# Publishable Summary from the TOICA M12 Periodic Report

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# Contents

# 1 Partner List

| Part N° | Short Name | Legal Name |
|---|---|---|
| 1 | AI-F | AIRBUS OPERATIONS SAS |
| 2 | AI-D | AIRBUS OPERATIONS GMBH |
| 3 | AI-UK | Airbus Operations Limited |
| 4 | ALENIA | ALENIA AERMACCHI SPA |
| 5 | ARTTIC | ARTTIC |
| 6 | ATHERM | ATHERM |
| 7 | CENAERO | CENTRE DE RECHERCHE EN AERONAUTIQUE ASBL - CENAERO |
| 8 | CHALMERS | CHALMERS TEKNISKA HOEGSKOLA AB |
| 9 | CRANFIELD | CRANFIELD UNIVERSITY |
| 10 | DASSAV | DASSAULT AVIATION SA |
| 11 | DS | DASSAULT SYSTEMES SA |
| 12 | DLR | DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV |
| 13 | EPSILON | EPSILON INGENIERIE |
| 14 | AI-H (ECPTR) | Airbus Helicopters (formerly EUROCOPTER SAS) |
| 15 | AGI (EADS) | Airbus Group (formerly EUROPEAN AERONAUTIC DEFENCE AND SPACE COMPANY EADS FRANCE SAS) |
| 16 | EUROSTEP | Eurostep AB |
| 17 | GKNAES | GKN AEROSPACE SWEDEN AB |
| 18 | ZA-INT | Zodiac Aerotechnics SAS (formerly INTERTECHNIQUE SAS) |
| 19 | LTS | LIEBHERR AEROSPACE TOULOUSE SAS |
| 20 | LMS-IMG | LMS IMAGINE SA |
| 21 | MAYA | MAYA HEAT TRANSFER TECHNOLOGIES LTD |
| 22 | MSC | MSC Software GmbH |
| 23 | ONERA | OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES |
| 24 | LMS-SAM | SAMTECH SA |
| 25 | SIEMENS | SIEMENS INDUSTRY SOFTWARE LIMITED |
| 26 | SNECMA | SNECMA SA |
| 27 | NLR | STICHTING NATIONAAL LUCHT- EN RUIMTEVAARTLABORATORIUM |
| 28 | THALES | THALES AVIONICS SAS |
| 29 | CAMBRIDGE | THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE |
| 30 | QUB | THE QUEEN'S UNIVERSITY OF BELFAST |
| 31 | PADOVA | UNIVERSITA DEGLI STUDI DI PADOVA |
| 32 | XRG | XRG SIMULATION GMBH |

# 2 Publishable Summary

## 2.1 Project Context and Objectives

Thermal behaviour of aircraft has recently become a crucial subject, for many reasons:

- The increasing number of complex systems required by modern, more electric, commercial aircraft (the total heat load generated by equipment has almost doubled in ten years)
- The introduction of hotter engines with higher by-pass ratios (the temperature of the engine primary flux increased by more than 150°C since the A320)
- The increased use of composite material in aircraft structures (a carbon/epoxy composite material is a hundred times less conductive than aluminium alloy),
- The confinement of highly dissipative equipment and systems in smaller areas to gain space for passengers and cargo

New advanced techniques to manage the aircraft thermal behaviour at the very early stages of development are essential to take the right configuration decisions while meeting market demands.

To work efficiently, and with emerging innovative solutions, it is essential to perform thermal management at the global aircraft level. Today, thermal studies are performed for sizing, stress or risk analyses in the context of systems and equipment integration.

The **TOICA project** intends to radically change the way thermal studies are performed within aircraft design processes. It will enable architects to manage the **thermal impact on the overall aircraft architecture** (which today is not possible) that will provide an optimised thermal behaviour of the overall aircraft. This will be shared in the extended enterprise with design partners through a collaborative environment supporting new advanced capabilities developed by the project:

- An Architect Cockpit, to allow the architects and experts to monitor the thermal assessment of an aircraft and to perform trade-off studies
- Super-integration, to support a holistic view of the aircraft and to organise the design views and the related simulation cascade

It will be achieved by:

- Proposing thermal architectures for improvement of conventional aircraft configurations as well as innovative architecture for the next aircraft generation, based on realistic industrial examples. These will be tested and validated in near-program conditions within an extended enterprise environment
- Improving the means for aircraft thermal experts and architects to better perform their operational role of design leader and arbitrator within the multi-partner and multidisciplinary design environment of today. A dedicated thermal architecture environment will be developed to support the decision process for aircraft design (Architect Cockpit)
- Studying new concepts for improved thermal load management of aircraft components, systems or equipment, integrating innovative cooling technologies and better exploitation of thermal heat sinks
- Developing multidisciplinary methods and simulation capabilities for new thermal aircraft concepts evaluation

The Behavioural Digital Aircraft (BDA) platform produced by the CRESCENDO project (2009-2012) is a key input and enabler for the project. TOICA will fully exploit the environment and develop additional capabilities to enable the non-conventional interaction of the different elements of the thermal dataset.

Six use cases illustrating new thermal strategies will demonstrate the benefits of the TOICA approach on realistic aircraft configurations.

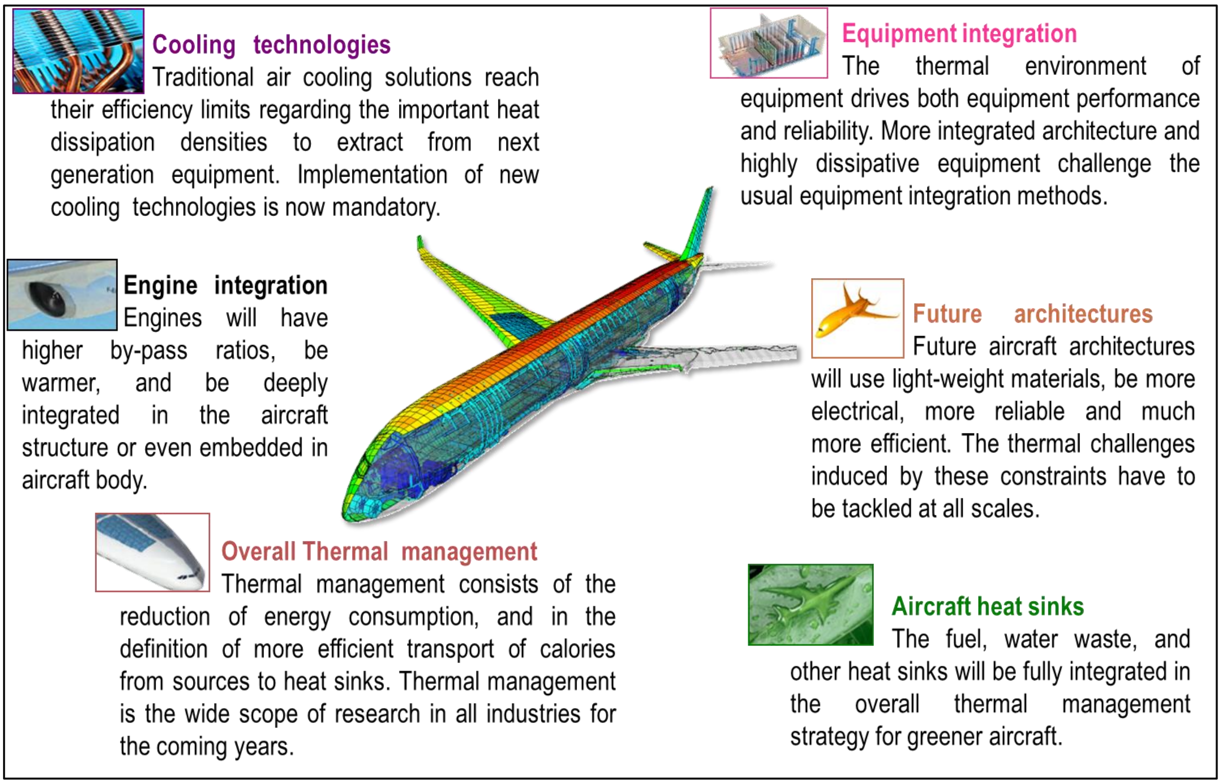


**Figure 1: Description of the six TOICA Use cases**

Throughout the project, a number of technical “plateaus” are organised with architects from Airbus, Dassault Aviation and Alenia and involve the whole consortium to:

- Test and improve the trade-off processes that will be increasingly instrumented by the capability enablers
- Validate the definition, selection and evaluation of thermally optimised aircraft configurations

These “plateaus” represent major milestones and are held to “drumbeat” the progress of the project.

In parallel, Technology Readiness Level (TRL) evaluations are put in place to assess the maturity of the developed technologies and support the deployment and exploitation of the TOICA results.

## 2.2 Work Performed and Main Results Achieved

### 2.2.1 Project launch

The TOICA project started 2nd September 2014. The kick-off meeting in October gathered all sub-project and work package leaders together with representatives from each partner. Product architects and project sponsors attended the first day of the meeting to express their support.

Intermediate technical kick-offs were organised between SPs in September in order to share and harmonise objectives and roadmaps.

To increase awareness of the project vision, the public website was launched (www.toica-fp7.eu), public dissemination documents were produced (leaflets, presentation, etc.), and the first presentations at conferences were made.

### 2.2.2 Milestones and plateaus

**The first project milestone (MSP1)** was successfully reached and gathered in one single technical plateau all actors (85 attendees). The objectives of the plateau, held 10-12 December 2013, were to:

- Clarify the roadmap and plan activities for next plateaus (MSPs)
  - Architects presented their detailed expectations
  - Aircraft baselines, roadmaps and first trade-off scenarios were described
- Present TOICA key concepts
  - Definitions of Architect Cockpit, Super-integration, Pyramid of Models, etc., were shared, discussed and challenged
- Understand and experiment capabilities
  - Conceptual capabilities were explained and handed over to SP3 actors, to be used for thermal trade-offs

**The MSP2 milestone** consisted in a series of three technical plateaus at AI-F, ALENIA, and DASSAV, which took place between 31st March & 11th April 2014. Dedicated Airbus Helicopters (ECPTR) sessions were included in the AI-F plateau. The objective of these plateaus was to review with architects and experts the technical progress on:

- The aircraft baselines and associated trade-off scenarios
- The capabilities required and to be developed for these trade-offs

The first technical implementation was done and tests appeared conclusive. Most target scenarios and trade-offs were specified and agreed by the architects.

MSP1 & MSP2 helped the partners to prepare the elementary capabilities for a first integration at **the MSP3 milestone** scheduled for September 2014.

### 2.2.3 TRL reviews

Internally to the Consortium, the first TRL reviews for Architect Cockpit, Super-integration & Flexible Model capabilities were held on 25th February 2014. Thanks to the quality of the presentations and the efforts made by the TOICA teams, the panels of experts were convinced by the maturity of the concepts presented.

Reviews were conclusive for:

- **Architect Cockpit**: TRL2 achieved
- **Flexible Model Generation**: TRL1 achieved
- **Super Integration**: TRL1 achieved

These innovative concepts underline the thermal trade-off capabilities developed in TOICA. On 5th June 2014, the **Thermal Trade-off Capabilities** were presented by the Project Coordinator to a panel of aircraft architects, industry representatives and Management Committee members. A TRL1 was achieved. This TRL review held at project level was the first step toward the TRL4 level targeted at the end of TOICA.

### 2.2.4 Main deliverables

The technical activities were mainly driven by the following project expectations:

- Define the work plan at aircraft level by describing the identified trade-offs, baseline configurations, and plateau targets (D41.1, D41.2 & D44.1)
- Structure and describe the use cases providing architects with the technical studies to be exploited during trade-offs (D31.1, D32.1 & D36.1)
- Deliver the first sets of data and descriptions of exchanges between partners in the thermal studies
- Specify and populate the BDA collaborative platforms (D13.1) with the data and metadata used during trade-offs and architect decision-making
- Submit requirements to the capability developers and start assessing the relevance of the technical solutions through a TRL process

- Deliver the first demonstrators of concepts for Super-integration (D11.1 & D43.1), Architect Cockpit (D12.1), and Pyramid of Models (D22.1 & D22.2)
- Apply management rules and prepare dissemination (D52.1, D52.2, D53.1, D53.2)

## 2.3 Expected Final Results and their Potential Impact and Use

### 2.3.1 Impact on aircraft development costs

TOICA will contribute to:

- **Reducing by 10% the equipment development cost** thanks to a more robust specification process allowing equipment suppliers or risk sharing partners to design systems and equipment according to more realistic margins.
- Reducing the costs and time associated to **integration and installation** of systems and equipment in aircraft by significantly reducing the need for late rework.

TOICA will provide important changes to current business practices through an introduction of a more robust, rigorous and collaborative design approach. The expected changes focus on the interactions between airframers, integrators and system designers. They are characterised by more efficient and robust specification and validation processes as the consequence of a new collaborative modelling and simulation approach.

TOICA capabilities will then reduce design lead-time by offering the capacity to perform **much more upstream analyses** to get a **right-first-time product design**.

### 2.3.2 Impact on aircraft operational costs

In parallel to trade-off capabilities, TOICA considers new technologies as a key source of innovation in thermal management and the driver of the next thermal concept aircraft.

Through its **6 use cases**, new methods and processes will be investigated for integrating new technical solutions or more integrated system architectures.

From these investigations, **TOICA will contribute to** optimise the thermal energy efficiency at Aircraft level and to **reduce** the global energy consumption necessary for thermal loads management.

TOICA will demonstrate at the end of the project:

- A reduction **by 5% the energy/power consumption** used for active cooling or controlling (heating) of systems
- An increase of the **Mean Time Between Failure (MTBF) by 15%** as the direct impact of more equipment-dedicated specifications

The TOICA partners are well aware that break-through technologies will be required to secure future competitive advantage, most notably in terms of thermal energy, management of complexity and environmental performance.

### 2.3.3 Impact on collaborative design

The concept of this project is built on various elementary enablers (Super-integration, Architect Cockpit, robust design, multi-level modelling and simulation capabilities, etc.) able to support and enhance the current trade-off approach. The intent is to offer architects and experts the opportunity to build and manage from end to end the complete **Pyramid of Models** allowing incremental and flexible analyses of aircraft alternatives and a better selection thanks to support for decision making.

TOICA will permit the **deployment of collaborative methods** to support the multi-level and multidisciplinary analysis and optimisation of new thermal aircraft architectures in order to:

- Improve the overall multidisciplinary conception of aircraft during the architecture phases

- Optimise the overall energy management of the aircraft by better controlling the thermal sources and sinks in the aircraft
- Reduce thermal constraints on systems and structure, and thermal risks
- Reduce weight and complexity by seeking a fully integrated structure / systems thermal design

### 2.3.4 Impact on supply chain

TOICA will use the Behavioural Digital Aircraft (BDA) environment to support the architecture of new thermal concept aircraft, thus enabling integrated multidisciplinary teams to work in the extended enterprise. The project expects to demonstrate to architects the following impacts:

- 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

### 2.3.5 Public impact

TOICA will communicate with the aeronautical community as a whole using means such as conferences, newsletters, and the public website (www.toica-fp7.eu).

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