

The First GE F414 Engine (but probably not the last...) in the Saab **GRIPEN** a/c



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At the morning Briefing...

Do you really feel as YOU actually have a “**No Vote**”?

or does it feel as you in fact...have “no **Vote at ALL**”...

Do YOU have the courage to stand up and use your “**No Vote**”?

Outline

- Gripen Demonstrator Program - *"a new way of working"*
- GE F414G Engine Installation
- My Flight Test Engineer Responsibility
- Conditions and Challenges
- Performed Engine Integration Tests
- Lessons Learned
- **GRIPEN NG** - the Integration of GE F414 continues...



GRIPEN Demonstrator Program



Purpose

The main purpose with the Demonstrator Program was to show the development capabilities of the **GRIPEN** aircraft.

Mission

“... the challenge to please the Project/Market demands, with a very tough time schedule, without compromising the Flight Safety...”



GRIPEN Demonstrator Program



- Some degree of "Skunk Works"
- Small organization
- Low profile until official "Roll Out"
- Communicate progress vs pressure on Env. Exp. Team
- Rebuilt a/c:
 - Engine
 - Fuel tank
 - Landing gear
 - Radar, etc
- GRIPEN Demo first flight may 2008



GRIPEN Demonstrator Program



- ▶ Adapting existing methods and processes
- ▶ Aggressive budget and Project goals
- ▶ "Good enough" technical solutions
- ▶ Project pressure = High priority ➡ Easy to work
- ▶ Fast design/project decisions
- ▶ Marketing interests and customer focus



The GRIPEN aircraft

- ▶ 4:th generation fighter
- ▶ Single engine
- ▶ Multi-role capability
- ▶ NATO compability
- ▶ Single seat and twin seat version

Length:	14.1 m
Height overall:	4.5 m
Span:	8.4 m
Empty weight:	6.8 tonnes
Max take-off weight:	14 tonnes



GE F414G Single Engine Installation

**Extended
Range**

**Higher
Operational
Mass**

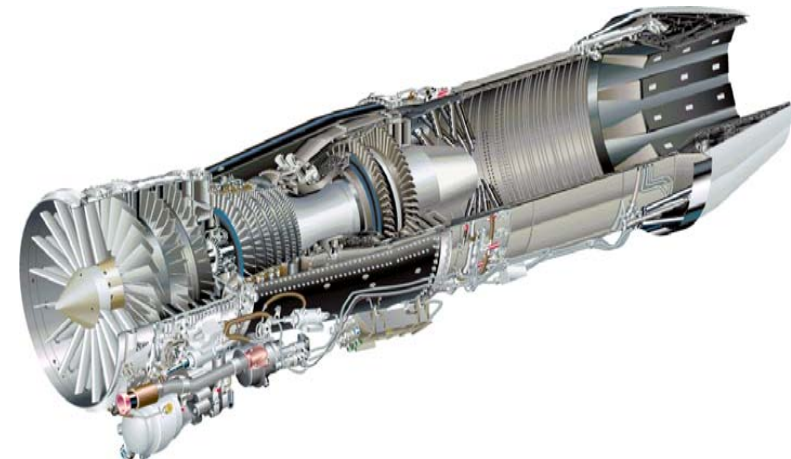
**More
Thrust**

- Replacement of GE F404 engine
- “Single engine modified” by VAC, Sweden (GE F404)
- Cooperation with GE Aviation (GE F414)
- Similar to F414-GE-400 for F/A-18 Super Hornet



GE F414G Single Engine Installation

- Single engine modifications
- Air intake moduls
- Engine mounts/physical interfaces
- Power take off shaft lowered
- Engine bay ventilation
- S/W and Avionics
 - FADEC s/w logic and functionality
 - Bus traffic to/from a/c (two channel FADEC)
 - Functional Monitoring alerts (Pilot warnings)
 - A/C and FADEC start up check (SC)
- Cockpit integration
 - FADEC channel shift
 - Emergency thottle control
 - Activation of Anti Ice
 - Throttle handling
 - Presentation



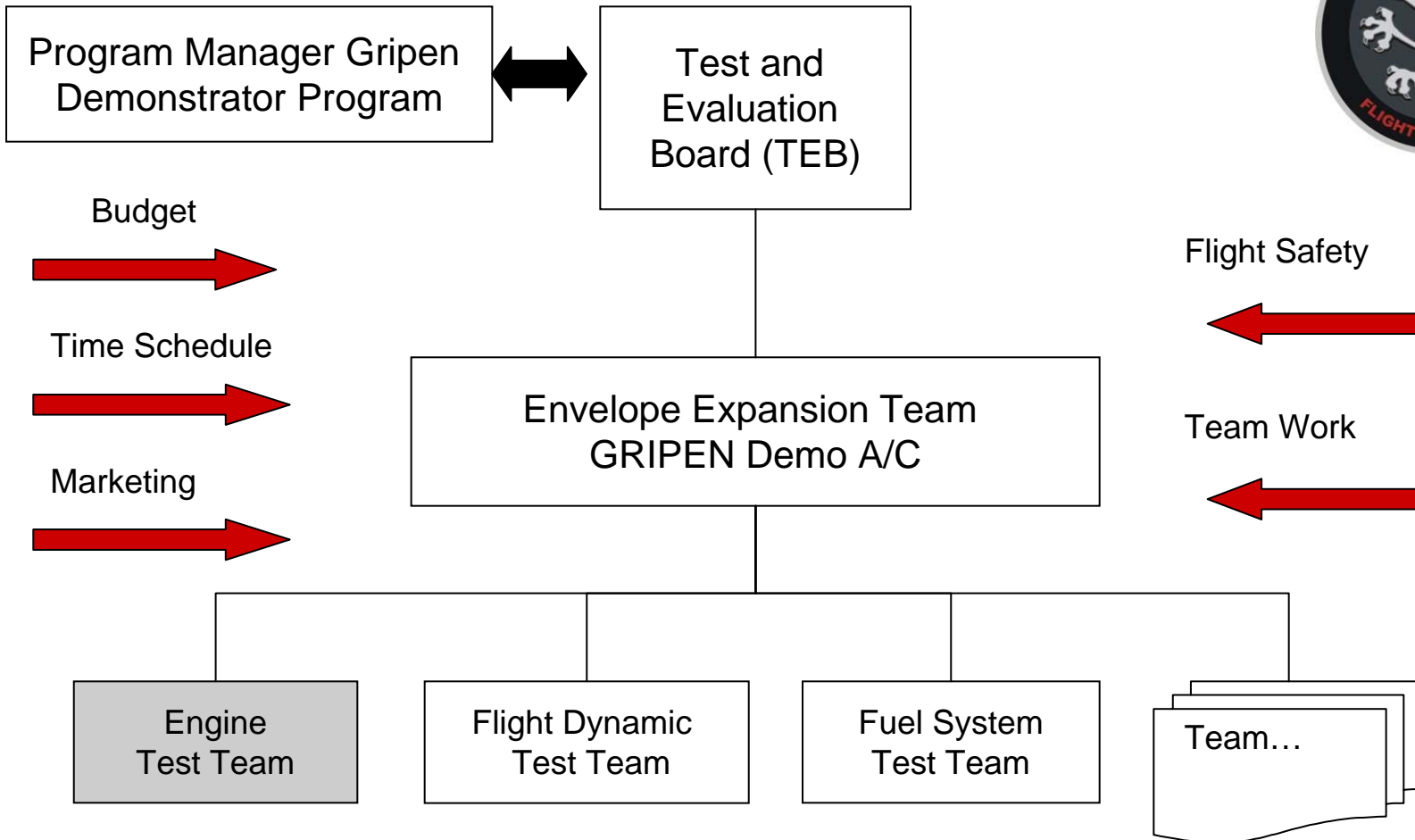
My Flight Test Engineer Responsibility

- Flight Test Engineer 2007-2009
- Integration of General Electric F414 engine in **GRIPEN** aircraft
- Plan, perform and report the tests
- Represent/submit the engine integration standpoint
- Enormous focus

**Should I really dare to
use my "No Vote" if needed?**



My Flight Test Engineer Responsibility



Conditions and Challenges


- "Failure is not an option"
 - one a/c of this unique configuration
- Successful Env. Expansion called for extended possibilities
 - Higher workrate
 - More shortcuts
 - More customer evaluations
 - One mistake is enough
 - Stay focused




Performed Engine Integration Tests

- ▶ System Simulator Test *Will the new s/w be integrated correct?*
- ▶ Engine Integration Test *Will FADEC/aircraft communicate?*
- ▶ Engine Installation *Will it really fit?*
- ▶ GRIPEN Demo Power on *A very important Milestone!*
- ▶ Engine/Aircraft Run-up *Will the engine start?*
- ▶ Ground Roll *Will the airflow/thrust be as expected?*
- ▶ GRIPEN Demo First Flight *An even more important Milestone!*
- ▶ Initial Flight Tests *Will the the engine perform as expected?*
- ▶ Envelope Expansion *Will the engine integration be sucessfull?*





**We can
do this!**



...with a high level of Flight
Safety Awareness...
despite the tough time
schedule?



...?



Is this really possible?

System Simulator Test

Will the new s/w be integrated correct?

- ▶ Real time s/w model of the FADEC h/w
- ▶ Team with s/w-, design- and test engineers
- ▶ Focus on airworthiness tests

FADEC = Full Authority Digital Engine Control



Flight Safety Awareness in all Decisions

- Official "Roll out" 4th December 2007
- "Problems" with the pyrotechnics
- Ashes on the **GRIPEN** Demo a/c
- Engine impact?
- Flight Safety awareness in all decisions



*This is also an aspect of Flight safety,
but not as obvious as build-up procedures
during envelope expansion...*

Engine Integration and Engine Installation Test

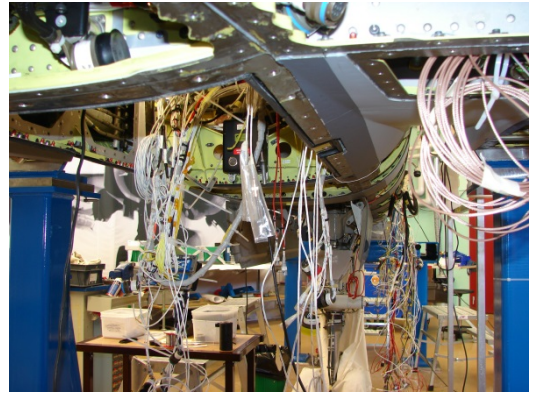
Will it really fit?

Will FADEC/aircraft communicate?

- ▶ Final installation 12th January 2008
- ▶ Small distances between engine/aircraft
- ▶ "A little bit up, a little bit forward, a little"...
- ▶ Special made installation equipment
- ▶ Risk reduction test FADEC/aircraft



Engine/Aircraft Run-up



Will the engine start?

Will the integration work?

- The first engine start 4th February 2008
- Engine run < 5 months after the first System Simulator test session
- Project: *Start testing with one new air intake modul...?*
- An important Project Milestone
- Engine started and integration worked as expected

Envelope Expansion



Will the the engine perform as expected?

Will the engine integration be sucessfull?

- Customer Evaluations, Photo flights etc
- Envelope Expansion strategy rewritten (... again and again...)
- Constantly changed envelope limits and restrictions
- Good teamwork, high discipline and flight simulations
- **I decided to use my “No Vote”**

And the Answer is...

- *Will it really fit?*
- *Will FADEC/aircraft communicate?*
- *Will power on be successful?*
- *Will the engine start?*
- *Will the airflow/thrust be as expected?*
- *Will First Flight be on schedule?*
- *Will the the engine perform as expected?*
- *Will the engine integration be sucessfull?*

YES



Lessons Learned

▶ Successful Program and Engine Integration due to:

- Hard work
- Rational decisions
- Good strategy and planning
- Exceptional teamwork
- Dedicated working methods
- Educated personnel
- High priority
- and finally...

Everyday Focus on Flight Safety



Lessons Learned

▶ An assigned Flight Safety Engineer:

- Available
- Broad flight safety perspective
- Mentor/Expert in the area
- Everyday flight safety questions (brainstorm etc)
- Support the Envelope Expansion Team
- Information, workshops etc
- Complement to TEB and Chief Test Engineer
- Discuss "stupid" questions - is this an issue?

TEB = Test and Evaluation Board



Lessons Learned



- The **"No Vote"**: a combination of several conditions:
 - Knowledge
 - Experience
 - Courage
 - Company/National Culture
 - Understanding of what "No Vote" really means

- Work active with the organization/company culture

- No "shortcuts" allowed, even with a tough time schedule!

GRIPEN NG

The Integration of GE F414 continues...



- ▶ Gripen Demo a/c is still a flying test rig
- ▶ GRIPEN Next Generation (GRIPEN E version)
- ▶ Reuse Gripen Demonstrator lessons learned



I used my "No Vote" ...
and if necessary I will do it again ...
That's my Promise!



*This was the first,
but most likely not the last, GE F414 engine installation
in the Saab **GRIPEN** aircraft.*





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