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Subscale Flight Testing of a Generic Future Fighter Aircraft

D. Lundström, A. Sobron, P. Krus
Linköping University, Sweden

C. Jouannet
SAAB AB, Sweden

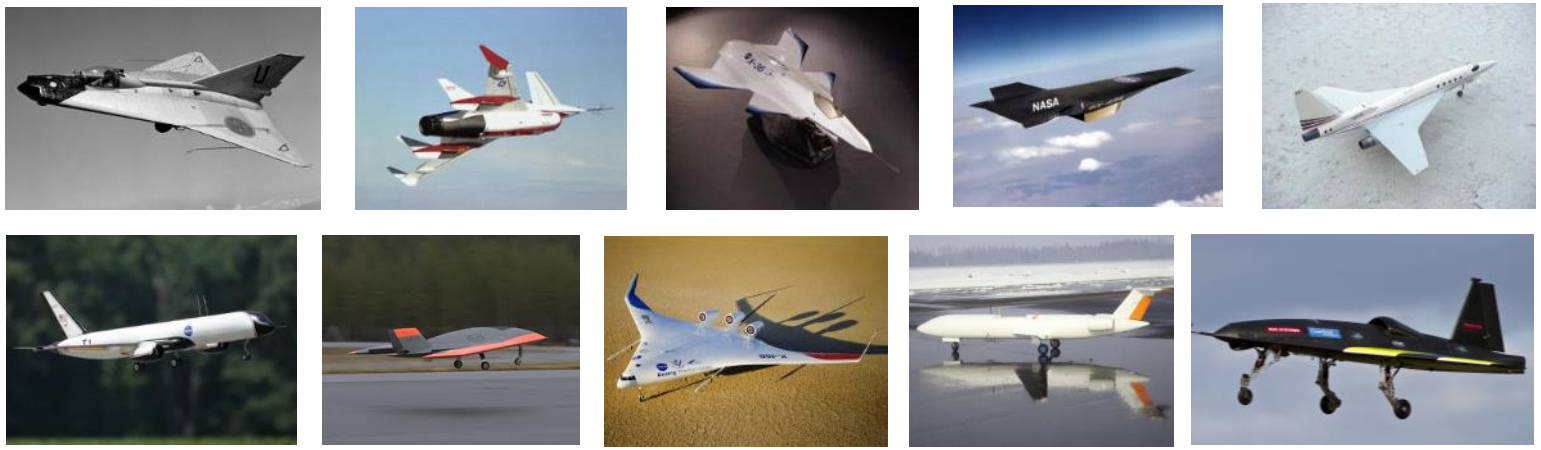
R.G.A. da Silva
Instituto Tecnológico de Aeronáutica, Brazil

Outline

1. What is Subscale Flight Testing? Why?
2. MSDEMO research project
3. The Generic Future Fighter platform
4. Flight testing
5. Flight data analysis and visualization tools

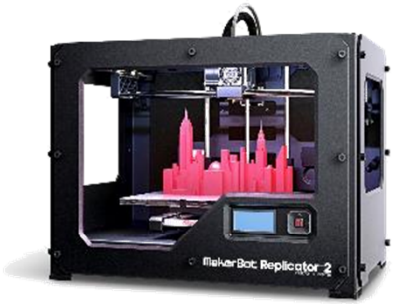
Subscale Flight Testing (SFT)

- Remotely controlled flight testing using sub-scaled aircraft
- Allows evaluation of flight characteristics prior to building a full-scale prototype
- Complements wind tunnel testing, and in some ways is a lower cost alternative
- Investigate high-risk portions of the flight envelope
- Evaluate, unconventional/high-risk platforms and technologies
- Subscale flight testing is not new, however rapidly growing research area



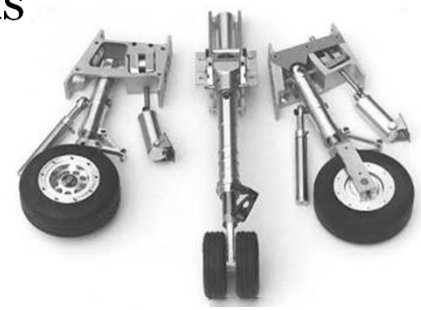
Enabling technologies

- Miniaturized electronics: sensors, processors, data storage, communication standards, etc.



- Rapid prototyping technologies

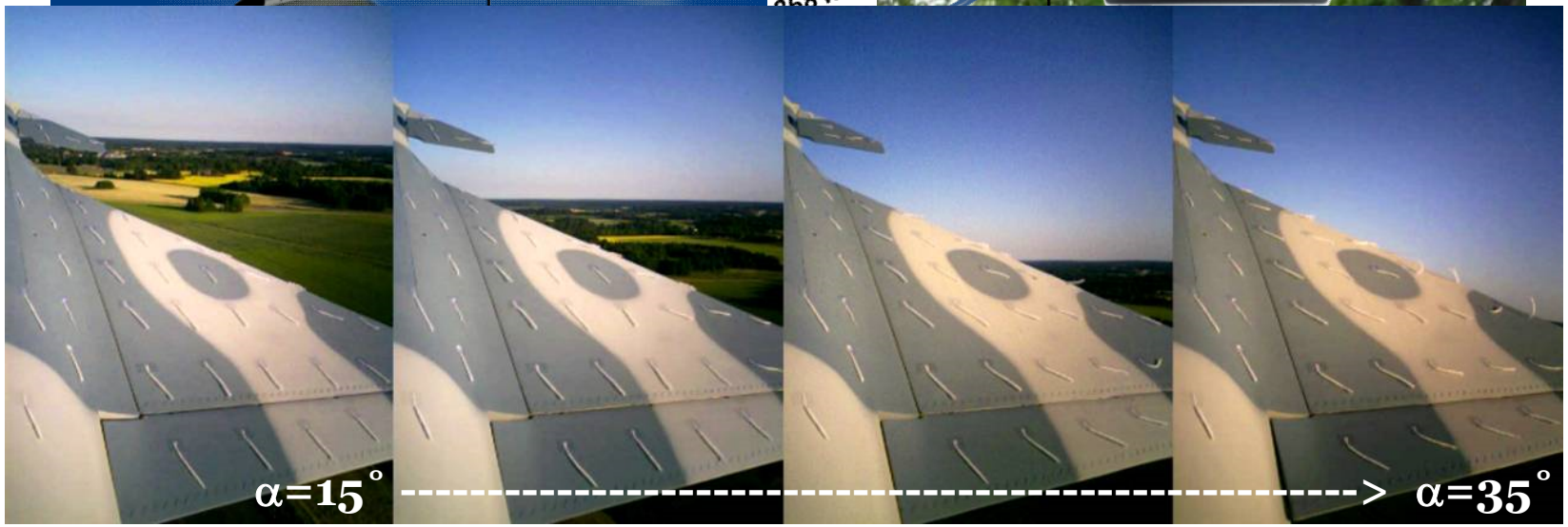
- Composite fabrication methods



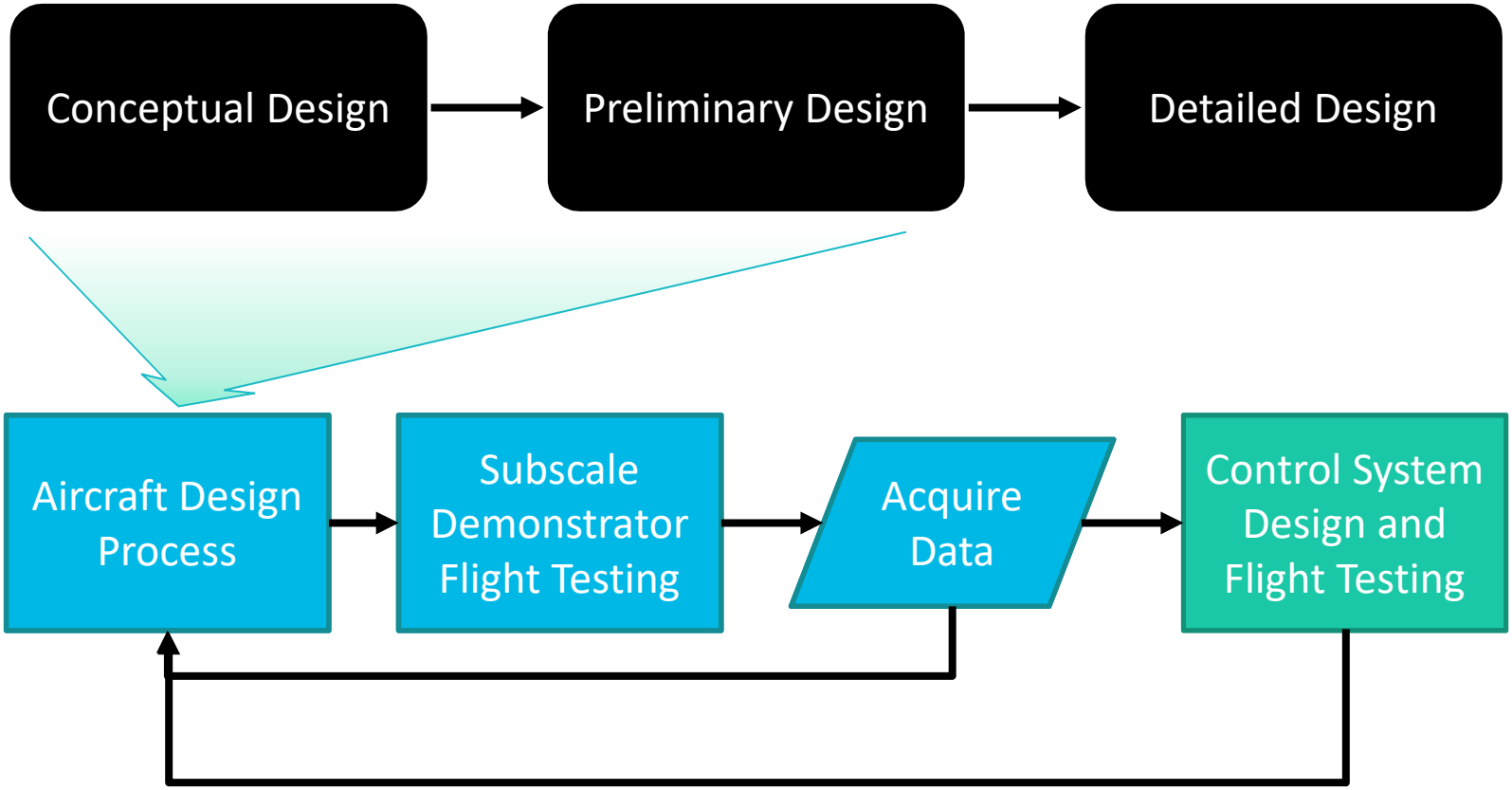
- RC hobby equipment developments

Information output

- Qualitative assessment of flying qualities
- Quantitative measure of aircraft properties
- Flow visualization



SFT in the aircraft design process



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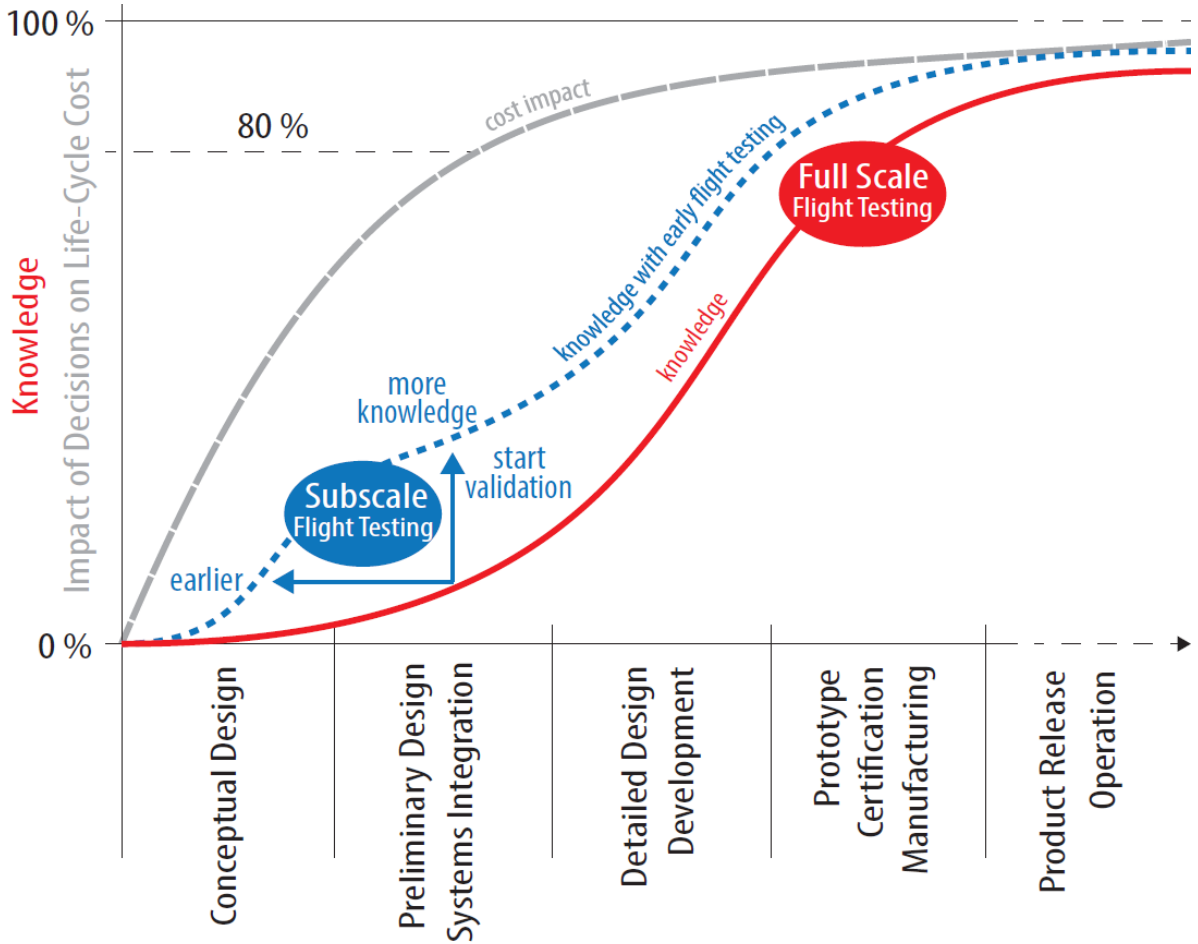


SFT in aeronautical education

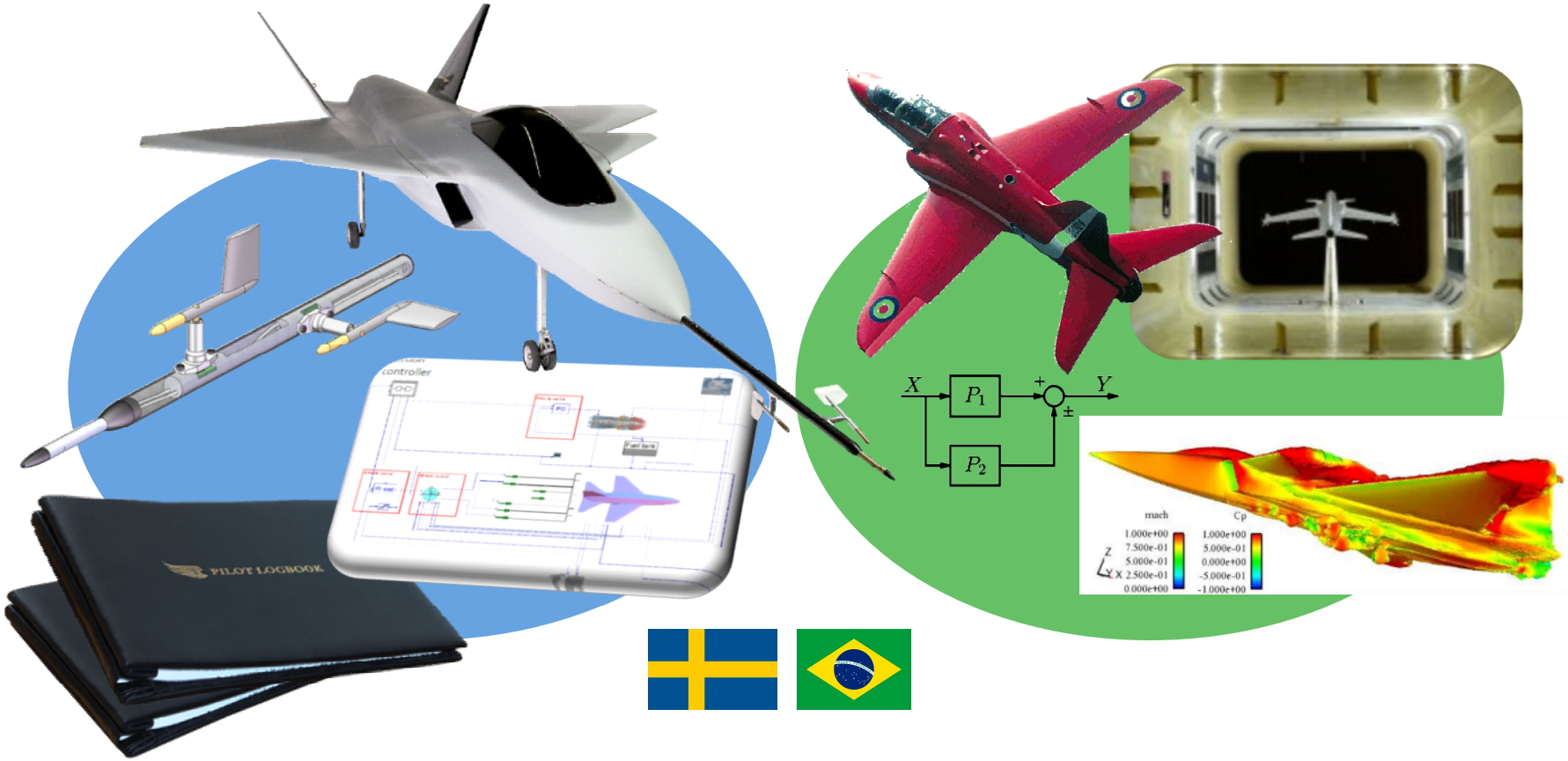
MSDEMO (FADEMO) research project

Methods for subscale demonstrator development and testing

Development and validation of flight control laws

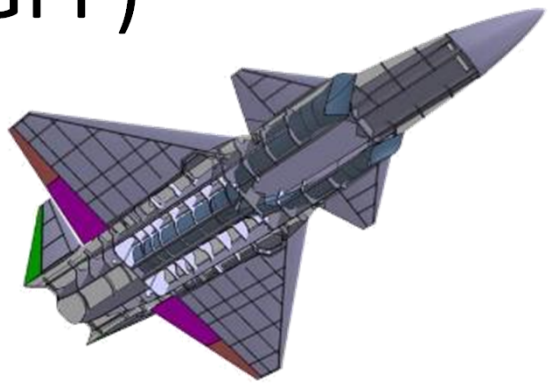
- Scaling effects
- Test/validation scenarios
- Avionics and test equip.
- Flight dynamics sim.
- System identification
- Flight control system

MSDEMO international collaboration



The Generic Future Fighter (GFF)

MSDEMO's main research platform

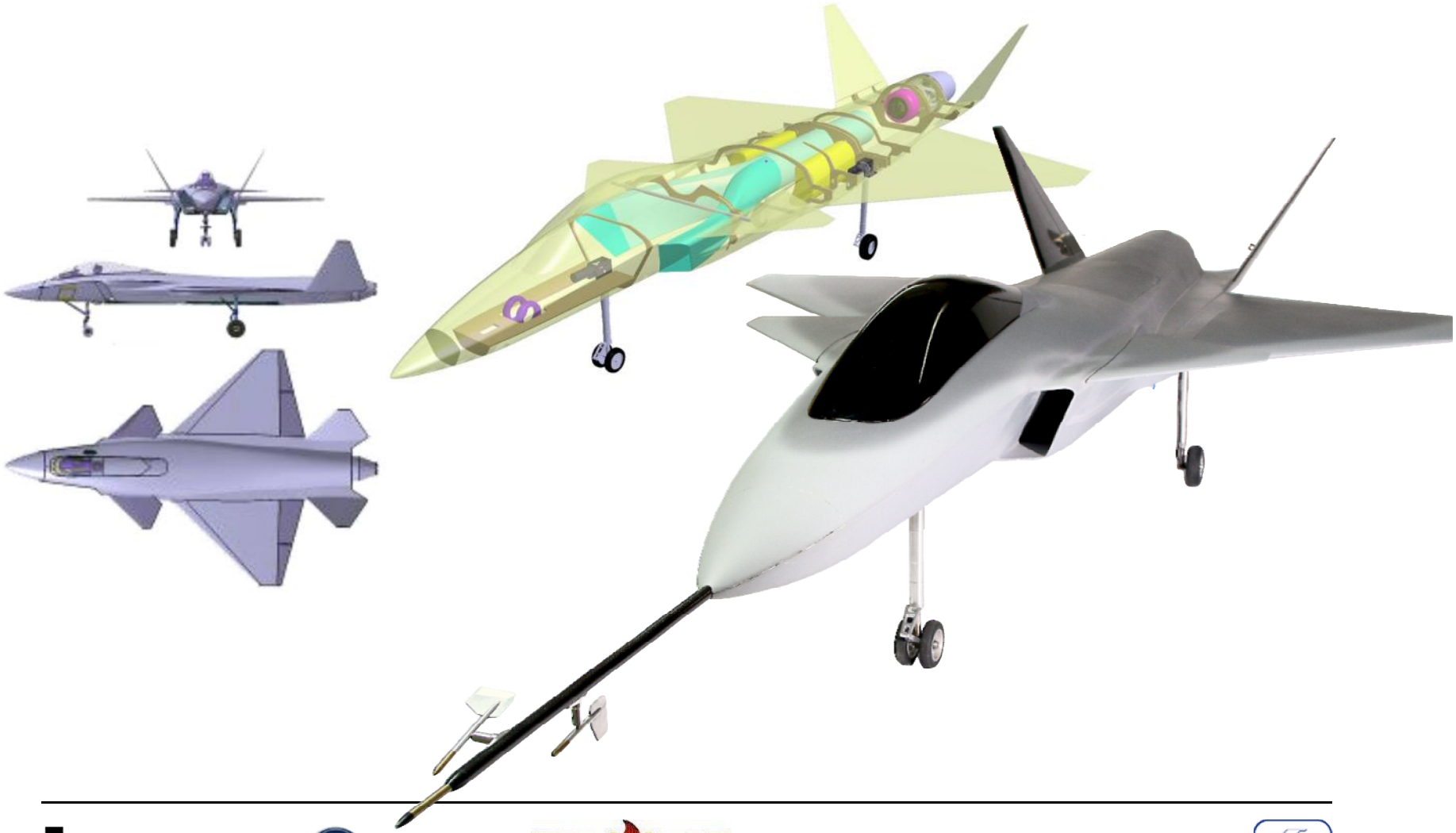


- Research study ordered by the Swedish Defence Materiel Administration (FMV), ending in 2009
- Parties: SAAB, Swedish Defense Research Agency (FOI), Volvo Aero, Linköping University (LiU), Royal Institute of Technology (KTH)
- LiU/FluMeS designed and flew a subscale demonstrator

Subscale GFF model

Scale	13 %
Length	2,4 m
Wingspan	1,5 m
TOW	18,5 kg
Propulsion	Jet, 160 N

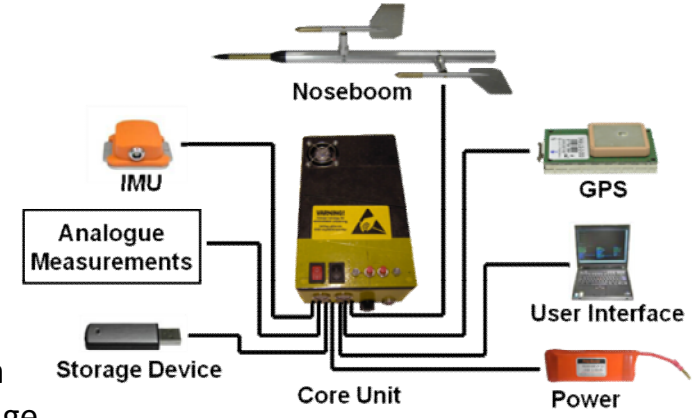
GFF subscale demonstrator

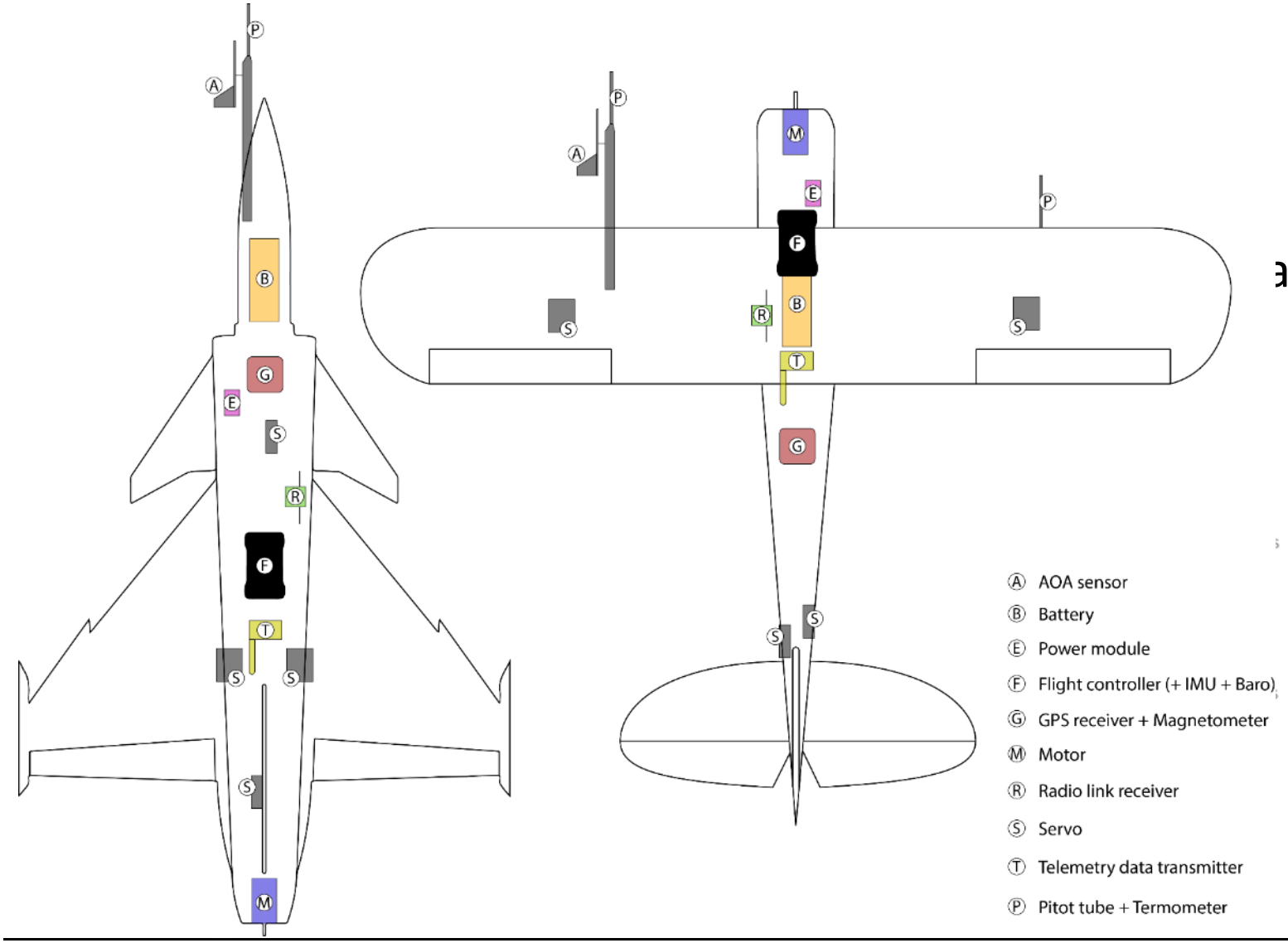


GFF subscale demonstrator

Previous data acquisition systems (2008)

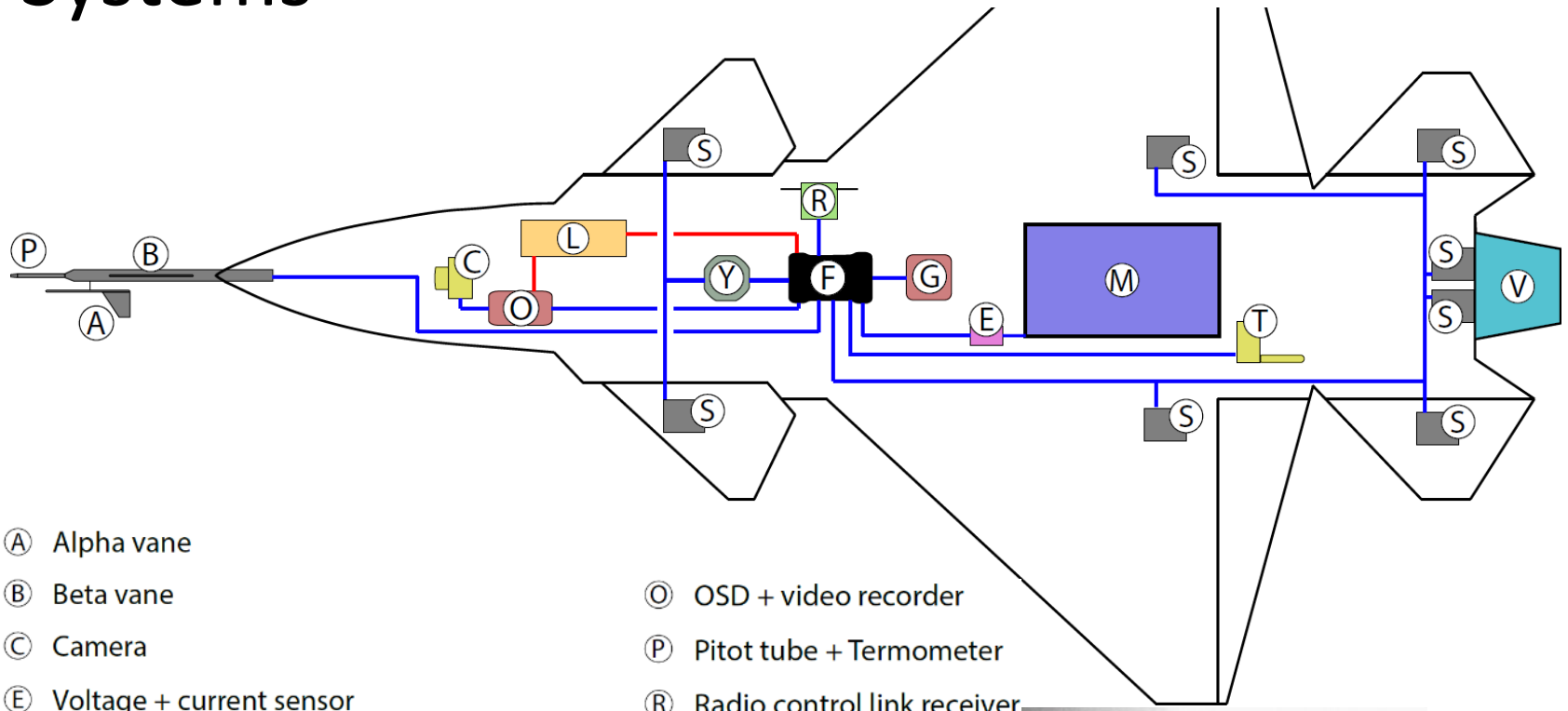
- First version
  - Single board PC as core unit (Pentium III processor)
  - OS: streamed Linux Kernel + C-language AP
  - → Cancelled due to problems with the OS, timing issues and being unnecessary large in size
- Second version
  - Experiment with an extremely reduced logging system based on a 8bit Microcontroller wit SD-card data storage
  - Programming language Assembler
  - → To slow, and to few integrated interfaces
- Third version
  - Usage of the new 32bit Microcontroller ”Atmel AT32 UC3A “
  - Programming Language C
  - External Flash data memory (4Mbyte)
  - → Good compromise between computational power and system size




Ⓐ AOA sensor
Ⓑ Battery
Ⓔ Power module
Ⓕ Flight controller (+ IMU + Baro)
Ⓖ GPS receiver + Magnetometer
Ⓜ Motor
Ⓡ Radio link receiver
Ⓢ Servo
Ⓣ Telemetry data transmitter
Ⓟ Pitot tube + Termometer

are

Systems



Ⓐ Alpha vane

Ⓑ Beta vane

Ⓒ Camera

Ⓔ Voltage + current sensor

Ⓕ Flight controller/data logger (+ 2xIMU + baro.)

Ⓖ GPS module + magnetometer

Ⓛ Logger LiPo battery

Ⓜ Jet engine

Ⓞ OSD + video recorder

Ⓟ Pitot tube + Termometer

Ⓡ Radio control link receiver

Ⓢ Servo actuator

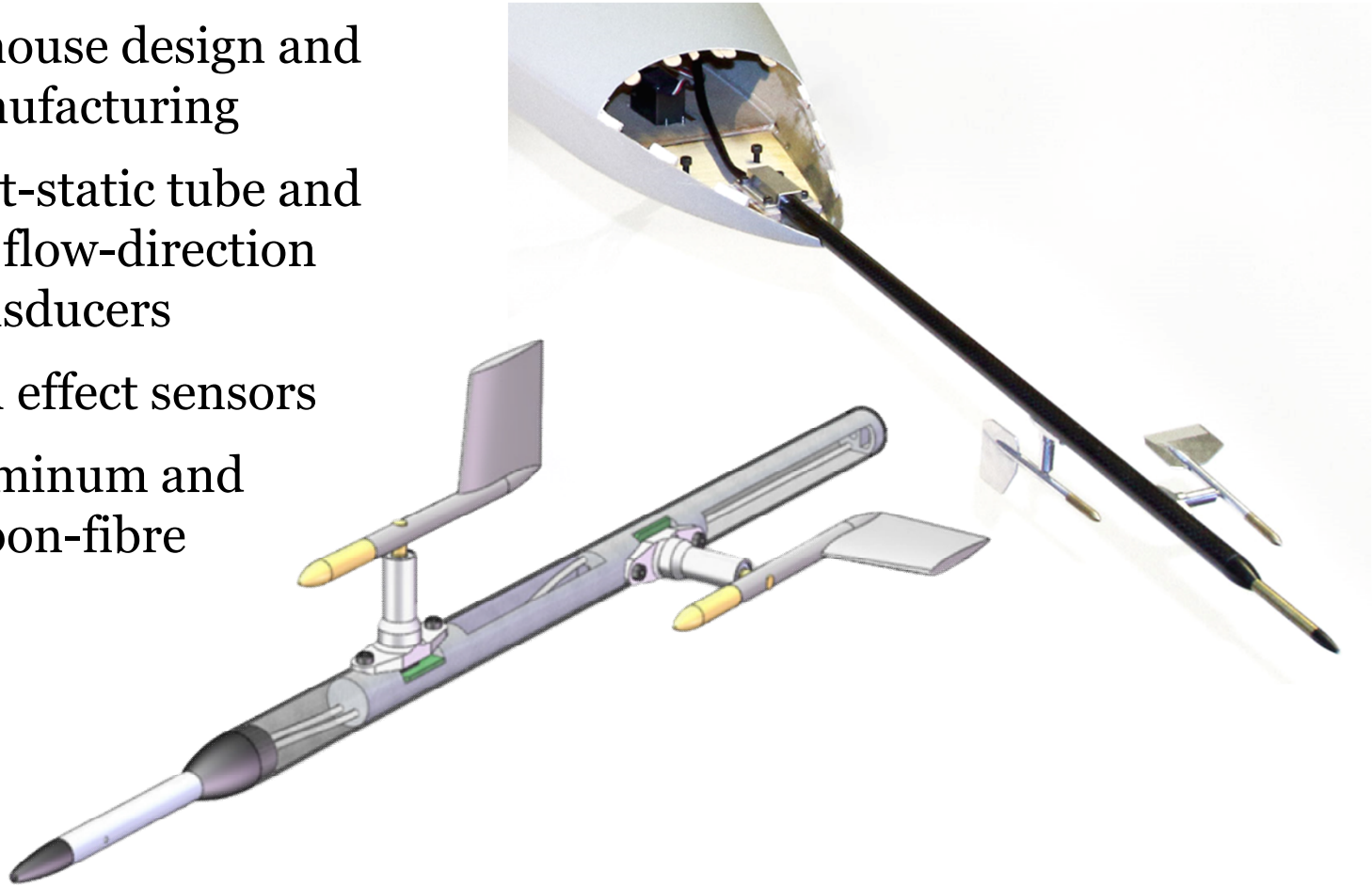
Ⓣ Telemetry modem

Ⓥ Thrust vectoring system

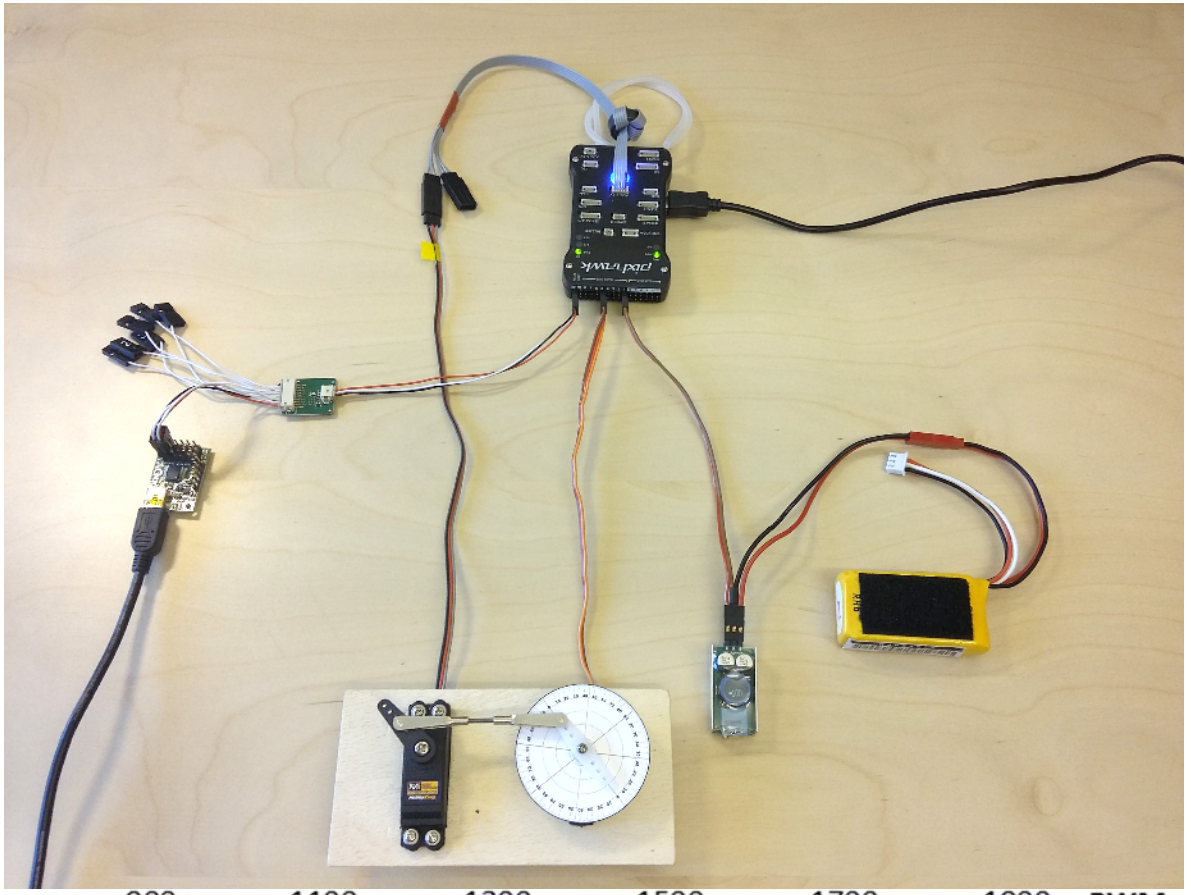
Ⓨ Auxiliar gyroscope sensor

Airdata nose-boom

- In-house design and manufacturing
- Pitot-static tube and two flow-direction transducers
- Hall effect sensors
- Aluminum and carbon-fibre



Estimation of control surface deflection



Certification

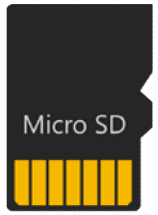
- Certified as a **Class 2 UAV** (> 7 kg take-off mass) according to the Swedish Transport Agency
- Pilot needs a **UAV operator** certification
- Operations and maintenance are kept in **logbooks**

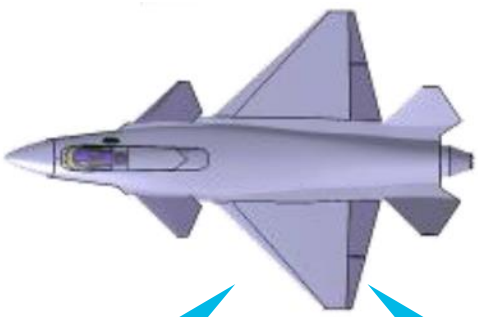
Operational procedures

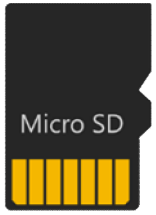
- Unpopulated area: closed military airfield
- Within line of sight
- Minimum three people:
  - Safety director
  - Pilot
  - Ground-station operator

Control and data management

Sensor data
5 to 50 Hz
log-rate







Video
HD resolution

Bi-directional
low-latency
control link

Bi-directional
telemetry link
(limited data rate)

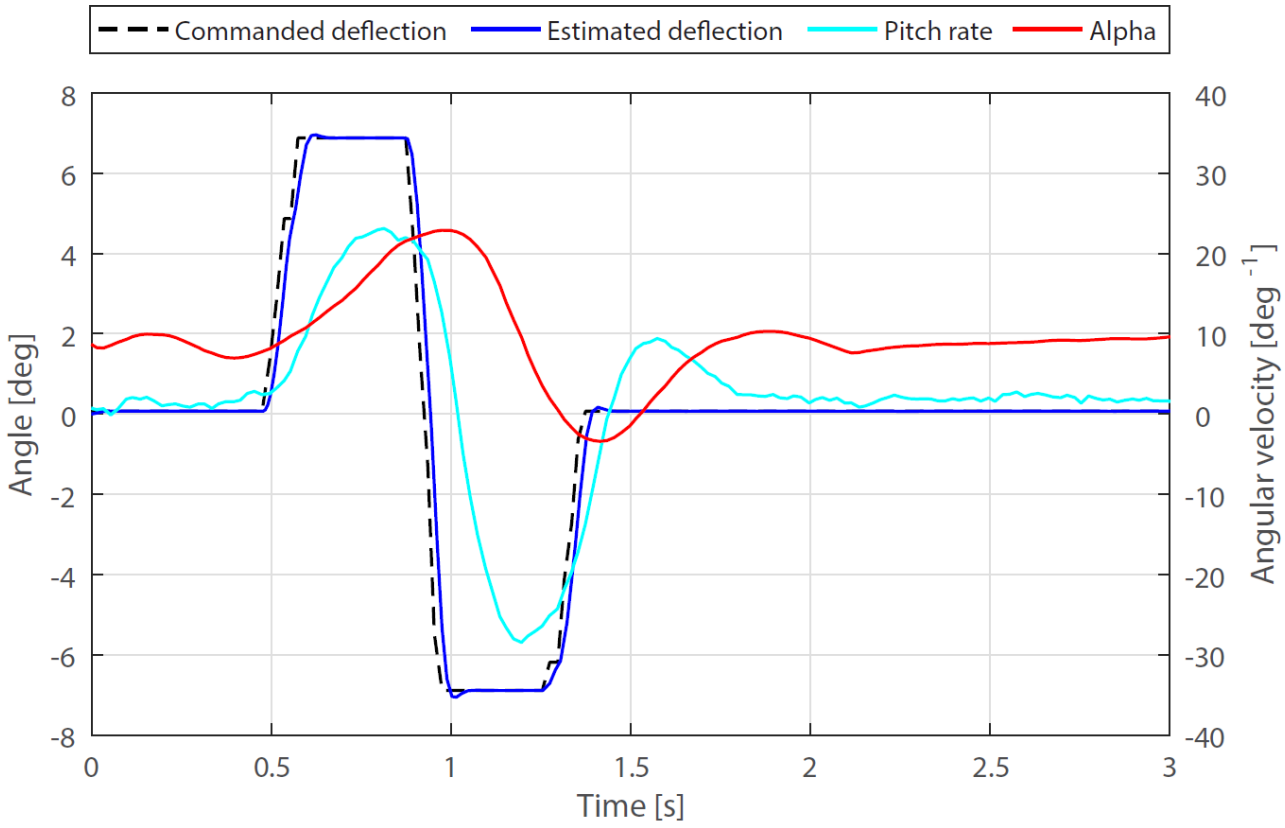
open source

Flight testing currently in progress

- Verify sensor data quality and robustness
- Expand progressively the flight envelope
- Evaluate performance
- Plan and perform appropriate excitation maneuvers

Flight testing currently in progress

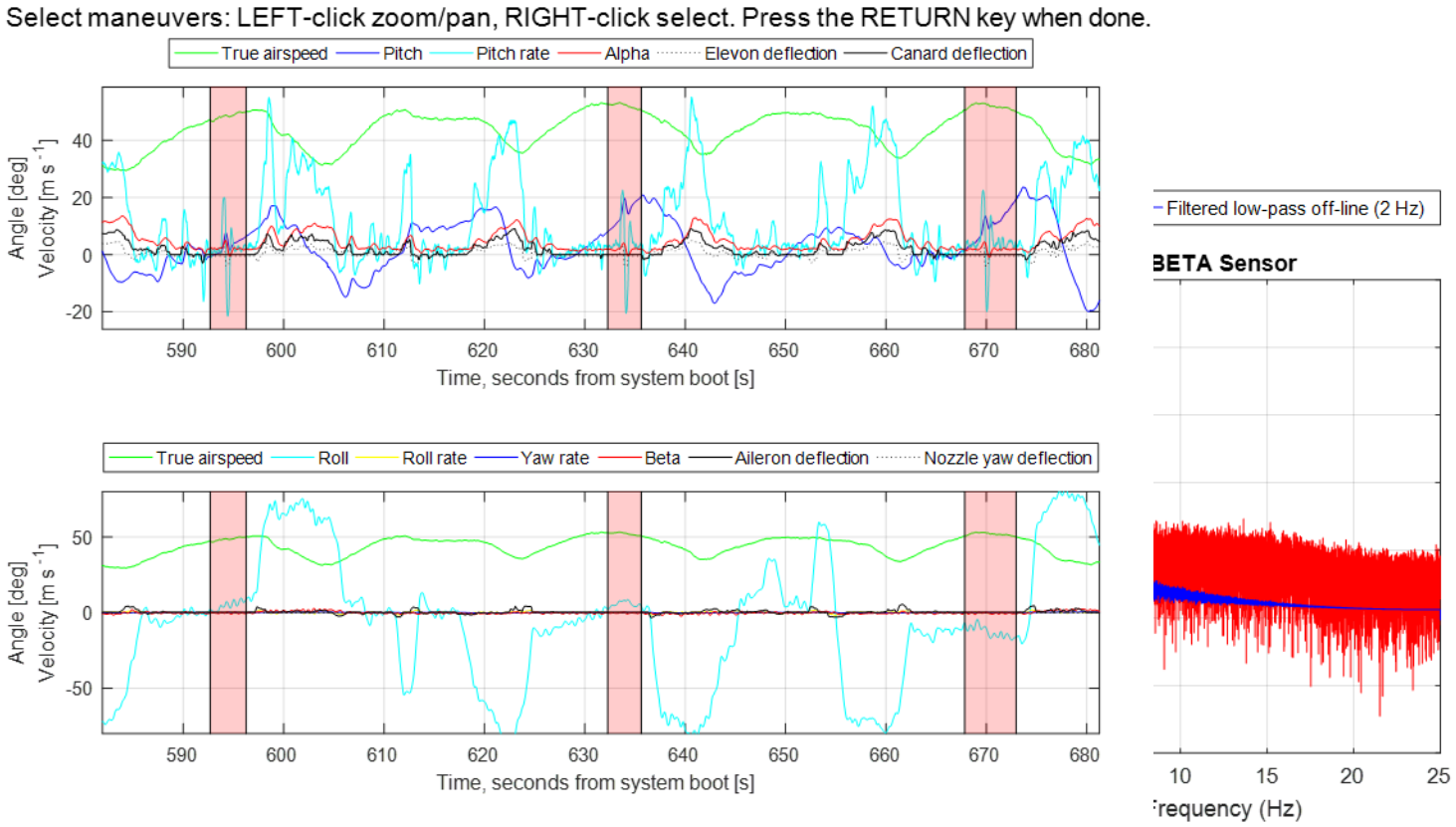
- Automation of commanded maneuvers



Flight testing currently in progress

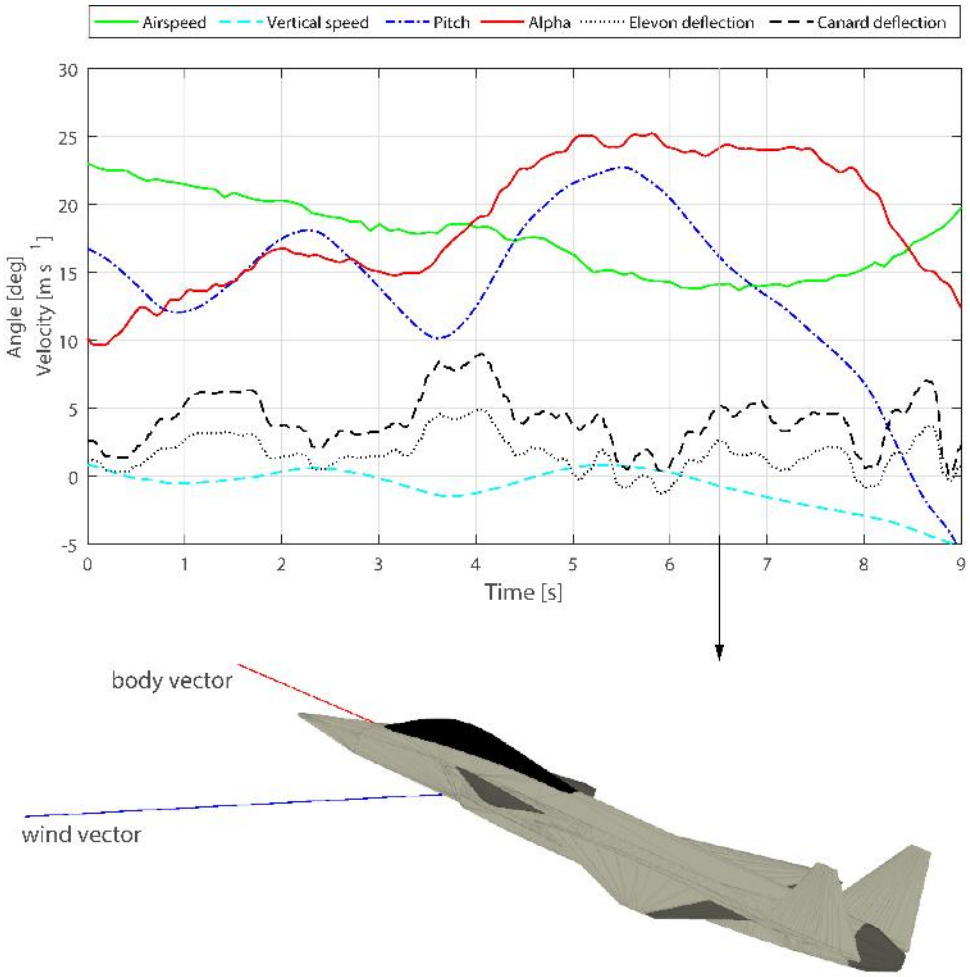
Flight data analysis

Signal



Flight evaluation

- 3-D animation
- Video footage



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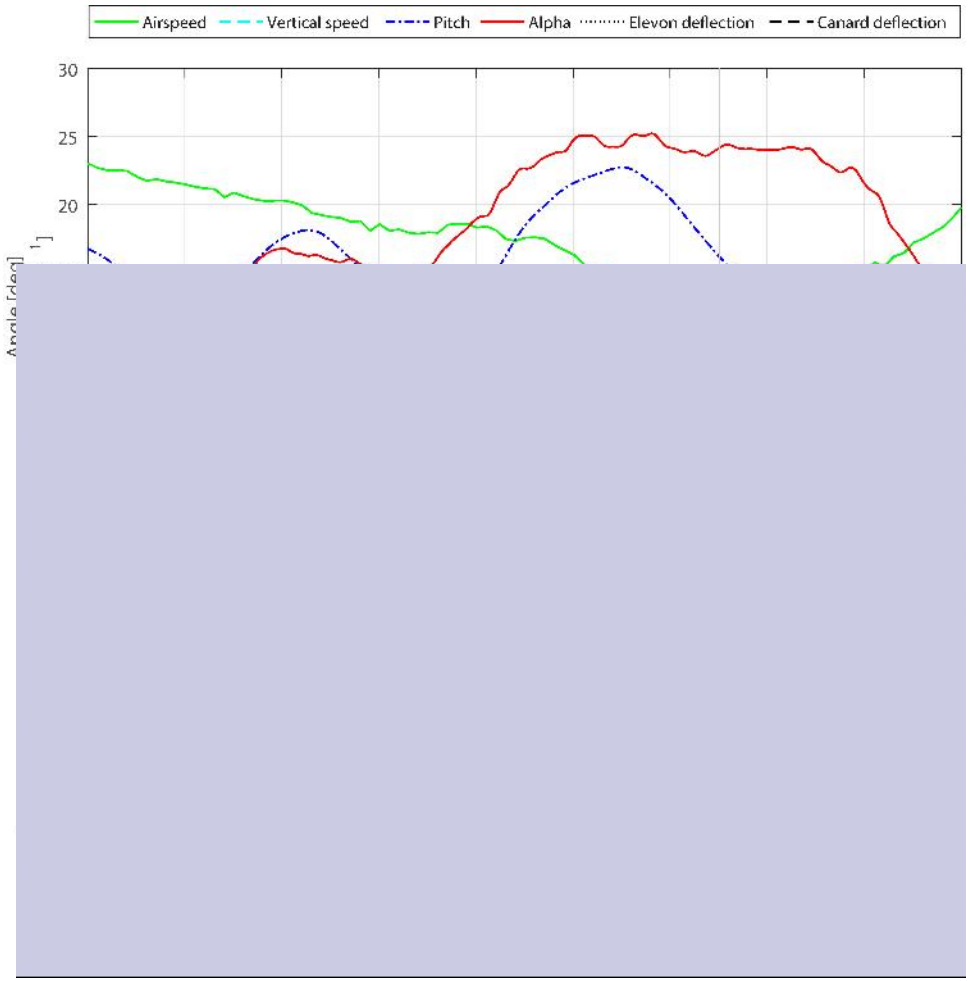
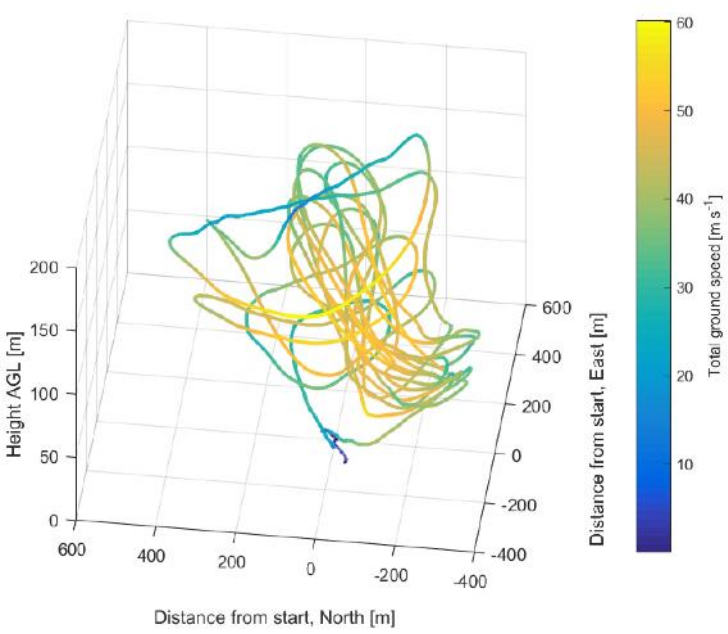
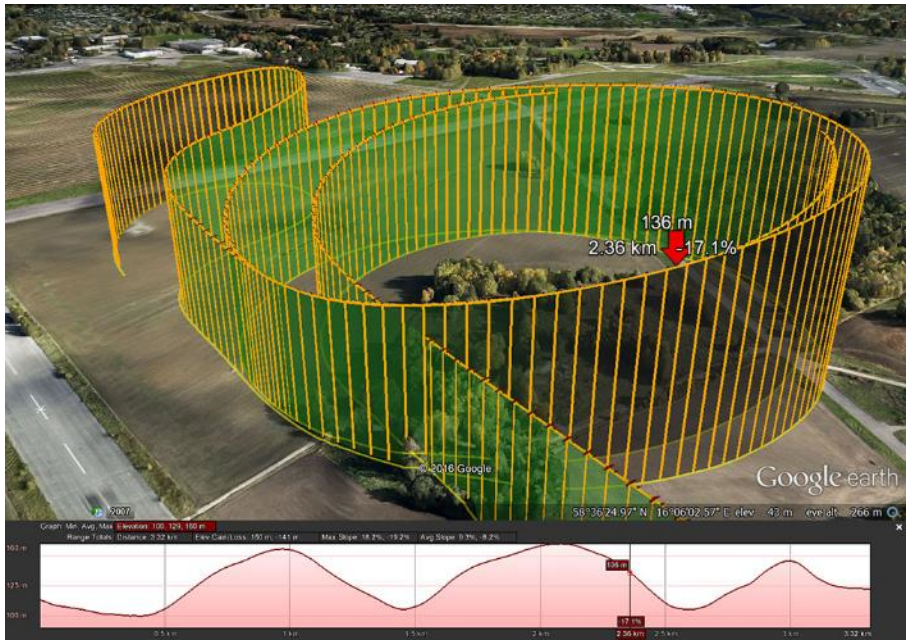


Flight evaluation

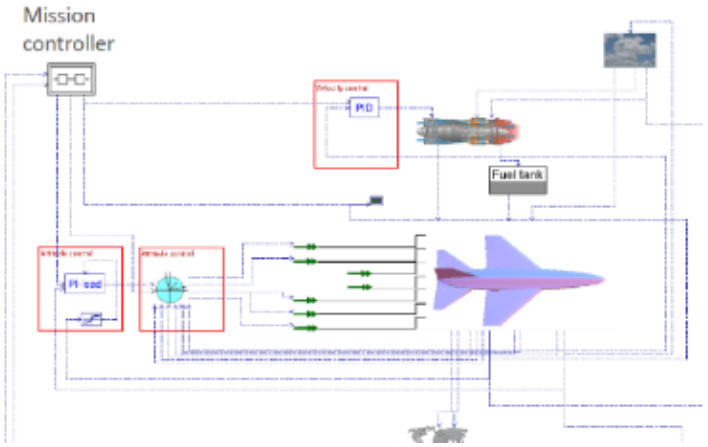
- Flight path in MATLAB and Google Earth
- PC aircraft simulation software (FlightGear)

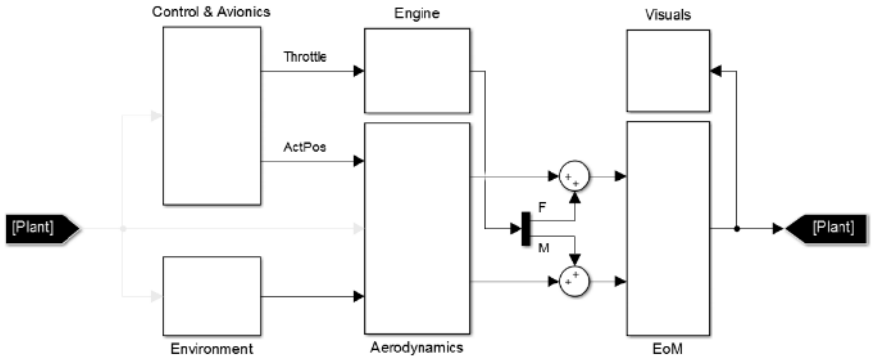




Simulation models

- Full-scale aircraft model in Hopsan
- Subscale model in MATLAB/SIMULINK
- Models for SID under development





Final remarks

- Project is currently ongoing
- Low-cost approach
- Limited reliability and service life of RC components
- New test equipment are continuously developed
- Learning on management of collaborative projects over long geographic distance

Final remarks

- Subscale testing present several challenges regarding flight test design
- Challenges also for system identification
- Flight tests currently performed in open-loop
  Positive longitudinal stability = design problem

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Thank you for your attention!

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