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 coordinator:\nNabil Ben Nasr, Research Engineer, ONERA, Department of Applied Aerodynamics

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Project website\ address: www.cobra-fp7.eu

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**

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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 (Touraevo)

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 (Touraevo)

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

Max of 0.2% of differences

Max of 0.4% of differences
Figure 14: CRTF baseline operating lines, comparison for each operating point.

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.