CLEAN SKY - *Green Rotorcraft ITD (GRC)*

Publishable Summary P6

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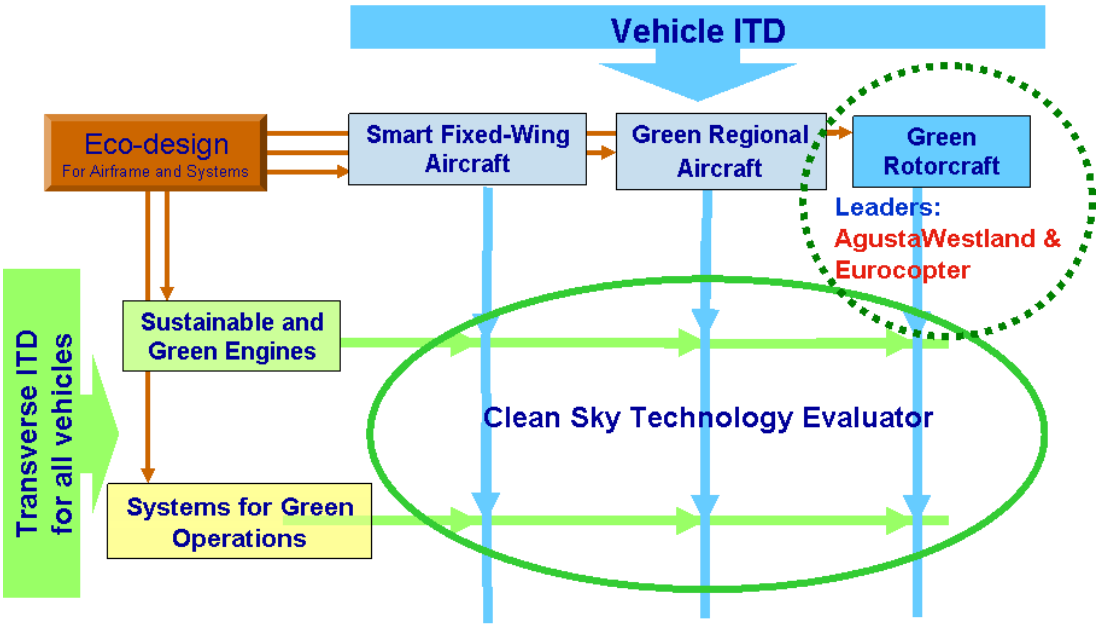
Publishable summary

The Green Rotorcraft Integrated Technology Demonstrator (GRC ITD) addresses environmental issues in relation to rotorcraft vehicle usage, as part of a wider Air Transport System considered in the Clean Sky Joint Technology Initiative (CS JTI).

Clean Sky aims to create a radically innovative Air Transport System based on the integration of advanced technologies and full scale demonstrators, with the target of reducing the environmental impact of air transport through reduction of noise and gaseous emissions, and improvement of the fuel economy of aircraft. The activity covers all main flying segments of the Air Transport System and the associated underlying technologies identified in the Strategic Research Agenda for Aeronautics developed by the Aeronautics Technology ACARE Platform.

Clean Sky is built upon 6 different technical areas called Integrated Technology Demonstrators (ITDs), where preliminary studies and down-selection of work will be performed, followed by large scale demonstrations on ground or in-flight, in order to bring innovative technologies to a maturity level where they can be applicable to new generation “green aircraft”.



The Green Rotorcraft ITD gathers and structures all activities specifically focused on the integration of technologies and demonstration on rotorcraft platforms (helicopters, tilt-rotor aircraft). There are however technical links with activities conducted within the Eco-Design ITD, the Sustainable Green Engines ITD, the Systems for Green Operations ITD and with the Technology Evaluator.

Overall objectives

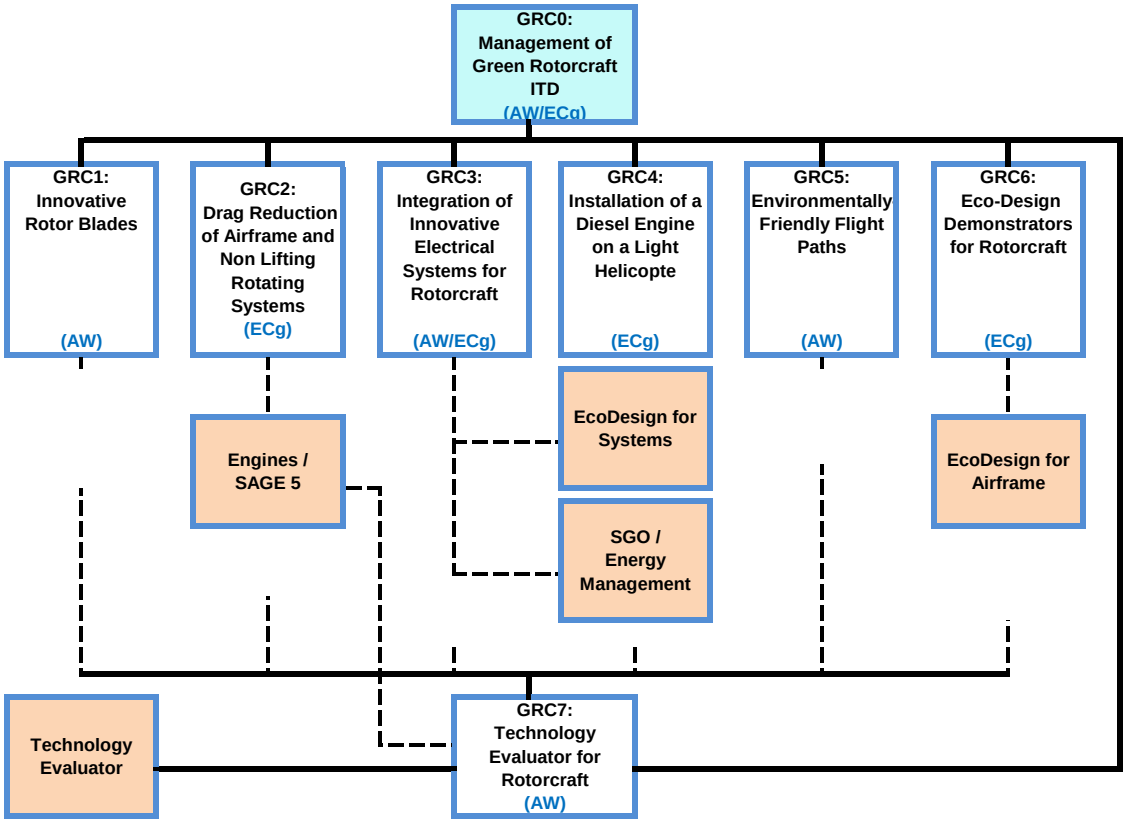
The Green Rotorcraft ITD addresses the challenge of minimising the impact of the sharply increasing rotorcraft traffic expected in the future, including tilt-rotors, through a more efficient usage of energy and through a drastic reduction of greenhouse gas emissions and noise footprints throughout the whole mission spectrum.

With the goal to contribute to the overall objective of coming back within 20 years to the present global level of environmental impact while sustaining the expected growth of rotorcraft services, the

Clean Sky initiative aims to reduce by half, within the next 10 years, the specific impact generated by rotorcraft operations on the environment. In detail, taking year 2000 as baseline, the objectives of the GRC ITD and concurrent activities in other Clean Sky ITDs are to reduce emissions of CO_2 by 26-40% and NO_x by 53-65%, according to vehicle and technologies used, and to reduce the average noise level by 10 dB.

In order to achieve those objectives, the project will develop new power plants, innovative rotor blades and new aircraft configurations. The project is organised along six technological streams, dedicated to key topics:

- Innovative rotor blades (GRC1)
- Reduced drag of airframe and dynamic systems (GRC2)
- Integration of innovative electrical systems (GRC3)
- Installation of a Diesel engine on a light helicopter (GRC4)
- Environment friendly flight paths (GRC5)
- Eco-Design demonstrators (rotorcraft) (GRC6)
- Technology Evaluator for Rotorcraft, interface and data preparation to TE, (GRC7)



The project includes also a management package (GRC0). It is scheduled to run over **an eight** year period starting on July 1st, 2008; it is jointly coordinated by AgustaWestland and Airbus Helicopters.

GRC0 - Management of Green Rotorcraft ITD

The GRC management structure aims at ensuring timely achievement of high quality technical demonstrations, and at providing proficient contractual and budgetary support and coordination of

the projects. It also intends to ensure that knowledge management and other innovation-related activities are coordinated at ITD level.

GRC1 – Innovative Rotor Blades

Assess the potential for active and passive rotor technologies to achieve a commercially viable solution that enables reduction of rotor power consumption and rotor acoustic signature. The targeted achievements shall be measured relative to fleet 2000 baseline helicopters as defined by GRC7.

Pursue development of the active twist concept from FRIENDCOPTER.

Carry out parametric study and optimisation of active and optimised passive blade lay-out for global rotor benefits.

Develop methods necessary for the optimisation of blade design, actuation system integration, sensory data transmission, power transfer and control algorithms.

Develop suitable open-loop and closed-loop control algorithms to manage the active system behaviour.

Conduct experimental activities in controlled situations (model rotor and wind tunnel tests) allowing for the detailed evaluation of benefits, behavioural characteristics and operational methods/ practices of such new technology. This work is important for the correlation of the newly developed computational 'methods' (to date no data exists to allow for correction of model predictions), to inform of the behavioural characteristics of active blade components that will ultimately be fitted to flight blades, to provide performance data under scientifically controlled conditions and to bring pan European expertise in the resolution of challenging problems.

GRC2 - Drag Reduction of Airframe and Non Lifting Rotating Systems

The general objective of GRC2 is twofold: first, to reduce rotorcraft overall drag by non-degrading its lift and handling quality, second, to decrease engine installation losses. The first goal goes towards a decrease of the required power of the rotorcraft, whereas the second one towards an increase of the engine available power.

Technological objectives

- Drag reduction of the rotor head and helicopter fuselage; drag reduction of the tilt-rotor fuselage and lift over drag increase of its wing and empennages.
- Efficiency improvement (i.e. decrease pressure losses and distortions) and noise emissions reduction of engine intake. Efficiency improvement (i.e. pressure recovery) increase of secondary mass flow, of engine exhaust.

GRC3 - Integration of Innovative Electrical Systems for Rotorcraft

Main objectives of GRC3 are:

1. Replacement of hydraulic systems on rotorcraft by electrically-powered systems.
2. Reduction of carbon emissions and improved overall electrical power system energy efficiency.

GRC4 - Installation of a Diesel Engine on a Light Helicopter

General objective is to take advantage of the extremely low specific fuel consumption which can be obtained thanks to turbocharged Diesel engine technology developed by automotive industry integrating this technology on helicopters to drastically reduce gas emissions.

GRC5 - Environmentally-Friendly Flight Paths

The general objective of subproject GRC5 is to reduce noise and polluting emissions through the optimisation of flight paths, leading to a reduction of CO_2 and NO_X for helicopter and tiltrotor

aircraft; and to develop new low-noise procedures to minimise the noise perceived on ground during the departure, low level flight and approach of helicopters and tiltrotor aircraft.

GRC6- Eco-Design Demonstrators for Rotorcraft

General objectives of subproject GRC6 are to demonstrate eco-friendly life cycle processes in the phases of manufacturing, maintenance and disposal for specific helicopter components, in continuity and complementarily with the innovative technology development achieved in the Eco-Design ITD.

- Demonstrate on actual rotorcraft specific parts the possibility to eliminate the use of hazardous substances, included in the “ASD priority declarable substance list (PDSL)”.
- Demonstrate dismantling capability and recyclability.
- Demonstrate the possibility to reduce emissions and energy consumption in manufacturing, maintenance and dismantling.

GRC7 - Technology Evaluator for Rotorcraft

Subproject GRC7 is the interface between GRC ITD and Technology Evaluator (TE). GRC7 collects rotorcraft fleet data and develop mathematical models to predict noise and gaseous emissions generated by rotorcraft l missions. Prepare generic rotorcraft design definitions representing all the commercial rotorcraft operating in the Year 2000, Year 2020+ with and without Clean Sky technology.

The objective is to provide to the Technology Evaluator with all the information and data needed to compute the rotorcraft environmental reduction based on the technologies developed in GRC. GRC7 in its support to the TE will endeavour to ensure that the uniqueness of rotorcraft operations in relation to fixed-wing aircraft is duly taken into account.

Objectives for the period P6 (2013)

GRC1 – Innovative Rotor Blades

- Development of full-scale section for testing of the active twist concept (from Friendcopter);
- Parametric studies of optimised passive blade lay-out;
- Model scale testing completion/reporting for the active twist blade;
- Development and testing of a model rotor AGF system;
- Design and development of a blade for the above;
- Preparation and testing of 2D Active Gurney Flap (AGF) aerofoil section at Uni Twente;
- Design of a full-scale rotor blades with an active Gurney flap (AGF) system;
- Procurement of Donor blades for installing the AGF system;
- Development of a blade specimen for dynamic testing at Icing Wind Tunnel, CIRA;
- Continue development of methods necessary for the optimisation of blade design;
- Actuation system integration;
- Capacitive contactless data transfer system development.

During 2013, GRC1 activities were to move from conceptual systems into testing and hardware evaluation. Design tool improvements continued and full scale rotor design became fully engaged. Included were preparations for full-scale testing of the active twist concept, parametric study of active and passive blade lay-out for global rotor benefits, model scale design and test, launch full-scale design of rotor blades with an active Gurney flap (AGF) system, continue development of methods necessary for the optimisation of blade design, actuation system integration, sensory data

transmission, power transfer and control algorithms; continue development of control algorithms etc. Aircraft preparation was also started for the AGF.

The decision was made to advance the AGF test activity to flight test, necessitating significant programme changes. A decision was taken about flight testing with passive optimised blade (resource dependent).

GRC2 - Drag Reduction of Airframe and Non Lifting Rotating Systems

- The benefit concerning drag reduction of two optimised landing skid fairings and one optimised aft body for the EC135 helicopter to be assessed in wind tunnel in the frame of the ADHeRo partner project.
- Aerodynamic optimization of AW light helicopter (AW109) rotor head, including hub fairings and beanie, and assessment of benefits in terms of performance Wind tunnel testing of synthetic and pulsed jets and steady blowing on blunt aft-body Preliminary design review for the new optimised side air intake for the EC135 helicopter.
- Evaluation of drag reduction for rotor hub fairings of the EC155 helicopter assessed by wind tunnel testing in the frame of the CARD partner project.
- Optimization of wing-nacelle and empennages of the common tiltrotor platform and and evaluation of benefits drag reduction) by numerical assessment.
- Aerodynamic optimization of AW heavy helicopter (AW101) intake and exhaust geometries

GRC3 - Integration of Innovative Electrical Systems for Rotorcraft

GRC3.1, Reference Helicopter: to continue providing assessments of technology combinations to GRC7 based on available data from CfPs results. To refine the supplied data for Single and Twin Engine Light configurations.

GRC3.2, Power Management, update annually the analysis, requirements and solution documentation associated with the Power Management Architecture in line with the evolution of both CfP and leading industry power supply technologies.

GRC3.3, Electrical Network, perform simulations by using software models provided by SGO ITD to perform comparison against test bench results, .

GRC3.4, Electrical technologies, progress through design, build and test.

- Starter Generator through a CDR and achieve the delivery of a first prototype.
- Power Convertor & Energy Storage provision of a software model, complete a PDR, CDR and provide a System Configuration Report.
- Energy Distribution & Consumer Systems to provide software models, analysis outputs, ensuring compatibility with evolving CfP technologies.
- Thermal Energy Recovery, CDR, deliverables of Qualification Test Reports for Thermal System & Thermal Management.

GRC3.5, Electromechanical Actuator technologies, progress through design, build and testing.

- EMA for Flight Control System progress through CDR and move to a demonstrator manufacture.
- EMA for Landing Gear assessed using an Acceptance Test Procedure against initial objectives and conclude with a Final Report.
- EMA for Rotor Brake provides a benefit analysis and modelling report as well as completing a CDR.

GRC3.6, progresses electrical drive technologies to the anti-torque function of a helicopter. This includes the definition and system design concept in support of the further system development using electrical test facilities and an airframe ground test rig at AW..

The conventional open tail rotor system delivery of an updated benefit analysis, and progresses through a CDR assessment. The fenestron system provide a Preliminary Concept.

GRC3.7, provide an Energy Supply System for the Piezo Actuation technologies being incorporated into helicopter dynamic rotor systems.

The CDR for PPSMPAB following the concept and design phases.

GRC3.8, brings together the technologies for evaluation on the Electrical Test Bench/Copper Bird.

The harmonization of technology Interfaces & Test Plans will continue in this period. Partners installing equipments on for test will continue to provide support to the Test Bench activity. This will include preparatory work for the integrated ground test demonstration with the scheming and design of equipment specific adaptation kits.

GRC4 - Installation of a Diesel Engine on a Light Helicopter

GRC 4.3 – Definition of optimal H/C architecture for Diesel engine

GRC 4.6 – Demonstrator power plant integration

GRC 4.7 – Demonstrator airframe

GRC 4.10 - Demonstrator avionics and electrical integration

GRC 4.11 – General engineering studies

GRC 4.12 – Integration and Demonstration

GRC5 - Environmentally-Friendly Flight Paths

Environment-Friendly Flight Paths can be defined by taking into account the two most environmentally detrimental aspects of helicopter flight:

- NO_X and CO_2 emissions related to the fuel consumption of the engines,
- The noise footprint generated by a helicopter (rotor blades, engines and transmission gears).

The noise impact during low altitude navigation, mandatory for unpressurised helicopter cabins, will be minimized thanks to 3D optimized VFR and IFR routes relying on accurate GNSS navigation (EGNOS, Galileo). Furthermore the use of an appropriate code for the prediction analysis of the helicopter noise footprint will allow the best choice of the flight procedures (Low-Noise Procedures) minimizing the noise perceived on ground during departure, low-level flight and approach. For tiltrotor aircraft, it will be investigated the possibility of minimizing the noise footprint during approach and departure by optimizing the schedule of nacelle tilt.

The following aspects of the helicopter flight will be taken into account and analyzed:

- IFR and VFR approach and departure paths based on the continuation of FP6 OPTIMAL and FRIENDCOPTER Integrated Projects
- Low level VFR & IFR en route navigation
- Specific Tilt-Rotor aspects

GRC6- Eco-Design Demonstrators for Rotorcraft

GRC6.1 - Integrated structure in thermoplastic composites

The objectives in Period 5 for GRC6.1 were mainly focused on demonstrator and tooling design, stress analysis and technology development. The selected technologies needed to be adapted to the demonstrator geometries and the available equipment. In parallel to these activities LCA data collection should be continued and two supporting calls for proposal had to be supervised.

GRC6.2 - Demonstrators for thermoplastic structural parts

Planned actions were the completion of manufacture of the demonstrator assembly and mechanical test to assess viability of the design when compared with existing material and design solutions. Testing should be based on existing component static test. The demonstrator should then be submitted for the recycling phase of the project in order to study the recyclability of the structure. LCA data associated with the materials and processes should be supplied to the EDA for use in assessing the eco-statement for the appropriate aircraft module.

GRC6.3 - Tail rotor transmission and input shaft demonstrator

The goal for this period was the complete assembly of the demonstrator employing the new protective treatments. The result should demonstrate the practicality of these treatments on real components and assemblies. Further proof of viability was expected by rig test of the complete gearbox assembly to assess any negative effect of the treatments on functionality when compared with existing treatments LCA data associated with the materials and processes was planned to be supplied to the EDA for use in assessing the eco-statement for the appropriate aircraft module.

GRC6.4 - Transmission Demonstrator

The goal for the final periods was to expose the GRC6.4 demonstrator to a salt spray test in order to get observations on treatments behaviour against corrosion. After that, a candidate should be chosen for Recycling CfP and the study on recyclability of the whole demonstrator. LCA in parallel should be collected to ensure the possibility to demonstrate the green aspect of the prototype. Considering LCA, a first step was planned to edit a strong methodology in order to assess properly the LCA within the frame of GRC6.4. In parallel, exchanges had to continue with EDA in order to harmonise and adapt the methodology.

GRC7 - Technology Evaluator for Rotorcraft

GRC7.2 - Software Development and Validation

The main goal in 2013 for GRC7 is to deliver 2 PhoeniX black box models:

- Version 3.1 for the 3rd TE assessment, this PhoeniX platform to be delivered at the end of February with the existing Twin Engine Light Update 1 (TEL-U1), Single Engine Light (SEL) helicopters and the first version of the Twin Engine Heavy (TEH) helicopter.
- Version 4.1 planned for delivery in December in advance of the 4th TE assessment to include all generic rotorcraft defined in V3.1 above plus the first inclusion of the Twin Engine Medium (TEM).

GRC7.3: Rotorcraft Synthesis and Input Data Preparation

To enable the above deliverables, parallel work will be maintained throughout Period 6 on helicopter generic rotorcraft derivation in particular the Twin Engine Heavy (TEH), Twin Engine Medium (TEM). Development of the Tilt-rotor (TLR) and Diesel Engine (DEL) models will contribute to deliverables planned for Period 7.

Assessment of the TE 2nd Assessment findings to be performed in order to introduce further improvements required to the Phoenix platform and methodologies used.

Turbomeca engine decks to be incorporated in the Phoenix platform.

Incorporation of GRC5 and GRC6 benefits to be performed to take into account any weight benefits.

A continual review of GRC(i) technologies to be made to ensure GRC7 generic rotorcraft to reflect updated benefits by Technology Readiness Level achievements in the Clean Sky programme.

The Phoenix platform to be continuously updated with improvements as identified throughout the GRC7process in (EUROPA/Engine model/Mission/HELENA).

GRC7.4 - Missions and Operations

GRC7 to cooperate with Technology Evaluator and GRC5 specialists, to model existing conceptual trajectories, to be used in the TE 3rd Assessment.

GRC7.5 - Assessment and Trade-off studies

GRC7 to perform internal trade-off with PhoeniX models to evaluate impact generated by GRC(i)'s technologies combination. Studies done according GRC(i)'s needs, to optimize the choice of technologies applied on Conceptual Rotorcraft delivered in 2013.

GRC7 to support the TE during the assessments in 2013 to ensure coherence with Rotorcraft specificities.