Executive Summary:
The DAEDALOS project aimed to develop methods and procedures to determine dynamical loads by considering the effects of dynamic buckling, material damping and mechanical hysteresis during aircraft service. Advanced analysis and design principles were assessed with the scope of partly removing the uncertainty and the conservatism of today’s design and certification procedures. The main goals achieved by the DAEDALOS project are summarized as follows:
- Evaluation of more realistic dynamic loads that act along an aircraft structure;
- Establishment of a scientific basis for reduction of pseudo-static loads to be used for sizing of aircraft structure, as well as for internal force redistribution;
- Assessment of new structural concept and design philosophy to refine the dynamic response of aircraft structure;
- Improvement of the knowledge regarding experimentation and numerical simulation of dynamic loads and material damping.

To reach these objectives a DAEDALOS aircraft model representing a mid-size business jet was developed. Analysis and in-depth investigation of the dynamic response were carried out on full finite element models and on hybrid models. For example, the force redistribution within a fuselage barrel section due to dynamic landing loads was analyzed using a partially condensed coarse finite element model, non-linear analyses and taking into consideration the effects of damping.

The material damping was experimentally evaluated for an aluminum alloy and two carbon-epoxy composites. The material loss factor was measured at coupon level using different techniques, such as the dynamic mechanical analysis and the hysteresis loop method on a hydraulic loading frame.

Different methods for damping evaluation were developed, implemented in finite element codes and experimentally validated. They include a strain energy method, a quasi-linear viscoelastic material model, and a generalized Maxwell viscous material damping.

Panels and shells representative of typical components of the DAEDALOS aircraft model were experimentally tested subjected to static as well as dynamic loads. Composite and metallic components of the aircraft model were investigated to evaluate the benefit in terms of weight saving.

The DAEDALOS project started on November 1, 2010. The duration of the project, initially planned for 36 months, was extended of six months to a total duration of 42 months, so it ended on April 30, 2014. The project involved 13 Partners from 8 European countries, including four aircraft industries, two SMEs, two research centers and five universities: Politecnico di Milano (Italy), Alenia Aermacchi (Italy), Aernnova (Spain), Advanced Lightweight Engineering (Netherlands), University of Brno (Czech Republic), DLR (Germany), FOI (Sweden), Israel Aircraft Industries (Israel), LLV (Czech Republic), University of Hannover (Germany), Technical University of Aachen (Germany), SMR (Switzerland) and Technion (Israel).

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Project Context and Objectives:
Today’s design and certification procedures of aircrafts are mainly based on conservative static loading which leads to additional weight and, potentially, to a structurally unsafe aircraft. The overall objective of the DAEDALOS project was to develop new methods and procedures to determine dynamic loads considering the effects of dynamic buckling, material damping and mechanical hysteresis during aircraft service. To this aim, numerical and experimental techniques were developed during DAEDALOS, and were integrated into a novel design philosophy aimed to partially remove the uncertainty and the conservatism of today’s design and certification procedures.
The main achievements of the DAEDALOS project are summarized as follows:
- Evaluation of more realistic dynamic loads that act along an aircraft structure;
- Establishment of a scientific basis for the reduction of pseudo-static loads to be used for sizing of aircraft structure, as well as for internal force redistribution;
- Assessment of new structural concepts and design philosophy to refine the dynamic response of aircraft structures;
- Improvement of the knowledge regarding experimentation and numerical simulation of dynamic loads and material damping;
- Updating the current design philosophy and estimation of the weight reduction in the structure.

DAEDALOS work hence forms the basis for improved common design practices by:
- Determining accurate dynamic load spectra to be used for structural sizing;
- Designing aircraft structural components by using more realistic dynamic loads instead of quasi-static loads;
- Establishing new analysis methodology to take into account material damping;
- Improving the knowledge regarding testing procedure of panels and shells subjected to static and dynamic loads.

The work performed within DAEDALOS was divided into one Workpackage devoted to management, dissemination and exploitation, and four technical Workpackages. The project included smaller manageable thematic Tasks with separate and distinct scientific and engineering objectives.

The main project targets of DAEDALOS were addressed by means of the following targets for the technical WPs.

WP2: Structural model and load cases definition
Workpackage 2 aimed to provide the basic information and the input data necessary to develop the research activities performed in WP3 and WP4. The activities of WP2 furnished also a reference for the comparison with the results available from the other Workpackages. The activities were organized into three Tasks, whose main objectives regarded:
1. Development of a DAEDALOS aircraft model representing a mid-size business jet;
2. Critical review and understanding of the definition of sizing dynamic loads;
3. Definition of the analysis models to be adopted for the different stages of analysis;
4. Generation of the numerical models with different levels of detail;
5. Identification of the typical time history loads related to landing, manoeuvres and gust loads according to the current state of the art.

WP3: Application of dynamic loading
In Workpackage 3, the critical dynamic cases available from WP2 were applied to determine more realistic loads acting along an aircraft structure. The Workpackage aimed to define a new design philosophy capable of improving the dynamic response of aircraft structures, and to expand the state of the art by means of new simulation methodologies. The main activities were directed towards the achievement of the following objectives:
1. Compare results between static and dynamic sizing loads by means of parametric analysis;
2. Analyze the force redistribution within a fuselage barrel section due to dynamic landing loads using a partially condensed coarse finite element model, non-linear analyses and taking into consideration the effects of damping;
3. Generate automated process to account for dynamic loads during preliminary sizing;
4. Develop different methods for damping evaluation: strain energy method, quasi-linear viscoelastic material model, and generalized Maxwell viscous material damping;
5. Evaluate the potential benefits due to the effects of damping on the structural response;
6. Implement optimization procedures accounting for damping effects;
7. Reduce the computational effort through the development of fast-tool techniques;
8. Define new structural concepts able to absorb dynamic loads;
9. Assess the potential benefits due to the use of viscoelastic layers in buckled panels.

WP4: Structural testing
Workpackage 4 covered the experimental activities of the project, consisting in the design and manufacturing of the structures under investigation, and in the testing and measurement of the relevant quantities at different scale levels. The experimental results furnished the basis for a comparison with the numerical results obtained with the methodologies developed in WP3. The main objectives of WP4 regarded:
1. Design and manufacturing of specimens, panels and shells;
2. Measurement of the material loss factor at coupon level using different techniques – dynamic mechanical analysis (DMA) and hysteresis loop method on a hydraulic loading frame – and comparison among them;
3. Experimental evaluation of the damping properties for typical structural components;
4. Testing of panels and shells representative of typical components of the DAEDALOS aircraft model, and subjected to static, including collapse tests, and dynamic loads;
5. Validation of the developed numerical methodologies.

WP5: Design guidelines and new technology validation
Workpackage 5 summarized and condensed the knowledge gained throughout the project, and allowed to derive specific guidelines and recommendations for the industrial applications of the results. The main objectives were:
1. Define a new procedure for the definition and certification of the loads to be used during aircraft design;
2. Quantify the potential weight saving of structural components due to the overloading effect of static loads, accounting for the effects of damping and dynamic loads;
3. Develop guidelines and recommendation regarding the design process, the analysis methodologies and the experimental procedures.

Project Results:
The work performed within DAEDALOS was divided into one Workpackage devoted to management, dissemination and exploitation, and four technical Workpackages. The project included smaller manageable thematic Tasks with separate and distinct scientific and engineering objectives. The structure of the Workpackages is shown in Figure 1, which displays also the links between them. In the following sections the most relevant results are summarized for each Workpackage.
WP1 - Management, dissemination and exploitation

WP1 regarded the management activities, and covered also the dissemination and exploitation of the results and of the knowledge generated by the project.

During the 42 months of project duration, nine meetings were organized.

A DAEDALOS website (public and internal parts) and an ftp server were established. Some results (movies, pictures...) and a list of publications of the DAEDALOS project can be seen on the public part of the website:

www.daedalos-fp7.eu

Besides the DAEDALOS website, passing knowledge to the public-at-large was done through presentations at conferences and publications. In particular:

- A special session dedicated to the DAEDALOS project was organized at the 17th International Conference on Composite Structures (ICCS17) on 17-21 June 2013, at the University of Porto. Eight papers were presented by the Partners;
- A special issue dedicated to the project was organized in the journal “Progress in Aerospace Sciences”, with eleven papers prepared by the Partners.

A number of 15 students collaborated to the project and achieved Master, Bachelor and Ph.D. degrees with Thesis works related to the DAEDALOS activities.

WP2 - Structural models and load cases definition

The activities of WP2 provided the input for all the other Workpackages and regarded:

- Definition of aircraft configuration to be analyzed;
- Development of finite element models;
- Definition of the dynamic loading conditions.

The activity aimed to critically review the current design practices of establishing static design loads for structural sizing. Furthermore, analysis models to be adopted for different stages of analysis were established, as well as dynamic load cases were identified.

A specific aircraft configuration was defined, and the procedures currently used in structural design were reviewed.

A DAEDALOS aircraft model was developed as a mid-size business jet, powered by two turbofan engines, mounted in the aft fuselage. A sketch of the aircraft model is presented in Figure 2.

The structural analysis, based on the current design approach, was performed using different models of the aircraft at different stages. In particular, condensed, detailed and hybrid models were used.

Condensed models constituted the baseline for assessing the dynamic behavior. They represent the structure of the full aircraft including the landing gear, and were used for comparison against the detailed models in terms of the dynamic response. Detailed models account for the modeling of almost every structural component, and display completeness in terms of stiffness elements.

In order to reduce the computational effort, hybrid models were introduced. They offer the advantage of combining detailed models at some critical areas with the simple model at uncritical areas.

The vertical tail and the wing were studied using hybrid models, where the aircraft is modeled using a stick model, while the tail and the wing are modeled in details. Similarly, hybrid models were realized to study the fuselage behavior. An example of the 3D model, the stick model and the fuselage hybrid model are reported in Figure 3.

The structural models were used to compute the loads at the most representative airframe sections, as
well as the stress quantities at the most critical structure elements in accordance with the current state-of-the-art design methods and procedures.

Activities performed in WP2 were the basis to improve the structure modeling and the analysis techniques performed in WP3. Loads were selected so as to be of interest in terms of frequency content compared to parts of the aircraft structure. In particular, the most critical loads were identified: vertical gust was considered for the wing, lateral gust for the vertical tail and impact landing for the fuselage.

WP3 - Application of dynamic loading

WP3 covered different activities related to the application of the dynamic loadings using the input provided by WP2. The activities regarded the investigation of the effects of the time varying loading on the structure, the comparison between static and dynamic results, the development of damping models, the investigation of the effects of the structural dissipation, and the analysis of the force redistribution due to instability. The work was concluded by the formulation of a modified load proposal, and the re-design of some of the aircraft structural components.

The definition of the worst structural response was conducted by means of a parametric analysis applied to some selected loading conditions, both in terms of amplitude and time scale. The analysis was performed at full aircraft level and at sub-component level, including the fuselage, the wing and the vertical tail. Different approaches were used, such as finite element modeling for the fuselage analysis, and hybrid models for the vertical tail and the wing. Figure 4 illustrates the comparison between different strategies for the fuselage analysis.

The introduction of the energy dissipation effects was achieved by developing new methods to assist the numerical analysis, and allowing accounting for the experimental measurements of the material damping properties. Different strategies were developed and compared, including the strain energy method, and a family of generalized-Maxwell material models. Furthermore, quasi-linear viscoelastic material models, based on Prony series representation of experimental data, were implemented in commercial and research finite element codes.

The force redistribution due to instability was studied using these developed and validated damping models. In particular, dynamic buckling analyses were performed at fuselage and sub-component levels. The response of the fuselage to sudden landing was simulated using a hybrid model and a dynamic non-linear analysis with quasi-linear viscoelasticity material behavior, capturing the buckles on extended fuselage areas. The results of the global/local approach are illustrated in Figure 5.

At sub-component level, different curved and flat panels were considered. In this context, a reduced order model was developed to improve the total time of the structural analysis. The approach revealed the ability to provide reasonable estimates of the dynamic buckling load with significant reduction of computational time.

Another tool was developed to mesh specific areas of a fuselage section, and accounting for quasi-linear viscoelasticity in the dynamic analysis.

Part of the activities of WP3 aimed to investigate the structural regions that can be overloaded, assessing the possibility to design replaceable dedicated structural components able to absorb extra load. To this aim three design strategies were investigated, consisting in the use of Passive Constrained Layer Damping (PCLD) on the wing skin, the comparison of two vertical tail configurations, and the mode shape localization on wing ribs.

With the aim of identifying lower set of static design loads on certain structural elements and assemblies, the dynamic loading were applied to the structures and compared with the equivalent static. The analysis
was performed at various scale levels, including the fuselage, the wing, the vertical tail and sub-component flat and curved panels. For the wing and the fuselage, the stress reduction was lower than expected. However, potential reduction areas were identified. For the vertical tail, some conservativeness was observed in the design based on static loads, and some benefits due to a dynamic approach were identified.

At sub-component panel level, dynamic buckling charts were realized considering suddenly applied loads, and quantifying the effects due to dynamics and damping on the buckling response.

Another aspect dealt by WP3 was the re-design of structural components and elements that may be designed lighter than under current static load. The main activities were the development of a composite coarse model. A wing hybrid model was developed and parametric analysis varying Rayleigh and PCLD damping constants were performed.

Another activity regarded the realization of a tool based on finite elements and genetic algorithms, which demonstrated the possibility of achieving weight saving while preserving damping properties. Furthermore, stiffened composite panels were optimized to maximize the first buckling and the collapse load. Finally, a dynamic buckling optimization was performed on flat panels by varying skin and stringers configurations.

WP4 - Structural testing

WP4 focused on the manufacturing and the testing of coupon specimens, panels and shells. The main achievements can be summarized as:

- Measurement of materials damping properties;
- Design of panels and shells representative of aircraft components;
- Comparison of the experimental results of static and dynamic load carrying capacity of different structural components;
- Comparison between experimental results and numerical predictions.

The damping properties of aluminum and composite materials were measured. In particular, specimens made of aluminum alloy 2024 and of composite carbon/epoxy materials with unidirectional and fabric reinforcements were tested.

The damping behavior was investigated with different strategies.

A first approach consisted in performing dynamic tensile experiments using the hysteresis loop method. From these results it was concluded that, unlike the aluminum, the composite specimens display a linear damping. Furthermore, it was observed that the damping constant of the composite material, in the configuration measured during the test campaign, is lower than the aluminum one.

A second strategy regarded the measurement of the loss factors of the material using the Dynamic Mechanical Analysis (DMA), an effective and reliable approach offering the advantage of requiring small coupons. The test set-ups for the damping characterization are presented in Figure 6.

Another part of the work focused on the design of panels and shells representative of typical components of the DAEDALOS aircraft model. In particular, the panels were chosen to be representative of the vertical tail, the wing and the fuselage. All the panels were stiffened, while the shells included unstiffened and stiffened configurations. The materials for the panels were aluminum and composite. Also a hybrid configuration, consisting of a composite skin with aluminum longerons, was tested.

Quasi-static buckling tests were performed on panels and shells, and some of them were tested until failure. The testing activity was conducted using different equipment, including a new testing machine that allows reaching small pulse duration.

The large variety of flat and curved panels and cylindrical shells was tested under axial compression in
static and dynamic conditions. It was observed that, at short loading duration, the buckling load increases. In most cases, the finite element codes were able to predict the buckling and post-buckling behavior of the structures with good correlation with the tests results. Difficulties were found during the tests in obtaining short time excitation with the load level requested by the strength of panels. Dynamic tests were not limited to dynamic buckling tests, but also modal tests were conducted to obtain natural frequencies and modal damping. The Vibration Correlation Technique was applied to the laminated stringer stiffened circular shells, as well as to the flat and curved stringer stiffened panels, showing to be adequate to find the natural frequencies as a function of the applied axial compression load. Some photos taken during the static and dynamic tests of the structures are reported in Figure 7.

WP5 - Design guidelines and new technology validation

WP5 collected the knowledge gathered during the project to determine in a systematic way more representative loads, thus yielding possible weight savings for representative aircraft components, and to provide a summary of the design guidelines. During the project, new methods for more realistic loads estimation were developed, which culminated in two proposals for a modified load process. The first strategy relies on the detailed stress finite element model and the simplified model, allowing determining the “reduction factor” which can be used to factorize the static loads to match the dynamic analysis results. The second strategy allows for a definition of an equivalent static loads set to be applied on a hybrid model for critical gust conditions. In general, the new design strategies can benefit from different approaches to model damping, including the strain energy method, Rayleigh damping and quasi-linear viscoelastic models, and to account for dynamic loading. Within this topic, an automated sizing process for static and dynamic loads was developed and implemented, and a fast tool based on reduced order modeling was proposed to improve the efficiency of the dynamic analysis. Simulations were performed using dynamic loads on hybrid models, as well as global/local models, developed to study in detail the response of structural components. Weight saving was obtained for the some investigated aircraft components. For the fuselage mid-section, the results presented a certain potential for loads reduction and weight savings, based on the presence of damping. On the other hand, no benefits were observed from the introduction of passive constrained damping layers. For the vertical gust load on the wing, the difference between calculated stresses using static and dynamic loads is very small. The analysis of the fuselage revealed that dynamic loads have a large impact on the local stress distribution. Areas of stress reductions were identified around the load introduction, while the average stress was observed to be increased. Final assessment and design guidelines were provided with regard to the use of the developed numerical tools and the knowledge gathered from the testing activity. With respect to the damping modeling, it was concluded that the strain energy method is well suited to quickly obtain an estimate of the modal damping, and can be effectively used in conjunction with the well-known Rayleigh damping, when global damping effects are of concern. On the other hand, the quasi-linear damping models turned out to be more effective to capture local dissipation effects. Attention should be paid on the material under consideration, as experimental results revealed the non-linear damping behavior of the aluminum alloy, which is not contemplated by this family of methods. In terms of structural testing methodologies, the optimal configurations and the strategies for the
computation of material loss factors were identified. The vibration correlation technique was found as an efficient approach in predicting the first buckling load of typical stringer stiffened panels, while it tends to over-predict the buckling load of cylindrical shells, due to its sensitivity to initial geometric imperfections.

In general the damping exhibited by composite material, at least for the investigated ones, is lower than the one being encountered in aluminum alloys. For this reason, the use of damping, as one of the major drivers for time decaying of the induced stresses due to dynamic loads, might be efficient in cases of bending, torsion, tension, but not for compression.

During DAEDALOS, knowledge and experience were obtained in terms of performing dynamic loading experiments. It was observed that, with the servo-hydraulic testing machines used within the project, no significant differences were found between static and dynamic buckling loads for the panels and shells tested. Moreover, an increase in the buckling load due to dynamic effects was not clearly observed.

Potential Impact:

The DAEDALOS objectives were in line with the Strategic Research Agenda (SRA) prepared by the Advisory Council for Aeronautics Research in Europe (ACARE). The SRA sets out the directions for European research over the next two decades towards fulfilling the ambition for the future of aeronautics established in the Report “European Aeronautics - a Vision for 2020”. In particular, DAEDALOS responded to the two top-level objectives identified in the SRA and the Vision 2020 Report: “to meet society’s needs for a more efficient, safer and environmentally friendly air transport” by ensuring advanced design technologies, new structural concepts and aircraft weight saving and “to win global leadership for European aeronautics, with a competitive supply chain, including small and medium size enterprises” by generating new methodologies for the design and analysis of aircraft structures.

DAEDALOS is an interdisciplinary European research project, involving complementary expertise from aircraft manufacturers and from the European aeronautical research community. DAEDALOS results, by taking into account the behavior of dynamic loading, and also the damping effects on airframes, will open new research paths in advanced material development and innovative aircraft concepts. Through the obtained validated advanced modelling, simulation tools and databases, the scientific results of DAEDALOS will provide the means for European airframe manufacturers to acquire advanced technology. DAEDALOS addressed the topics of new aircraft concepts, breakthrough technologies and possible structural weight reduction, which all aim at reducing aircraft development and operating costs as well as increasing passenger safety. The investigation of possible weight reduction, that can lead also to reduced emissions, was performed introducing new advanced structural concepts as well as an increased and optimized use of composite materials.

The DAEDALOS technology is applicable to the present and future generation of civil aircrafts. Indeed, DAEDALOS opens new perspectives in future safe lightweight design, new tool development, and new numerical methods regarding non-linear material behavior and structural models, that will lead to a new design philosophy and in the long term will yield significant benefits towards the achievement of new aircraft concepts and unconventional configurations.

European industries already have the technology and scientific knowledge in the lightweight structural design area, and new breakthrough technologies can further strengthen European research and industrial competitiveness. This will secure existing jobs in Europe and will additionally increase employment in the aeronautics industry since the manufacturers will be capable of keeping their lead position in the civil
aircraft market. Therefore DAEDALOS results will have a strategic impact on:
- New concepts in aircraft design;
- Reduction of the operating costs of new aircrafts due to fuel saving by weight reduction;
- Reduction developmental costs and timescales due to an efficient concurrent engineering process.

DAEDALOS will also contribute to meeting the requests regarding the report for European Aeronautics “A vision for 2020 – meeting society’s needs and winning global leadership”. Aeronautics must satisfy rising demands for lower travel costs, better service quality, the very highest safety and environmental standards: increased choice, convenience, comfort and lowered costs for customers.

Besides, DAEDALOS successfully contributed to science and technology cooperation at international level by bringing together a strong project team comprising a mix of “industrial” and “academic” partners.

Dissemination

The dissemination strategy for DAEDALOS promoted the transfer of skills, expertise and knowledge both internally within the consortium and externally to the wider community. During the project all the major dissemination targets were achieved ensuring that the knowledge developed is being utilized in industrial, research and educational communities.

In addition to conference and journal publications, which are detailed below, dissemination to the wider community has taken place through the public website: www.daedalos-fp7.eu. The website will continue to be maintained beyond the end of the project.

A total of 19 presentations were given at international conferences on the developed methodologies and the obtained results. They enabled feedback from the wider community, which has directly benefited the project progression. The number of conference publications is likely to increase over the forthcoming months.

The dissemination activity included the following presentations:


A special issue of Progress in Aerospace Sciences, an International Journal published by Elsevier, dedicated to the DAEDALOS project is on the way and will be published in 2015. Eleven papers related to the project are planned for this special issue:

1. Chiara Bisagni, “Overview of the DAEDALOS Project”.


Concerning Universities and Research Centers, the knowledge acquired during the DAEDALOS project will allow to promoting new forms of collaborations in terms of consultancy and research activities with industries and other academic institutions.

Universities and Research Centers presented, and will continue to present and publish, their research results at conferences and in international journals, and in this way will make their developments known and available to potential users.

On the basis of the obtained results, it can be assessed that:
- Knowledge gained in the field of viscoelasticity and material damping allowed improving the education material for graduate courses and for professional training;
- Methodologies developed for dynamic tests of composite panels advanced the skills in the area of structural testing;
- Procedures developed for finite element modelling and validation increased the knowledge for the analysis of structural dynamic and non-linear responses;
- Investigation of the influence of dynamic loads on the preliminary aircraft sizing process allowed understanding the complete loads estimation and sizing process more accurately;
- Results and design guidelines increased the knowledge in the area of lightweight structures.

Regarding Industries, the knowledge and experiences gained in DAEDALOS are circulated inside the “company” to designers and technologists, emphasizing what concerns the methodology for loads redistribution based on the results of dynamic loading analyses using complex finite element models and comparisons to results of dynamic loading analysis using traditional simplified models.

The DAEDALOS has shown that is possible to obtain some, although limited, amount of load reduction based on dynamic response analyses of full aircraft stress models. This reduction could be more important for larger and more flexible aircrafts which exhibit lower natural frequencies.

Additional investigation is being done in order to map more precisely the areas of the aircraft structure in which the load reduction is more important. This effort is aimed to refine the guidelines method based on the location of areas more susceptible to be influenced by the dynamic effects present in the complex models.

From the SME’s standpoint, the knowledge that was acquired during the DAEDALOS project is fundamental for future work and can be applied in several fields. For example, the layered orthotropic
viscoelastic damping model and the viscoelastic parameter identification developed in the project is exploited with specific software, being published and being promoted to customers. SMEs are planning to commercially exploit this knowledge by actively promoting it to their clients, not limited only to aircraft applications.

The project allowed to considerably enlarging the knowledge of all partners on viscoelastic composite material modelling and dynamical analysis. As dynamic analysis is a general topic and is part of the design process in many industries, the knowledge acquired during the DAEDALOS project is therefore of large and important use in future projects and applications.

List of Websites:
The DAEDALOS website is located at the following address:

www.daedalos-fp7.eu

The logo of the DAEDALOS project is reported in the Figure.

The DAEDALOS project involved 13 Partners from 8 European countries, including four aircraft industries, two SMEs, two research centers and five universities:
Politecnico di Milano (Italy), Alenia Aermacchi (Italy), Aernnova (Spain), Advanced Lightweight Engineering (Netherlands), University of Brno (Czech Republic), DLR (Germany), FOI (Sweden), Israel Aircraft Industries (Israel), LLV (Czech Republic), University of Hannover (Germany), Technical University of Aachen (Germany), SMR (Switzerland) and Technion (Israel).

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Related documents

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