5. DEMONSTRATIONS & DEMONSTRATORS

The objective of demonstration in the Clean Sky is to bring the integration of the innovative technologies that will be matured during the program to the readiness level that will allow their application in the development of the aircraft and rotorcraft programmes that will be launched in the future.

Demonstrations will be performed both by ground and flight tests.

Ground tests will be used in the Engine Platform to demonstrate the complete powerplant integration. It is already planned that rig tests of subassemblies of the engine will be appropriate to reach the objectives of demonstrating maturity of the technologies in an integrated application.

Ground tests will be used also for demonstration purposes in those cases where testing in flight is not required or not cost effective. Some subsystems, components and systems architectures, and advanced structures, are cases for which current planning considers ground tests to be exhaustive. Ground testing is also propedeutical to flight tests for advanced structures and systems architectures.

Flight test demonstration and the demonstration of several technologies integrated on a flight vehicle will be under the responsibility of the Aircraft Manufacturers.

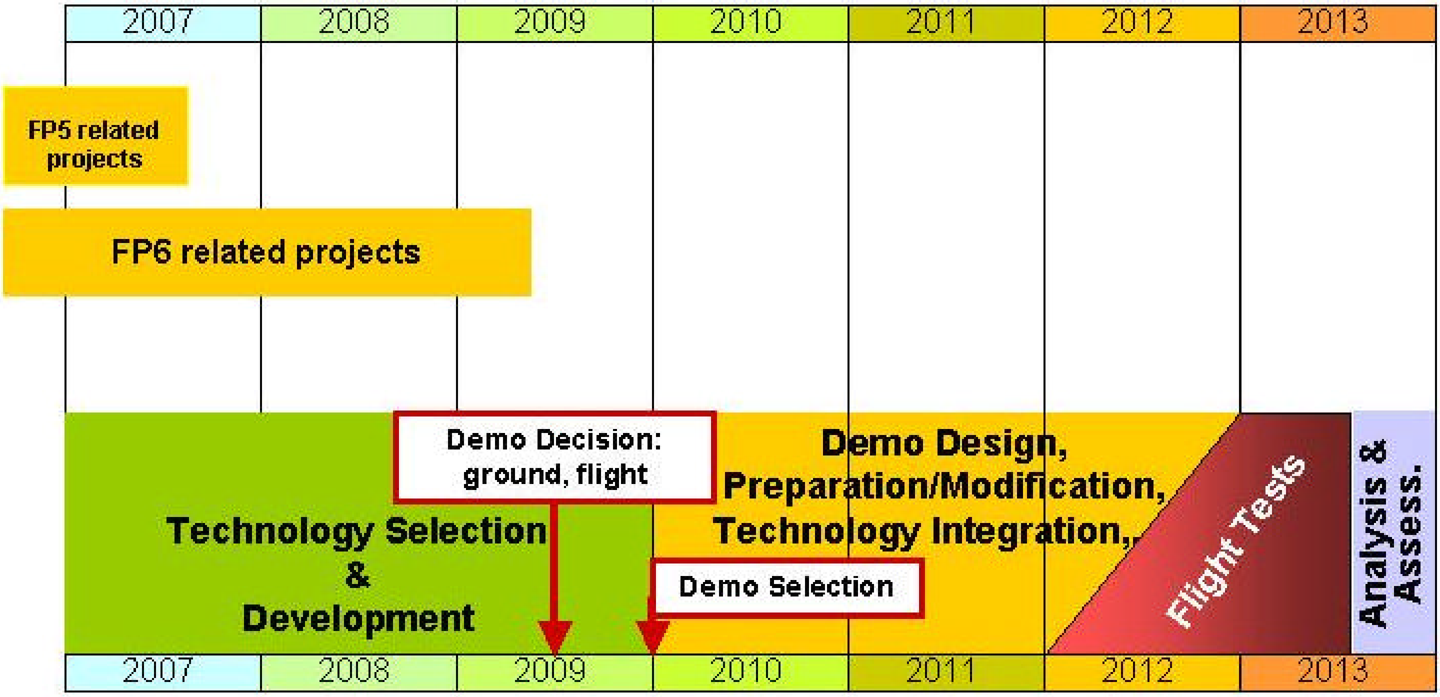
Demonstration on ground of specific technologies for systems components will be under the responsibility of the Systems Platform.

The demonstration needs are defined by each Platform and reported hereafter in an integrated view that reflects the present understanding of the Platform Leaders. Which technical solutions will be actually tested will depend on the outcome of the maturing of the technologies and on the application studies to be performed in the very first stage of the program. Consequently the current proposal has some degree of flexibility coherent with a research program with such an extent of technology domains, platforms and time scale. Also the means to be used for the demonstration will be defined based on the outcome of the first years of research activities, with the objective of satisfying the Platforms requests with a cost effective approach.

The following figure illustrates the principle of workflow for the implementation of demonstration in "Clean Sky". However, it must be understood that, depending on applications and technology domains, particularly for systems:

- Demonstrators might be available early in "Clean Sky", even at start, so that demonstration and flight test could be scheduled very early

- The principle workflow could be performed twice, for implementation of two demonstration cycles, a first one in the early years of "Clean Sky" using technologies from previous projects, another one at the end "Clean Sky" with technologies matured all along the "Clean Sky" programme.



5.1 Integrated vision of "Clean Sky" demonstrators:

The following tables sum up the deliverables of the whole "Clean Sky" JTI in terms of demonstrations. It explains also how those technology demonstrations will be shared between ground and flight demonstrators.

One of the main added values of Clean Sky is that a broad number of its platforms will deliver technology to be integrated in some shared demonstrator facilities, especially for flying demonstrators.

The timeframe does not appear in the following table. For the System demonstrations, the two development cycles are detailed in the technical description (chapter 6) and in the following sub-chapter.

5.1.1 Ground Demonstrators

The Ground demonstrators are mainly dedicated to Engines, Systems and Manufacturing technologies. All technology platforms will contribute to those demonstrations as describe in detail in the following sub-chapter.

Demo deliverables	Domain	Demonstrator target	Candidate Demonstrator facilities	Techno demonstrations	Platforms wich will deliver techno for the demonstrators
GROUND DEMO	ENGINES	Fixed-Wing Aircraft Engines	Core test altitude test facility + Full engine with modified LP system + Full scale rig test + Full engine ground demonstrator	Thermal Management Techno	ENGINES SYSTEM
				More electric technology	
				Low noise drag and weight techno	
				Lightweight Low Pressure techno	
			Full engine and nacelle ground demonstrator	New techno for "cold" low pressure components	ENGINES SFWA SYSTEM
				Advanced design for low pressure turbine	
				Advanced CMC exhaust system	
				Advanced nacelle systems	
				Innovative configurations (open-rotor, contra-rotor, geared turbofan)	
			Modified regional engine	Improved HP turbine	ENGINES REGIONAL
				New generation of combustor compatible to alterntive fuels	
				Improved HP compressor	
		Civil helicopter engine	Modified helicopter engine	Low NOx combustor design	ENGINES ROTORCRAFT
				Enhanced thermodynamic cycles	
				Noise attenuation techno	
	SYSTEMS	Global electrical / thermal benches	MOET + POA	Large-scale architectural integration of electrical generation and energy management technology	SYSTEMS ECO-DESIGN REGIONAL ENGINES ROTORCRAFT
				Large-scale architectural integration of thermal management technology	
		Mission and trajectory management systems	Aircraft operated on ground + cockpit simulator	Demonstration of green mission	SYSTEMS REGIONAL
				Demonstration of smart ground operations	
				Simulated green trajectories	
	MANUFACTURING	Life-cycle demonstrator	Fixed-wing A/C fuselage section and partial wing	Life-cycle demonstration from manufacturing to dismantling	ECO-DESIGN ROTORCRAFT SYSTEMS

5.1.2 Flying Demonstrators:

The flying demonstrations will enable large-scale tests in real conditions, mainly dedicated to Flight performance technologies, global aircraft configurations and innovative system and structure architectures.

ype of demo	Domain	Demonstrator definition	Demonstrator facilities	Techno demonstrations	Platforms wich will deliver techno for the demonstrators
FLYING DEMO	BASIC FLIGHT & FLIGHT PERFO	Narrow and Wide body A/C	A320/UAV/Falcon	New Active wing (active loads & flow control architecture) New configurations (rear configuration, wing configuration)	SFWA SYSTEMS
		Regional Aircraft	Regional Aircraft / UAV	Low noise configuration (High lift, integrated aero functions)	REGIONAL SYSTEMS
		Rotorcraft	Light & medium helicopter	Low noise and drag configurations (tail surfaces,landing gears,blades) Environmental friendly flight path Innovative active blades Diesel Engine Integration	ROTORCRAFT SYSTEMS
	SYSTEMS and STRUCTURES	Narrow and Wide body A/C	A320/UAV	Green approach demonstration (low noise high precision trajectories) Selected technologies for more electrical architecture (Set A)	SYSTEMS
		Regional Aircraft	ATR / Regional Aircraft	Low weight configuration (multifunction sensorized composite structures) Selected technologies for all electrical architecture (Set B)	REGIONAL SYSTEMS ECODESIGN
		Rotorcraft	Light & medium helicopter	Low noise and drag configurations (tail surfaces,landing gears,blades) Innovative active blades, electrical systems and architecture	ROTORCRAFT SYSTEMS

Candidate demonstrators’ facilities:

Among the candidate demonstrators facilities, a limited number of ground and flying test capabilities will be down-selected, in order to improve cost efficiency of the global set of demonstration.

5.2 Platform contributions for "Clean Sky" demonstrators:

The following sub-chapters provide detailed information on the needs of each platform to perform above-described demonstrations.

5.2.1 Demonstrations for Smart Fixed Wing Aircraft

5.2.1.1 Demonstrator objectives:

a. Active wing: to deliver mature "ready to use" technologies and methods to apply the most efficient active flow and loads control to future aircraft

b. New configuration: to plug on the active wing concept other selected major innovative components into one or several overall configurations

This objective develops through the design, development, flight test and technology assessment of integrated active loads/flow control architectures and configurations

5.2.1.2 Required demonstrator characteristics:

To answer the SMART Fixed Wing aircraft requirements the demonstrator(s) has(ve) to be:

a. Large**:** Sufficient in overall size to reach the necessary flight Re numbers.

b. Fast: Cruise speeds into the transonic regime, typically in a cruise region of M =0.8-0.85

c. Modular: We should have a fuselage section with suitable interfaces (structural & system) to allow replacement of wings and empennage.

d. Sustainable: Should not be a one off, but some thing that will be a long-term facility, allowing us to experiment cheaply with new technologies in flow, load and flight mechanics.

e. Operated probably by a separate group in line with sustainability needs

The SMART Fixed Wing flying demonstrator(s) will either be existing aircraft (s) modified to integrate the new technologies or a dedicated technology demonstration large unmanned vehicle, specifically design for the purpose of Clean Sky.

5.3 Demonstrations for the Green Regional Aircraft

5.3.1 Demonstration for Low noise aircraft configuration

Demonstration of low noise aircraft configurations will be achieved mainly by flight tests.

The configuration to be tested in flight will use the technologies developed and matured in the first part of the program with reference to a generic regional aircraft type. For an effective demonstration, the configuration to be defined will take into consideration the requirements for low weight, high aerodynamic efficiency, low cost, in an approach of multidisciplinary optimisation that will take benefit from technologies deriving from other Platforms.

The demonstrator vehicle will be selected after the technical solutions to be brought to flight will be defined.

The choice will reflect the adequacy of the existing aircraft to represent with appropriate modifications the configuration to be validated. Cost effectiveness will be a strong requirement. The selected aircraft will have modifications mainly to the leading edge and to the trailing edge of the wing, to flight controls, and to associated systems and structures.

5.3.2 Demonstration for low weight configurations

The sensor technology and the multi-layer / multifunction materials to be used in different types of structures will be selected in the first phase of the research program by small-scale tests. Selected architectures will undergo structural and performance tests in laboratory at different scales. The correlation existing between:

- Sensors output and results of inspection
- Multi-layer /multifunction sandwich and the lamina properties

will be specifically assessed, for selected structural items.

The laboratory tests will be followed by testing in the real flight environment, that will evidence the impact of vibrations, noise, external loads on the performance of the advanced structures to be validated.

5.3.3 Demonstration for All Electric Aircraft

Specific architectures and technical solutions developed for the Regional Aircraft will be integrated within the regional platform up to demonstration according to its specific requirements. Flight testing of a partial configuration of all electrical aircraft will be carried out.

5.3.4 Demonstration for Mission and Trajectory Management

Also in this case the demonstration will apply to the specific technical solutions defined for the regional aircraft type.

Demonstration is envisaged on ground using a cockpit simulator.

5.3.5 Demonstration for New Configurations

Advanced aircraft configurations tailored to the regional aircraft requirement, defined in the course of Clean Sky will be validated in wind tunnel testing.

Should these unconventional configurations be strongly required by issues of pollution and noise, flight testing will have to be planned.

This need, if emerging during the program, will have to be accommodated using the flexibility built in the Clean Sky.

5.3.6 The regional aircraft flying demonstrator

The specific regional aircraft that will be utilised for the in flight demonstration of the technologies specifically intended for the Green Regional Aircraft will be defined after about two years from the start of Clean Sky. At that time the most promising solutions required to reach the very ambitious objectives for a greener regional transport system will be identified. The strategy of the demonstration and the choice of the vehicles to use for the flight tests will then be defined.

In general terms, the requirements now envisaged for the regional flying demonstrator are:

Cruise Mach Number up to M= 0.78, the speed at which the short ranges typical of regional aircraft find today the best compromise between fuel consumption and pollution on one side, and mission duration on the other. This speed drives the wing aerodynamic design, that is the main issue of the Low Noise Configuration demonstration. It could be lower with growing fuel price.

Low Weight Configuration and All Electric aircraft demonstration accepts aircraft with lower speeds.

Cruise altitude between 25,000 and 30,000 ft

These requirements can be met by existing regional aircraft powered by turboprop and turbofan engines.

Depending on the technology to be demonstrated, it might be more appropriate and cost effective to use an UAV for low noise configuration and, if decided, for the new configurations.

5.4 Demonstration for Green Rotorcraft

5.4.1 Demonstration of external noise reduction

After the development phase is objective of the rotorcraft platform to validate the external noise reduction technologies through a dedicated test activity.

Different demonstrations will be performed to achieve a comprehensive evaluation of the improved items.

In detail will be evaluate:

– Rotor Model: The rotor model with active blade twist will be tested in a wind tunnel facility in conditions representative of the defined flight envelope. This activity is directly correlated with tests performed on the whirl tower as part of the FRIENDCOPTER project.

– Full Scale Rotor Blades: Full scale rotor blades with distributed twist actuation will be tested on the whirl tower facility to demonstrate the validity of the concept and the configuration achieved. According results obtained during these ground tests, this active rotor might be finally tested on a helicopter in flight.

– Improved Installation Engine: Wind tunnel tests will be performed to demonstrate the validity of the new solution defined. Also in this case in accordance with the results obtained during these tests, further demonstration will be performed on a helicopter in flight.

5.4.2 Demonstrations of the Electrical Integration Components

In detail will be evaluated:

- A demonstration of the novel electrical actuators and energy management systems selected during the first phase of Clean Sky will be conducted on an electrical integration bench.
- The electrical tail rotor equipped with an electrical control booster and, possibly with an electrical drive, will be tested on a dedicated Iron Bird to demonstrate the performance of this configuration.

5.4.3 Demonstration of the Diesel Engine Installation

Based on the airframe of an existing single engine helicopter, ground testing for feasibility demonstration and a physical performance evaluation will be defined. After this activity a flight demonstrator will be performed.

5.4.4 Technology ground & flight demonstrations

Iron Bird or Ground Test Vehicle will be used before flights to perform a complete range of ground tests to evaluate the dynamic or active novel concepts with and without rotation of engines and rotors, in order to perform final verification and tuning operations.

After this phase the integration of the new concepts regarding airframe and dynamic components aiming to reduce the parasitic drag etc. will be demonstrated in flight on at least two different helicopters, in order to represent the broad spectrum of rotorcraft size and configuration.

5.4.5 Environment-friendly flight path demonstrations

Regarding the environmentally friendly IFR navigation, approach and departures procedures demonstrations will be conducted to validate the flight path defined in accordance with the ICAO criteria related to rotorcraft operations.

Final objective is to demonstrate a reduced impact in terms of noise, etc. in all the flight operations performed near to the ground or that have a significant impact on the population.

5.5 Demonstrations for Green Engines

5.5.1 Introduction

The primary focus of engine demonstration will be ground test to deliver proven architectures for advanced engines and mature "ready to use" technologies, and will include the following:

- Core-test within Altitude Test Facility
- Whole engine ground test within indoor test cell
- Whole engine ground test on outdoor noise test bed

The most efficient way of testing new technologies is ground testing under conditions which are representative of the engine environment and where one can test a wide range of operating conditions because there are not the same reliability or safety constraints as there are for flight tests. The possible measurements during ground test are very much important than those available from flight testing.

The "New Configurations" work stream may demand "Flying Test Bed" testing, where new engines will be flight tested on a modified existing airframe also equipped with conventional engines (for example a rear-mounted open rotor engine on a conventional narrow-body aircraft equipped with existing under-wing mounted engines). However, it should be noted that such testing is extremely costly, and the requirement for it has not, as yet, been fully determined. If such testing proves necessary, then it is likely that the scope of the overall engine demonstration activity will be reduced to less than five.

As discussed in section 6.4, there is a wide range of candidate demonstration vehicles, distinguished by application (helicopter, regional, narrow-body and wide-body) and by engine architecture (2-shaft, 3-shaft, radical). It will be neither affordable nor efficient to define and execute demonstrator programmes covering this full suite; however, many technologies have the option of being validated in more than one demonstrator vehicle, and it is proposed to select demonstrator vehicles as Clean Sky proceeds. These will be selected based upon technology maturity and market requirement, and to maximise the technology validation opportunity (i.e. a suite of demonstrators will be chosen which maximises the set of technologies which are validated at TRL6). The following sections outline the scope of the potential demonstrator programmes, from which the programmes to be executed will be selected.

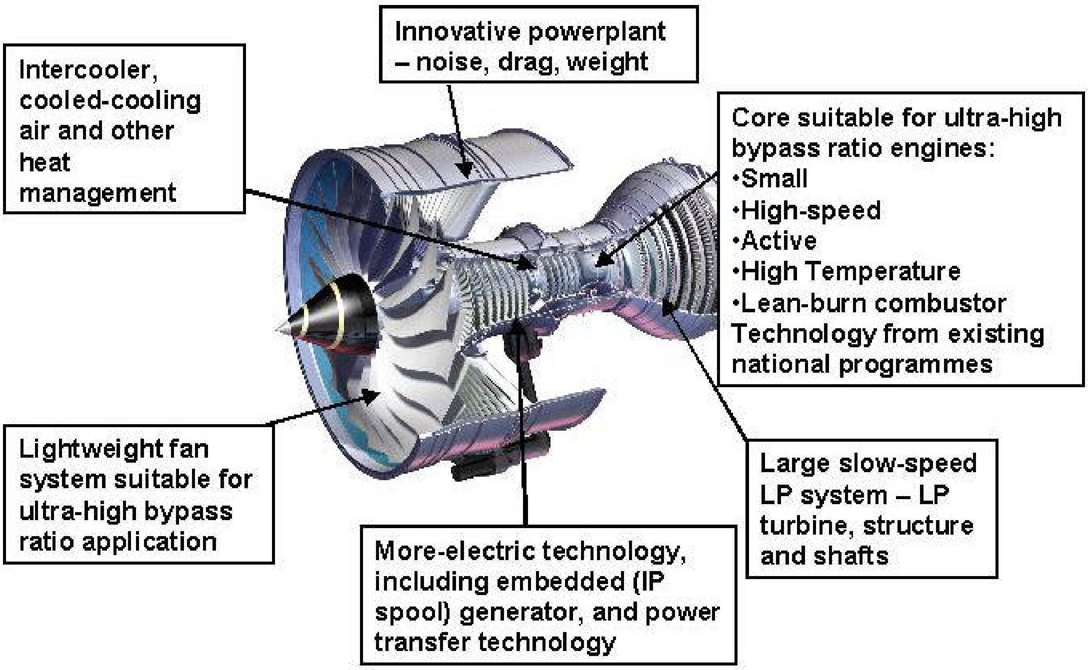
5.5.2 Demonstrators

5.5.2.1 Commercial Airline Wide Body Aircraft Engine

SAGE 6

The validation of technologies for the longer-range wide body aircraft market is likely to be required slightly later in the Clean Sky programme. Engine performance will continue to be the dominant market driver to maximize aircraft range in this sector, but the technological challenges of high-thrust engines will continue to require direct-drive ducted turbofan architectures. These will, however, feature very high bypass ratio compared with current engines, which will make the integration of small high-speed cores with large, low speed fans even more challenging than it is today.

A full engine demonstrator will certainly be required before such a product could be launched, and the main deliverable from this programme will be the ground test of this demonstrator.



Integration of new technology from all domains of the engine platform would be demonstrated, including those shown of the above figure

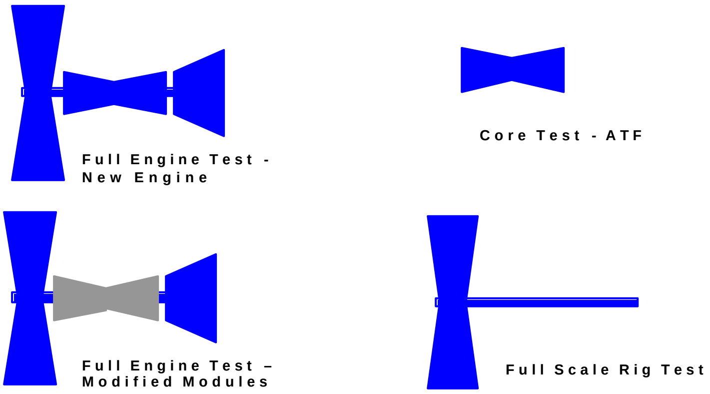
5.5.2.2 Commercial Airline Narrow Body Aircraft Engine

SAGE 1

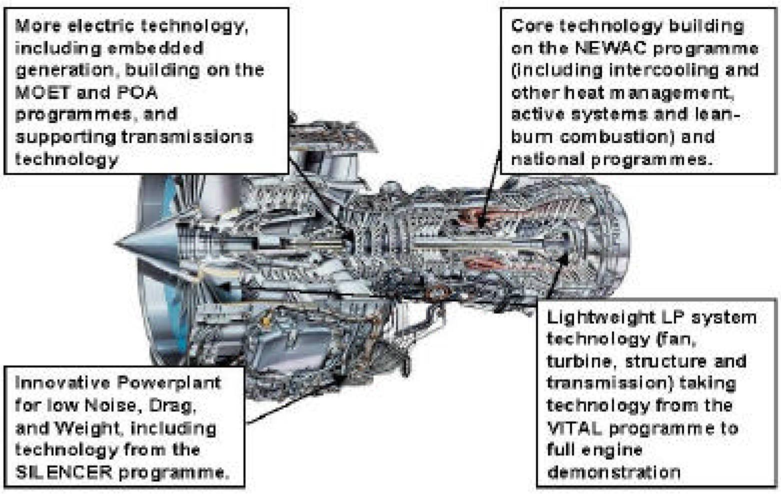
The engine for the next generation of narrow-body aircraft requires innovative technology in all domains – core, LP system, powerplant and engine systems. It is intended that this technology will be validated in a ground test of a complete new engine; however, the timing of downstream product development programmes may mean that this is not feasible, in which case a combination of:

- Core test in altitude test facility;
- Full engine test with modified LP system modules and/or Powerplant in donor engine; and
- Full scale rig test

will be used (introducing a higher degree of risk to the downstream programme).



The principal candidate technologies for this demonstrator will be those shown of the above figure



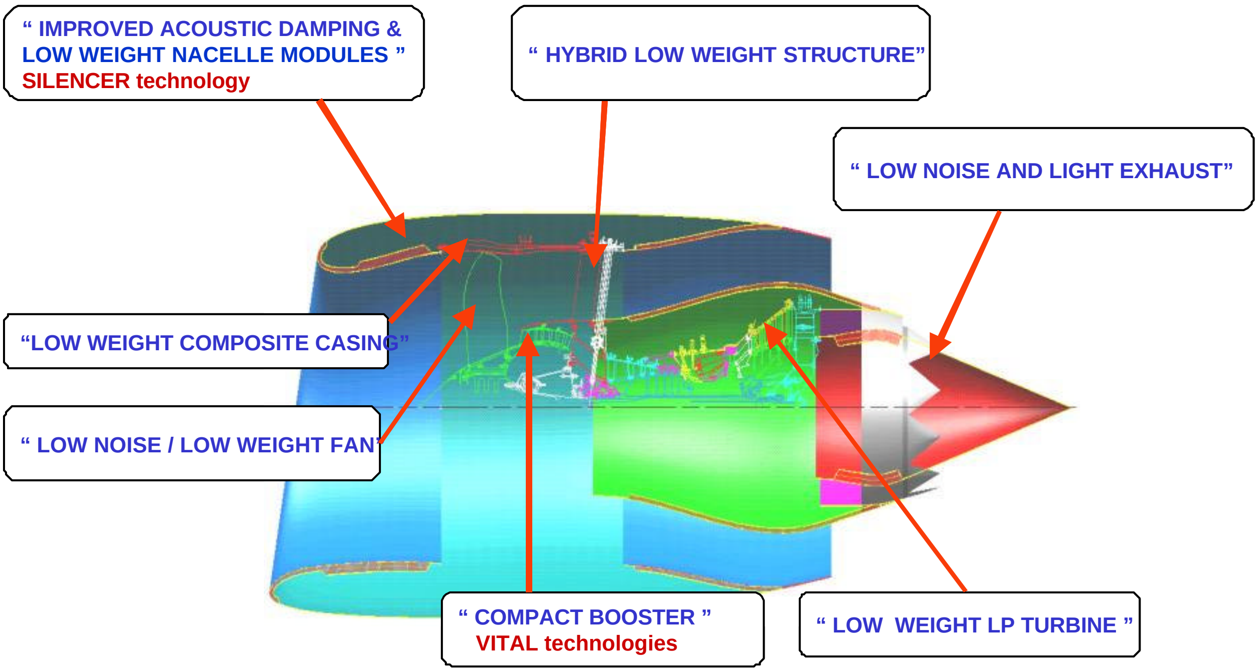
SAGE 2

This demonstrator for a future narrow body aircraft engine will consist of a complete engine and nacelle. It will integrate the results of FP5 SILENCER and FP6 VITAL programs as well as national programs on weaved composite fan and CMC exhaust system components.

The demonstrator is intended to integrate, test and bring to higher maturity levels in a real engine environment several technologies enabling by-pass ratio increase and reducing by the same way noise and fuel burn. Candidate technologies will be:

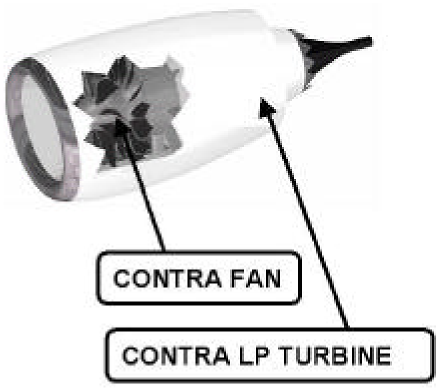
- New lightweight / low noise / high performances technologies for "cold" low pressure components (fan, booster, casing, structures). Use of composite technology is anticipated as well as the integration of VITAL booster results
- Low weight / high performances low pressure turbine based on aerodynamic, material and structural design advancements
- New lightweight / low noise exhaust system based on CMC material use and jet noise reduction technologies
- Low weight nacelle parts and advanced noise damping technologies using SILENCER results.

Demonstration would be full engine test in closed and then in open air bench (acoustics) including modified LP modules and modified nacelle/power-plant modules.



Alternative architectures to SAGE 2:

A step change could happen if in 2006, the contra-fan acoustic testing is positive in VITAL. In such case, the demonstration will be done on this configuration with contra-fan and contra-rotating LP turbine and all the previous technologies adapted to this new configuration.



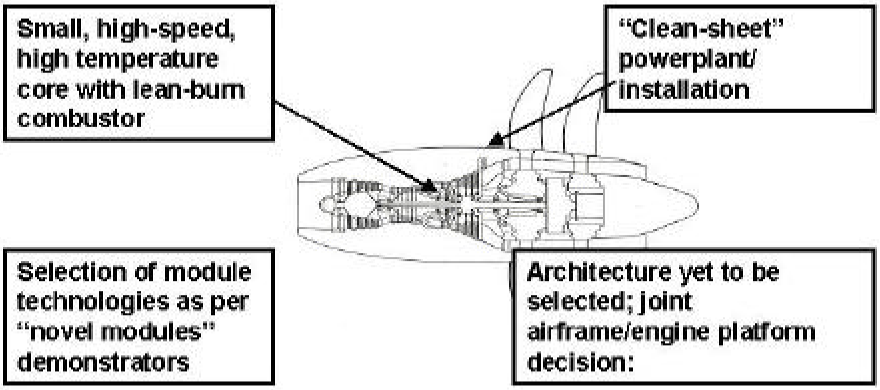
If the pressure on fuel consumption becomes much bigger than the pressure on noise reduction, other types of alternative architectures could be considered

SAGE 3

The possibility exists that the narrow-body aircraft application will adopt a much more radical architecture in order to make a step change in environmental performance. Reducing flight speed and altitude could make the case for ultra high bypass (20-35) engines. For this to become a reality, a technology validation vehicle covering the whole powerplant would be essential in a joint engine/airframe programme.

Ground test of the engine may be followed by flight test in flying test bed configuration, although affordability of such a step would require significant reductions in scope within other areas. Several of the technologies required to deliver such an engine are not yet being matured in existing European and National programmes, and would required accelerated programmes within the “Enabling Technologies” element of the work breakdown structure; this is an area where the flexibility offered by Clean Sky is invaluable.

Considerable study work is planned under the “New Configurations” domain of the Fixed Wing platform during the initial stages of Clean Sky in order to inform decisions to launch enabling technology and engine demonstration programmes for radical architectures.



The core modules for this demonstrator would draw on the same technology base as the less radical architectures. The powerplant/installation would be a completely new concept jointly developed between aircraft manufacturer and engine manufacturer. Candidate architectures include:

- Open rotors
- Contra-rotors
- Geared turbofan

In the event the market accepts the need for more radical solutions, it is possible that more than one of the options above could be selected

5.5.2.3 Commercial Airline Regional Aircraft Engine

SAGE 4

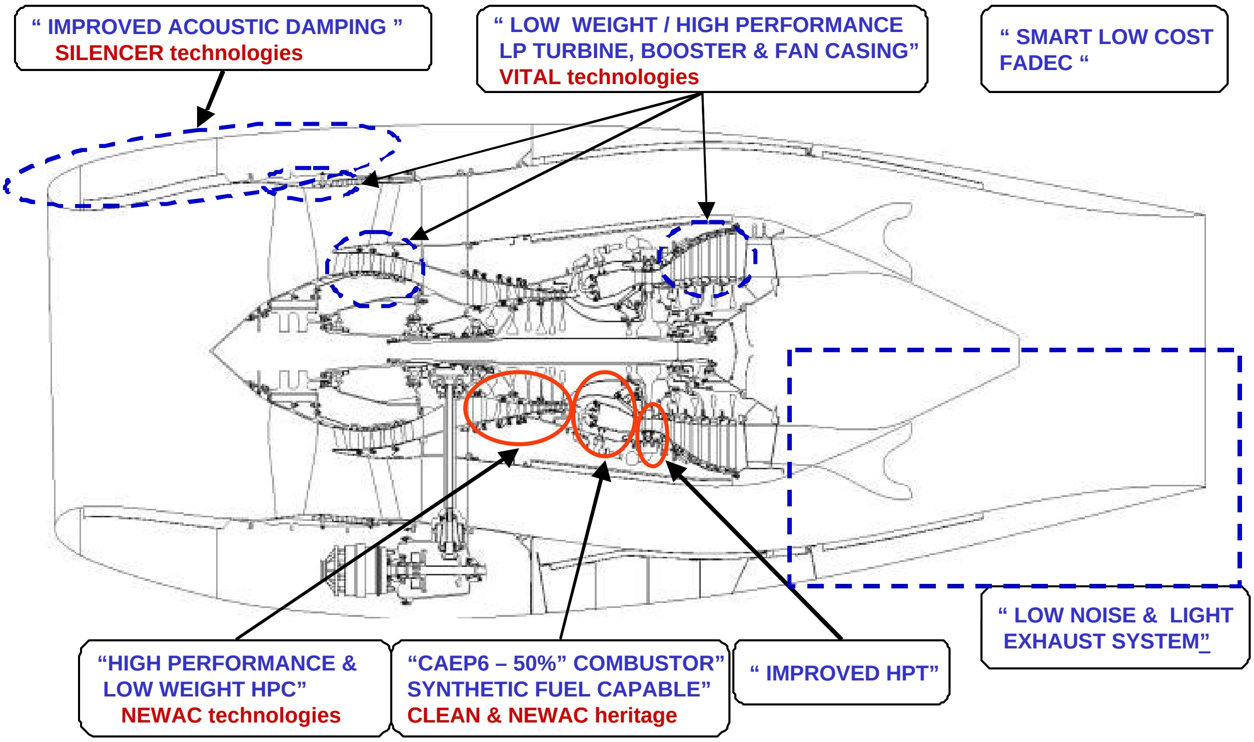
This demonstrator is devoted to the regional jet market for which a third generation of engines has to be prepared including technologies coming from higher thrust engines but also technologies specific to the range of thrust of the regional market.

The demonstration will concentrate on the high-pressure core. Candidate technologies will be:

- HP compressor building upon the NEWAC programme (Flow Controlled Core work package) and national programmes
- New generation of combustor taking advantage of technologies developed in CLEAN and NEWAC programmes (lean / staged injection systems, etc.) and national programmes. This combustor would be tested also with alternate fuel like bio or synthetic kerosene.
- Improved HP turbine (e.g. low cooled outer shroud, highly efficient blades)

Some technologies related to noise reduction, weight reduction and performances improvements for low pressure modules and nacelle components foreseen in the SAGE 2 demonstrator would be integrated in the SAGE 2 or the SAGE 4, depending on the SAGE which will be selected during the program.

A smart low cost FADEC will be also considered in the demonstration.



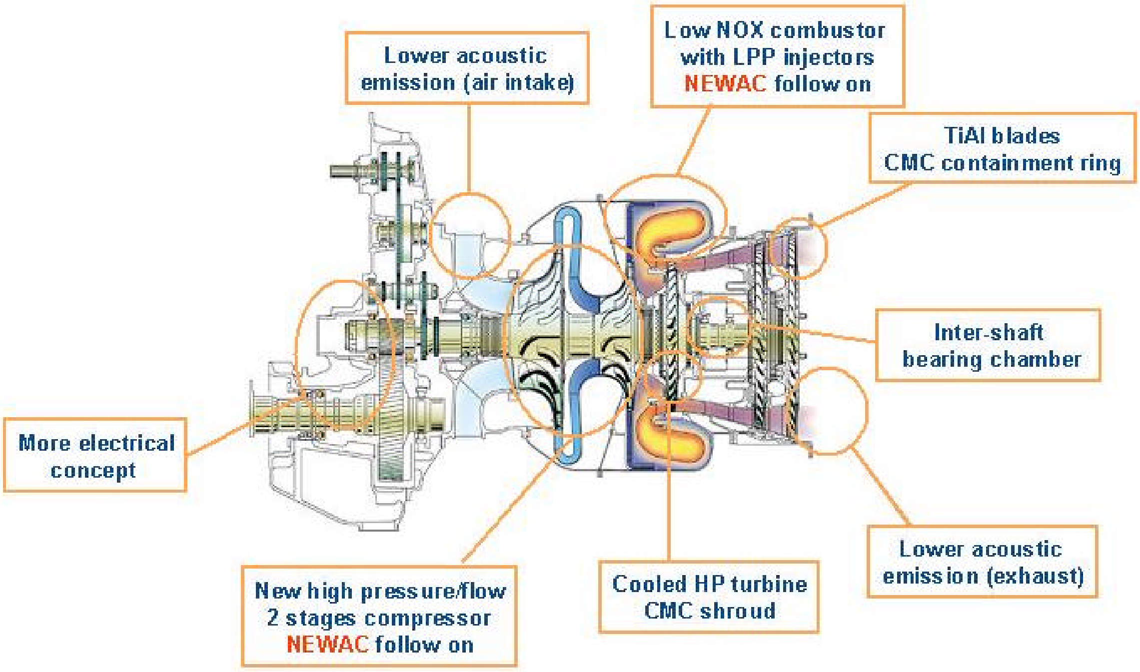
5.5.2.4 *Civil Helicopters Engine*

SAGE 5

This demonstrator is related to the range of 300 to 3000 kW engines used to power helicopters.

The demonstrator will incorporate most of the low emission technologies, which were developed in FP5 and FP6 programmes as well as national projects. The main target is to show the capability of the low NO_X combustor design and noise attenuation technologies to be associated with enhanced thermodynamic cycles (higher compressor OPR / higher loaded high pressure turbine stage). At an early stage of the project the demonstration of alternative fuels (as synthetic or bio-mass fuel) will be considered in accordance with the low emission target.

This demonstrator will also prepare technologies for the MPG (Main Power Generator) concept for the more electrical aircraft APU. Such aircraft require critical power units, as the APU becomes the main source of energy for the vital functions.


Lower acoustic emission (air intake)
Low NOX combustor with LPP injectors NEWAC follow on
TiAl blades CMC containment ring
Inter-shaft bearing chamber
More electrical concept
New high pressure/flow 2 stages compressor NEWAC follow on
Cooled HP turbine CMC shroud
Lower acoustic emission (exhaust)

5.6 Demonstrations for Systems

5.6.1 Systems demonstration cycles

Though the detailed planning will depend on the completion and deliverables of other projects, being European or national, it is anticipated that studies and demonstrations will follow two cycles:

- First cycle for ground or flight demonstration of technologies, systems and sub-architectures which have shown sufficient maturity in previous European and national projects. This cycle will take place during the first years of Clean Sky:
  - **Flight**: Demonstration of already proposed green approaches (e.g. CDA – Continuous Descent Approach).
  - **Flight**: Testing of electrical technologies which have the relevant maturity (e.g. electrical air system)
  - **Aircraft on Ground:** taxi using landing gear
  - **Ground**: use of existing electrical integration bench for final testing before flight or for full maturity.
  - **Ground**: Simulated green mission
  - **Simulation**: value assessment together with the Technology Evaluator
- Second cycle for demonstration of integration and architectures which will be investigated during the course of Clean Sky. Corresponding demonstrations will be taken to flight test in the latter years of Clean Sky.
  - **Flight**: Full demonstration of environmentally friendly functions and airborne procedures.
  - **Flight**: Full scale test of energy management functions and architectures (when relevant)
  - **Aircraft on Ground**: Demonstration on aircraft of smart ground operation capabilities.
  - **Ground**: Cockpit simulation, with green mission and multi-criteria optimisation.
  - **Ground**: Integration of a new cycle of energy management technologies and architectures in ground benches
  - **Simulation**: value assessment together with the Technology Evaluator

5.6.2 Systems demonstrators

The following table gives an overview of the large-scale integration demonstrators which will be available to this platform. The choice of demonstrator will be made according to the maturity of technology, during Clean Sky itself.

Facility	MAE [15]	MTM[16]	TRL	Usage	Status
Airbus A320	x	x	6	Flight and taxi test	Existing and available from 2008
ATR	x	x	6	Flight test	Existing and available late in Clean Sky
Sky-X UAV		x	6	Flight test	Existing
PROVEN (used in MOET)	x		5-6	Electrical integration rig	Existing and available from 2008
ASVR (used in POA)	x		5-6	Partial integration rig (engine/systems)	Existing and available from 2007
Small network rig (used in MOET)	x		5	Electrical integration rig	Existing and available from 2008
Power integration (used in MOET)	x		5-6	Thermal management	In preparation and available from 2009
MARS		x	5	Cockpit simulator	Existing and available
EPOPEE		x	5	Cockpit simulator	Existing and available


Left: The 'ASVR' used in POA could be used for large-scale integration of electrical equipment. Right: State-of-the-Art cockpit simulator

[15] Management of Aircraft Energy

[16] Management of Trajectory and Mission

5.7 Demonstrations for Eco-Design

5.7.1 Eco-Design for airframe

The last phase of activities is a proof of eco-design demonstration through the carrying out of complete lifecycle demonstration of aircraft representative components. The list of components will cover most of the critical items highlighted through the initial eco-statement.

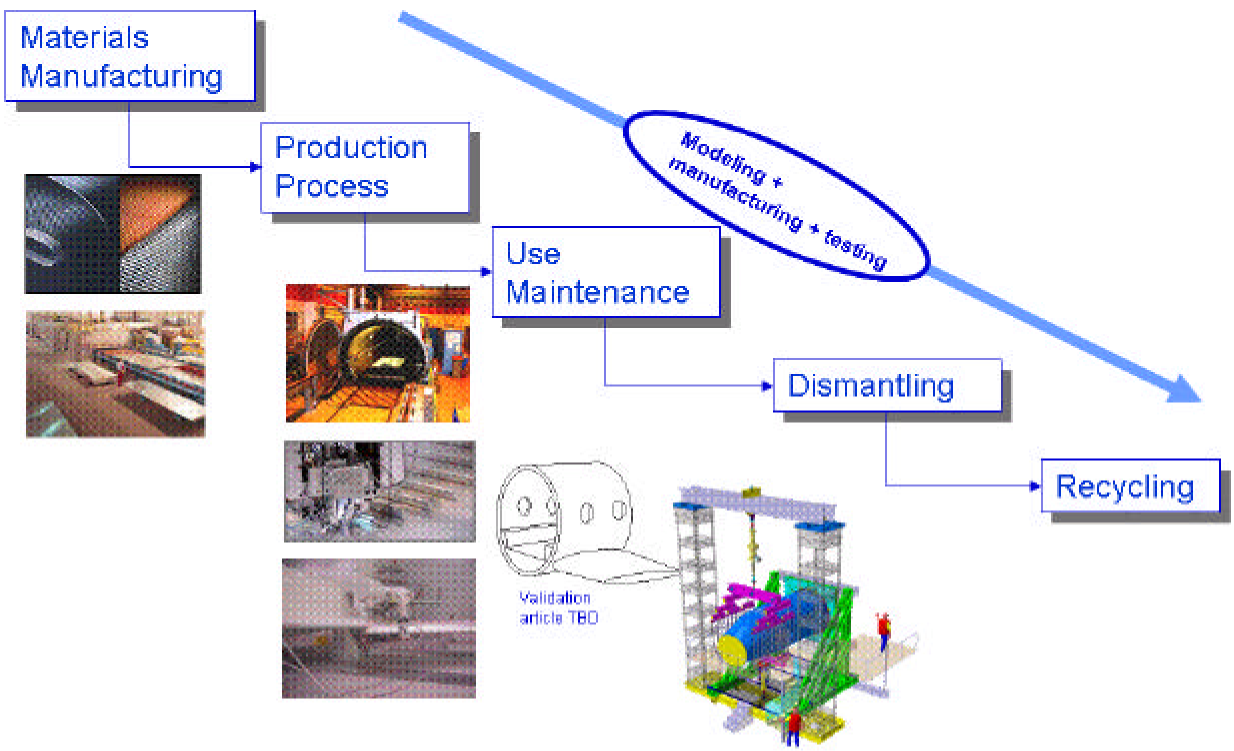
At this step of "Clean Sky" activities, the definition of the demonstrators is highly hypothetical. However, a preliminary vision is to have 3 complementary demonstrator types.

5.7.1.1 Fixed wing aircraft fuselage section and partial wing

The demonstrator would be based on the **composite** approach. It would include a fuselage section including the structure and the cabin interior. A piece of wing would be manufactured and attached on the fuselage section.

A schematic view of the demonstration is represented on the following figure

The demonstrator is a full or half scale prototype to be designed, manufactured (with relevant materials) duty cycled under a representative environment and dismantled, recycled at the end of use simulation.



5.7.1.2 *Partial metallic demonstrators*

For the **metallic** approach, the demonstrator should be based on a part of the composite demonstrator. For example, part of the wing and attach to fuselage could be considered as being a critical structural node.

The demonstrator should include only structural pieces but not cabin items, as they are included in composite demonstrator.

5.7.1.3 *Complementary demonstrators*

The above demonstrators are related to fixed wing aircraft structure and cabin interior. Additional demonstrators could be necessary for items demonstrated as critical through the initial eco-statement. Examples of such items are: rotorcraft blade, turbine blade, tyres, engine components, and microelectronics…

5.7.2 Eco-Design for Small Aircraft Systems

The global Iron Bird is composed of two test benches, one dedicated to explore the energy behaviour of an all electrical systems architecture, and another one devoted to the investigation of its thermal behaviour. These benches are designed in a way they can "communicate" to each other and exchange data pertaining to the real behaviour of the equipment under scrutiny. For instance, the thermal signature generated by the equipment undergoing tests on the energy bench may be reproduced on the thermal bench.

Whereas the Systems platform ground tests are mostly devoted to technology maturation, the objective of the eco-design ground tests is to validate the methodology to optimise a complete aircraft level system architecture for an all-electric aircraft. The deviation between the test results and the simulation results will be assessed and analyzed, in order to refine the models to make them as representative to the real behaviour of the equipment as possible.

5.7.2.1 *Energy Iron Bird*

The energy test bench will allow the simulation of the electrical architecture of a complete all electrical aircraft. Notably, the power generation systems will comprise one starter-generator per engine, an emergency generator (alternator) to be mounted on an APU or a RAT and a set of batteries. The electrical network will consist of a High Voltage (HV) bus bar and a Low Voltage (LV) bus bar, and all associated contactors.

The power users will include a set of flight control surface actuators (both primary and secondary) and utilities actuators (landing gears and bay doors, braking system and Dirav), and other systems such as fuel pumps, moto-compressors for the conditioning system and the anti-ice protection system.

All the loads applied to the LV network will be simulated, via a programmable scheme allowing both preset schedules and real-time modifications. The resulting positioning and actual loads of the actuators will be measured.

The bench will be designed in such a way the most representative currents and voltages and the thermal signatures of the power users and of the working fluids will be observable and measurable. This provision will ensure that a constructive confrontation with model simulations may take place.

Existing test rigs will be adapted for the energy Iron Bird, such as the one developed in the frame of the European Power Optimised Aircraft ("POA") project.

5.7.2.2 Thermal bench

The thermal test bench will contribute to the refinement of the global modeling capability for investigating more electrical aircraft architectures. Its objective is to help mastering the thermal management of these architectures, by investigating the thermal behavior and operation constraints of the innovative technologies to be installed in them and defining ways to face the increased flammability risks inherent to them.

This bench will be constructed around a mechanical test airframe structure, and will include a set of realistic pressurized and un-pressurized bays, equipped with heating devices. Appropriate and representative thermal loads will be applied throughout the bench, which objective will be to define and assess optimal cooling concepts.

An optimized thermal management scheme would not only lead to an increased overall architecture efficiency but also allow the improvement of the external air off-take requirements, which would yield to a beneficial drag reduction, improving even further the platform efficiency, via a decrease of the fuel consumption.

This bench will allow the thermal mapping of the convective, radiative and conductive fluxes which take place in an architecture embedding innovative technologies. Analyses performed on such mappings will contribute to the validation of the architecture lay-out and of the integration concepts of the innovative technologies under investigation.

6. CLEAN SKY TECHNOLOGY EVALUATOR

6.1 Rationale

A number of promising new technologies have been identified in the Aeronautics and Air Transport domain to meet the ACARE goals, in terms of environmental impact. The 6 Technology Platforms of Clean Sky propose to develop and demonstrate these technologies, bringing them to a maturity level where they could be applicable for new generation “Green aircraft”.

It is necessary to be able to **measure the quantified impact** of the introduction of each of these technologies on Environment and People, but also to **provide guidance** on the most efficient combinations of these technologies, and **assess the potential for improvement** at ATS level.

The translation of the impact of innovative airframe, engines, systems and eco-design technologies into overall ATS performance, with respect to environmental challenges, is the general object of the Technology Evaluator of Clean Sky.

6.2 Objectives

The Clean Sky Technology Evaluator will have to provide four main capabilities:

- Evaluate the **merit of contributing R&T activities** performed within each of the technology platforms, in relation to the ACARE targets,
- Help substantiate **consistency between all platforms** and identify best trade-offs for global environmental ATS objectives,
- Provide elements of guidance and justification for **decision making** within “Clean Sky”, to maximize synergies between platforms,
- Provide a continuous **monitoring tool** for Clean Sky stakeholders and Public Authorities to oversee the whole JTI. It will contribute in delivering reporting material for critical Clean Sky milestones.

These capabilities have been used to serve as a base for the elaboration of structure and features of such a Technology Evaluator

The Clean Sky Technology Evaluator will be the first available European complete integrated tool based on simulation delivering direct relationship between advanced technologies, still under development, and high-level local or global environmental impact. It will contribute to feedback / design tuning at different levels: aircraft design, aircraft operations and global ATS.

6.3 Potential associates and partners

Because of the importance of its objectives within "Clean Sky", important decisions regarding Technology Evaluator critical orientations will be taken in a collegial manner, under responsibility of the Technology Evaluator Steering Committee:

- General objectives, specifications,
- Modes of operation,
- Definition of evaluation metrics,
- Definition of evaluation scenarios,
- Delivery of assessment results contributing to "Clean Sky" Demonstrators selection and delivery of final assessment results to "Clean Sky" Executive Committee.

All Platform leaders will be members of the Technology Evaluator Steering Committee.

European Aeronautics Research Establishments: CIRA, DLR, NLR and ONERA, because of their recognized skills and achievements in areas it covers, are also expected to be associated to the "Clean Sky" Technology Evaluator, with one common voice in the Technology Evaluator Steering Committee.

They will bring major contributions in the area of models definition and validation, simulation specification, exploitation and results shaping.

6.4 General approach and content

The Technology Evaluator will benefit from numerous recent or on-going European studies on:

1. Collaborative Engineering and Multi-disciplinary Design Optimisation, addressing environmental effect of new technologies at aircraft design level (e.g. VIVACE (FP6)),
2. New operational procedures for minimal environmental effects in airport vicinity (e.g. SOURDINE II (FP5) or OPTIMAL (FP6)),
3. Environmental impacts at Air Transport System level, including inventories and scenarios. Among them: AERO2K (FP5, ATS global emissions), CONSAVE 2050 (FP5, ATS global scenarios, up to 2050), SPADE (FP6, environmental issues at airport level), QUANTIFY (FP6, climate impact of global European transport system).

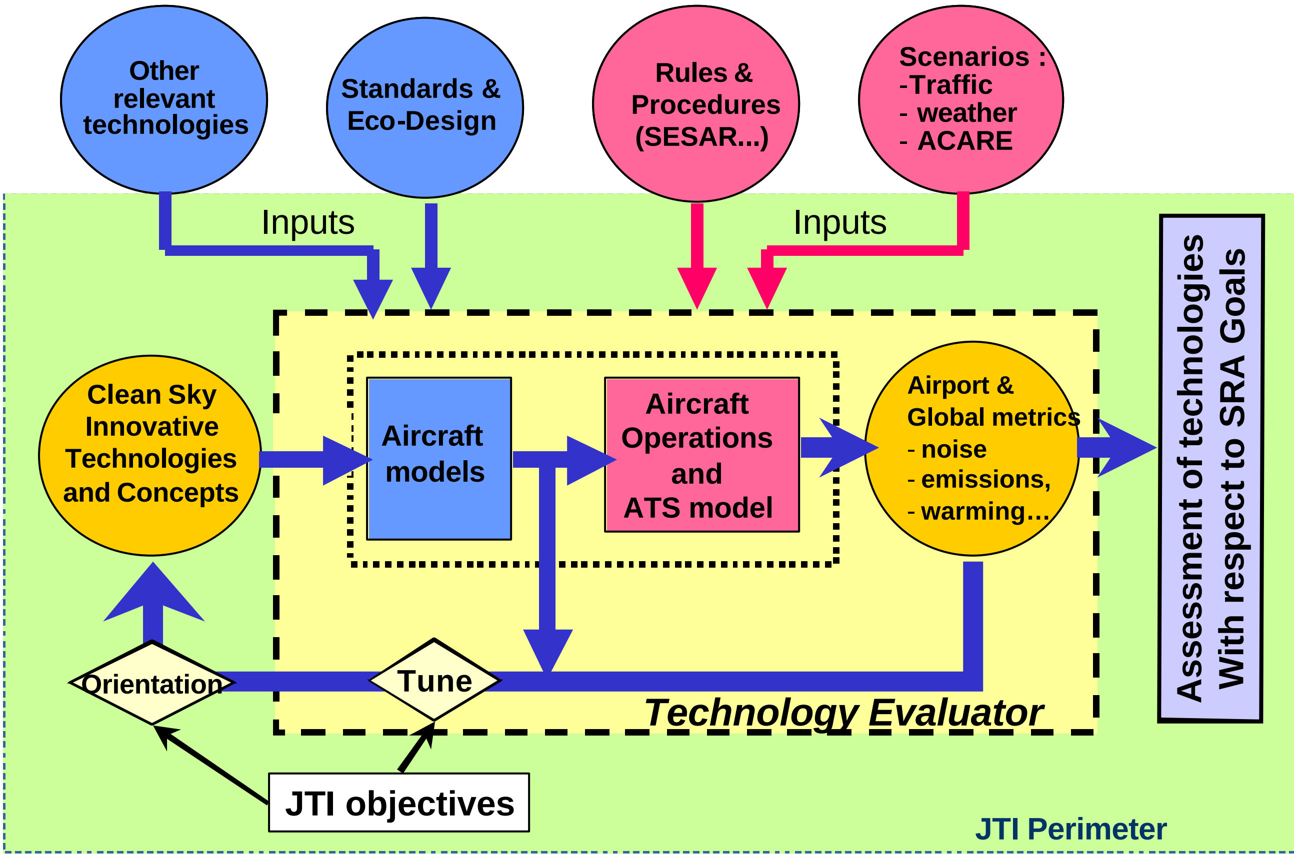
The "Clean Sky" Technology Evaluator will capitalize on models and methodologies developed for all of these studies.

It will specially focus on the impact of introduction of detailed **new Conceptual Aircraft** types, progressively replacing aircraft of the present generation.

The Technology Evaluator will translate the impact of innovative (platform) technologies in terms of overall ATS performance with respect to environmental objectives; it will consist of 3 levels of assessment, each having its own features, dedicated models, metrics and feedback loops:

- Aircraft Model evaluation level, focussing on aircraft design to consider integration aspects for technologies consistency and balance. This evaluation level will mostly rely on the technology assessment performed within the platforms.
- Aircraft Operations level, covering the performance of the aircraft in the context of local air quality, noise and capacity around airports. Departure/approach procedures and Air Traffic Management as developed within SESAR will be applied to transitioning mixed fleet of "Old" and new "Clean Sky" Conceptual Aircraft.
- Air Transport System level, where the global impact of Clean Sky technologies will be assessed in terms of contribution to climate changes and environmental cost, for instance for the Eco-design platform.

Technology Evaluator Input/Output scheme:



The Technology Evaluator will consider inputs coming both from inside and outside of "Clean Sky" perimeter:

- Environmental "Clean Sky" objectives, derived from ACARE targets.
- Innovative "Clean Sky" technologies and concepts, to be evaluated through their insertion in new Conceptual Aircraft whose performance will be modelled.
- Other potentially applicable innovative technologies, not covered by "Clean Sky" platforms developments (nanotechnologies, new fuels…), if they prove to be of real interest.
- Relevant standards, eco-design requirements and various regulations.
- Air traffic growth assumptions (derived from ACARE scenarios or other sources).
- The evolution of ATM, mainly fed by the SESAR study, with which a tight coordination will be achieved by Clean Sky.

The Technology Evaluator will deliver environmental metrics at different levels: aircraft, airport and global (Earth). These metrics will be used internally to Clean Sky, for tuning or orienting technology insertion within the Conceptual Aircraft solutions.

Airport or global metrics will also permit assessment of expected ATS impact with respect to ACARE goals.

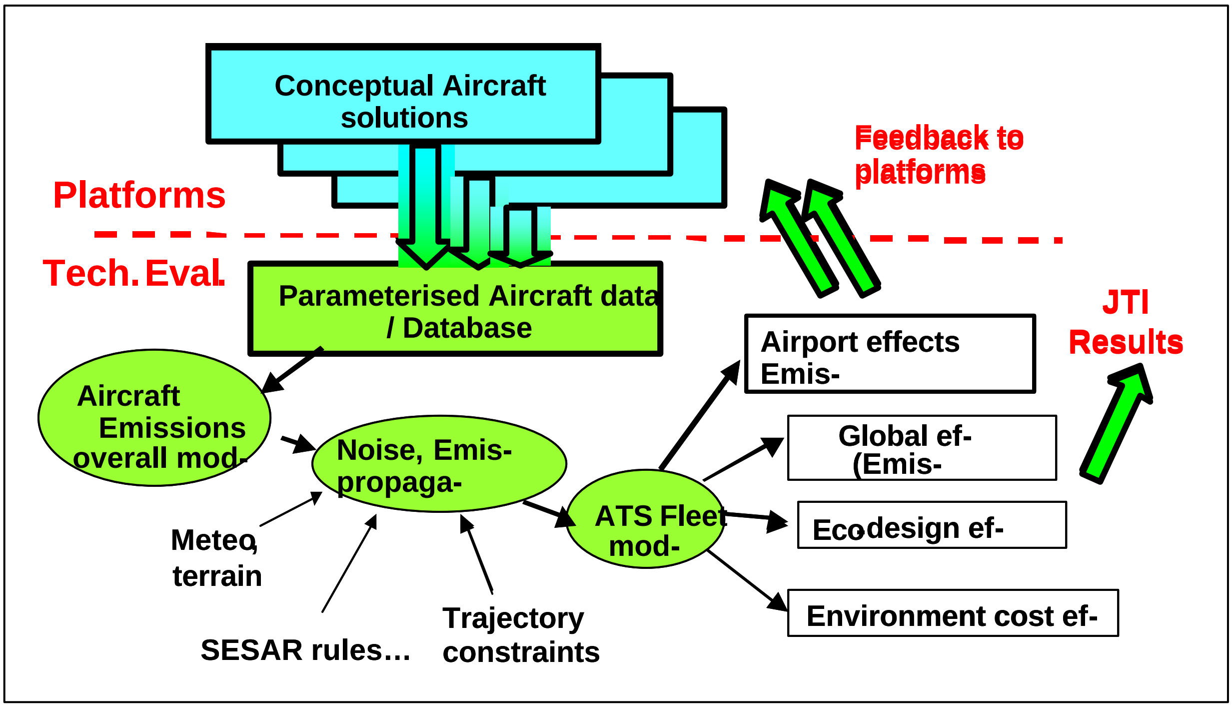
6.5 Technical approach and interface with platforms

The definition of optimised cases for new Conceptual Aircraft will be done within "vertical" platforms (Smart Fixed Wing, Green Regional, Green Rotorcraft), integrating internal technologies and technologies coming from the "horizontal" platforms (Engines, Systems, Eco-design). The aircraft Integrators will be responsible for Conceptual solutions validity, using internal know-how and tools.

Each new Conceptual Aircraft solutions will then be translated into a **Parameterised Aircraft model,** within its originating platform.

Each Parameterised Aircraft model will be a complex set of data, characterising the aircraft in terms of flight performance (flight envelop, engine thrust, drag…) and environmental features (specific engines emissions, noise contributions versus flight phase, contents of polluting materials at disposal…). Regarding noise, main aircraft contributing elements will possibly be characterized independently, for specific assessment of each technology in the overall result.

The Parameterised Aircraft data sets will be organized for use with databases, whose structure will permit both representations of present aircraft to be used as references, and of new Conceptual Aircraft solutions.



The Technology Evaluator models will derive overall Noise and Emissions models for each Aircraft type and will compute Noise and Emissions ground effects, depending on aircraft trajectories and, if required, meteorology conditions, local digital terrain model… Then overall fleet contribution, derived from harmonised and consistent scenarios will be summed up, to derive airport noise dB contours, local air quality contributions and global effects through CO2 and other emissions with climatic impact. Eco-design and environmental cost effects will also be evaluated.

The Technology Evaluator probably will be operated over a distributed network.

Depending on the final Mode of Operation that will be decided between “Clean Sky” participants during early definition phases, its architecture could be either based on a limited number of simulation replications, running independently on different sites using and feeding local databases for aircraft definition and results, with periodical results consolidation at “Clean Sky” level, or a fully distributed system enabling multiple running capability from common distributed databases for inputs and results.

The network distributed simulation structure will also permit remote operation of simulation models or modules that can stay resident within any participant facility and just propagate selected data over the network.

Whenever applicable, distributed real time or fast time simulations could be set up

Whichever architecture solution is decided, integration and validation of successive simulation versions, as well as configuration control will be performed under responsibility of one or of a group of “Clean Sky” members.

6.6 <u>Exploitation - Deliverables</u>

Technology Evaluator development will be a continuous effort during nearly all “Clean Sky” duration, with delivery of several upgraded versions.

Assuming initial specification and definition phase (6 months), a first operational version of the Technology Evaluator shall be ready around 2 years after contract (integrated and validated on present reference aircraft types and fleet). This is early enough to play an active role in the selection process of “Clean Sky” Demonstrators (around 2010).

A new significant version should be delivered on a yearly basis, following new achievements in technology platforms for which constant support will be delivered.

Continuous refinement of models will keep on, until Ground or Flight tests of “Clean Sky” Demonstrators. If necessary, the final version will be fine-tuned to reflect experimental results.

A final extensive exploitation phase will deliver contribution to final “Clean Sky” report.