Clean Sky programme

Green Rotorcraft ITD

CLEAN SKY Info Day
Warsaw, 12 September 2011

Outline

- GRC at a glance
- Activities insight

Clean Sky / Green Rotorcraft : heading toward ACARE goals

Green Rotorcraft - Environmental Impact

Fuel Consumption, CO_2, NOx emission

Light Helicopter Powered with advanced Diesel engine

-30% SFC
-40% CO_2
-53% NOx

Improved Helicopter with Turboshaft Engine

-10% SFC
-26% CO2
-65% NOx

Emissions reduction

Noise Reduction
- 10 EPNdB

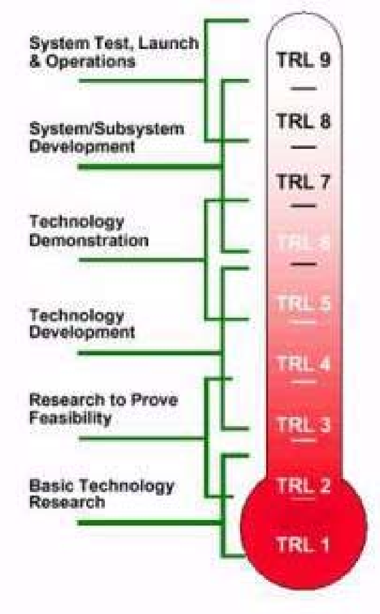
Halving noise

REACH compliance

Green Life Cycle

Towards a High maturity

A high level of « technology readiness »: the technologies are integrated into large demonstrators, in-flight or on-ground



- Demonstrators definition close to the market needs: the demonstrator is the last R&T phase, before starting a development
- Schedule is key to keep this link (be neither too early, nor too late)
- A large part of this downstream research activity lays within big players, « integrators » - a typical feature of aeronautics
- These activities must be thoroughly coordinated

A large programme focused on *environment*…

… and *competitiveness*

These features create the conditions for a Public-Private Partnership

GRC: Participants & Global Shares

160M€ Total Budget: 10% of Clean Sky

ITD-leaders (< 50%)

- **Agusta-Westland (co-leader)**
- **Eurocopter (co-leader)**
- Liebherr (D)
- Hispano-Suiza (F)
- Thales Avionics Electrical Systems (F)

Associates (<25%)

- DLR (D)
- ONERA (F)
- PZL Swidnik (Pol)
- CIRA-SELEX ATS: *cluster (I)*
- IGOR*: cluster of 10 members (NL, B, D)*

Airborne Composite, Eurocarbon, Fibre Optic Sensors and Sensing Systems, LMS; Microflown Technologies, Micromega Dynamics, NLR, Technische Universiteit Delft, Universiteit Twente

Partners (>25%)

Main Stakeholders of the domain presents in the ITD GRC:
Helicopter Manufacturers, Research Institutes, Systems suppliers
10 members composed of 23 legal entities

Green Rotorcraft – Programme Concept

2009	2010	2011	2012	2013	2014	2015

NOISE REDUCTION

OPTIMIZED CONFIGURATIONS

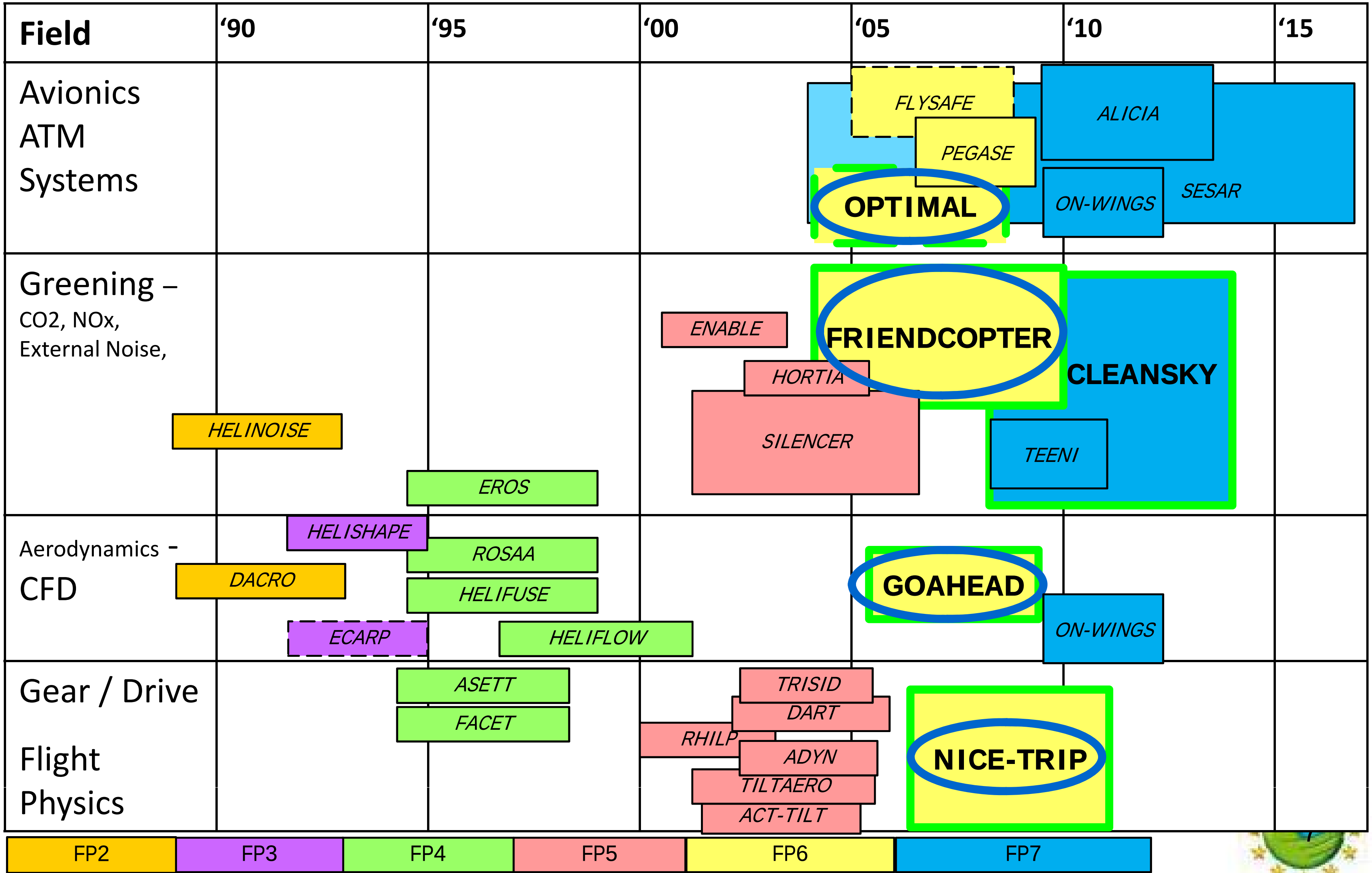
Selection of breakthrough Technologies and advanced configurations for impact on Rotorcraft Noise reduction and Greener Operations.

Design, Build and Integrate the technologies in ground and flight Demonstration

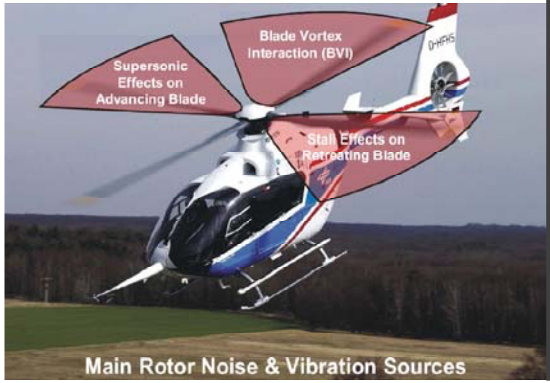
Flight Test and Validation of rotorcraft Technologies and configurations

Criteria definition for Demonstration

GRC: Background from Rotorcraft EU-projects

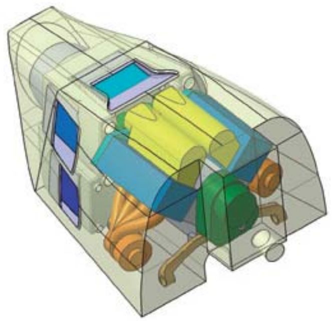


Major Technology Demonstrator Programmes



Q2/2015

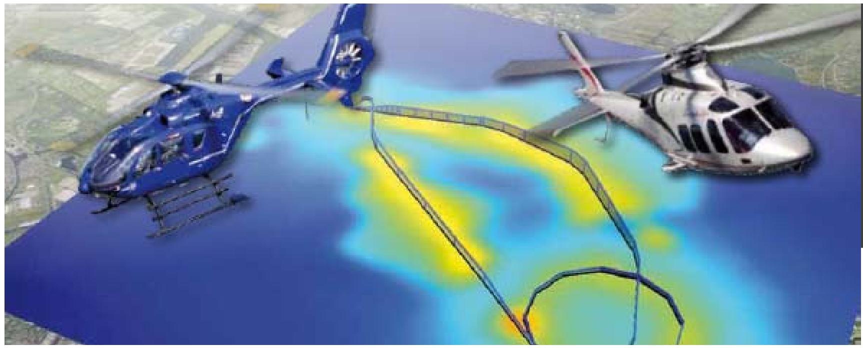
- Innovative Rotor blades:
  - Active twist blade
  - Gurney flap rotor
  - 3D blade profile optimised for dual speed rotor
- Shape optimisation and flow separation control devices for drag reduction



Q2/2014

Diesel Demo

- Diesel core engine
- Power pack integration

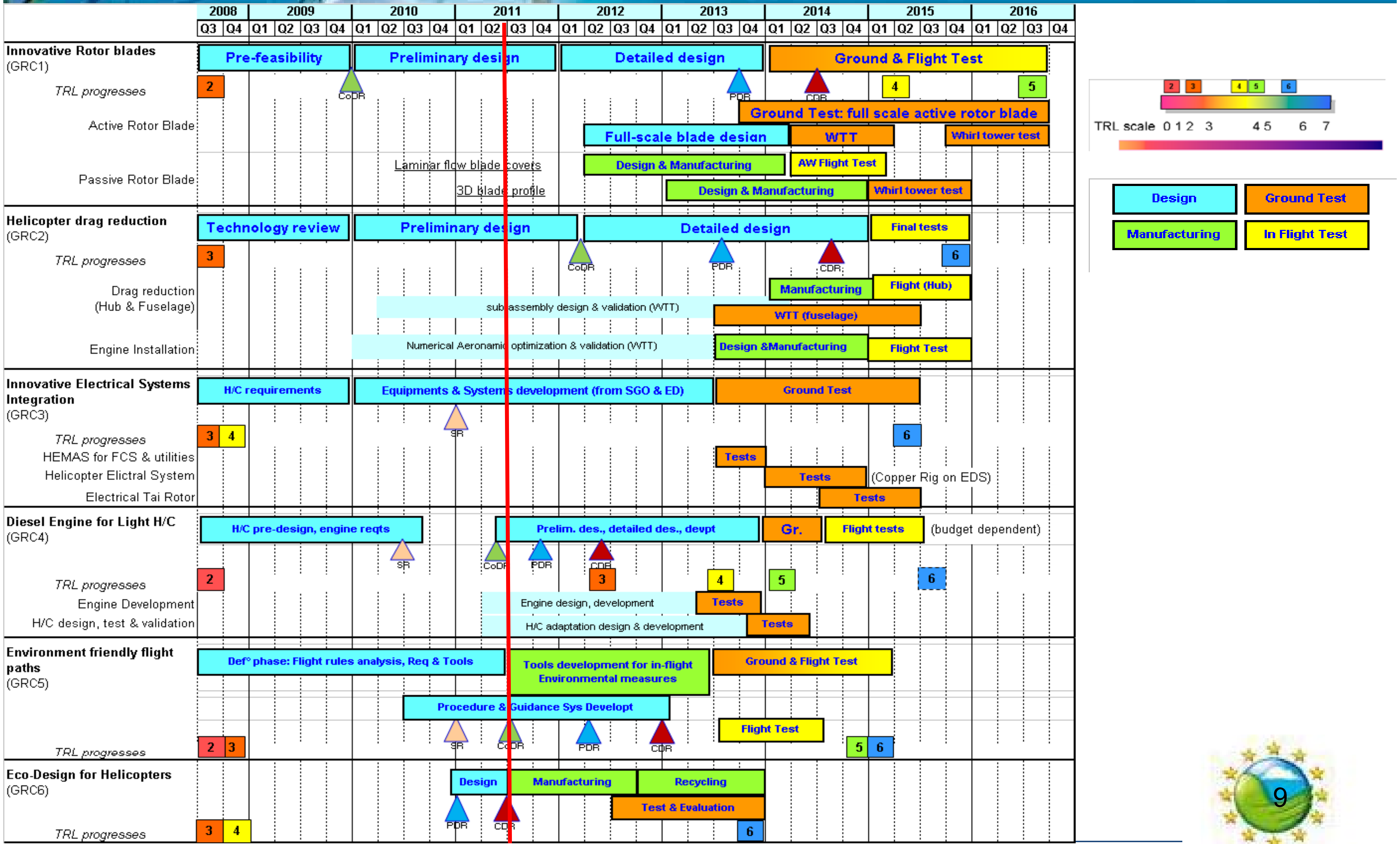


Q1/2015

Systems for flight path optimisation

- Rotorcraft
- Aircraft
- Underpinning and complementing SESAR

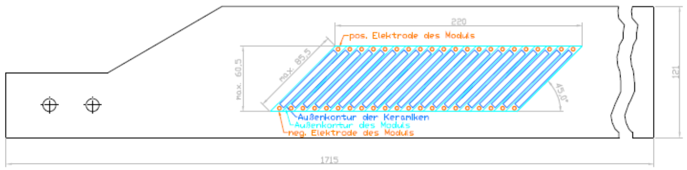
GRC Master Plan



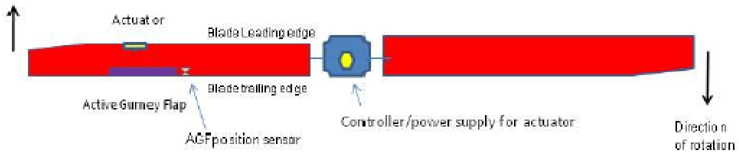
Innovative blade devices

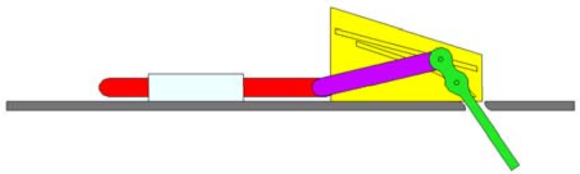
GRC1 – Innovative Rotor Blades : Planned Results

❖ **ACTIVE TWIST** – full scale demonstration of active twist system, with analysis to assess future exploitation challenges, benefits in line with GRC1 objectives and airworthiness / safety evaluation

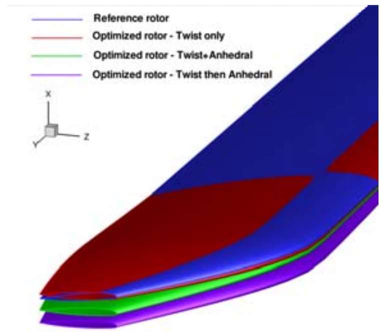


❖ **ACTIVE GURNEY FLAP** – full scale demonstration and testing of a full main rotor with a built-in, actively controlled Gurney flap system





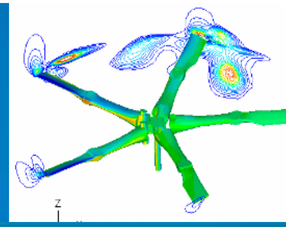
❖ **PASSIVE ROTOR OPTIMISATION** – full scale demonstration and testing of an optimised passive rotor on a whirl tower, with further analysis of other passive technology concepts

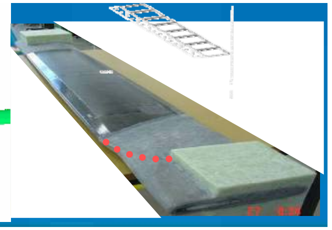


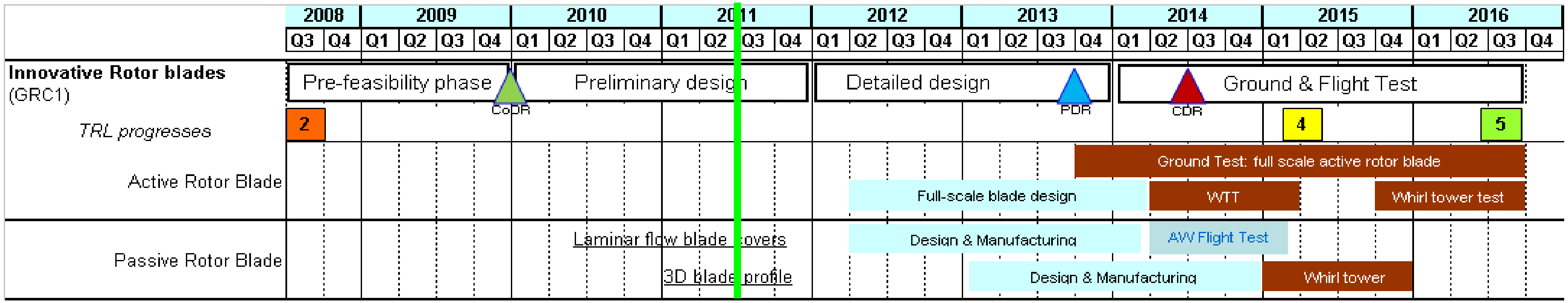
❖ **LAMINAR FLOW AEROFOILS** – testing of laminar flow aerofoils installed on top of conventional main rotor blades

❖ **SUPPORTING TECHNOLOGIES** – development of all necessary manufacturing techniques, control and power supply systems, and data gathering capabilities necessary to support the physical demonstration activities

GRC1- Rotor Blades - Master Plan & demonstration







Demonstrators

- ✓ Various levels of component testing for GRC1 developed technologies
- ✓ Bench test of full scale active twist blade section (concept progress from FRIENDCOPTER)
- ✓ 2D wind tunnel testing of GRC1 developed technologies
- ✓ Model rotor testing of active dual speed rotor concepts
- ✓ Whirl Tower (full-scale blades) testing for active blades (laminar airfoil or dual speed rotors) and passive optimised blades
- ✓ Flight tests of existing blades fitted with laminar flow covers

On-going projects selected through Calls for proposals

WP	ACRONYM	Title	CS Funding (€)	Starting date	Duration (months)
GRC1	MulticompAct	Multilayer Piezocomposites for Active Twist Rotor Blade	206,250	Jan 10	24
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	92,400	Oct 10	12
GRC1	MORALI	Performance/benefit assessment of advanced rotor configurations including active and passive blades	275,880	Nov 10	48
GRC1	PT656	Gurney flap actuator and mechanism for a full scale helicopter rotor blade	371,063	May 11	58

Competencies sought as from 2012

- ✓ Design, test and manufacturing: moulds for active model rotor blades, passive model rotor, down-scale models, data transfer system, active control system for full scale active blades
- ✓ Wind Tunnel test campains of new devices

Drag Reduction of Airframe and Non Lifting Rotating Systems

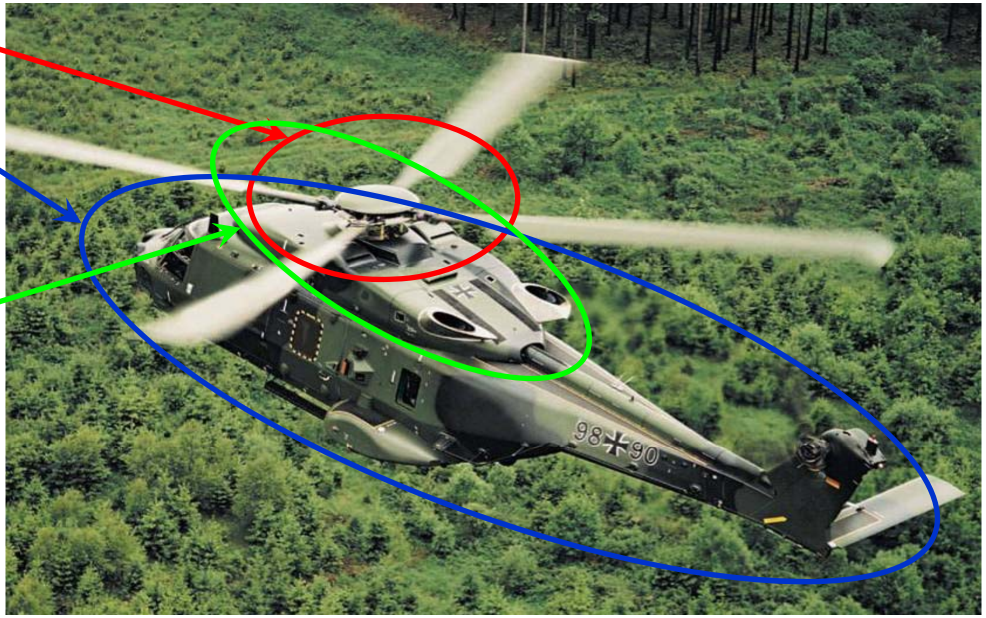
GRC2- Drag reduction - Technologies

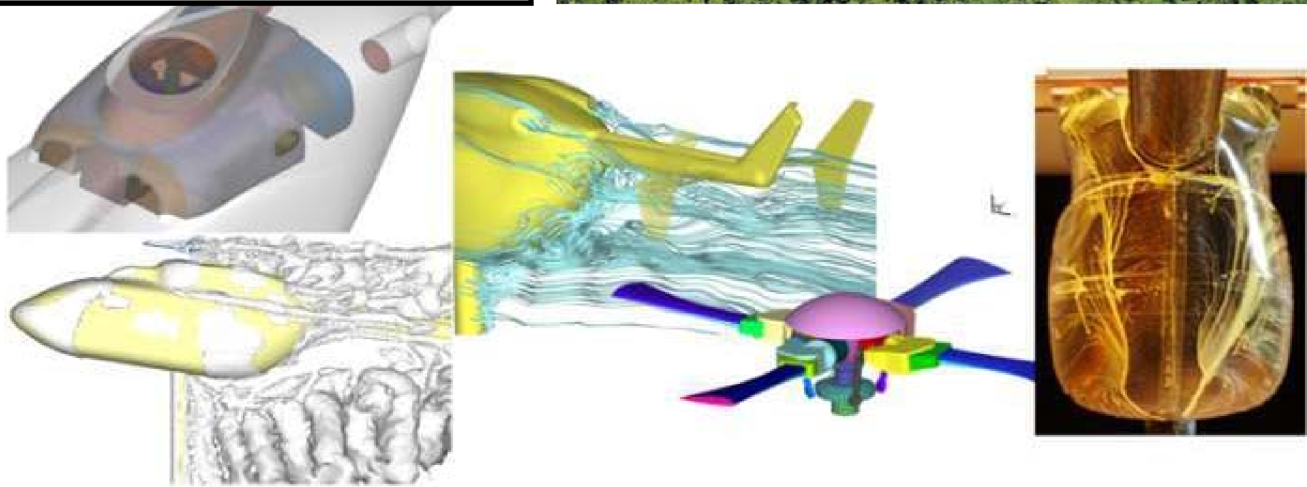
GRC 2.1 – Rotor hub drag
=> Gas emission reduction

GRC 2.2 – Fuselage drag
=> Gas emission reduction

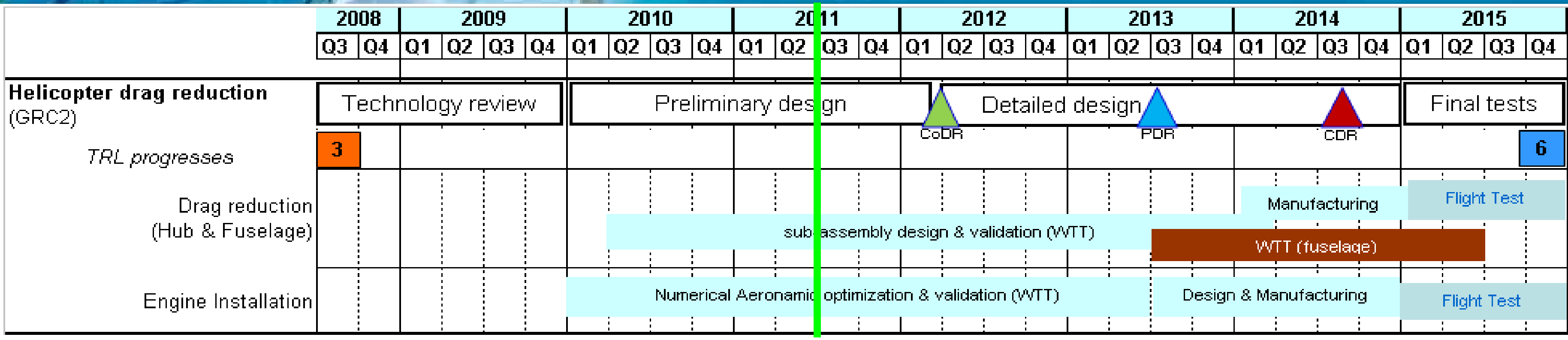
GRC 2.3 – Engine installation
=> emission & noise reduction

GRC2.4 – Optimised design
(H/C & T/R - full airframe)





GRC2- Drag reduction Master Plan & demonstration



Demonstrators

- **Rotor hub for light & medium helicopters**
  - ✓ Wind tunnel tests of new hub cap solutions
  - ✓ Flight tests of the new hub cap
- **Fuselage and Empennage optimization for light/medium/heavy helicopters & Tilt-Rotor**

  Laboratory & Wind tunnel tests
  - ✓ Flow control devices applied on a blunt helicopter fuselage
  - ✓ Passive and active devices of blunt light/medium and heavy helicopter fuselages
  - ✓ Helicopter empennage with movable control surfaces
  - ✓ Enhanced fuselage components of the common ERICA tilt rotor
- **Engine Installation: light/heavy helicopter and the ERICA tilt rotor**
  - ✓ Wind tunnel tests of different engine installation solutions
  - ✓ Ground and/or flight-test measurements of the optimised engine installation
- **Optimised Design: the common helicopter platform**
  - ✓ Wind tunnel tests on the optimised geometries

On-going projects selected through Calls for proposals

WP	ACRONYM	Title	CS Funding (€)	Starting date	Duration (months)
GRC2	TILTOp	Contribution to the study of the air intake and exhaust integration into a tiltrotor nacelle	286,200	July 10	18
GRC2	CODE-Tilt	Contribution to design optimisation of tiltrotor for drag (fuselage/wing junction, nose, landing gear, empennage)	637,200	Oct 10	36
GRC2	CARD	Contribution to analysis of rotor hub drag reduction	375,000	Nov 10	36
GRC2	ADHeRo	Contribution to the aerodynamic design optimisation of a helicopter fuselage including its rotating rotor head.	618,250	Jan 11	42
GRC2	HEAVYcOPTer	Contribution to optimisation of heavy helicopter engine installation design	439,200	Under nego	24
GRC2	HELIDES	Helicopter hub and fuselage drag investigation by means of hybrid URANS/LES methods	147,285	Under nego	24

Competencies sought as from 2012

- ✓ WT tests campain and characterisation
- ✓ Design and manufacturing of new engine installation

More electrical rotorcraft

GRC3 – Innovative Electrical Systems: Progress Status

For each H/C class, reference hydraulic and electric power off-take (MGB, engine) are defined (GRC7 & GRC3.1)

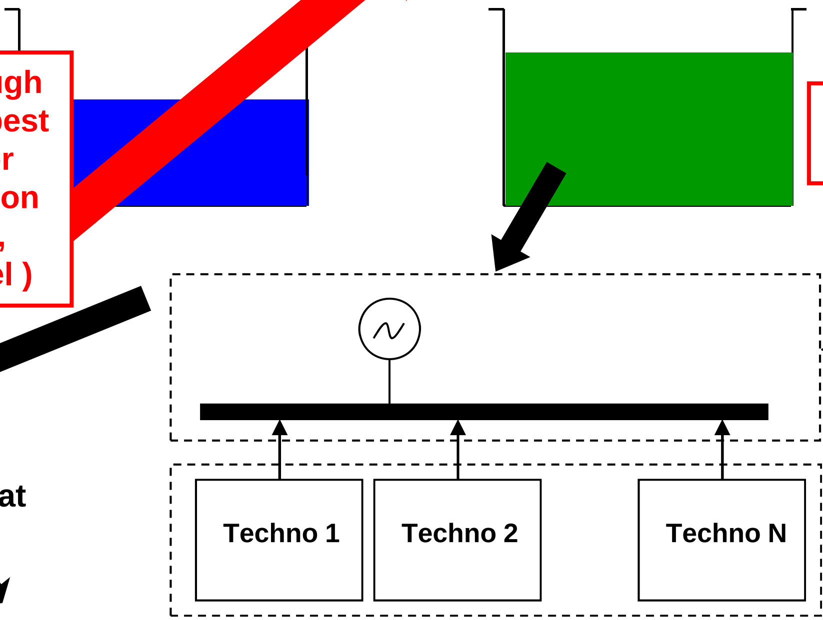
More electrical A/C Objectives:

- Reduce fuel consumption
- Remove hydraulic fluids
- Lower weight systems
- Improve efficiency at system level

Need for new Electrical Technologies, Distribution & Power Management

Hydraulic power

Electric power



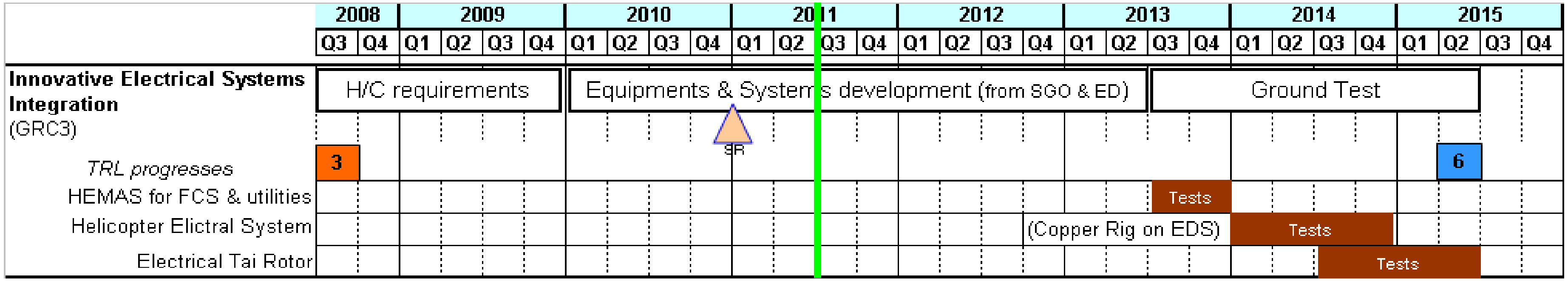
Feedback to GRC7 through GRC3.2 / 3.3: Choice of best techno combination for each H/C type and mission profile (Power, weight, performance at H/C level)

- GRC3.3: New Electrical Networks Structure (270Vdc for Medium / Heavy H/C)
- GRC3.2: How to manage new loads & sources within the electrical networks: logic part of the electrical networks
- GRC3.5-3.6-3.7: New Technologies for replacement of hydraulic power
- GRC3.4: New Technologies for improved Electrical systems efficiency

Evaluation of new technologies integrated at the system level

- In Copper bird (Demonstrators), GRC3.8
- In Simulation activities - Copper Bird limited in functionalities representativeness

GRC3 – Integration of Innovative Electrical Systems - Master Plan & demonstration



Demonstrators

- EMA system for medium/heavy helicopter flight control
- Electric taxiing
- Heat Energy recovery system
- Rotor braking recovery
- Management of energy recovery
- Multi-source regenerative systems power conversion (incl. storage device)
- Brushless 28VDC Starter-Generator
- Electrical driven tail rotor motor
- Piezo Power Supply module *(→Active rotor blade demonstration)*

Demonstrations performed at system level in a dynamic and representive way on the Copper Bird Test Bench

Running projects awarded from previous call

WP	ACRONYM	Title	CS Funding (€)	Starting date	Duration (months)
GRC3	RECYCLE	Innovative energy recovery for electrical use	176,250	July 10	29
GRC3	ELETAD	Electric Tail Drive - Modelling, Simulation and Rig Prototype Development.	1,858,826	Oct 10	66
GRC3	PPSMPAB	Piezo Power Supply Module	320,513	Mars 11	49
GRC3	RENERGISE	Innovative management of energy recovery for reduction of electrical power consumption on fuel consumption	344,736	July 11	29
GRC3	RETAX	Rotorcraft Electric Taxiing	523,835	Oct 11	24
GRC3	HERRB	Helicopter Electric Regenerative Rotor Brake	698,329	Oct 11	27

Projects launched in the next call

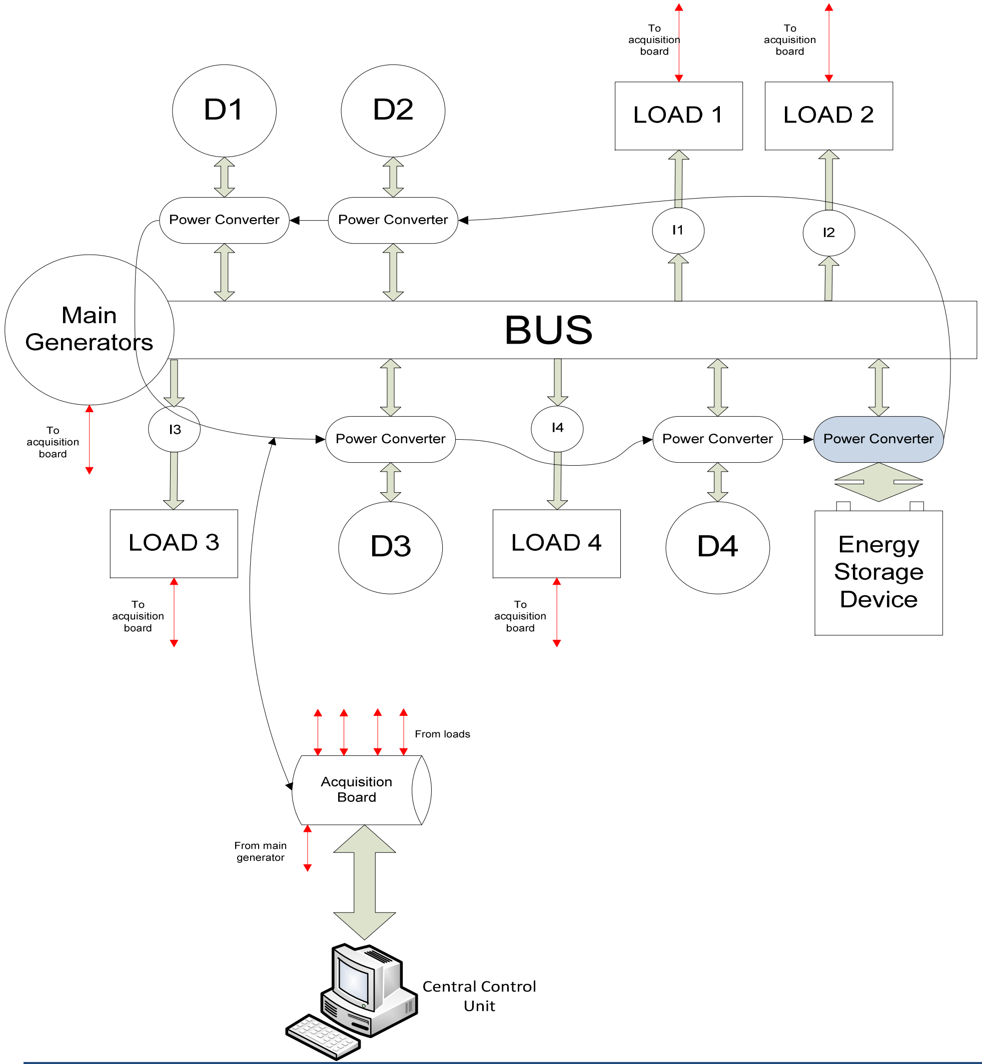
Topic	Title	Budget (€)	Starting date	Duration (months)
JTI-CS-2011-03 –GRC-03-010	Advanced Programmable Loads for Electrical Test Bench	210,000	Early 12	29
JTI-CS-2011-5-GRC-03-011	Multi-source regenerative systems power conversion	912,000	Early 12	24

Competencies sought as from 2012

- ✓ Design, test and manufacturing capabilities in electrical domain with sound background in helicopter domain

Call description of topic 1 in call 10

GRC3 CfP Multi-Source Regenerative Systems Power Conversion



Power Converter: Nominal power scalable in a range of 1KW to 55kW, Mass baseline target ~ 5kg

Battery: 270V, 40Ah, burst power: 60kW (10 seconds)

Call description of topic 2 in call 10

GRC3 CfP Advanced Programmable Loads for Electrical Test Bench

✓Power consumption: between 100 – 150 kW/kVA for the whole system, possibility to split the load banks (preferably physically) in 4 to 6 units of 20-30kW/kVA mandatory.

✓Power rejection: at least 50kW/kVA for the whole system, possibility to split the system (preferably physically) in 2 to 6 units capable to reject up to 20kW/kVA mandatory.

✓Load consumption and rejection profiles: highly dynamic loads are expected, switching frequency capability of at least 1kHz mandatory (2,5kHz nice to have).

✓Load measurement coded on 12-bits for full load scale (30kW for instance) mandatory.

✓Capability to be used on a 270Vdc network and 540Vdc network mandatory. At least 100 kW/kVA can be used on 270Vdc and 50 kW/kVA can be used for 540Vdc network.

✓Capability to be used on 3x115Vac and/or 3x230Vac (360Hz to 900Hz) nice to have.

✓Load operative mode: constant current, resistance, power adjustable by phase and power factor (cos φ).

✓Source operative mode: voltage regulation, power regulation and current regulation onto the aircraft network.

Diesel engine on a light helicopter

GRC4 - Diesel Engine on a Light Helicopter

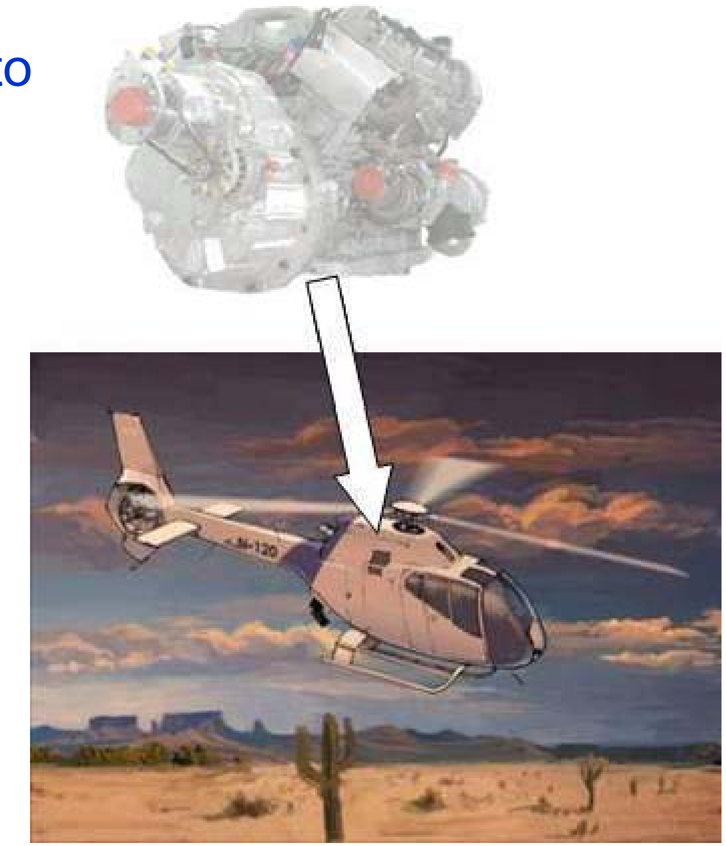
❖ Objectives

- To reduce drastically CO_2 emission thanks to the very low fuel consumption of modern Diesel engine technology

  Typically -30% to -40% over full flight envelope

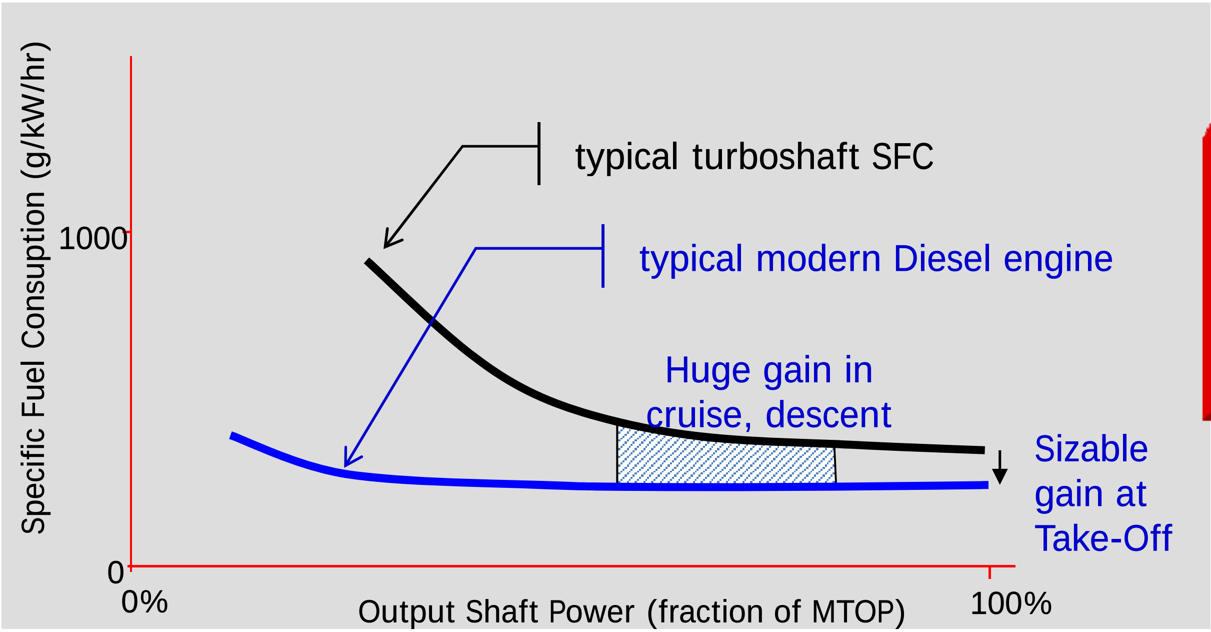
- Using regular kerosene fuel (or biodiesel)

- To integrate the engine minimising the potential adverse effects :
  - weight penalty ;
  - Vibration ;
  - Cooling system



What about engine fuel efficiency?

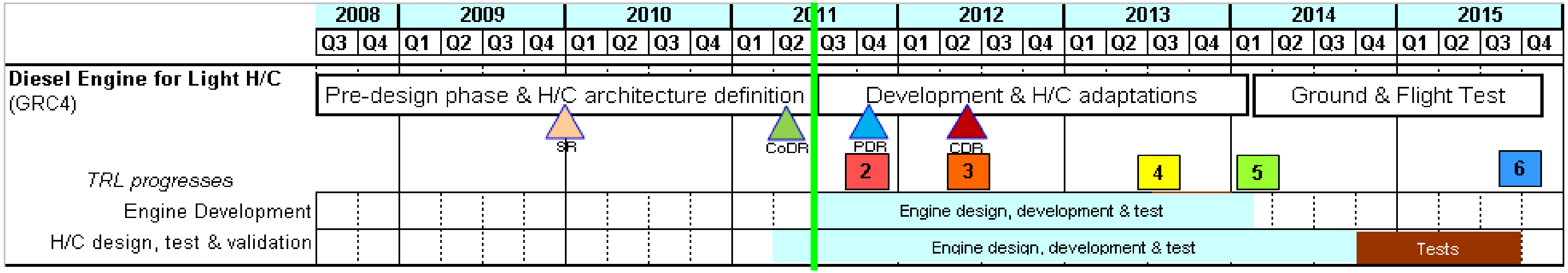
- Incremental fuel-efficiency improvements for small turbo-shaft engines
- Major improvement opportunity offered by Diesel technology:



POTENTIAL:
More than 30% fuel/CO_2 economy on a typical H/C mission profile

- Even higher benefits in hot/high conditions
- Engine size effect

GRC4 - Diesel Engine on a Light Helicopter Master Plan & demonstration



Demonstrators

- Flight worthy helicopter demonstrator based on EC120 and modified to integrate an adapted Diesel engine, to be tested on ground
- Main modified/new components: primary structure, engine installation, transmission, clutch system, cooling system, control system.
- Aeronautical Diesel power-pack designed for helicopter use (power rating, weight reduction, FADEC).

Demonstration Objectives

- Specify, test & validate a Diesel engine prototype responding to helicopter requirements

    Existing General Aviation engines: too small and/or too heavy

- Identify & resolve major integration difficulties

    Requires exploration of full flight envelope (maturity TRL 6)

- Substantiate achievement of fuel & emission reduction targets

The demonstrator H/C will be a prototype of the small single-engine EC120 which can most conveniently be modified for that purpose.

Demonstration Project Members

EUROCOPTER
AN EADS COMPANY
Clean Sky Member / Topic Manager

- ✓Budget 9,3 M€
- ✓T0: June 2011
- ✓Duration: 39 months

HIPE AE440 Consortium (Clean Sky Partners)

TEOS POWERTRAIN ENGINEERING
Participant

Austro Engine
Project Coordinator

MECACHROME
Third Party

D2T POWERTRAIN ENGINEERING
Generating Excellence
Third Party

BOSCH
Invented for life
Bosch General Aviation Technology GmbH
Sub-Contractor

IFP Energies nouvelles
Third Party

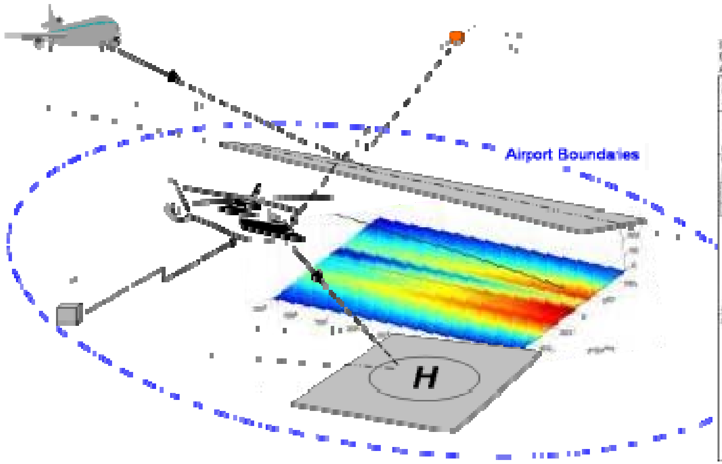
Environmentally friendly flight path

GRC5- Flight Path – Principles (1/2)

❖ For helicopter (further OPTIMAL) & Tilt Rotor A/C (further to NICE-TRIP):

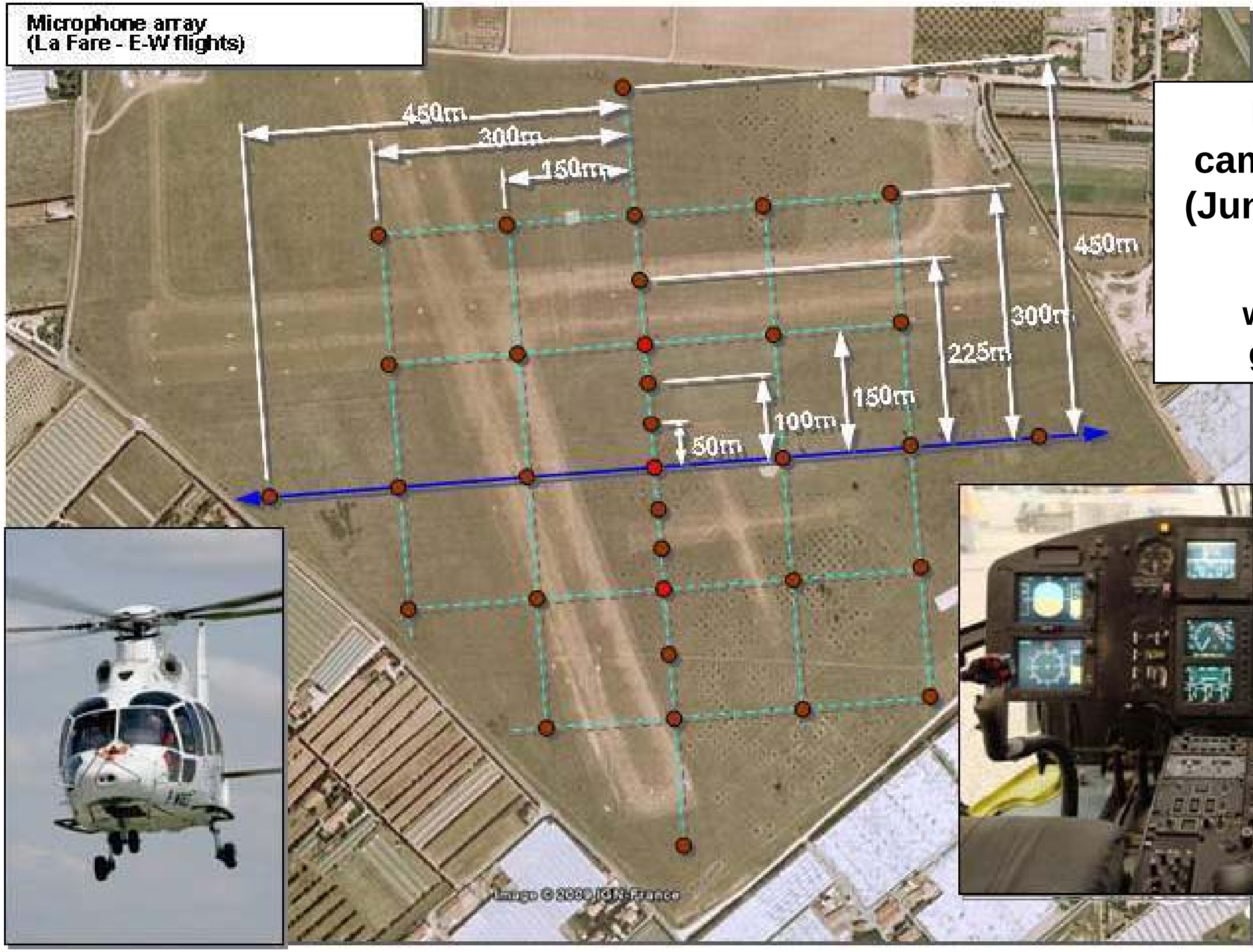
- ✓ Low-noise on-board system
- ✓ En-route optimised flight paths for the reduction of polluting emissions
- ✓ IFR & VFR approach and departure procedures (noise footprint minimisation)
- ✓ Low level VFR & IFR en route navigation (noise impact minimisation)
- ✓ SNI shorter routes to minimise fuel emission and gas emission

Flight guidance systems



Operational Requirements

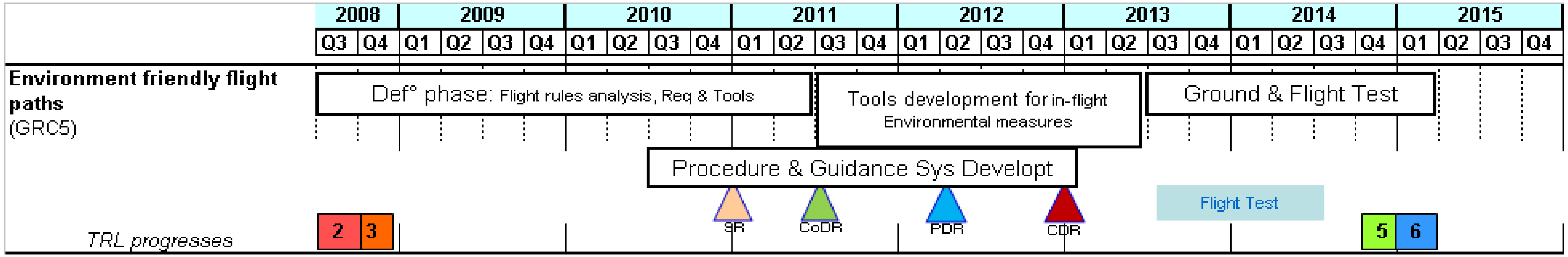
GRC5- Flight Path – Technologies (2/2)



First flight test campaign completed (June 2010 – Spring & autumn 2011)

with experimental guidance system

GRC5- Flight Path – Technologies (2/2)



Demonstrators

- Validation of On Board Management (of Low Noise Flight Paths)
- Final Flight Test Demonstrations (Operational Demonstration on real area as airports, heliports and confined helipads)
- Applicability to Different Aircraft Configurations (i.e. Tilt-Rotor)

On-going projects selected through Calls for proposals

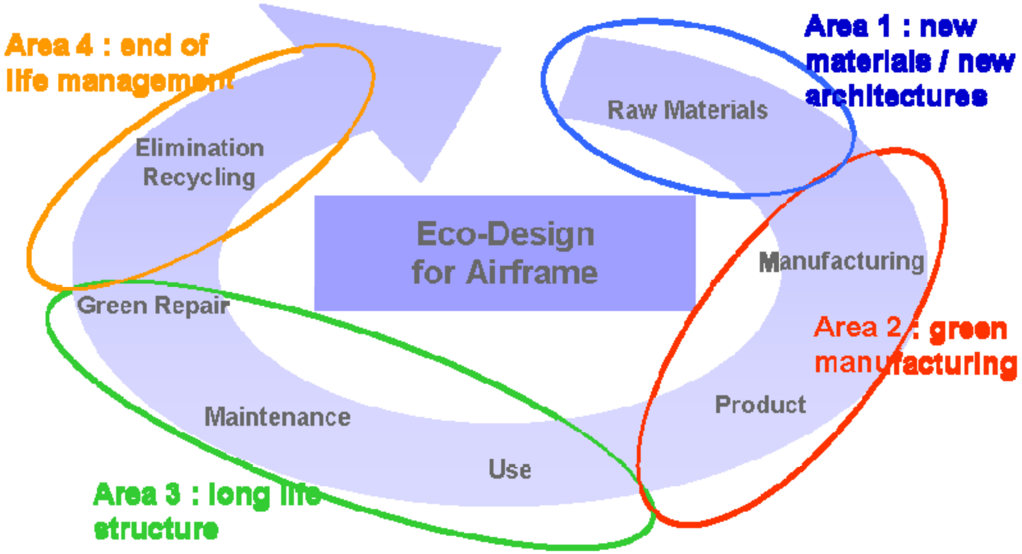
	ACRONYM	Title	CS Funding (€)	Starting date	Duration (months)
GRC5	EMICOPTER	Emission analysis: Tools required to perform the emission analysis and evaluation methodology	299,543	Jan 10	18
GRC5	GARDEN	GNSS-based ATM for Rotorcraft to Decrease Emissions and Noise	370,231	Jan 10	66
GRC5	MAEM-RO	Emission analysis - Tools required to perform the emissions analysis and evaluation methodology, experimental support	288,500	July 10	20
GRC5	ANCORA	ANotec-COmoti Rotorcraft Acoustics initiative for preliminary acoustic flight tests for the tuning of simplified rotorcraft noise models	213,150	July 11	9
GRC5	GARDEN	Tilt Rotor ATM Integrated Validation of Environmental Low Noise Procedures	573,640	Q4 11	39

Competencies sought as from 2012

- ✓ Avionics, tests & integration, algorithm, procedures & regulation

Eco-Design Demonstrators (Rotorcraft)

GRC6 – EcoDesign Demonstration for Rotorcraft Airframe



- Doors & Structural
  - Recyclable composite parts
  - Surface preparation for composite-metallic bonding
  - Bonding and painting

❖ Transmission components

- ✓ Cd free protection
- ✓ Repair AND painting
- ✓ testing

❖ Gear Box Housing

- ✓ Cr6 free Magnesium protection & touch up AND painting
- ✓ Testing

Projects launched in the next call

Topic	Title	Budget (€)	Starting date	Duration (months)
JTI-CS-2011-3-GRC-06-004	Dismantling and recycling of ecodesigned helicopter demonstrators	200,000	April 12	18

Competencies sought as from 2012

✓ Recycling on metal parts for transmission

Technology Evaluator for Rotorcraft

Impact assessment of GRC results (for TE) - Simulation Framework

PhoeniX: Platform Hosting Operational & ENvironmental Investigations for Rotorcraft

Helicopter Mission → **Simulation Framework** → **Noise Footprints**

Image courtesy of Eurocopter

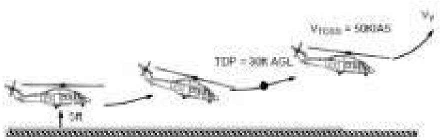
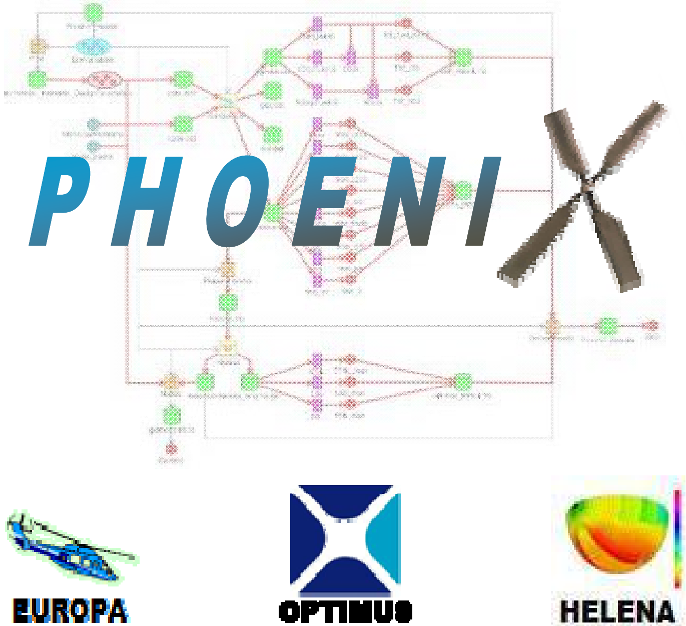
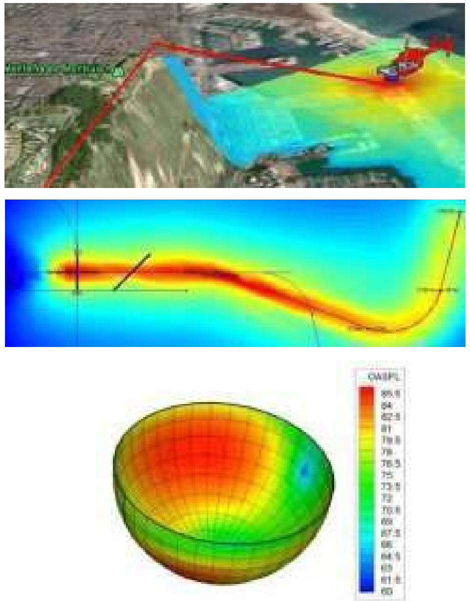


Image courtesy of AgustaWestland

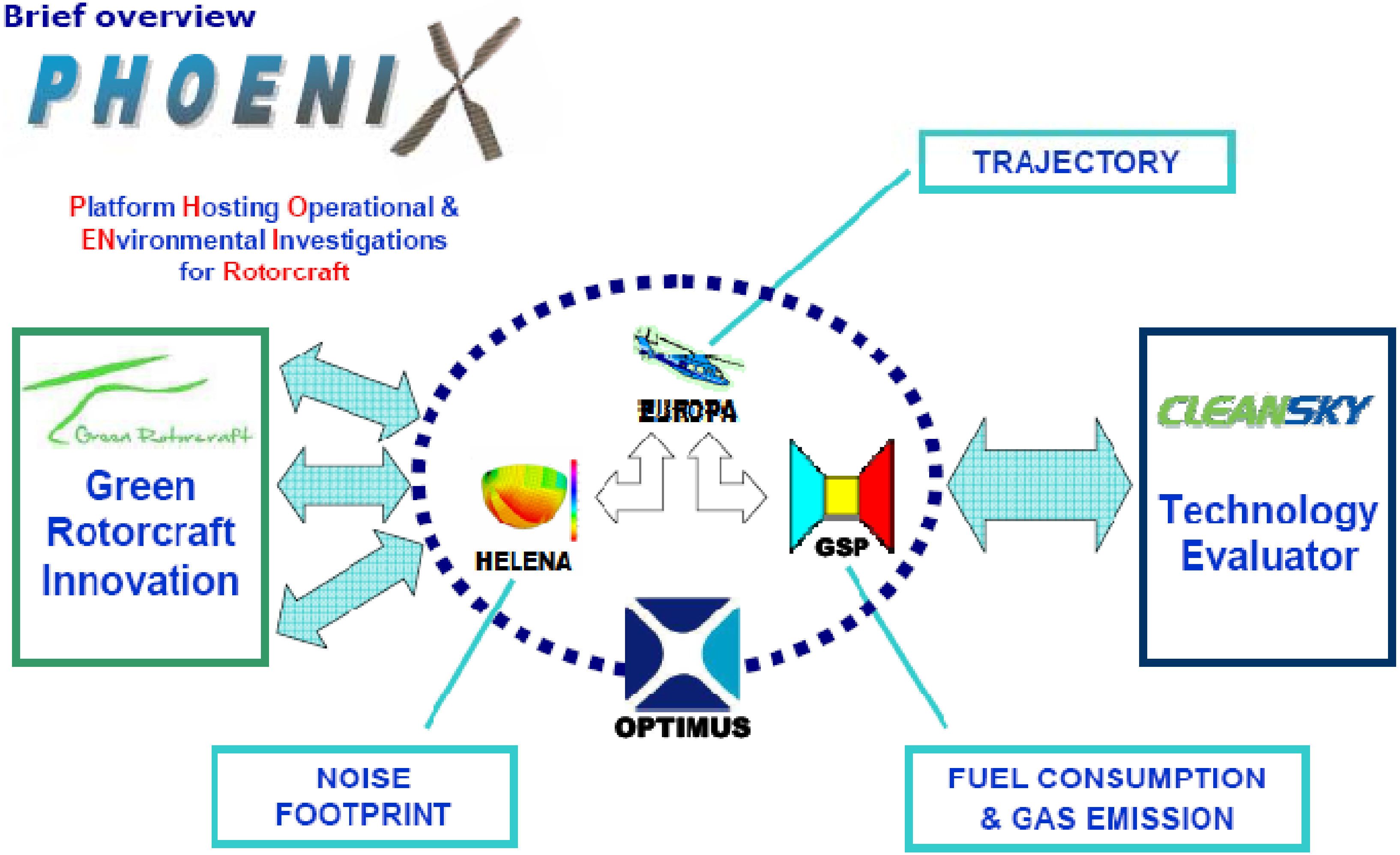




Impact assessment of GRC results (for TE) - Noise Reduction

Phoenix

Brief overview



Cross ITD interactions

SAGE ITD – SAGE5, Turboshaft engine

Turbomeca
Groupe SAFRAN

Innovative Core Engine

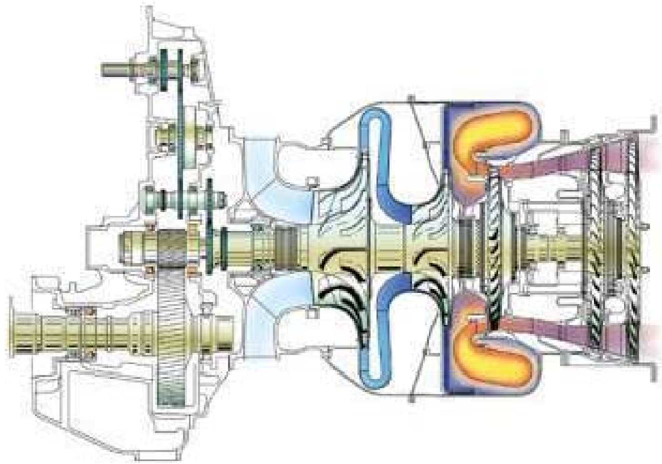
Airframer requirements and installations

Preliminary DR
Jan. 2010

Engine test
Sept 2012

Turboshaft engine development → full-scale engine demonstration

Demo spec. — Prelim. design Partner selection — Detail design Manufacture — Build and test

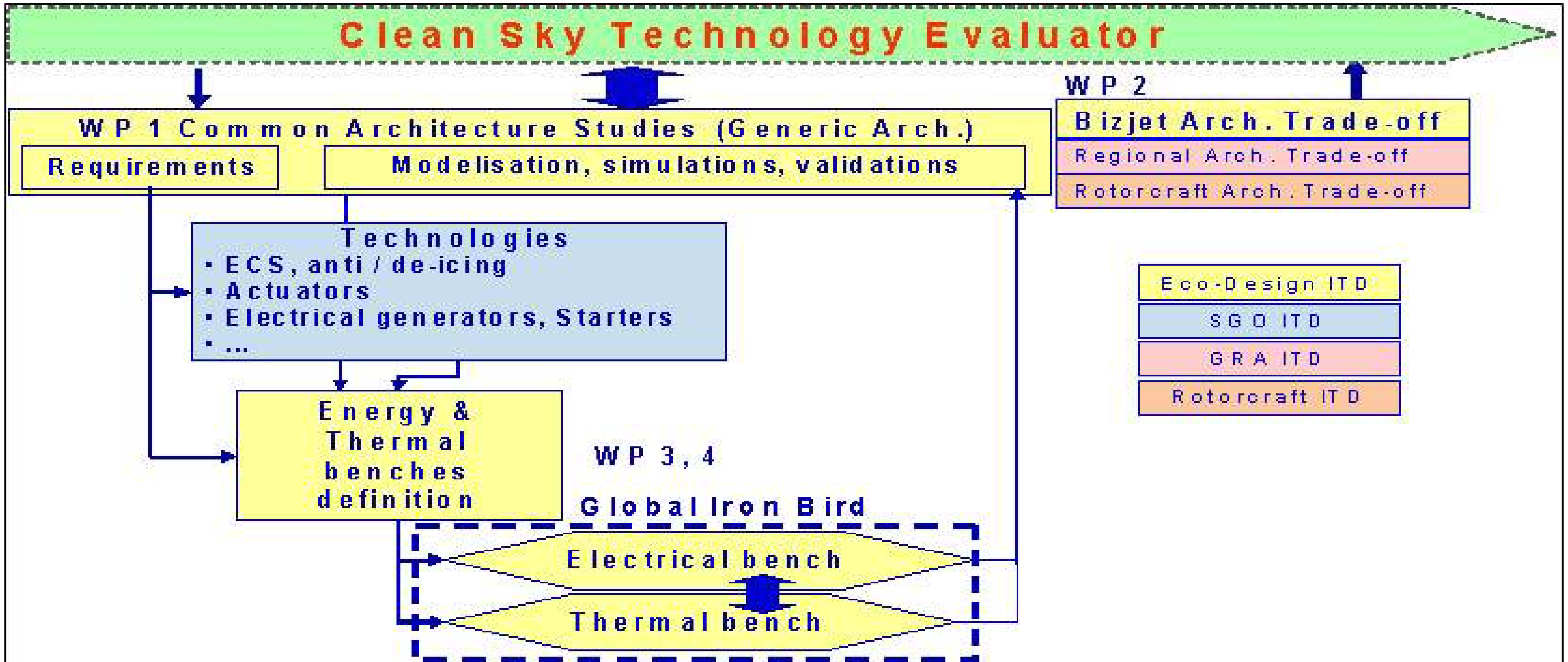


Project launch
1 Jan. 2009

Critical DR
July 2011

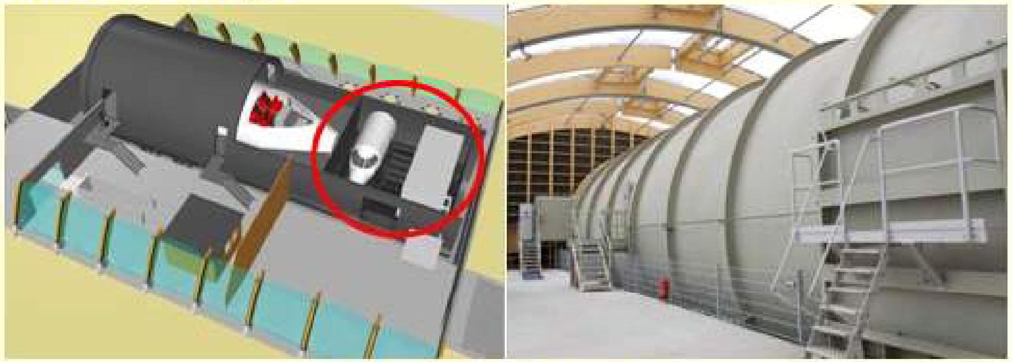
Project completion
2013

EDS ITD



Integration and models demonstration through

Electrical test bench



Thermal test bench

Contact us

For further information:

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Thank you for your attention