# The Gripen forges ahead - in 'Super' mode

*This diminutive Scandinavian fighter has transformed into one of the world's most potent and cost effective combat aircraft. Here's how Saab's success story is playing out.*

At a time of diminishing defence budgets and out-of-control development and manufacturing costs across the globe, one major defence programme visibly stands out. Beginning as a light fighter, produced in comparatively low numbers for a captive, domestic customer, this project has quietly built momentum since it began in the early 1980s and now stands as arguably the most promising export-oriented combat aircraft programme in the world – the Saab JAS 39 Gripen.

Focused studies for the replacement of Sweden's Saab 35 Draken and 37 Viggen fighters began in 1979, with the goal of producing a high-performance but affordable fighter that would accomplish the roles of both preceding aircraft types. This led to the 'JAS' designation – *Jakt* (fighter), *Attack* (air-to-surface strike) and *Spaning* (reconnaissance) – essentially indicating a multirole aircraft. Saab proposed a number of designs to fulfil the Swedish requirement, and the Swedish Defence Materiel Administration (*Försvarets Materielverk* – FMV) eventually settled on a lightweight single-seat, single-engine aircraft that incorporated the latest in aerodynamically unstable design and fly-by-wire technology. To keep costs and risks low, a General Electric F404-400 afterburning turbofan, modified and produced by Volvo Aero as the Volvo RM12, was selected, continuing a successful trend of adapting and manufacturing Western powerplants for use in Swedish fighters.

Progress on the Gripen was quite rapid by the standards of the day, at least among European fighter development programmes. It first flew in December 1988, and the first production aircraft was delivered to the FMV less than five years later, in mid-1993. Designed to be highly upgradable right from the outset, in terms of both hardware and software, development work on an upgraded export-oriented model of the Gripen began shortly after the first Gripen A/B deliveries had commenced. Thus, Sweden's cumulative Gripen orders totalling 204 aircraft were fulfilled in three batches. The first of these batches was delivered under a fixed price contract but interestingly, Saab and the Swedish FMV agreed on a 'target price' concept for the second batch, with any deviations from the target price (whether a cost overrun or a cost saving) would be borne by both Saab and the FMV. The third batch was an order for 64 upgraded Gripens (50 Gripen C and 14 Gripen D), fulfilled in 2008. This last batch was delivered at a cost that was 10 per cent *less* than the agreed-upon price, continuing to set the tone for what was becoming a highly efficient programme.

In 2007, on the tail of the third Swedish production batch, as well as the recognition that the global fighter market was entering a phase of fiercely competitive growth, a two-seat Gripen NG demonstrator was ordered. This aircraft incorporated the most comprehensive upgrades for the type – a new engine to facilitate increased kinetic performance and higher payload, greater range as a result of increased internal fuel capacity and a raft of avionics updates, including an AESA radar. The aircraft, numbered '39-7,' served essentially as a development testbed for the technologies that would ultimately be fielded in the definitive 21st century variant of the Gripen – the JAS 39 Gripen E/F family (also known as the Gripen NG – new generation). The Gripen Demo aircraft first flew in May 2008, and has clocked hundreds of test flights since then as part of a concerted campaign to minimise development time (and therefore programme cost).

## Electronic wizardry is the future

If the Gripen E/F programme had a *mantra* it would probably be 'high capability at low cost.' This central theme means that Gripen NG development has been ruthlessly focused on producing an aircraft that is at least as good as its peers but at a fraction of the cost – both to acquire as well as to operate. The GE F414 engine, for instance, is well known for the level of reliability it marries to high performance, and was a natural choice for a new powerplant. Sensor development was conducted by Saab as well as avionics partners, such as Selex ES, leveraging a mix of innovative solutions and proven technologies to ensure that costs remained controlled. Airframe changes were minimised to essential areas so as to reduce certification issues and limit the changes that would be required to production tooling and processes.

All this results in an aircraft that looks much the same – and feels much the same – but brings a quantum leap in performance and combat ability to the type. *[See box item]*

The performance and payload improvements embodied in the Gripen E/F have been largely validated already – for instance, the Gripen demo aircraft showed off its supercruise ability as far back as 2009. However, the real 'heart' of the programme, so to speak, is in the new electronics. Saab has rightly recognised sensor performance as one of the key areas in future air combat and a significant portion of the Gripen E/F project is dedicated to the fielding of vastly enhanced sensors compared not only to the preceding Gripen variants, but also to contemporary fighters worldwide.

***Gripen NG demo aircraft pictured with 'swing role' payload – LGBs, Meteor BVRAAMs, IRIS-T SRAAMs and underwing drop tanks.***

***Gripen demo aircraft in air-to-air configuration with a single drop tank and multiple Meteor BVRAAMs and IRIS-T SRAAMs***

To this end, Saab and its partners have invested heavily in cutting edge technologies such as gallium nitride (GaN) for sensors such as AESA radars and electronic warfare (EW) systems. While the Selex AESA uses proven gallium arsenide (GaAs) technology for its transmit/receive modules, the Gripen E/F will feature a GaN-based EW suite that provides tremendous situational awareness. It is significant that both Selex and Saab have thrown their weight behind the new GaN technology, which is expected to enable more powerful and yet more reliable AESA antennae as compared to those that use existing GaAs modules. Additionally, with the impending proliferation of low-observable combat aircraft around the world, Saab has incorporated a Selex Skyward-G infrared search and track (IRST) sensor and a new IFF (identification friend-or-foe) system.

The Selex Raven ES-05 AESA radar is the first production AESA in the world to be mounted on a rotating swashplate, vastly improving the radar's field of view. Most AESA arrays are fixed and therefore have a fixed field of view, which is often considered quite narrow when compared to older mechanically-steered radar arrays. However, the range and instantaneous scanning ability of AESA radar sets make them tremendously attractive in modern day combat. Combining the two – AESA performance and mechanical steering – gives the ES-05 a much larger field of view than comparable arrays, estimated at over 100°. The new three-antenna IFF system provides low-latency coverage across the radar's entire field of view and matches its maximum range, providing reliable information on targets within detection range of the Gripen.

The IRST employs a long-wave focal plane array sensor, also called a 'staring array,' with three fields of view. In long-range search mode, the system effectively behaves as an infrared telescope and in wide-angle mode it provides a night-vision image that can be projected on the head-up display (HUD). Being a passive sensor, IRST systems can only provide reliable azimuth and elevation data but the Skyward-G is also able to provide rudimentary range information via 'kinetic ranging,' wherein the aircraft performs a weaving manoeuvre and range to target is determined by the change in azimuth or elevation angles. Additionally, the IRSTs on two (or more) aircraft can triangulate range to target by sharing tracking information over their datalinks. Skyward-G is based on the Selex PIRATE system used on the Eurofighter Typhoon, but by virtue of being newer, has seen more development on both the hardware and software fronts, allowing for better and more discriminate performance.

When all the new detection hardware, that is the ES-05 radar, the Skyward-G IRST unit and the IFF system are employed together, the situational awareness provided to the pilot, including against low-observable targets, is remarkable. Crucially, however, the IRST adds a level of self-defence to engagements with low-RCS targets that other fighters equipped only with AESA radars would lack. As a passive sensor, it emits no signals and is therefore undetectable as it scans for targets. Once a target is acquired, the IRST can continue to track it whilst undetected, waiting until the last possible moment to switch to an active (but detectable) sensor such as the AESA radar. With 'lock on after launch' (LOAL) technology, the IRST can even be used to guide a missile toward the target without using any active sensors at all, letting the missile seeker conduct terminal guidance to the target. Not only does this make the Gripen E/F an effective 'counter-stealth' platform at a very affordable cost, it also makes the platform much more survivable against any opposing fighter – stealth or otherwise.

This level of sensor fusion and situational awareness makes for much more effective performance in various situations. For example, in the air defence role, a Gripen E can operate safely even among civilian traffic – the IFF system would handle information from friendly/commercial aircraft, freeing up the other sensors (radar, IRST) to track or engage unidentified or hostile craft.

As of going to press, the Gripen Demo aircraft (39-7) has flown with both the ES-05 AESA radar and its swashplate mounting and the production-standard Skyward-G IRST system. The IFF system

## What makes the Gripen E/F so 'Super' ?

While externally similar to earlier Gripens, the Gripen E is revolutionary development of the JAS 39 platform, and is different from the Gripen C in a number of ways.

- The new F414G-39E engine produces around 98 kN of thrust in afterburner, over 20 per cent higher than the F404-based Volvo RM12 in the Gripen C. This has necessitated larger air intakes.
- The Gripen E has a higher maximum takeoff weight (16.5 tonnes versus 14 tonnes), translating to higher payload.
- The undercarriage has been redesigned with the mainwheels relocated to bulges under the wing roots, freeing up room inside the fuselage for an incredible 40% increase in internal fuel capacity as well as increasing space under the airframe for additional hardpoints.
- The Gripen E incorporates a new self-protection and EW suite, using the latest gallium nitride (GaN) antenna technology.
- A new AESA radar from Selex is one of the primary distinguishing features of the new Gripen. The antenna is mounted on a rotating swashplate that widens the field of view of the planar array. Additionally, the Gripen E also incorporates a new IFF (identification friend-or-foe) system.
- An infrared search and track (IRST) sensor, also from Selex, is one of the most visible changes to the Gripen E, and allows the aircraft to track even low-RCS targets at beyond-visual ranges.

*Gripen NG demonstrator, showing its relocated mainwheels and additional under-body pylons to good effect.*

is expected to be delivered for testing sometime in 2014.

In addition to the on board EW and self-defence suite, the Gripen will also be the first aircraft to offer the new 'BriteCloud' off-board active decoy from Selex. BriteCloud is a self-contained Digital RF Memory (DRFM) jammer for fighters, and was launched by Selex on 6 November 2013. Saab will offer BriteCloud as an electronic warfare option on all versions of Gripen.

BriteCloud is specifically aimed at defeating modern tracking systems, both ground-based and air-based. Its DRFM technology is able to defeat even contemporary chaff discrimination techniques, effectively creating a convincing false target that allows a wide range of threat systems to be countered.

As an off-board device, BriteCloud avoids the 'home-on-jam' vulnerabilities of on-board devices where the source of jamming itself acts as a beacon for hostile sensors and munitions to target. Additionally, since BriteCloud does all processing and transmitting inside the unit rather than on the platform, it is able to put a significant distance between itself and the fighter after launch. This minimises the risk of incoming missiles detonating in close proximity to the platform, further increasing the efficacy of the system.

## Testing and production

As noted briefly before, the Gripen NG programme began with a low-cost technology demonstrator based on the Gripen D, modified to incorporate many of the proposed Gripen E/F changes, from the new engine to redesigned landing gear, and of course, an all-new cockpit layout (implemented for the rear seat only). This risk-reduction platform, aircraft 39-7, has logged some 300 flights (totalling around 260 hours) since it first flew in 2008, validating the vital systems and airframe attributes of the new project whilst Saab drummed up sales interest in the type around the world.

A model-based design technique is yielding enormous cost savings through the development and testing of this programme. Advances in design and manufacturing are being pursued parallel to the flight testing of 39-7, allowing Saab to project significant increases in productivity and savings once the aircraft finally enters production. As an example, the demonstrator activity conducted by aircraft 39-7 has been performed for just 40% of its initial projected cost.

*Aircraft 39-7 pictured inside the Saab facility at Linköping in 2012 (photo: Angad Singh)*

Now, however, Saab has begun the next stage and started fuselage assembly work on the first of three 'new-build' Gripen E test aircraft at its Linköping facility, and has also revealed more detailed design information on the type. The three upcoming test aircraft will be constructed from the ground up as Gripen Es, as opposed to modifying an existing structure as in the case of 39-7. In effect, this makes them the first 'proper' prototypes for the programme. It is interesting to note that while Sweden's order for 60 Gripen E specifies that the aircraft must be remanufactured from existing Gripen C stocks in service with the Swedish Air Force, the Gripen E actually does not retain much of the older airframe, only reusing parts of the fuel and air systems, the ejection seat, windshield, canopy and outer elevons.

The first new flight test aircraft will be numbered '39-8' and will be followed by a static test airframe numbered '39-83.' The latter is also already under assembly at Linköping. The first components that will be used in the construction of second test aircraft '39-9' are also under production, and that aircraft will enter assembly late this year or early in 2015.

First flight of the lead test aircraft (39-8) is scheduled for next year, with the single-seater to be used primarily for airframe and flight control system testing. 39-9 is then expected to take to the air in the first half of 2016, and will support tactical systems development. Any changes identified from these two flight test aircraft will be embodied in the last airframe, '39-10,' which will join the programme in 2017, virtually in production configuration. Once again, cost

*The Czech Gripen fleet completed 10,000 flight hours in 2010, and the aircraft are contracted to remain on lease until 2029.*

savings are realised by conducting a large portion of modelling in software. Where the Gripen C/D programme required some 4,000 test sorties to conclude development, the Gripen E/F is expected to require less than 1,200 sorties spread across all three test aircraft, a tremendous feat in both engineering and cost-control.

The first production example should follow close behind 39-10, with Saab targeting military type certification in early 2018. This should result in the commencement of deliveries of new-build aircraft in the 2018-2019 period.

Production is arguably the linchpin of any military manufacturing programme – all the technology in the world is of no use if it is delayed, unreliable or unaffordable. This reality is not lost on Saab, which has long had to balance Sweden's fierce neutrality with its aspirations toward self-reliance in defence. Indeed, the Swedish defence industry as a whole has long been regarded as *the* model for frugal, well-engineered solutions. It is not surprising therefore, although certainly impressive, that the Gripen E/F programme will cost less than the Gripen C/D programme, with savings across the board from development to production as well as operational costs. The Gripen E/F represents that rarest of capability improvements, one that does not come with a correspondingly hefty price tag.

Extensive pre-production design work has resulted in a reduced parts count for the new airframe, and shorter component manufacturing times, making each aircraft less complex and quicker to put together, resulting in large savings on the factory floor. Saab estimates a 50 per cent increase in productivity as compared to the later stages (that is full rate production) of the Gripen C.

The firm has not only drawn on its experience from the Gripen A/B to C/D conversion programme, but also on industry best practices acquired from manufacturing work done for Airbus and Boeing commercial products. Saab's involvement in the multinational nEUROn unmanned combat air system (UCAV) project has also paid dividends.

The worldwide Gripen fleet, presently operating in six countries (Czech Republic, Hungary, South Africa, Sweden, Thailand and the UK) has logged over 203,000 flight hours, and according to Saab, has demonstrated extraordinary reliability and low operating costs. The Swedish Air Force, for instance, currently estimates the total cost per flying hour (CPFH) of the type as being around $7,560. With the changes to production processes applied for the Gripen E/F programme, it is not unreasonable to expect the new variant to enter service with comparable hourly operating costs. In any case, a 2012 study by HIS Jane's noted that the Gripen boasted the lowest operating costs of any contemporary Western fighter. Jane's metrics had the Gripen outmatching even the F-16 Block 40/50, an aircraft that is often used as a benchmark for comparing operational costs across various fighters.

Saab forecasts that it will sell between 300 and 400 new Gripens across the globe over the next 20 years. Given the promising trajectory of the programme so far, that target actually seems modest !

**Angad Singh**

*Three Gripen C and one Gripen D conduct a formation display over their 'home city' of Linköping, Sweden (photo: Angad Singh)*

## History in motion !

Sixty-four years separate these Saab aircraft types, from the J-29 to the JAS-39. The Saab 29 Tunnan first flew in 1948, and the JAS 39 Gripen remains in production today. Saab AB is among the oldest aircraft manufacturers in existence and has operated continuously in the aerospace arena for 77 years.