Next Generation Combat Aircraft Technologies - NGCAT

COSTEO

Model the **CO**mpressor di**ST**ortion induced by the engine air intake and validate by **E**xperiment the predicted perf**O**rmances

Duration of the project: 01/05/2025 - 01/02/2028

Budget: 5 898 970 €

of which RHID contribution:

5 428 000 €

Key words: compressor, distortion, operability, experimental

PROJECT DESCRIPTION

The propulsive system of the next-gen fighter will have to provide unprecedented low-observability performance. Stealth aircrafts will be designed to generate an as-low-as possible radar signature, implying, among other, the full integration of jet in the fuselage. In these circumstances, the compressor (i.e. the front part of the engine) will be "protected" by a highly 3D inlet duct, completely shielding it from the intake. This configuration will mitigate its upstream radar emission and contribute to foreign objects ingestion protection. Yet, it will come at the expense of strong inlet distortions being generated with a direct negative impact on the compression system performance and operability (stability).

The induced distortion pattern and its impact on the engine compressor is out of the current European legacy and thus require innovative and technological progress versus current state-of-the-art.

COSTEO aims at addressing this latter point by modelling the distortion and assessing their impacts by representative testing:

- The first step of the project is to define an inlet geometry representative of the next-gen fighter configuration that will be used as a reference for the modelling activities.
- Enhanced modelling tools are required to reliably predict high levels of unsteady flow distortion due to convoluted aero-engine intakes. Well consolidated industrial modelling practices (URANS) will be benchmarked and enhanced by higher-fidelity methods for the effective unsteady simulation of distorted inlets. In parallel, the pairing of these techniques with state-of-art

machine-learning approaches (AI), will allow to improve their validity as well as their capability of surveying a large and complex design space.

- To increase the tests representativity, advanced distortion replicating devices will be designed and manufactured to reliably reproduce the highly distorted inlet flow and its associated key distortion descriptors at the aerodynamic interface plane upstream the compressor face. This will be achieved through the development and maturation of advanced aero-mechanical distortion grids design techniques. Joint grid(s)+inlet duct design will also be considered to target the replication of unsteady distortion patterns. Advanced 3D Additive manufacturing techniques are key to manufacture complex and freeform design with no tooling costs while complying with the mechanical constraints of a full-scale test.
- Novel test monitoring and data post-processing tools will be developed integrating the use of advanced numerical models (see above) in real time guaranteeing a robust and reliable solution for the experimental tests.
- Experimental tests will be performed at full and representative scale and engine conditions on a compressor that will be adapted to be representative of the current state-of-the-art technologies for distortion aero mitigation. This step provides the final validation input of the modelling approach with a complete and precise assessment of its performance, as well as a reference for future technologies development.

The expected outcomes of the project mainly concern the generation of new knowledge about stealth impact on future Variable Cycle Engines compressors, and particularly the development of new capabilities for testing NGCAT compressor in stealth operating conditions. Indeed, on one hand, new modelling of inlet duct as well as advanced methodology of designing complex distortion replicating devices will bring a major step-forward in the ability to test and understand stealth installation impact on the engine operating. On the other hand, validating the distortion replication thanks to the advanced design compressor and its associated mitigating technologies will both prove Belgium capability to perform future NGCAT compressor testing with adequate instrumentation and post-processing, and provide important information about next generation compressor behaviour in stealth conditions.

The ambition is to use these outcomes to prepare a follow-on project with broader scope, and notably with a development and test of a full-scale distortion-robust compressor front block with a 3D inlet duct upstream of it.

To achieve such ambitious project, COSTEO can rely on a skilled, competent, and capable ecosystem of complementary partners with transverse expertise in all required areas: aero-mechanical simulation, unsteady aerodynamic modelling, machine learning, aerostructure & compressor design, experimental tests, real time software development and 3D Additive Manufacturing.

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LINK(S)

N/A.