Results

1. Periodic Report Summary 2 - CRESCENDO (Collaborative and robust engineering using simulation capability enabling next design optimisation)

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Abstract: Project context and objectives:
Context and challenges
In today's context of global competition, European aircraft, engine and equipment manufacturers are facing greater challenges than ever before:
- customers demand more complex products to be developed with shorter lead times and more cost effectiveness;
- environmental and regulatory constraints as well as market expectations demand more efficient aircraft behaviour;
- trade-off decisions are needed to manage the impacts of customer expectations and introduction of new technologies on operational and functional behaviour;
- globalisation means aircraft manufacturers and suppliers need collaboration solutions to work together in multi-disciplinary teams across the extended enterprise;
- behavioural characteristics need to be managed effectively throughout the development lifecycle to avoid rework;
- multi-physics analysis is needed to eliminate risks early in the design process and to accurately predict functional behaviour in the detail definition phase;
- testing and certification is more and more demanding and needs to be anticipated by simulation to reduce need for repeat physical testing

CRESCENDO addresses the critical challenge to ensure product maturity (at all levels) at entry into service, by improving the management and evolution of the aircraft behavioural dataset from concept to certification.

High-level objectives and impact
The ambition of the CRESCENDO consortium is to initiate a step change in the way that Modelling and simulation (M&S) activities are carried out, by multi-disciplinary teams working as part of a collaborative enterprise, in order to develop new aeronautical products in a more cost and time efficient manner. CRESCENDO results, once deployed and exploited, should then contribute to the following High-level technical objectives:
- 10 % reduction of development lifecycle duration and cost;
- 50 % reduction in rework; and finally
- 20 % reduction in the cost of physical tests.

Through these objectives, the CRESCENDO project impacts the following three specific targets of the aeronautical industry's Strategic Research Agenda:
- halve the time to market for new products with the help of advanced electronic

analytical, design, manufacturing and maintenance tools, methods and processes;
- increase the integration of the supply chain into the network;
- maintain a steady and continuous fall in travel charges through substantial cuts in operating costs.

Hence, CRESCENDO results will provide the aeronautics supply chain with the means to realistically manage and mature the virtual product in the extended / virtual enterprise with all of the requested functionality and components in each phase of the product engineering life cycle. CRESCENDO will make its approach available to the aeronautics supply chain via existing networks, information dissemination, training and technology transfer actions.

Project results:

Summary of progress made during first period - Proof-of-concept phase (M1 to M15)
The main achievements for the proof-of-concept phase are summarised as follows:
- Requirements, benefits and HLO assessment system set up: The CRESCENDO system engineering database (CSEDb) was established, using a set of 'templates' to provide a consistent format for gathering requirements across the use cases, test cases and Behavioural digital aircraft (BDA) capabilities, and linking these with expected benefits and high level objectives.
- BDA architecture framework and first functional analysis: An overall framework for designing the BDA architecture was established and the first requirements and functional analyses were completed for the model store, simulation factory, quality lab and enterprise collaboration enabling capabilities.
- Test cases defined with scenarios, models and methods: For the initial 20 test cases, detailed simulation process maps and associated models and methods were described. Links between test cases were identified. More generic process descriptions for lifecycle phases represented by SP2, SP3 and SP4 were also described.
- BDA awareness workshop with first demonstrations: This was a key step to complete the concept phase, improving (a) visibility of the preliminary implementation of BDA capabilities started by individual and combined technology providers; and (b) requirements capture and feedback between SP5 and SP2 / 3 /4.

The following assessment was made versus the targets for the proof-of-concept phase:
- overall requirements completeness and maturity = 60 % (versus 75 % target);
- overall development completeness & maturity = 22 % (versus 35 % target);
- overall validation completeness and maturity = 5 % (versus 20 % target).

Summary of progress made during second period - Prototype phase (M16 to M26)
Considering the progress of work and maturity of results reported at the first annual review, several corrective actions were defined and carried out by the consortium during the prototype phase:
- Rescheduling of project iterations and milestones to compensate for 3-month project delay identified at M12.
- Set-up of the 'Integration teams' to secure the refinement of requirements and improve communication between SP 2 /3 /4 and SP1 / SP5, as well as set-up of the 'Task forces' within SP5, to ensure a coherent definition of the BDA platforms architecture and implementation of the Federated validation platform (FVP) across the SP5 Work packages (WPs).
- A rationalisation (reduction in intermediate versions) and realignment of the deliverables, together with set-up of a master steering schedule for the prototype phase, to improve interactions between SPs.
- Work to clarify the CRESCENDO scope for Virtual testing, including an SP4 workshop at

M18 to ensure the motivation of the involved partners.
- Work on the three SP2 energy aircraft test cases (S2E1, S2E2, S2E3) was stopped at M18. As a consequence, the results from the Energy Aircraft Use Case will be limited to illustrate how the availability of virtual testing methods can be applied to reduce dependency on physical testing for the validation and verification of the energy systems integration at aircraft level (S4E1). The overall lifecycle applicability of the BDA will still be ensured through increased focus and effort on the value generation, thermal aircraft and power plant integration use cases.
- Revision of Description of work (DoW) to R2.0 (submitted April 2011 for EC approval) including adjustments and redistribution of efforts and budget in response to partners requests to release effort due to forecast resource commitments to end of project, and justified opportunities to increase technical contributions from other partners.

At the end of the second period, the main achievements for the prototype phase are summarised as follows:
- Requirements are finalised and assessed to be close to 100 % complete and mature. Considerable effort has been made through the cross-project integration teams (involving SP1, SP2, SP3, SP4 and SP5 WP representatives) to share understanding, refine and improve the clarity of requirement statements, and capture these in an agreed format (template) to populate the CRESCENDO CSEDb. This has been done in two main areas - those requirements specifically targeting BDA collaborative capabilities and platforms development, and those targeting behavioural M&S methods and technology improvements.
- An intermediate version of the BDA platforms architecture specification has been completed. This follows the BDA architecture framework defined in period 1 and adopts a three-layer information model including business concept model, business object model, and data model based on system engineering (AP233) and product lifecycle support (AP239) standards.
- A deeper functional analysis of BDA capability areas (model store, simulation factory, quality lab and enterprise collaboration) has been performed and further work is ongoing to explicitly map the functions to the agreed requirements and the emerging solution implementations (prototypes). As a result, 10 key innovation areas for the BDA collaborative capabilities have been identified.
- Demonstration and validation plans for the test cases have been defined and a considerable effort has been placed on completing an intermediate integration at use-case level for the thermal aircraft and power plant integration.
- Prototype implementations of BDA collaborative capabilities and platforms have been built, and prototype developments have been completed for specific M&S methods and technology improvements (in such areas as model preparation, surrogate modelling, multi-physics coupling and optimisation).

The above results and achievements have been brought together at the M26 BDA prototype development workshop (PDW, June 2011), to demonstrate the emerging business value of the overall BDA approach. The workshop was attended by approximately 180 people including all consortium partners together with the European Commission (EC) project officer and external reviewers. A total of 50 presentations were made across parallel sessions. These were organised to show the seven main areas of project results: value generation use case; thermal aircraft use case; power plant integration use case; energy system virtual test; BDA collaborative capabilities and platforms architecture; behavioural M&S methods and technology innovations; and CRESCENDO project technical integration results. In addition, 18 technical posters were prepared to further illustrate the results.

Potential impact:

Expected Final Results
The major result of the CRESCENDO project will be to develop the foundations for what is referred to as BDA. There are three key concepts to be described:
1. The BDA dataset is considered as a multi-partner, multi-level, multi-discipline, multi-quality behavioural digital representation of the evolving Aircraft and all its constituent systems and sub-systems. A single, but federated, BDA dataset would typically exist for a given major aircraft development program.
2. BDA platforms implement collaborative services solutions and behavioural multi-physics simulation capabilities to manage, manipulate, preserve, re-use and enrich all the models and associative data needed to create, evolve and mature the BDA dataset. Several instances of BDA platforms would typically exist across the collaborative enterprise. The aim for CRESCENDO is to define a generic BDA architecture specification that any given platform implementation should comply with. However, different aircraft and engine manufacturers, partners and suppliers may need to use only part of the complete functional specification, and may choose different vendor solutions to implement the BDA platform for their organisations.
3. Finally, it is envisaged that there could typically be thousands of potential users, collaborating in teams across the extended enterprise, creating and sharing their information more efficiently through the BDA platforms, to create and build the BDA dataset. Such users range from aircraft program architects and chief engineers, through to teams of design, M&S engineers, supported by Information system / information technology (IS / IT) specialists. During the course of the project, 10 key innovations have been identified that will be brought by the deployment of the BDA platforms:
i) multi-partner collaboration environment;
ii) multi-level hierarchy of models / organisations;
iii) multi-physics M&S integration.

Effective trade-offs by:
4. full traceability;
5. orchestrated end to end M&S processes;
6. quality including VV&A;
7. value and risk informed decisions (with capture);
8. reusability (of knowledge, models, methods and tools);
9. M&S activities earlier in the development lifecycle
10. An Aircraft Program Architect decision Environment

The CRESCENDO project will also deliver results to illustrate:
(a) the ability of the BDA capabilities to be applied in the preliminary design, detailed definition, test and certification phases of the product development lifecycle;
(b) the ability of the BDA capabilities to be applied for technically complex and challenging areas of M&S on which CRESCENDO will provide improvements, referred to in CRESCENDO as the 'use cases'.

At the project start, four use case areas were considered: value generation, thermal aircraft, power plant integration, and energy aircraft. The use cases are further decomposed into 17 test cases that represent realistic scenarios for specific decisions to be made within one of the phases of the product development lifecycle.

As well as developing innovations, in particular behavioural M&S capabilities, the use cases and test cases serve to demonstrate the project results by showing the applicability of the BDA platforms capabilities to support this range of representative and realistic situations.

Essentially, the result in the preliminary design and earlier definition phases will be 'design driven by simulation', transitioning towards 'design validated by simulation' in the later test and certification phase of the lifecycle.

List of websites: http://www.crescendo-fp7.eu/

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Collaboration Sought: N/A

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This result was rewritten as an offer

Streamlining from drawing board to take-off

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Related Programme(s) / Project(s)

Programme	Project Reference	Project Title
FP7-TRANSPORT	234344	Collaborative & Robust Engineering using Simulation Capability Enabling Next Design Optimisation

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