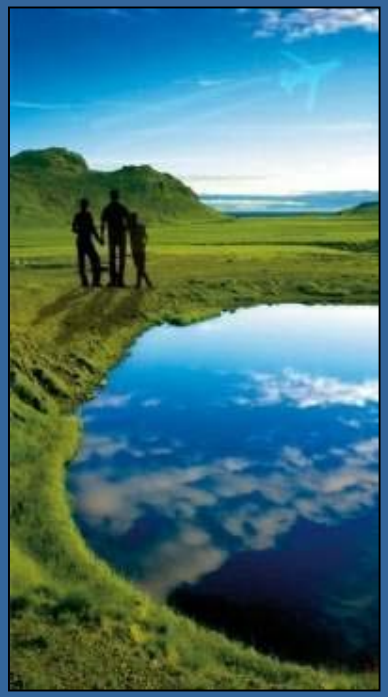


Clean Sky Joint Technology Initiative

SAGE Integrated Technology Demonstrator

ICAS Congress, September 23rd 2010

Arnaud Lebrun, Snecma, Mark Pacey, Rolls-Royce

Contents

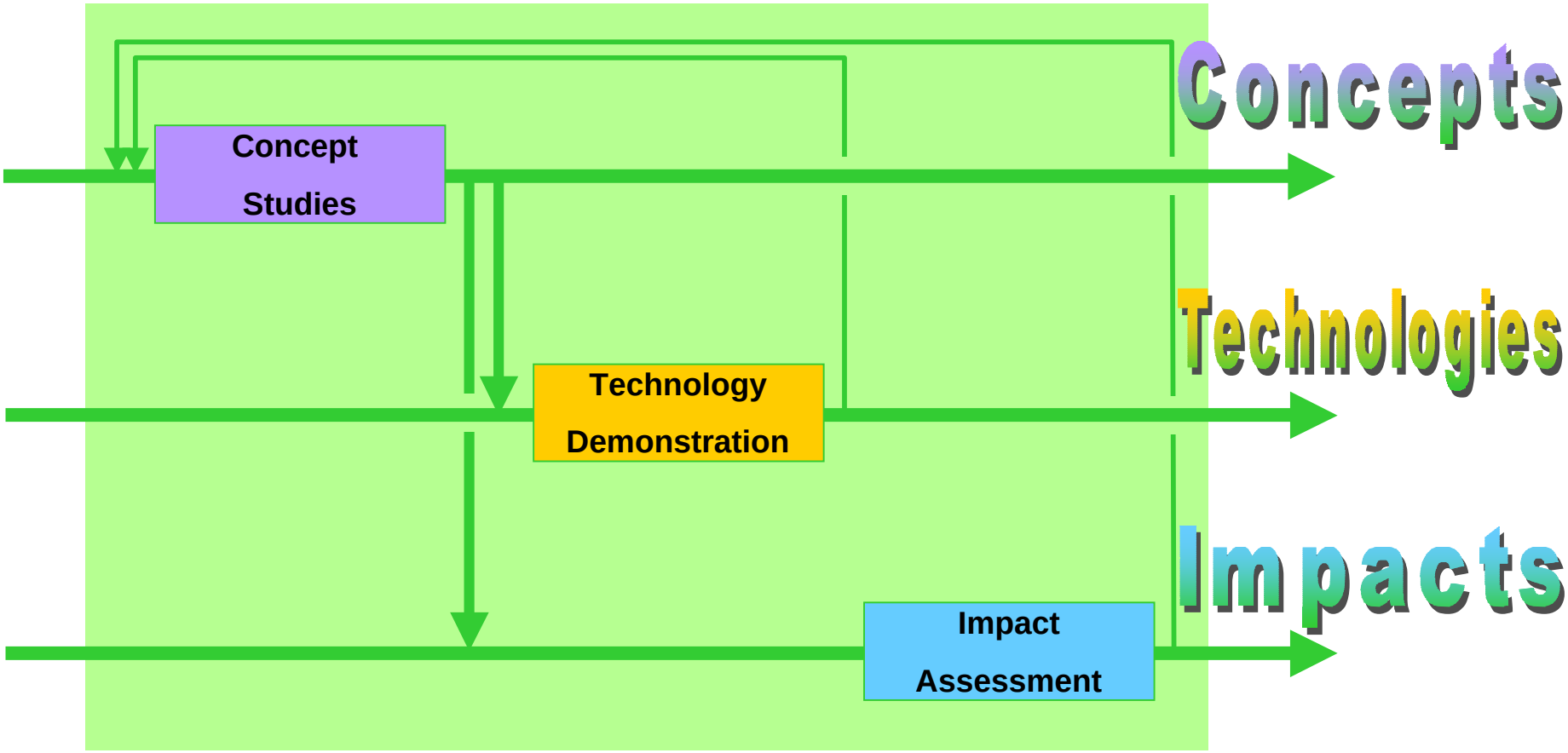
- Clean Sky Joint Technology Initiative
- SAGE Integrated Technology Demonstrator
- SAGE Engine Demonstrations

Clean Sky Joint Technology Initiative (JTI)

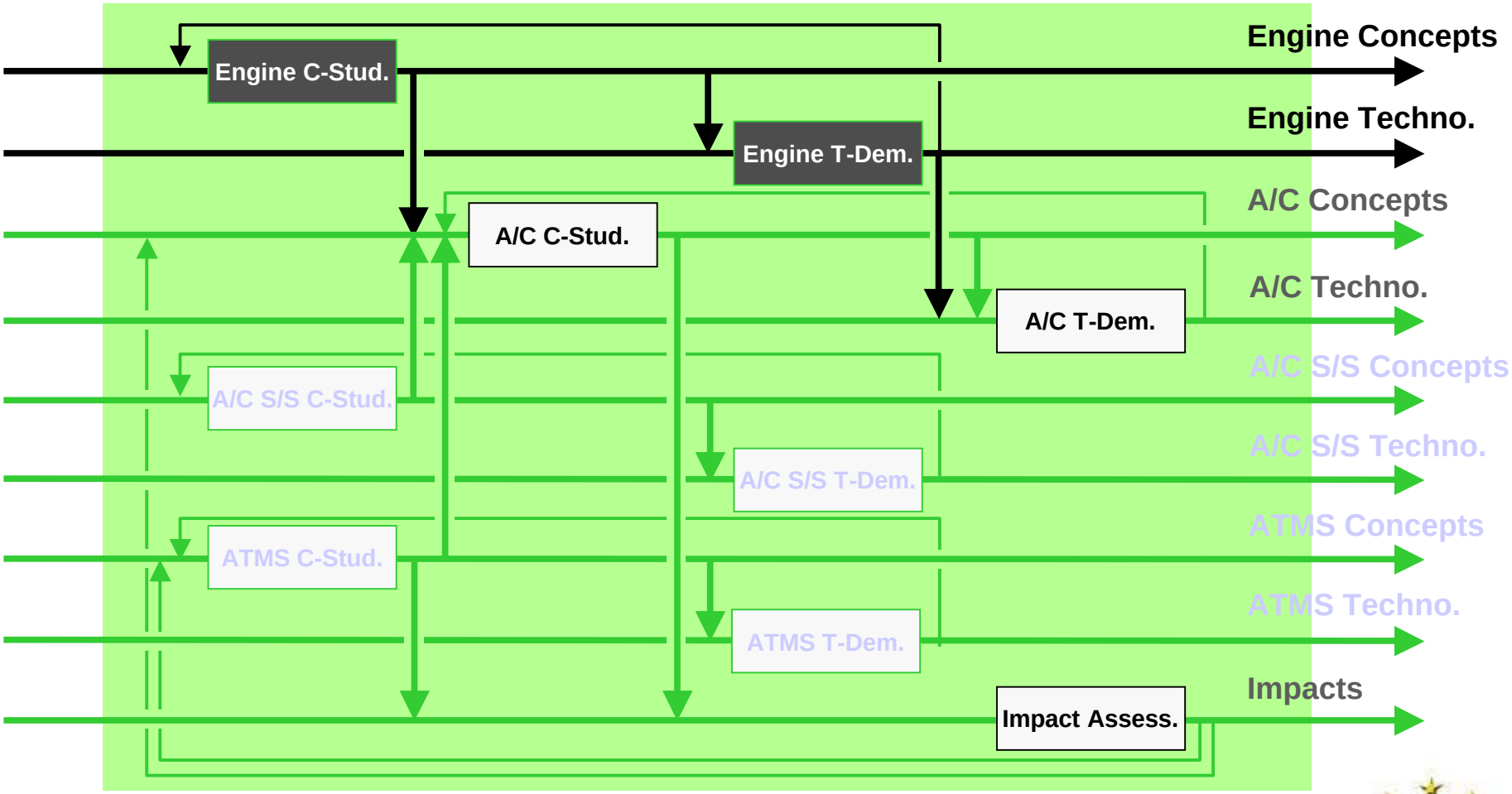
- **Objectives**
  - To increase the competitiveness of the European industry
  - To accelerate the reduction in global emissions
    - Implementing the ACARE goals
  - To encourage the rest of the world to make greener products
- **Organisation**
  - Public-Private Partnership between EC Commission and Industry
  - An independent legal entity : the Clean Sky Joint Undertaking
    - Placing contracts & coordinating the programme
- **Budget : 1.6 billion €**
  - 800 million € max from EC Commission in-cash
  - 800 million € min from industry in-kind
- **Timing : 2008 - 2015**

Note : to know more about Clean Sky JTI, see Council Regulation (EC) No 71/2007

Clean Sky JTI – Activities & Deliveries

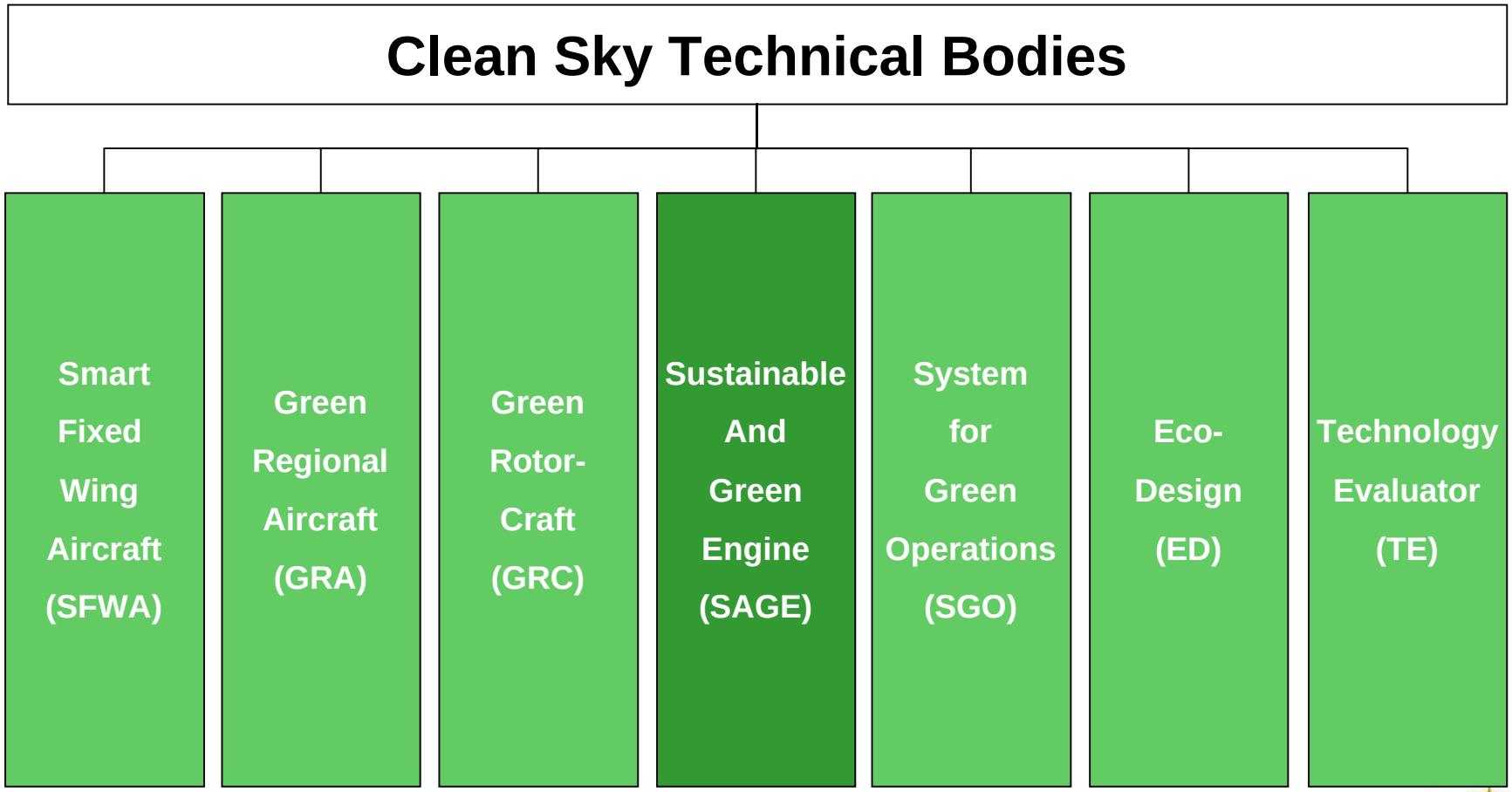


Clean Sky JTI – Engine related Activities & Deliveries

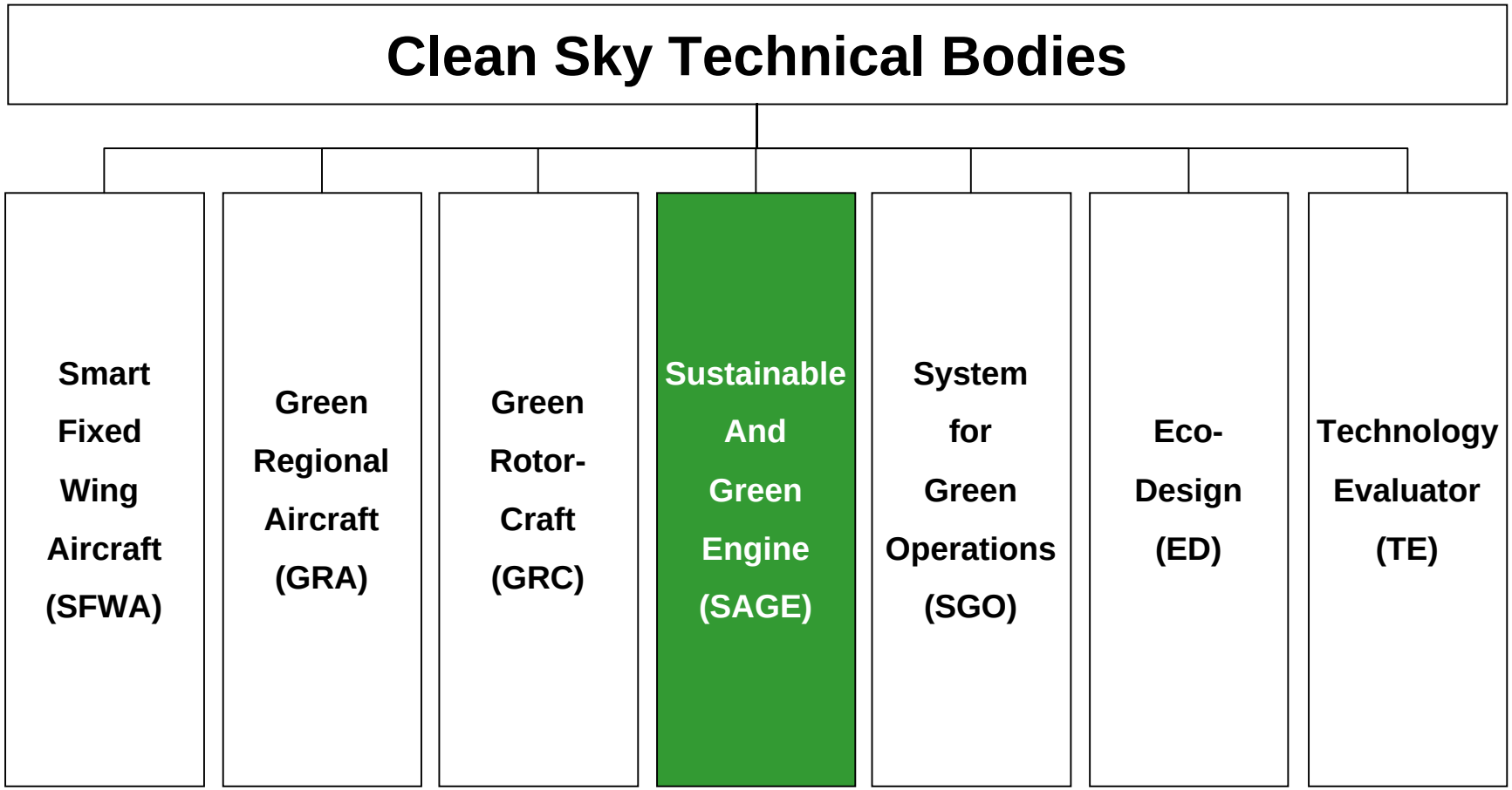


Note : CS enabling processes (tools development, …) supposed as included in represented processes

Clean Sky JTI – Engines Activities over ITDs & TE



SAGE Integrated Technology Demonstrator (ITD)



SAGE ITD – Membership

- **Clean Sky Members**
  - **Clean Sky Leaders :**

AIRBUS, AleniaAeronautica (A Finmeccanica Company), Rolls-Royce, SAFRAN

  - **Clean Sky Associates :**

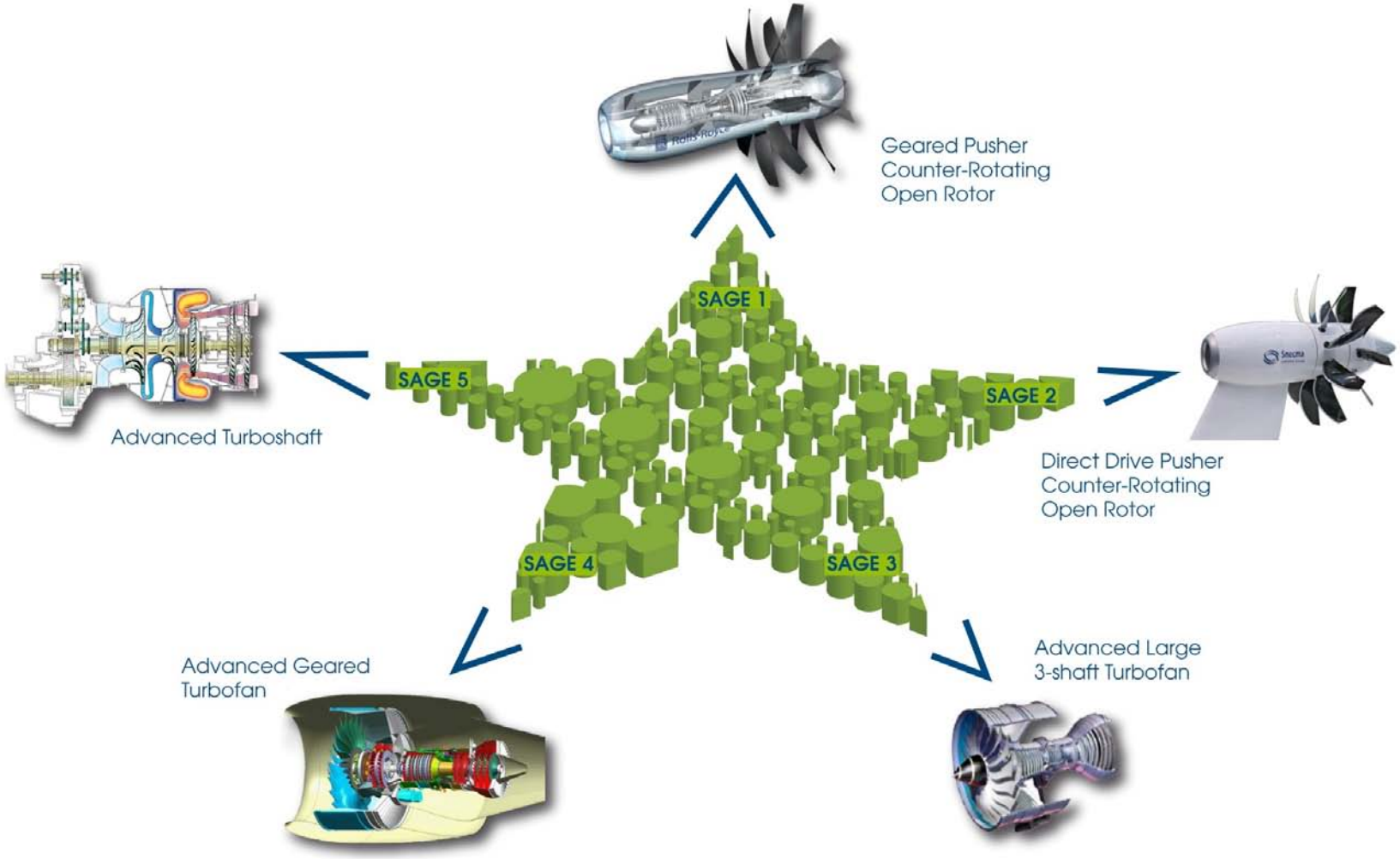
Avio (innovative propulsion), ITP, MTU Aero Engines, VOLVO AERO

- **Clean Sky Partners**
  - **From Call for Proposals (CfP) #1 :**

GE, FAG, TRONICO, inasmet tecnalia, Oxsensis (multi parameter optical sensing), SENER, Warsaw University of Technology

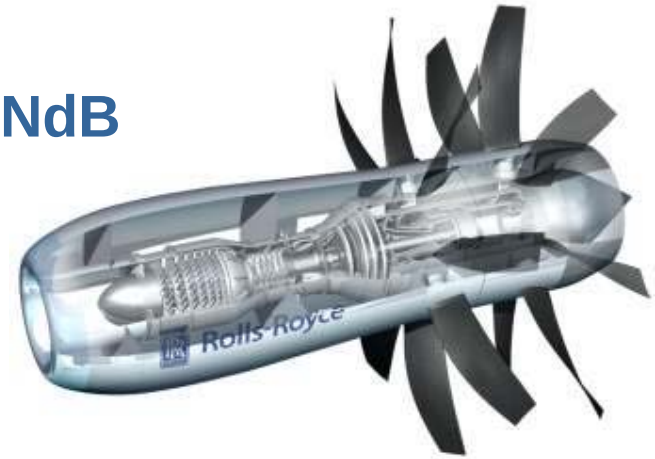
  - **From coming CfPs : …**

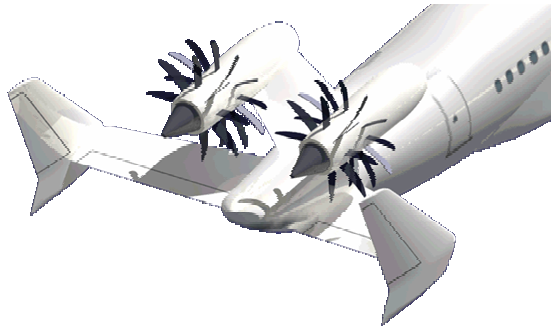
SAGE ITD – 4 Concepts, 5 Demonstrations



Pusher Counter-Rotating Open Rotor – Concept Objectives

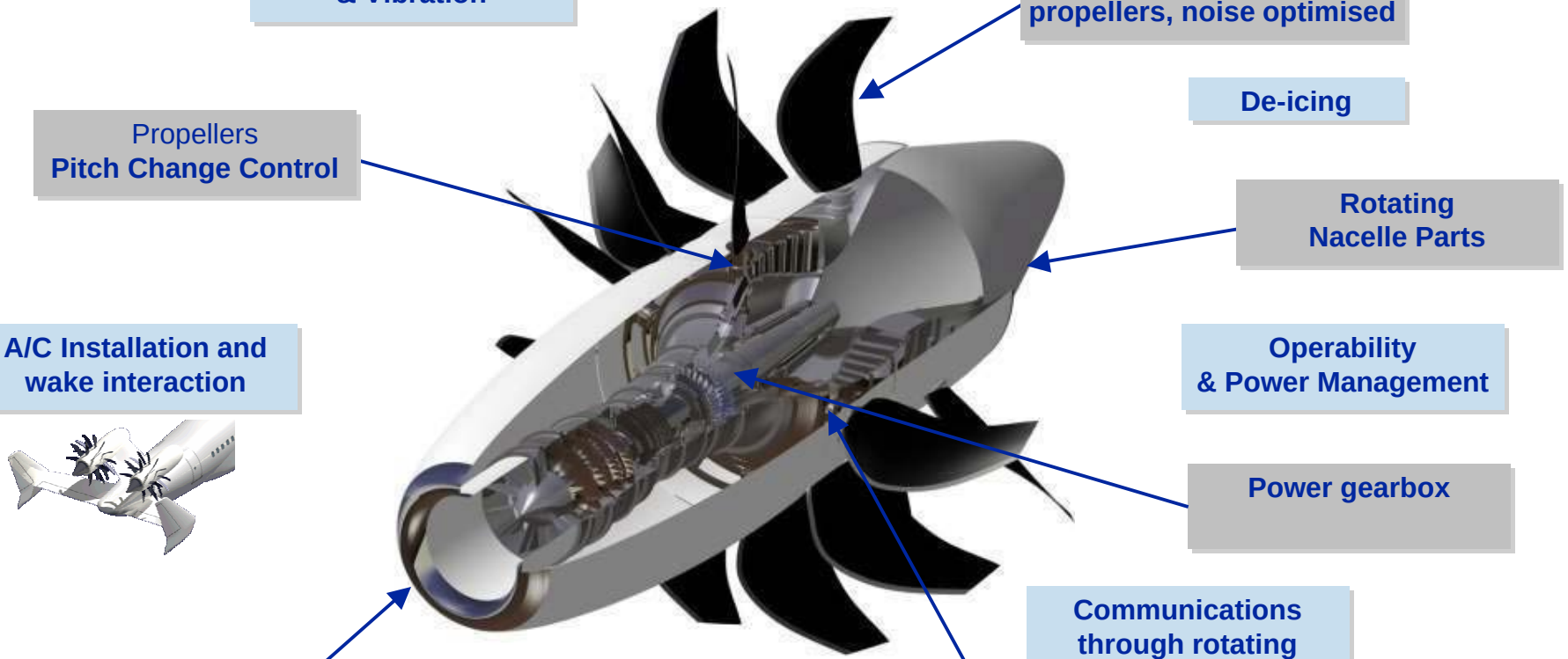
- **Thrust class : 21,000 – 30,000 lbf**
  - **Primary application to middle of aircraft market**
  - **Potential regional application**
- **CO2 reduction* : - 25 / - 30 %**
- **NOx reduction* : - 40 / - 60 %**
- **Noise reduction* : - 10 / - 20 EPNdB**





(*) Reference : current engine on current aircraft

Pusher Counter-Rotating Open Rotor – Concept Challenges

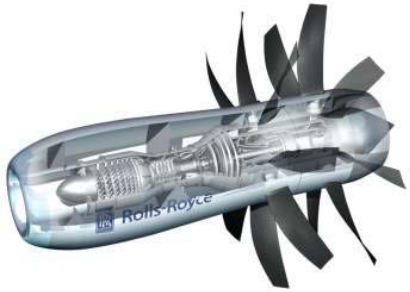


Geared Pusher Counter-Rotating Open Rotor – SAGE1 Demonstration

Plan

Concept DR
Nov. 2009

Critical DR
Feb. 2012



Open rotor technology development • full-scale engine demonstration

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

Project launch
1 June 2008

Prelim. DR
June 2011

Project completion
2014

First achievements

- Concept Design Review completed November 2009
  - Outline definition of pusher demonstrator
  - Sub-system requirements definition
  - Selection of BR715 donor for gas generator
  - Gas generator modification requirements definition
  - Completion of trade studies to define baseline concept design

DR : Design Review

Direct Drive Pusher Counter-Rotating Open-Rotor – SAGE2 Demonstration

v Plan

Project launch
1 June 2008

Concept DR #1
Nov. 2009

Concept DR #2
Sept. 2010

Prelim. DR
June 2011

Critical DR
Dec. 2011

Project completion
2013

Open rotor technology development • full-scale engine demonstration

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

v First achievements

- 4 **First Concept Review held in November 2010**
  - Ø **Engine concept updated by propellers WTT results**
  - Ø **Both geared & direct drive configurations similarly assessed**
  - Ø **Pitch Control System & PGB concepts screened**
- 4 **Partners working on Pitch Control System & PGB bearings**
  - Ø **And further calls for proposals prepared**

DR : Design Review

Advanced Large 3-Shaft Turbofan – Concept Objectives

- Thrust class : 60,000 – 95,000 lbf
- CO2 reduction* : - ~15 %
- NOx reduction* : - ~60 %
- Noise reduction* : - ~18 EPNdB

(*) Reference : current engine on current aircraft

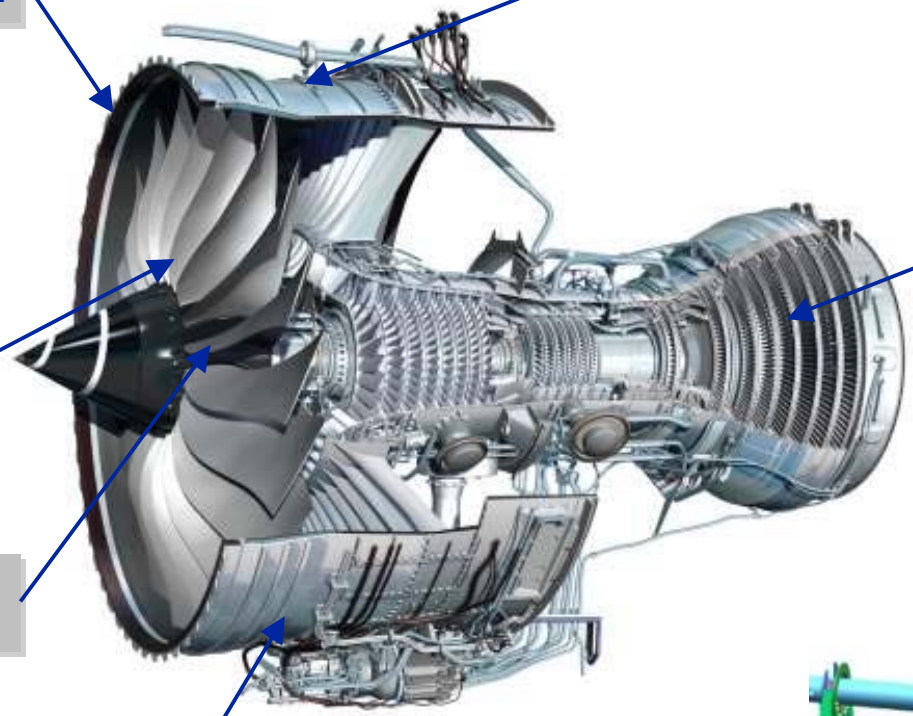
Advanced Large 3-Shaft Turbofan – Concept Challenges

Intake optimised to composite fan system

Composite fancase

Novel intake with optimised aero and acoustic liners

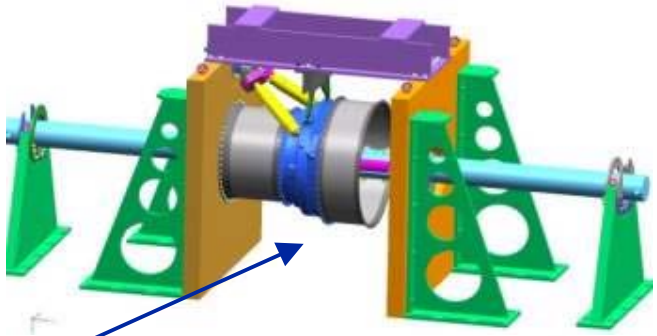
Lightweight, high efficiency LPT



Composite fan blades

Improved controls heat management

Lightweight annulus fillers



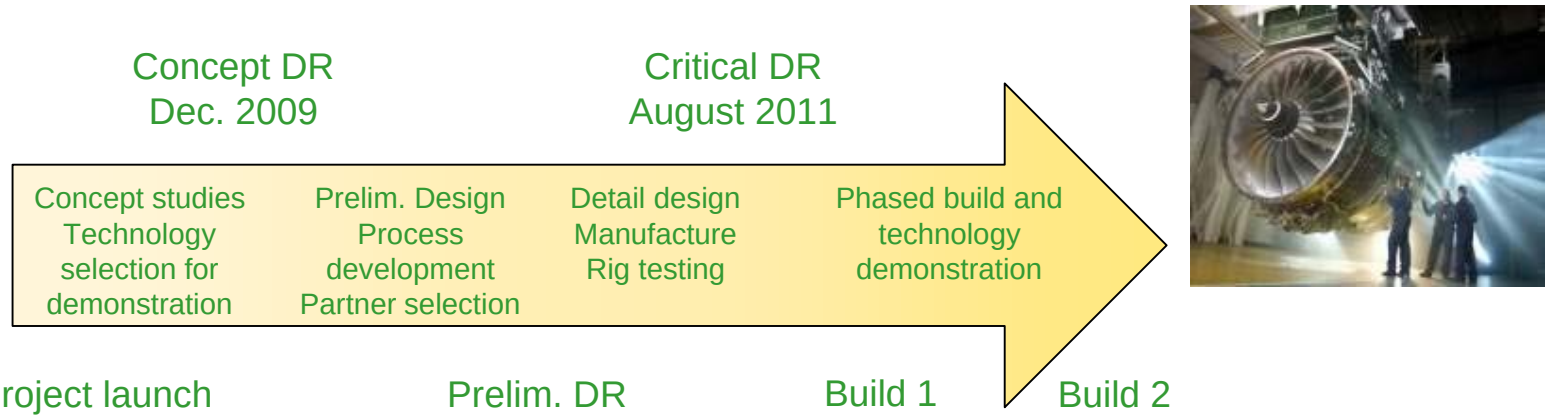
Advanced integrated dressings

Advanced sealing technologies

Technologies for lightweight, efficient intercase structures

Advanced Large 3-Shaft Turbofan – SAGE3 Demonstration

v Plan



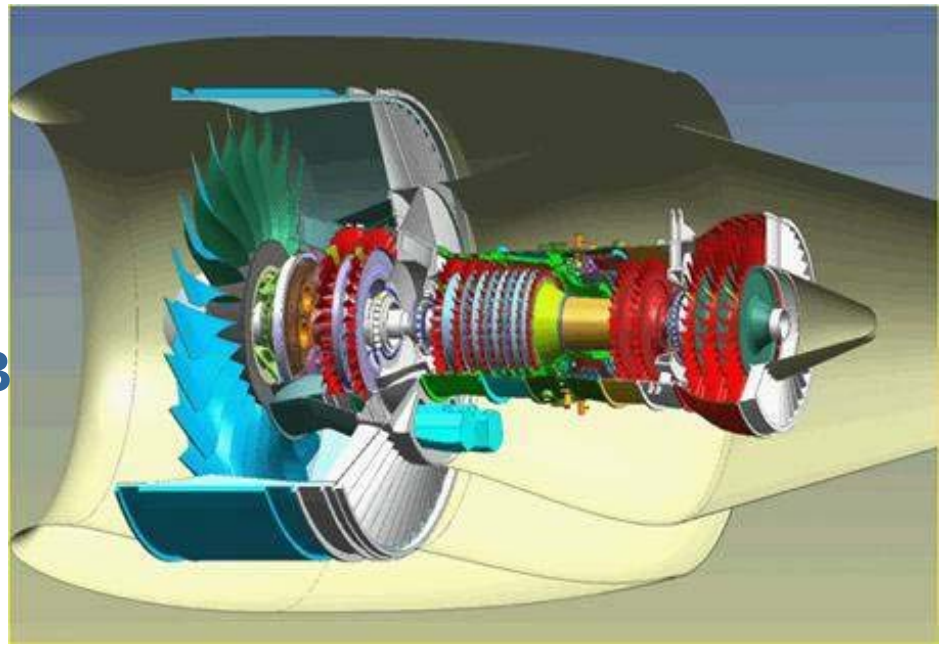
v First achievements

- 4 **Concept Design Review completed December 2009**
  - 4 **Technology validation requirements defined**
  - 4 **Selection of technologies for demonstration**
    - 4 **Focus on LP system and cold structures**
    - 4 **High aerodynamic efficiency, low weight, low noise**
    - 4 **Applicability to range of regional and large engines**
  - 4 **R-R Trent 1000 demonstration vehicle selected**
    - 4 **Validation strategy including rig and engine testing**

DR : Design Review

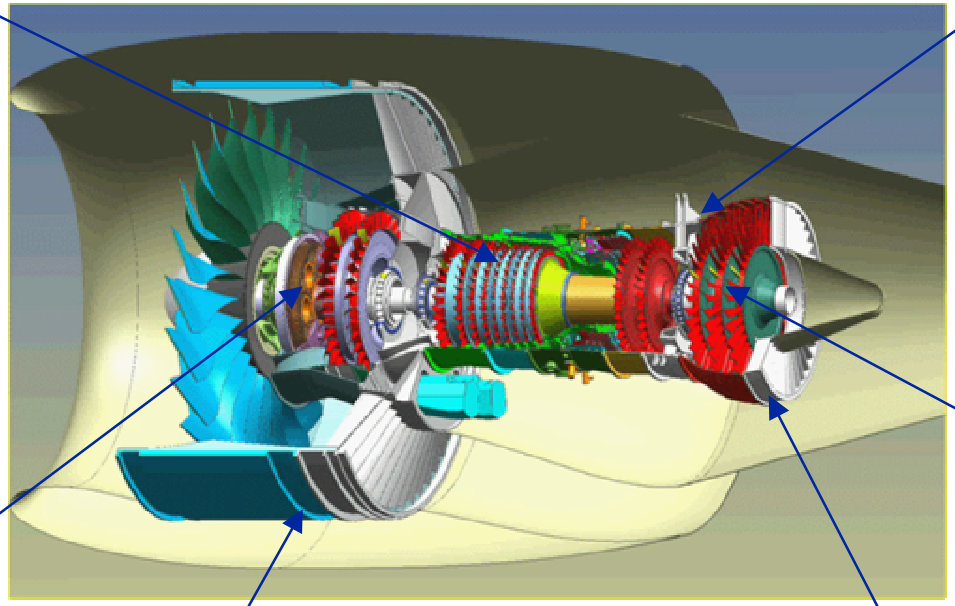
Advanced Geared Turbofan – Concept Objectives

- Thrust class : 16,000 – 40,000 lbf
- CO2 reduction* : - ~16 %
- NOx reduction* : - ~57 %
- Noise reduction* : - ~19 EPNdB



(*) Reference : current engine on current aircraft

Advanced Geared Turbofan – Concept Challenges



Efficiency & Performance

New High Efficient High Pressure Compressor

Mid Turbine Frame with aggressive Interduct

Innovative Designs & Mfg Processes

Weight & Mech. Integration

New High Speed Low Pressure Turbine

Advanced Fan Drive Gear System

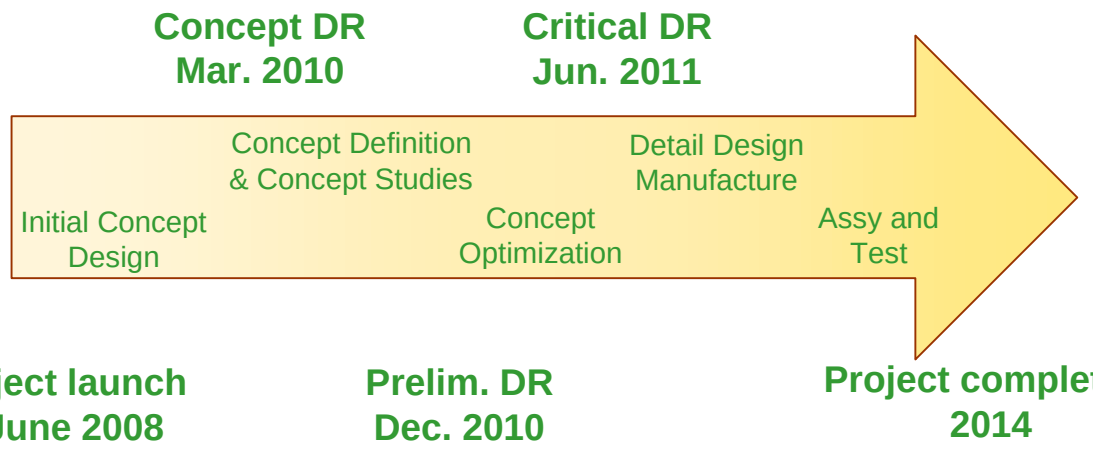
Engine Control & Power System

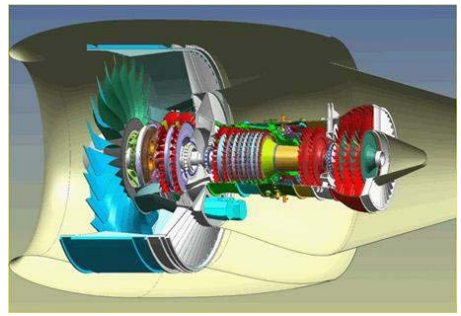
Temps & Materials

New Lightweight Exhaust Frame

Advanced Geared Turbofan – SAGE4 Demonstration

v Plan





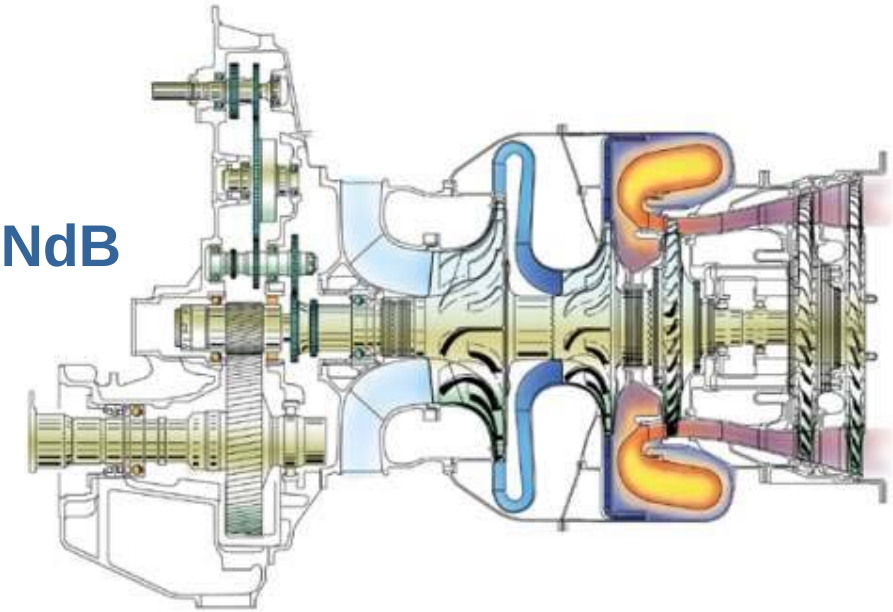
v First achievements

- 4 Concept DR held in March 2010
- 4 Selection of donor engine
- 4 Call for Proposals initiated
- 4 Product definition in progress

DR : Design Review

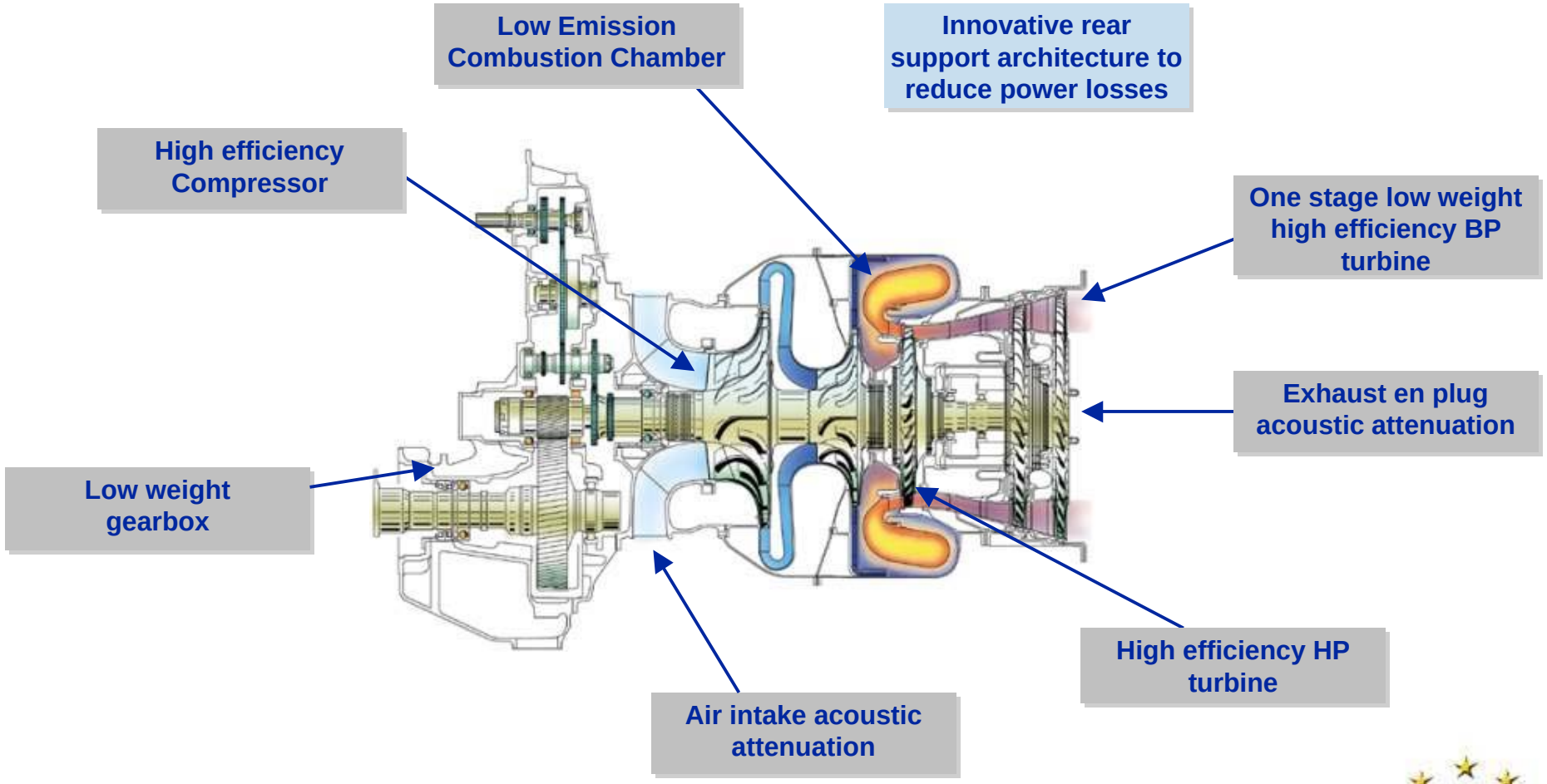
Advanced Turboshaft – Concept Objectives

- Power class : 750 – 1000 kW
- CO2 reduction* : - ~15 %
- NOx reduction* : - ~60 %
- Noise reduction* : - ~10 EPNdB



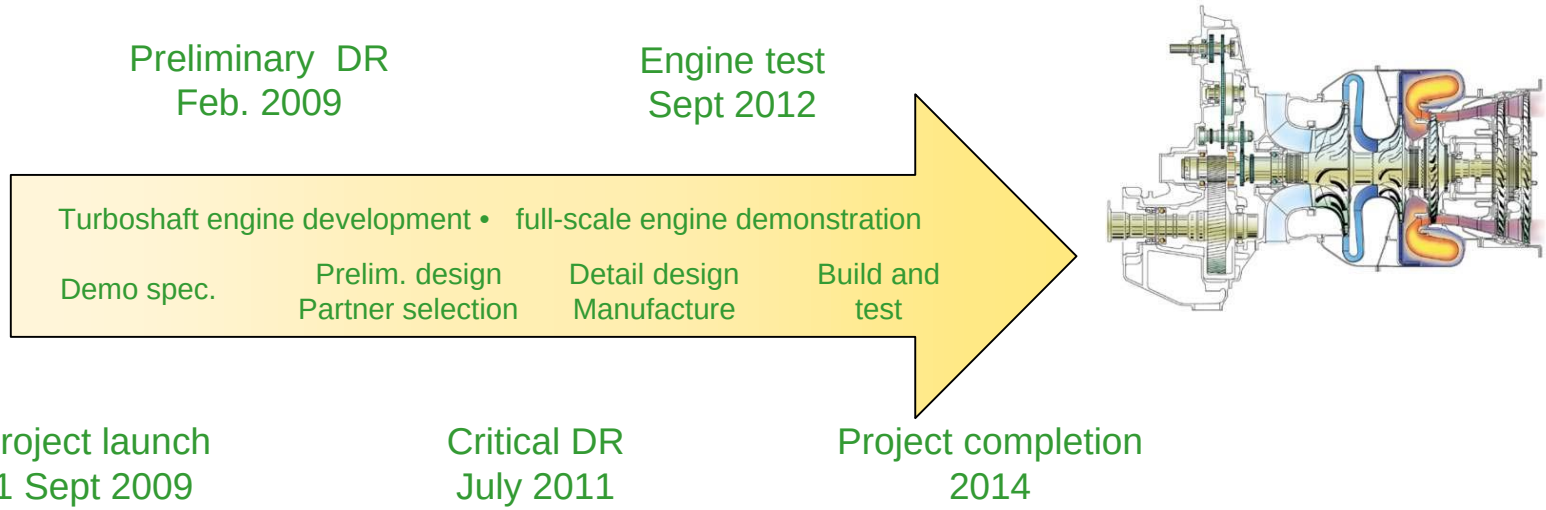
(*) Reference : current engine on current rotorcraft

Advanced Turboshaft – Concept Challenges



Advanced Turboshaft – SAGE5 Demonstration

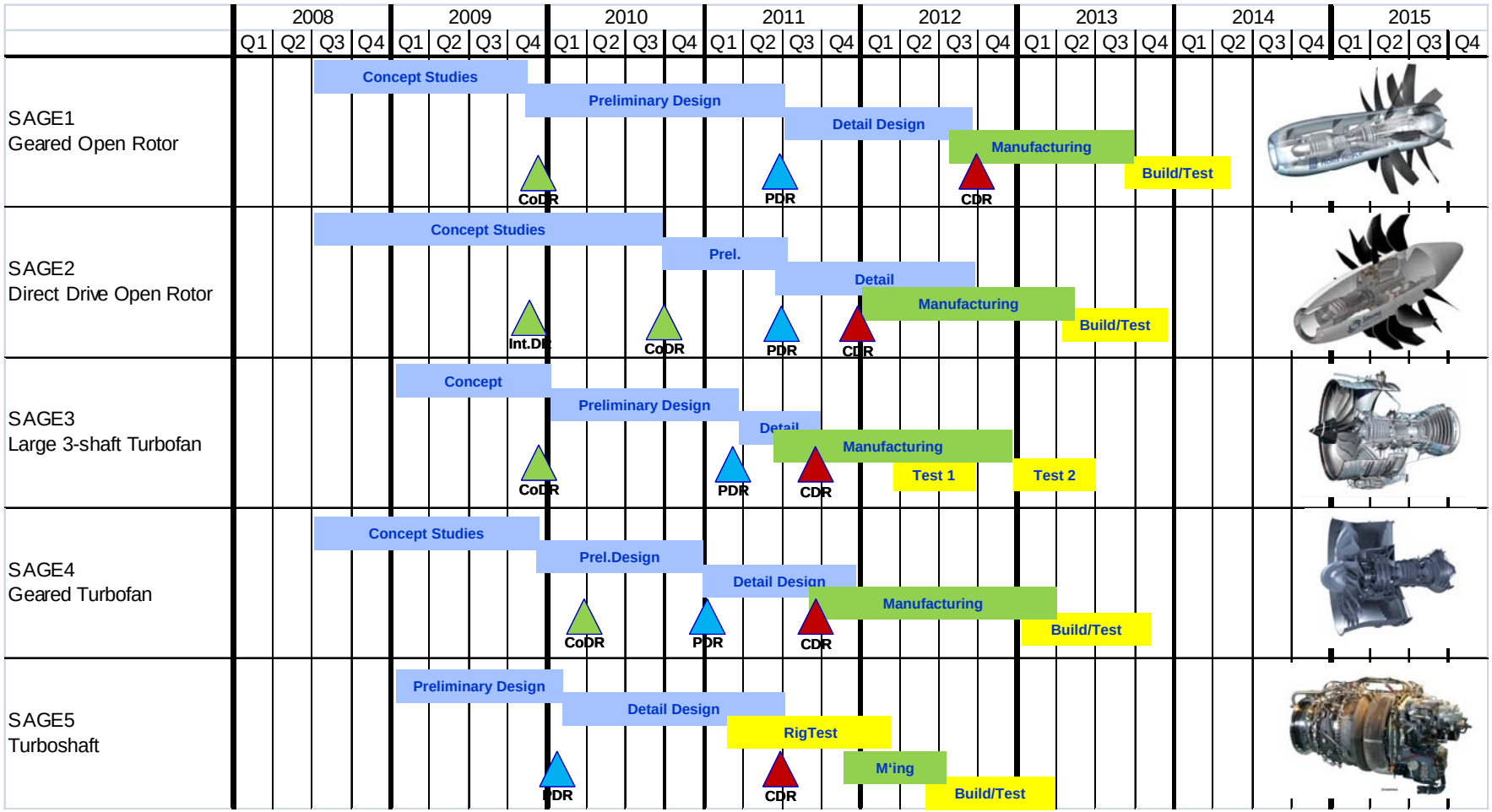
- **Plan**



- **First achievements**
  - **Preliminary Design Review held in February 2010**
  - **Preliminary rig test of variable inlet compressor completed**
  - **Preliminary rig test of HP turbine ring completed**
  - **Partners selected on various sub-systems**
    - **And further calls for proposals prepared**

DR : Design Review

SAGE ITD – Time Schedule



SAGE ITD – Main Achievements and Perspectives

- Since the SAGE programme was launched on 1 June 2008, it has
  - Defined in detail five engine demonstrator projects, including Leaders' and Associates' work-shares and opportunities for Partner involvement
  - Launched calls for proposals about specific topics and selected Partners to work with the SAGE consortium
  - Delivered design trade studies and completed Concept Design Reviews for all five demonstrators
- The projects are now in the detail design and planning phase, with Preliminary Design Reviews planned during 2011
- The first engine demonstrations are planned in 2012

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