Clean Sky 2
Information Day dedicated to the 8th Call for Proposal (CfP08)

FAST ROTORCRAFT IADP
Topics related to FRC WP1 – Next Generation Civil TiltRotor Project

Leonardo Helicopters
Brussels, 22/05/2018

Innovation Takes Off
www.cleansky.eu
FRC Overview
Filling the Mobility Gap

MISSIONS
EMS, SAR, Coast guard
Disaster relief
Oil & Gas offshore
Corporate Transport
Air Taxi

AIRFIELD
Unprepared Area
Helideck
Door-to-Door
Heliport
Local airfield
Regional Airport
Large Airport

TRANSPORT RANGE & PRODUCTIVITY
Local Transport
Short range
Medium Range
Long Range

Helicopter
Compound R/C
Tilt-Rotor A/C
Turboprop
Turbofan & CROR
FRC Overview
Clean Sky 2 Context

Vehicle IADPs

Fast Rotorcraft
Leonardo Helicopters
Airbus Helicopters

Large Passenger Aircraft
Airbus

Regional Aircraft
Leonardo

Large Systems ITDs

Eco-Design
Fraunhofer Gesellschaft

Airframe ITD
Dassault – Airbus Defense & Space – Saab

Engines ITD
Safran – Rolls-Royce – MTU

Systems ITD
Thales – Liebherr

Small Air Transport
Evektor – Piaggio

Technology Evaluator (TE)
German Aerospace Center (DLR)
Declared CleanSky 2 Objectives:
Low environmental impact with high productivity and efficiency
Approach for NextGenCTR Program: 2 Phases

**NextGenCTR**
A 2-Phase Program

**Phase 1**
Design, Build, Fly a Technology Demonstrator under CS2
*NextGenCTR TD*

- De-risk program, expand current TR capability
- Prove Architecture, Technologies, Operations
- Supported by external funding
- Develop collaborations and partnerships
- Sow the seeds for future technologies & products
- Technology exploitation and dissemination

*if the market is ripe on-going business case development*

**Phase 2**
Develop & Certify a Product
*NextGenCTR*

- Tailored for diverse missions
- State-of-the-art Technologies embedded
- Competitive RC & DOCs vs. Helicopters
- No Legacy with AW609 technologies
Key objectives will be pursued within CS2 by a Technology Demonstrator focusing on the Design & Development effort of **Key Enabling Technologies**:

1. Fixed-engine, Split Gearbox Drivetrain concept
2. Efficient Nacelle architecture
3. Advanced Wing architecture
4. Optimized Tail configuration
5. Advanced Modular, Distributed & Scalable Flight Control System

Throughout this effort the development and validation of predictive models and tools for air vehicle performance (including environmental), efficiency and productivity
New Technologies to be tested within CS2 for First Flight (TRL = 6)

- New Wing (no dihedral and no swept) Integration (T-WING)
- Mast tilt for control improvement (LH)
- Distributed FCS system (LH)
- New control laws (LH)
- Advanced empennage configuration (LIFTT)
- Innovative fuel system (DigiFuel & DEFENDER)
- Splitted gearbox architecture to support non tilting engine (LH)
- Flow through engine
New Technologies to be tested within CS2 after First Flight (TRL =<6)

- Rotor system new material application (MMC,...) (LH)
- New tailcone & empennage material manufacturing (LIFTT)
- Active inceptors (Partner to be engaged)
- General System new applications (i.e. Electrical low pressure compressor, ...)
  (Call to be assigned)
- Additive Manufacturing technology gearbox housing – (AMATHO)
Technology transfer from CS1 to CS2

Accessibility of this technology is granted

No direct accessibility of this technology: there is no impact on NGCTR-TD development

No direct accessibility of this technology: it should be useful for NGCTR-TD development
Technology transfer from CS1 to CS2

**GRC1**
- **LamBlade** - Development and provision of a numerical model to solve laminar turbulent boundary layer transition and boundary layer velocity profiles for unsteady flow conditions
- **COMROTAG** - Development and supply of an advanced numerical model suitable for commercial code (Fluent) to investigate complex unsteady interational phenomena

**GRC2**
- **TP13** - Optimised geometry of the common tiltrotor platform.
- **TILTOp** - Contribution to the study of the air intake and exhaust integration into a tiltrotor nacelle.
- **TETRA** - Assessment of optimized tiltrotor engine intake performance by wind tunnel tests.
- **TP10** - Optimised turboshaft installation of the common tiltrotor platform.
- **CODE-Tilt** - Contribution to design optimisation of tiltrotor for drag (fuselage/wing junction, nose, landing gear, empennage).
- **DREAm-TILT** - Assessment of tiltrotor fuselage drag reduction by wind tunnel tests and CFD.

**GRC3**
- **ELETAD** - Electrical Tail Rotor Drive – Modelling, Simulation and Rig Prototype Development
- **REGENESYS** - Multi-source regenerative systems power conversion
- **HERRB** - Innovative Dynamic Rotor Brake
Technology transfer from CS1 to CS2

**GRC5**

- **EMICOPTER** - Development of computational tools for engine gas emission prediction
  Tools required to perform the emissions analysis and evaluation methodology
- **MAEM-RO** - Development of methodology for helicopter flue gas measurements and flight measurement campaign
  Tools required to perform the emissions analysis and evaluation methodology, experimental support
- **ANCORA** - Preliminary acoustic flight tests for the tuning of simplified rotorcraft noise models
- **TRAVEL** - integrated ATC/TR simulation of low-noise procedures for impact evaluation on operators
- **MANOEUVRES** - Innovative measurement and monitoring system for accurate on-board acoustic predictions during rotorcraft approaches and departures. Sensing and cockpit monitoring to reduce noise in manoeuvring flight.
- **TP1** - Eco-flight VFR Procedure.
- **TP2** - Eco-flight IFR Procedure.
- **TP4** - Eco-Flight Planner.

**GRC6**

- **ECOfairs** - "Manufacturing of Thermoplastic Structural Demonstrators. Development of technology & design for demonstrator“
- **RE MART** - End-of-life solutions for metallic structures - Recycling of Metallic Materials from Rotorcraft Transmissions

**WP1.5** - CS2 FRC WP4 - Technology Evaluator Methodology
- WP1.5 - CS2 FRC WP4 - Technology Evaluator Methodology
- WP4 - NGCTR - AIRCRAFT TEST and DEMONSTRATION
- WP2.4 - NGCTR - ROTOR SYSTEMS
- WP2.6 - NGCTR - ELECTRICAL and AVIONIC SYSTEMS
- WP4 - NGCTR - AIRCRAFT TEST and DEMONSTRATION
- WP1.5 - CS2 FRC WP4 - Technology Evaluator Methodology
- WP2.2 - NGCTR - TILTROTOR SYSTEM DESIGN
- WP4 - NGCTR - AIRCRAFT TEST and DEMONSTRATION
- WP2.5 - NGCTR - AIRFRAME STRUCTURES
- WP3 - NGCTR - AIRCRAFT INDUSTRIALISATION and ASSEMBLY
- WP1.4 - CS2 FRC WP3 - Eco-Design Implementation
- WP2.5 - NGCTR - AIRFRAME STRUCTURES
- WP3 - NGCTR - AIRCRAFT INDUSTRIALISATION and ASSEMBLY
NGCTR WBS - Clean Sky 2 Demonstrators Definition & Plan

1. Fixed-engine, Split gearbox drivetrain concept
2. Efficient nacelle architecture
3. Advanced Wing architecture
4. Optimized Tail configuration
5. Advanced Modular, Distributed & Scalable FCS

D1 Wind Tunnel Model
D2 TDH – Tie Down Tilt Rotor
D3 Flying Demo
D4 Drive system and components
D5 Wing Assembly
D6 Engine-nacelle integration
D7 Fuel system components
D8 Flight control and Actuation systems and components (SaIL)
D9 Digital Mock-Up (DMU)
D10 Airframe Structural Components

CO₂ and Noise Footprint reduction
Reduced cost of ownership (operating & MRO)
Fast Forward Speed
High Efficiency, High Productivity
• **FRC-01-18:** Adoption of a “Digital Transformation” approach to improve NGCTR design and simulation

• **FRC-01-19:** Certification by Simulation for Rotorcraft Flight Aspects (CSRFA)

• **FRC-01-20:** Design, development and flight qualification of a supercritical composite shaft drive line for tiltrotor main drive system

• **FRC-01-21:** Development of effective engine air intake protection system for Tilt Rotor

• **FRC-01-22:** Development of engine exhaust wake flow regulator for Tilt Rotor

• **FRC-01-23:** Experimental characterization and optimization of the RH and LH Engine intakes configuration of the next generation Tilt Rotor

• **FRC-01-24:** High efficiency full electrical low pressure Compartment Pressure Control System for tilt-rotor applications
FRC-01-18: Adoption of a “Digital Transformation” approach to improve NGCTR design and simulation
FRC-01-18: Adoption of a “Digital Transformation” approach to improve NGCTR design and simulation

- **Topic Manager:** Leonardo Helicopters;
- **Collab.= Implementation Agreement**
- **Indicative Funding Value:** 1,750 M€;
- **Duration:** 60 Months
- **Type of Action:** RIA
- **Overview:** Leverage on new technologies and methods (Big data and AI algorithms) to sustain the development of the NGCTR-TD.

- **Objectives:**
  - Increase efficiency and accuracy in flight data analyses
  - Improve design choices
  - Optimize flight campaigns
FRC-01-18: Adoption of a “Digital Transformation” approach to improve NGCTR design and simulation

- Build the Big Data Appliance:
  - Computational power to explore complex, large and heterogeneous data-sources
  - Advanced data processing and visualization capabilities

- Implementation of new algorithms, aimed at:
  - Automate data anomalies detection
  - Perform event recognitions
  - Predict aircraft behavior
  - Build predictive models learning from data
The project will use the existing Tiltrotors data to train the system and NextGen tilt-rotor as application case.

- To facilitate the Flight Data Analysis for TD;
- To feed simulation activity
- To support future full size Tiltrotors design and Certification process
FRC-01-19: Certification by Simulation for Rotorcraft Flight Aspects (CSRFA)
FRC-01-19: Certification by Simulation for Rotorcraft Flight Aspects (CSRFA)

- **Topic Manager:** Andrea Ragazzi
- **Collab.:** Implementation Agreement
- **Indicative Funding Value:** 3 M€
- **Duration:** 36 Months
- **Type of Action:** IA
- **Overview:** The aim of this topic is to bring together the rotorcraft industry, the certification authority and simulation excellences to define a virtual certification process for rotorcraft flight aspects.
- **Objectives:**
  - to improve from the current case-by-case to a more standard approach;
  - to improve safety;
  - to reduce program costs;
  - to increase insight into design;
  - to reduce environmental impacts.
Simulation has three big advantages: safety + economy + effectiveness.

Flight simulation requires:
- simulation models that satisfy real-time constraints;
- simulation hardware that provides adequate cues.

The research activity shall:
- identify the areas of the certification process/rules that can be substituted/supported by simulation;
- define guidelines for acceptable CSRFA simulation models fidelity;
- define guidelines for acceptable CSRFA simulator cueing systems fidelity;
- study for each rule the approach using the above simulation assets.

To maximize the benefits for rotorcraft industries (especially smaller ones) CSRFA will consider both high-level and affordable technology, possibly scaling the use of simulation in place of real flight with the fidelity level.
The research shall address helicopters and tilt-rotors.

CSRFA results will use the NextGen tilt-rotor as application case
- To facilitate the Permit to Fly release for TD;
- To support future full size Tiltrotors design and Certification process

The project shall use Leonardo Helicopters simulation models and simulation facility (with the possibility to modify it to support this research).
FRC-01-20: Design, development and flight qualification of a supercritical composite shaft drive line for tiltrotor main drive system
FRC-01-20: Design, development and flight qualification of a supercritical composite shaft drive line for tiltrotor main drive system

- **Topic Manager:** Leonardo Helicopters;
- **Collab.= Implementation Agreement**
- **Indicative Funding Value:** 0.400 M€;
- **Duration:** 42 Months
- **Type of Action:** IA
- **Overview:** Design, development and flight qualification of a supercritical composite shaft drive line for tiltrotor main drive system
- **Objectives:**
  - design a supercritical composite drive shaft line for a tilt rotor drive system, whose architecture should conceive suitable supports, damping behaviour into the whole operating range, capability of coping with angular deflections
  - innovative monitoring and diagnostic system able to properly and timely detect possible damages of the whole drive line.
FRC-01-20: Design, development and flight qualification of a supercritical composite shaft drive line for tiltrotor main drive system

- Capability of properly transmitting design torque not operating continuously at a critical whirling speed;
- The use of composite material technology can allow to realize non-isotropic shaft, tailoring the shaft design such that it can withstand the torque load while having proper flexible bending properties
- Use of suitable active bearings to control the stability and vibration of the highly flexible driveline
- Capability of accommodating flexural curvature to allow for the effects of wing deflection and possible misalignment of the support bearings;
- Usage and health monitoring system performances (i.e. embedded sensors)
- Light and compact design;
FRC-01-21: Development of effective engine air intake protection system for Tilt Rotor
FRC-01-21: Development of integrated engine air intake and protection systems for Tilt Rotor

- **Topic Manager:** Leonardo Helicopters;

- **Collab. Implementation Agreement**

- **Indicative Funding Value:** 2.5 M€;

- **Duration:** 60 Months

- **Type of Action:** IA

- **Overview:** Design, manufacturing, testing and flight qualification of an integrated engine air intake protection system for Tilt Rotor.

- **Objectives:**
  - Design and development of engine air inlet with barrier filter for VTOL and high speed operations.
  - Integration of anti-ice system, compressor washing system and filter self/easy cleaning system.
  - Computational fluid dynamic analysis of the entire air intake system.
  - System testing for icing conditions and bird strike.
FRC-01-21: Development of integrated engine air intake and protection systems for Tilt Rotor

- Development of an intake protection system for harsh Tilt Rotor operating environment.
- Design optimization process for the integration of the intake sub-systems and the compliance with aircraft operational requirements.

- Validation of the air intake system for Flight Clearance against inadvertent icing, vibrations and bird strike damage.
FRC-01-22: Development of engine exhaust wake flow regulator for Tilt Rotor
FRC-01-22: Engine exhaust wake flow regulator for Tilt rotor

- **Topic Manager:** Leonardo Helicopters
- **Collab.**= Implementation Agreement
- **Indicative Funding Value:** 1.6 M€
- **Duration:** 60 Months
- **Type of Action:** IA
- **Overview:** Design, manufacturing, testing and flight qualification of an engine exhaust with variable geometry and active engine bay cooling system.
- **Objectives:**
  - Development of an exhaust system able to convert residual gas energy into thrust.
  - Development of an innovative system for bay cooling by directing the secondary pressurized flow to the exhaust.
  - Computational fluid dynamic and structural analysis to support the entire design phase.
FRC-01-22: Engine exhaust wake flow regulator for Tilt rotor

- Optimization process for tiltrotor performance during both hovering and level flight conditions.
- Design of a two-position primary nozzle to improve turboprop cycle (max expansion efficiency) in VTOL and turbojet cycle (max thrust efficiency) in airplane mode

![Diagram showing the engine exhaust wake flow regulator for Tilt rotor]
FRC-01-23: Experimental characterization and optimization of the RH and LH Engine intakes configuration of the next generation Tilt Rotor
FRC-01-23: Experimental characterization and optimization of the RH and LH Engine intakes configuration of the next generation Tilt Rotor

- **Topic Manager:** Leonardo Helicopters;
- **Collab.=** Implementation Agreement
- **Indicative Funding Value:** 3.500 M€;
- **Duration:** 30 Months
- **Type of Action:** RIA
- **Overview:**
  To test in wind tunnel the datum engine intake configuration, to optimize and test the internal ducts and to make an analytical assessment of the icing and snow effects on the configuration.
- **Objective:**
  To experimentally provide the datum intake performances for NGCTR-TD and to address the optimized configurations suitable for the NGCTR aircraft.
### Workpackages 1/2

1. **Numerical assessment of the datum configuration (NGCTR-TD)**
   - CFD analysis in different flight conditions of the datum configuration as supplied by the ITD leader
   - Rotor effects shall be included

2. **Design, manufacturing and wind tunnel testing of the datum configurations (NGCTR-TD)**
   - Accomplishment of wind tunnel test on a scaled model (rotating parts not required) to support and confirm the CFD prediction in the previous WP1 (performances, distortion, losses, etc.)

3. **Optimization of the internal ducts**
   - CFD optimization of the internal ducts of datum configuration aimed to maximize intake efficiencies in different flight conditions (airplane mode and helicopter mode)

4. **Design, manufacturing and wind tunnel testing of the optimized configurations**
   - Accomplishment of wind tunnel test on a scaled model (rotating parts not required) to support and confirm the CFD optimization in the previous WP3 aimed to address the NGCTR configuration
FRC-01-23: Experimental characterization and optimization of the RH and LH Engine intakes configuration of the next generation Tilt Rotor

Workpackages 2/2

5. Icing and Snow analysis

- Analysis of the datum configuration (NGCTR-TD) in terms of ice accretion in order to identify possible criticalities.
- Investigation of the intake characteristics into snow environments
- Activities not related to the TD but fundamental to support the NGCTR development that exploits the same intake concepts

Expected capabilities from the Applicant

- Proven skills in internal duct analysis and optimization
- Wind tunnel tests management, test conduction and experimental data analysis on similar subject (proprotor nacelles)
- Qualified and demonstrated skills in both numerical multi-objective optimization and simulation (CFD) for fixed and rotating (blade/propeller) components, wind tunnel testing and icing prediction.
FRC-01-24: High efficiency full electrical low pressure Compartment Pressure Control System for tilt-rotor applications
FRC-01-24: High efficiency full electrical low pressure compartment pressure control system for tilt-rotors applications

- **Topic Manager:** Leonardo Helicopters;
- **Collab.=** Implementation Agreement
- **Indicative Funding Value:** 1.2 M€;
- **Duration:** 48 Months
- **Type of Action:** IA
- **Overview:** Development, testing and qualification of a full electrical modular-based low pressure compartment pressure control system.
- **Objectives:**
  - Development of the best architecture and hardware for a bleedless pressurized system.
  - Development of an integrated system composed by the electrical air compressor, cabin pressurization system components and management.
FRC-01-24: High efficiency full electrical low pressure compartment pressure control system for tilt-rotors applications

- Development of an electric compressor to enable the bleedless engine architecture pursuing the philosophy of the More Electric Aircraft.
- Optimization of energy supply modulation: ability to provide energy as necessary