Subproject Proposal Submission Form

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Proposal acronym	ANTASME
Proposal title (max 200 char.)	Advanced modelling techniques for aerospace SMEs

LIST OF PARTICIPANTS

Number	Region	Name	Short name
1 (C)	LOM	Dipartimento di Ingegneria Aerospaziale, Politecnico di Milano	DIA
2	LOM	Dipartimento di Elettronica e Informazione, Politecnico di Milano	DEI
3	LOM	University of Bergamo	UNIBG
4	LOM	Carlo Gavazzi Space SpA	CGS
5	LOM	A.D.S. International	ADS
6	NBR	University of Eindhoven	TUE
7	CAT	CENTRE INTERNACIONAL DE MÈTODES NUMÈRICS EN ENGINYERIA	CIMNE
8	CAT	COMPASS INGENIERÍA Y SISTEMAS	COMPASS
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PERSON IN CHARGE (COORDINATOR)

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SUBPROJECT ABSTRACT (please copy and paste from page 1 of the Administrative forms)

This project aims at transferring a large spectrum of high quality and state of the art modelling capabilities to aerospace SMEs, to enhance their knowledge of the tools they need to support front end technologies and competition.

In fact the more agile exploitation of high end technologies in the aerospace sector implies that SMEs are more and more involved in complex aerospace projects, both autonomously and as subcontractors. Whatever the case, they have to face advanced designs of complex systems requiring complex modeling tools, capable of supporting all design phases: from conceptual inception to detailed design, requiring high end modeling techniques for both analysis and synthesis. This change in scale, and the need to rapidly adapt to the evolution of the market, requires their ability to easily acquire and maintain state of the art modelling, analysis and design capabilities at a low price and high added value.

The related objectives will be achieved through a series of case studies of interest to the participating SMEs, encompassing a wide set of aerospace problems of general enough interest to be potentially useful to not participating SMEs as well, e.g.: attitude and orbit control, aero(servo)elasticity and adaptive control, thermal control, multidisciplinary optimization, real time simulation, space borne payloads, large space telescopes, small satellites in LEO and GEO, aircraft structures.

Since the transfer of advanced modelling capabilities will be carried out by public research institutions it an inter regional network of excellence between academia, research establishments and many interested SMEs will be easily established.

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2.1. Addressed needs

Nowadays, those SME industries that find themselves involved in complex aerospace projects, both autonomously and as subcontractors, have to face advanced designs of complex systems requiring complex modeling tools, capable of supporting all design phases: from conceptual inception to detail design, requiring high end modeling techniques for both analysis and synthesis. The above mentioned capabilities encompass the need of both off-line and realtime simulation of sub and whole systems and must be capable of satisfying the many specification constraints imposing high level of reliability, lightness and overall design robustness against harsh environments and an ample set of generalized loading conditions.

On the one end, aerospace companies usually pay attention and priority to the reliability of the components and their simulation, putting some inertia in driving innovative approaches for the solution of their problems. This is important because the safety and the flight reliability and duration are of utmost importance in aerospace.

On the other hand what mentioned above often involves multiphysics systems including complex aero-thermo-elasto-electromagnetic interactions that can be faced only with complex multidisciplinary computer simulations for distributed/lumped system models.

Even assuming that SMEs have appropriately educated engineers, with full knowledge and expertise of what is needed to support their design needs, they can often afford neither the time nor the resources to internally develop the software they need and have to resort to commercial programs of high cost and complexity.

In such a view they can usually satisfy their most general and common needs but might find themselves not prepared in facing complementary, yet important parts, of their projects, especially when they find themselves either in the need to compete for new projects and/or want to expand their capabilities.

Many times a ready solution comes from cooperation with Universities and Research Centers, mostly public, in search for either an immediate support to solve a problem at hand or to expand and acquire new skills. Support from professionals can be a viable alternative but Universities and the likes are preferred mostly because expanding knowledge is part of their mission so SME find it easier to acquire technology transfers from such institutions, so that the expansion of their internal knowhow is far easier.

In such a view this subproject aims at demonstrating how a significant part of what depicted above can be tackled by using advanced state of the art multidisciplinary tools for the analysis and design of a relatively vast set of problems highly meaningful to SMEs engaged in aerospace competition. Compared to the support SMEs could possibly find anyhow by cooperating with the research institutions involved in this subproject separately, the present joint effort has the advantage of setting the ground for a significant cooperative network of researchers that can better show to SMEs a more integrated view of a vaster problem solving and readily available expertise of people and institution willing to help in transferring technology and knowledge.

So the goal of this research is to contribute an innovative step ahead in modeling and simulation tools of aerospace systems, supporting aerospace SMEs in achieving significant improvements in quality, costs and development time reductions.

The participants have a long standing experience in the development and use of modeling and simulation tools, with, but not only, particular reference to integrated modeling, analysis and design of smart/intelligent advanced aerospace systems; by way of example: thermal systems, deformable aerospace vehicles, space robots, autonomous exploration systems design, trajectory and attitude control, stability augmentation, aeroservoelasticity, optimum design.

So the combination of methodological competences on one side and of many and varied applied experiences in the aerospace domain on the other side should guarantee the possibility of providing a significant and useful improvement in the development practice of modeling and simulation tools for aerospace SMEs.

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2.2. Objectives

The aim of this subproject proposal is to demonstrate the advantages which can derive to SMEs from the adoption and integration of existing state of the art advanced modelling techniques in various fields of aerospace engineering, to effectively realise a related transfer of knowledge and technology in this area. This objective will be achieved by tackling one or more case studies of interest, realistic but not necessarily actual, to aerospace SMEs. The research will focus on a varied set of aerospace problems using a wide range of existing modelling tools: a survey has been carried on during the proposal preparation phase in order to identify with the involved SMEs case studies of interest.

The interested participating SMEs are not numerous but enough to establish a web of applications sufficient to warrant that the findings of this subproject will not be valuable only for them but will afford a significant knowledge body for other SMEs accessing all the public results of this research. Furthermore, their participation in SMEs consortia allows a natural way to widely disseminate the results to a larger number of SMEs.

Also important will be the capabilities of the participant research institutions to exploit this subproject in such a way to set up an integrated inter regional network with a working methodology and experience of technology transfer, proving that it can work for real.

While the success or failure of the research will be inferred only at its end the list of the applications on which this subproject will be based, combined with due knowledge and expertise of the research institutions supporting this subproject seems to be well instrumented to meet the above goals successfully.

So the technology transfer cases will be related to:

- attitude and orbit control;
- aero(servo)elasticity and adaptive control;
- thermal control;
- mechatronic systems for servo control;

aiming at an implementation, whenever practical, of

- multidisciplinary optimization and
- real time simulation

of what above. The practical application of these techniques will be for:

- spaceborne payloads;
- large space telescopes
- small satellites in LEO and GEO;
- aircraft and helicopter structures

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2.3. Approach and general implementation plan

Maximum length: 2 pages + the forms specified below

(Describe in detail the planned work and the methodology that will be followed to achieve the objectives for the whole duration of the proposed subproject.)

To be significant the transfer of expertise related to advanced modelling technique to SMEs should:

- include a web of applications covering a vast subset of aerospace design and analysis problem;
- contain a significant transfer of knowledge;
- be able, in combination with the above, to afford tools allowing SMEs to achieve not only advanced modelling capabilities but some autonomy in doing something advanced on their own.

As already hinted the way chosen to fulfil the above requirements is the determination of a set or true/plausible modelling cases capable of proving that the network of public research institutions gathered within this subproject is apt to meet the above needs. Since most of the participants are well introduced in the aerospace research field and compete in the international research arena, it is clear that they can support research activities covering a broad enough area of interest to allow an ample superposition of their capabilities. So due care has been exercised in avoiding duplication, at least in relation to the immediate needs of the participating SMEs. That does not mean that this research activity is tailored to the participating SMEs only, as it is vast enough to be useful to most of those aerospace SMEs willing of access the results of this subproject in the future. The following list of technology/knowledge transfer should prove it.

DIA:

Will demonstrate feasibility and advantages of using advanced existing active/massively-adaptive technologies and know-how for large ground based telescopes to a new generation of large space based telescopes using integrated state of the art, free, multiphysic simulation tools to support the development of a space telescope system. The research will be based on a preliminary conceptual design made available by CGS and ADS and should prove how SMEs can profit from the availability of free(dom) tools and knowledge to ease interaction with public research centres, technology transfer and widen their scope capability and competitiveness. Modelling technique to be used include: structural/thermal FEM, multibody simulation and existing programs specifically developed for massively control adaptive optics. Along the line of transferring models development capabilities, programs, tools and libraries already available for automatic differentiation will be used to demonstrate how small SMEs could expand also their modelling capabilities autonomously, with relative ease and efficiency.

DEI:

Will develop multi-domain modelling and simulation environments for aerospace systems, with specific attention to mechatronic electrohydraulic systems and to spacecraft attitude and orbit dynamics. The environments will offer hierarchical modular modelling capabilities, to ensure models reuse, and a "natural" (i.e. not requiring a specific modelling knowledge) approach to complex model definition. The hierarchical model building will allow to build a complex model by connecting simpler (lower level) models. A library of basic acausal (i.e., whose equations are stated without consideration of the computational order) models of the physical components of a system shall be developed. Existing in-house model libraries and commercial tools shall be used as far as possible and the development of new service (e.g., 3D graphic animations) software minimized. Most of the effort shall be related to modelling, and the wide past experience on modelling of the participants taken advantage of, as far as possible. A minimum set of essential interface functions shall be developed, for the effective and efficient use of the modelling and simulation software. Among them the 3D graphic animation of simulation results and masks to input model parameters. Particular care shall be placed in the development of the model structure in order to exploit as much as possible the potential advantages of the object-oriented approach. Finally, the proposed environment shall include the possibility of modelling a formation or a constellation of spacecraft and to include in the description of the individual satellite such detailed features as the presence of flexible components such as gravity gradient booms, antennas and inflatable or extensible appendages. The validity of the proposed modelling approach shall be validated in the development of modelling and simulation tools for two actual forthcoming missions which are currently at phase A development level at CGS.

CIMNE:
The objective of the work is to integrate and validate robust, accurate and efficient numerical methods to be applied to multidisciplinary design optimisation (MDO) and multi objective problems in aeronautics with particular emphasis to the fact that an aircraft is an aeroelastic system. The research activity will validate and integrate: advanced finite element-based analysis modules, robust evolutionary and deterministic optimisation tools, mesh generators, capability for parallel computing and pre and post processing. The final aim of the research is to demonstrate how SMEs working for the aerospace sector, such as QUANTECH and COMPASS involved in this activity could exploit an MDO collaborative environment with its building blocks interfaces for 1) the optimum design of aircraft structures; 2) multi criteria drag reduction and aerodynamic efficiency of high lift configurations with uncertainties and 3) fluid/structure design optimisation using distributed evolutionary algorithms.

UNIBG and TUE:
Will demonstrate the use and efficiency of passive two-phase heap pipes (LHP) having great application potentialities for spacecraft thermal control. LHP is a passive heat transport device that use capillary forces to circulate a two-phase working fluid. In cooperation with CGS an innovative LHP will be used in the Alpha Magnetic Spectrometer (the so-called 'AMS-02' project for the ISS) as the core thermal system in order to control the temperature of a set of cryocoolers by means of a direct condensing radiator. In this context, a recent development defined the design and fabrication of a new propylene LHP with a by-pass valve. A numerical model of the propylene LHP will be developed by UNIBG using a code initially developed by NASA (SINDA/FLUINT). SINDA is a network-style thermal simulator. SINDA/FLUINT modelling allows an analysis integrated with the ISS system level model, by means of a time-varying sink temperature definition. For a better assessment of different state of the art available modelling capabilities TUE will demonstrate the use of modelling techniques based on distributed numerical approximations, e.g. FEM and FD, so that interested SMEs could fully be knowledgeable of the pros and cons of the different available modelling methods.

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2.3.1. Workpackage list				
WP number	Workpackage title	Start month	End month	Leading[1] participant n.
1	Project management	1	13	1
2	Automatic differentiation techniques	1	9	1
3	Innovative finite element methods for unsteady aeroelastic analysis	1	12	7
4	Advanced evolutionary algorithms for transonic drag reduction and high lift of 3D configuration using unstructured FEM	1	12	7
5	Simulation of massively controlled space tele-scopes	1	12	1
6	Object-oriented modelling of mechatronic elec-trohydraulic systems	1	12	2
7	Object-oriented modelling of spacecraft dynamics	1	12	2
8	SINDA/FLUINT simulation of the LHP prototype	1	12	3
9	Lumped and "distributed" analysis of the by-pass valve	3	11	3
10	Dissemination of results	1	12	1

1

2.3.2. Gantt chart													
WP number	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X			
3	X	X	X	X	X	X	X	X	X	X	X	X	
4	X	X	X	X	X	X	X	X	X	X	X	X	
5	X	X	X	X	X	X	X	X	X	X	X	X	
6	X	X	X	X	X	X	X	X	X	X	X	X	
7	X	X	X	X	X	X	X	X	X	X	X	X	
8	X	X	X	X	X	X	X	X	X	X	X	X	
9			X	X	X	X	X	X	X	X	X		
10	X	X	X	X	X	X	X	X	X	X	X	X	

2.3.3. Deliverable list[2]				
Deliverable number	WP number	Deliverable title	Delivery month	Dissemination level[3]
2.1	2	Automatic differentiation tools	3	PU
2.2	2	Integration of ADT within OO codes: ac-curacy and timings	9	PU
2.3	2	Public release of a MBDyn version with ADT capabilities	10	PU
3.1	3	New computational system for aeroelastic	12	PU

[1] Number of the participant responsible for the activities foreseen in the workpackage.

[2] Please list all the project deliverables as described in the various 2.3.4 forms. You may add as many lines as needed.

[3] Please indicate the dissemination level of the deliverable according to the following explanations:
PU for "Public" (may be published on the MATEO website);
RE for "Restricted" (may be distributed to other MATEO subprojects participants;
CO for "Confidential" (only for participants of this subproject).
Note that the **RE** and **CO** dissemination levels include the MATEO and INTERREG IIIC management committees.

		analysis		
4.1	4	New evolution algorithms	12	PU
4.2	4	Validation Report	12	PU
5.1	5	Multibody simulation of space telescope deployment	8	PU
5.2	5	Active adaptive shape control of a space telescope	12	PU
6.1	6	Design description of the object-oriented library for mechatronic electrohydraulic systems	6	PU
6.2	6	Assessment of the performance of the mechatronic electrohydraulic library in a case study	12	PU
7.1	7	Design description of the modelling library for spacecraft dynamics	6	PU
7.2	7	Assessment of the performance of the spacecraft dynamics library in a realistic case study	12	PU
8.1	8	Simulation of the LHP in orbital conditions	4	PU
8.2	8	Simulation of the LHP prototype in the thermal chamber (ground test)	10	PU
8.3	8	Comparison of numerical data and ground test results	12	PU
8.4	8	Definition of data input and output structures for future implementation in general multidisciplinary codes	12	PU
9.1	9	Analytical model of the by-pass valve	6	PU
9.2	9	FEM analysis of the by-pass valve	9	PU
9.3	9	Implementation of the FEM data in the SINDA/FLUINT network scheme	11	PU
10.1	10	Subproject web site	3	PU
10.2	10	Dissemination of results	12	PU

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2.3.4. Workpackage description

Workpackage n.	1	Start month			1	End month				13
Workpackage title[1]	Project management									
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months	1									

Objectives

- General coordination;
- Coordination of the research-related activities ;
- Coordination of training and dissemination.

Description of work

The coordinator will supervision and monitor the project process. He will deliver the reports as agreed. Another important part of his tasks will be the coordination of meetings and communications within partners (e.g. between RTD performers and SMEs) to ensure appropriate information flow. Two meeting are planned. The first one will be kept in Barcelona, the second closing one in Milan. E-mail and phone conferences will be extensively used in order to keep the partners informed of each other activities. This will allow to reduce travel and organization expenses and to devolve a larger quota of the balance to technology transfer activities.

Expected results

Deliverables

Use as many copies of this page as needed

[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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Proposal acronym	ANTASME

2.3.4. Workpackage description										
Workpackage n.	2	Start month		1		End month			10	
Workpackage title[1]	Automatic differentiation techniques									
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months	8				1					

Objectives

Investigate the use of automatic differentiation techniques (ADT) for the rapid development of new, complex elements; particular attention will be paid to components of multiphysics models, such as those used in the free(dom) multibody code MBDyn.
Check the compatibility between automatic differentiation and object-oriented languages. Compare the solution accuracy and run time efficiency of elements with Jacobian matrices built using automatic differentiation techniques and elements built using analytical Jacobian matrices.

Description of work

The first step of the project will be a survey of possible open approaches and tools/libraries already available for automatic differentiation.
In view of the possible use of these techniques for the rapid development of elements, particular emphasis will be put in the compatibility of available tools with object-oriented languages. Following this survey, it will be possible to develop (if necessary) or adopt an already existing automatic differentiation tool, and introduce it in MBDyn, an open-source, object-oriented multidisciplinary code developed by DIA. The automatic differentiation approach will be applied to a limited set of both new and already existing MBDyn's elements and sampled in cooperation with the needs of a SME. The use of already existing elements will allow to compare simulation results and run times of the automatic differentiation and analytical approach, to check the accuracy of the ADT approach, and ultimately to better understand the pros/cons of modern automatic differentiations techniques.

Expected results

Demonstrate that the adoption of ADT can lead to huge time saving in the development of new elements, with as little as possible expense in simulation run-time. This will help SMEs in better using the free software, MBDyn in particular, and to to gain autonomy for the rapid development of their own elements. Allow SMEs to expand their modelling competitiveness and creativeness easing technology transfer and cooperation with universities and research centres.

Deliverables

2.1 Automatic differentiation tools;
2.2 Integration of ADT within OO codes: accuracy and timings;
2.3 Public release of a MBDyn version with ADT capabilities.

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[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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Proposal acronym	ANTASME

2.3.4. Workpackage description

Workpackage n.	3	Start month			1	End month			12	
Workpackage title[1]	Innovative finite element methods for unsteady aeroelastic analysis									
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months							12	4	4	20

Objectives

Development of highly efficient unstructured finite element methods for the analysis of unsteady aerodynamic accounting for aeroelastic effects. Both Euler and Navier-Stokes CFD solvers will be used. Adaptive mesh refinement procedures will be used for controlling the accuracy of the coupled solution process. The aim is to predict the loads on the aircraft structure during unsteady flight conditions.

Description of work

The numerical solution will be obtained by coupling existing state of the art Euler/Navier-Stokes finite element (FE) codes based on a new stabilized FE formulation using unstructured meshes of linear tetrahedra elements with advanced structural shell/beam models available to CIMNE. Adaptive mesh generation will be carried out using new error estimation algorithms for FE analysis of Euler/Navier-Stokes equation and the GiD pre/post processing system developed by CIMNE.

Expected results

New integrated computational system for aeroelastic analysis of aircrafts in unsteady flight conditions via adaptive unstructured finite element methods.

Deliverables

3.1. New computational system for aeroelastic analysis.

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[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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Proposal acronym	ANTASME

2.3.4. Workpackage description

Workpackage n.	4	Start month	1	End month	12
Workpackage title[1]	Advanced evolutionary algorithms for transonic drag reduction and high lift of 3D configuration using unstructured FEM				

Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months							8	4	4	16

Objectives

An emerging technique for optimisation and MDO is Evolutionary Algorithms (EAs). It is well known that EA can provide solutions to problems that cause difficulty to traditional optimisers. These problems are generally multimodal, involve approximation, are non-differentiable and require the consideration of multiple objectives. Over the past three years, the evolutionary optimisation group at CIMNE has developed a robust evolutionary optimiser for aerodynamic shape problems. The foundations of the algorithm lie upon traditional evolution strategies and incorporate the concepts of a multi-objective optimisation, hierarchical topology, asynchronous evaluation and parallel computing. The algorithm works as a black-box optimiser and can be coupled to several aerodynamic and aircraft conceptual design solvers. The overall objective of this WP is to develop and demonstrate the possibility of the method for transonic drag reduction using unstructured finite element Euler and Navier-Stokes codes.

Description of work

This WP aims at developing an aerodynamic shape optimisation framework that combines three-dimensional CFD solvers, an automatic unstructured mesh generator and a hierarchical asynchronous parallel evolutionary algorithm. The aerodynamic analysis is performed first by a hierarchical topology of Euler/finite element methods for fluid flow analysis. The system level optimiser manipulates the wing geometry (aspect ratio, thickness-to-chord ratio, wing sweep, etc.).
The study will focus first on the unstructured Euler code solver and optimiser coupling with the use of parallel computing strategies to speed up the computational time.
The work will concentrate on the application of the developed methodology to the aerodynamic design of aircraft. It is specifically intended to optimise the aerofoil section and the platform of these systems with minimization of transonic drag and maximization of the aerodynamic performance.

Expected results

- Enhanced evolution algorithms for low/medium fidelity optimisation problems in aeronautics using unstructured FEM.
- Validation of the EA optimisation algorithm for multi objective optimisation applications in aeronautics using unstructured FEM meshes and parallel computing.

Deliverables

4.1. New evolution algorithms.
4.2. Validation Report.

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[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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Proposal acronym	ANTASME

2.3.4. Workpackage description

Workpackage n.	5	Start month		1	End month			12	
Workpackage title[1]	Simulation of massively controlled space telescopes								
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months	9			1	2					

Objectives

Demonstrate the feasibility and the advantages of using existing advanced active/massively-adaptive technologies and know-how developed for large ground based telescopes adaptive optics systems to a new generation of large space based telescopes using integrated state of the art, free, multiphysics simulation tools to support the design and the simulation of an all space based telescope system. The research will be based on a preliminary conceptual design made available by CGS and ADS. The proposed activity should prove how SMEs can profit from the availability of free(dom) tools and knowledge to: ease interaction with public research centres, technology transfer, widen their scope capability and competitiveness.

Description of work

- Modelling of all parts of a conceptual design of a new generation future large space telescope using active/adaptive optics exploiting the capabilities of a free(dom) DIA multibody code to integrate different multiphysiscs models;
- Use of those models to simulate various design and analysis phases of the integrated system;
- Simulation of the telescope deployment, using both batch and real time simulations; including the assessment of the constraint imposed by real time simulations to model complexity;
- Simulate the interaction of low frequency active control with high frequency massively-adaptive shape control;
- Verify obtainable performances against space environment disturbances and interactions with other satellite subsystems including attitude and pointing control.

Expected results

- Verification of the possibility of porting to space application the most advanced active/adaptive technologies developed for large ground telescopes;
- Preliminary implementation of this technology in a space based telescope;
- Technology transfer from research at DIA to SMEs;
- Reinforcement of SMEs capabilities in the field.

Deliverables

5.1 Multibody simulation of space telescope deployment
5.2 Active adaptive shape control of large space telescope optics

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Proposal acronym	ANTASME

2.3.4. Workpackage description

Workpackage n.	6	Start month		1	End month				12
Workpackage title[1]	Object-oriented modelling of mechatronic electrohydraulic systems								
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months		9								

Objectives

The main objective of the present WP is the development of tools for simulations of mechatronic components used in the actuation chains for aerospace systems. The proposed models, implemented in accordance with the state-of-the-art paradigms in object-oriented modelling and simulation, shall guarantee modularity and reusability and shall be suitable for both the dynamic design of the actuators and the assessment of the overall performance of the controlled system. Specific reference will be made to electrohydraulic actuators.
As a case study, the integration of the actuators model within a helicopter system model, based on rotorcraft flight mechanics and able to match the prevailing dynamic phenomena involved in helicopter handling and control, will be studied. Evaluations of consequences deriving from single or multiple failures at actuator level will be fundamental in the context of the aeronautic certification of new-generation fly-by-wire actuators.

Description of work

- Design of the general architecture of the components library;
- Implementation of detailed mechatronic models for DDV (Direct Drive Valve) electro-hydraulic actuators;
- Validation of the general parametric actuator model with available constructive and experimental data;
- Realization of a complete helicopter system model finalized to:
    - Reproduce by means of simulation the dynamic loads acting on actuators in the whole flight envelope of the helicopter.
    - Evaluate the helicopter closed-loop performances starting from the existing control laws (basic stabilization and advanced autopilot modes).
- Assessment of safety margins in case of actuators failures.

Expected results

This activity shall produce the following main outputs:
- Models of DDV electrohydraulic actuators
- Verification of the usefulness of the models in a realistic case study (helicopter control)

Deliverables

6.1 Design description of the object-oriented library for mechatronic electrohydraulic systems
6.2 Assessment of the performance of the mechatronic electrohydraulic library in a case study

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[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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Proposal acronym	ANTASME

2.3.4. Workpackage description

Workpackage n.	7	Start month		1	End month				12
Workpackage title[1]	Object-oriented modelling of spacecraft dynamics								
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months		9		1						

Objectives

The aim of this WP is to exploit existing object-oriented modelling and simulation technologies in order to develop a set of advanced tools for the simulation of spacecraft attitude and orbit dynamics. The goal is to arrive at a detailed, yet easy to use tool which can serve as a reference in the preliminary design and performance assessment of spacecraft attitude and orbit control systems. Particular care shall be placed in the development of the model structure in order to exploit as much as possible the potential advantages of the object-oriented approach.

The validity of the proposed modelling approach shall be verified in the development of modelling and simulation tools for two actual forthcoming missions which are currently at phase A development level at Carlo Gavazzi Space SpA.

Description of work

- Design of the general architecture for the proposed components library;
- Implementation of the basic components for the modelling and simulation of:
  - Space environment
  - Spacecraft attitude and orbit dynamics
  - Interaction between the spacecraft and the environment
  - On-board attitude determination and control algorithms
- Validation of the developed code using both commercial software and experimental data;
- Provision for advanced features such as:
  - Modelling and simulation of multi-spacecraft systems;
  - Modelling and simulation of multibody, possibly non rigid spacecraft.
- Verification of the developed tools in the study of a real life mission.

Expected results

Main outputs of this activity shall be:
- The complete spacecraft modelling and simulation environment described above;
- The verification in a real-life case study of the validity of the proposed approach.

Deliverables

7.1 Design description of the modelling library for spacecraft dynamics;
7.2 Assessment of the performance of the spacecraft dynamics library in a realistic case study.

Use as many copies of this page as needed

[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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2.3.4. Workpackage description										
Workpackage n.	8	Start month		1	End month				12	
Workpackage title[1]	SINDA/FLUINT simulation of the LHP prototype									
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months			12	1		1				

Objectives

A comparison between the microgravity and the unit gravity model is important to understand as much as possible of the LHP working. It is desirable to understand the behaviour under both conditions because, although a satellite's operational life is spent in orbit under microgravity conditions, the satellite undergoes extensive ground testing (1 g) before launch to ensure all components are working correctly. Therefore the objectives of this WP are:
1) building the network scheme of the propylene loop heat pipe
2) simulating the LHP orbit and ground behaviour using Carlo Gavazzi Space data for the orbits
3) modelling the physical processes in the LHP evaporator and condensator using the last results in the literature
4) implementing the results obtained in the WP 9 using a "mixed approach"

Description of work

Using a lumped code (SINDA/FLUINT) every component of the AMS propylene Loop heat pipe will be modelled. The boundary conditions will be time varying elements, simulating different orbital periods defined through previous flight conditions supplied by the Carlo Gavazzi Space. The same model will be then adapt to simulate a ground LHP, looking at empirical correlation in gravity for the two-phase thermodynamics and flow. Also the LHP boundary conditions will be varied in order to assure that the same heat transfer dissipated during flight conditions will be reached when also natural convection is present, i.e. in the thermal chamber. The 1g model will be compared with results obtained in the thermal chamber experiments in China typically by correcting the unknown conductances in the model. The whole LHP will be then reduced to an "object" in which input data are represented by the boundary conditions both for the evaporator and the radiator and the results are constituted by the thermodynamics values of the propylene in the points necessary to fix the loop working and failure. Finally the results of the WP x.2 will be used in a sub-network set regarding the by-pass valve regimes, using an innovative "mixed approach" from "distributed" simulation to the lumped simulation code.

Expected results

The comparison between the microgravity and the gravity models will give us the necessary information about the optimal ground testing, which will be applicable for the LHP final operational testing. The experimental data will help to tune the behaviour in the evaporator and in the condenser where the two-phase heat transfer is difficult to predict. The definition of data input and output structures reduce the LHP model to few objects necessary in a future implementation in multidisciplinary codes. The usage of the FEM results describing the by-pass valve inside the SINDA/FLUINT code will help to understand the best implementation strategies in such "mixed approach".

Deliverables

8.1 Simulation of the LHP in orbital conditions
8.2 Simulation of the LHP prototype in the thermal chamber (ground test)
8.3 Comparison of numerical data and ground test results
8.4 Definition of data input and output structures for future implementation in general multidisciplinary codes

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[1] "Project management" and "Dissemination of results" are mandatory workpackages.

MATEO Matching Technologies and Opportunities
PROJET COFINANCE PAR L'UNION EUROPEENNE
Nord Est SUD Ouest INTERREG IIIC

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2.3.4. WORKPACKAGE DESCRIPTION

Workpackage n.	9	Start month		3		End month			11	
Workpackage title[1]	Lumped and "distributed" analysis of the by-pass valve									
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months			4	1		2				

Objectives

In order to avoid extra-operational and transitory failures of the propylene LHP, a passive valve is necessary. The by-pass valve consists of two pressure compartments that are separated by a stem. The pressure difference between the two compartments acts on the valve stem and determines whether the valve is open or closed. A compressed gas (Ar) creates the back-pressure on the upper side while the pressure in the other compartment is the saturation pressure of the propylene. The objectives of the work are to characterize the valve both thermodynamically and fluidmechanically by an analytical and FEM analysis. The by-pass valve allows the LPH to work as a fully passive device. Despite the essential role of the by-pass valve, its behaviour is not well understood and must be investigated in more detail.

Description of work

AMS includes 4 Stirling Cryogenic Coolers (Cryo-Coolers), which extract parasitic heat from one of the thermal protection shields. The Cu-collar of the cryocooler is connected via the LHP system to the corresponding quarter of the Zenith radiator.
The purpose of the by-pass valve is to keep the AMS Cryo-cooler above a fixed minimum operating temperature in order to avoid formation of ice that may cause failure of the LHP. Simulations with the SINDA/FLUINT model determined the range in which the minimum inlet temperature of the valve lies. This inlet temperature is an important input parameter for the analytical and FEM analysis of the by-pass valve. Objective of the analysis are determination of the pressure drop and the thermal loss inside the valve both in the recycling and in the through-flow operating mode under steady-state conditions. The results provided by this analysis are used to determine more accurate input parameters for the by-pass valve in the SINDA/FLUINT model. Finally, a combined lumped/distributed approach can be used to study the operating transient mode of the valve (WP 8).

Expected results

Depending on the inlet properties of the propylene, the by-pass valve needs to assure a fast open/close mode in order to prevent a decreasing of the temperature or to let the fluid reaching the radiator to be finally condensed. A full analysis can give information about the right regime of the valve during a steady state mode. Fixed the saturation temperature in the inlet of the valve, the final result is the temperature and the pressure in the outlet. This information will then be integrated in the lumped code SINDA/FLUINT and is fundamental to understand if the valve is properly working during every orbital position.

Deliverables

9.1 Analytical model of the by-pass valve
9.2 FEM analysis of the by-pass valve
9.3 Implementation of the FEM data in the SINDA/FLUINT network scheme

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[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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Proposal acronym	ANTASME

2.3.4. Workpackage description

Workpackage n.	10	Start month		1	End month				12
Workpackage title[1]	Dissemination of results								
Participant number	1	2	3	4	5	6	7	8	9	TOT
Person-months	1			2						

Objectives

To spread the acquired technology transfer experiences both

- at the end of the key phases of the project to the participating SMEs and
- beyond the subproject duration and partners.

Description of work

DIA will set up a web page, with a description of the subproject, with links to all of the partners' web pages illustrating their workpackages. All the public deliverables will be published on the web. The knowledge gained by academic partners during the subproject will be transferred, as far as possible, to their study curricula.
Participating SMEs will attend contractual progress meetings and any other 'demonstration-day' of the tools developed in order to gain confidence in their use and potentiality.
All the partners are committed in spreading the knowledge by presenting their results in international conferences in Europe and/or publishing them in peer-reviewed international journals. PhD students and/or post-doc may be involved in the subproject. The partners will strive to making the work as publicly exploitable as possible, trying to foster technology transfer and competition to non partecipating SME as well. A closing project open day will be organized by the partecipating partners in concomitance with the final subproject meeting. The closing open day will be promoted using e-mail, distributing brochures, and via already established networks within the industrial community, such as, e.g. for Italy, AIPAS (Italian Association of Aerospace SMEs).

Expected results

- Training of PhD students;
- Scientific publications;
- Web dissemination;
- Meeting with participating SMEs
- closing project open day

Deliverables

10.1 Subproject web site
10.2 Dissemination of results

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[1] "Project management" and "Dissemination of results" are mandatory workpackages.

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2.4. Impact

Maximum length: 1 page

(Describe how the proposed subproject contributes to realise the strategic objectives of MATEO[1].)

The four European Regions involved in the project have a long tradition in innovative and leading industry in mechanical, aerospace and advanced technologies.

Heavy industry and bulk manufacturing lost momentum and gave way to more agile, high technology small and medium enterprises. This change in scale, and the need to rapidly adapt to the evolution of the market, requires the ability to easily acquire and maintain state of the art modelling, analysis and design capabilities at low price and high added value, with the highest possible quality/cost ratio. At the same time, large manufacturers are turning into system builders, which means that their traditional work is being split in subtasks, many of which are delegated to subcontractors in a strong competition within each other. To survive and grow, subcontractors cannot just rely on low cost, because they do not benefit from large scale economies; as a consequence, they need to develop independent analysis and design capabilities to acquire the ability or adapt to the needs of the contractor, without the possibility to afford the high cost and impact of traditional commercial analysis and design tools and procedures.

One of the aims of this project consists in providing very high quality and state of the art modelling capabilities to the participating SMEs. At least two WPs will be based on open standard, free or low cost software; other WPs exploit open libraries of general purpose models, thus emphasizing the great openness of a publicly funded technology transfer.

The integration of existing software that is instrumental to setting up advanced modelling and analysis capabilities within the SMEs of the four Regions; the development of a common ground of understanding of sophisticated analysis techniques; the possibility to improve the capabilities of the software in an open interchange process, either because the software itself or the model libraries are open source; all these factors create the conditions to establish a network of excellence between the academia, the research establishment and the industries, significantly the SMEs, of the four European Regions involved in the project.

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2.5. The consortium

[1] The strategic objectives of MATEO are:

(a) to develop and carry out activities stimulating regional innovation through close cooperation between entities from the four European Regions involved in the project;

(b) to stimulate the cooperation and networking of entities involved in hands-on innovation work: research centres, technostarters, incubators and innovative SMEs.

- Public research institutions:

CIMNE: A research center in Barcelona specialized in development and application of numerical method in aerospace engineering. The objective of the work of CIMNE is to develop, integrate and validate robust, accurate and efficient numerical methods for its application to multidisciplinary design optimization (MDO) and multi objective problems in aeronautics.
The research work proposed by CIMNE will be carried out with the support of COMPASS and Quantech.

DIA: DIA (Dipartimento di Ingegneria Aerospaziale) is the reference point, at Politecnico di Milano, for aerospace teaching and research. The participants in this research have a strong background in real-time simulation, active control of aeroelastic systems, multibody/multiphysics modeling and programming, MDO optimisation.
The research work proposed by DIA will be carried out with CGS and ADS.

DEI: DEI (Dipartimento di Elettronica e Informazione) is one of the largest Departments of Politecnico di Milano (170 professors and researchers, 200 PhD students and post-doc). The Department is organized in four Sections (Automation, Computer Science, Electronics and Telecommunications). The participants in this research all come from the Automation section. They have strong expertise in the development of multi-domain simulation software tools for a wide range of applications including aerospace systems. Their field of research includes also: signal and systems modelling and identification, automation, industrial robotics.
The research work proposed by DEI will be partly carried out with CGS.

UNIBG: LSRM Laboratory is a cluster of 3 laboratories inside the Technology Transfer Centre of Bergamo (POINT): Microfluidics and Chemistry Lab, Lab of Robotics, Mechatronics and Sensors. The lab is specialized in electronic cooling, thermal design, thermal control for space components.TUE: the Department of Mechanical Engineering of the Eindhoven University of Technology (TUE) performs research on complex problems in heat transfer. Specific fields of interest include heat and granular flow, turbomachinery, sustainable energy, micro-cooling, heat transfer in humans and compact heat exchangers.
The research work proposed by UNIBG and TUE will be carried out with CGS.

- SMEs:
QUANTECH: A SME in Barcelona specialized in development customization and marketing of computer simulation software and decision support system for non linear thermo-mechanical analysis of composite structures and metal forming processes.
COMPASS: A SME in Barcelona specialized in development customization and marketing of computer simulation software for fluid dynamics, fluid-structure interaction, computational electro-magnetics and pre and post-processing.
ADS: A SME working in the field of telescopes and radiotelescopes design as well as the design and production of innovative scientific instrumentation. In particular ADS expertise covers the development of innovative systems for active and adaptive optics in large ground based telescopes.
CGS: A SME in Milan involved in the development of wide class of space systems, CGS has consolidated expertise, resources and facilities to carry out a range of activities that stratch from the development of space systems to manufacturing, integration, qualification and in flight certification.

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2.6. Project resources

Maximum length: 1 page

(Demonstrate how the subproject will mobilise the critical mass of resources necessary for success and show that the overall financial plan is adequate.)

The subproject resources appear adequately structured. In fact, being devoted to transferring modelling technologies and tools, they are mostly related to the costs of research institution staffs engaged in the depicted transfer case studies. The similarities of resources distribution of Lombardy research institutions clearly show a balance of the related work packages, with almost all of the resources dedicated to direct staff costs and little side expenses for publications and promotion. It is important to remark also that the activities of the supported/supporting SMEs consistently entails mainly staff work on the related technology transfer and to support the definition of modelling of meaningful advanced case studies, suitable for an affective knowledge transfer. In such a view the only notable difference are the DIA added coordination costs, which should well comply to standard percentages due to such an activity in similar projects. Other remarkable points are at one end the lowest cost of TUE, which is readily justified by the complementary, albeit highly significant, nature of their contribution in relation to the mainstream transfer job carried out by UNIBG.

On the other hand one cannot avoid noticing the largest cost of Spanish work packages. They can be explained in relation to the somewhat different type of the related transfer projects, involving modelling activities requiring far larger computational resources and the integration of distributed models of very large sizes. Such kind of problems cannot be simplified too much, a loss of validation being granted otherwise and, despite a high level of automation, they are known to involve a substantially higher man power with respect to the kind of advanced models related to other work packages. Notice that this is in accordance with the higher budget of the cooperating SMEs, that will closely interact with CIMNE for the whole duration of the project to drive and focus the model development.

So the somewhat heterogeneous activities involved in this subproject maintain a significant degree of consistency in relation to the wide spectrum of technology and knowledge transfer to be carried out so that the mobilised resources and financial plans should be adequate for the subproject success.

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2.7. Project management

Maximum length: 1 page

(Describe the organisation, management and decision making structures of the subproject. Also describe the previous experience of the coordinator.)

Prof. Mantegazza is the coordinator of the subproject. His previous experiences, that may be significant to the project, are:

- teaching of "Dynamics and Control of Aerospace Structures" and "Aeroservoelasticity" within the Master degrees in Aeronautics and Space Engineering at DIA;
- 3 decades of activity in aerospace research and teaching, with emphasis on aeroelasticity and active/intelligent structures and systems;
- having been the coordinator of the Ph.D. curriculum in Aerospace Engineering for more than a decade;
- chairing of "Consorzio Rete", a network of Lombardy Universities and two Aerospace Companies, scientifically supporting the Polo Tecnologico e Scientifico Lombardo" (a regional institution aiming at scientific and technology transfer and incubation of new activities in the area north west of Milano).

He will be assisted by Dr. Morandini and supported by the administration of DIA.

A huge management and decision making infrastructure is not needed, as the different parters are all in good agreement, willing to cooperate for the success of the subproject and the project has a relatively short life span. Moreover, a slender management will be of help in reducing administrative costs of the subproject. For the same reason, electronic exchange of informations is encouraged, and only a mid and a final term meeting are planned in Milan.

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2.8. Other issues

Environmental issues

Maximum length: one third of a page

(If there are environmental issues associated with the subproject, show they have been adequately taken into account.)

The subject of the proposal does not involve environmental issues.

Gender issues

Maximum length: one third of a page

(If there are gender issues associated with the subproject, show they have been adequately taken into account.)

The gender action plan consists of the following rules:

- Every effort will be made to ensure gender equality. Every position in the project will be open to any member irrespective of gender.
- Women are recruited to work on the project activities, and in the case of equal suitability for the job, female scientists will be preferred over male scientists.

Ethical issues

Maximum length: one third of a page

(If there are ethical issues associated with the subproject, show they have been adequately taken into account.)

The subject of the proposal does not involve ethical or safety issues.

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LETTER OF INTENT FOR PARTICIPANTS ELIGIBLE FOR FUNDING (PUBLIC AND PUBLIC EQUIVALENT BODIES)

In the event of approval of the above mentioned subproject applying for assistance from the INTERREG IIIC Regional Framework Operation "MATEO", we hereby certify that

(Participant legal name)

is a (please tick appropriate field)

- ❑ public body
- ❑ public equivalent body

as defined in the Guide for proposers, note 14 of the "Administrative forms explanatory notes"

and, listed as participant number ______ in the "Subproject Proposal Submission Form", will provide € ___________,00 as co-financing to the subproject budget (co-financing rate: 50% for Catalonia, Lombardy and North Brabant; 25% for South-West Bohemia).

We furthermore confirm that any expenditure related to our participation to the above mentioned subproject has not been/is not/will not be funded by any other European programme.

(Signature) (Date: DD/MM/YYYY)

(Printed name of signatory) (Position within the participant organisation)

(Participant official stamp)

Only for Italian participants

(Participant legal name)

is aware that the Italian State and Lombardy Region will cover the above stated co-financing commitment respectively with 35% and 15% co-financing quotas (see "Delibera CIPE n. 67-68, 22/06/2000" and "Art. 27, Legge Regionale n. 37/97 e successive modificazioni e integrazioni").

(Signature) (Date: DD/MM/YYYY)

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Proposal acronym	ANTASME

LETTER OF INTENT FOR PARTICIPANTS NOT ELIGIBLE FOR FUNDING (PRIVATE SMEs)

In the event of approval of the above mentioned subproject within the INTERREG IIIC Regional Framework Operation "MATEO", we hereby certify that

(Participant legal name)

listed as participant number ______ in the "Subproject Proposal Submission Form"

- is a Small or Medium Sized Enterprise (SME) as defined in the Guide for proposers, note 16 of the "Administrative forms explanatory notes",
- wants to be named as Interested Party and
- is willing to cooperate to the above mentioned subproject without funding.

(Signature) (Date: DD/MM/YYYY)

(Printed name of signatory) (Position within the participant organisation)

(Participant official stamp)

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