



PROJECT FINAL REPORT

Grant Agreement number: 605379

Project acronym: COBRA

Project title: Innovative counter rotating fan system for high bypass ratio aircraft engine

Funding Scheme: Collaborative project

Date of latest version of Annex I against which the assessment will be made:

Period covered: from 01/10/2013 to 31/12/2017

Name, title and organisation of the scientific representative of the project's coordinator¹:

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¹ Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

² The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

1. Final publishable summary report

1.3 Description of the main S&T results/foreground

Specifications



Feature	Unit	Value
Number of pax	-	150-200
Design range	nm	3000
Cruise altitude	ft	35000
Cruise mach number	-	0.8
TOFL	m	< 2200
Time to climb (to ICA 33,000 ft)	min	25
Approach CAS	kts	146
OEI ceiling	ft	10000
MTOW	kg	80150
MLW	kg	72860
Technology standard	-	2000

Feature	Unit	Value
Number of pax	-	180-220
Aircraft range	km	6000
Cruise altitude	ft	36000
Cruise mach number	-	0.8
Takeoff weight	kg	110'000
Cruise thrust	kN	33
Takeoff thrust	kN	180

Short/medium range aircraft selected as basis of European specifications.

Long range aircraft (Tupolev 204-100) selected as basis of Russian specifications.

Figure 1: Selected aircraft and associated requirements.

Design and optimisation

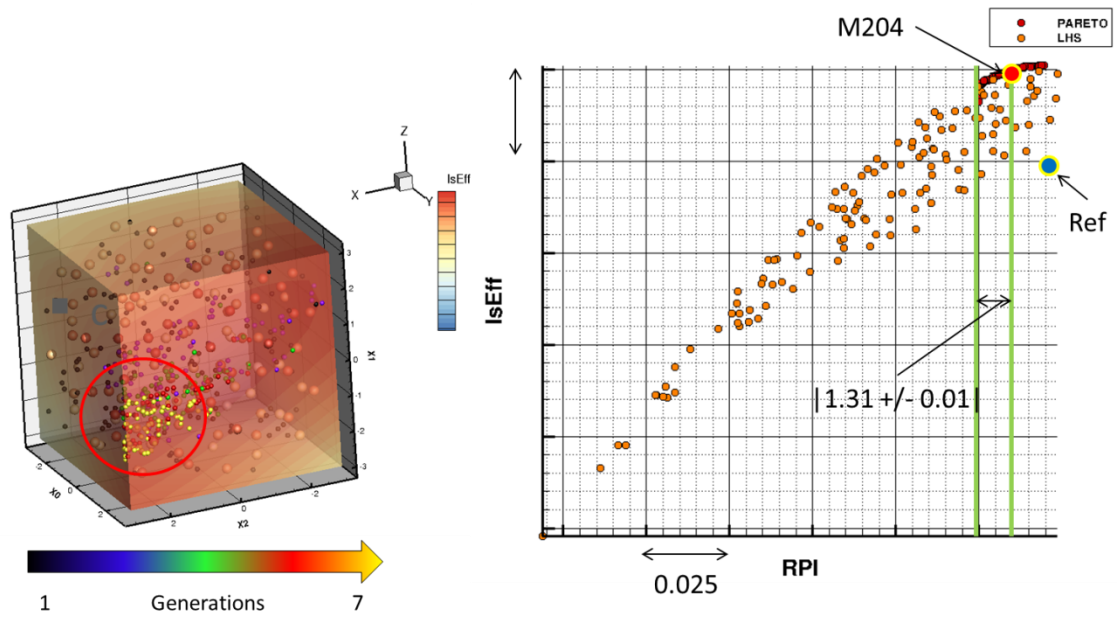


Figure 2: ONERA results of advanced aero-acoustic optimisation.

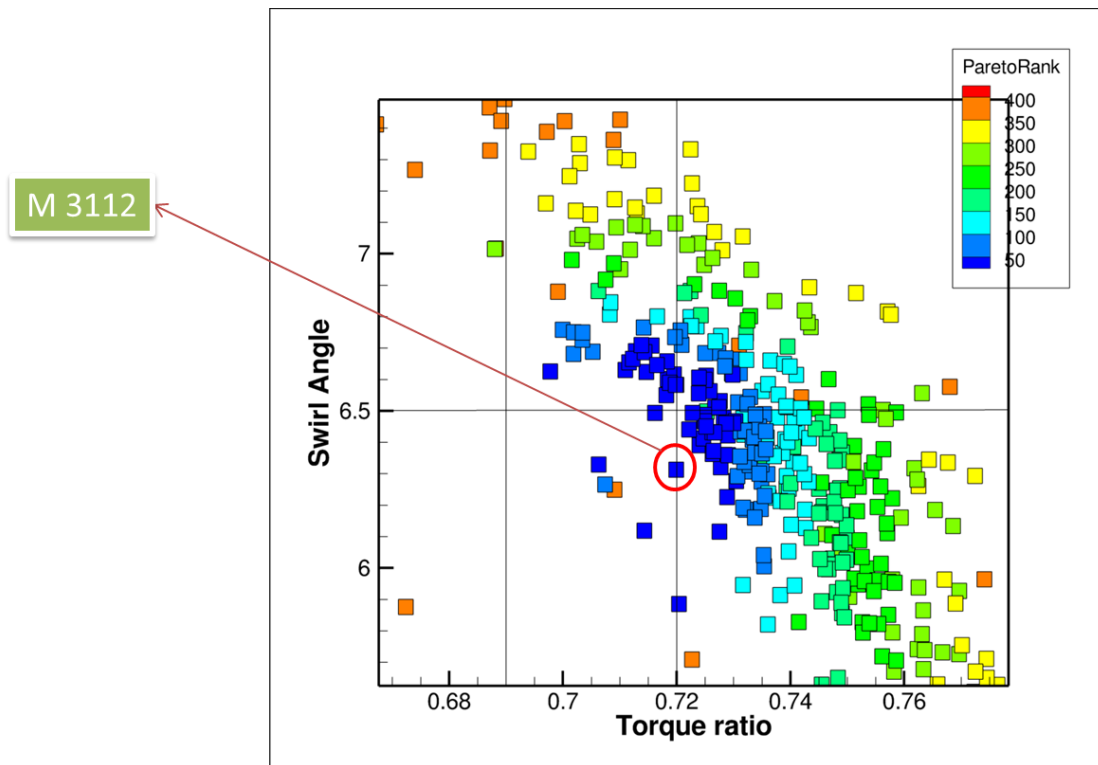


Figure 3: DLR result of advanced aero-acoustic optimisation.

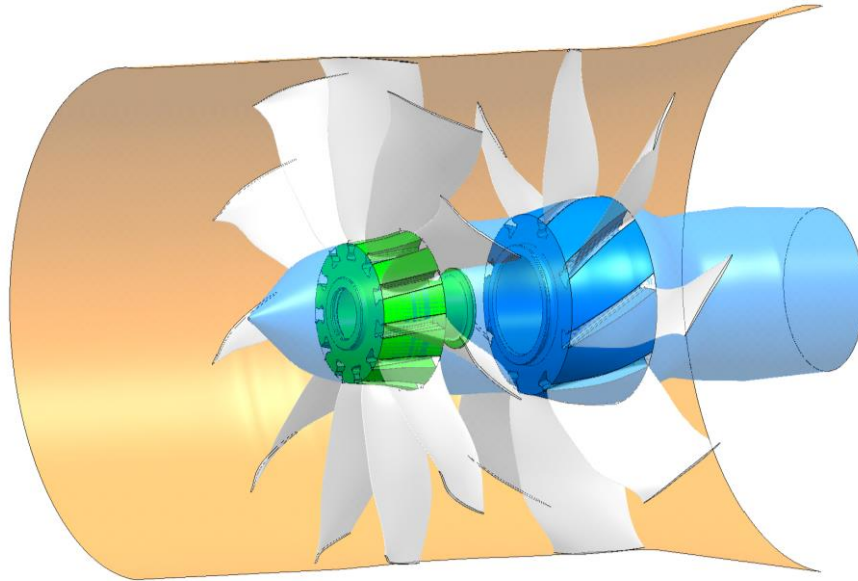


Figure 4: Geometry proposed to CDR.

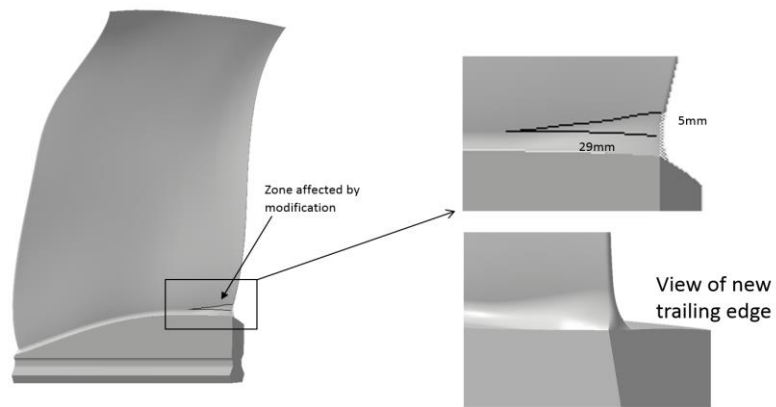


Figure 5: Re-design of the rotor 2 root section for stress peak reduction.

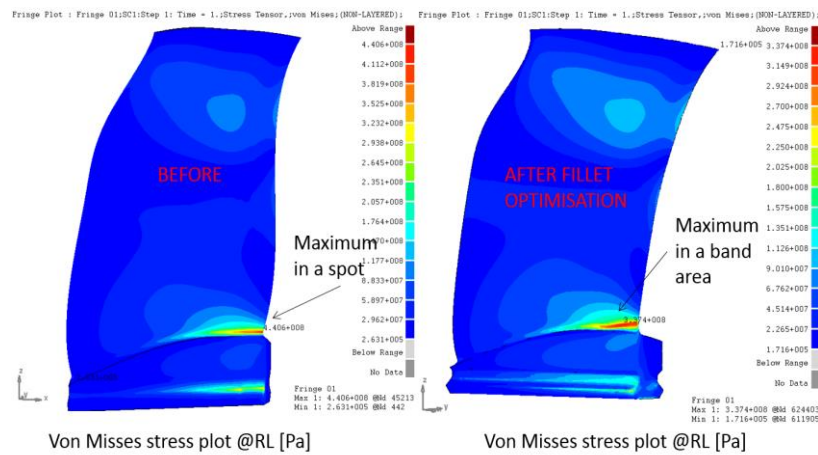


Figure 6: Resulting stresses after re-design of the rotor 2 root section.

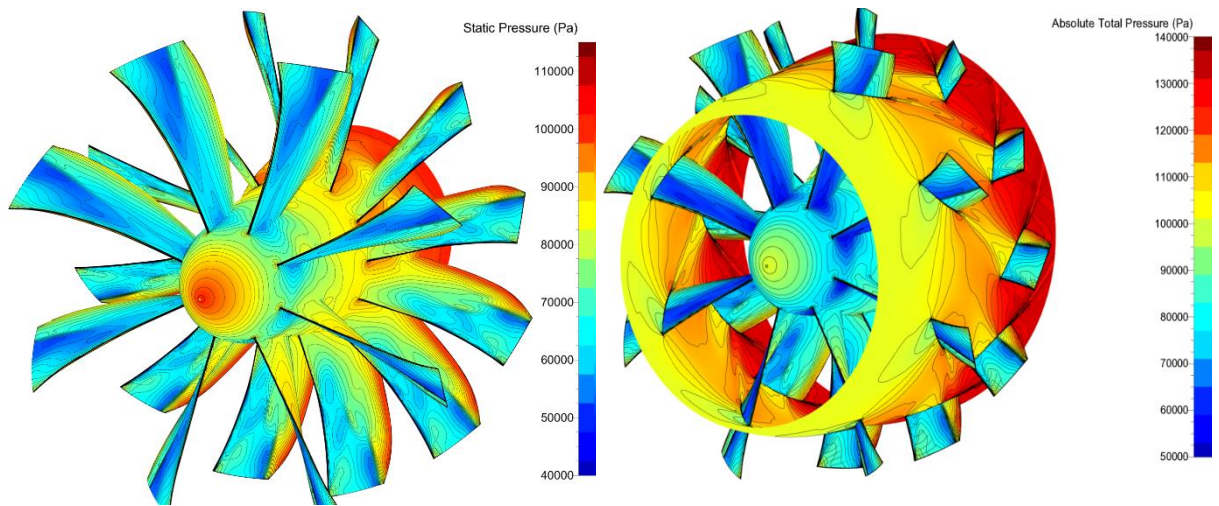


Figure 7

*700mm CRF with BPR
appr. 15-17 mounted on C-3A rig in CIAM (Touraev)*

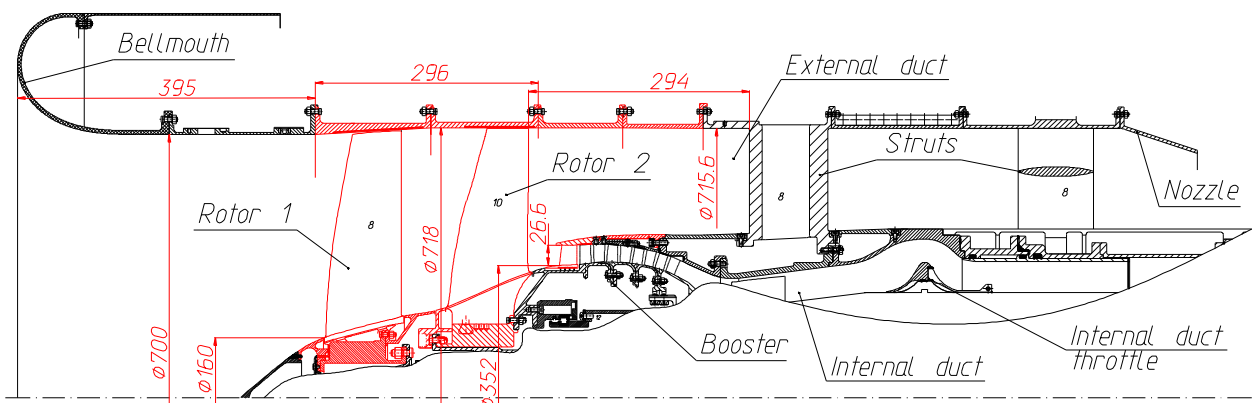


Figure 8: Arrangement of the counter-rotating fan model with by-pass ratio of 15÷17 (European arrangement).

*700mm CRF with BPR
appr. 20 mounted on C-3A rig in CIAM (Touraev)*

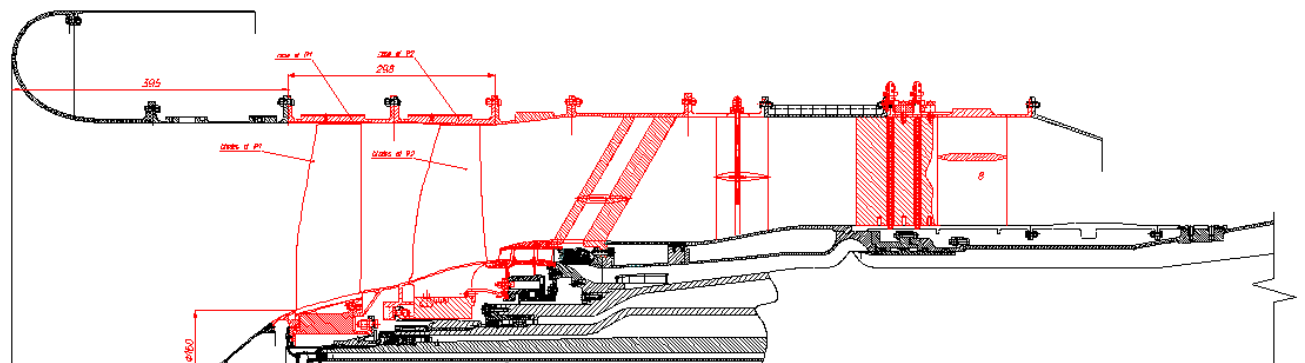


Figure 9: Arrangement of the counter-rotating fan model with by-pass ratio of ~ 20 (Russian arrangement).

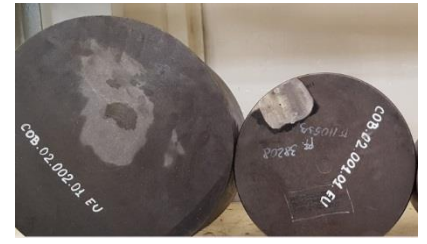
Manufacturing



Forged titanium alloy TiGrF5 raw parts



Rolled aluminium alloy raw parts



Forged steel 17-4PH raw parts

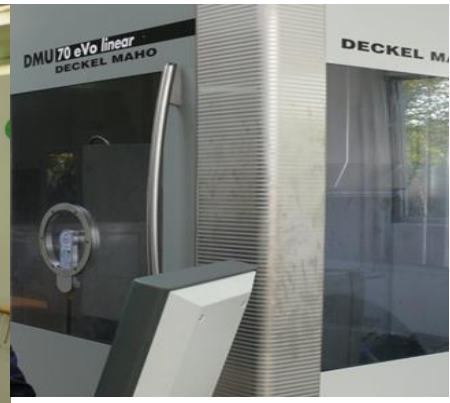
Figure 10: Example of Raw materials ordered and used for COBRA parts.



Vertical CNC lathe SC 14 CNC



Horizontal CNC turning centre CTX 620 Linear



Vertical CNC milling centre DMU 70 eVo linear

Figure 11: Machines used for COBRA manufacturing process.



Aluminium alloy parts



Blades

Figure 12: Shipment preparation.

Experimental campaigns

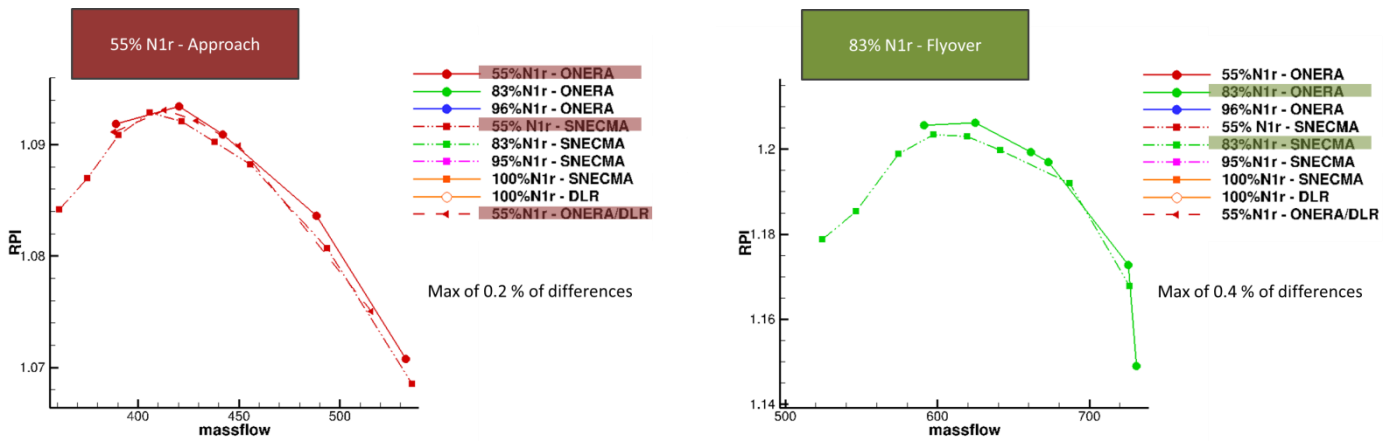


Figure 13: COBRA-Variant1 fan model installed at the C-3A test bench in CIAM.

Experimental Results

Multidisciplinary Assessment

Aerodynamic



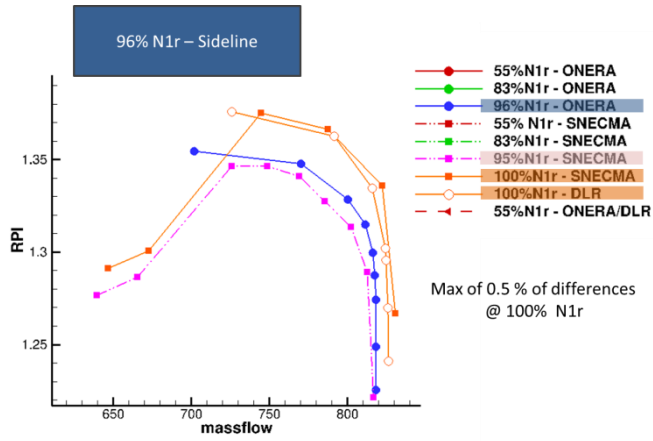
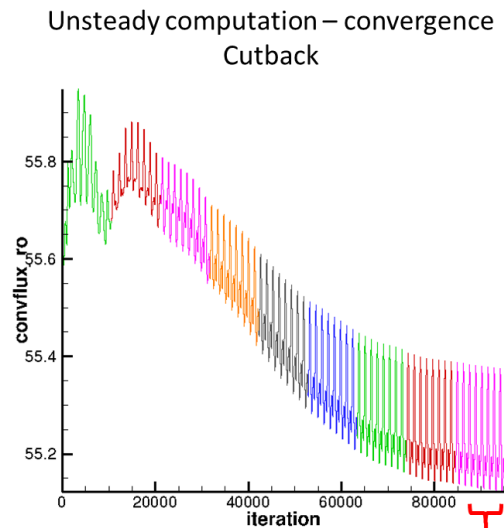
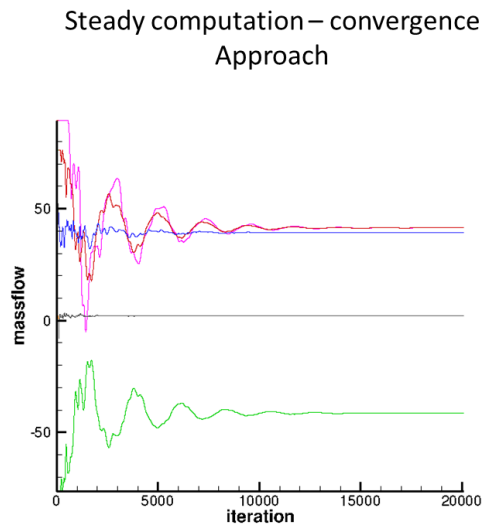


Figure 14: CRTF baseline operating lines, comparison for each operating point.



Wall pressure extraction for CAA (Sneema) ←

Figure 15: Example of steady and unsteady convergence history.

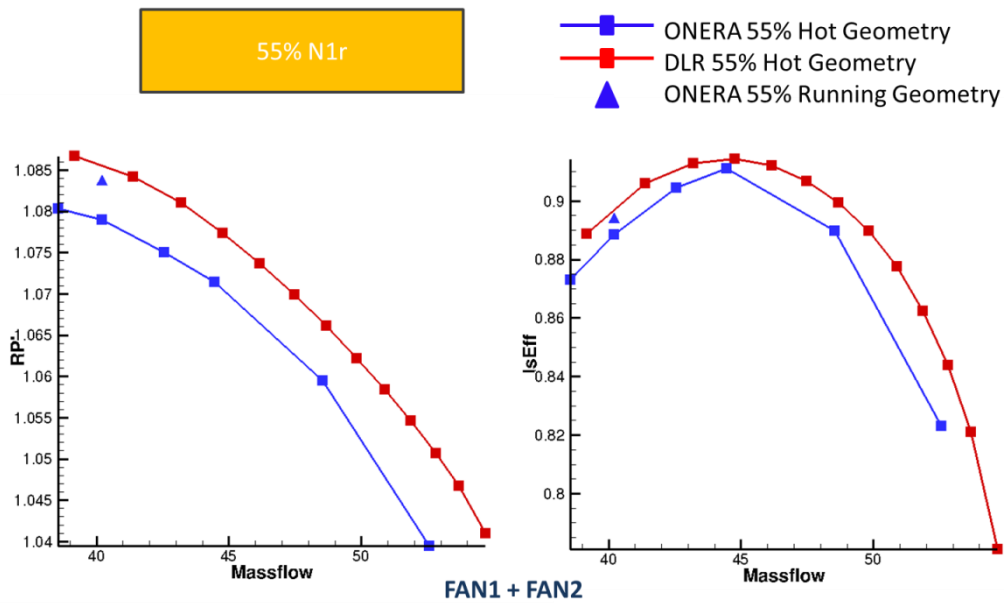


Figure 16: ONERA DLR aerodynamic performances benchmark and comparison to obtained result by using running geometry at approach flight condition.

Acoustic

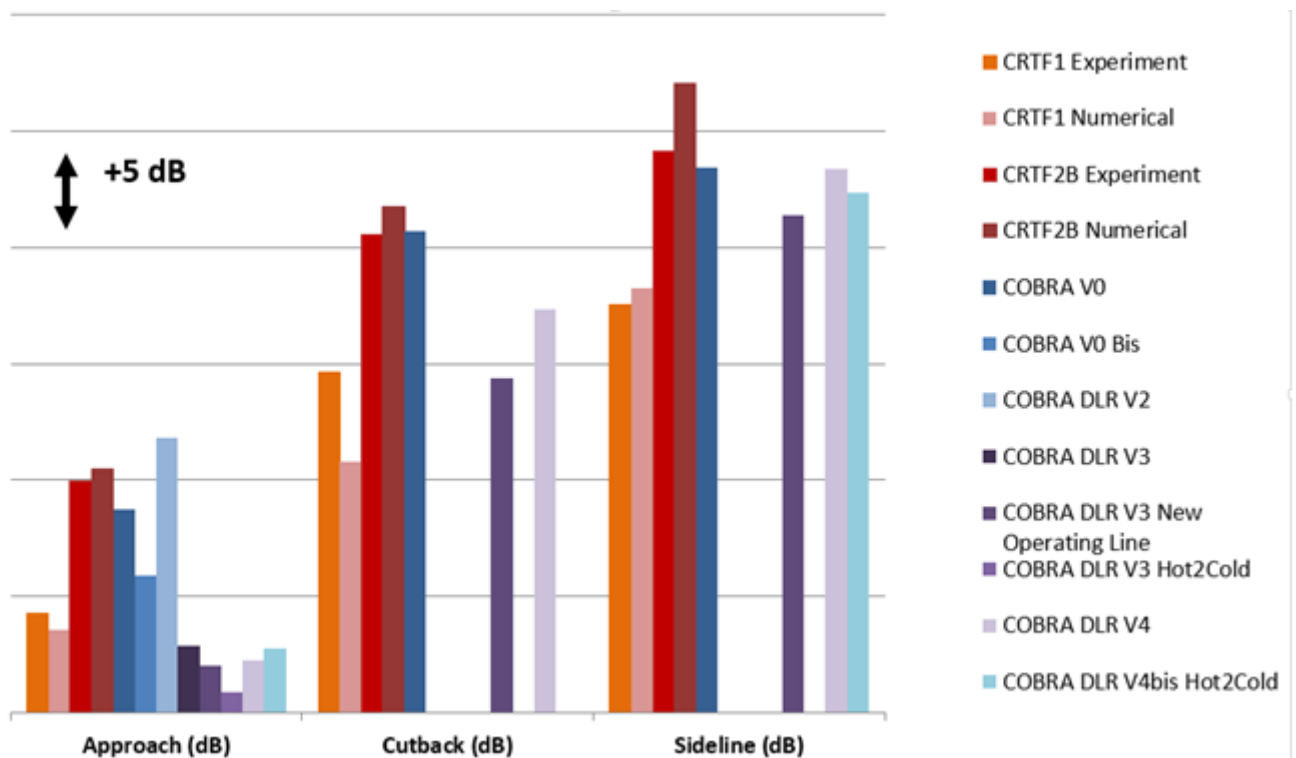


Figure 17: Summary of obtained acoustic results and comparison to the baseline and VITAL (CRTF1 & CRTF2B) outputs.

Structural

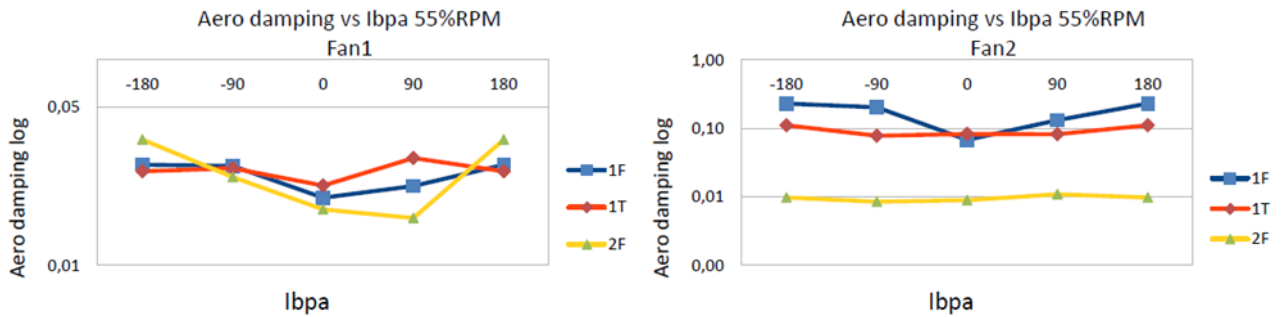


Figure 18: Aerodynamic damping vs. inter blade phase angle (IBPA) for several Eigen mode at 55% of N1r.

Update on 01.05.2018

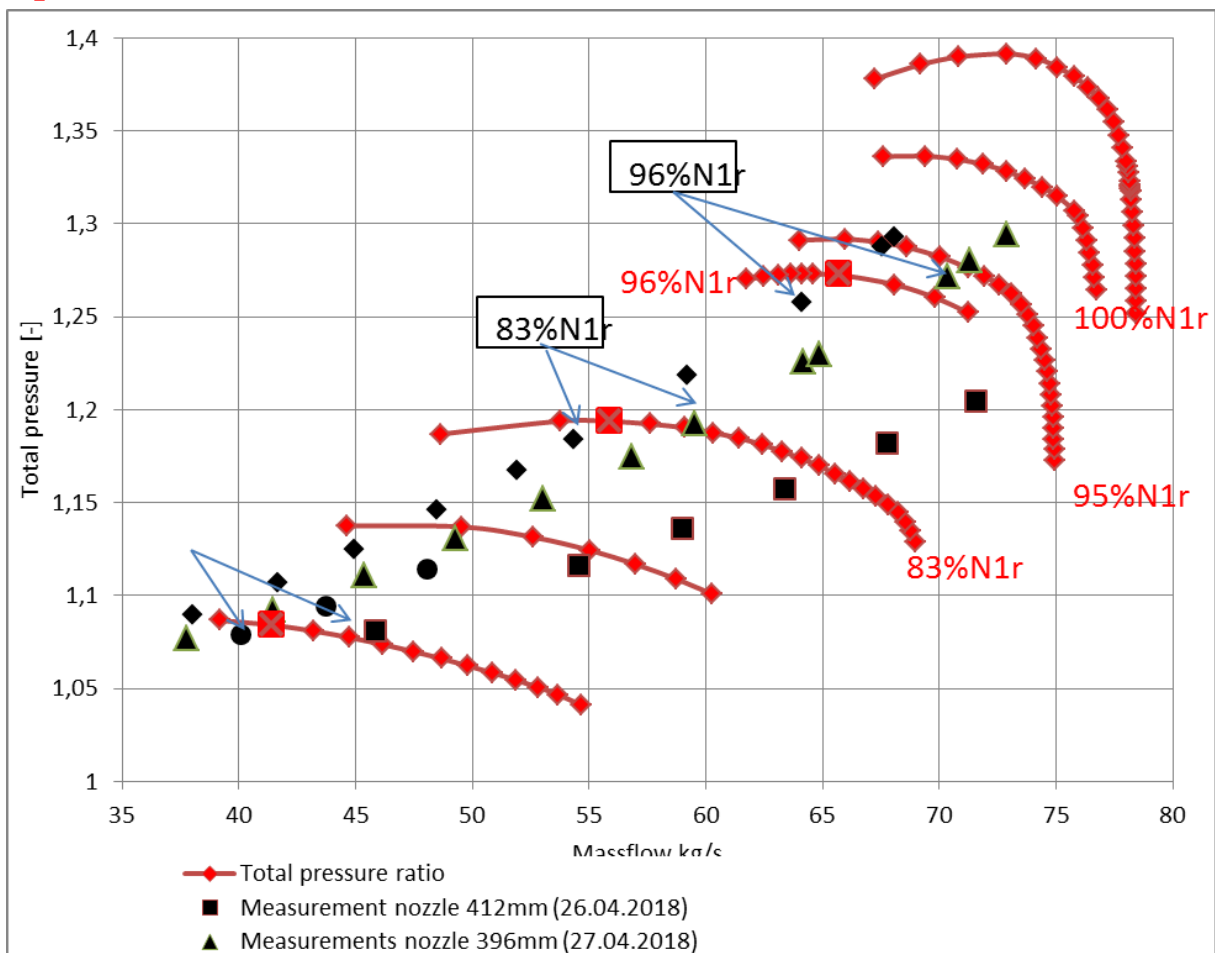


Figure 19: First aerodynamic measurements, comparison to numerical results.



Figure 20: Mounted CRTF European variant on CIAM C-3A test rig.