SIXTH FRAMEWORK PROGRAMME

PRIORITY 4
AERONAUTICS AND SPACE

INTEGRATED PROJECT

Publishable final activity report

Period Covered: from 01/01/04 to 31/12/07

Date of preparation: 23rd April 2008

Start date of project: 1st of January, 2004

Duration: 48 months

Project coordinator name: Philippe Homsi

Revision: R1.0

Project coordinator organisation name: Airbus SAS

Revision Table

Issue	Issue date	Modifications
1.0	23/04/2008	Final Issue based on Steering Committee approved information from the Technical Leaflet called “Final Technical Achievements” and material presented at the Forum 3 public event

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1. PROJECT EXECUTION

1.1. BACKGROUND

The VIVACE (**V**alue **I**mprovement through a **V**irtual **A**eronautical **C**ollaboration **E**ntreprise) integrated R&T project, co-ordinated by Airbus and co-funded by the European Commission, was set-up in the framework of AECMA addressing Aeronautics' Vision 2020 objectives. It was launched in January 2004 and was run for 4 years. 63 companies and institutions co-operated in the project, among which there were 8 SMEs participating.

VIVACE used past experiences and results gained in concurrent engineering activities such as the European project ENHANCE (1999-2002) as a start point.

1.2. VIVACE OVERALL OBJECTIVES

VIVACE intended to achieve a 5% cost reduction in aircraft development and a 5% reduction of the development phase of a new aircraft design combined with a contribution to a 30% reduction in the lead-time and 50% reduction in development costs respectively for a new or derivative gas turbine engine. To achieve this overall objective, the work in VIVACE was organised around Use Cases, i.e. real industrial simulations of a components or sub-components of the aircraft or the engine or of a development process, reflecting both the Virtual Product and the Virtual Extended Enterprise. Each of these included on the one hand requirements for early product simulation and on the other hand requirements for distributed working methods.

1.3. PROJECT STRUCTURE

VIVACE was comprised of three technical sub-projects (see Figure 1). Two of them represented the aircraft and engine products, and the third ensured the integration of component frameworks developed by the first two into an advanced concurrent engineering design framework — the VIVACE Collaborative Design Environment.

At its end, VIVACE delivered a Virtual Product Design and Validation Platform based on a distributed concurrent engineering methodology supporting the Virtual Enterprise.

Virtual Aircraft Sub-Project (leader: Airbus France)

The **Virtual Aircraft** Sub-Project revolved around the main components that constitute an aircraft, and had six integrated technical work packages (System Simulation, Components, Global Aircraft, Flight Physics Simulation, Complex Sub-systems, Supportability Engineering). They were selected to cover the aircraft product throughout the development life cycle (design, modelling, interfacing and testing).

Virtual Engine Sub-Project (leader: Rolls-Royce plc)

The **Virtual Engine** Sub-Project consisted of five integrated technical work packages performing fundamental research to provide capabilities for a competitive European jet engine industry working across extended enterprises (Extended Jet Engine Enterprise Scenario, Life Cycle Modelling within the Virtual Engine Enterprise, Whole Engine Development, European Cycle Program, Supply Chain Manufacturing Workflow Simulation). It developed the different engine modules of the aircraft propulsion system and key areas of multi-disciplinary optimisation, knowledge management and collaborative enterprises.

Advanced Capabilities Sub-Project (leader: EADS-IW-F)

The **Advanced Capabilities** Sub-Project was a key integrating work area that developed common tools, methodologies and guidelines. It consisted of six technical work packages that provided cohesion between the first two sub-projects through activities that were generic and common to both (Knowledge Enabled Engineering, Multi-Disciplinary Design and Optimisation, Design to Decision Objectives, Engineering Data Management, Distributed Information Systems Infrastructure for Large Enterprise, Collaboration Hub for Heterogeneous Enterprises).

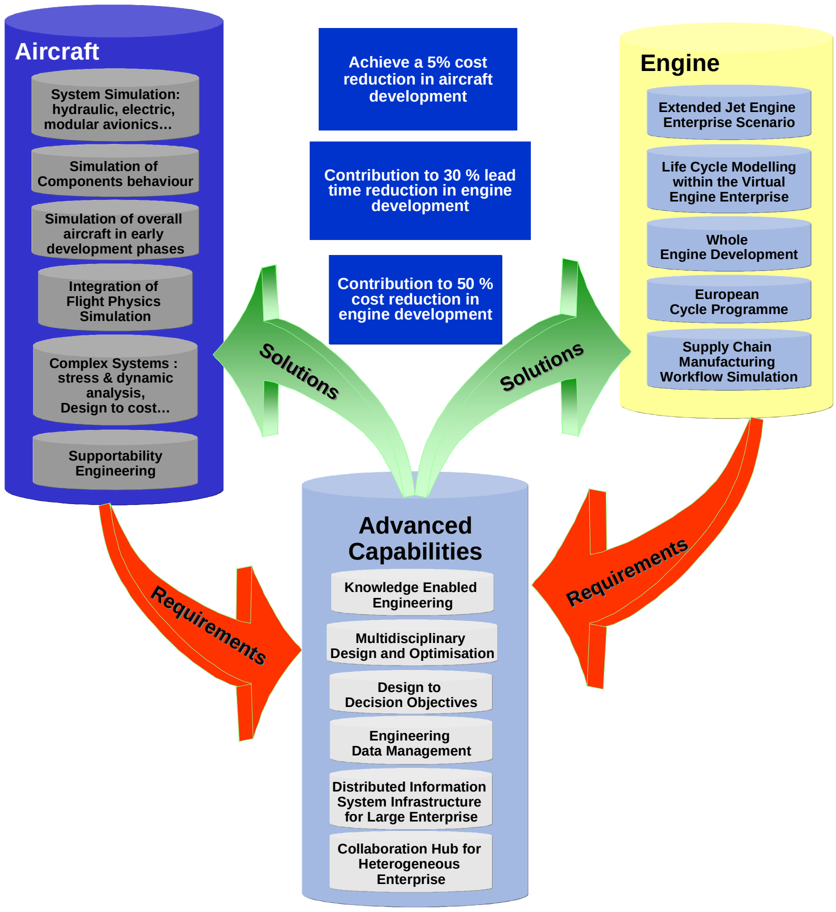

Figure 1: VIVACE overall structure

1.4. CONTRACTORS INVOLVED

Airbus SAS (Co-ordinator)	
Airbus Deutschland GmbH	Airbus France
Airbus UK Ltd	Ajilon Engineering
Alenia Aeronautica S.p.A.	Arttic
Avio S.p.A.	Baes (Operations) Limited
Cenaero	Cerfacs
Cimpa	Cranfield University
Dassault Aviation	Dassault Data Services
Dassault Systèmes	Deutsches Zentrum für Lüft- und Raumfahrt e.V.
EADS France (Innovation Works)	EADS Deutschland GmbH
Empresarios Agrupados Internacional, S.A.	EPM Technology
ESOCE Net	Eurocopter SAS
Eurostep Group AB	Hewlett-Packard Limited
Hydro-Control-Steuerungstechnik GMBH	Iberespacio
Imperial College of Science, Technology and Medicine	Inbis (Assystem UK)
Industria de Turbopropulsores S.A.	Intespace
Isight Software Sarl (Engineous)	Leuven Measurements & Systems International N.V
Lulea University of Technology	Messier-Dowty Limited
MSC Software GmbH	MTU Aero Engines GmbH
Nationaal Lucht- en Ruimtevaartlaboratorium (NLR)	National Technical University of Athens
Onera	Oktal
PC Software	Politecnico di Milano
Politecnico di Torino	Queen’s University Belfast
Rolls-Royce Deutschland Ltd & Co KG	Rolls-Royce Plc
Samtech S.A.	Snecma
Technische Universität Hamburg-Harburg represented by TUHH-Technologie GmbH	Techspace Aero S.A.
Teuchos	Thales Avionics
Thales Avionics Electrical Systems S.A.	The University of Nottingham
The University of Warwick	Transcendata
Turbomeca SA	Uninova – Instituto de Desenvolvimento de Novas Tecnologias
Universität Stuttgart	UPS – Institut de Recherche en Informatique de Toulouse
University of Manchester	Volvo Aero Corporation
Xerox Italia S.p.A.	

1.5. THE VIVACE TOOLBOX AND FIVE WONDERS

At the end of this four year endeavour, this vision of an Aeronautical Collaborative Design Environment has now been well defined as demonstrated at the VIVACE Forum 3. It is also referred to as the ***VIVACE Toolbox**,* highlighting the fact that it is a re-usable result that will be exploited after the end of the VIVACE project.

To understand the role of Advanced Capabilities in this environment, it is important to consider firstly the linkage of the VIVACE System with the business needs and the actual implemented tools that VIVACE partners modelled using the ***8-layer Model***, and secondly the way the Advanced Capabilities all contributed to the VIVACE Toolbox through a common ***Generic Service Architecture***.

The 8-layer model (see

Figure 2), is a representation of the various aspects considered in the VIVACE project. VIVACE partners identified this model as a valid representation to structure results from the technical activities conducted in the project. This model should not be considered as an architecture but as a segmentation (or taxonomy) of technical subjects handled in the project.

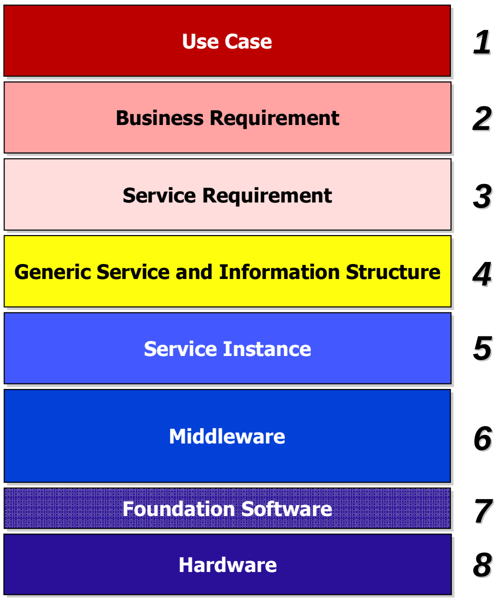

Figure 2: The 8-layer Model

The main advantage of this model is that it highlighted the segmentation between level 4, which was the focus of the VIVACE System, and business issues (levels 1,2,3) and implementation issues (levels 5,6,7,8). This shows that VIVACE results were not software tools but *generic services and information structure and standards* that were implemented and demonstrated using software tools.

All Advanced Capabilities contributed to level 4 of the 8-layer model by developing a set of *Generic Services* and to level 5 by implementing these Generic Services in software tools for validation and demonstration.

"Generic Services" should be understood as follows:

- Service means an aeronautical engineering IT capability, organised from an IT perspective using the "Service-Oriented Architecture" approach. It could be a service to retrieve knowledge elements in a specific aeronautical context, or a service to share and manage simulation models, as demonstrated during Forum 2 in late 2006. A service, by nature, is open to being used by several users, or Use Cases;
- Generic refers to the independence from any implementation: VIVACE Generic Services can be implemented on several IT infrastructures, using different commercial tools (in this sense "Generic" refers to the Model Driven Architecture from the Object Management Group).

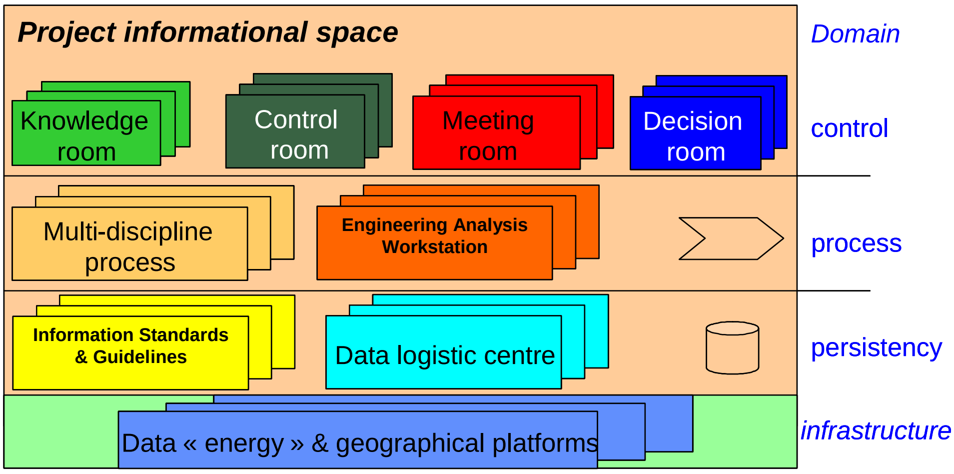

Figure 3: VIVACE Toolbox Capabilities architecture

The Advanced Capabilities provided a set of services also organised using a standard "4-tier architecture" as shown in Figure 3. The Forum 3 demonstrations showed the exploitation of this Toolbox through several use case scenarios. Depending on the specific needs of a collaboration (need to share knowledge, need to organise and trace the exchanged data, need to set-up multi-disciplinary processes, and so on), the Toolbox was used to build the right "Aeronautical Collaborative Design Environment" required to support the collaboration between teams in a Virtual/Extended Enterprise context. That is why, even if the Advanced Capabilities are described independently hereafter, it is important to keep in mind their linkage, as well as their global organisation as shown in Figure 3.

1.6. IMPACT OF VIVACE

The VIVACE results or capabilities impacted primarily the preliminary design phase of the development cycle (see Figure 4) where the importance of making the best decision had the greatest impact on future development costs. In this way, development costs and time could be achieved in the development phase even if there was a slight increase of development costs in the preliminary and detailed design phases of the cycle.

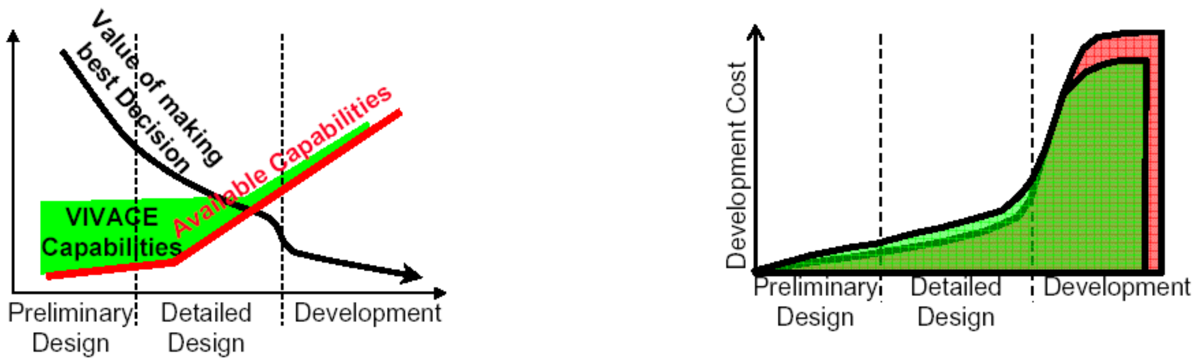

Figure 4: Influence of VIVACE results on the development cycle

The 150+ elementary results of VIVACE were identified in the VIVACE Catalogue and also classified into the 5 VIVACE wonders. The impact of these wonders (solutions) on five important areas of progress was evaluated, the overview of which is provided in Figure 5.

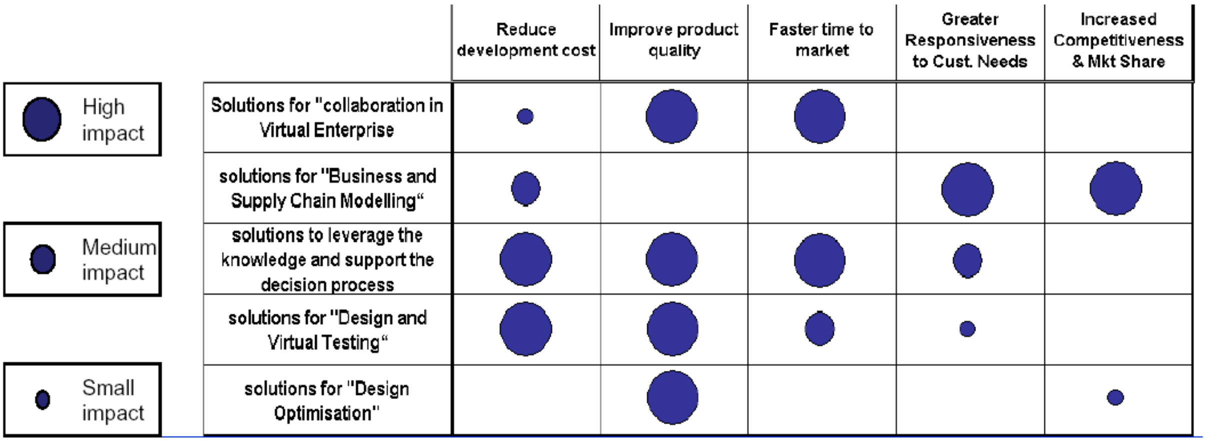

Figure 5: Level of impact of VIVACE wonders

1.7. OVERALL ACHIEVEMENTS

The main result of VIVACE was an innovative Aeronautical Collaborative Design Environment and associated Processes, Models and Methods. This environment, validated through real industrial Use Cases, will help to design an aircraft and its engines by providing virtual products having all the required functionalities and components for the product design phases of the aeronautics product life cycle to the aeronautics supply chain operating in an extended enterprise mode.

The large size of VIVACE and its integrated platform structure are helping its deployment of results toward the European aeronautical supply chain and in particular toward the small and medium sized suppliers.

VIVACE is making its approach available to the aeronautics supply chain via existing networks, information dissemination, training and technology transfer actions.

At the Forum 3 Public event, the VIVACE Co-ordinator on behalf of the Consortium, drew the following conclusions on what VIVACE as a project had achieved:

- *VIVACE has built the virtual product foundation: innovative methods have been created, validated and are currently being industrialised and deployed within the business*
- *VIVACE has built the Virtual enterprise foundation: innovative technologies have been created, validated and are currently being industrialised into software vendors product lines*
- *VIVACE has strongly impacted the state of the art and international standards with 35% of results achieving TRL6, 50% TRL5, 10% TRL 4 and the remaining 5% of results TRL 3.*

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VIVACE Web site

http://www.vivaceproject.com

More details of the VIVACE project and results are available in the booklet entitled: "Final Technical Achievements (2004-2007)"

2. DISSEMINATION AND USE

For each of the major results, the following information is provided:

- The business and technical objectives of the result/solution
- A description of the solution
- The added value that can be achieved through the exploitation of the solution
- The position of the solution in regards to the State of the Art
- How the solutions were validated
- The next steps towards the exploitation of the solution
- The current level of maturity measured against TRL 1 to TRL 6

2.1. VIVACE SOLUTIONS FOR "COLLABORATION IN THE VIRTUAL ENTREPRISE"

The Engineering Data Management Framework for controlled collaboration:

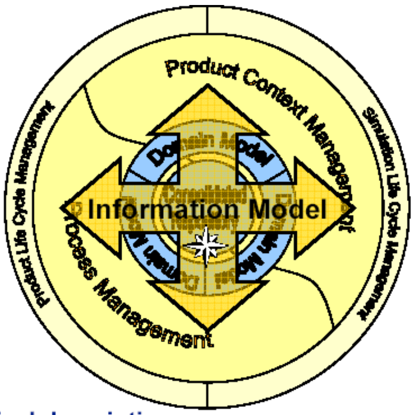
OBJECTIVES:
- Engineering Data Management framework proposes a non-invasive add-on based solution
  - to complement user environment features provided by COTS (eg. PLM & SLM), portals, legacy tools, etc.
  - to monitor multi-views activities and manage collaborative environment

VALUE FOR PRODUCT:
- Right first time
- Lead time reduction
- Increase information integrity, quality and traceability

POSITION VS STATE OF THE ART:
- RTD/Innovation

VALIDATED ON:
- Pylon & Engine Integration
- Preliminary design stochastic analysis
- Power Plant system maturity validation

NEXT STEP:
- Validation in an operational environment



Technical description:
- **Product Context Management** Framework to link Product / Process & Resources
- Integration of COTS and legacy tools
- Extended enterprise services to
  - manage heterogeneous data in context
  - ensure persistence of relevant information to be shared
  - Manage business process between partners, domains, disciplines

The Flexible Virtual Entreprise Collaboration Hub framework:

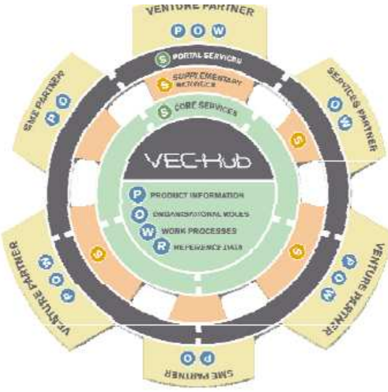
OBJECTIVES:
- The founding standard-concept for an operational environment Serving the Virtual Enterprise
- The neutral partnership collaboration platform securing partner intellectual property rights
- Manage the enterprise common agile set-up of Product information, Organisational roles, Work processes and Reference data
- Based on and defining new international standards enabling flexibility and support by commodity tools

VALUE FOR PRODUCT: *(R. Parchem, Coordinator)*
- *"A key enabler for coming up with the idea of this*) collaborative work scenario…"*

POSITION VS STATE OF THE ART:
- The new standard-concept for Virtual Enterprise collaboration in European Aeronautics business

*) **VALIDATED ON:**
- Multi-site and multi-partner automated engine design

NEXT STEP:
- Large scale business implementation
- Manage knowledge via *http://www.VEC-Hub.org*



TECHNICAL DESCRIPTION:
- A conceptual specification on how a number of "services" provide collaborative and shared data functionality to a set of partners working together in a Virtual Enterprise
- A complete specialisation of the Service Oriented Architecture specification by OASIS:SOA RM
- Virtual enterprise services

Request and decision driven Process Management and Information Share:

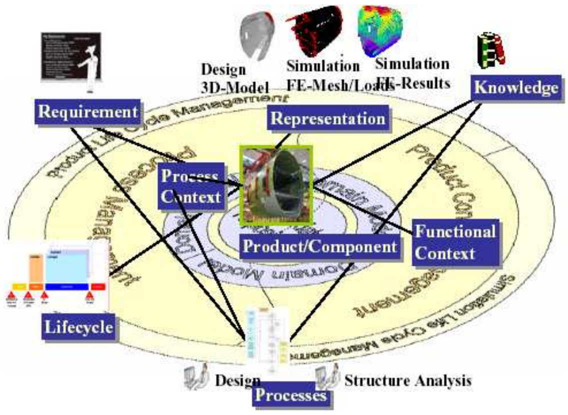
OBJECTIVES:
- Enlargements for Product Context Management framework to serve dynamic "build on demand" business processes and full context interlinks

VALUE FOR PRODUCT:
- Lead time reduction
- Increase information integrity, quality and traceability
- Right first time

POSITION VS STATE OF THE ART:
- RTD/Innovation

VALIDATED ON:
- Structural design "Request for Work" scenario
- Test Bench

NEXT STEP:
- Fully implementation into EDM framework



Technical description:
- Enlarged Product Context Management Framework to link Product / Process & Decisions / Knowledge / Requirements / Product-Data
- Dynamic "build on demand" of business process chains
- Model driven Test Bench for demonstration and validation

Secure Collaborations for Virtual Entreprises:

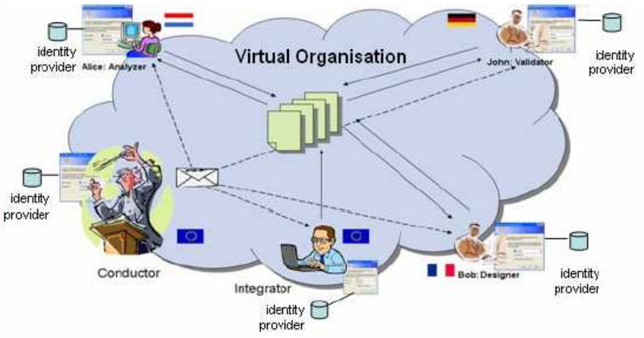
OBJECTIVES:
- Enable a secure and manageable way of information sharing in a virtual aeronautical organisation.

VALUE FOR PRODUCT:
- Secure and manageable collaboration, protecting company assets like Intellectual Property Rights (IPR) sensitive information.

POSITION VS STATE OF THE ART:
- Innovates information security in a virtual aeronautical organisation. Administration of identities, provisioning of credentials and attribute-based access control are more manageable, scalable and secure than currently employed solutions.

VALIDATED ON:
- Tailored Engine MDO workflow

NEXT STEP:
- Deployment of Public Key Infrastructure (PKI)



Technical description:
- Multi-partner collaboration in a virtual aeronautical organisation
- Automated workflow connecting several tool suites
- Security infrastructure protects multi-company assets according to TSCP security concepts.

International standards development:

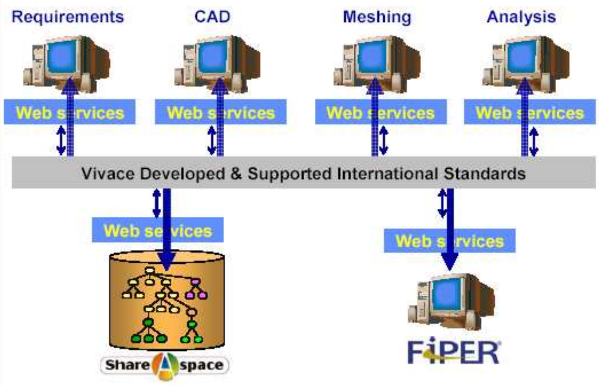
OBJECTIVES:
- Influence and direct the development of International Standards for Data exchange and sharing based on Aerospace Sector requirements
- Promote use of these Standards in Aerospace Industry

VALUE FOR PRODUCT:
- Improve communication between partners
- Reduce "tie-in" to vendor solutions

POSITION VS STATE OF THE ART:
- Standards now available and in commercial usage

VALIDATED ON:
- Multi-site and multi-partner automated engine design
- VEC-Hub

NEXT STEP:
- Wide scale validation in an operational environment



Technical description:
- **OASIS PLCS-PLM Web Services**
  - **Web based tool/tool communication**
- **ISO 10303-233 Systems Engineering and Design**
  - **Systems Engineering data exchange model**
- **ISO 10303-26 EXPRESS Binary Data Format**
  - **Highly optimized data format**

2.2. VIVACE SOLUTIONS FOR BUSINESS AND SUPPLY CHAIN MODELLING

Agent-based simulation of the value chain

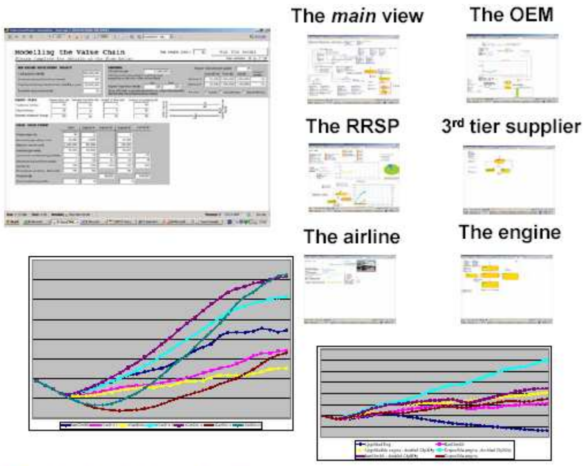
OBJECTIVES:
- To model the value chain of the extended enterprise to explore dynamic behaviour
- To demonstrate the effect of operations strategy

VALUE FOR PRODUCT:
- Provided a quantitative 'evidence-led' approach to strategic decisions
- Increases visibility of the long-term impact of current and possible future business strategies

POSITION VS STATE OF THE ART:
- A *new* modelling technique applied to a novel areas of business research. Not currently in use for decision support

VALIDATED ON:
- Consultation with industry experts

NEXT STEP:
- Implementation & application in one of the VIVACE industrial partners
- Potential for further research in the effect of decisions
- Explore industry trends and the drivers for current performance



Technical description:
- Uses agent-based modelling methodologies to simulate operations strategy for the extended enterprise
- Simulations explore both *operational* company agents and *customer* agents

Supply chain simulation:

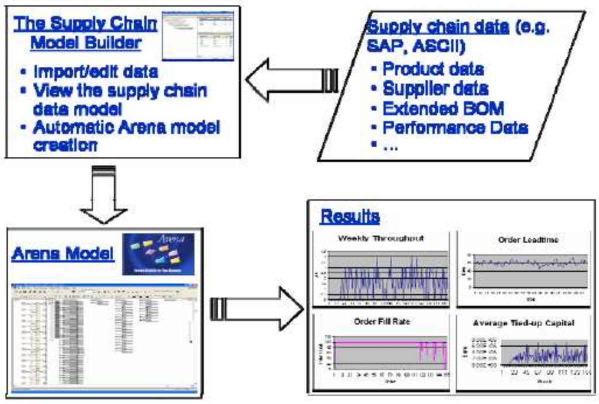
OBJECTIVES:
- Applying the novel data-driven supply chain simulation approach to supply chain design, improvement and operations
- Investigating the effects of supply chain control mechanisms and parameters on supply chain dynamics and supply chain effectiveness

VALUE FOR PRODUCT:
- Reduced tied-up capital, cost, delays
- Improved customer service level

POSITION VS STATE OF THE ART:
- New approach facilitating the application of simulation to supply chain analysis which was difficult with traditional approaches

VALIDATED ON:
- Use Case comparisons with historical data
- Judgements by experienced managers

NEXT STEP:
- Application in VIVACE industrial partners, further development, dissemination



Technical description:
- Builds models of upstream supply chain based on existing company ERP data
- Automatic creation of discrete-event supply chain simulation models
- Experimentation and performance analysis to design and improve aerospace supply chains

Life Cycle Cost modelling for Engine Manufacturers:

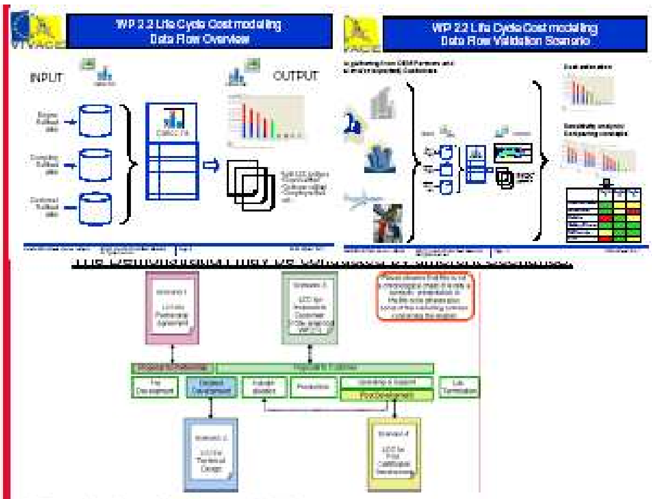
OBJECTIVES:
- Improvement of Life Cycle Cost Estimation Process
- Reduction of administrative Effort/Trips and Costs by less iterations
- More efficiency on cost estimation due to the use of a common Model
- Reduction of Time to Market for a new Product
- Optimizing the Product by giving advice for design changes having identified critical areas early in the Development Phase

VALUE FOR PRODUCT:
- More quality as a result of a specific aero engine tailored estimating Tool
- Tool developed with the knowledge of Cost Estimation from three European Engine Manufacturer

POSITION VS STATE OF THE ART:
- Real Parametric Estimation Tool

VALIDATED ON:
- Test / Simulation comparison
- Test Business Scenario

NEXT STEP:
- Use on the next European Project



Technical description:
- Standardized Life Cycle Cost Nomenclature and Structure
- Parametric Cost Estimation Relationships
- Response surface allows quick sensitivity analysis
- Flexible Handling to Input and Output Parameters

Internal Logistics Simulation:

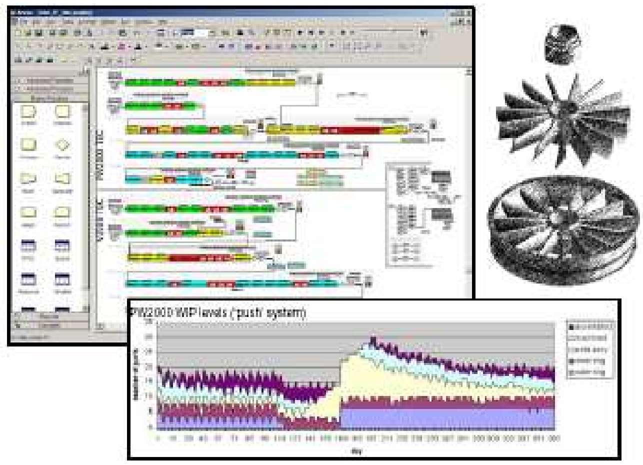
OBJECTIVES:
- Investigate alternative systems of logistic control within business units, and their effect on the supply chain

VALUE FOR PRODUCT:
- Reduced tied-up capital
- Improved throughput and order fill rate
- Greater supply chain robustness

POSITION VS STATE OF THE ART:
- Novel system of parametric logistic control allows many different scenarios to be evaluated in a single model: reduced time and cost with increased confidence in results obtained

VALIDATED ON:
- Comparisons with historical data
- Modular construction approach aids validation

NEXT STEP:
- Wider dissemination



Technical description:
- Models of partner facilities, allowing alternative logistic control strategies to be explored, seeking greater throughput without disrupting the supply chain

2.3. VIVACE KNOWLEDGE MANAGEMENT AND DECISION SUPPORT

Knowledge Enabled Engineering to support Robust Design:

OBJECTIVES

- Demonstration of the Context-Based Search Platform capabilities to leverage Robust Design experience applied to a Turbine Rotor Design

VALUE FOR PRODUCT

- Shorter design lead-time and improved quality, through providing the applicable engineering resources such as robust design tools and methodology at the right time to the right user during the design process.

POSITION VS STATE OF THE ART

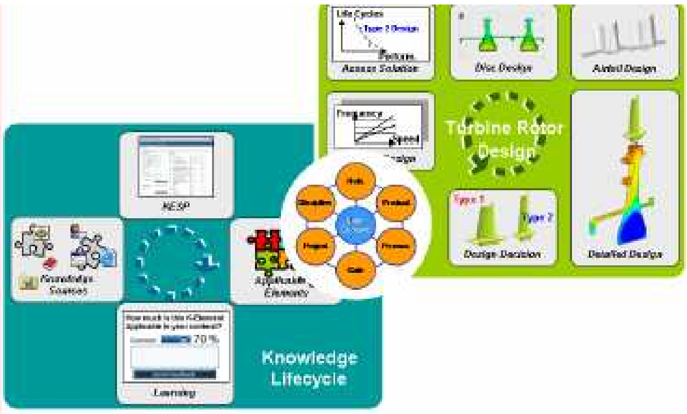
- Innovative way of searching based on retrieval of engineering resources applicable in the same or similar user context

VALIDATED ON

- Context based search platform and Robust design techniques were validated in piloting activities performed in semi-operational environment

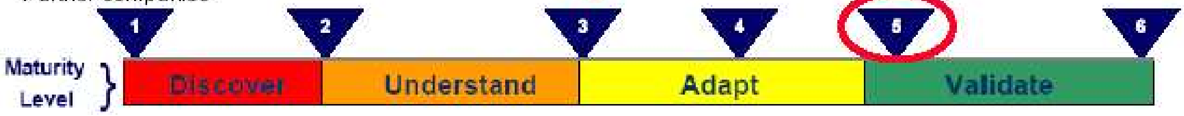
NEXT STEPS

- Promote the use of KEE solutions and robust design techniques in complex, distributed environments within Partner companies



Technical description:

- Context-based Search Platform: the self-learning software system that provides the engineer with the contextualized Knowledge Elements actually needed to perform his/her job
- Re-use of engineering processes and knowledge related to the robust design of a turbine stage
- Distributed and open architectures integration



Tailoring the Decision Process Support Framework to your needs:

OBJECTIVES

- present the Design to Decision Objectives methodology and framework and demonstrate how it supports seamless decision-making processes and the management of significant but complex decisions within the extended enterprise.

VALUE FOR PRODUCT

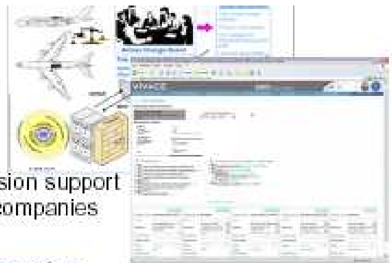
- Improved **Decision Quality** by following a structured approach, provision of relevant information at the right time and easy application of supporting methods for analysis and assessment
- Improved **traceability of decisions** for later consideration or investigation by capturing decisions including context and history information
- Improved **Company Knowledge Base** by transformation of decision and decision context into knowledge base

POSITION VS STATE OF THE ART

- Enhancement and provision of complementary concepts for existing decision support approaches

VALIDATED ON

- COMPASS Use Case: Request for Work process

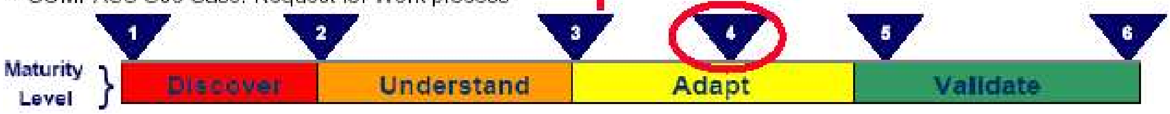


NEXT STEPS

- promote the use of decision support solutions within partner companies

TECHNICAL DESCRIPTION:

- the demonstration will illustrate the Decision Process Support Framework by means of the DtDO Validator (software demonstrator) tailored to different exploitation scenario needs including:
  - Decision Processes: Assess RFW and Assess Elaboration Results
  - Information provision by collaborative engineering data environment
  - Decision Room, guidance through a seamless decision process
  - Demo of DtDO Services to support decision-making within decision process



Change Impacts Analysis:

OBJECTIVES:

- Methodology and supporting toolset to support decision making in the Engineering Change Process & evaluation of architecture robustness throughout the product development lifecycle.

VALUE FOR PRODUCT:

- Facilitate shared understanding & visibility of product & process information
- Support design validation compared to specifications
- Reduce the risk of costly rework and process iterations
- Support capability / technology development roadmaps

POSITION VS STATE OF THE ART:

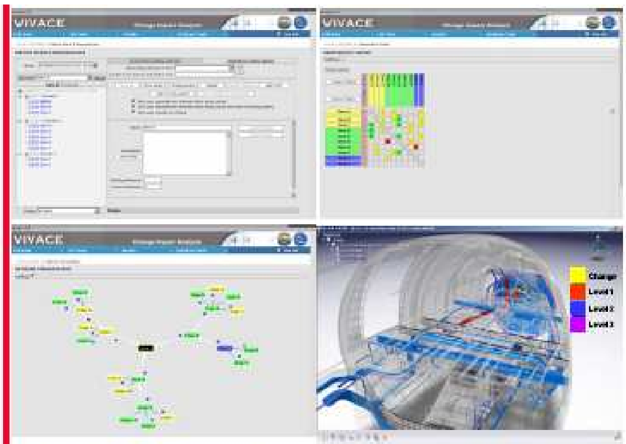
- Innovative combination of features not available in any comparative toolset. CIA-DMU exploitation subject to patent.

VALIDATED ON:

- Architecture behaviour analysis applications ready to deploy for aircraft section models.
- Specification verification applications demonstrated.
- Capability / technology roadmap applications demonstrated
- Integration with other VIVACE capabilities demonstrated.

NEXT STEP:

- Wider deployment within Airbus and user feedback to drive continuing functional development.



Technical description:

- Innovative modelling toolset to capture knowledge of information dependencies, and providing change propagation algorithms, different modes of information visualisation, interfaces with DMU environment & other applications.

Managing uncertain information in the pre-design process:

OBJECTIVES

- present the DtDO Service 'Mastering Uncertainties' and demonstrate how it supports the decision-making

VALUE FOR PRODUCT

- seamless and transparent understanding and quantification of uncertainties in the pre-design phase
- enable more "mature" decisions in terms of risks and opportunities

POSITION VS STATE OF THE ART

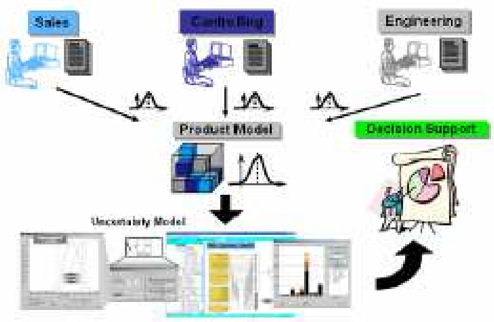
- enhancement and improvement of existing pre-design processes with advanced approach for probabilistic analysis

VALIDATED ON

- pre-design process (weight estimation) within Eurocopter

NEXT STEPS

- implement approach in EC pre design department



TECHNICAL DESCRIPTION

- How to identify and capture uncertainties within a systems design
- How to propagate uncertainties through a functional model in order to achieve a global and quantitative picture of uncertainties in the pre-design process
- How to perform sensitivity analysis to identify risk drivers and their impact on the project

Design to Cost for Pre-design:

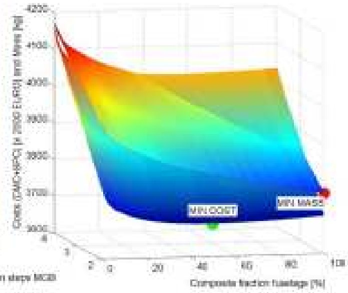
OBJECTIVES:
The objective was to find an optimum helicopter design which not only complies to performance requirements, but also satisfies the customer's requirements at lowest costs.

VALUE FOR PRODUCT:
Reduced operational cost for the operators/owners of helicopters.
Support of helicopter marketing by providing the LCC relationship for multi-mission combinations.

POSITION VS STATE OF THE ART:
A multi-disciplinary design of a helicopter to cost vs. the traditional design to weight for the performance and multiple mission requirements.

VALIDATED ON:
An example helicopter pre-design.

NEXT STEP:
Extension of the parameters in the models used.



Technical description:
A Life Cycle Cost (LCC) model was integrated in the helicopter preliminary design tool SPEAR.
A multidisciplinary optimisation methodology was developed for design to minimum total LCC.
A methodology was developed to apply the design to minimum LCC optimisation for multiple missions of multiple customers.

2.4. VIVACE SOLUTIONS FOR DESIGN AND VIRTUAL TESTING

Affordable complex systems simulation for design efficiency

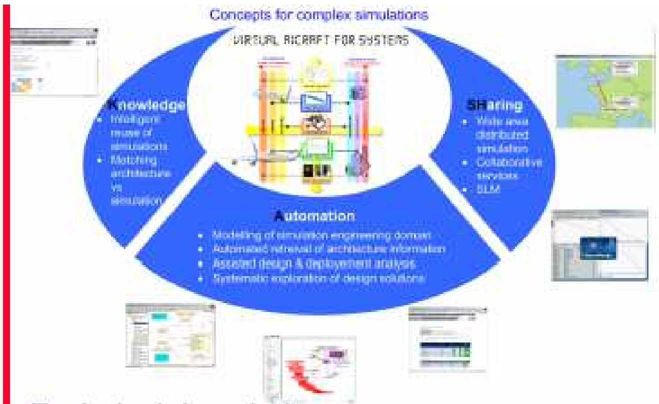
OBJECTIVES:
- Play the integration of aircraft systems at the earliest
- Cost-Effective development and deployment of complex distributed simulations
- Share and reuse simulations in extended enterprise
- Illustrated on Hydraulic Simulation

VALUE FOR PRODUCT:
- Enable right first time
- Reduce lead time of complex simulations
- Reduce operation costs of complex simulations

POSITION VS STATE OF THE ART:
- New state of the art created

VALIDATED ON:
- Simulation of hydraulic & flight control
- Virtual fuel test rig
- Flight management collaborative simulation

NEXT STEP:
- Go up at Aircraft or Air transport system level



Technical description:
- Virtual Aircraft for Systems is a capability enabling virtual design team to build, operate and reuse complex simulations
- Assisted design and deployment of real time distributed simulation using the systems architecture information
- Reuse simulations already deployed in extended enterprise

Preliminary robust mechanical design of Whole Engine:

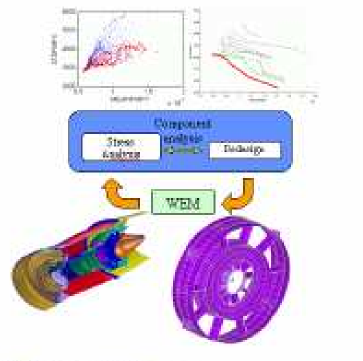
OBJECTIVES:
- Methods for early fit-for-purpose preliminary structural modelling of engine components.
- Timely assessment of response of whole engine to variations of flight loads and extreme events.
- Behaviour of the final design to be more predictable through the engine's life.
- Confidence in component / whole engine interaction.
- Improved design for fuel economy.

VALUE FOR PRODUCT:
- Robust design

POSITION VS STATE OF THE ART:
- New state of the art created

VALIDATED ON:
- Whole engine designs representative of industry.
- Component designs representative of industry.

NEXT STEP:
- Multi discipline, engine – aircraft interaction



Technical description:
- Mixed-dimensional geometry & finite elements for automated structural modelling fit for prelim design.
- Component to component module assembly.
- Variability of engine response to design and operational parameters.
- Reduced rework thro' improved, early understanding

Improved Engine Performance Design and Simulation in a collaborative environment

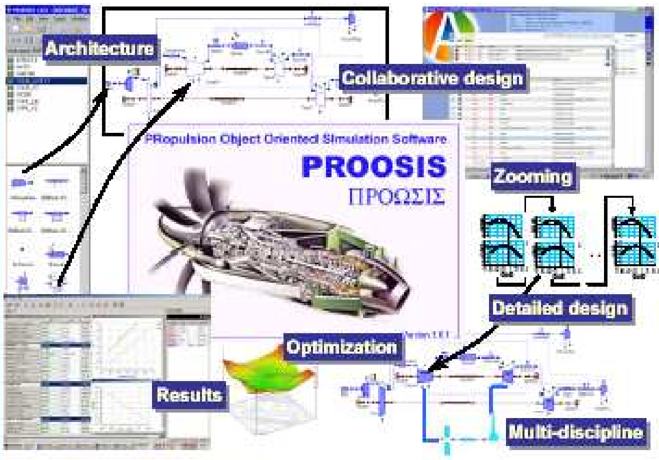
OBJECTIVES:
- PROOSIS enables Collaborative modelling of Engine Performance for Design and Simulation and improves integration efficiency and simulation quality.

VALUE FOR PRODUCT:
- Reduce integration time for collaborative engine model
- Improve models quality using multidiscipline high fidelity simulation

POSITION VS STATE OF THE ART:
- Compliant with latest aeronautical standards
- Same level as NPSS (NASA performance tool for GE)

VALIDATED ON:
- Collaborative engine test case (POA)
- Commercial software (GASTURB,...)
- Company specific tools and models

NEXT STEP:
- Interfaces for zooming and multidiscipline need to be generic



Technical description:
- **Collaborative Design and Simulation tool for engine performance**
- Standard Component and Engine Library
- Easy connections to external tools for zooming, multi-discipline optimisation and distributed calculation

From simulation based design towards virtual certification:

OBJECTIVES:
- Achieve early validation and sizing for aircraft systems and equipments
- Improve the simulation based design process
- Reduce the number of design loop with simulation
- Optimize the physical tests (from large scale tests to components testing)

VALUE FOR PRODUCT:
- Enable right first time
- Reduce NRC and lead time

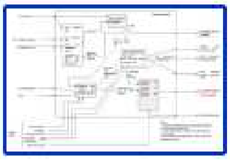
POSITION VS STATE OF THE ART:
- New state of the art created

VALIDATED ON:
- Hydraulic & flight control design
- AFDX& SCI
- Electrical system
- Flaps

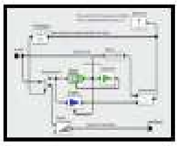
NEXT STEP:
- Enlarge the scope of simulation and achieve confidence to propose a virtual certification strategy

Technical description:

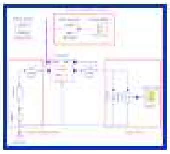
- Real time high fidelity Hydraulic simulation



- Modelling of AFDX and SCI for sizing optimization



- Improved multi-level modelling, right sized simulation and fault case for electric system



- Multi body model of flaps including all effects for all system conditions

Timely Whole Engine Model Validation

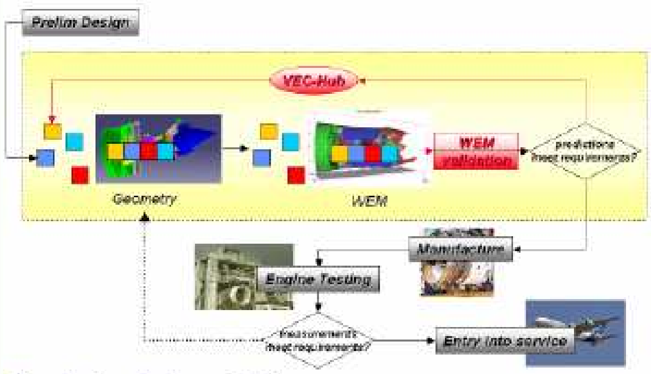
OBJECTIVES:
- Early validation of component and engine and predictions, ideally ahead of manufacture.
- Timely generation of high-quality predictive whole engine models in a multi-partner environment.
- Cost and time efficient physical testing.
- Quick assessment of component design interactions with engine for loads, tip clearance and dynamics.
- Reduced engine assessment process time.

VALUE FOR PRODUCT:
- Confidence in design ahead of manufacture.
- Cost savings thro' rehearsed & efficient testing.

POSITION VS STATE OF THE ART:
- New state of the art created.

VALIDATED ON:
- Whole engine designs representative of industry.
- Industry supplied aero-engine components.

NEXT STEP:
- Engine assembly nonlinear response.



Technical description:
- 'Supermodel' concept proven as reference response.
- Engine model validation by simulation.
- Whole engine model update management.
- Physical test rehearsal via simulation.
- Efficient & novel physical testing of engine casings.
- Physical testing correlated with virtual testing.
- Improved confidence in virtual engine.

2.5. VIVACE SOLUTIONS FOR DESIGN OPTIMISATION

Conceptual Aircraft Design:

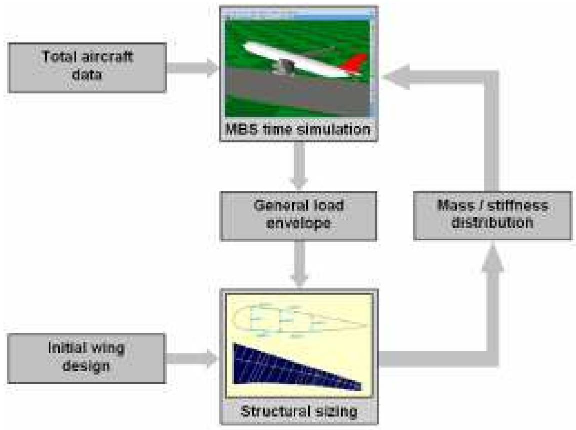
OBJECTIVES:
- Propose a **modular environment for aircraft pre-design**; sample application: modular time simulation of elastic aircraft for analysis of aeroelastic / flight mechanic coupling and sizing based on rational loads

VALUE FOR PRODUCT:
- Improved analysis capabilities for pre-design

POSITION VS STATE OF THE ART:
- New, modular combination of analysis methods

VALIDATED ON:
- Simulation comparison
- Existing aircraft design

NEXT STEP:
- Needs to be validated in an operational environment
- Extention to rotating wing aircraft applications



Technical description:
- **Modular Time Simulation Loop** for aircraft pre-design
- Coupling of flight mechanics, aeroelasticity and beam element structural sizing tool
- Use of multibody dynamics for time simulation of flight load history

Tailoring Multidisciplinary Optimisation of Wing Design in the Extended Enterprise

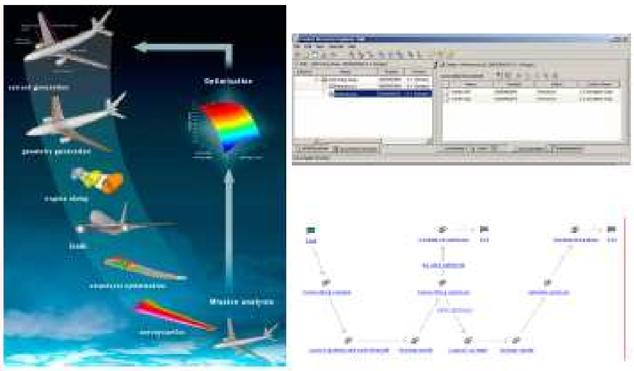
OBJECTIVES:
- Integrate advanced multidisciplinary wing analysis system with a COTS-based product life-cycle management system

VALUE FOR PRODUCT:
- Aircraft wing optimised for multiple targets
- Traceability of early stage engineering data and design choices

POSITION VS STATE OF THE ART:
- Efficient multi-objective optimisation of wing design by advanced multidisciplinary analyses
- Introduce product life-cycle management in earlier design stages

VALIDATED ON:
- Wing MDO use case

NEXT STEP:
- Further enhance work-flow aspects
- Further validation in operational environments



Technical description:
- Integrated multidisciplinary wing design analysis and multi-objective optimisation
- Efficiency through advanced meta-modelling
- Integration of wing MDO with EDM system
- Capture comprehensive design information in workflow system

Stress & Loads Optimisation of a Wing and Pylon based on Manoeuvre Loads

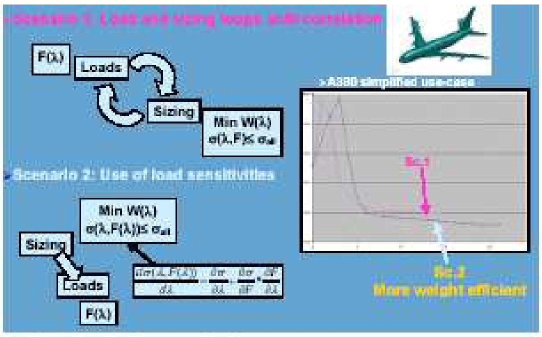
OBJECTIVES:
- Development of a process and a framework for stress and loads optimisation (standard loads)

VALUE FOR PRODUCT:
- Weight saving benefit

POSITION VS STATE OF THE ART:
- Simultaneous optimisation of weight and loads

VALIDATED ON:
- Wing and Pylon structure use case

NEXT STEP:
- Further validation in an operational environment



Technical description:

Two scenarios are compared:

- The standard scenario – 'load loops' - based on iterations between structural sizing and load computation. These iterations are performed up to convergence.
- An improved scenario – 'aero-elastic tailoring' - where these iterations are driven by a weight minimisation, the flexibility effect on loads being accounted for in stress responses.

The 'aero-elastic tailoring' scenario is shown to be more weight efficient compared with the first scenario.

Engine MDO in the Virtual Entreprise:

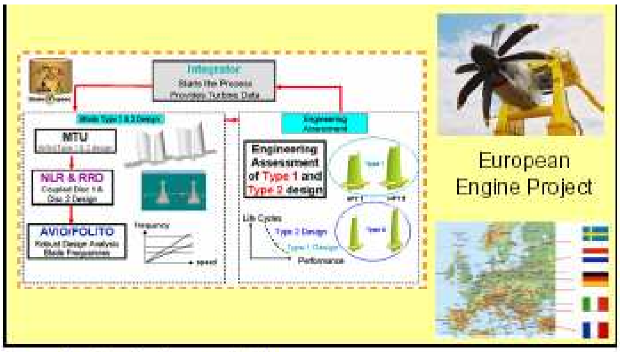
OBJECTIVES:
- Demonstration of an automated distributed design process for an engine module within an European engineering community

VALUE FOR PRODUCT:
- Optimised and robust design solutions for collaborative engineering projects
- Fulfil of customer requirements

POSITION VS STATE OF THE ART:
- Automated distributed design process with an engineering consortium based on individual design framework solutions from all contributing partners

VALIDATED ON:
- Global feasibility demonstrated within VIVACE research partner community
- Validation of local design frameworks individually at each partners company

NEXT STEP:
- Validation of collaborative design framework in an operational environment



Technical description:

- Online collaborative multi disciplinary optimisation and robust design process of an aero engine module
- Implementing design frameworks at each partners company
- Coupled optimisation process between companies (not only single optimisation at each company)
- Assessment of two design concepts based on results from optimisation and robustness analysis