Design and Integration of a Low Observable Engine Intake and Outlet for the MULDICON Platform

H. Edefur, M. Tormalm, M. Dalenbring,
L. Tysell & M.J. Quas

Swedish Defence Research Agency, FOI

2019-10-08

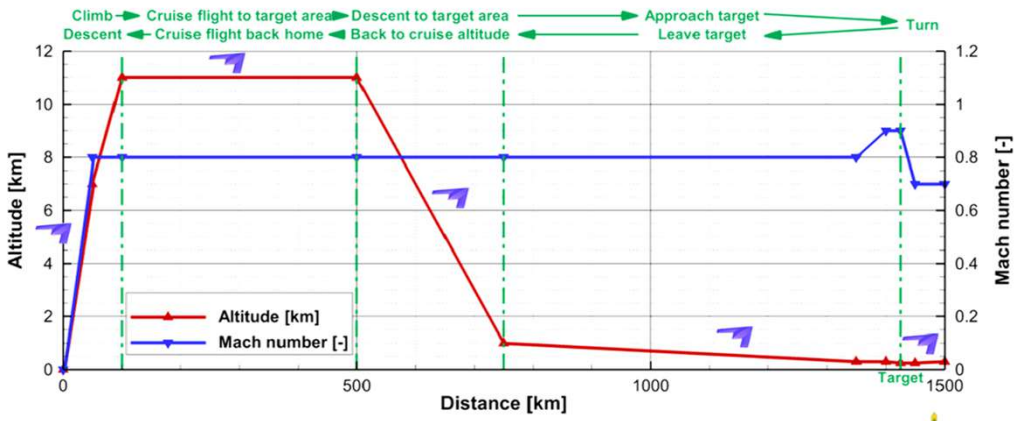
FOI

Low Observable (Intake) Design

FOI

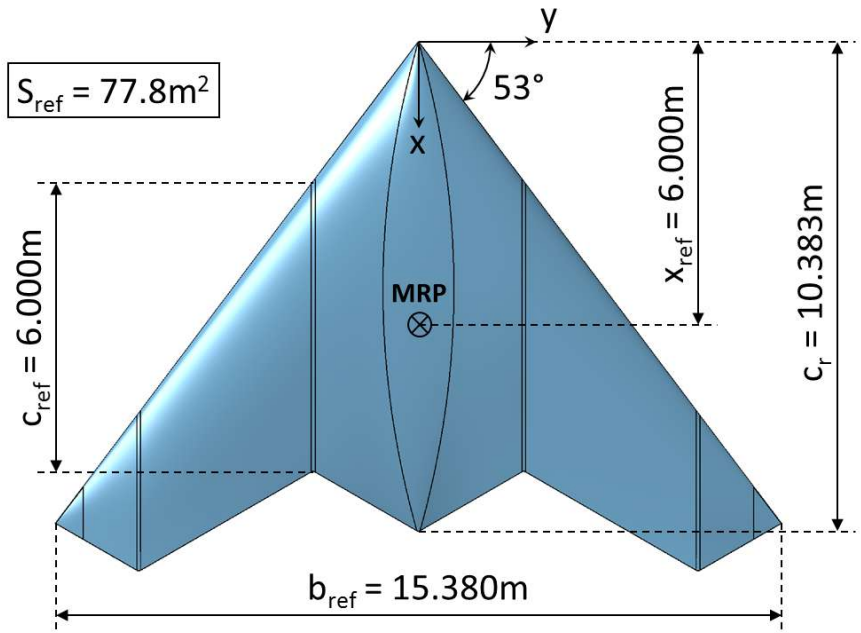
NATO-STO AVT-251

- Multi-Disciplinary Design and Performance Assessment of Effective, Agile NATO Air Vehicles
- MULDICON – MULti-DIsciplinary CONfiguration
- 5 sub-groups:
  - Designs Specification and Assessment Group (DSAG)
  - Aerodynamic Shaping Group (ASG)
  - Engine Integration Group (EIG)
  - Control Concept Group (CCG)
  - Structural Concept Group (SCG)



FOI

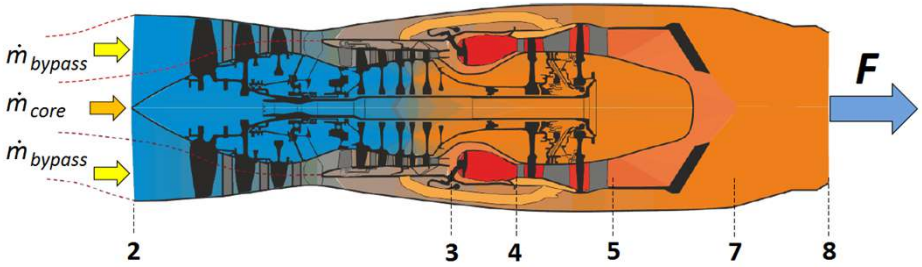
MULDICON Wing and Engine



A. Schütte, J. Vormweg, R.G. Maye, T. Jeans, "Aerodynamic shaping design and vortical flow design aspects of a 53deg swept flying wing configuration", AIAA Aviation and Aeronautics Forum and Exposition, Atlanta GA, June 2018.

R.K. Nangia, J. Coppin, M. Ghoreyshi, "A UCAV Wing Design, Assessment and Comparisons", AIAA Aviation and Aeronautics Forum and Exposition, Atlanta GA, June 2018.

S. Zenkner; R. Becker, "Preliminary Engine Design for the MULDICON Configuration", AIAA Aviation and Aeronautics Forum and Exposition, Atlanta GA, June 2018.

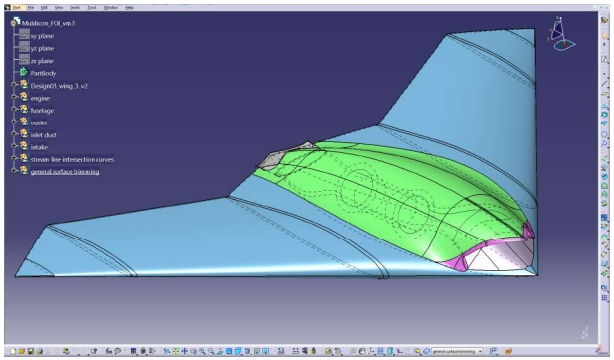


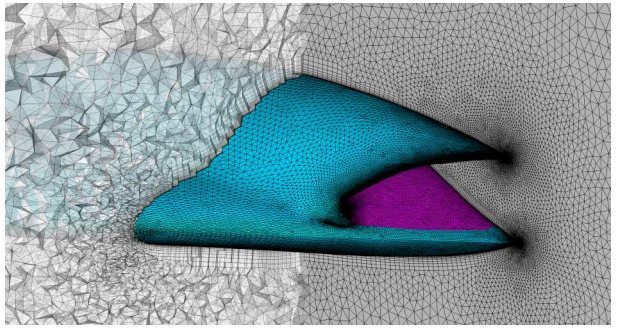
Engine Design	UCAV_F	UCAV_G	UCAV_G, v4
Thrust @ TO (kN)	60	60	60
$\dot{m}$ @ TO (kg/s)	126.55	113.95	113.95
$\dot{m}$ @ CR (kg/s)	38.40	33.57	33.57
Fan diameter (m)	0.990	0.900	0.908
Throat area (m²)	0.550	0.450	0.555
Nozzle area (m²)	0.380	0.340	0.340
Length (m)	2.300	2.200	2.200

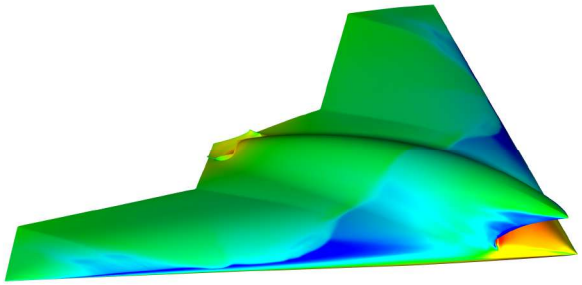
FOI

Tools

- **CATIA**
  - CAD model
- **ICEMCFD and TRITET**
  - Mesh generation for CFD and RCS
- **M-Edge**
  - CFD calculations
- **SAFIR**
  - IR analysis
- **NASTRAN**
  - Structural analysis
- **GRECO and Puma-EM**
  - RCS analysis

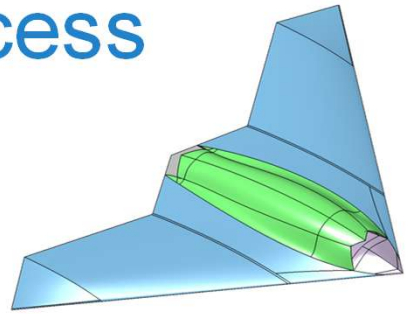


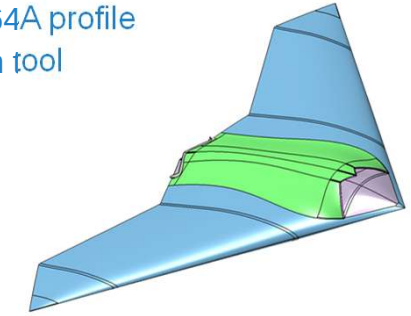




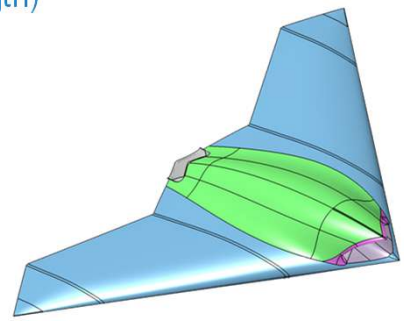
Intake Integration Design Process

- **Version 1**
  - UCAV_F Engine
  - Preliminary wing using NACA-64A profile
  - Early version of the duct design tool



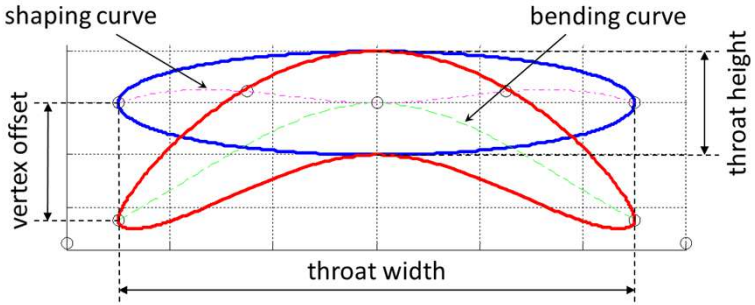


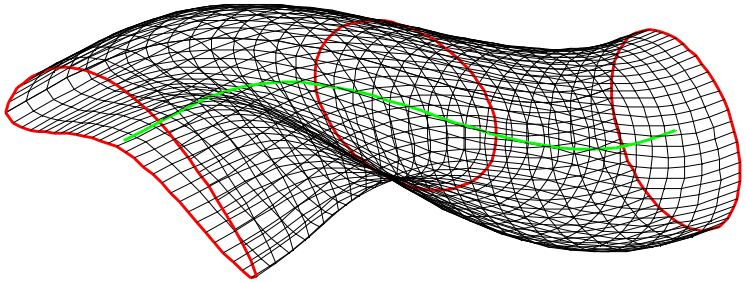
- **Version 2**
  - UCAV_G Engine
  - Wing design 3
  - “CAD-duct”
- **Duct Design**
  - Stand alone duct design with shape parameters slightly adapted to final wing and engine (offset intake throat and engine fan, and duct length)
- **Version 3**
  - UCAV_G, v4 Engine
  - Wing design 3
  - Intake duct from duct design process



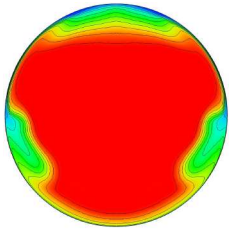
FOI

Intake Duct Design Tool

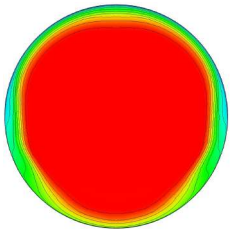




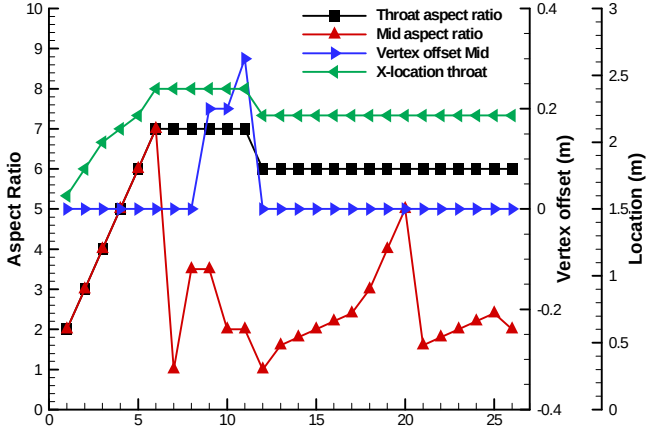
Approx. 4.5*10^6 cells / 1.5*10^6 nodes

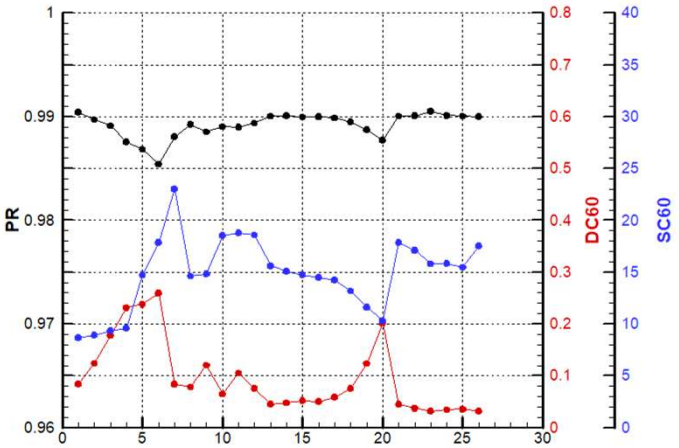


No. 13



No. 21



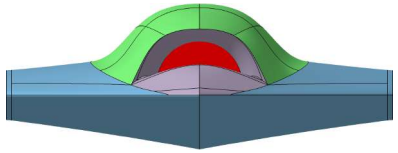


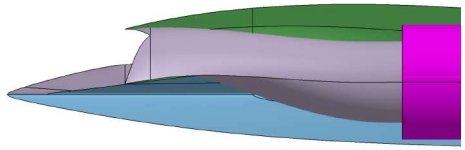
FOI

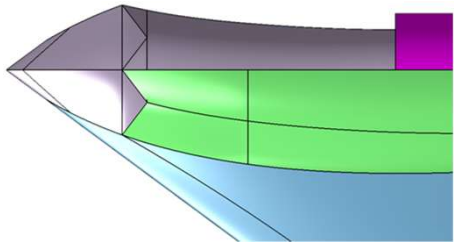
Intake Integration – Version 1

Front view: *Side view:* *Top view:*

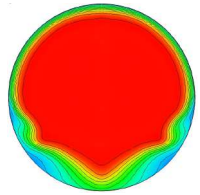
vers. 1.1



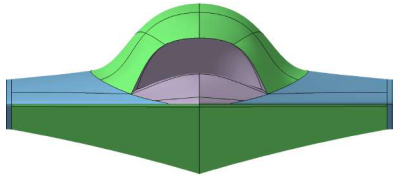


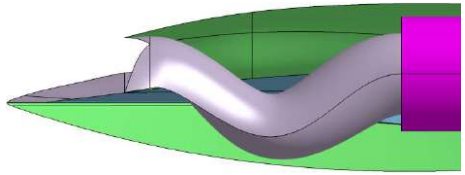


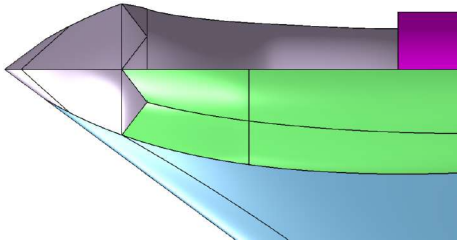
PR = 0.986, DC60 = 0.119



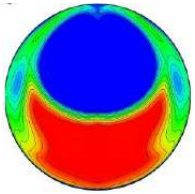
vers. 1.2



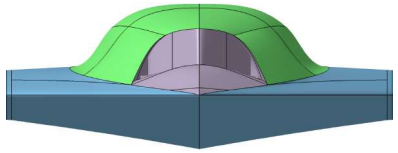


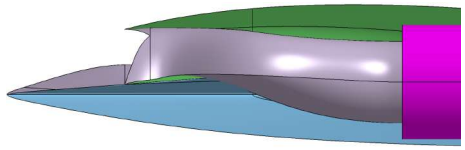


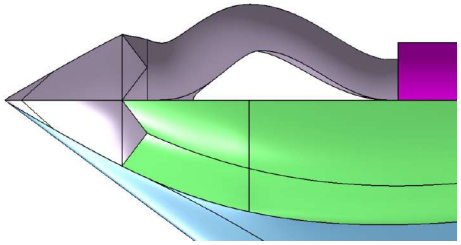
PR = 0.927, DC60 = 0.541



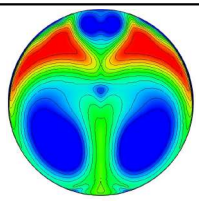
vers. 1.3





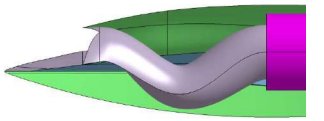


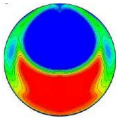
PR = 0.960, DC60 = 0.385



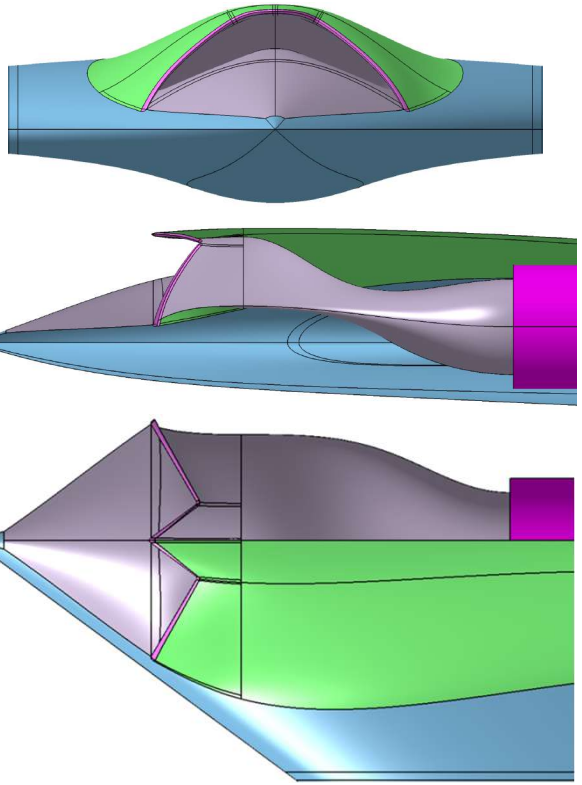
FOI

Intake Integration – Version 2





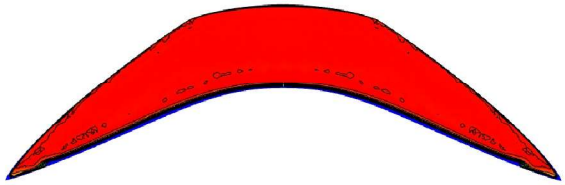
PR = 0.927
DC60 = 0.541



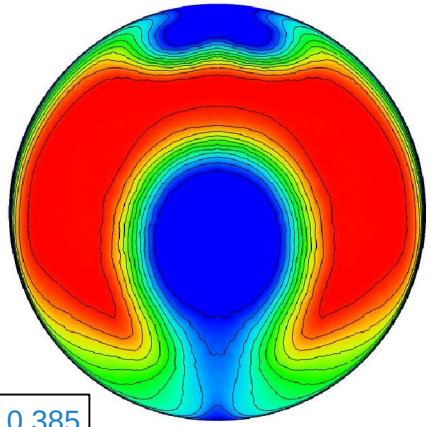
Free stream:

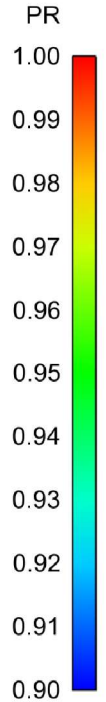
M_0	= 0.8000	T_0	= 217 K	β_0	= 0.000 deg
V_0	= 236 m/s	T_{T0}	= 244 K	μ_0	= 1.4217e-05Kg/s
P_0	= 22616 Pa	ρ_0	= 0.364 Kg/m^3	CA	= 0.7967
P_{T0}	= 34474 Pa	α_0	= -0.000 deg		

Throat



AIP



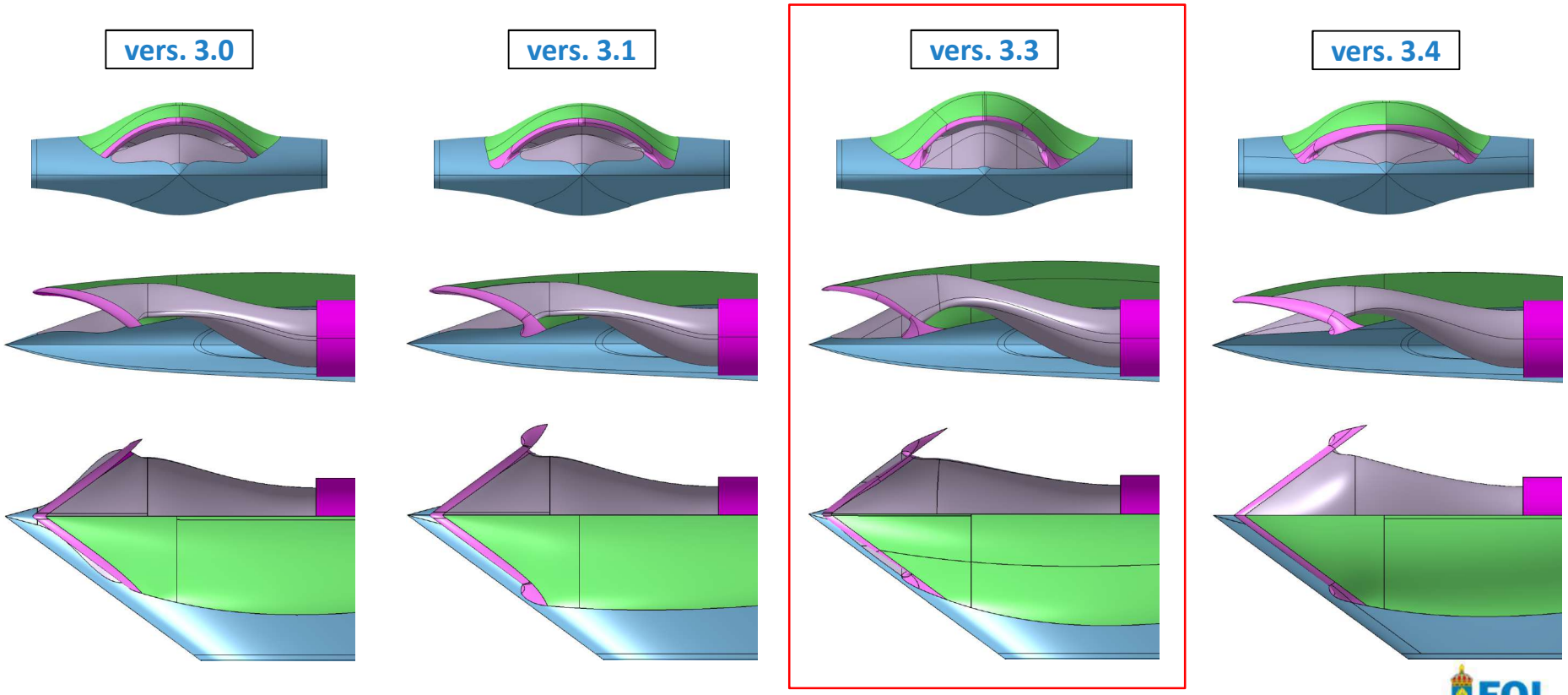


PR = 0.960, DC60 = 0.385

PR_1	= 0.9911	T_{T1}	= 244 K	PR_2	= 0.9596	T_{T2}	= 244 K
M_1	= 0.5323	ρ_1	= 0.424 Kg/m^3	M_2	= 0.3973	ρ_2	= 0.435 Kg/m^3
V_{x1}	= 162 m/s	w_1	= 33.584 Kg/s	V_{x2}	= 121 m/s	w_2	= 33.551 Kg/s
P_1	= 28108 Pa	$w_{1,ac}$	= 91.713 Kg/s	P_2	= 29478 Pa	$w_{2,ac}$	= 94.568 Kg/s
P_{T1}	= 34167 Pa	A_1	= 0.4910 m^2	P_{T2}	= 33080 Pa	A_2	= 0.6366 m^2
T_1	= 231 K	Duct AR	= 1.2965	T_2	= 236 K	RE_2	= 5.9783 10^6

FOI

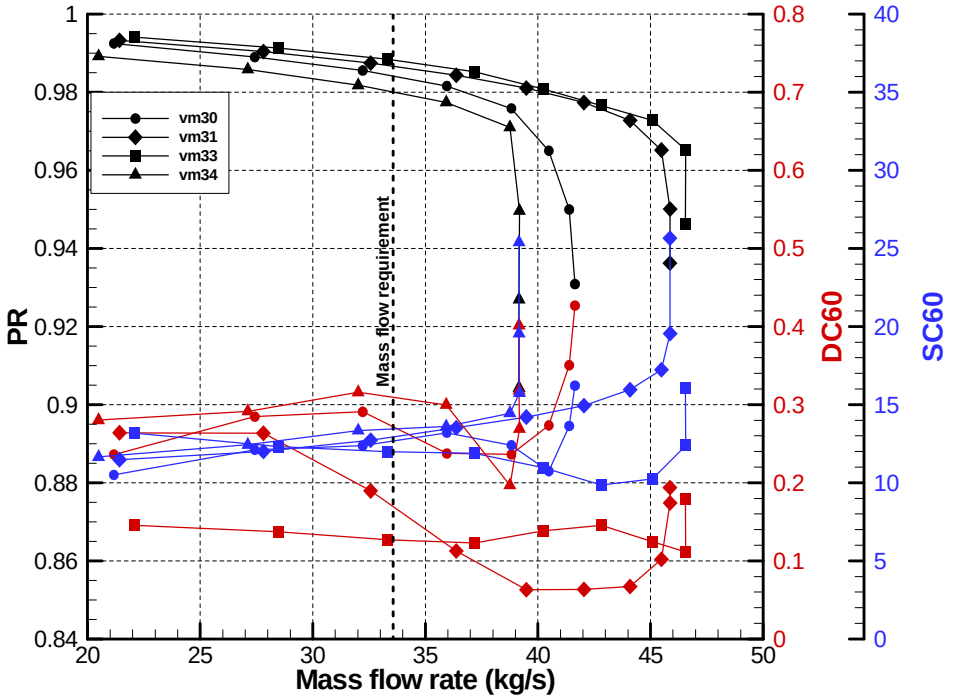
Intake Integration – Version 3

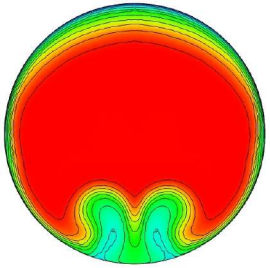


FOI

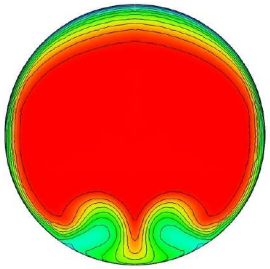
Intake Integration – Version 3

Cruise conditions: Mach 0.80, Alt. 11 km

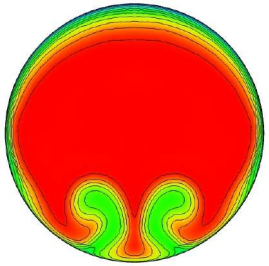




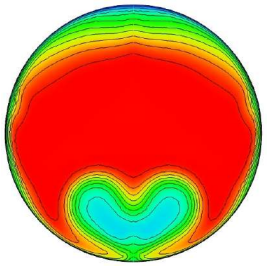
Version 3.0
PR = 0.986, DC60 = 0.291



Version 3.1
PR = 0.987, DC60 = 0.189



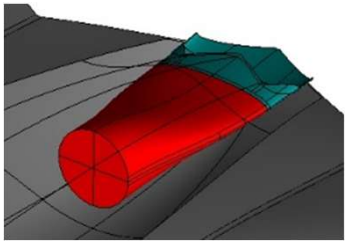
Version 3.3
PR = 0.989, DC60 = 0.127

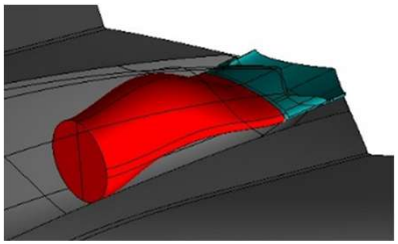


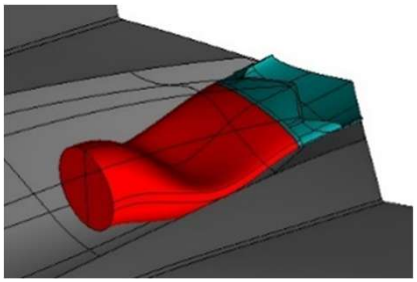
Version 3.4
PR = 0.982, DC60 = 0.316

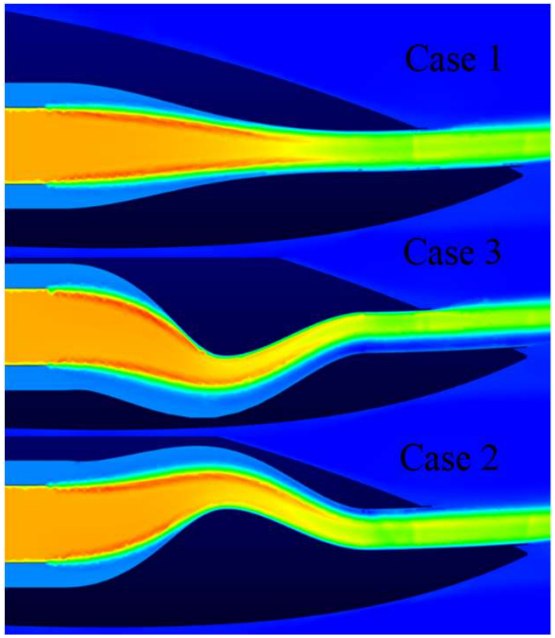
FOI

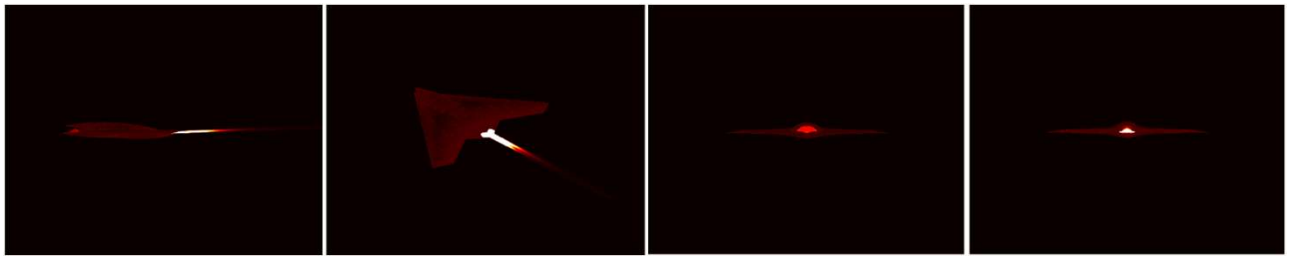
IR Signature

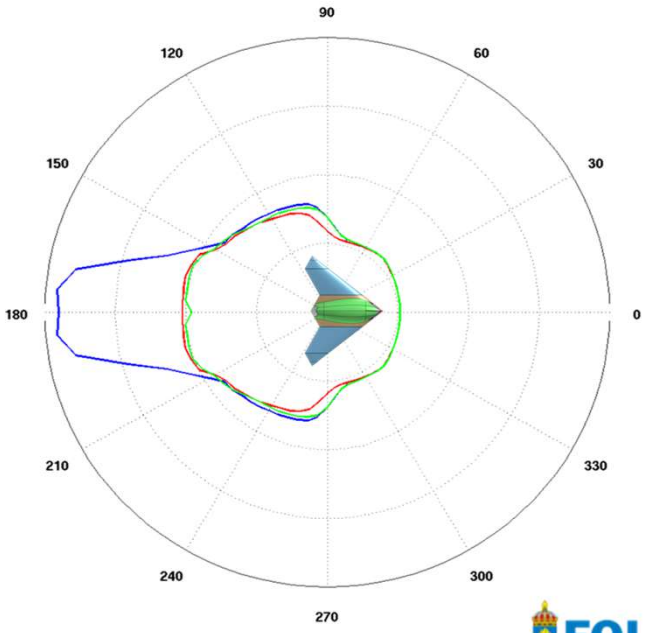




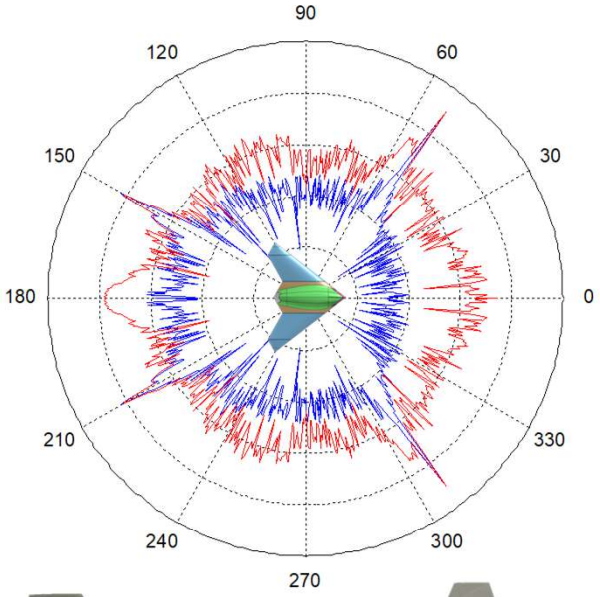


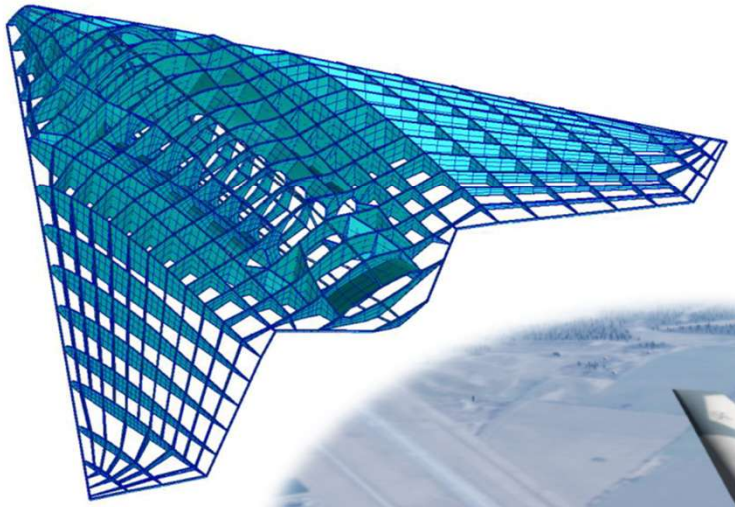


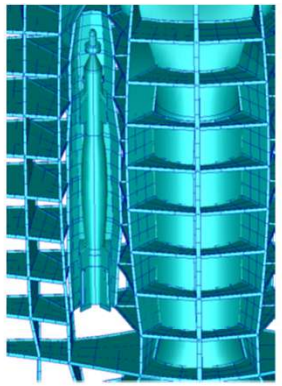


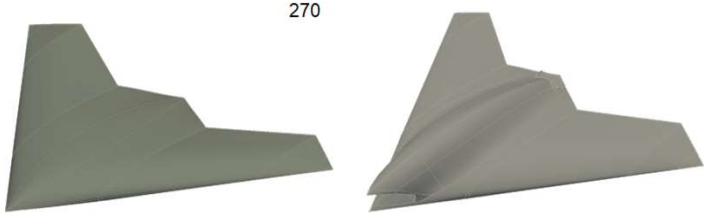


A multidisciplinary approach









FOI

Questions