crosswinds had exceeded that limit. Saab felt that the accident would influence the flight test programme in a positive way since crashes with new military aircraft have often resulted in improvements.

The SHK noted that there was a great deal of applicable knowledge available at Edwards Air Force Base in the United States and suggested that Saab and the FMV should try to use it to prevent further accidents. In consequence, after the crash Saab was given access to some special expertise that had been built up by the Calspan Corporation and used that company's modified Lockheed NT-33A to introduce some major modifications to the FCS software that was to be loaded into the second Gripen prototype. A test programme was begun which lasted 78 flights and 74.6 flight hours and over 350 landings were made to simulate conditions experienced during the crash landing.

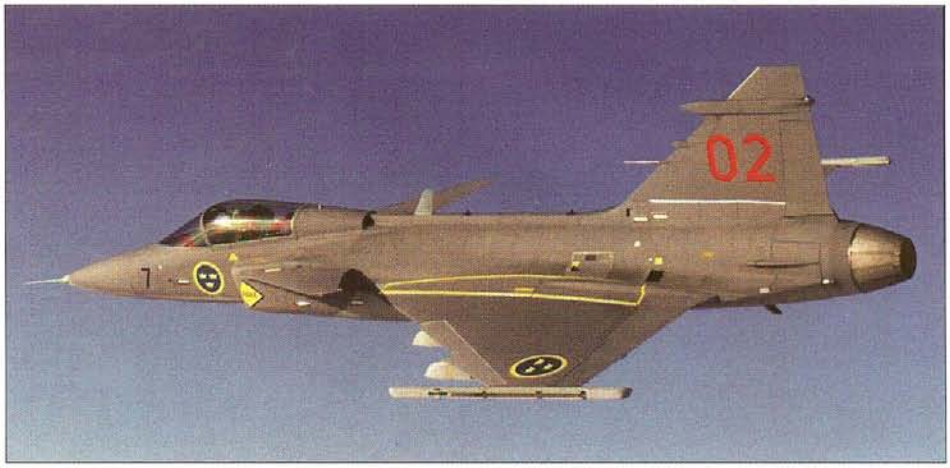
The NT-33A had been used for technological research on many American fighters and also for the Israeli Lavi, which had suffered problems with a very sensitive flight control system, and the Indian Light Combat Aircraft. The big difference with its involvement in connection with the Gripen was that the NT-33A was introduced after the Gripen's flight test programme had begun; other companies had used it to obtain information to try to prevent any accidents with expensive prototypes before their flight testing commenced.

Loss of the Second Production Gripen

On 8th August 1993 Lars Rådeström was involved in another Gripen loss. While flying a display over Stockholm for the Water Festival, his aircraft, JAS 39A 39102, became uncontrollable and he had to eject, which he achieved

The first Gripen prototype on one of only six flights before it crashed.

Early-production Gripens such as 39102 had a very different supplier base than later aircraft. These first-generation Gripens will be brought up to the same standard as later aircraft if the programme to do so is deemed cost-effective.



successfully. Fortunately, although he was flying over the centre of the city which was filled with people who were there for the festival, no one was injured in the accident and for this reason the Gripen was labelled, rather cynically, the safest aircraft in the world!

The aircraft that crashed was 39102 which, two months earlier, had been the first Gripen delivered to the Swedish Air Force; when it was lost it had completed 51 sorties. Rådeström, a Saab pilot who was flying the display because the Swedish Air Force did not have its own display pilot, described the feeling just before ejection as 'just like sitting on a piece of butter on a hot potato'. After the crash, all Gripens were grounded by the Accident Investigation Board until further notice. It was also Rådeström's last flight as a Gripen test pilot because of the 50-year age limit.

On August 18th the SHK published its preliminary findings concerning the loss. The accident was caused by the high amplification of stick movements by the flight control system, in combination with large, rapid stick movements by the pilot. This led to the stability margin being exceeded and the aircraft entered a stall. The main conclusions were:

- The only malfunction before the crash was the electronic map, which had nothing to do with the loss.
- The flight control system, engine and all other systems worked as specified until the aircraft impacted.
- No external cause is suspected.
- The pilot was properly trained and equipped.
- The limits for minimum altitude and maximum angle of attack were exceeded insignificantly and did not have anything to do with the crash.
- The manufacturer and the customer knew that large and rapid stick movements could cause divergent pilot-induced oscillations, but considered the likelihood of it actually happening to be insignificant and so none of the pilots were informed.
- The red warning light telling the pilot that the control system was saturated illuminated too late for him to do anything about it.
- The low altitude, 886ft (270m), made it impossible for the pilot to try to regain control.

On 6th December 1993 the SHK published its final report which confirmed the cause of the accident:

- The flight control computer was severely damaged in the crash but all of the pieces were recovered and the memory circuits identified, which allowed their information to be read properly. This meant that the data from the complete crash sequence was available to the investigators in full.
- The way that the display was planned was not in accordance with the goals stated for the flight test programme and no reasons were stated for the departures made from the pilot's manual.
- The limits set for the display were exceeded by the pilot, although this did not directly contribute to the accident.
- The control laws were complex which meant that there had been problems in fully analysing their function.
- The effects of control surface movement speed limitations had not been fully investigated for the full flight envelope.
- The validation process had not successfully identified the pilot-induced oscillation properties of the aircraft.
- When flying the simulator, less work with the control stick was needed than when flying the real aircraft.
- Simulator studies had shown that it was possible to stall the Gripen at less than 20° angle of attack during similar conditions.
- During a low-speed left turn the automatic roll trim was disconnected, exactly as it was automatically intended to be at angles of attack over 20°. Because of this the control stick had to be kept 2° to the right in order to maintain a constant bank angle.
- The stick movement to the right at the end of the turn was the same as when using the training simulator, but it had begun with the stick already 2° to the right. When the stick reached the end position it led to a higher rate of roll than during training.

The primary reasons given for the second crash were, in brief, the pilot's commands, the properties of the control stick, limits to the control laws and limits to the control surfaces. The secondary reasons were based on the fact that this production-series aircraft differed from the prototypes in certain ways, for which the pilot had not been fully briefed:

1. The aircraft was lighter which gave a higher thrust-to-weight ratio as well as making it unstable in pitch.
2. The control stick required lower input forces.
3. The control stick could be moved to give a larger roll input, resulting in the availability of higher roll rates.
4. The mass distribution was different, requiring the control stick to be kept 2° to the right to maintain constant bank angle when the automatic roll trim system was disconnected.

First In-Service Loss

At 14:22 on 20th September 1999, two JAS 39A Gripens (39128 and 39156) took off from Såtenäs for a routine exercise. They were to perform one-on-one air combat training at low altitude over Lake Vänern. The flight leader was to represent the target aircraft and the number two the attacking aircraft. The target aircraft was supposed to fly at 656ft (200m) altitude and at Mach 0.66 and for this particular exercise it was not to exceed 6g/17° angle of attack during combat manoeuvring; nor was it to start evasive manoeuvring after visual contact had been established with the attacking aircraft.

The exercise began when the two aircraft split formation. The attacker, 39156, quickly established radar contact and, at a distance of five miles (8km), made visual contact and began combat manoeuvres. The two aircraft met head-on several times. After about one minute of manoeuvring the attacking aircraft flew too close to the target aircraft's tail sector, forcing the pilot to to initiate an evasive climbing manoeuvre followed by a steep diving turn at an indicated airspeed of approximately 249mph (400km/h). During this manoeuvre the attacking aircraft flew through the target aircraft's vortices, resulting in an increasingly negative pitch attitude that left the attacker in an almost vertical dive at approximately 3,281ft (1,000m) altitude.

The ground collision warning system was activated but the manoeuvre recommended by the system was impossible to perform at such a low altitude and the pilot decided to eject. Ten minutes after take-off the pilot, 29-year-old F/Lt Rickard Mattson, ejected from his the aircraft about 4.5 miles (7km) from the island of Djura in Lake Vänern. He landed in the water and was spotted by the target aircraft's pilot. Mattson, who had 1,063 career flight hours to his credit with 103 on the Gripen, was rescued at 14:59 by an Hkp 10 helicopter from Såtenäs; at the time the water temperature was 15°C.

The target aircraft, 39128, made it back to base after the fateful mission on 20th September 1998. Disturbances caused by this aircraft most probably caused the faulty warning received by the pilot of 39156.

One of the aircraft's Emergency Locator Transmitters (ELT) was found at a depth of 262ft (80m) below the surface and salvage work began immediately to ensure a full investigation could be undertaken and to prevent other interested parties from obtaining information from the wreckage. Shortly after the preliminary accident investigation report was published, all Gripens were cleared to fly again, it having been established that the cause of the accident was not due to any technical malfunction aboard the aircraft.

This was the third Gripen loss and the first operational casualty and the search for the black box flight data recorder was a long one. By the middle of May 2000, 70% of the wreckage had been salvaged and stored in a maintenance hangar at Såtenäs. On 12th December 2000, shortly after the search for other parts of the wreckage had ended, the flight data recorder was found 50ft (15m) from an emergency locator transmitter. The final total of recovered material accounts for 74% of the aircraft and includes the engine.

The engine was production number 12.121, originally delivered to Saab on 15th November 1994 where it was installed in 39123, the aircraft being delivered to the Swedish Air Force on 7th March 1996. Its total running time had reached 195.3 hours, 97 of which had been made in 39123 including one C-service. For its D-service it was returned to Volvo where it received some modifications, after which the engine was installed at Saab in the brand new 39156.

The aircraft completed seven flight tests before being delivered to the FMV for acceptance trials; four of these flights brought nothing in the way of adverse comments, the others brought some minor remarks but these had no bearing on the crash. The aircraft was then transferred to FMV:PROV and after another 15 flight hours it was sent to F7 Wing.

The aircraft had not received Modification A (ordered well before the aircraft left the assembly line), it being recommended but not compulsory. Mod A comprised some major and minor modifications to production aircraft 39103 to 39176 to bring them up to the final Batch 2 standard. The degree of the work would depend on when the aircraft left the assembly line; 39103 would receive the most extensive update package. By November 2001 all Batch One Gripens had received Mod A.

The Gripen's Markkollisionvarningssystemet (Ground Collision Warning System or GCWS) has four levels of warning depending on the level of danger.

Level A: Arrows show on all indicators (HUD and HDD) with continuous lighting and an oral warning 'pull up' is given three seconds before the pilot has to perform a pull-up manoeuvre using 80% of the available lift power.

Level B: The light now flashes and the pilot has only 1.5 seconds left to perform the pull-up manoeuvre; the acoustic warning is now on maximum volume.

Level C: The time available for pre-emptive action is over. Now it is necessary to pull up with at least 80% of available lift. If the pilot is behaving correctly, ie pulling the right amount of g, the GCWS-symbol will follow the velocity vector up to a safe altitude.

Level D: At this stage a manoeuvre using 80% of the Manoeuvre Load Limiter (MLL) is no longer sufficient. The GCWS symbol (two arrows pointing upwards and connected by a bar at the bottom) starts to grow and the required load factor is presented numerically in the bottom of the symbol. On the occasion of the crash the pilot received a Level D warning with a load factor of over 10g, so he decided to eject.

The research undertaken by the SHK was based mainly on the information found on the black box flight data recorder (FDR). According to the crash report the effect of the vortices and other disturbances from the opposition aircraft disturbed the measurements being made by the instruments that also feed the GCWS. The FDR data showed that the specific warning that was supposed to be issued shortly before ejection should have been Level A or B, and Level C at the time of ejection.

The pilot flew through vortices made by the target aircraft. when he did not receive the requested response from the stick, but instead received a Level D warning from the GCWS with an advised load factor of over 10g, he made a textbook decision to eject. Just prior to this the target aircraft had made what was basically the same manoeuvre but without the problems encountered by 39156.

According to Olof Norén, author of the technical report of the accident investigation report, the most likely cause of the non-design behaviour of the GPWS was a pressure disturbance around the secondary pitot placed halfway on the vertical fin. The SHK made ten recommendations to the FMV:

1. A study should be undertaken to examine flight through all types and size of vortices and the effects they have on the Gripen's flight characteristics. Priority should be given to aircraft drop with heavy manoeuvring and to an atmospheric model that indicates the strength of the vortices. The results and experience gained during these studies should be mentioned in the Gripen flight handbook and explain clearly the consequences of aerodynamic disturbances caused by vortices.
2. The FMV should investigate GCWS functioning in extreme turbulence and vortices and any changes should be entered in the Gripen flight handbook.
3. The FMV should ensure that the knowledge gained is included in pilot training.
4. A risk analysis should be made for the training manual.
5. The FMV should ensure that the arm restraint system on the ejection seat is improved so that it complies with design demands.
6. The liferaft battery should be changed to one better suited to Swedish conditions (ie, lakes with low levels of salt).
7. The FMV should ensure that the correct training procedures and equipment are introduced for emergency ejections.
8. The FDR should be housed in such a way that it does not break in an emergency and an ELT should be incorporated in it to ensure that the FDR can be found more easily.
9. The FMV should re-examine the variables that should be recorded by the FDR, and at what intervals they should be recorded. This would help future accident investigations. An increase in FDR memory was advisable to back this up.
10. The FMV should replace the current Hi-8 video system with new equipment that will not be damaged by water.

Chasing Sales

On 11th February 1994 the British and Swedish Ministers of Defence, Malcolm Rifkind and Anders Björck, signed a Memorandum of Understanding in Stockholm to provide a framework for the two countries' defence industries to work together in developing and marketing existing and new programmes. This paved the way for further negotiations and co-operation and in early 1995 Saab found its Gripen partner in British Aerospace.

A marketing agreement was signed to develop the Saab Gripen for the export market on June 12th 1995, at that year's Paris Air Show, and BAe become the biggest foreign partner in the programme. BAe had a much broader customer base with a wider marketing reach and 55% of the work for any export Gripen was to be carried out by Saab and 45% by BAe. The aircraft was no longer marketed as the JAS 39 Gripen, but instead just Gripen. The co-operation did not stop there; in 1998 British Aerospace bought a significant portion of Saab, giving the British company a greater motivation to promote the aircraft.

For airshow performances and other flight demonstrations in support of the export drive, 'Smokewinders' are used to help onlookers track the aircraft during its manoeuvres.

On 3rd September 2001 it was announced that the joint venture between Saab and BAE Systems (formerly British Aerospace) had been brought into a single company called Gripen International with offices both in Sweden and the UK. However, that announcement was somewhat premature since the change was not implemented until 2002.

Australia

The Australian government began its search for a new defence system in May 1999, not just to replace its F-111s and F/A-18s but in fact the entire defence structure which was considered to be too expensive. The requirement was called AIR 6000 and on 31st January 2002 Saab announced that it had answered the Australian Ministry of Defence's request for information with the new Network Centric defence structure that combined the Gripen and UAVs working together. The system would be introduced in 2012 and Saab pointed out that it was cheap and saved money even during peacetime operations. The F/A-18 was to be withdrawn from Royal Australian Air Force service between 2012 and 2015; the F-111 would survive to between 2015 and 2020.

Other aircraft under consideration were the Typhoon, Rafale, F/A-18E/F Super Hornet, the latest Block 60 F-16C Fighting Falcon, F/A-22 Raptor, F-15C Eagle, F-35 (JSF) and an unspecified aircraft from Sukhoi. In the end the Australian government announced that it had decided to join the JSF programme, the official view being that JSF would possess capabilities that none of the other contenders had.

Austria

Austria could be called Saab's most faithful customer since the Österreichische Luftstreitkrafte (Austrian Air Force) has previously used in its inventory the J 29 Tunnan, the J 35 Draken and the Saab 105 jet trainer. When Austria bought the Draken in 1985, Sweden was already preparing for the JAS 39 and, looking to the future, Saab stated that the new fighter would be the ideal aircraft to replace the Drakens. The Draken deal included a considerable degree of offset work which, in early 2002, was estimated to have reached a value worth over 160% of the original contract.

During the 1990s the Austrian defence budget was cut back severely and in 1999 the Austrian Chief of Air Staff, Brig Josef Bernecker, thought that it was unrealistic to expect a Draken replacement before 2005 since elections were planned in Austria at the end of the year.

To help the Austrian Drakens last until 2005, five more examples from F10 Wing at Ängel-

Single-engined	Mikoyan MiG-21*bis*	Hawker Hunter	Dassault Mirage III	Atlas Cheetah	F-16A Fighting Falcon	Saab J35J Draken	Saab JAS 39 Gripen
Empty weight, kg (lb)	5,450 (12,015)	5,501 (12,128)	7,050 (15,542)		7,070 (15,586)	8,250 (18,188)	6,622 (14,599)
Max take-off weight, kg (lb)	8,725 (19,235)	10,885 (24,000)	13,700 (30,203)		16,057 (35,400)	12,270 (27,050)	12,473 (27,498)
Internal fuel, litres	2,880	2,390	2,288		4,000	3,000	
Max external fuel, litres	1,750		3,400	3,400		5,000	3,300
Max ordnance, kg (lb)	2,000 (4,409)	3,357 (7,400)	4,000 (8,188)	4,000 (8,188)	5,443 (11,142)	2,900 (6,393)	6,500 (14,330)
Engine thrust, kN (lb)							
dry power	40,2 (9,038)	4,600kg (10,150)	41,97 (9,436)	49,03 (11,023)		56,89 (12,790)	
with afterburner	69,7 (15,653)		60,80 (13,668)	70,82 (15,873)		78,51 (17,650)	
Ferry range, km (miles)	1,470* (913)*	2,965 (1,840)	4,000 (2,486)		3,887 (2,415)	2,840 (1,765)	3,500 (2,174)
Operator	Czech, Poland	Switzerland	Brazil	South Africa	Netherlands Norway	Austria	Sweden

Twin-engined	Cessna Dragonfly	Northrop F-5E Tiger II	Mikoyan MiG-29 *Fulcrum*	McDonnell Douglas F-18A	Saab JAS 39 Gripen
Empty weight, kg (lb)	2,817 (6,211)	4,349 (9,558)	10,900 (24,030)	10,455 (23,050)	6,622 (14,599)
Max take-off weight, kg (lb)	6,350 (14,000)	11,187 (24,664)	18,500 (40,785)	22,328 (49,224)	12,473 (27,498)
Internal fuel, litres		2,563	4,300	6,140	3,000
Max external fuel, litres	1,512	3,120	3,800	7,710	3,300
Max ordnance, kg (lb)	1,860 (4,100)	3,175 (7,000)	3,000 (6,614)	7,711 (17,000)	6,500 (14,330)
Engine thrust, kN (lb)					
dry power	2x12,68 (2x2,850)	2x15,5 (2x3,500)	2x49,42 (2x11,111)		12,141lb
with afterburner	No afterburner	2x22,2 (2x5,000)	2x81,39 (2x18,298)	2x71,2 (2x16,000)	18,105lb
Ferry range, km (miles)	1,628+ (1,012+)	3,720 (2,314)	2,100 (1,305)	2,130 (1,323)	3,500 (2,174)
Operator	Chile	Brazil	Hungary	Australia	Sweden

From the outset, the JAS 39 Gripen was intended to replace second and third-generation fighter aircraft, starting with the Swedish Air Force's remaining Drakens and Viggens. To meet this aim, the Gripen's weight class and number of engines were important factors in helping to keep costs down without losing operational capability and versatility. The tables (left) compare the Gripen to single-engined and twin-engined second and third-generation aircraft operated by a number of different nations around the world and identified by Saab and Gripen International as potential customers for the Gripen. Over the years, much effort has been put into trying to secure export orders to help defray the Gripen's development and production costs.

holm were transferred in late May/early June 1999 and were stripped for desperately needed spare and structural parts. In the meantime, to help with pilot training, an exchange programme was introduced with F21 Wing in Sweden whereby each Austrian Draken pilot would fly 100 hours on the Viggen, a third-generation fighter that was more modern and up to date than Austria's Drakens.

In March 1997 an Austrian Air Defence pre-evaluation team, made up of two pilots and a flight engineer, flew a total of nine sorties in the JAS 39B Gripen two-seater and logged about 50 hours in various tactical and technical simulators at Saab. Brig Gen Erich Wolf, who had flown all the competing aircraft (Mirage 2000-5, F-16C/D, F/A-18C/D) said that the Gripen was beyond comparison with the elderly Draken. Each pilot completed four flights with Gripen test pilot Ola Rignell in the back seat.

Sweden and Austria also worked together in other ways. Austrian Air Force weapon training is only possible outside Austria and so between 15th September and 6th October 1998 this was performed over Sweden's Vidsel test range, the missions being flown from Ängelholm. This was not the first time that the Austrian Air Force had used the Vidsel range having also completed its annual practice there in 1990, 1991 and 1993.

On 30th June and 1st July 2000, an airshow held at Zeltweg Air Base in Austria included in the static display Gripen 39141 while other Gripens to visit the show were 39162 and 39172. Saab was committed to making a favourable impression in Austria.

In 2000 an ultra right wing party formed Austria's new government but, although the political ties between the countries were reduced, the Austrian and Swedish air forces continued to work together, which meant Austrian pilots still trained in Sweden.

However, Herbert Scheibner, Austria's new Defence Minister, recognised that the Draken was way past its useful life and needed replacing. He stated that five aircraft were in competition for the requirement (F-16C/D, F/A-18E/F, Mirage 2000-5, MiG-29SMT and the Gripen), and that he would prefer new equipment. All the aircraft had been test flown by the Austrian Air Force and two (Mirage 2000-5 and Gripen) in Austria itself.

The decision as to which type was to be acquired would be made before 4th February 2001 and, because Austria would need its new fighter immediately, an interim type was also required. Saab proposed the Viggen, on which some Austrian pilots had trained already, and after the transition period the Austrian Air Force would receive Batch Three-standard Gripens.

A Request for Information was sent to SAAB-BAE Systems for Gripen, to Dassault for the Mirage 2000-5, Lockheed Martin for the F-16C/D and Boeing for the F/A-18E/F. In mid-January 2001 an invitation to bid was also belatedly sent to Eurofighter. Answers were expected by the end of March 2001 and, according to Bernecker, now Commander-in-Chief of the Austrian Air Force, it was not reasonable to exclude any aircraft from the competition, although he left no doubt that he favoured the Gripen.

On 22nd January the Swedish team submitted provisional information based on 24 single-seat and 6 two-seat Gripens with pilot training either in Austria or, as with the Draken pilots, in Sweden. Austrian Draken pilot training had stopped after the retirement of the F10 Wing Draken squadron which made the replacement even more urgent – Austria could no longer train any pilots for its Drakens.

The Austrian press speculated that 30 Gripens would cost 21,000 million Austrian Schillings. Meantime, Dassault took itself out of the running while Eurofighter promised delivery of the first aircraft in 2004, which meant that if Austria chose the Eurofighter it would enter Austrian service before ahead of the four partner nations' air forces.

A public opinion poll of almost 50% of the population revealed that investments in defence were felt to be worth it if Austria wanted a serious defence capability, but almost 42% of the population thought it was all a waste of money since there was no real threat to Austria.

On 18th April 2001 Austrian President Klestil visited Swedish Prime Minister Göran Persson in Sweden and mentioned during a press conference that the Draken replacement would be chosen in the autumn, and that the choice had narrowed to the Gripen and the F-16C/D.

Bernecker told the press that the Bundesheer was getting impatient because the risk of keeping its Drakens in service for so long was a fairly irresponsible thing to do – the sooner the Drakens were replaced the better. This supported the then Defence Minister's policy while at the same time forcing Sweden's aerospace industry to push the politicians because it was afraid that the best deals would be lost to others in the fighter competitions under way in nearby Poland and the Czech Republic.

However, on 18th June the Austrian Finance Minister, Mr Grasser, dropped a bombshell when he declared, loud and clear for everybody to hear, that there was no money to replace the Drakens and that the decision on acquiring a new fighter should be postponed until the next government term, in 2005.

This announcement was a slap in the face for Defence Minister Scheibner and the political shuffling went on for some months before a conference of the Landesverteidigungsrat (basically the country's Defence Council) was called for 9th July 2001. It had no real decision-making power but important and influential people had to give their opinions on Austria's defence needs. The Landesverteidigungsrat voted to acquire a new fighter and so Scheibner was able continue on schedule and issue a Request for Proposals to the five companies on 10th October 2001.

The contenders were given until 23rd January 2002 to reply; their proposals would then be studied for about a month, after which two short-listed finalists would be given the chance to make final best offers. The final decision would be made by the end of the first quarter of 2002.

An interim aircraft was still necessary while the required offset deal was for 200%, which according to some experts was too high. Gripen International, however, stated that it was possible. At this time the Austrian press revealed that the Austrian Air Force had only 8 to 17 airworthy Drakens from the 23 in the inventory; a replacement fighter was now more urgent than ever.

On 24th January 2002 Gripen International held a press conference in Vienna to tell the Austrian media about its offer to their government. In fact there were two options: one for 24 single-seater Gripens and an optional six two-seaters plus 12 Gripens offered on lease as the interim aircraft; the other for 24 single-seat and four two-seaters to an earlier, undefined delivery date that removed the need for a lease agreement.

The first of the Gripens would be in service before the Draken was retired and the first operational squadron was planned for 2005, either with leased or newly bought aircraft depending on Austria's chosen option. Austria could also be a part of any future Gripen enhancement programme. The Gripens would have an air-to-air refuelling capability, the best available datalink and the capability to operate with international forces. If Austria chose the second option the Swedish Air Force would voluntarily defer the delivery of its own Gripens to a later date.

Three contenders, Eurofighter, Lockheed Martin and Gripen International, were each invited to submit a best and final offer, which they did by 30th April. Gripen International's amended offer included modified offsets, earlier delivery dates and alternative financing; the early deliveries were possible due to the excellent relationship between the Swedish and Austrian air forces.

On 2nd July 2002 the decision was finally announced and, against all expectations and press reports, the winner was the Eurofighter. Scheibner said that the most modern fighter had been chosen and that the first examples would be delivered in 2005. From the first quarter of 2003, six Eurofighters would be made available to the Austrian Air Force so that pilots could train on the type; consequently the Draken would be retired from service from 2003.

Photograph on the opposite page:

Two of the Austrian Air Force's elderly J 35OE Drakens lead a trio of F7 Wing Gripens. Because of its history as a Draken operator, Austria was considered a perfect customer for the Gripen. Unfortunately, and somwhat suprisingly, Austria has chosen instead to order 18 Eurofighter Typhoons.

Since then, however, the cost of clearing up after heavy flooding in Austria and much of Central Europe has forced the country's government to cut the number of Eurofighters to be bought from 24 to 18.

Another problem arose for the Eurofighter consortium when on 21st November 2002, the DA6 two-seater prototype crashed in Spain as a result of a double engine failure. What effect this loss may have on the flight test programme and production schedules and deliveries remains to be seen

Because forming the new Austrian government took some time to complete, EADS extended the date by which Austria had to confirm its intent to buy Eurofighters. Gripen International subsequently made a new offer of 18 aircraft. In March 2003. Defence Minister Gunther Platter, who had previously worked for Defence Minister Fasslabend, stated that he would prioritise analysis of all the relevant information so as not to prolong the acquisition process unnecessarily, and then proceed with the acquisition of a Draken replacement.

Al the Paris Air Show in June 2003, Gripen International stated that they were still hopeful of a change in Austria's choice of fighter, and pointed out that to date the Gripen is the only fourth-generation fighter to have won export orders. However, Gripen International's hopes were dashed on 1st July 2003 when, just a day after the four partner nations had declared Eurofighter ready to enter service, the Austrian government signed up for 18 of the aircraft at a value of 1.98 billion euros. The first four aircraft will be delivered from mid-2007, 12 in 2008 and the final two in 2009.

Brazil

In the 1970s, thanks to concerns about regional instability, American President Jimmy Carter put Latin America under a strict United States arms embargo. At the time, dictators were ruling most Latin American countries and, as a result, the region was considered to be unstable. The embargo was broken only once, in 1982, when the United States sold 24 F-16A/Bs to Venezuela, which had successfully argued that Cuba was a real threat to its territory.

The embargo also affected Brazil which therefore had to look to countries that were not linked to the United States. The result was that Brazil purchased French Dassault Mirage IIIs.

By the mid-1990s the Mirages were old and needed replacing. With this in mind, Brazilian officials attended the final trials that led to Gripen being declared operational in Sweden.

At the FIDAE exhibition in 1998, Saab-BAe took the chance to show the Gripen to Brazilian politicians and military staff. However, in late October 1999, the French aerospace industry bought 20% of the Brazilian manufacturer Embraer in a deal which, it was thought, might help the export chances of the Mirage 2000-5. The Força Aérea Brasileira (Brazilian Air Force) was unhappy with the privatisation of Embraer and the situation became very political.

There was a good relationship between the Swedish and Brazilian air forces which allowed an exchange between these organisations, this including two pilots and two technicians of each service who trained and worked with the other service. The Brazilians had also bought the Erieye AEW system which, because certain of its systems were compatible, would be easier to integrate and better able to communicate with the Gripen. However, because some 30% of the Gripen is US-made, any overseas sale would require US State Department approval, which reduced the aircraft's export prospects; sales to an South American countries would certainly be a problem.

In early July 2000, after a trip to Brazil and Chile where he spoke to Brazilian Defence Minister Geraldo Magela Quintao, Swedish Defence Minister Björn von Sydow stated that the chances of exporting the Gripen to these countries had improved. On 13th July Brazilian President Fernando Henrique released US $3,000 million for Brazilian Air Force spending up to 2007. One objective was to replace the remaining F-5E/F Tiger IIs and Mirage IIIs in the inventory – the Mirage III was expected to be retired in 2005 while the programme to replace the F-5 was called the FX. The seven contenders were the Block 50 F-16C/D, F/A-18E/F, Mirage 2000-5 Mk.2, MiG-29SMT, an Su-27 variant, Eurofighter and Gripen.

The Gripen was felt to have insufficient internal fuel capacity which led to the rumour that Brazil would buy the two-seater and contract Embraer to add extra fuel tanks in place of the rear cockpit.

A Request for Proposals for up to 24 fighters was issued on 1st August and the favourite was thought to be the Mirage 2000BR (a Mirage 2000-5 specially adapted for the Brazilian Air Force), with final assembly transferred to Embraer. Answers were due by 1st October, after which a shortlist of three would be drawn up, with the final decision due in 2002; one condition was 100% offset.

It was expected that the winner would get some repeat orders at a later date because the Brazilian Air Force needed more than 24 fighters; these repeat orders were a very important aspect and so for the contenders the stakes were high. It was, however, deemed unnecessary to have any Gripens at the FIDAE 2002 exhibition.

During April 2002 a Brazilian team visited Linköping to evaluate the Gripen; shortly after, on 20th May, the final bids were due. Like Dassault with Embraer, Sukhoi had teamed with the Brazilian company Avribas and offered final assembly of an Su-27 variant in Brazil. The various proposals are now being studied – the Brazilian Air Force considers that Dassault and Sukhoi would be favoured because of the promise of final assembly, but there is speculation that the Gripen may have a good chance because both Dassault and Sukhoi may have problems with offset agreement, something that does not worry Gripen International.

Immediately after the elections the tender for the new fighters was delayed by a year as the president thought that the money could be better used for social matters.

Chile

Chile is another of the Latin American countries affected by the US arms embargo since 1977. It too was dependent on countries willing to undermine it – business with Israel was the natural result in the form of updates to Fuerza Aérea de Chile (Chilean Air Force) F-5Es and Mirage 50s.

In April 1994 Gen Carlos Alvarez Kraemer announced that the Chilean Air Force needed to replace its Hawker Hunters and then, by 2005, its Cessna A-37B Dragonflies. The Hunters were replaced by second-hand Mirage 5s from Belgium while the most oft-mentioned candidate to replace the A-37Bs is the Gripen.

Saab noted at the 1993 Paris Air Show, before its partnership with BAe was established, that Chile was a prospective future customer for the Gripen. In 1994 Saab participated for the first time at the 8th FIDAE in Santiago de Chile, taking a mock-up of the Gripen cockpit to the show; two years later Saab, now in partnership with BAe, attended the 9th FIDAE with a full-size mock-up of a complete Gripen painted blue. Chile did not want to be dependent on the US and so refused to consider or evaluate the F-16 and F/A-18.

When Peru bought second-hand MiG-29s and Su-25s from Belarus in late 1996, it was a major shock to both Chile and the United States, the latter realising that here was another region in which it could not necessarily influence the acquisition of advanced military equipment to its advantage.Chile has to defend itself against two scenarios: attack from Argentina in the west and invasion from Peru in the north – and Peru now had the best air force in the region.

In 1997 the Chilean Minister of Defence Edmundo Peréz Yoma visited Stockholm to meet his counterpart Björn von Sydow, and on 28th May they signed a defence co-operation agreement. United States arms producers like Lockheed Martin and McDonnell Douglas had begun putting pressure on Washington to allow them to export their aircraft, which in turn helped the Gripen. Chilean military officials said that French and Swedish jets remained the more likely to be selected, but that if Washington relaxed its weapon embargo the Gripen stood little chance.

In September 1997 a Chilean evaluation team under the command of General Marcos Meirelles visited Linköping. Twelve flights were made in a Gripen, ten being flown by Chilean pilots in the front seat with Gripen test pilots in the back; General Meirelles became the first Chilean to fly the Gripen. On 14th October the Commander-in-Chief of the Chilean Air Force, Gen Fernando Rojas Vender, visited Linköping and flew in a Gripen with Saab pilot Reino Lidvik. In January 1998 the Swedish Prime Minister visited Chile and met President Eduardo Frei and his Defence Minister.

Saab took two single-seat Gripens (39132 and 39133 from the Swedish Air Force inventory) to the 10th FIDAE in Santiago de Chile between 23rd and 29th March 1998. The Gripens were shipped to Chile, transported to an airport and from there flown to Antofagasta Cerro Moreno (brown mountain) Air Force Base in northern Chile. From there they flew to Santiago. One Gripen went on static display while the other performed flight demonstrations.

Because Chile and Brazil were showing interest in the Gripen, this was the biggest Saab-BAe presence to date at any airshow. It was also the first visit of the Gripen to the southern hemisphere and Saab introduced Frederik Müchler as the alternative international air display pilot to Ken Lindberg. Other Saab pilots present were Berndt Weimer, Reino Lidvik and former chief test pilot Stig Holmström. After FIDAE the two Gripens left for Anápolis in Brazil for display to more military and political officials.

At a press conference given in the Saab-BAe chalet, Swedish Air Force Commander-in-Chief Kent Harrskog reported that the Gripen cost some SKr 16,000 for each flight hour compared to the Viggen's figure of SKr 30,000. To the claim from some publications that it was not 'macho' to fly the Gripen, Harrskog was blunt: 'Stupid – it is a lot less macho to be shot down by a Gripen'.

During FIDAE, Gen Fernando Rojas Vender said that the choice of a new fighter would be made in May 1998. High-ranking officers from Brazil, South Africa and Poland also visited the Gripen during the show.

A Summit of the Americas was held in Santiago from 16th to 20th April 1998, during which representatives from the Clinton administration cast doubt on the possibility that it would allow the AIM-120 AMRAAM to be sold to any Latin American country. Such a move would affect the Gripen's chances.

The Chilean fighter decision was suspended at the end of June 1998 as a result the economic crisis in South-East Asia; which type would have won the contract is unknown. In May 1999 the bidders were asked to renew their offers and the process began again.

Saab took more aircraft to FIDAE 2000, held from 27th March until 2nd April, than it had ever taken to a show before – two single-

Hans Kruger of Saab congratulates Commander-in-Chief of the Chilean Air Force General Fernando Rojas Vender after his flight in the Gripen in October 1997.

Gripens attended FIDAE 2002 in strength: two JAS 39As and one JAS 39B. The two-seater was used to fly Chilean Air Force representatives as well as their counterparts from the Brazilian Air Force, long thought of as a potential customer for the Gripen.

JAS 39B 39803 takes off from Santiago de Chile during FIDAE 2000 for a photo-shoot over the Andes. Note that the aircraft is armed, not normally the case when the Gripen is giving its display flights, and carries 'Smokewinders' to enhance its flight demonstrations.

Photographs on the opposite page:

The Andes Mountains provide a dramatic backdrop for these Gripen's participating in FIDAE 2000.

seaters (39166 and 39174) and one two-seater (39803); this was also the first time that the two-seater had been to the southern hemisphere. The aircraft were taken by ship to Brazil and from there flown to Santiago. (Two years earlier, the Gripens had been shipped direct to Chile through the Panama Canal, but this brought some minor problems because all of the explosives had to be removed from the aircraft, including the ejection seats; this was the rule when passing through the Canal.)

The two-seater was put on static display but whenever an official of the Chilean Air Force was granted the opportunity to fly the Gripen, it was towed out of the static park and used for the demonstration flight. According to Saab, about 85 Gripens had now been delivered. The Chilean Air Force's short-term need was for 6-12 aircraft, and the long-term need 30-40.

General Rios, Commander-in-Chief of the Chilean Air Force, undertook a European tour shortly before the Farnborough Air Show and flew in the front seat of a two-seat Gripen when he visited Saab on 18th July. Björn von Sydow visited South America in early July and on his return expressed the opinion that the Gripen's sales prospects had improved.

However, in January 2001 the Chilean government confirmed that it had chosen the Lockheed Martin F-16C/D to meet its needs. There remained doubts about the carriage of AMRAAM on the F-16 – if the sale of the missile was blocked by the US government, would another aircraft take its place? At this time the European Meteor AAM had not been tested on the Gripen and the question remained as to whether this combination would be ready in time to fill the Chilean requirement.

Another option for the Gripen team became available, however, when the South African Kentron Company displayed its new V4 MRAAM which had just entered service with the South African Air Force. This weapon was going to be integrated with the Gripen and South Africa would have no problems exporting to South American countries. All hopes for Gripen International, however, were finally killed off when the Chilean government signed for six F-16Cs and four F-16Ds on 1st February 2002, to be delivered from 2005 onwards.

Czech Republic

In 1985, when Mikhail Gorbachev came to power in the Soviet Union, no one would have believed that 15 years later three Warsaw Pact countries would join NATO. The 'velvet revolution', as it was called, took place in 1989 and started a reorientation towards Western Europe and NATO.

During the early post-Eastern bloc years, Czechoslovakia's political problems were primarily internal and the splitting up of the country became politically unavoidable. On 1st January 1993 Czechoslovakia was divided into two new states, the Czech Republic and Slovakia, and the armed forces were shared out on a basis of two to one in favour of the Czech Republic. The Czech Republic ended up with many of the MiG-21s, Su-22s, Su-25s and a dozen MiG-29s. The latter were sold, which left the Czech Republic with only second-generation fighters all of which needed replacing.

During the 1993 Paris Air Show, Saab, prior to its partnership with British Aerospace, confirmed that it was targeting the Gripen at some former Warsaw Pact countries, one of which was the Czech Republic. These countries were seen as cash-strapped and incapable of buying an expensive fighter aircraft but the Gripen was a light fighter, cheaper and thus possibly affordable.

A telling indication of the Czech Republic's cash shortage was the average number of flying hours achieved by České Létectvo A PVO (Czech Air Force) pilots each year, the figure having dropped to less than 50 during 1998. During 1999 the level had to increase to an average of 80 hours, and even more during each succeeding year, to ensure that pilots reached the minimum number of flying hours required by NATO. The Czech armed forces also had no money for spare parts and aircraft had to be cannibalised to keep others flying; both of these factors led to accidents.

The Gripen had a cost curve that was going down compared to previous fighter generations in the same category which gave it a good chance in the Czech competition. During 1996 the then Prime Minister Vaclav Klaus acknowledged that the Czech Air Force needed a replacement fighter and when Saab and BAe formed their partnership to promote and export the Gripen, the aircraft's chances of success were thought to have considerably increased due to the strong historical connections between the UK and the Czech Republic.

The marketing effort increased during 1997 and on 9th, 10th and 11th May three Swedish Air Force Batch One Gripens, 39120, 39124 and 39125, visited the IDET airshow. This was the first visit by the Gripen to the Czech Republic and 39124, piloted by Ken Lindberg, flew in formation with two Mil Mi-24 *Hind* helicopters from the Czech display team. Gripen 39120 stood in the static display while 39125 acted as the spare flight aircraft. Afterwards a Czech magazine wrote that the Gripen in Czech colours would look good for the Gripen and for the colour scheme.

In August the Gripen team inspected Čáslav Air Base, likely to be the home for the first examples of any new fighter. During the last weekend of the month, the Saab-BAe Gripen team were busy attending the Czech Air Force's 80th anniversary celebrations at Hradec Králové Air Base, the Gripens present being 39132 and 39133. The previous Wednesday, both aircraft had visited Romania before leaving for a special demonstration to Czech Air Force pilots on the Thursday and Friday.

On 27th October the Chief of the Czech Air Force, Ladislav Klima, flew the Gripen for the first time; Klima was the first Czech pilot to fly the type and the second Chief of Staff of a former Warsaw Pact air force to do so. The next day, Major General Pavel Strübl flew the Gripen; he was one of three Czech pilots nominated to evaluate the type (another group had already evaluated the F/A-18 Hornet in December 1996).

At this time, however, there were plenty of doubts regarding any purchase of new aircraft, opposition parties in the Czech parliament suggesting that the government should wait and see first what role would be assigned to the

JAS 39B 39803, configured for the air defence mission, breaks away from JAS 39A 39174 during their attendance at FIDAE 2000. The deployment of the two-seater allowed pilots and representatives of the Brazilian and Chilean air forces to fly the Gripen.

army by NATO (which the Czech Republic was to join in 1999).

On 12th March 1999 the Czech Republic along with Hungary and Poland became the three newest member states of NATO. Reports suggested that the Czech Republic was about to issue a Request for Proposals for the acquisition or lease of 36 fighters to be delivered from the 2003 (apparently the joint Czech Republic-Hungary-Poland agreement was no longer valid).

By the end of March, Peter Wallenberg and a group of Swedish businessmen had visited the Czech Republic to see what kind of offset deals were possible should the Gripen be chosen. According to Wallenberg, the visit was also necessary because of a lack of Swedish investment in the Republic. Major General Kazimierz Dziok, Commander-in-Chief of the Polish Air Force, also reported that he and his counterparts in the Czech Republic and Hungary favoured the same choice of aircraft for a MiG-21 replacement.

In fact the decision to buy a new aircraft was delayed by the early fall of the Czech government and an RFI for up to 36 fighters was not issued until 19th May 1999, by which time the required 2003 delivery date was near impossible to achieve. According to the Czech Minister of Defence, Vladimir Vetchy, deliveries would begin in 2004.

Many were surprised when the Eurofighter consortium was invited to submit a proposal because, the fighter being seen an unlikely contender because of the Czech Republic's financial problems. The Czech government however, wanted to consider all of the options and the other contenders included the Mirage 2000-5, F-16C/D, F/A-18C/D and the Gripen. Replies were requested by the end of September.

The annual Czech International Air Fest was held in early September 1999 and Gripen 39163 took part in both the static and flying displays. The flying routine was split into two parts; the first was flown in 'clean' configuration before the Gripen landed and was rearmed by conscripts within ten minutes, after which it took off again and completed the second stage in an armed configuration.

In March 2000 it was announced that BAE Systems was to sign an MoU for pre-offset deals connected to the acquisition of Gripens. The contract was to be signed on 14th March and was seen as a sign that the type was the favourite for the Czech Republic order. A couple of months earlier, British Prime Minister Tony Blair had sent a letter to Miloš Zeman, the then Prime Minister of the Czech Republic, promoting the Gripen, it being standard practice for politicians to support products from their own national defence industries. There were unsuccessful attempts to make a scandal out of this support; both Boeing and Lockheed Martin protested, saying that this was unfair competition (although some American companies later signed a similar document).

On 15th March 2000 the Czech Security Board voted that there was a real need to buy new fighters and the Czech government agreed to discuss it in parliament on 15th April; parliament, however, decided that more information was needed. The Czech Defence Minister made an official three-day visit to Sweden from 16th April and visited Såtenäs to take a close look at the Gripen.

On 10th May parliament agreed to buy a new fighter and an official tender was to be issued before year's end. Prime Minister Miloš Zeman said that he expected a minimum 150% offset programme for Czech industry which needed this kind of investment very badly. The Finance Minister had until September to draw up the arrangements to pay for this acquisition.

During this period, DASA and General Dynamics signed an agreement with the Czech government similar to the Saab/BAe document of 14th March. Furthermore, the US dollar rose in value against the Czech Kroner (CzK), making a batch of Aero L-159s on order to replace Su-25s so expensive that the Czech military could not afford to buy anything else (parts of the L-159 contract with US suppliers were negotiated and signed without any exchange rate protection).

It was becoming increasingly whether or not the Czech government was going to continue with the tender to find a replacement for the MiG-21s, although one Czech pilot present at the Farnborough 2000 Air Show stated that the need for a new fighter was urgent since only 7 of the 30 MiG-21s based at Čáslav were technically capable of flying. He also said that Czech test pilots favoured the F/A-18 and the Gripen but that Eurofighter was an unrealistic option.

Boeing, however, realised that the F/A-18E/F Super Hornet option would be too expensive for Eastern Europe and so came up with the idea of marketing second-hand F-15 Eagles currently in desert storage. The F-15 was, of course, more expensive than the F-16 and the Gripen but, according to Boeing, the user would need less aircraft. The variant was called the F-15R (R for Renewed) and at the Hradec Kralové airshow on 2nd September 2000, Lt General Klima got the chance to fly an F-15D that Boeing had sent specially for this purpose.

In January 2001 the Czech Republic finally issued its Request for Proposals for 24 or 36 fighters with a minimum 150% offset of which 60% had to be defence related. Answers were to be received by 31st May 2001 which would give the government until October 2001 to make its decision. The Czech government however, acknowledged that the economic situation could threaten the entire project, so the financial element of each offer was going to weigh very heavily in their consideration.

A US government official also stated at the end of March that the United States might pull out of the tender if the Czech government did not change its stipulation that the bids had to be submitted in the Czech language and with all costings in the Czech currency (the United States usually makes overseas military sales in US dollars). In truth the Czech Defence Ministry had been badly hurt by the dollar contract on the L-159 and wanted to avoid a repetition.

On 23rd May 2001 it was officially announced that both Boeing and Lockheed Martin were pulling out of the tender, but Prime Minister Miloš Zeman told the press that he saw no reason for cancelling the project just because the Americans had withdrawn – there was speculation that Zeman favoured the Gripen. The next day both EADS and Dassault also dropped out, leaving the Gripen as the sole contender.

In the meantime the opposition ODS party's shadow defence spokesman Petr Necas had stated that the tender should be postponed because the government had more urgent things to do than buy fighters. Zeman countered by pointing out that it was the ODS that had initiated the process in 1997 when they were in government.

On 31st May 2001 the only response that complied with the Czech requirements was submitted by Saab/BAE and since the Gripen team was the only survivor the company took the unusual decision to publish the details of their offer during a press conference held on 5th June. The offer was for either 24 or 36 aircraft with the first delivery in 2004. The details mostly concerned the offset deal or, in their own words, the benefits to the Czech Republic, which were:

- Delivery of 150% offset within ten years according to the regional and industrial priorities set out by the Czech government.
- Offset programme targeted to meet the strategic objectives of the Czech Republic.
- Offset benefits amounting to 50% of the total contract value (the total value was not given) committed within two years of contract signature.
- Economic benefits from offset generated ahead of finance repayments.
- Significant repayments for long-term finance package deferred until 2006.
- 85% of financing provided by a consortium of international banks under an export credit loan supported by both the United Kingdom and Swedish governments.
- The remaining 15% of financing funded by a local currency loan through a consortium of Czech banks. Financing repayments to be made will be less than 5% of the total at the time of first delivery in 2004.
- Payments spread over 15 years, to minimise impact on the Czech national economy.
- Provision for foreign exchange risk protection.
- Finance package tailored to assist the Czech Republic's ambitions to secure European Union accession in 2004-05.
- Optional parallel commercial loan for amount equivalent to 15% of contract value at attractive interest rates, to reduce debt and deficit levels by replacing more expensive loan facilities.

Besides the benefits to the economy, there were reasons why the Czech Air Force wanted the Gripen (Chile, for example, said that it wanted a fighter aircraft, not an offset programme). According to Saab/BAe, the specific benefits of the Gripen for the Czech Air Force were:

- Delivery of the most capable and cost-effective multi-role combat aircraft in worldwide operation today to meet national, NATO and European defence needs.
- A fully NATO-compatible and interoperable fighter which supported all NATO priorities for standardisation of doctrines and procedures, including datalink communications and an air-to-air refuelling system.
- Deliveries to commence in 2004 with the first Gripen squadron fully operational in 2005.
- Delivery of all aircraft to be completed by the end of 2008.
- Greatly reduced cost of operating Gripen will enable higher levels of operational training without the need for increased expenditure.
- Opportunity for Czech Republic to be involved in future enhancement programmes (this was not only a benefit to the Czech Republic but also for Czech industry and, therefore, the Czech economy).
- Comprehensive support and training in place before Gripen operations begin.
- Maximum weapons and support commonality with the Czech Air Force L-159 fleet.
- Customised logistics support capable of utilising existing facilities.
- Maintenance and ground support system which included an option for expansion to manage and track aircraft and component maintenance across the whole Czech Air Force.
- Eurofighter had also made an offer, which was surprising after the consortium had stated earlier that it would not participate, but it did not comply with the Request for Proposals.

Gripen International was so confident of winning an order from the Czech Republic that it released this photo of JAS 39A 39145 and JAS 39B 39802 with Czech Air Force national insignia on the tail.

The Czech government was budgeting CzK 100 billion for the acquisition of these aircraft; the actual cost of the 36 aircraft was far less than has been advertised. The Gripen deal was attacked quite frequently by the Czech press – why, for example, had the other four companies withdrawn from the tender? As a result, Gripen International produced a brochure at the Hradec Kralove show which gave the press the figures and details concerning the financing of the Czech Gripens.

The Hradec Králové show was considered so important that two Gripens were present, 39173 on static and 39174 in the flying display. However, the press became even more aggressive, while Petr Necas suggested that the Gripen's technology was ten years old and so the aircraft should not be bought. Elements of the Czech press went further and stated that Hungary's decision to acquire the Gripen was a mistake.

The 10th of December 2001 was to be the date on which Czech government would make its decision. The Defence Minister stated that his ministry would like to buy the Gripen but only on condition that the necessary finance did not come from the defence budget. This would mean that parliament would have to vote on the deal.

The government voted in favour of buying the Gripen and stated that a contract would be signed by April 2002. To finance the project, however, the Czech parliament and senate had to vote for a special law, which could have complicated matters as the government was in a minority. Elections were to take place later that year. The cost of the Gripen acquisition was calculated at CzK 50 billion with the interest on the price calculated at CzK 15 billion.

The total cost of the Gripen, if its pilots flew 270 hours per year, was quoted as follows (in billion CzK):

Acquisition costs	50
Interest over the loan	15
Armament	5
Infrastructure adjustments	8
Operational expenses until 2035	17
Modernisation in year 2020	4.5

On 14th February 2002 the Czech parliament voted on the financing law and accepted it on its first reading; it was primarily the opposition ODS and US parties that voted against the law, using the excuse that they did not want the Czech Republic to have such a large debt, but the minority government was helped by the Communist party and the Christian Democrats.

Although the time schedule was tight, the second reading of the law was delayed until April. This made acquisition of the fighter very insecure because elections were getting closer and it was doubtful that the senate and the office of the president would accept the law in time. Gripen International said that the contract negotiations were going smoothly on their side.

An underestimate by the Ministry of Defence of the amount of paperwork that needed to be completed delayed the discussions even more. Parliament had to decide on the matter during its last meeting before the elections to give time for the senate and the President to either

Top left: **A very satisfied Commander-in-Chief of the Czech Air Force, Ladislav Klima in the cockpit of a JAS 39B shortly after his first flight in the Gripen on 27th October 1997.**

Top right: **Czech Air Force evaluation pilot General Strübl after his evaluation flight with Commander-in-Chief of the Swedish Air Force, Lt General Kent Harrskog.**

Left: **During the Hradec Králové air show in 2001, this model of a Gripen in Czech Air Force markings was exhibited.**

accept or refuse the financing plan. If it was refused by either the plan would return to parliament after the elections.

On 9th April four Swedish Air Force Gripens landed at Čáslav Air Base to give the staff and the press a better look at the new aircraft and to show that there would be no problems as to its interoperability. The aircraft were used for ground and air displays and two JAS 39Bs, 39805 and 39806, gave demonstration flights with Czech Air Force officials in the back seat; among the Czech pilots to fly in the Gripen were the commanders of the Čáslav and Náměšť nad Oslavou air bases. The two single-seat JAS 39As both came from the second batch and had the original cockpit display systems.

The Czech government agreed to the financing of the Gripen on 22nd April; besides taking a loan the money acquired by the privatisation of Czech Telecom would also be used to cover the investment. The plan was presented in the Czech parliament two days later, but it was rejected by one vote. The Czech Prime Minister, however, arrived late and some other government party members were not present, so the government planned to try again and hopefully get the contract signed before the elections.

One of the reasons for the hurry was that Gripen International was offering a better price to the first Eastern European country to buy the Gripen, the argument being that the first buy would have a follow-on effect in that other countries would then make the same choice.

On 7th May the government returned the law to parliament and it was passed by 86 votes to 84; two days later it successfully passed its third reading. The most difficult stage was yet to come however, because the senate would be a more difficult barrier to clear due to the government having a smaller representation there. The senate had to decide within 30 days.

If the contract was signed during June 2002, the first delivery of Gripens to the Czech Air Force would take place in October 2004 and the final delivery in September 2007. Four aircraft would be delivered in 2004, ten in 2005, six in 2006 and the remaining four during 2007.

Shortly before the senate was to vote, Prime Minister Miloš Zeman announced that contract signature would be postponed until September, after the general elections. He hoped that this step would gain enough support in the senate but on 31st May it refused the Gripen financial plan. Now the last chance for the government to get an agreement would be if the Czech parliament overruled the senate's decision and this was tried on 13th June, the day before the elections, but the proposal did not gain the 102 votes required.

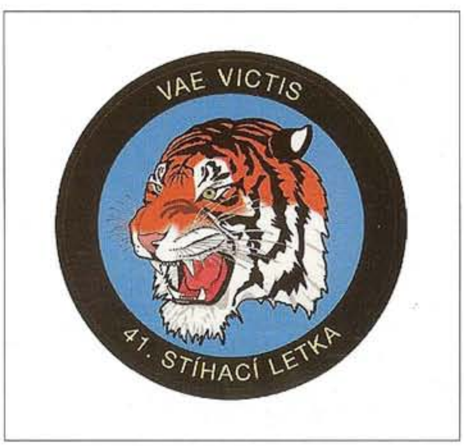
The elections were expected to change the political map in the Czech Republic quite considerably in favour of the right wing parties, but in fact the results were very different to what had been predicted. The ruling party won the election, but it lost some seats in parliament.

The new parliament had to restart the Gripen acquisition process again, but changes in the political landscape made it unclear what would happen. When the initial negotiations to shape a new government began, one of the CSSD's negotiating points was that the Gripen should be bought, but this was not accepted by the potential coalition partner, Unie Svoboda.

Then unforeseen events in August 2002 brought a new complexion to the situation. Much of Eastern Europe was severely flooded and declared a disaster area and on 19th August, Minister of Defence Jaroslav Tvrdik announced that the Czech Republic could not afford to buy new fighters because the money was needed to pay for the massive clean-up operation. The government had not formally cancelled the Gripen purchase, but the flood damage had changed everyone's priorities and it could no longer afford to buy 24 fighters. From that moment Gripen International began to lobby strongly in an effort to save the deal.

On 18th November 2002, before the NATO conference in Prague, the Czech government formally announced that it would not sign the contract for the 24 Gripens. The government now wanted to pursue the concept of *spolecne nebe* ('shared airspace') with the Slovak Republic; and for the concept to become a reality the Slovak Republic had to be admitted into NATO. It was, however, a vague concept, with no real information as to what form it would take. Poland and Hungary were invited to join as well.

The Ministry of Defence was given the order to look at different options, some of which came from unexpected areas. The Canadians offered 40 CF-18A/Bs and this offer gained a lot of attention in the press. Other offers were German F-4F Phantoms II about to be replaced by the Eurofighter Typhoon; and surplus F-16A/Bs were offered by Belgium, the Netherlands and the United States. Saab could offer surplus Gripens from the Swedish Air Force. A final decision has yet to be announced, but it is clear that an acquisition of second-hand aircraft is now being favoured.



The Czech Air Force unit that would receive the Gripens would be the 41st Fighter Squadron based at Čáslav Air Base. The squadron's tiger badge is illustrated.

Denmark

Denmark was another J 35 Draken operator and by 1989 it was clear that the remaining 44 examples had to be replaced. One option was to acquire more F-16s; the other involved an order for Batch One Gripens, but on the understanding that Saab would agree to develop a two-seater. The Gripen was at a considerable disadvantage, because the Kongelige Danske Flyvevåbnet (Royal Danish Air Force) already operated F-16A/Bs, making standardisation on the type the favoured choice.

Before the serious competition phase was reached, however, cuts to Denmark's defence expenditure led to the disbandment of the two Draken squadrons (the last examples were withdrawn in December 1993) and the scrapping of the need to replace them. On 28th May 2002 Denmark signed up as a Level Three partner in the JSF programme.

Finland

In 1989, when Finland announced that it wanted to replace its aging MiG-21s and Saab Drakens, the Mirage 2000-5, F-16A/B, and Batch One Gripen were thought to be the candidates to replace the Drakens. The MiG-21s were tipped to be replaced by the MiG-29 or Su-27, so when Finland sent out a Request for Quotation to Dassault, General Dynamics (later Lockheed Martin) and Saab for 20 single-seat and five two-seat fighters, with an option for 20 more, it was assumed that these were to replace the Drakens under the DX requirement. Initial submissions were made by 31st October 1990.

A second RFQ followed on 3rd January 1991 for 60 single-seat and seven two-seat fighters and, at the same time, Finland announced that it could no longer afford to maintain two different types of fighter aircraft; only one type would be acquired to replace both the MiG-21 and Draken. Cold War politics had previously meant that Finland operated mixed fleets of Soviet and Western origin, so this would be the first occasion that Finland could choose just one type. It was immediately stated that Finland would select a Western fighter, but that but the country wanted a minimum 100% offset.

At this point, there was no international variant of Gripen available and the Batch One version was in the early stages of its flight test programme. This put the Gripen at something of a disadvantage because it was by no means certain that Saab could fulfil the delivery schedule requested by the Suomen Ilmavoimat (Finnish Air Force). Saab, however, was confident of its chances because Finland had considerable experience with the Draken and the company had offered final assembly of Finnish Gripens plus the manufacture of some parts for Swedish Air Force machines.

The McDonnell Douglas F/A-18C/D Hornet entered the equation when it was included in the bid shortly after the third RFQ on 12th April 1991.

On 15th July 1991 Saab handed its proposals to the Finnish Air Force and on 23rd September the Finnish Minister of Defence Elisabeth Rehn visited Saab. By the following November Finland had become the first foreign country to put the Gripen through its paces in Sweden (in fact, it was the only foreign country that undertook flight evaluations in a single-seat Batch One Gripen). Three Finnish pilots, Jukka Koskela, Vesa Keinanen and Pauli Perttula, arrived to make around ten flights having first trained in the Gripen flight simulator.

Jukka Koskela made his first Gripen flight on 2nd December, Vesa Keinanen made his two days later, and Koskela completed six flights totalling 4 hours 18 minutes. Koskela's opinion was that the Gripen 'will be a very good fighter when it is ready. It is a multi-role capability aircraft with a good man/machine interface...reasonable pricing will most probably make it a serious competitor in the market'. Pauli Perttula only evaluated the Gripen from the simulator.

Finland was being offered the Gripen with offsets worth 30% of the value of the order plus the final assembly, which indicated just how much importance Saab attached to this tender. Saab sent Gripen 39-5 (because it was the prototype nearest to the production standard)with pilot Johan Gille to Finland for further flight evaluation during February and March 1992 (the competing F-16, F-18, Mirage 2000 and MiG-29 were also present). Gille was the only pilot to fly the Gripen in Finland; no Finnish pilots were given the chance to evaluate it during the aircraft's stay at Halli Air Force Base.

However, in May 1992 Elisabeth Rehn announced that Finland would order 57 single-seat F/A-18C and seven two-seat F/A-18D Hornets. The Gripen had failed because it was not yet sufficiently developed, it was not yet cleared to carry AMRAAM (the US Department of Defense had not allowed Saab to undertake AMRAAM integration work outside the United States), there was a worry that the Gripen could not be delivered in the required time frame, the lack of a two-seater was another weakness and, overall, the Gripen was just too expensive. When the Finnish Air Force began converting to the F/A-18C/D in 1995 it was clear that Saab could not have met the required delivery dates because the two-seater was not yet available.

Another reason surfaced in 1998 when Peter Wallenberg, the owner of Investor AB which owned Saab AB and many other Swedish companies or parts thereof, was accused in a book by the then former Minister of Defence Elisabeth Rehn, of extortion. According to Erik Belfrage, Wallenberg's personal advisor, it was all down to a remark made during a luncheon ('If you choose the Gripen then the trade between our two countries will be bigger and that automatically means less unemployment') which had been blown out of all proportion.

Hungary

Hungary was another of the three former Warsaw Pact countries that joined NATO in March 1999. It was also one of the first countries to show interest in an export version of the Gripen. The first occasion when it was openly admitted that Hungary had an interest in the aircraft was in mid-1992, less than three years after the Iron Curtain had came down. In November of that year the Swedish Minister of Defence met Hungarian Prime Minister Jozsef Antall for official talks about the possibilities of Hungary buying the Gripen.

Three years later a Memorandum of Understanding was signed between the two countries. The Chief of the Swedish Air Force, Lieutenant General Kent Harrskog, then visited Hungary on 30th and 31st October 1995 when the Gripen was introduced to a larger group of Hungarian officials at Kecskemét Air Base. Aircraft 39107, flown by Mikael Seidl, was used to give some basic demonstrations in the air and on the ground, the first time that the Gripen had visited a former Warsaw Pact country. The Swedish government was in favour of exporting the Gripen and had instructed the FMV and the Swedish Air Force to help Saab wherever necessary.

On 18th December the two countries signed an agreement covering greater co-operation and exchange of information in regard to defence matters. It was signed by Swedish Minister of Defence Thage G Peterson and Mr Dunai, the Hungarian Minister of Trade and Commerce, and meant that sensitive defence information could now flow between the two countries. As an incentive to the Hungarian government one company, Danubian, received a deal in November 1995 to make eleven tail-cone parts for the first 140 Gripens to be built for the Swedish Air Force.

In July 1996 it was generally expected that Hungary would issue an RFP for up to 36 fighters, but in the event this was postponed indefinitely. In January 1997 a wider agreement was signed between the state secretary and Saab; offset programmes were already in place as part of the preparations for an eventual Gripen buy. A Gripen office was opened in Budapest

This illustration of a JAS 39B in Hungarian Air Force markings was released by Saab in June 1997. In reality the aircraft is 39802 of the Swedish Air Foce.

to support the marketing effort to the Magyar Honvedseg Repülö Csapatai (Hungarian Air Force) and to show that the company was serious about a long-term relationship with Hungary and its industry. It was also 'here to win'.

Between 22nd and 25th May 1997 the Gripen team sponsored NATO Express, an airshow held at Kecskemét to promote integration of former Warsaw Pact nations into NATO. Three Gripens were in attendance; 39114 and 39120 on the flight line while 39124 was shown in the static display with all its competitors – the F-16, F/A-18 and Mirage 2000-5. The aircrew present were Torsten Öhman, Ola Rignell and the display pilot Ken Lindberg.

Shortly afterwards, in early June, just before the Paris Air Show, a team including two Hungarian pilots visited Saab at Linköping to test-fly the two-seat JAS 39B Gripen. The first Hungarian pilot, and the first East European, to fly the type was Col Ferenc Varga; Lt Col Zsolt Rácz was the second Hungarian pilot to fly it, becoming the 50th different pilot to do so. To support the marketing effort the official Saab Internet site showed a doctored illustration of JAS 39B 39802 with the Swedish Air Force insignia replaced by the Hungarian Air Force chevron.

A report in the Czech press said that Poland, Hungary and the Czech Republic would consider and negotiate which aircraft type they would like to buy together, the idea being that the bigger the order, the better the terms and conditions that would be offered. However, the individual countries' timetables for replacing older aircraft were different, Hungary not being in quite such a hurry because it had acquired MiG-29s by way of repayment of part of the debts that Russia owed.

On 9th September 1997 the Hungarian Air Force's Commander-in-Chief flew the Gripen two-seater, with Ola Rignell in the back seat, and thus became the first foreign C-in-C to fly the type. The Commander-in-Chief of the Swedish Air Force, Lieutenant General Kent Harrskog, followed the Gripen in a Viggen.

During a visit to Sweden early in 2000 the Hungarian Defence Minister said that a tender for a new fighter would be issued but not for at least two years; however, on 30th November Saab replied to the Hungarian Request for Information. Saab/BAE Systems submitted an offer of up to 24 Gripens, of which four would be two-seaters, and included in the offer a training package that would see some Hungarian pilots get their training with F7 Wing at Såtenäs in Sweden. Deliveries would begin in 2005.

Then, on 9th February 2001, the Hungarian Minister of Defence made a surprise announcement – Hungary had chosen 24 second-hand F-16A/Bs from the US inventory. Saab was shocked by this announcement and rushed in a new offer the same day with the aid of the Swedish Ambassador Staffan Carlsson. This offer was to loan up to 24 NATO-operable 'swing-role' Gripens at a cost that would only have to cover their updating to NATO standards. The Gripen team stated that this would be cheaper than the F-16 option because those aircraft were stored in the desert and needed to be brought back to flying status and, to be operatively effective, upgraded to at least MLU standard. Gripen operating costs were well below those of the F-16.

The Commander-in-Chief of the Hungarian Air Force after his evaluation flight on 9th September 1997, which he clearly enjoyed.

The new Gripen offer would be a government-to-government deal – the only role for the Gripen team would be to modify the aircraft for the Hungarian Air Force. The F-16 offer covered a five-year lease with the option of extending it for another five years, after which ownership of the aircraft would pass to Hungary. Considering that the F-16A/Bs concerned would be by that time about 35 years old, and probably ready for the scrap yard, this was not quite the generous offer that it had seemed.

Ferenc Juhasz, leader of the Hungarian opposition MSZP party, stated publicly on 12th February his displeasure about the used F-16 lease announcement, saying that a tender should be announced in which all contenders that wished to participate could compete as equals. He was shocked that such an important and long-term budget decision had been made without a tender. Saab of course hoped that this would have the desired effect of forcing a fair competition.

The Hungarian Minister of Economics Gyorgy Matolcsy said in Moscow on 2nd March that Hungary had not dropped its plans to modernise its MiG-29s to NATO standards, nor had it decided to buy the American F-16A/Bs. This statement came as a surprise and clearly the choice for a replacement fighter was still to be made. In fact public opinion and the political discussions that followed confirmed the fact that no final decision had been taken and that the tender was still open to both the F-16 and the Gripen. According to the Gripen team, negotiations between themselves and the Hungarian and Swedish governments for the leasing of 24 Gripens from the Swedish Air Force inventory were ongoing.

The press frequently reported that the Hungarian government had made a final decision in favour of the F-16, but on 10th September 2001 the Swedish Ministry of Defence announced that Hungary had chosen Gripen International as it favoured bidder and was interested in leasing 14 Gripens. The value of the contract was estimated to be around US $500 million and the offset deals that were offered amounted to a full 100%. Defence Minister John Szabo declared that the Gripen International offer was the most modern and financially attractive and details of the contract would be negotiated between the Hungarian Defence Ministry and the FMV. The 14 Batch One Gripens would come from the Swedish Air Force's inventory, but any updates were dependent on the negotiations.

This was an important result because Hungary was the first NATO country to actually choose the Gripen, although it was only leasing aircraft with an option to buy. This deal was much desired by Gripen International since it gave the company its first foothold within NATO and thus made it easier to offer the aircraft to other potential NATO customers such as Poland and the Czech Republic; it was also thought that these countries would be influenced by Hungary's decision.

On 20th September Swedish Defence Minister Björn von Sydow went to Hungary to meet his opposite number, John Szabo, and begin the negotiations. Three days later, in Stockholm, they signed a Memorandum of Understanding for the lease of 14 Gripens for a period of ten years, which ended any chances of the F-16 being acquired by Hungary.

The offset contract was expected to be signed separately in December 2001. The initial training of pilots and technical staff was to take place in Sweden and the first deliveries were expected to begin by the end of 2004 so that a squadron would become operational by the summer of 2005. Saab would undertake the upgrade work needed to make the aircraft NATO-compatible and to fulfil the requirements of the Hungarian Air Force. The Gripens were supposed to replace the MiG-29s based at Kecskemét, but 14 of these were sent to Russia for a life extension so that they could serve until 2005.

The actual lease agreement was signed in Budapest on 20th December by the FMV and the Acquisition and Security Investment Bureau (ASIB) of the Hungarian Department of Defence. The contract value was kept confidential for commercial reasons. The ten-year lease would begin at the end of 2004 with the delivery of the first aircraft and covered 12 JAS 39As and two JAS 39Bs. The last aircraft was to be delivered during June 2005.

The updating of the aircraft would include some standardisation with the Swedish Air Force Gripen fleet and incorporate new communication systems, APUs from Sunstrand, general electronic control units and FADEC. Additional updates specifically for the Hungarian Air Force were an IFF system, ILS, 'Have Quick' radios, revised weapon functions for external weapons and modified and upgraded software.

The following staff would be trained in Sweden – 15 pilots in three batches (this would include operational and tactical training), 32 maintenance technicians, two technicians for the flight simulators and five fighter controllers. Integrated Logistic Support was also part of the contract and would give the Hungarian and Swedish air forces, through a 'pooling' system, access to all kinds of Gripen spare parts and replacement units – this was why standardisation with Swedish aircraft was so important.

The Hungarian Air Force had the right to buy the 14 Gripens after the ten-year lease but if this option was not taken up, they would be available to the same standard as Swedish Batch Two machines. At the time it was not clear which production aircraft would be involved.

At the same time, the offset deal was signed by the Hungarian Ministry of Economical Affairs and Gripen International – the total offset would exceed the Hungarian commitment. Ian McNamee, Managing Director of Gripen International, explained 'we have already delivered pre-offset worth US $661 million to Hungary and are in discussions with over 40 companies to build on this existing commitment'. Eight days later the contract between the FMV and Gripen International was signed for the modification and support of the 14 Swedish Air Force Gripens designated for the Hungarian Air Force and the period of the lease.

Far left: **The badge of Dongó Squadron, Kecskemét Wing, Hungarian Air Force. Both of the squadrons are currently equipped with MiG-29s, but which one will receive the Gripens remains to be seen.**

Left: **The badge of Puma Squadron, Kecskemét Wing, Hungarian Air Force.**

Below: **The sight of Hungarian Air Force MiG-29s and Gripens flying together will become more frequent as and when Hungary starts to take delivery of its Gripens.**

The official responses from various bidders to the Netherlands' Request for Information. Note the small model of an F-16.

In September 2002 Hungary asked the FMV to renegotiate the lease because it now wished to receive JAS 39C and D standard aircraft instead of upgraded As and Bs. The FMV is to reopen negotiations and it is expected that if the deal is switched to the higher-grade aircraft, delivery will take place to a revised timescale and the value of the contract will increase. If the parties do not agree on these changes, the original contract will be honoured. Speculation about successful negotiations was rife by the end of November, but neither the FMV or the Hungarian government offered any confirmation.

During January 2003 the Minister of Defence announced that he intended to upgrade the Gripen contract, but no details were forthcoming. Finally, on 3rd February 2003, it was announced that the FMV had come to an agreement with the Hungarian government on a 30-year 'lease-and-buy' deal for 12 JAS 39Cs and two JAS 39Ds. First deliveries will now take place in 2003. Other technical or financial information has not been revealed.

Hungarian Air Force Gripens will be mostly new aircraft, i.e. new-build fuselages but with some older components that do not interfere with the capability of the JAS 39C.

The Hungarian Air Force is proud of Kecskemét Air Force Base, which is why all official visitors are usually received there. The 59th Tactical Fighter Regiment has been stationed at the base since 1952 and in 1958 it was named after Dezsô Szentgyörgyi, the most successful Hungarian fighter pilot with 33 kills. The 59th TFR currently comprises two squadrons, Dongó (meaning 'bumble bee') and Puma, which both fly the MiG-29.

The Dongó squadron was the unit chosen to re-equip with the Gripen. At the Paris Air Show in June 2003, Wing Commander Colonel Nandor Kilian stated that he was happy with the choice of the Gripen and that he thought the Hungarian government would also choose to replace the remaining MiG-29s with additional Gripens, other aircraft types being too expensive to justify their acquisition.

Pilot training for the Hungarian Air Force will commence in 2005 at F7 Wing's base in Sweden. The first group of five Hungarian pilots will be very experienced as they will go on to become Gripen instructors. The second group of pilots will be a mix of experienced and young, while the third and last group to be trained in Sweden will comprise young pilots. After these groups have completed their training in Sweden, all additional pilot training will be conducted in Hungary.

The Netherlands

One of the first countries to buy the F-16 was the Netherlands and the last Koninklijke Luchtmacht (Royal Netherlands Air Force) example was delivered in February 1992. It was thus one of the first countries to look for a replacement. In 1999 the Dutch parliament was notified that the RNAF needed a next-generation fighter to replace its ageing F-16A/Bs and on 3rd June a Request for Information was sent to interested parties. The Gripen offer was received on 22nd October. However, on 19th November the United States officially invited the Netherlands to participate in the EMD phase of the JSF programme.

The RNAF had its mind set on the JSF but the government had to evaluate all of the possible candidates. The first step taken by the Royal Netherlands Air Force to test the Gripen was to send its Chief of Staff, General Ben Droste, to Sweden so that he could fly the type on 2nd March 2000. A week later a Dutch delegation led by the State Secretary of Defence, Henk van Hoof, visited Linköping for a full Gripen briefing. On 15th March van Hoof presented a basic document giving the following choices:

- Various F-16 options.
- The Gripen. (Two comparisons were made; the first was that the take-off weight of the Gripen was 14 tonnes and for the F-16 it was 16 tonnes, the second was that the Gripen had less hardpoints for weapon carriage; both were seen as a disadvantage).
- Eurofighter Typhoon.
- Dassault Rafale.
- F/A-18E/F Super Hornet.
- JSF.

Royal Netherlands Air Force officials said that they preferred JSF because, at the time they would buy their new aircraft, the Gripen, Rafale and Eurofighter would present 1990s technology while the JSF would offer 2001 technology; it also had the advantage of an internal weapon bay which the other fighters lacked.

In March 2000 a Dutch evaluation team tested the Eurofighter and Rafale. It was also intended to test the Gripen and the competing American aircraft, but exactly when this would happen was uncertain. All of the competitors (including a JSF mock-up) turned up at the Royal Netherlands Air Force Open Days held at Volkel on 1st and 2nd September; the Gripen was represented by 39186.

On 3rd October Henk van Hoof presented a report to the Dutch parliament detailing the results so far. It stated that all of the candidates had been evaluated and the Gripen did not fulfil the requirements – the most important factor (and the only one mentioned) was that with a heavy weapon load the Gripen did not have a satisfactory range because of its limited internal fuel capacity; Saab had been informed of this.

On 8th February 2002 the Dutch government decided that the JSF was the best option to replace its F-16s and that it would participate in the project's EMD phase.

Norway

In March 1995 the Norwegian Defence Ministry took the first steps to obtain a new fighter to replace the F-5A/Bs in service with the Kongelige Norske Luftforsvaret (Royal Norwegian Air Force). The aircraft under consideration were the Eurofighter, Rafale, F-16C/D and the Gripen. Saab retired from this bid pretty quickly when it became clear that the Royal Norwegian Air Force preferred a twin-engined aircraft.

The Swedish Air Force had planned to present one of its Gripens at Bodø Air Base in Norway on 5th June 1999, the first time that the Gripen would have visited the country, but the crisis in what had been Serbia prevented this taking place.

The choice of the winning fighter was postponed for several years but on 20th June 2002 Norway signed up for Level Three participation in the JSF programme. The expectation is that 48 such aircraft will be ordered in due course.

The Philippines

In mid-April 1997 the Hukbong Hinpapawid ñg Pilipinas (Philippine Air Force) announced a Request for Proposals for 18 single-seat and six two-seat multi-role fighters to replace its F-5A/Bs, the aircraft under consideration being the Mirage 2000-5, IAI Kfir 2000, MiG-29, F-16C/D, F/A-18C/D and Gripen. However, the Saab-BAe consortium told journalists at that year's Paris Air Show that it did not see the Philippine Air Force as a serious future customer, though it did respond to the RFP.

In April 1998 the Philippines sent a team headed by General Alfonso de Los Santos to Sweden to evaluate the Gripen and one week later an invitation to bid was released. Unfortunately, soon afterwards the Philippine peso was caught in the financial crisis that had started in South Korea and Japan and was devalued by about 25%. Not surprisingly, in June the newly elected Philippine government announced that it was putting the acquisition of certain new military equipment on hold.

On 12th July 2001 the Chief of the Philippine Air Force, Benjamin P Defensor Jr, reported that bidding for 36 new multi-role fighters would start soon. He added that it would be two to three years before first deliveries would take place. As yet there is no news on a likely winner.

Poland

Poland is one of three former Warsaw Pact countries to show an interest in the Gripen; it is also the biggest and has the largest requirement to replace its MiG-21s and Su-22s.

The Gripen made its first appearance in Poland on the occasion of the International Military Equipment Fair at Babie Doly Naval Air Base; two of the three aircraft that visited (39111, 39120 and 39125) also called in on the same day at the Hungarian Air Force base at Kecskemét. The pilots, Major Ken Lindberg and Lt Col Jan Andersson, left Malmen in Sweden early in the morning to fly to Kecskemét where Lindberg performed two displays. After refuelling they left for Poland and the next day gave two more air displays before, on 27th September, the air routine was combined with a ground display. This time the aircraft was refuelled and rearmed (with four additional AMRAAMs) while the engine was still running and after four minutes it was taxying out for the next performance. In the afternoon the aircraft flew back to Sweden after what had been an impressive East European promotional tour.

On 7th March 1997 Saab-BAe announced that an eventual partnership might include final assembly of any Gripens for the Polskie Wojeska Lotnicze (Polish Air Force) at the PZL Mielec plant, with engine assembly to be undertaken at Rzeszów.

On 15th April a security agreement between Sweden and Poland was signed by Swedish Minister of Defence Björn von Sydow and his Polish counterpart, Stanislaw Dobrzanski, which would speed up future flight evaluation of the Gripen. Thanks to this agreement, Polish pilots could now fly in the JAS 39B two-seater, which was previously impossible because some of equipment in both cockpits was classified. If Poland should decide to buy the Gripen the agreement also opened the door for future co-operation and partnership opportunities which might include the transfer of high-value technology to Polish industry.

Three days later the Polish Defence Minister Janusz Onyszkiewicz announced that he would issue invitations to tender for 250 new multi-role fighters in October or November with selection due in May or June 1998. However, during the following month the planned number of multi-role fighters was cut from 250 to about 100 with little likelihood that such a number would be acquired within the near future.

On 30th August JAS 39A 39.140 was seen on static display at Bydgoszcz while the next day JAS 39A 39.114 gave a public air display at Mielec. On 18th November Major General Kazimierz Dziok, the Commander-in-Chief of the Polish Air Force, flew in a Gripen for the first time with Reino Lidvik in the back seat (this made Dziok the third former Warsaw Pact air force chief to fly a Gripen).

In autumn 1998 BAe/DASA/Saab submitted a joint proposal to the Polish Ministry of Defence with three solutions, divided into immediate, short-term and long-term:

Immediate Option 1: The Polish Air Force's MiG-29s to be extensively modernised, using DASA's experience, to the German Block III standard;

Immediate Option 2: Groups of Polish Air Force pilots to undergo an extensive ten-week course in the UK, including flights with 100 Squadron, paid for by the UK government;

Immediate Option 3: Up to 1,000 flying hours of pilot training per year in Viggens at Såtenäs (and in Gripens from 2000), the cost to be met by the Swedish government.

The short-term solution included the procurement of 20 Hawk training aircraft from BAe; the long-term proposed the purchase of Gripens and Eurofighters by the Polish Air Force in return for Polish industrial participation in major European programmes. (Acquisition of Eurofighters was unrealistic given Poland's financial situation.)

In May 1999 the Polish government agreed on a schedule to buy 42 advanced fighters with tendering due in early August. The choice was expected a year later and the aircraft known to have a chance were the F-16, F/A-18, Mirage 2000-5 and Gripen. Delivery was supposed to start in 2006 and there might be a chance for a follow-on order of 90-100 aircraft. Interim fighters could also be introduced as early as 2001; this was easier for the American companies because surplus F-16A/Bs and F/A-18A/Bs were available; Sweden could offer ex-Swedish Air Force Viggens and deliver them with little trouble by 2001.

In June 1999, a week after the Paris Air Show, F7 Wing participated in Drogowy Odcinek Lotniskowy 99 (Highway Landing Strip 99), a road base exercise on the Kliniska highway strip, one of roughly 15 in Poland, held in co-operation with the Polish Air Force. This gave the Poles a chance to take a really close look at the Gripen. Saab hoped that this would have a positive effect on the Polish government's decision on a new fighter due to be made in the near future. The 'runway' for the exercise was approximately 6,560ft (2,000m) long and 46ft (16m) wide.

After his flight in a Gripen, Commander-in-Chief of the Polish Air Force Major General Kazimierz Dziok shakes the hand of Hans Kruger from Saab. Lt Kent Harrskog is the onlooker.

During the campaign to win an order from the Polish Air Force, Swedish Air Force Gripens actively supported the export effort by participating in exercises in Poland, including operating from the Kliniska highway strip in June 1999.

Four JAS 39As and one JAS 39B participated in the exercise, and about 200 officials saw the Gripen in action from the pilot's point of view. The pilot's cockpit information was presented in real time on big screens, a step made possible by the TIDLS that was in contact with a Gripen on the ground.

On 15th July 1999 it was revealed that Saab-BAe had suggested that, if Poland chose the Gripen, the Swedish Air Force could loan 18 of its aircraft to the Polish Air Force until the first Polish production examples arrived; this offer presented no problems to the Swedish Air Force since it still had more Gripens than trained pilots. The 18 Swedish Air Force aircraft would need updating to NATO standards (the update cost was included in the offer) and were available from 2001; they would be due for return once the first Polish production Gripens had been delivered.

On 17th April 2001 Defence Minister Bronislaw Komorowski confirmed a plan to replace Poland's elderly MiG-21s and the Request for Proposals was to either buy, lease or transfer 16 aircraft by 2003 plus a subsequent purchase of another 44 aircraft. Poland needed the 16 before 2003 to fulfil its commitments to NATO and about 60 all told by 2006. Offers were due by the end of May 2001, but forthcoming elections would delay the final choice.

In the first week of June, two Gripens participated in a road exercise near Szcecin; the Swedish fighters had to operate alongside the aircraft in the Polish Air Force's inventory and they performed well – according to Saab the Gripen is the only fourth-generation fighter capable of using forward bases or unprepared roads, a fact proven by Sweden's daily use of the Gripen on its BAS90 forward base system. The most important point here, however, was that once again that the Gripen had proved that it could easily be operated amongst other NATO aircraft types.

The three companies invited to bid were Saab-BAE Systems with the Gripen, Dassault with the Mirage 2000-5 Mk.2 and Lockheed Martin with the F-16C/D. After the elections the new government continued the competition but with a one-year delay.

During early December 2001 the new Polish Minister of Defence, Jerzy Szmajdzinski, announced that the decision would be made by August 2002; and he commented that he was not surprised by the fact that both Hungary and the Czech Republic had chosen the Gripen. He felt that the American and French companies had to put more weight into their co-operation with local industry – a clear sign that he preferred the Saab/BAE Systems bid.

Then the Polish Air Force got help from an unexpected source. Germany, which had been using ex-East German Air Force MiG-29s, was selling some Leopard tanks to the Polish Army and to sweeten the deal they threw in their 23 NATO-compatible MiG-29s for just one euro. This alleviated the need for Poland to acquire second-hand fighters and, therefore, new proposals were requested on 8th July 2002 for 48 aircraft rather than 60. A final decision was due by the end of December 2002 but the Polish president and government were sending out contradictory messages – the President of Poland favoured F-16s but the government seemed to favour the Gripen.

The pressure for a decision grew as the Polish Air Force had a greater number of aircraft to replace than other ex-Warsaw Pact countries. President Bush went so far as to say that if Poland wanted to become a significant partner in NATO, it would have to buy American. Finally on the night of the 26th December 2002 it was announced that the winner of the tender was the Lockheed Martin F-16C/D.

Dassault voiced its anger at the decision, stating Poland should have bought European after being invited to join the European Union. Owe Wagermark of Gripen International stated that politics was the main reason for the selection as the Gripen was technologically the most advanced and the cheapest option on offer. Defence Minister Komorowski countered that it was not a political decision, the invitation to tender having helped prevent politics influencing the choice.

Contract signature was scheduled for February 2003, but this was delayed even though the contract negotiations were complete. Because negotiations on a separate contract for offset work had not gone smoothly, the Polish government decided that it could not sign the contract until the issue of offset work was resolved to its satisfaction. By way of a negotiating tool, Polish officials reminded the Americans that they could – and would, if necessary – revert to their second choice, namely the Gripen.

Romania

Another first for the Gripen came when two examples visited Timisoara Air Base in Romania on 25th August 1998. These aircraft had flown to Romania because important military and political delegations were going to be present. In truth, Romania was not expected to have the financial means to buy new fighters for another ten years, but the Fortele Aeriene Romanie (Romanian Air Force) had been eyeing the Gripen for some time and this was its first opportunity to take a close look.

Cash-strapped Romania eventually invested more money in its MiG-21s, updating them with the help of IAI so that they could be used for a few more years. It is hoped that the financial situation will improve so that Romania can one day afford to procure a replacement.

Slovenia

The President of Slovenia made a three-day visit to Sweden during the first week of October 1999 as a guest of King Carl Gustaf XVI and this ended with a trip to the Saab factory. He was accompanied by several of his ministers and the delegation had the chance to take a closer look at the Gripen, which has been targeted for export to Slovenia.

South Africa

Thanks to its policy of apartheid, South Africa was for many years the subject of an arms embargo. The United States imposed a stringent weapons embargo which included any bit of defence technology and the only country willing to supply arms to South Africa was Israel. In the 1990s, after the political map had been redrawn and apartheid had been abandoned, South Africa's politicians and military chiefs turned their thoughts to updating the country's defence forces.

The South African National Defence Force (SANDF) was at the time using Cheetah and Dassault Mirage F1AZ fighters plus the Atlas Impala as an advanced trainer. The Cheetahs were French Mirage IIIs updated by the South African Atlas company from the mid-1980s onwards.

Because of the arms embargo, South Africa had also begun to develop its own fighter in secret, but in January 1991 the government cancelled this project for financial and technical reasons. After making peace with Angola the extra cost of developing the new fighter was unnecessary. This in turn signalled that South Africa would buy an off-the-shelf fighter although, at the time, the arms embargo was still in place.

The Atlas Impala was the first aircraft that would need replacing; after that would come the Mirage F1AZ and later the Cheetah C and D. The Minister of Defence approved the staff requirement for an Advanced Fighter Trainer on 18th October 1994 plus the option that in the future a medium fighter should also be acquired. The programmes for the Impala replacement and the Cheetah and Mirage replacement were called Project Uhkozi and Project Kambro respectively.

A Request for Information was issued and 23 replies were evaluated according to a value classification covering aircraft systems, airframe performance, onboard systems, avionics, support systems, acquisition cost index and operating/support cost index. The result was:

Rank	Aircraft system	Score	Status
1	Saab Gripen	0.899	In production
2	Sukhoi S55	0.887	Under development
3	Sukhoi S54	0.884	Under development
4	Lockheed-Martin F-16	0.859	In production
5	Aermacchi AMX-T	0.788	In production
6	DBD Alpha Jet	0.766	In production
7	CASA ATX	0.763	Under development
8	MiG AT	0.703	Under development
9	Aero Vodochody L-159	0.693	In production
10	Yakovlev Yak 130	0.682	Under development
11	CATIC/PAC K-8	0.668	In production
12	FMA IA 63 Pampa	0.648	In production
13	Aermacchi MB339FD	0.647	In production
14	AIDC AT-3	0.631	In production
15	BAe Hawk 100	0.623	In production
16	IAR 99	0.553	In production
17	Atlas Impala	0.335	In service
18-23	LCA, Jet Squalus, Venga TG-10, KIRAN Mk.2, KTX-2		Not evaluated due to insufficient information

The result clearly favoured the Gripen. After this the trainer contenders had to fulfil five criteria to ensure that they would not be eliminated:

1. Aircraft to be jet-propelled and have a tandem cockpit to resemble a modern fighter.
2. Aircraft to have a better performance than the Atlas Impala Mk.2 to fill the training gap between the Pilatus PC-7 Mk.2 Astra and Atlas Cheetah C.
3. Aircraft must be in advanced development or production.
4. Delivery must not be later than 2003.
5. Manufacturer must indicate a willingness to participate by having replied to the request for additional information (27th March 1996) or the reminder (6th June 1996).

Of the original 17 evaluated candidates only nine remained by 31st July 1996. The nine respective manufacturers or suppliers were visited during September and October and a shortlist was drawn up of those suitable for the Request for Proposals round. These were:

Type	Refusal Comments	Acceptance Comments
AMX-T		In production, multi-role, growth path
HAWK 100	High cost does not satisfy SAAF operational requirements	
AT-2000		Potential for wide-band performance at reasonable cost. Best opportunity for industry participation. High programme risk.
Gripen	Unaffordable	
L-159		Balanced performance and systems at reasonable cost. Good logistic support. SAAF might be only user outside Czech Republic.
MB339FD	Low performance cannot satisfy user requirement	
YAK-130		Balanced all round performance for multi-role. Re-engine option. Feasible only if also acquired by the Russian Federation.
MiG-AT	High development and production risk	
S-54	Insufficient/incomplete information provided	

Early in 1997 the Chief of the South African Air Force (SAAF), General Willem Hechter, said that the entire aircraft force needed replacing, which meant that the SAAF would need at least two squadrons of Gripen-class fighters to replace the Cheetah plus another type to replace the Impala. Both replacements had to be in service by 2015 and a decision on each would be taken in a year's time.

Thanks to some budget cuts in 1997, the finance for these acquisitions was reconsidered. The 5.2 billion Rand for the Uhkozi project and 8 billion Rand for the Kambro project was thought to be unaffordable. The SAAF command council therefore decided that the Uhkozi project should be modified into a new project replacing both the Kambro and Uhkozi requirements. Thus the Advanced Light Fighter Aircraft (ALFA) requirement was born on 7th July 1997, the type being intended to replace the Impala, Mirage F1AZ and Cheetah.

The South African government issued its Request for Information (RFI) on 23rd September 1997. The full package that it wanted was four corvettes, four maritime helicopters to go with them, four submarines, 104 main battle tanks, 48 light fighters and 60 light utility helicopters. The RFI was sent to the UK, Germany, France, Spain, Italy, Canada, Brazil and Sweden and, later, Russia and Denmark. The deadline for answers was 31st October 1997, but the Czech Republic was subsequently allowed to bid with its Aero L-159 Advanced Light Combat Aircraft.

Because the UK could offer a wider package to meet South Africa's 'shopping list', both Saab and BAe agreed that the Gripen should be part of a UK package and that Sweden would not reply to the RFI itself.

Cost-cutting led to a reduction in the ALFA requirement from 48 to 38, the new plan calling for eight two-seaters and 30 single-seaters (some of the other requirements had their quantities reduced and the need for battle tanks was dropped entirely). The RFI evaluation gave the highest military value to the AT-2000 (which was being proposed in conjunction with Denel of South Africa), the Mirage 2000 came second and the Gripen third; these three types were shortlisted for the RFP.

An important factor noticed by the SAAF command council was that the step between the Pilatus PC-7 Astra and the ALFA was too great and there was a need for a Lead-In Fighter Trainer – in short, the original plan was back on the table. However, a meeting held on 19th and 20th November to examine the papers sent by the 'ALFA' suppliers revealed that, in every case except the Mirage 2000, it might be possible to convert pilots from the Astra straight on to the proposed fighter.

Since South Africa wished to buy a complete package, BAe was also offering the Hawk trainer in competition with other aircraft. On 8th January Saab's CEO officially opened the Sweden/South Africa Business Centre in Cape Town. This was 'good for business' because the fighters that South Africa needed to replace had supplied Atlas and other South African companies with much-needed development and support work, so one condition stipulated by South Africa was that any tender should be accompanied with direct and indirect industrial offset programmes plus details on how they would be implemented.

The Saab/BAe coalition proposed the export version of the Gripen but the press suggested that this could not win because the South African arms embargo had not yet been lifted. Nevertheless, Saab/BAe were very confident that the embargo would not be a problem; but in mid-February they was told by the United States that it would not grant a licence to re-export US technology to South Africa.

The decision reignited the argument that Saab/BAe should make the Gripen an all-European fighter with no dependence on the United States for future export orders. This was only speculation of course, the reality being that such a move was impossible without lengthy and costly delays; any new systems would first have to be tested on the Gripen.

In mid-February 1998 the US Department of State returned unanswered Saab/BAe's request to re-export American technology fitted in the Gripen to South Africa. During the United Nations embargo against South Africa the South African arms procurement agency, Armscor, had been found guilty of breaking sanctions and, since then, US companies had been barred from dealing directly or indirectly with that body. The US State Department viewed the Gripen subcontracting as an indirect deal with Armscor

In the United States, however, representatives of the defence industry were putting pressure on the Clinton administration to lift the arms embargo so that they could also bid to the South African requirements.

The campaign in the United States led to an announcement by US Vice-President Al Gore and South African Deputy President Thabo Mbeki on 28th February that the United States had withdrawn its arms embargo, thus making normal defence trade possible again. After all the unnecessary haggling and obstruction by the United States, Saab/BAe could finally participate in the ALFA tender in the normal way.

The RFP was issued on 14th February 1998 and sent to DASA, Dassault and Saab/BAe; answers were expected by 14th May. Shortly before the FIDAE 98 show in Chile, a South African evaluation team visited Linköping to study the Gripen and the companies that supported it. Armscor sent three engineers along with three SAAF pilots and the latter enjoyed two new experiences – flying in a fourth-generation fighter and landing and taking off in snow. According to John Bayne, one of the SAAF pilots, it was fun and a challenge and if South Africa chose the Gripen, its pilots would fly the fighter in entirely different weather conditions to Swedish Air Force pilots. The Armscor engineers were impressed with the ease and short time it took to change an engine (less than an hour).

At the FIDAE 98 one Saab test pilot stated that, in his opinion, the South African team had been the most thorough of all the evaluation teams that had so far visited Linköping.

All three contenders replied to the RFP on the 14th May deadline. Now the arms embargo was lifted, it was thought worthwhile for the Swedish Defence Minister to give a 'helping hand' to Saab's export efforts, which was one reason why he visited South Africa between 31st May and 6th June 1998.

British Aerospace was also involved in another tender to South Africa, the Lead-In Fighter Trainer (LIFT) requirement intended to replace the Atlas Impala. BAe first briefed the SAAF about the Hawk in May 1992 and by 15th June 1998 the companies and aircraft short-listed for tenders were:

- Aermacchi MB-339 (which had a good chance due to its price and commonality with the Atlas Impala).
- Yakovlev/Aermacchi YAK/EAM-130.
- Aero L-159.
- British Aerospace Hawk (the most expensive competitor but according to some observers it had a good chance if the Gripen was also chosen).

For a month the Saab/BAe Gripen team toured South Africa, starting out at Ysterplaat Air Force Base near Cape Town. The inhabitants of Cape Town were very interested in the two Swedish Air Force Gripens, as indicated by Cape Town International Airport's air traffic controllers who requested a flypast so that everyone could have a first-hand view of the fighter. Afterwards the Gripens visited the SAAF Flying School at Langebaanweg AFB.

Defence Exhibition South Africa 1998 (DEXSA 98) was held at Waterkloof Air Force Base from 17th to 21st November and for the first time acted as an international show (previously only South African companies had displayed their hardware there). The Gripen and Dassault Mirage 2000-5 were both present and vying for the contract for the new fighter; the Gripens present were 39132 and 39133. The Hawk was also present for the fighter-trainer bid but none of its competitors paid a visit.

Saab/BAe gave displays to military and political delegations and when the South African government announced on 18th November that both the export version of the Gripen and the Hawk had gained the preferred supplier position, it was clear that those industry observers who had favoured the Gripen/Hawk package had guessed correctly.

The same day, the South African government announced all of the preferred companies for its other arms requirements (although each could theoretically still lose their contract to the second-placed manufacturer) and stated that contract negotiations with the winning bidders could begin The planned arms buy comprised:

- 3 submarines to a German contractor.
- 4 maritime helicopters to the British company GKN Westland.
- 40 utility helicopters to the Agusta company.
- 4 corvettes to a German ship-builder.
- 24 fighter trainers – the winner was the British Aerospace Hawk.
- 28 light fighters – the winner was the Saab/BAe consortium Gripen.

The total value of these orders was expected to be 29.7 billion Rand (on the day of the announcement one US Dollar was worth 5.65 Rand). Since Saab/BAe had won the preferential position in the light fighter contest, it was now 99% sure that it would get the contract. This was the first confirmed success for the Saab/BAe Gripen joint venture since it was formed in 1995 and the order was valued by the South African government at 10.875 million Rand. Details were still to be negotiated so Saab/BAe could not say what exactly would be included in the deal, saying only that it would depend on what the customer wanted.

Dassault was said to have offered more aircraft (38 Mirage 2000-5) for the same price while Aero Vodochody expressed surprise at the decision to acquire Gripens and Hawks because Armscor officials had apparently said that the L-159 was technically and economically the best aircraft for the fighter-trainer requirement. However, Aero Vodochody's offset deal did not meet South Africa's stated requirements.

The biggest problem facing all those involved in the deal was that South Africa was still, to a degree, politically and economically stable. Every other political organisation in the

One of the SAAF evaluation pilots, Lt Col Mike Edwards, in the Gripen dome simulator in Linköping. Edwards later returned to Saab to work on developing the export Gripen.

During the Gripen's first visit to South Africa in November 1998, the aircraft were photographed against a backdrop of well-known landmarks including Table Mountain.

country criticised this 'arms deal of the century'. Some saw it as an early and expensive Christmas present for the defence ministry; others felt it was a disgrace because bigger problems, such as housing and other social programmes, needed to be addressed. A statement on the defence package published the following estimates in the table below.

The important part for the South African aviation industry was that, due to the technology that would be transferred to it and the maintenance work it would receive, it could now assure future customers that its own products (for example the Denel Rooivalk attack helicopter) and the provision of long-term support, would not be a problem.

On 7th January 1999 BAe and Denel signed an MoU which opened the way for a technology transfer from BAe to the South African company. The next step would be the privatisation of the South African aerospace industry, including Denel. Saab/BAe reported at the IDET 99 show, held from 4th to 7th May 1999 in Brno in the Czech Republic, that the contract, to be signed by the end of that month, would cover 19 single-seat and 9 two-seat Gripens. Saab/BAe also mentioned that this could be the first batch because the SANDF would like to standardise its air force and, in the long-term, would need more than the 28 aircraft on order.

On 27th May 1999 the South African company Grintek Avitronics won a Gripen supply contract to develop the Communications Control and Display Unit, which would help to fulfil the required offset deals agreed in November 1998. A day later another South African offset contract was awarded, this time to Denel, to develop new pylons for the Gripen which were to have a common NATO MIL-standard mechanical interface; an important factor for possible sales to the three new NATO members – the Czech Republic, Hungary and Poland – because Sweden's interface standard was different and not NATO-compatible.

Product	No	Cost	Investment	Exports	Local sales	No of jobs
Corvette	4	6,001.5m	2,112m	2,109m	11,786m	10,153
Submarines	3	5,212.5m	6,262m	22,950m	1,062m	16,251
Utility Helicopters	40	2,168.75m	431m	2,847m	1,407m	4,558
Maritime Helicopters	4	785.5m	268m	227m	2,225m	2,536
Trainer Aircraft	24	4,728.13m	2,552m	4,566m	1,462m	7,472
Light Fighter Aircraft	28	10,875m	14,387m	26,481m	7,445m	23,195
TOTAL		**29,773m**	**26,012m**	**59,180m**	**25,387m**	**65,000**

During May and June, news began leaking out that the South African government would have to cut its wants list and that the Gripen would one of the first victims. In contrast, during the second week of August the Swedish press ran a story that the Gripen deal was done and that this would be confirmed in about three weeks; neither Saab nor BAe commented on these stories.

An International Offers Negotiating Team (IONT) was installed by the South African cabinet on 18th November 1998 so that negotiations could start in earnest. On 26th May 1999 IONT recommended that the ALFA programme should be postponed and received orders to discuss the possibilities for deferring parts of the Hawk and Gripen buys.

BAe responded with an offer that led to the so-called 'reverse options' whereby deliveries would now be made in batches, the first comprising 12 Hawks and 9 two-seat Gripens, the second 12 Hawks only and the third 19 single-seat Gripens. If one of the tranches was cancelled the remaining aircraft would become more expensive – if, for example, Batch Two was cancelled, the price of other Hawks would be 35% more than the average cost of 24 Hawks; if Batch Three was cancelled, each Gripen would cost 34% more than the average cost of 28 aircraft. All of the non-recurring costs would have been covered by the first batch but it was obvious that cancelling one of the batches would be an enormous waste of money.

On 15th September 1999 the South African government gave its final approval to acquire all of the weaponry (except the maritime helicopters) on its list. The Gripen and Hawk contracts were divided into orders with reverse options as proposed by BAe. The optional Batch Two bail-out had to be approved by the government in 2002 and the Batch Three bail-out was to be approved by 2004 at the latest. Five days later an F7 Wing Gripen crashed. A sceptical Swedish press thought this would affect the South African order but, according to a South African official,it would have no bearing on their decision.

The contract for 9 Gripen two-seaters and an optional 19 single-seaters was signed in Pretoria on 3rd December. There was, however, a clause in the contracts which stated that the deal for Gripens was covered by financial viability, which meant that if the South African economy dropped to a very poor level, the options could be cancelled.

On the same day the contract was also signed for 24 Hawk trainers with another 12 options. The entire defence deal had a value without options of 21.3 billion Rand; the options were worth 8.5 billion Rand.

Deliveries of Gripens to the SAAF were planned to begin in July 2007, the first single-seater was expected by August 2009 and the last single-seater in 2012. The Hawks were to be delivered in 2005 and 2006 and would be operational ahead of the Gripens. According to Jayendra Naidoo, South Africa's chief negotiator, Saab/BAe had to meet regular offset deal milestones otherwise more than 10% of the contract value would be retained.

The Gripens were to be the export variant with air-to-air refuelling capability and their production, in Sweden, was to start immediately after completion of the last Swedish Air Force Gripen. In 2000 the SAAF contacted Zeiss, a Rafael subsidiary, about the Litening pod. During FIDAE 2000 in Chile the SAAF's Chief of Staff revealed that the F-16 and F/A-18 had never been considered for the contract, the reason being that Armscor was still upset about the long-running US arms embargo.

The Gripen contract price in US Dollars was reported to be as follows:

Description	Unit Cost	Equipment Cost	Total Cost
Single Aircraft	34,214,607	19,839,980	54,054,587
28 Units	958,009,000	555,526,996	1,513,535,996

The equipment cost included operational support and ground support equipment, spares, initial logistic support equipment, the mission planning and ground support system, non-recurring engineering and testing, technical training, flying training, training aids, technical publications, technical support services, programme management and customer liaison.

The South African aerospace and defence exhibition was held at Waterkloof Air Base near Pretoria from 5th to 9th September and Saab, following its success two years before, sent JAS 39A 39174 and JAS 39B 39804. Lt General Roelf Boekes, Commander-in-Chief of the SAAF, expressed full confidence in the programme and felt that there would be no problem for South Africa to obtain all 28 Gripens it had ordered.

The V-Darter medium-range air-to-air missile, which was to be integrated with South Africa's Gripens, was exhibited at the show for the first time; the A-Darter short-range equivalent was also shown but was still in development and in competition with other short-range missiles from abroad.

The 5th of September 2000 was also the 80th anniversary of the SAAF, an event celebrated at Waterkloof Air Base alongside the defence exhibition. This gave Saab the opportunity to let South African military staff fly in the two-seat display Gripen. Among those to do so was Lt General Boekes, who completed his first flight in the Gripen.

On 9th May 2001 Lt General Boekes unveiled his plans for the future of the SAAF which included some base closures but also revealed

The Israeli Rafael Python 4 ASRAAM and the South African R-Darter on the Gripen; a weapon load configuration under test but not only for the South African Air Force.

An SAAF Cheetah C in special colours leads JAS 39A 39174 and JAS 39B 39804 during the Gripens' visit to South Africa in 2000. South Africa has nine two-seaters on order and should receive them after the Swedish Air Force has received its JAS 39B/Ds.

Commander-in-Chief of the South African Air Force, Lt General Roelf Boekes congratulates one of his pilots who will become in time one of the first SAAF operational aircrew to qualify on the Gripen.

the airfields where the new fighters would be based. In fact, because so few new aircraft of each type were being bought, there would only be one squadron of each type. Ysterplaat Air Force Base near Cape Town, where Gripen International had started its presentation in 1998, was to close.

The SAAF was thought to have 48 Atlas Impala trainers and 39 Cheetah C/D fighters and these were to be reduced to 24 and 28 respectively, the same numbers as their respective replacements. The Hawks were to go to Hoedspruit Air Force Base in the north-east of the country near the Krugerpark.

The Gripens will be operated by 2 Squadron, the 'Flying Cheetahs', based at Louis Trichardt Air Force Base, also in the north of the country.

Above left: **The unit patch of 2 Squadron, SAAF.**

Above: **The 2 Squadron, SAAF patch as worn by the pilots of the 'Flying Cheetahs'.**

Switzerland

At the end of 1986 the Schweizer Luftwaffe (Swiss Air Force) took its first steps towards procuring a new fighter to replace its Vampires, Hunters and Mirage IIIs. The Swiss were interested in the F-16, F-18, Northrop F-20 Tigershark and Mirage 2000 and, depending how fast the procurement process would take, the IAI Lavi and Batch One Gripen would also be taken in consideration. Switzerland was the first country to express an interest in the Gripen. In the event, the IAI Lavi was cancelled and the Gripen was seriously delayed by problems with its FCS software, which made it a very unlikely contender. In addition, unlike Finland, Switzerland did not send any pilots to Sweden to evaluate the Gripen in the air.

The Swiss government chose the F/A-18C/D in 1998. However, replacement of Switzerland's F-5E/F Tiger IIs, some of which have been acquired by the US Navy, will present the next opportunity for the Gripen to compete to a Swiss requirement – if Switzerland can afford more aircraft. A replacement programme was expected to be initiated during the latter part of 2002.

Below: **The Gripen's future has been secured by the Swedish Air Force and the South African Air Force. Other countries willing to buy Gripens can benefit from the research being conducted today for those two air forces and could therefore benefit from future upgrades. However, due to the upgrades being modular, an air force could effectively have their Gripens 'customised' to meet specific requirements.**

Gripen Specifications Comparison with Competitors

	Saab Gripen	Dassault Rafale C	EF-2000 Eurofighter	Lockheed-Martin F/A-22 Raptor	F-35 JSF¶	IAI Lavi
Max take-off weight, tonnes	12.7	21.5	21	36	32.5	17.1
Normal take-off weight, tonnes	9	15.2	15	27		
Max external load, tonnes	Ca4.5	8	6.5			
External hardpoints	7	14	13	10		11
Thrust, kN	80	146	180	310	177	90
Thrust-to-weight ratio	0.9	0.98	1.23	1.17		
Wing area, m^2	30.7	46	52.4	78	42.7	32.5
Wingload, kg/m^2	293	330	286	346		
Max g-load, g	9	9	9	9	9	9
Take-off distance, metres	395	395	295			
Landing distance, metres	490	395	490			
Max speed, Mach	2.0	1.8§	2.0	2.2-2.5	1.6	1.85
In service (year)	1993	2002	2003	2005	2008	–
Initial operational capability	1997	2006	2007		2011	–
Estimated price per unit, US$ (millions)	30	51	51	156	40	–
First Flight of						
1st Technology Demonstrator	–	04/0786	08/08/86	29/09/90	24/10/00	
2nd Technology Demonstrator	–	–	–	30/10/90	24/06/01‖	–
3rd Technology Demonstrator	–	–	–	–	16/12/00	–
First Flight of 1st Prototype	09/12/88	19/05/91	27/03/94	07/09/97		31/12/86‡
2nd Prototype	04/05/90	12/12/91†	06/04/94	29/06/98		30/03/87‡
3rd Prototype	25/03/91	30/04/93*	04/06/95	06/03/00		09/09/89
4th Prototype	20/12/90	08/11/93	14/03/97*	15/1100		–
5th Prototype	23/10/91	–	24/02/97	05/01/01		–
6th Prototype	9/09/92§	–	31/08/96*	05/02/01		–
7th Prototype	29/04/96*	–	27/01/97	15/10/01		–
8th Prototype	–	–	–	08/02/01		–

*The two-seat variant of the fighter concerned; † Marine versions with a reinforced undercarriage for carrier landings.
‡ Two-seat prototypes but with the second seat occupied by test instruments.
§ Actually a production aircraft but used as a test aircraft after the loss of a prototype to prevent any further delay.
¶ Conventional take-off and landing version; ‖ Launched and landed vertically.

GRIPEN

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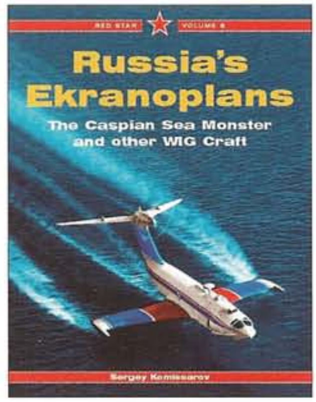

Known as wing-in-ground effect (WIGE) craft or by their Russian name of ekranoplan, these vehicles operate on the borderline between the sky and sea, offering the speed of an aircraft coupled with better operating economics and the ability to operate pretty much anywhere on the world's waterways.

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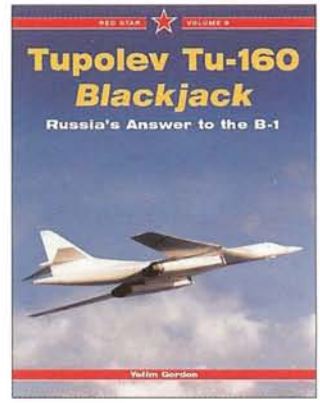

How the Soviet Union's most potent strategic bomber was designed, built and put into service. Comparison is made between the Tu-160 and the Sukhoi T-4 ('aircraft 100', a bomber which was ahead of its time), the variable-geometry 'aircraft 200' – and the Myasishchev M-18 and M-20.

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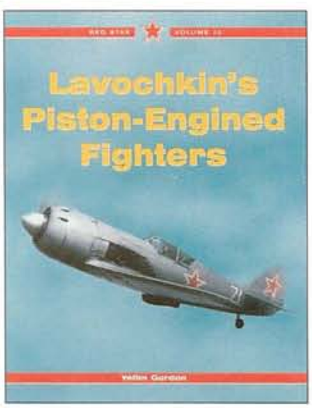

Covers the formation and early years of OKB-301, the design bureau created by Lavochkin, Gorbunov and Goodkov, shortly before the Great Patriotic War.

It describes all of their piston-engined fighters starting with the LaGG-3 and continues with the legendary La-5 and La-7. Concluding chapters deal with the La-9 and La-11, which saw combat in China and Korea in the 1940/50s.

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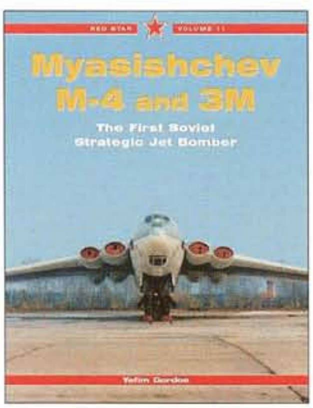

The story of the Soviet Union's first intercontinental jet bomber, the Soviet answer to the Boeing B-52. The new bomber had many innovative features (including a bicycle landing gear) and was created within an unprecedentedly short period of just one year; observers were stunned when the aircraft was formally unveiled at the 1953 May Day parade. The M-4 and the much-improved 3M remained in service for 40 years.

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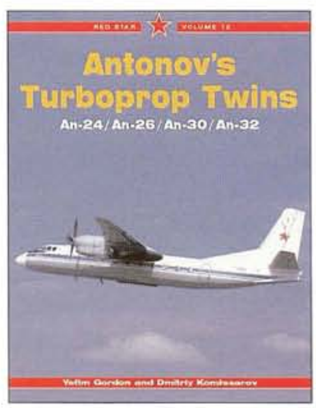

The twin-turboprop An-24 was designed in the late 1950s and was produced by three Soviet aircraft factories; many remain in operation.

The An-24 airliner evolved first into the 'quick fix' An-24T and then into the An-26. This paved the way for the 'hot and high' An-32 and the 'big head' An-30, the latter for aerial photography.

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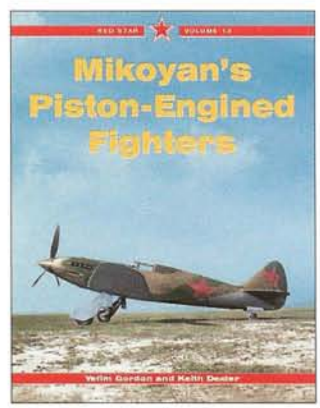

Describes the early history of the famous Mikoyan OKB and the aircraft that were developed. The first was the I-200 of 1940 which entered limited production in 1941 as the MiG-1 and was developed into the MiG-3 high-altitude interceptor. Experimental versions covered include the MiG-9, the I-220/225 series and I-230 series. A separate chapter deals with the I-200 (DIS or MiG-5) long-range heavy escort fighter.

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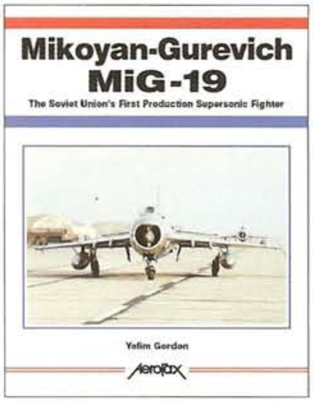

The MiG-19 'Farmer' represented a major technological leap for the VVS as it was one of their first fighters to accommodate AAMs, ground control intercept system and other advances. By the end of the 1950s it became their standard fighter and was integrated into the inventories of most Warsaw Pact countries and Soviet allies. It was produced in thousands in the USSR, Czechoslovakia and China (J-6, JJ-6 & Q-5); export customers included Cuba, Egypt, Albania, Vietnam and Pakistan.

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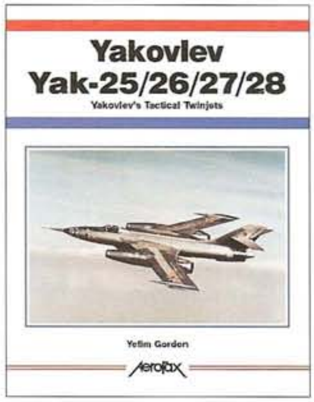

During the 1950s and 1960s the Soviet design bureau Yakovlev was responsible for a series of swept-wing twin-engined jet combat aircraft, known in the west under various names including *Firebar, Flashlight, Mandrake, Mangrove, Brewer* and *Maestro.*

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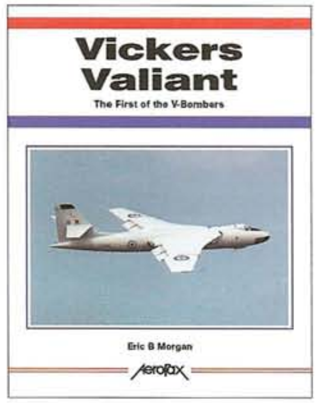

The Valiant was the shortest-lived of the post-war V-bombers, first flying in 1951 and with production of 104 aircraft ending in 1957, and official withdrawal in January 1965 after investigation had shown that the main wing spars were suffering from metal fatigue. Valiants participated in British atomic bomb tests and made noteworthy long-distance flights, principally operating from Marham and Gaydon. Includes a full listing of each aircraft history.

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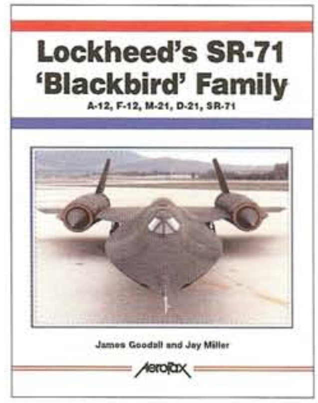

Though only 50 of these craft were built, everything about them was unique. The stories of the development program, the General Dynamics 'Kingfish' competition, the M-21 and D-21 effort, the F-12 saga, and the operational history of the A-12 and SR-71 under the auspices of the CIA and the USAF are all covered in detail. The high-speed, high-altitude recce overflights performed by SR-71As from bases in the US, Japan and the UK during the Cold War are also covered.

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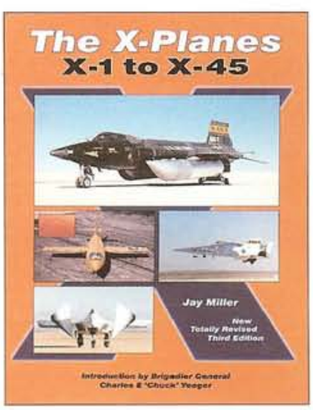

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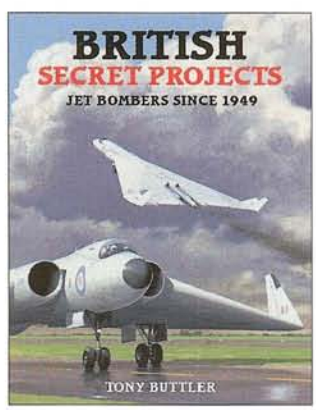

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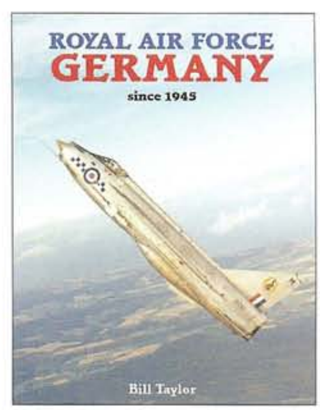

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Top: **JAS 39As 39150 and 39141 display the Gripen's air superiority (four Rb99 AMRAAMs and two Rb74s) and air defence (six Rb74 Sidewinders) weapon loads.**

Above: **High over the Andes, JAS 39A 39174 and JAS 39B 39803 accompany a Chilean Air Force A-36 Halcon during the Gripens' attendance at FIDAE 2000.**

Front cover illustration:
Beautifully lit against an Arctic sunset, JAS 39A 39184 patrols the skies above Sweden.

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