Model behavior

Aerospace testing International

Smart testing for a smart fighter: the Gripen E is being developed and tested to ensure maximum value and efficiency

On May 18, 2016, Saab unveiled its latest Gripen E fighter prototype at its Linköping facility in Sweden. Described as a 'smart fighter' by the manufacturer, the Gripen E is the result of an equally smart development program, which is already yielding a considerable reduction in costs and time.According to Lars Ydreskog, Saab's head of aerospace operations, "We have reduced development and production costs by 40%." Rather than using traditional design drawings, the Gripen E's three-year full-scale development effort has been based around what the Swedish manufacturer calls model-based systems engineering (MBSE).

Test data has been gathered in advance of the Gripen E's first flight using experience from previous, in-service Gripen variants (JAS 39A to D), and a dedicated test airframe, the Gripen Demo, colloquially known as the 'Dash 7'. (The Gripen Demo is aircraft 39-7, while the first full prototype Gripen E is aircraft 39-8).Thanks to MBSE, costs relating to modeling, evaluating and building the Gripen E have been trimmed. And once the Gripen E takes flight later this year, Saab aims to continue its lean approach via a considerably reduced flight test campaign.

Added capabilities

Compared with the Gripen C/D, the Gripen E carries 40% more fuel, offers greater thrust, has more weapons stations and increased overall weight. Sweden's Defence Ministry plans to buy 60 new-build Gripen E fighters, and is considering buying another 10 on top of that, while Brazil has ordered a total of 36 aircraft under a US$4.5bn contract. Ultimately, there is the potential for a future Brazilian Air Force fleet exceeding 100 aircraft while the Brazilian Navy could buy 24 examples of a navalized Sea Gripen, or Gripen M.

"First flight was traditionally important," Ydreskog explains. "The first flight for us of Gripen E is of course important, but it is not that important for us to verify that all the functions work." As such, the abbreviated flight test campaign will focus on areas that are difficult to model

using computer software alone.The Gripen E program involves an entirely new-build airframe allied with a new engine and new, but proven, technology.

Software step change

In order to reduce the quantity of certification test work required for the Gripen E, the amount of computer software code relating to flight-critical elements has been cut to just 10%. The remaining 90% of code is dedicated to tactical functionality. This has the additional benefit of enabling Saab engineers to make rapid tactical upgrades without having to modify flight-critical avionics. Saab likens this approach to adding apps to an existing smartphone. The first Gripen E prototype will be used to complete the verification of the flight control software. In the meantime, the software is being proven on the ground, using a simulator and test rigs. Gripen test pilot Marcus Wandt says that tests of the software in the simulator show that it is already “very stable”.

Certain key features are intended to separate flight management software from tactical management software, explains Wandt. “You don’t want code from tactical management to affect flight management.

We need to be able to change tactics really quickly and also be able to change hardware without touching the applications.”

Speaking to Aerospace Testing International, Ulf Nilsson, Saab’s head of aeronautics, confirmed that the company’s new approach to testing reduces the number of test flights required by 30 to 40% compared with the traditional model – as was used for development of the previous-generation Gripen C/D. “We see potential for even more reductions,” says Nilsson, “now that we are using the philosophy of working with the simulators and the model-based design and everything that is bringing with it.”

The wealth of data that will be obtained prior to the first flight of the Gripen E also means that the first test aircraft will be much more similar to the production fighter that follows than was the case in previous programs. “The model-based design is a really important point,” observes test pilot Wandt. “The first test aircraft will be surprisingly similar to the production aircraft. Normally you have to test the prototype and then you have to go and test the production aircraft, with a lot of overlapping testing. We avoid this overlap by being able to provide a lot of the answers to test points right now.”

Demo paves the way

The Gripen Demo is a key element in the program’s risk-reduction effort. This aircraft, originally a two-seat JAS 39D, was extensively rebuilt as a surrogate two-seat ‘Next Gen’ variant, and was first flown as such in 2008, just seven months after the Swedish government approved plans to develop some of the features

proposed for the future Gripen E/F.
Items of new technology destined for the Gripen E have been progressively added to the Demo airframe and then tested. At the time of the roll-out, Saab had flown a total of “several hundred” sorties.As first flown in May 2008, the Gripen Demo included an increased-area wing, new landing gear, additional hardpoints under the wing, and the new General Electric F414 engine. After a total of 79 sorties – including demonstration of super-cruise capability at Mach 1.2 – the Gripen Demo was returned to the manufacturer to receive a host of further modifications. It returned to flight in October 2009, now with active electronically scanned array (Selex ES-05 Raven) radar, elements of the self-defense system, as well as activation of its increased internal fuel capacity.
“We’ve been flying the AESA radar for a long time,” confirms Ydreskog. Furthermore, the Gripen Demo has also flown with the Selex Skyward-G infrared search and track (IRST) sensor and other avionics elements.

It is certainly a step change from the beginning of the Gripen program, when a modified Saab Viggen was required to serve as an avionics ‘surrogate’ for the maturing fighter, completing almost 250 flights until it was retired from the program in 1991. Another break in the flight test program saw the Gripen Demo fitted with its current open-architecture avionics (with separation of flight-critical and mission critical functionality), new tactical mission computers, Ethernet capability and new cockpit displays. The aircraft returned to flight in May 2011.

In March 2014, the Gripen Demo was first flown with the production-standard IRST. Also previously test flown in the Demo jet is the new missile approach warning system (MAWS), satellite communications (SATCOM), new displays and avionics architecture (installed in the Demo’s rear cockpit), and the new digital head-up display (HUD). In terms of structural test, the Demo has flown trials of the increased internal fuel, new landing gear, and the two new stores stations.

Marcus Wandt talked about his experience of the Gripen Demo as regards fulfilling the test program criteria: “As long as we can answer the questions, we can move on with the test program. Some of the tests include a lot of test points and we have developed some software as well to ensure that we can do as many test points as possible during one flight, or during one synthetic test. We also have a really thorough qualification of all test equipment we are using, always asking: ‘To what level can we answer the question using this system?’ For instance, there are some things you can’t answer in a rig or on the ground. And that will be stated in the test points. By doing this, by taking care of a lot of the test points that it is easy to get an answer on, by covering a lot of those in the rigs, we can devote the actual flight test to the tricky parts, which is something I like as a test pilot.”

Saab plans to complete three Swedish Gripen E test aircraft, which are additional to the 60 aircraft on order for the Swedish Air Force. The initial prototype will be handed over for flight-testing this summer and will take to the air before the end of the year.

The next two prototypes are both now under construction at Linköping. Saab will complete a further test aircraft for the Brazilian side of the program. This will undergo initial tests in Sweden before being handed over to Brazil, where it will trial certain elements specific to the Brazilian aircraft, including a local communications suite, different weapons, and a large-area display cockpit. Saab is currently establishing a Brazilian development and flight test center at Gavião Peixoto, in partnership with Embraer. Ultimately, a full production line will exist in Brazil, and this will also be responsible for the two-seat Gripen F, which to date has only been ordered by Brazil.

The next phase

Many test requirements have already been verified and the number of live flight-test points has been dramatically reduced thanks to work undertaken using test rigs in flight sciences laboratories, simulation modeling, and live test flights using the aforementioned Gripen Demo aircraft.Once the first Gripen E has taken to the air, the certification period is currently planned to run from mid-2018 to the end of 2023. When this is complete, the Gripen E will mark full operational capability with the definitive MS22 software configuration (the current Gripen C/D is currently at the MS20 standard).

Now, after all the preparation work in the Gripen Demo, and using synthetic aids, Marcus Wandt is looking forward to exploring the flight envelope and characteristics of the Gripen E. “Some of the handling qualities, where the dynamics come into play, can only be explored in the Gripen E. You can have a full-motion simulator, but that’s only motion, it’s not vibration, it’s not workload. It’s not the same thing.

“With some of the test points you have to go up there and fly to make sure that the control system in the human brain does not interfere with the aircraft,” Wandt continues. “We have to see what happens with the pilot-in-the-loop in given situations. Using the simulators we can take it all the way to ‘this is definitely ready for flight’, and get that warm and fuzzy feeling prior to the flights. But then we have to go and fly to verify that the model is real. And when we’ve done that, we can use the model again to fill out some of the test points and take it to the next level.”