SIGNOS

A 5G fighter front-end demonstrator with low radar signature

Anders Höök	Saab
Jakob Bjerkemo	Saab
Gerhard Kristensson	Lund UoT
Jan-Olov Olsson	Saab Bofors Dynamics AB
Michael Andersson	ACAB

Prediction

Future need for stealth

- Stealth is, and will be a part of a balanced fighter design
  - for reduced-RCS, Low Observable (LO) or Very Low Observable (VLO)
  - for all roles (AA, CAS, ..)

The Problem
Radar´s RCS too high

- Flat-plate antennas
  - antenna RCS: 0 dBm^2
  - problematic for all 4G a/c

- Standard AESA ?
  - antenna RCS: -10 dBm^2, worse with radome
  - better, but not VLO, not even LO
  - great care needed for 4G a/c integration

- A *stealth* AESA is necessary
  - for all 5G a/c
  - but is it sufficient?

The Problem

From antenna to fighter front-end

- A stealth AESA
  - Improves signature
  - ≈ OK for reduced-RCS, 4G aircraft
- *Per se*, not enough for LO/VLO
  - RCS contributions from *interaction* with the radome
  - conflict between aerodynamics / stealth / antenna function
- VO/VLO: entire front-end must be managed
  - fuselage, bulk-head
  - antenna
  - radome

Project prerequisites

- A stealth requirement
  - in a forward threat sector
  - useful in the long perspective
  - admitting affordable solutions (develop, acquire, maintain)
  - admitting decent flight envelope, radar performance
- A stealth AESA solution
  - ECM, radar function: 1 GHz bandwidth
  - ESM: 4 - 12 GHz
  - so low RCS that a simple dielectric radome can be used
- An FSS-radome
  - band-pass or low-pass filter characteristics
  - an *a priori* choice that emphasizes stealth vs ESM

The RCS requirement

Mission success vs RCS

- Simulations and excercises yield similar results
  - if your RCS > σ_c: you´ll always lose
  - if your RCS < σ_c: you´ll always win

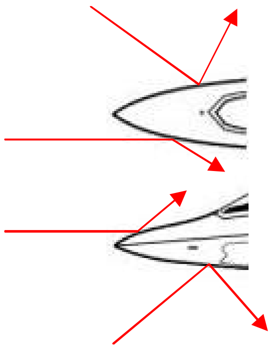
- "True", but only if
  - everything else kept equal
  - you don´t adapt tactics vs your/opponents RCS

- σ_c is very scenario dependent

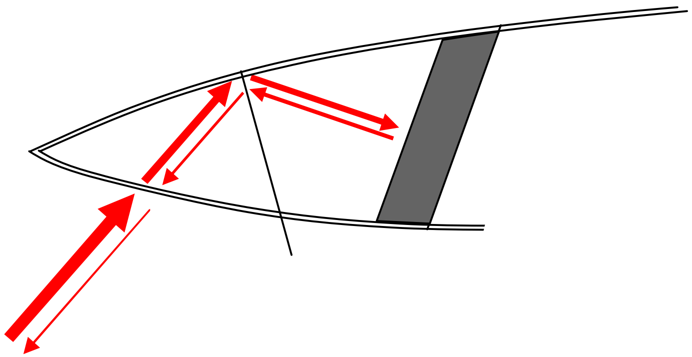
Geometry definition

Starting point of stealth design

- Wet surface
  - aerodynamically acceptable
  - no specular reflections in forward threat sector



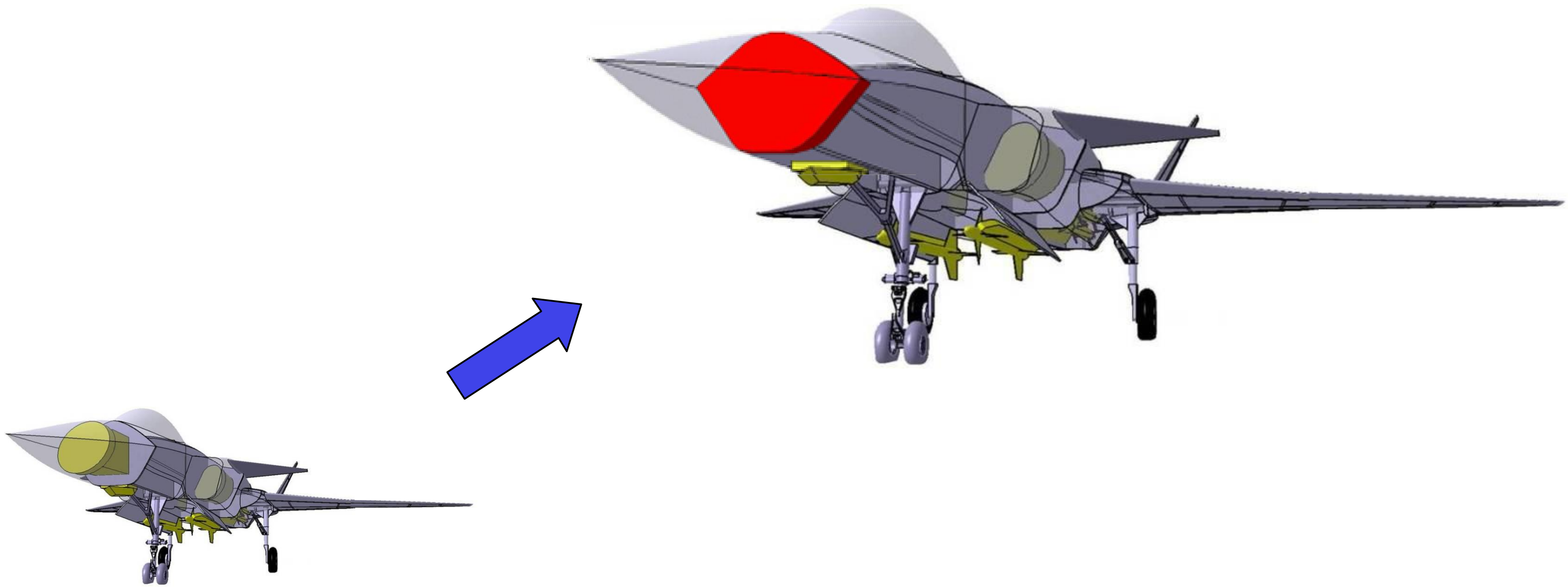
- Good transmission in ECM, radar band
  - not too pointed radome



- Internal reflections
  - outside forward threat sector
- Flatness requirement on radome curvature
  - weakly curved in one principal direction
  - facilitates EM design and manufacturing

Geometry
Results

- Modified FS2020 radome/fuselage geometry
- Bulkhead tilted backwards, moved forward, entirely covered
- Requirements on radome transmission, antenna absorption



Computer-aided engineering

A priori verification of concept

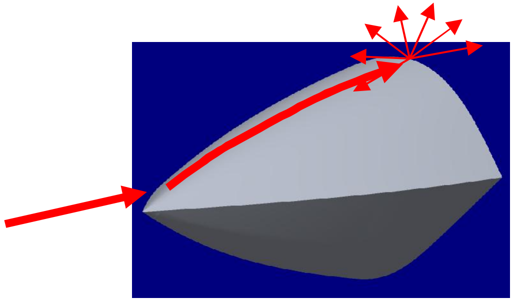
- Verify that specular reflections are outside threat sector
  - fuselage echoes
  - multiple reflections

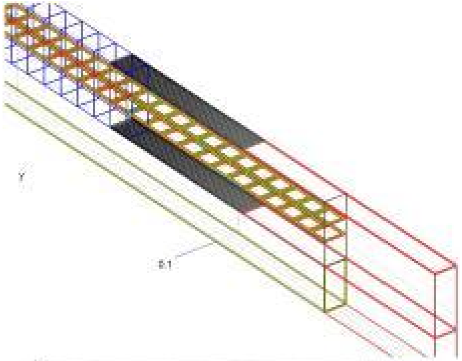
- Analysis includes
  - exact geometry
  - radome transmission
  - AESA reflection

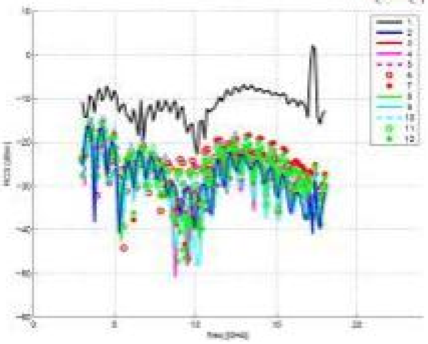
R&D issues

Some examples

- Radome/fuselage interface
  - patented solution from 2003
  - validated in subsequent projects
- Scattering analysis
  - of said interface
- Tolerance analysis
  - Are manufacturing deviations acceptable?



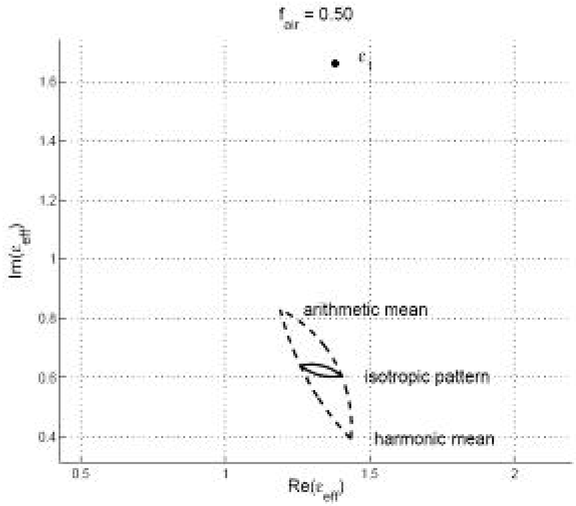




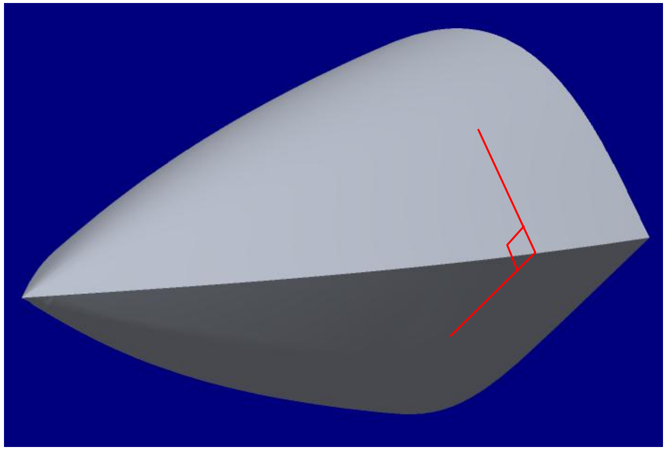
R&D issues

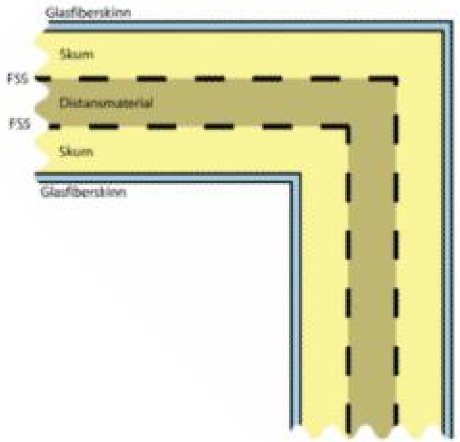
Some examples

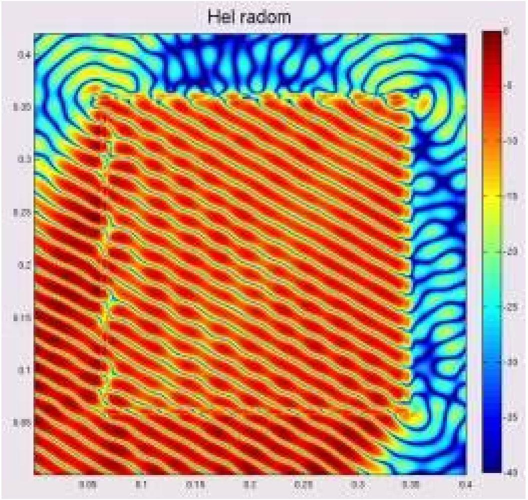
- Control of material parameters
  - antenna absorbers



- Radome edge scattering

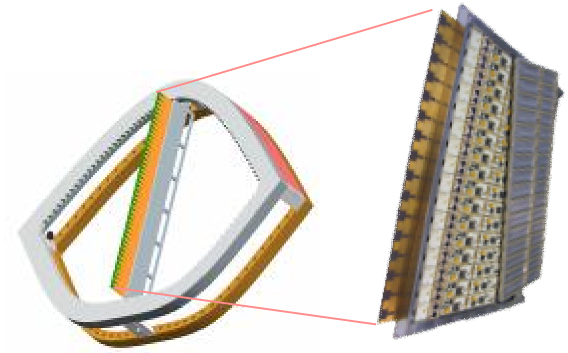






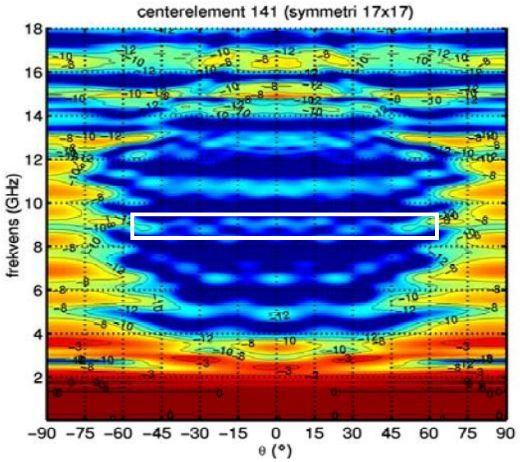
Stealth AESA
If LO/VLO is to be achieved

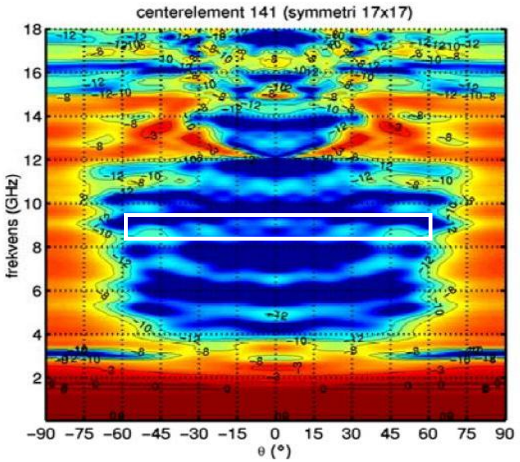
- Design includes 16 solutions
  - of which 15 are for free
  - the 16:th increases AESA cost by 20%
- Bad news
  - you cannot convert a COTS AESA
  - solutions must be inherent from design start
- Standard brick architecture
  - ordinary T/R modules will do
- *E.g.* the Saab Xecond T/R module brick
  - low-cost, organic laminate concept
  - entirely pick-and-place:able
  - only freely available COTS-components



Stealth AESA
Result

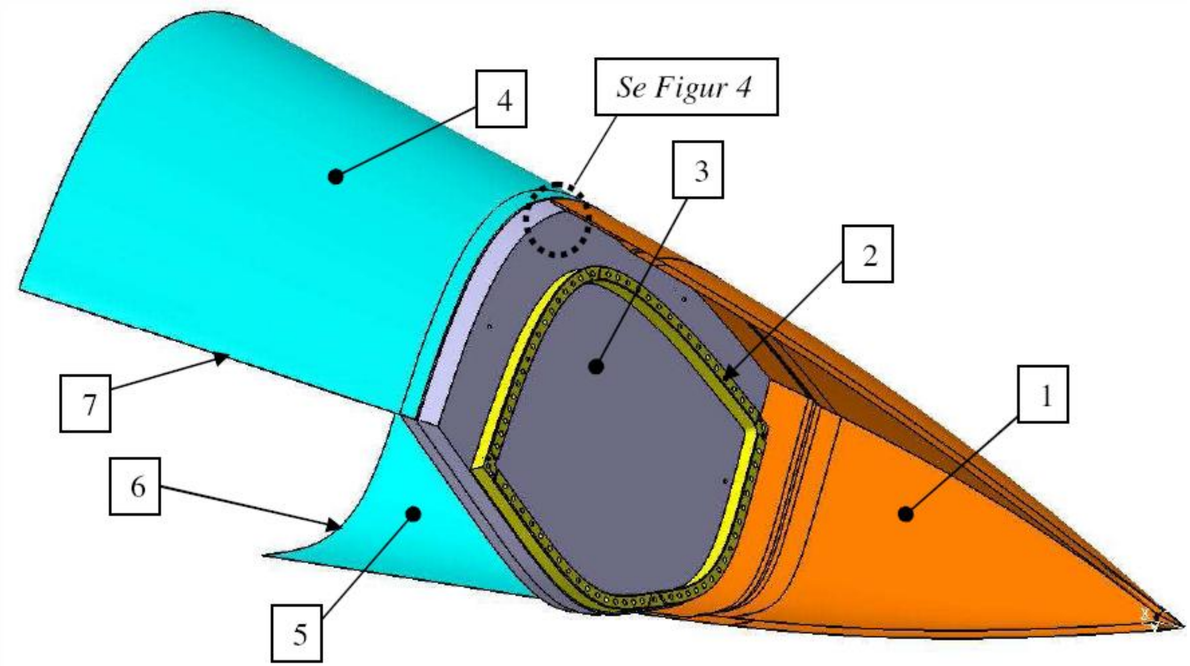
- Well-matched AESA aperture
  - for plane wave incidence
- Wide-band matched
  - wider than FSS radome transmission band
- Wide-angle matched
  - even for incident waves outside threat sector
- Dual-polarization matched
- The AESA works as an absorber
  - in parity with commercial absorbers
- The RCS grating lobes completely managed





Integration

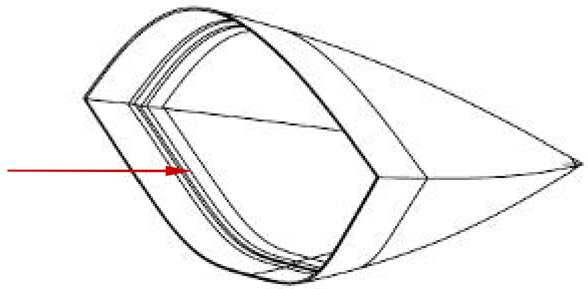
New radome/fuselage integration method



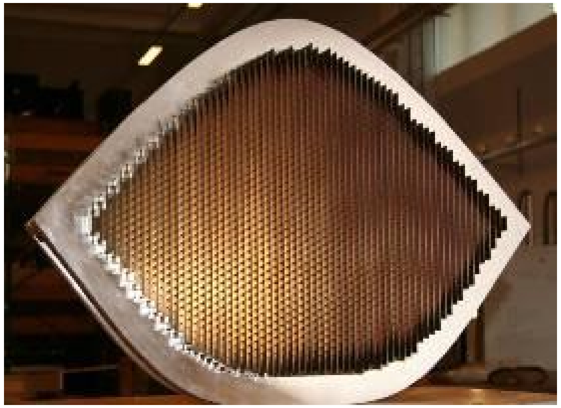
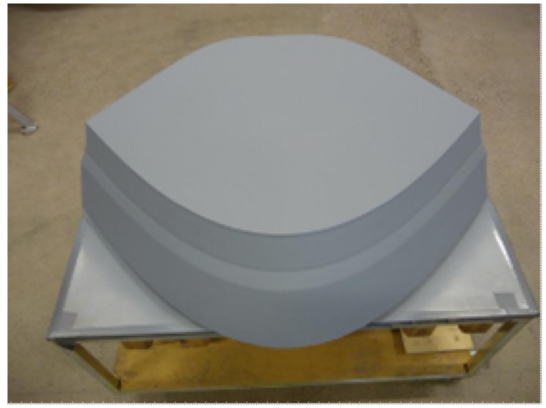
Figur 3. Nospartiet: 1. Radom, 2. Antenn, 3. Radarskott, 4. Plåtsvep övre, 5. Plåtsvep undre, 6. Förstyvningsspant (ej på bild), 7. Förstyvningsstringer (ej på bild)

Radome

- Band-pass FSS
  - low-pass also considered
  - dielectric radome feasible
- Simple pattern application method
  - low-cost technique
- FSS to PEC transition
  - implementation of Lund design

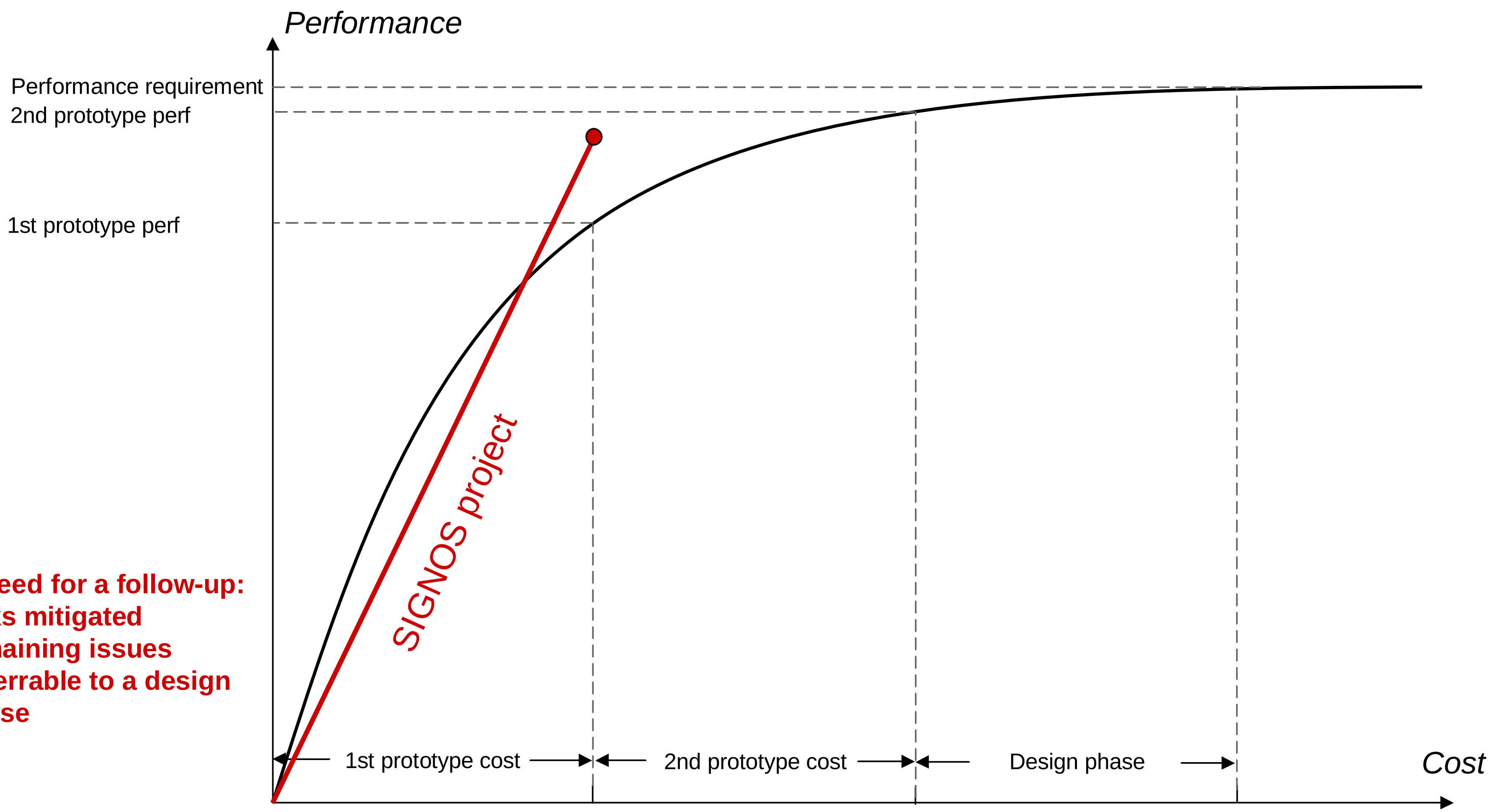


Gallery


Result

Result vs cost



No need for a follow-up:
- **risks mitigated**
- **remaining issues deferrable to a design phase**

Result

- Quantitative results will not be shown
  - for obvious reasons
- Project technically and economically successful
  - RCS close to target
  - a very useful level achieved
- A few, known hot-spots...
  - intentionally left out of demonstrator for economical reasons
- A few, new hot-spots...
  - detected by means of ISAR techniques
  - identified and deemed manageable