



# ENHANCE

## PUBLISHABLE REPORT

### **Abstract**

This contractual document - ENHANCE PUBLISHABLE REPORT- contains a summary of activity performed on the ENHANCE project after 40 months work. It covers the whole project duration from 01 February 1999 to 31 May 2002.

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## 1. PROJECT MAIN OBJECTIVES AND STRUCTURE

The European project ENHANCE addressed the joint call “**Concurrent Engineering in Aeronautics**” issued by the Brite Euram programme (DG XII) and Esprit programme (DG III) and received funding from the supplementary budget of the 4<sup>th</sup> Framework Programme. It is a large and coherent R&D initiative in the field of Concurrent Engineering aimed at improving European Aeronautical industry competitiveness by providing new ways of reducing product development lifecycle and costs.

### 1.1. MAIN OBJECTIVES

The ENHANCE main objectives were:

- to define the **new common way of working** for joint European aeronautics product development, applicable from the initial design phase throughout the entire life of the aircraft, thus encompassing the whole aeronautical supply chain
- to propose a set of **operational tools and solutions for Aeronautical Concurrent Engineering** implementation
- to describe the associated **engineering methods and organisation guidelines**
- to validate the new approach through a full range of **industrial experiments and business case studies**

### 1.2. STRUCTURE

A set of 12 “COMMONS” tasks in the Work Breakdown Structure formed the kernel of the ENHANCE project. Each COMMON has defined a common way of working in a given domain for engineering in order to create the European Aeronautical Extended Enterprise. They have developed a set of Concurrent Engineering processes that can be adopted by all the parties in a collaborative aeronautical project.

- ◆ There were 3 levels of **Experiments** — Information Technology, Concurrent Engineering Experiments (CCE) and Business Case Studies (BCS’) which demonstrated and validated the COMMONS and their mutual interactions.
- ◆ An Information Technology Work Package was devoted to the assessment of IT tools for the environment needed for Concurrent Engineering.

The Dissemination and Exploitation tasks widely promoted the outputs of the ENHANCE project and contributed to the acceptance of these as industrial standards.

## 2. GLOBAL TECHNICAL RESULTS

Significant technical results have been reached, in line with the ENHANCE project programme and the industrial partners needs.

- The COMMONS activities reached most of their targets in proposing methods and best practices for future deployment of aeronautical Concurrent Engineering principles.

- Development and installation of demonstrators and illustrators reached a good level of maturity.
- The creation of a multi-site ENHANCE E-Lab established a suitable environment for implementing the demonstrators and CCE experiments and some of the Business Case Studies (BCS'); of note is the running of experiments using the multi-site network in real time. The main partners saw this Lab infrastructure as a crucial tool for testing and demonstrating new methods and tools in the domain of Concurrent Engineering.
- The definition and running of the 8 BCS' was the most difficult task to be performed due to the tight time schedule and some difficulties in exploiting the COMMONS results. Nevertheless, during the last year of the project, a major step was accomplished in bringing all the BCS' to a significant level of achievement, demonstrating interesting showcases of how to deploy ENHANCE results in a real business process.

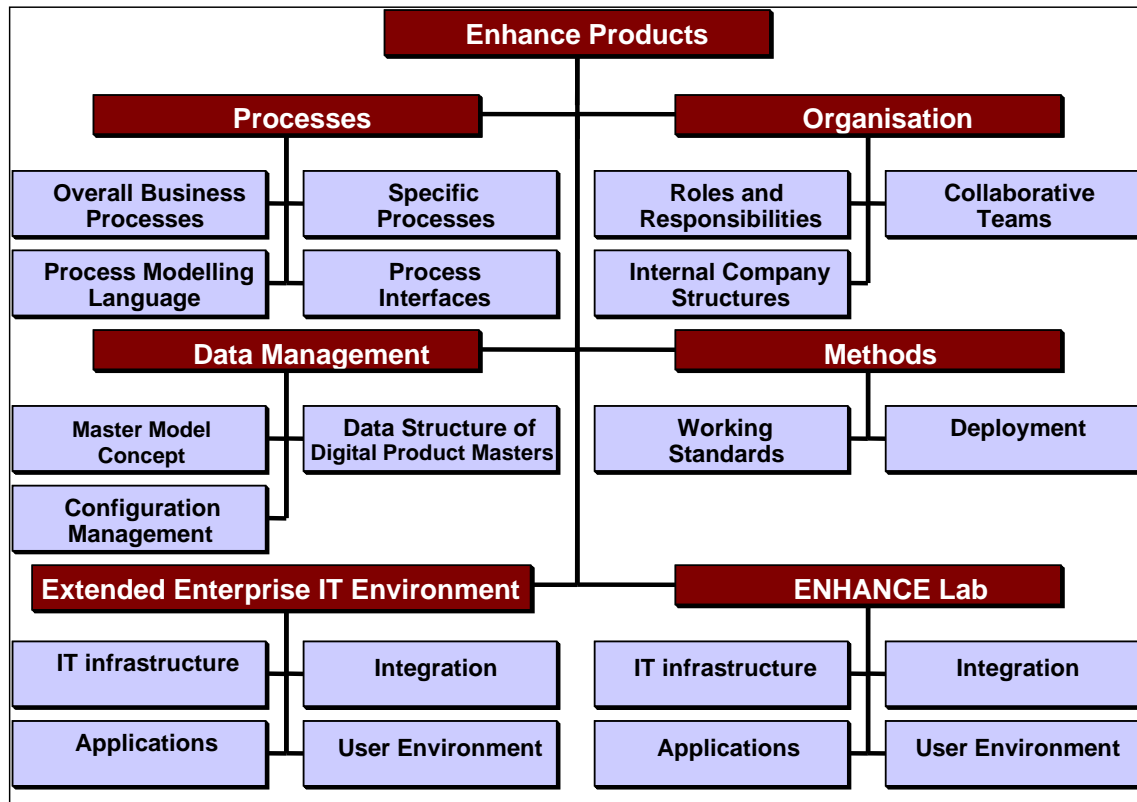
These results have contributed to the overall Concurrent Engineering industry quantitative targets set out in the project programme by helping to (*both during the project by partners using interim results and ideas in their current work and by planned adoption on new projects discussed in their exploitation plans*):-

- reduce the aircraft development lifecycle by 30%,
- reduce the development costs by 30%,
- accelerate the use of common exchange standards in a more effective and efficient way to increase substantially the competitiveness of the whole sector,
- reduce by 20% the costs associated with interpretation, translation and regeneration of transmitted data,
- establish a strong European presence and influence in the generation and adoption of engineering standards,
- generate opportunities for the supply chain to better interface with virtual enterprise organisations, at the European and world world-wide level.

### 3. ENHANCE PROJECT MAIN TECHNICAL ACHIEVEMENTS:

Globally, the project technical results were in line with the technical objectives and satisfied the industrial partners of the ENHANCE Consortium.

These results are depicted in the ENHANCE product breakdown structure shown here:



Only an overview of the major achievements follows hereunder, see the ENHANCE public web site ([www.enhanceproject.com](http://www.enhanceproject.com)) for more information.

### 3.1. PROCESSES

The processes used within aeronautics were studied and adapted to the Extended Enterprise environment and associated collaborative working and Concurrent Engineering requirements.

- The generic aircraft development lifecycle has been created for Airframe and Engines. In the detailed definition phase, the Airframer development lifecycle has been aligned with the development life cycle of the major subsystem manufacturer (Engine, Avionics & Landing Gear).
- The management data (WBS, PBS, organisation, risk management data...) flow between the airframer and its supply chain, linked to the Design lifecycle milestones, was detailed in the ILM (Interface Life-cycle Model).
- The supportability (reliability, maintainability, testability, maintenance programmes and costs) process activities and the associated information objects were defined.
- The certification process and the workflow management of certification activities in the Extended Enterprise were defined.
- The acoustics, structural and aerodynamics distributed calculation processes between different partners were described and improved using standards for exchange and interoperability (e.g. new STEP interfaces, PDM systems, CORBA based middleware, CGNS, etc).

For each process, the different interface items have been recorded and are characterised by the relevant information (what, who, to whom, when, in which maturity...) which needs to flow between the different partners.

The demonstrators supporting the automation of these processes and managing interface data have been defined, developed and implemented on the ENHANCE IT Platform - the so called "E-Lab". These demonstrators were based on IT tools with IT workflow capabilities such as Windchill, Enovia VPM and ASP.

To connect sub processes implemented on heterogeneous workflow management systems, a Workflow System illustrator was defined and developed. Windchill, SPINEWare and KPM were first interfaced and then to support the interoperability implementation of other workflow management systems a framework called SWIFT was developed.

Most of these processes and demonstrators were experimented upon by a set of concurrent and collaborative use case experiments as well as during broad industrial business scenario experimentation. Even though this experimentation was not performed to the extent initially expected in the ENHANCE Project Programme, they definitely proved the improvements these results brought to the collaboration within the Extended Enterprise in terms of time savings.

Most of these results were presented and demonstrated at the final ENHANCE Forum. See public web site for details.

### **3.2. STANDARD PARTS**

The definition of the architecture and organisation of an electronic catalogue of standard parts was achieved. This catalogue is dedicated to the design engineering function within the supply chain and allows the sharing of a validated components database with access to standards parts CAD file, standard documents, choice guide...

A demonstrator based on an off-the-shelf standard part database was customised and demonstrated during the 2<sup>nd</sup> ENHANCE Forum. This demonstrator was successfully installed on the ENHANCE IT Platform (E-Lab main site).

### **3.3. DATA MANAGEMENT**

ENHANCE Teams defined a Digital Product Master structure for managing all product related data that covered all disciplines along the whole aircraft lifecycle allowing its evolution following the design rules and meeting the industrial requirements for product data management identified in the first phase of the project. Thus 23 Digital Product Masters were defined, and associated processes and methods for managing their configuration and to work with them are defined and documented.

To show the Digital Product Master Models in operation, a demonstrator based on a representative product data management system was developed.

This demonstrator was tested within the ENHANCE experimentation phase. During this phase, the Digital Product Master concept was validated in several experiments and Business Case Studies.

Furthermore, a methodological approach for implementing the DPMs concept in an existing PDM system currently deployed and used in a big company was established. An associated demonstrator was developed to show the feasibility of this progressive implementation.

All these results were presented and demonstrated during the final ENHANCE Forum.

The data exchanges based on STEP standards for CAD, PDM data & document exchanges were identified and their efficiency studied and evaluated. Usage recommendations were

disseminated within ENHANCE. Additional requests were made to the ENHANCE IT providers in order to get relevant and long-term generic tools in the near future.

The Technical Data Packaging demonstrator, based on STEP AP232, was defined, developed and integrated with a workflow from the ENHANCE Innovative IT task. This demonstrator allows various partners of the Extended Enterprise access to a set of product-related information and data (CAD file, PDM data, documents...) securely on a Web site with automatic awareness of information disposal and consultation. This demonstrator was successfully installed on the E-Lab main site.

During the final phase of the ENHANCE project, STEP AP203, AP214 and AP232 technologies were employed within CCE and BCS experiments. These experiments proved STEP could support a common data exchange process. They also highlighted limitations with respect to end-user prior expectation. These limitations were captured within the ENHANCE Data Translation Capability Model. The experiments helped to raise awareness of data translation limitations amongst members within the ENHANCE project.

A navigation tool (PDM Navigation illustrator) was defined and developed and installed in the distributed sites of the E-Lab (i.e. ENOVIA VPM at the E-Lab main site and Windchill at the NLR secondary site). It allowed the different users to access data through various systems in different locations. Data sharing and data exchange between these distributed systems was experimented upon by the CCE Experiments task and by BCS2 and BCS7 case studies. This illustrator integrated through the E-Lab sites with secured networking demonstrates how to securely share information and data over the Extended Enterprise.

### **3.4. COLLABORATIVE WORKING**

State of the art, best practices, and requirements for collaborative working within the Extended Enterprise were identified, specified and illustrated with typical scenarios (use cases).

A concurrent and collaborative Extended Enterprise model for aeronautics has also been established presenting a structured set of methodologies enabling collaboration with a CE approach. This included an inventory of off-the-shelf hardware and software that could support remote collaboration within the Extended Enterprise, specifying incompatibilities of these tools with current operating systems, CAD and PDM tools ...

Finally two demonstrators have been defined and developed for supporting distant collaboration between two or more people during the design activities covering - component interference detection, problem resolution, component integration study, CAD files viewing and sharing etc...

The collaborative working methods and tools developed were experimented upon by all the BCS'. This experimentation highlighted the lack of experience using these new tools; so to solve this issue a guideline of implementation and use of collaborative tools was produced. Other tools have been identified for use by BCS' during the last phase of the project. They were demonstrated by BCS2 at the final ENHANCE Forum.

### **3.5. TRAINING**

A training system web-site platform was developed and is now available with new tools and methods to generate courses and necessary learning progress and results.

This platform provides the opportunity for an SME to access a training package on demand. It also provides a set of tools to assess/validate the knowledge and a set of tools to communicate between trainees / trainers / experts.

This Web platform is populated with:

- A CE training course developed by ENHANCE
- Movies from 2<sup>nd</sup> and 3<sup>rd</sup> ENHANCE Forums synchronised with PowerPoint presentations

### **3.6. CONTRACTING WITHIN THE EXTENDED ENTERPRISE:**

State-of-art and the best practices for contract exchange within the aerospace supply chain and aeronautics industry was documented.

A process for contracting remotely was outlined. The process shows firstly how to get up and running with the suggested IT solution and secondly how to manage a contract change. This process is based on an e-mail approach and addresses all major issues like security, authentication, validation, ratification and electronic signing of documents. Two demonstrators presented at the final ENHANCE Forum support this process.

These results were experimented on by BCS7 with a positive outcome.

### **3.7. IT INFRASTRUCTURE FOR THE EXTENDED ENTERPRISE AND ENHANCE IT PLATFORM (DISTRIBUTED E-LAB)**

An architecture of the IT infrastructure (with relevant security devices and protocols) for the Extended Enterprise was proposed and realised through the distributed ENHANCE IT Platform (E-Lab main and secondary sites). The concept of a project zone, coupled with firewalls and a secured networking illustrator allowed confidential information to be kept completely shielded and shared information to be available to the selected partners within the Extended Enterprise.

The Secured Networking Illustrator investigated how to interconnect the organisations within an Extended Enterprise in a secure manner. In doing this it studied the possibilities and the limitations of the innovative protocol IPsec (Internet Protocol Security).

The Secured Networking Illustrator contributed to the development of the COMMON IT Security Approach which has also been used to set-up the distributed E-Lab Environment.

### **3.8. HUMAN ISSUES AND CONCURRENT ENGINEERING**

Aeronautical CE reference, state of the art and best practices in CE processes in a multi-site organisation, and Roadmap and guidelines for implementation of CE methods and organisation were issued for both CE aspects and Human factors in CE processes. The collected information and developed technologies have been fed into the project and disseminated through the deliverables and by active participation to project events (Workshops, Forums and external conferences).

Assessment of the impact of cultural differences on efficient team-working across Airbus has been performed and solutions to increase this cultural awareness have been defined.

Team-working behaviours during remote meetings using the ENHANCE remote collaborative demonstrators and different communication conditions (face to face, text messaging only and text plus telephone) were studied. Differences between communication media with respect to its various impacts on the task were analysed and outlined.

### **3.9. EXPERIMENTATION**

Most of all the ENHANCE results previously mentioned were validated firstly to check the functionality provided and to improve them through close integration with other ENHANCE results and secondly to validate the potential benefits they bring to the daily business in aeronautics.

At the first level, 85 test cases (so called CCE Experiments) were defined addressing data storage, data access, data transfer, data translation, system security, concurrent data and application sharing, collaborative meetings and workflow process management. Some 56 CCE experiments have been run and demonstrated at the E-Lab.

At the second level, 8 BCS Tasks defined industrial scenarios for experimentation covering new rotorcraft concept, engine, airframe, in-service support, air generation unit, cabin customisation, avionics systems and product improvement fields.

Results and feedback from the experimentation carried out at the E-Lab were documented and most of them were presented at the final ENHANCE Forum.

As an overall conclusion, the experimentation allowed improvement of ENHANCE results in the last phase of the project and has shown that the results developed within ENHANCE were addressing actual business needs in the context of Concurrent Engineering in the aeronautics Extended Enterprise.

### **3.10. PUBLIC AND PRIVATE WEB SITES ( ENHANCE DOCUMENTATION REPOSITORY)**

The ENHANCE public Web site was continuously updated and improved throughout the project. It can be accessed at <http://www.enhanceproject.com>. It contains ENHANCE dissemination material, a standards map and is linked to many other European projects and organisations web sites. A short description is given in the appendix to this report.

A private Web site for managing the huge amount of ENHANCE documents was defined and developed at the beginning of the project. Continuously improved and populated, it is still accessible by all Enhancers who have a user-id and a password provided by the Management Team

### **3.11. OPEN DAYS**

Three specific dissemination events targeting Senior Managers from ENHANCE partners were held within the E-Lab sites to present the project technical achievements. These events increased the awareness of the project inside the consortium.

## **4. CONCLUSION**

Future European research or deployment projects could take advantage of ENHANCE findings; for instance projects in the field of knowledge engineering and management, use of virtual reality in the design of complex products, advanced techniques for global virtual prototyping or developing new concepts for Extended Enterprise.

On the Industry side, high potential of exploiting the project results exists as stated in the different Company Exploitation Plans.

## 5. APPENDIX: ENHANCE PUBLIC WEB SITE

The public ENHANCE web site can be accessed through [www.enhanceproject.com](http://www.enhanceproject.com).



This home page presents the main menu of the site. The navigation items on the bottom:

The two first items (**factsheet** and **presentation**) link to pages introducing the project. That's where the scope and objectives of the project, as well as the Consortium description, can be found.

The **news** presents the main events (Forums, conferences) related to the ENHANCE project. The ENHANCE Forums presentations are available here.

The **products** item links to information about Workpackages/Tasks activities. This is where the dissemination deliverables of the project can be found.

**research** links to other projects related to the Concurrent Engineering domain.