AirTN-NextGen Seminar
Towards virtual certification: Key challenges in the field of simulation capabilities for European Research Infrastructures.
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TOICA

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v1

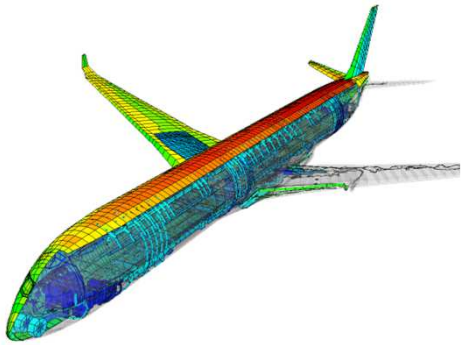
Contents

TOICA at a glance

TOICA stands for "**T**hermal **O**verall **I**ntegrated **C**onception of **A**ircraft"
It is a **3-year** European project coordinated by Airbus that started in September 2013. Its Consortium gathers **32 partners** from 8 countries, for a total budget of **26.5M€.**

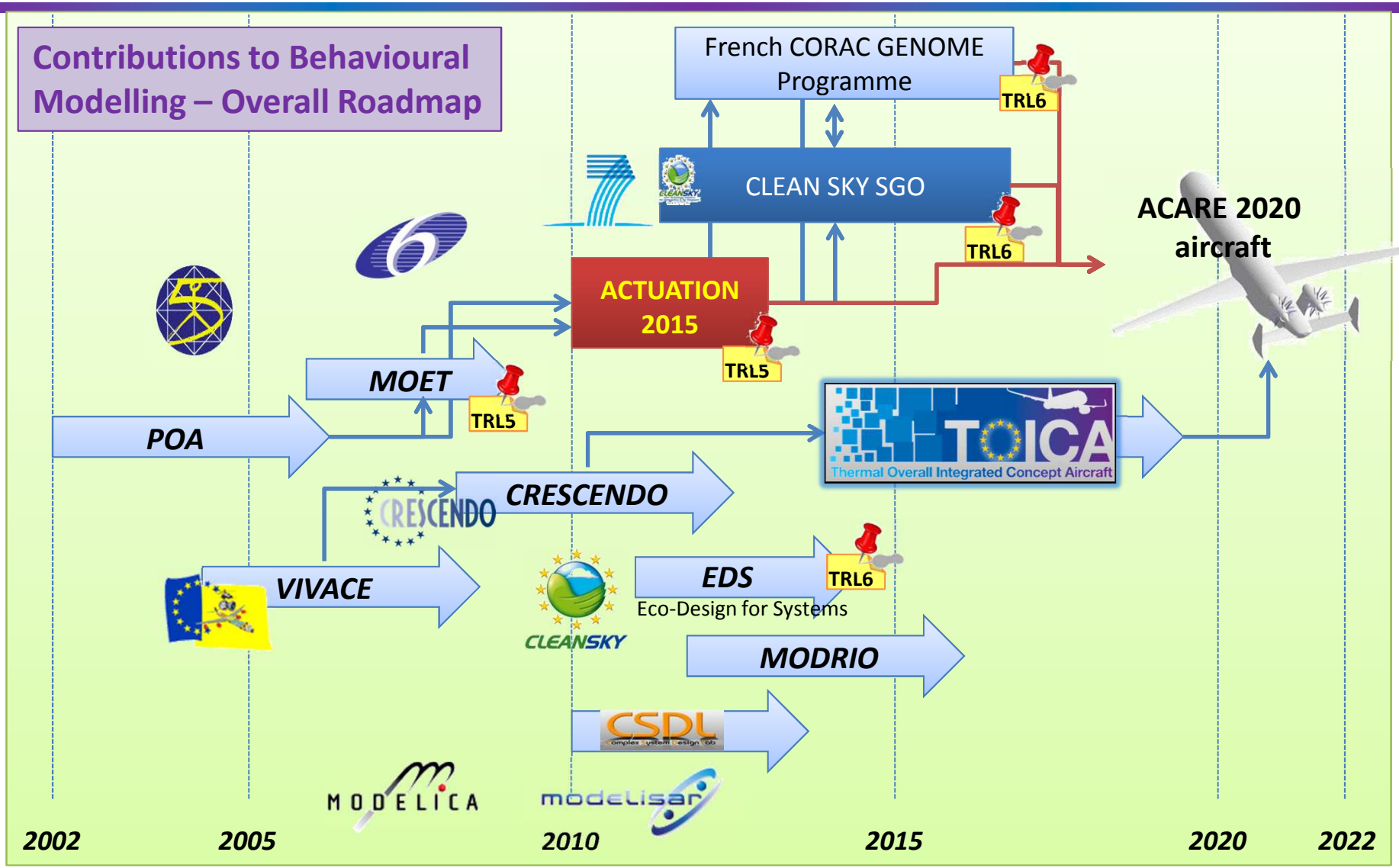
TOICA intends to:

- Develop a **dedicated thermal architecture** for the whole aircraft
- Build a complete **transverse thermal process view** impacting the overall aircraft design, from the architecture phase to the certification
- Extend the **Behavioural Digital Aircraft environment** with new capabilities

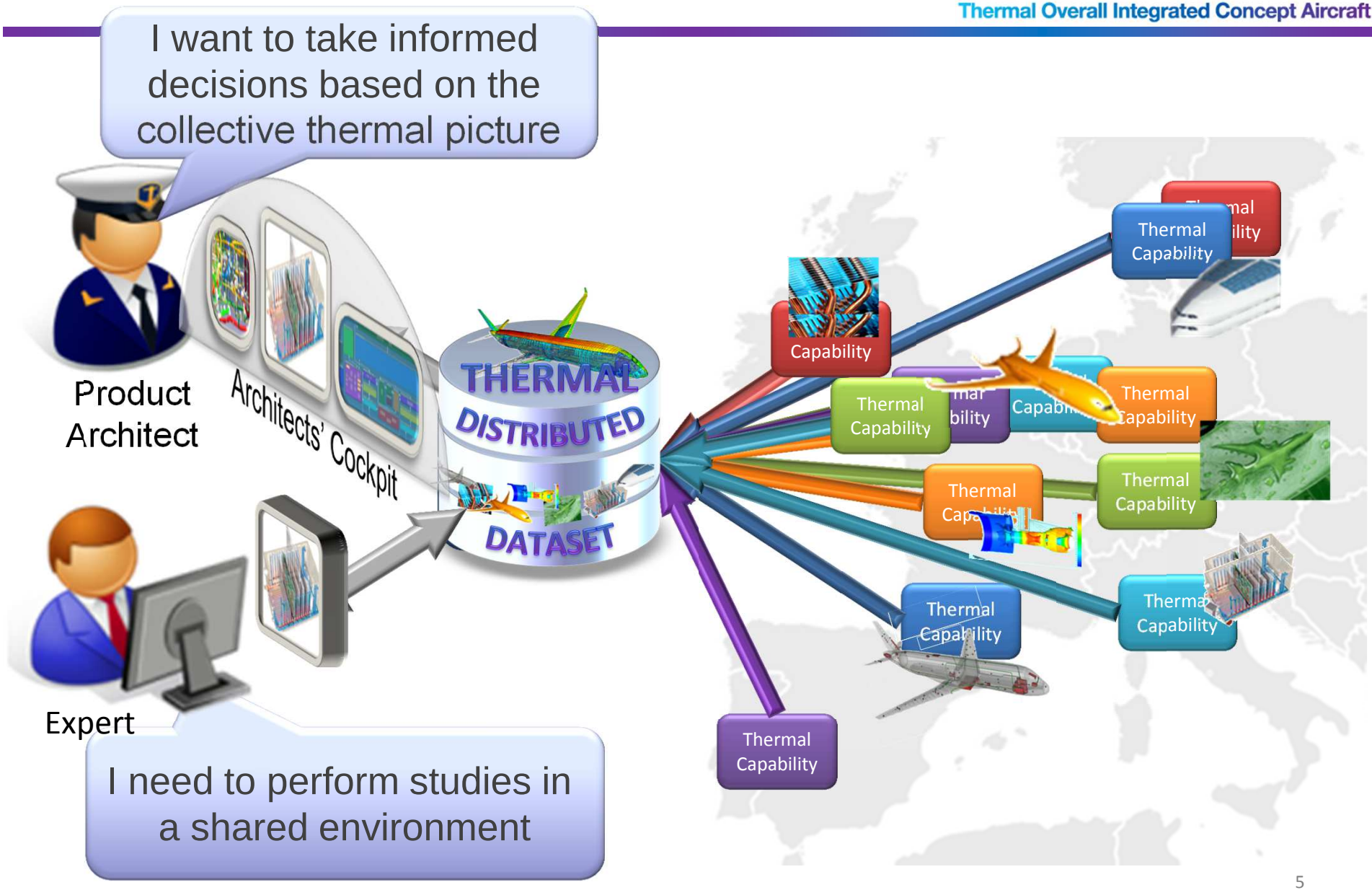


*TOICA will provide a complex representation of the **thermal behaviour** of the **whole aircraft** and will support the **overall product architecture and design**.*

The history of TOICA



The business needs



TOICA High-level objectives

TOICA defined four high-level objectives to improve the methodologies and processes for aircraft design.

HLO1: Develop **customised collaborative and simulation capabilities** improving the generation, management, and maturity of the **B**ehavioural **D**igital **A**ircraft (**BDA**) dataset.

HLO2: Develop **new concepts for improved thermal load management** for aircraft components, systems and equipment, which will integrate innovative cooling technologies and products.

HLO3: **Assess and validate** the developed capabilities and technology concepts **against different common reference aircraft** targeting both “EIS 2020 and EIS 2030+ Thermal Concept Aircraft”.

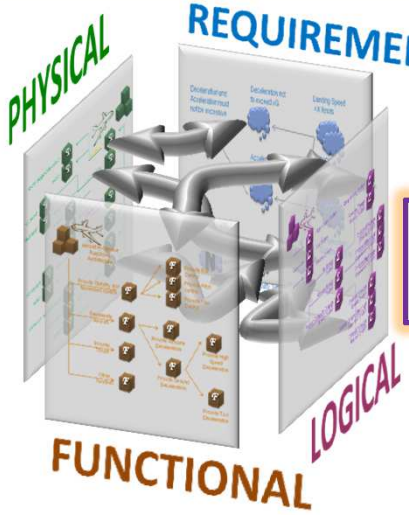
HLO4: Optimise aircraft design by **enabling highly dynamic allocation and association between requirements, functions and product elements** (Super integration) for product innovations.

What will TOICA address?

AIRFRAMER

Technical Requirements

Functions



Super Integration

HOW TO CHALLENGE REQUIREMENTS & SOLUTIONS ?

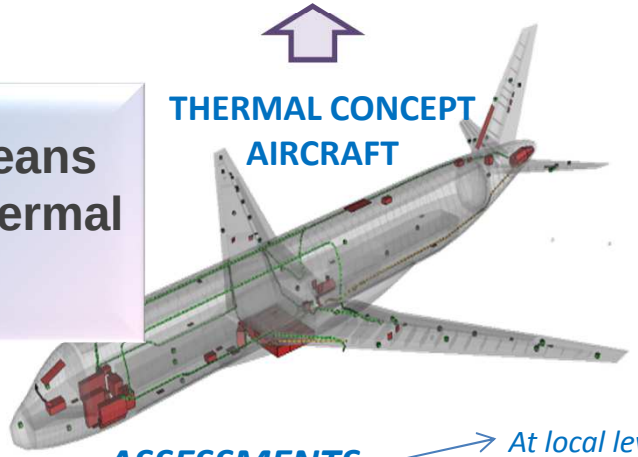
CONTROL, MONITOR & DECIDE

DEFINE THE ARCHITECTURE

Functional view

TOICA will deliver to the architects the means to build, manage and assess the overall thermal concept aircraft definition.

THERMAL CONCEPT AIRCRAFT



Physical view

ASSESSMENTS

At local level
At global level

Thermal behaviour
Structural behaviour
Performance ...

TOICA Consortium

Industry	Software Editors	SMEs	Research centres	Universities
AIRBUS (F, D, UK)	DASSAULT SYSTEMES	ARTTIC	DLR	CAMBRIDGE
ALENIA	EUROSTEP	ATHERM	EADS-IW	CHALMERS
DASSAULT AVIATION	LMS IMAGINE	CENAERO	NLR	CRANFIELD
EUROCOPTER	LMS SAMTECH	EPSILON	ONERA	PADOVA
GKNAES	MAYA HTT	XRG		QUEEN'S
INTER-TECHNIQUE	MSC			
LIEBHERR	SIEMENS			
SNECMA				
THALES				
11	7	5	4	5

32 partners from 8 countries

Expected results & key deliverables

TOICA will demonstrate how to build the **complex representation of the thermal behaviour of the complete aircraft**.

TOICA will also deliver new advanced capabilities:

- **An architect cockpit,** to allow the architects and experts to monitor the thermal assessment of an aircraft, to perform trade-off studies, and to define a robust convergence plan for the product development
- **Super integration mechanisms** to support the **holistic view** of the aircraft and to organise the design views and the related simulation cascade
- Improved **multidisciplinary methods and simulation capabilities** for the evaluation of new thermal aircraft concepts

Integration of new technologies

Thermal Overall Integrated Concept Aircraft

Common reference aircraft

Benefits assessments

Fuel & water waste heat sinks

Equipment in un-pressurised compartments

Full liquid cooling

Optimised pylon for engine with BPR = 18

Etc…

Thermal architectures

Best final architecture

Integration of best solutions

USE CASES WILL DELIVER NEW RADICAL ARCHITECTURE ALTERNATIVES

Architect support

Modify Concept

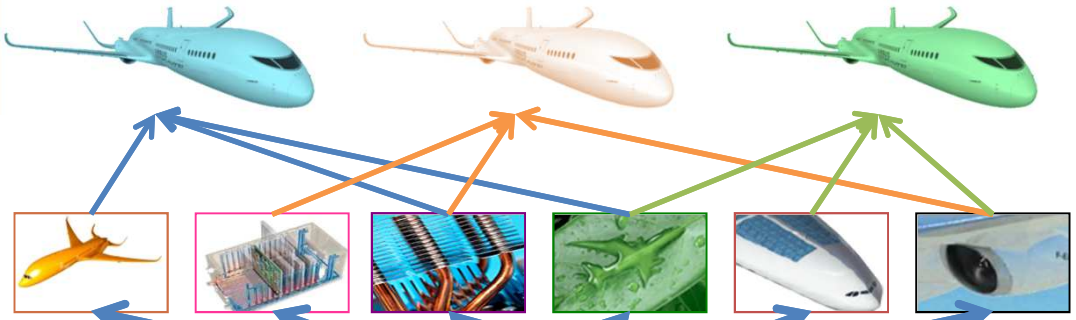
- Modify trade-off
- Combine solutions
- Reuse lessons learnt
- Add innovative solutions
- Assess risks vs. margins and decide new targets
- etc.

Assessments

Alternative A

Alternative B

Alternative C



Options

Modify Process

- Reconfigure cockpit with new targets, trades, KPIs
- Change the overall process
- Process & performance analysis (TCQ)
- Launch new collaborations
- etc.

Define/Update aircraft baselines

Architect Cockpit

Trade-off analysis and decisions

Curves | Dashboards | Spider-charts

Behavioural reviews

Curves | Navigation | Exploration

Quality Gate

Define/Update/Operate trade-offs

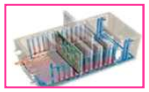
Define/Update simulation framework

TOICA use cases

Thermal Overall Integrated Concept Aircraft

Cooling technologies

Traditional air cooling solutions reach their efficiency limits regarding the important heat dissipation densities to extract from next generation equipment. Implementation of new cooling technologies is now mandatory.

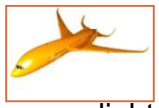


Equipment integration

The thermal environment of equipment drives both equipment performance and reliability. More integrated architecture and highly dissipative equipment challenge the usual equipment integration methods.

Engine integration

Engines will have higher by-pass ratios, be warmer, and be deeply integrated in the aircraft structure or even embedded in aircraft body.



Future architectures

Future aircraft architectures will use light-weight materials, be more electrical, more reliable and much more efficient. The thermal challenges induced by these constraints have to be tackled at all scales.

Overall Thermal management

Thermal management consists of the reduction of energy consumption, and in the definition of more efficient transport of calories from sources to heat sinks. Thermal management is the wide scope of research in all industries for the coming years.

Aircraft heat sinks

The fuel, water waste, and other heat sinks will be fully integrated in the overall thermal management strategy for greener aircraft.

Target aircraft configurations

Thermal Overall Integrated Concept Aircraft

Two target aircraft configurations are considered within TOICA:

1. **EIS 2020**: Next aircraft entering into service in 2020's, deriving from existing aircraft and integrating innovative solutions for a set of components and/or systems or engine. Targeted aircraft families include **single aisle family** (Airbus), **Falcon business jet family** (Dassault Aviation) and **ATR regional aircraft family** (Alenia Aermacchi).

2. **EIS 2030+**: Next aircraft entering into service in 2030's, considering integration of a broader set of technologies with more radical aircraft configurations. The typical baseline is the next generation of **short range aircraft family** (A30X) from Airbus. This baseline will integrate most of the mature technical solutions investigated through the use cases in order to **reach an efficient thermal concept aircraft aligned with the 2050 vision**.

TOICA WBS organisation

Thermal Overall Integrated Concept Aircraft

SP1 - BDA capabilities enabling Architecture Evaluations Platforms supporting Aircraft Design Concepts :
WP11 - Super-Integration capabilities to enable global simulations
WP12 - Architect Cockpit capabilities enabling trade off management and execution
WP13- Additional BDA collaboration capabilities

SP2 - Multi-disciplinary M&S Capabilities for new thermal aircraft concept evaluation :
WP21 - Parametric Aircraft Modelling
WP22 - Fast Technologies for Preliminary Assessments
WP23 - Multi-Physics & Multi-Level Coupling Methods for new thermal requirements
WP24 - Multi-Objective and Overall thermal aircraft optimisation capabilities
WP25 - Robust simulation capabilities for Risk Reduction

SP3 - Application through Use Cases :
WP31 - Future architectures - WP32 - Equipment Thermal integration
WP33 - Cooling technologies - WP34 - Aircraft heat sinks
WP35 – Thermal management for system optimisation - WP36 - Powerplant integration

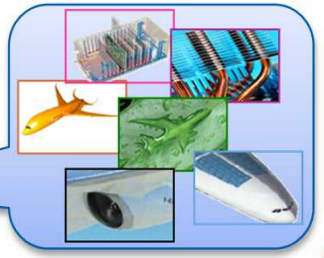
PLATEAUS

SP4 - Thermal Trade-Off and A/C Alternative Selection - Integrated Demonstration of Thermal Super-Integration for a 2020/2030+ EIS Aircraft
WP41 - Produce the Baseline Aircraft Data-Set
WP42 - Launch Thermal Trade-Off Evaluations
WP43 - Define, prepare and execute collaboratively thermal Super-Integration Innovation Scenarios
WP44 - Value Assessment of Innovations through Super-integration

SP5 – TOICA Project Management
WP51 - Technical coordination
WP52 - Administrative coordination
WP53 – Dissemination & exploitation

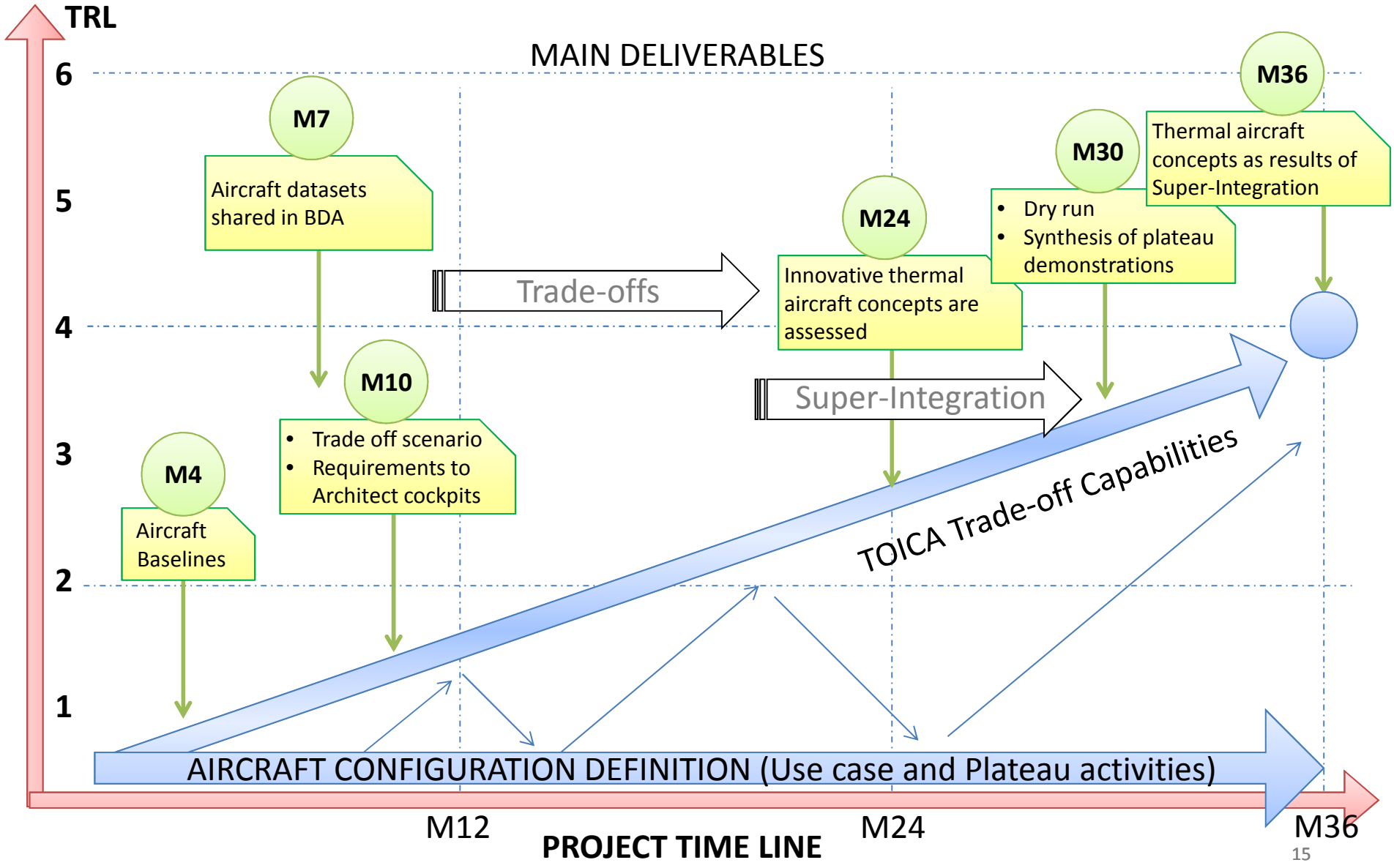
SP1 & SP2 develop and deliver capabilities

SP3 & SP4 specify and validate

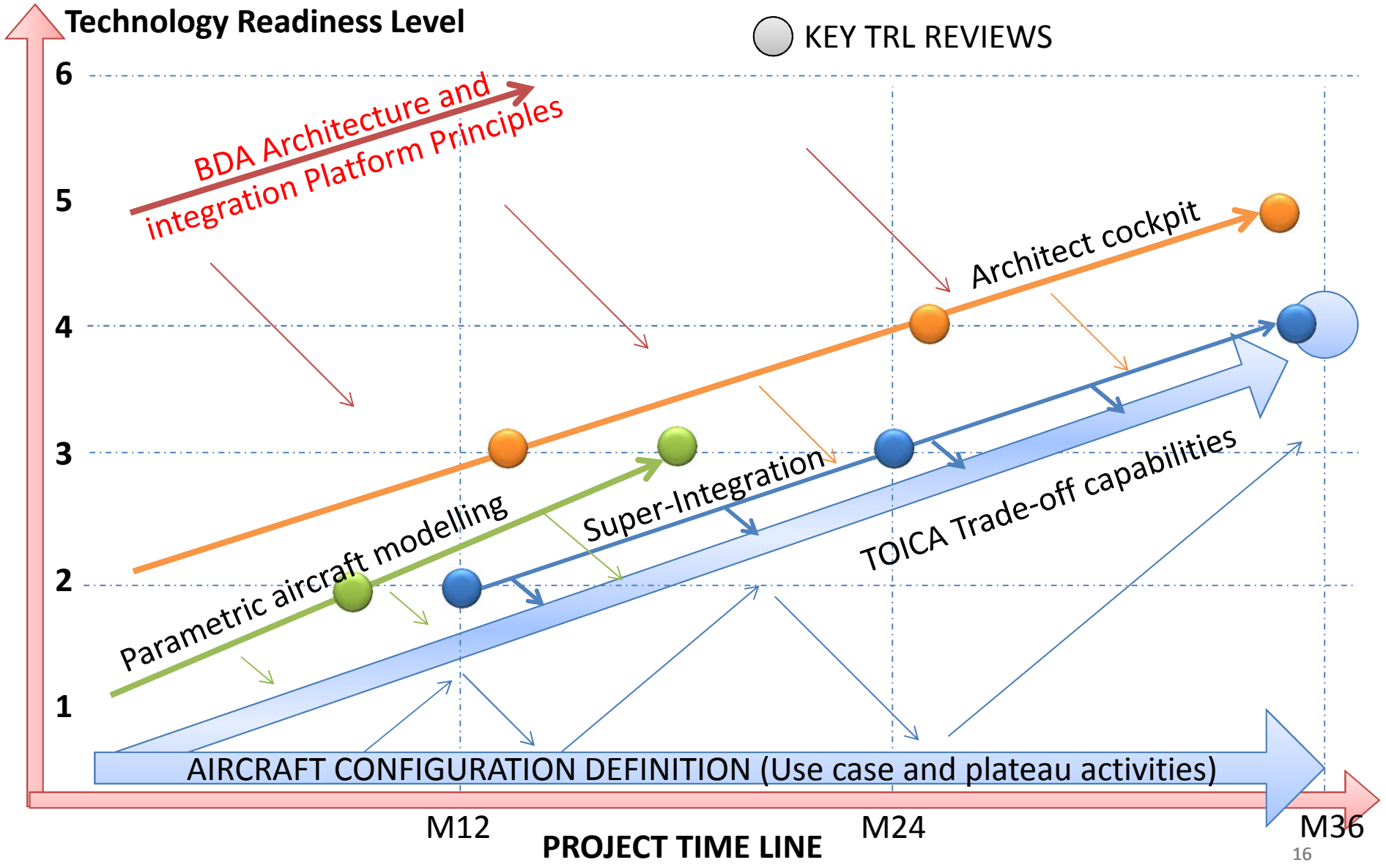


Study requests
From architects
Solutions from use cases

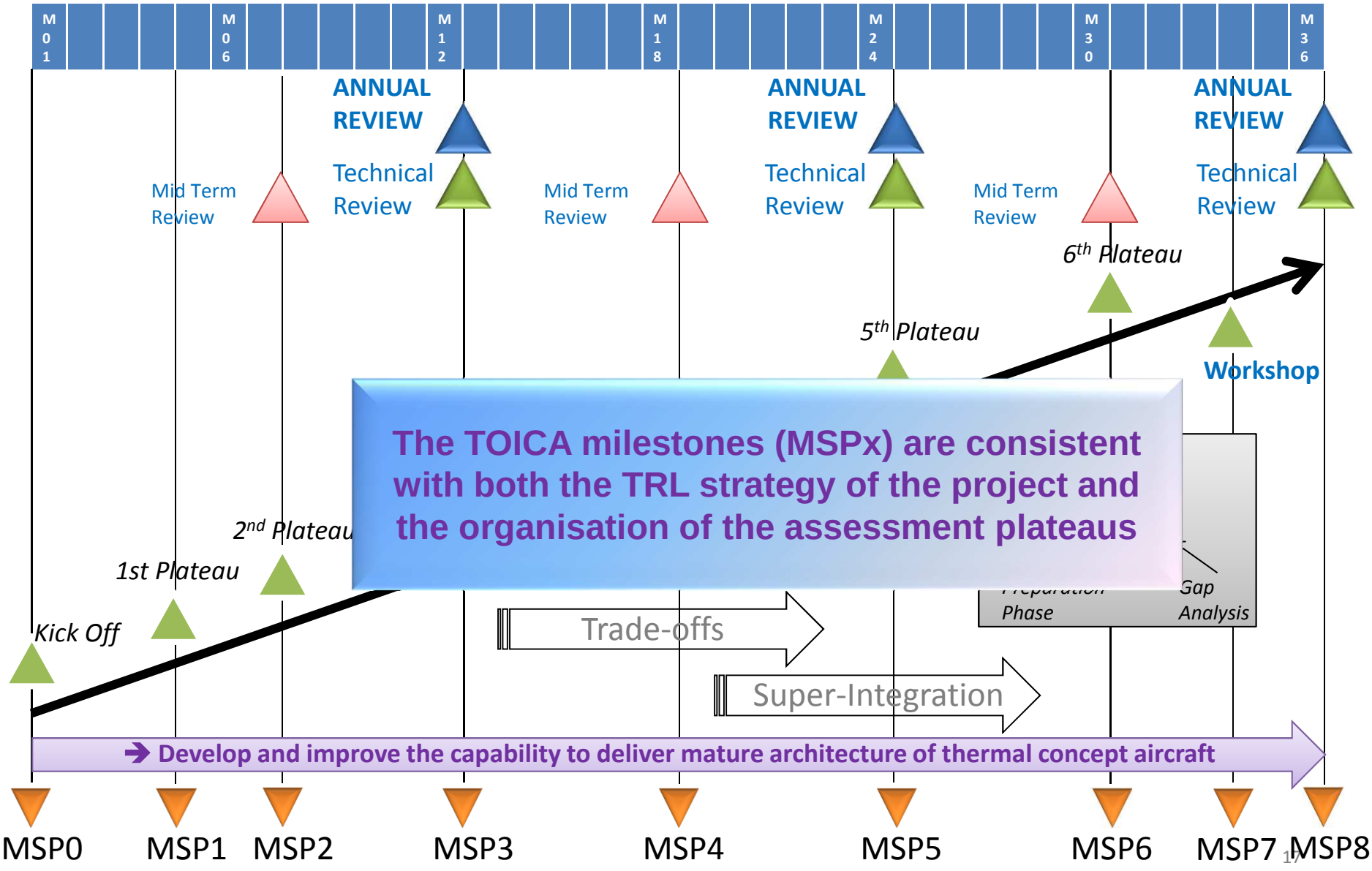
Maturity we want to demonstrate



Maturity we want to demonstrate



TOICA milestones and roadmap



The TOICA milestones (MSPx) are consistent with both the TRL strategy of the project and the organisation of the assessment plateaus

Expected impact of TOICA (1/2)

TOICA directly addresses “Challenge 3 – Competitiveness through innovation” of the **ACARE SRA2** High Level Target Concept (HLTC) “High Efficient Air Transport System” and subsequent SRIA issued in September 2012. It will impact:

1. **Aircraft development costs**: TOICA will contribute to:
   - **Reduce by 10% the equipment development cost** thanks to a more robust specification process allowing equipment supplier or risk sharing partners to design systems and equipment according to more realistic margins.
   - Reduce the costs and time associated to integration and installation of systems and equipment in aircraft by strongly reducing the need for late rework.
2. **Supply chain efficiency:** TOICA will contribute to:
   - Reduce by **50%** the **lead time of an aircraft thermal architecture assessment** to drop below three months.
   - **Shorten by 6 months the equipment development process** by improving the exchanges of thermal requirements with the suppliers by sharing the overall thermal view information across the supply chain.

Expected impact of TOICA (2/2)

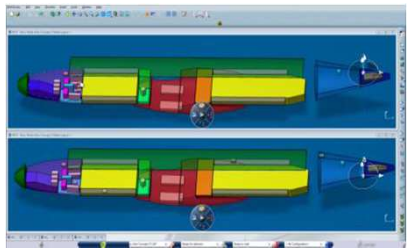
3. Aircraft operational costs: Through the **6 TOICA use cases**, new methods and processes will be investigated for integrating new technical solutions or more efficient system architectures in order to:
   - Reduce **by 5% the energy/power consumption** used for active cooling or controlling (heating) of systems
   - In[illegible] s the di[illegible]
4. Collab[illegible]
   - Im[illegible] during the architecture phases
   - Optimise the **overall thermal management** of the aircraft through a reduction of the aircraft energy consumption
   - **Reduce thermal constraints** on systems and structure, and thermal integrated risks
   - **Reduce weight and complexity** through a fully integrated structure / systems thermal design

Thanks to its specific Consortium makeup and innovative plateau organisation, TOICA will be an important enabler for the reduction of development costs and an added value for the complete supply chain.

TOICA is exploitation-oriented

Thermal Overall Integrated Concept Aircraft

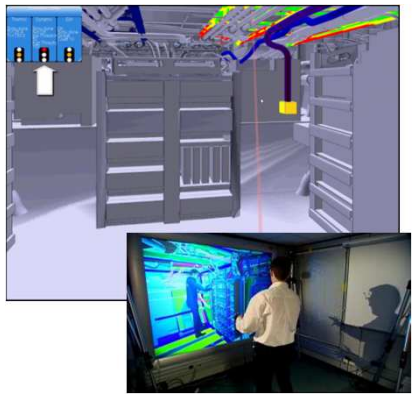
Architects and experts will work with Behavioural Digital Aircraft in A/C programme-like conditions: plateau phases will be organised along the project for use case deliveries, managing the interactions with the enablers: Super Integration, techno, simulation, collaborations



TOICA intends to provide crucial thermal innovations to challenge current architectures and demonstrate a deep integration of the thermal constraints in the multi-level, multi-disciplinary design. A/C architects are sponsors of the project.

TOICA will deliver to the new airframer programmes the capability to organise and adapt design processes and methods between designers and suppliers to reach an overall thermal optimisation of the aircraft.

TOICA targets to deliver the most mature and innovative architect work bench tested, improved and operated for the concepts selection of the next aircraft generation.



Questions

Thank you

This publication reflects only the author's views and the European Union is not liable for any use that may be made of the information contained therein. The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 604981.

TOICA TRL process

For each of the key results of TOICA, Technology Readiness Level (TRL) reviews will be performed to **assess the progress and maturity of the key capabilities** delivered to engineers.

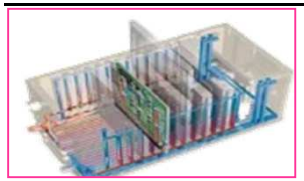
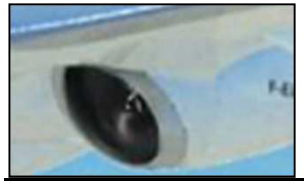
Super integr L4 at M36
Architect co L5 at M36
Advanced m L3 at M18
Thermal trad L4 at M36

In parallel, the BDA Data Exchange Specification (DEX) will be submitted to standardisation through ASD-SSG (MOSSEC).

Specific demonstrations in plateaus and dedicated evidence will be produced by the project to support the TRL process.

TOICA use cases (2/2)

Thermal Overall Integrated Concept Aircraft

	Aircraft architectures	Leader: AI-F	Provide to architects a set of tools to thermally evaluate the investigated aircraft architecture, measure the right high level metrics, identify alternatives and support decision making.
	Equipment thermal integration	Leader: EADS	Ensure tight links between equipment, systems and airframe manufacturers to enable design optimisation in a multi-level integrator/supplier relationship context.
	New cooling technologies	Leader: THALES	Evaluate the candidate techniques foreseen for the cooling of future equipment.
	Heat load management	Leader: ALENIA	Demonstrate that more benefits can be taken from aircraft heat sinks by enhancing the evaluation and prediction of the heat transfers between fuel, the fuel systems and the aircraft structures, while considering all related risks.
	Thermal (energy) management for system optimisation	Leader: DASSAV	Increase the performance of aircraft systems by optimising links between generation, transmission and storage of thermal energy.
	Powerplant integration	Leader: GKNAES	Develop requirements, methods and tools to analyse and orient the Powerplant integration in the early development phase. Collaborative design and optimisation will be key enablers of the new engine integration process.