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TOWARDS THE 3RD GENERATION MDO COLLABORATIVE ENVIRONMENT

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Abstract

The current work introduces the research activities in the field of MDO in overall aircraft design at DLR, and introduces the ongoing EU funded research project AGILE. AGILE is developing the next generation of aircraft Multidisciplinary Design and Optimization processes, which target significant reductions in aircraft development costs and time to market, leading to cheaper and greener aircraft solutions. The paper presents the background and the needs identified for the next generation of MDO collaborative environment in aircraft design, with focus on the formalization aspects. The addressed open challenges are also behind the formulation of AGILE project's objectives. The AGILE project structure is briefly introduced.

1 Introduction

When a project for a new aircraft product is initiated, designers need knowledge and competences from multiple disciplines in order to make the right decisions on the aircraft's systems and functions. Typically the aircraft pre-design activities rely on consolidated design methodologies, based on statistical data and pre-knowledge which accessible by the design team. However, the assessment of the next generations' air vehicles, promising large benefits [1-2], cannot rely on conventional design processes, especially at the early development stages. Thus, in order to determine the vehicles' performance properly, and to minimize the risks associated with the development of unconventional configurations, multiple effects need to be accounted from the beginning of the design process. Therefore, from the start of the aircraft development process computer simulations play a major role in the prediction of the aircraft behaviors. The recent advancements in computational performance and simulation capabilities provide accessibility to sophisticated physics based models, which can deliver disciplinary analysis in a time effective manner, even for unconventional configurations [3]. Nevertheless, these codes are often not included in the early stages design activities, due to the complexity, and the time demand, faced by the designer's team to pre-process and to instantiate the multiple disciplinary specific models required during the Overall Aircraft Design (OAD) activities.

Furthermore, Multidisciplinary Design Analysis and Optimization (MDAO, or MDO) techniques offer the support to understand the interdisciplinary couplings and dependencies which may affect the development of a new concept. However, a major challenge arises in aircraft design as the properties from different disciplines are in constant interaction with each other. The challenge is even higher when specialized disciplinary teams are distributed not only between disciplinary divisions of the same organization, but even among different organizations [4]. It is therefore important not only to connect the simulation models between organizations, but also the corresponding experts to combine all competences and accelerate the design process to the best possible solution. In this paper Section 2 presents the evolution of the MDO design environments, corresponding achievements and limitations. A brief introduction to the collaborative design environment architecture and to the central data model CPACS developed at DLR is also provided, as representative of the state-of-the-art in distributed MDO for Overall Aircraft Design applications. Thereafter, the remaining open challenges and enhancements necessary to the implementation of the next generation of MDO environments are addressed. Section 3 addresses the formalization aspect of MDO and design phases, and introduces the definition of Competence Levels, as example of lack of formalization in MDO. All the open challenges identified are tackled by the ongoing EU funded research project AGILE, whose main structure and objectives and briefly presented in Section 4. Current status the outlook on the next activities is provided in Section 5.

2 Towards the 3rd Generation MDO

Although aircraft design tasks are multidisciplinary by nature, and Multidisciplinary Design Analysis and Optimization techniques are formally developing since more than three decades, there are still multiple factors hampering the introduction of the full MDO capabilities in industrial application. The evolution of the MDO systems has been initially addressed by Kroo [6]. The concept is here reformulated and extended by the authors' perspectives, and highlighting the research focus within each generation. The evolution trends clearly reflect the increase of available computational power, as well as the increase in the complexity of the aircraft design tasks during the last decades.

2.1 The Evolution of MDO environments

2.1.1 First generation

The first generation MDO refers to applications which tightly integrate disciplinary capabilities and optimizer as a monolithic system. In such environment all the analysis modules are directly available to the design team lead, and the design process is deployed via direct interfaces among the multiple design capabilities. A schematic is illustrated in Figure 1. The implementation is typically formulated by exploiting efficient coupling techniques in order to capture the sensitivity of the overall system, with respect to the selected design parameters.

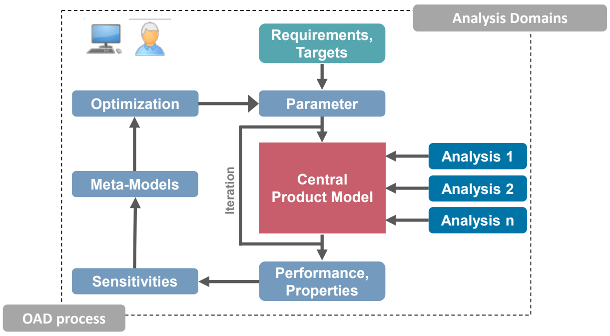

Figure 1 1st Generation MDO Environment

Such optimization systems are the most computationally efficient from a running time perspective, and are extremely attractive in combination with simulation models whose governing equations merge multiple disciplinary domains. Research efforts connected to the first generation, have largely focused on the developments of efficient optimization algorithms, and on the enhancement of the disciplinary solvers capabilities, with the objectives to reduce the operational time of the design system to deliver an optimal solution, and at the same time to support the designers' decisions. Parametrization techniques [7] and sensitivity analysis [8-10] supporting the optimization process have been key enablers for the first generation environments. However, the monolithic architecture of such design systems typically lacks the flexibility to exchange and update the subset of the integrated design modules, when improved disciplinary analysis modules become available or when it is necessary to adapt the system to cope with new configurations. A second limitation is in the scalability of such a design system. As soon as more disciplines and effects are accounted in the design process, the integration into a single system becomes impractical, or to reconfigure the design process. At the present, monolithic design environments are widely used mainly in two scenarios. The first application is in conceptual design, during which the design team may need to quickly investigate multiple effects by employing simple models. The second application is in detailed physics based optimization with a very limited set of disciplines involved, which require strong couplings. A classic example is the aero-structural solvers, based on adjoint formulations. The first limitation is partially tackled by the second generation MDO.

2.1.2 Second generation

The second generation is characterized by the distribution of the analysis capabilities on dedicated computational facilities, which are called by a centralized design and optimization process, as shown in Figure 2. Such a system provides on one side the required flexibility to exchange or to update the design modules (providing type of function provided), without affecting the reconfiguration of the entire design process, and on the other side to optimize the computing facilities to the requirements of each individual module. In such a setup, dedicated experts are in charge for providing the disciplinary modules, and the team in charge for the design lead assumes the role of process integrator and central optimizer. Multiple design modules need to "communicate" each other and with the centralized optimization components, which requires the implementation of interfaces in order to transform the various data formats, and an effective data management system, in order to limit the overheads due to the data transfer.

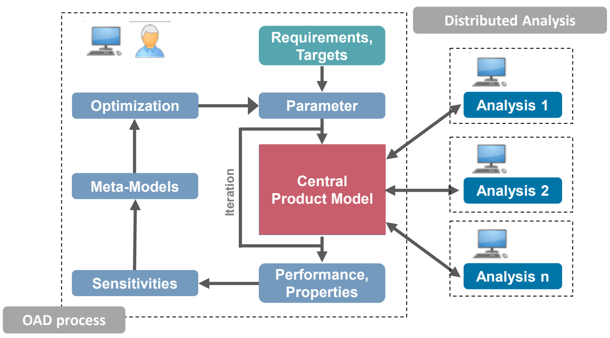

Figure 2 2nd Generation MDO Environment

In the second generation system major research efforts have focused on improving the formulation, or architecture, of the design and optimization process structure, in order to exploit the distributed computational capabilities, as well as the functional structure in place within the organizations involved in the design task. Multiple decomposition methodologies have been proposed for the partitioning of the optimization problem in sub-tasks, and for the coordination strategies among the sub-tasks [11-12]. New approaches are continuously under development, in order to exploit the latest solvers and the optimization algorithms [13]. The increase in computational power has also lead to an increasing demand for automation in every disciplinary field, with the aim to reduce the manual non creative activities during the execution of large scale optimization processes [14]. Geometric centric and CAD based product data models become a standard for the exchange among the disciplinary analysis [15]. Knowledge based engineering systems have been developed to support such operations, and multiple engineering frameworks have been developed to facilitate the coordination of the analysis capabilities within the optimization task. Nevertheless, the industrial application of such a system to large scale aircraft design problems is still limited. The setup and the implementation of such a centralized design process may easily become a prohibitive task, with the risk to neglect or not properly account the relevant effects during the process implementation.

2.1.3 Third generation

Nowadays, the design of a competitive aircraft product requires the integration of an increasing number of systems (and connected disciplines) in order to find the overall benefit of novel concepts. Furthermore, the complete design is not the endeavor of a single actor anymore, but rather the results of collaboration among hundreds of engineers, distributed among multiple specialized organizations. These limitations are challenged by the third generation MDO environments, represented in Figure 3. In this case the distribution does not involve only the analysis capabilities, but the distribution of the overall design task. Researches have focused of the development of decomposition methods, such as Concurrent Engineering and Collaborative optimization [16-17], which promise to enable the reality of participative engineering.

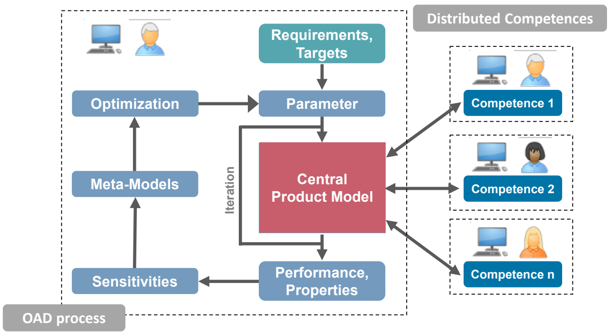

Figure 3 3rd Generation MDO Environment

With such complex interactions, one of the priorities of the third generation MDO is to support the human judgement, and lessen the aforementioned complexities. Hence, a number of non-technical barriers have been clearly identified in the latest years [18]. These range from organizational structure of the companies involved in the design tasks, to large data handling and interpretation of the results, to communication among parties. Improvements in visualization techniques, standardization efforts, as well as educational efforts are undergoing activities with the aim to deliver the expected potentials in MDO. Nevertheless, the implementation of the third generation MDO is not completely realized yet.

The next sections summarize the state-of-the art of the distributed MDO currently environment under development at DLR, and the open challenges to reach the 3rd generation MDO system.

2.2 Distributed Design Environment at DLR

As discussed in the previous section, distributed design approaches offer the flexibility to adapt the design workflow when new design modules become available, and to tailor it specifically to the scope of the design investigations. The German Aerospace Center (DLR) has been developing a distributed design environment to foster the collaboration among the disciplinary specialists and the integration of disciplinary expertise into the overall aircraft design (OAD) process [19]. The design environment is built on the centralized data structure CPACS [20] (Common Parametric Aircraft Configuration Schema), an arbitrary number of analysis and design modules, and on the open source design framework RCE [21-22] (Remote Component Environment), which enables the orchestration of the design workflows. CPACS is a data format based on XML technologies, and used for the interdisciplinary exchange of product and process data between heterogeneous analysis codes and name spaces. CPACS contains data such as the geometry of the aircraft model, but also all the parameters needed to initialize and to drive the disciplinary analysis modules, for instance the aerodynamic and the structural solvers. Figure 4 depicts the CPACS concept as a unique data structure (or language common to all the disciplinary domains), instantiating the disciplinary analysis modules.

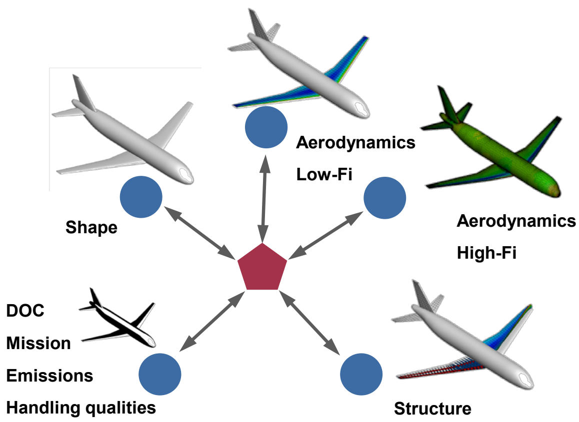

Figure 4 CPACS concept

The framework RCE enables the orchestration of the design process, and integration of the analysis modules in a workflow. The RCE architecture is based on a decentralized computing system, in which the analysis competences are hosted and run on dedicated servers. Thus, in the design workflow only input and output data are made accessible to the integrator designer, and exchanged during the process, whereas the source codes are controlled by the tools' developers and the disciplinary experts. The system is in operational use in all the DLR aeronautical branches [23], and with external research and academic institution [24]. Applications making use of CPACS and RCE have already pushed the boundaries and limits identified in the 2nd generation of MDO systems, and are actively used as basic elements for the deployment of the third generation MDO environments.

2.3 Remaining Open Challenges

Modern state-of-the-art MDO design environments may rely on massive computing facilities, efficient optimization strategies, an increasing number of sophisticated simulation capabilities to cover all the domain, and robust process management frameworks. However, the challenge to make use of the full MDO potentials for a complete aircraft remains open.
As highlighted by Belie [18], although very successful MDO applications have been demonstrated for a subset of disciplines (usually tightly coupled, such as aero-structural problems), the ultimate value of MDO will be in its ability to optimize the aircraft as a whole system. The extensive ongoing virtualization of the entire life cycle of the products (from design to production) will enable MDO to concretely support the design and the assessment of the entire product in terms of manufacturing, operations, and its life phases. Higher benefit are also expected for the assessment of novel designs [25], for which interdependencies, and design drivers may still need to be unveiled. Hence, multiple projects with focus on demonstrating MDO techniques have been sponsored by national and international research programs. Typical duration for such projects in the aeronautics is 3-4 years, and the project setup is typically reflecting the industry environment and requirements. A brief survey of MDO related projects and related developments is provided in Ref. [26]. When looking at the majority of the projects developing an MDO environment, we identify three main phases:

1. a **setup** phase
2. an **operational** phase
3. a convergent **solution** phase

The activities carried on during the setup phase include: the formulation of the design task and MDO problem, the pre-selection of the design drivers, the preparation and connection of the disciplinary tools. During this phase the entire design process is formulated first (often based on legacy design stages), and implemented into a system(s). During the operational phase, the assembled design environment is executed to determine the product's properties and to explore a prescribed design space. Human judgement is involved in the assessment of the results, or to determine if the process needs to be re-configured for instance by including extra analysis or additional details. This phase represents the stage in which most of the data are generated and exchanged among the different parties involved. Large enhancements have been achieved targeting the operational phase, such as the automation of individual disciplinary design capabilities, efficient decomposition strategies, and exploitation of parallel computing. Trends shown in [27-28] illustrate that MDO based design may lead to an increase in the time spent in reasoning on the results, even when the assembling of the system may actually take a longer time respect to legacy approaches. However, independently on the computational power and simulation models available, when a large number of disciplines are planned to be invoked, a large part of the project time is spent in the setup phase of the environment itself. Activities such as the complete definition and deployment of the design process, the development of interfaces between the heterogeneous components, the identification of input-output relations during the integration, require huge efforts. The challenges to deploy such a system are even higher, when involving the multiple Partners participating with an own design system, and with different focus within the design task.
Furthermore, within such environment, the complexities connected to the provenance of the results and errors detection, risk to reduce the time available to explore the design options. Often, the excellent systems developed in surveyed MDO projects [26], provide only ad-hoc solutions, which are no longer maintained after the duration of the projects, and whose rational behind the implementation is only partially formalized.

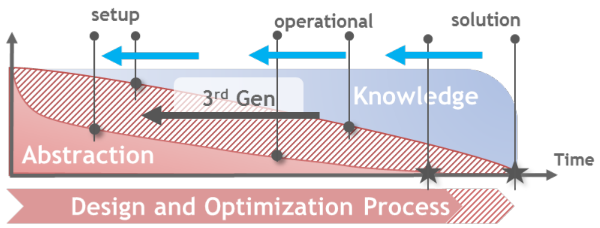

Figure 5 Generalized Design and Optimization Process

It becomes clear the implementation of the 3rd generation of MDO system will need to support the collaborative design team through all the identified three main phases, which are generalized in Figure 5. The objectives are on one hand to shorten the overall development process, on the other side to minimize the uncertainties and increase the knowledge available at the early design stages. According to the authors, the required enhancements and needs for the future MDO environments may be formulated as follows:

- Reduction of time needed to setup and deploy the Collaborative Environment, and its main elements;
- Facilitate the integration of new design competence within existing design processes, and the exchange of data among partners;
- Formalization, storage, and reuse of the rationale behind the overall design process.
- Supporting the design teams to detect of the dependencies among the heterogeneous distributed sub-tasks;
- Assist the design teams with the selection of the decomposition strategy according to design competence, resources available;
- Quantify the benefit of different MDO techniques in real scale applications, in terms of “knowledge”, and costs;
- Enable the quick deployment and assessment of novel MDO architectures and algorithms to reduce the time needed to convergence;
- Facilitate the provenance and traceability of the design activities and design choices.

3 Towards MDAO Formalization

Since the emerging of MDO as individual research discipline, several related concepts have been organized and formalized in this field. As mentioned in Section 2.3, the formalization of the knowledge at each level of the design and optimization process represented in Figure 5 will enable the implementation of the 3rd generation MDO environments. The following sub-sections address briefly the status of the formalization efforts in the field of MDO, and the current limitations. The discussion targets the application to overall aircraft design (OAD) activities.

3.1 Elements of MDO in OAD

An early MDO taxonomy has been initialized by Sobieski in 1993 [29], which list the multiple domains which need to be addressed by MDO research activities. Similarly, the AIAA MDO Technical Committee has arranged the MDO in categories addressing the existing barriers from a technical perspective first in 1991 [30], and extending to non-technical aspects in 1998 [31]. These categories have mainly served to identify and group all the required enhancements to let the MDO deliver the promised impact within industrial applications.

An interesting point raised was the lack of an assessment and benchmark for MDO approaches, with respect to traditional design methodologies. Thereafter, several works have focused on formulating a MDO formalization focused on the decomposition aspects of the optimization problem, in order to be able compare multiple MDO architectures in a unified framework [32-34]. Recent works have translated the definition of such MDO formalization into proper ontologies [35], which will enable the generation of a knowledge base with the objective to support the design team in selecting the most promising architecture for a given optimization problems.

However, most of the comparisons studies attempting to quantify the advantages of the various MDO architectures have referred to rather simple application cases [36]. Analytical objective functions, with a known optimum, and simple models for the disciplines involved, constitute the main use cases available to test the partitioning schemas. Furthermore, the assessments of the processes mainly refer to the number of evaluation calls for each of component, as a representative index of the operational and convergence efficiency. Other aspects concerning the setup phase of the optimization architectures are mostly tackled in a qualitative way [37].

A second point common in MDO surveys is addressing the scope of the MDO within the overall aircraft design process. Product design is traditionally composed by sequential activities, whose complexity increases with the development time. In OAD these are the well-established conceptual, preliminary and detailed design stages [38-39]. Nevertheless, the already mentioned enhancements, such as automation and massive computing facilities, are changing this traditional process structure. The availability of affordable physics based analysis, and robust automation techniques, enable large design space explorations already at the very early design stages. Such a shift is advisable, especially for the development of novel aircraft configurations, where traditional methodologies or empirical data are not available. As illustrated in Figure 5, such a shift will contribute to increase the knowledge from the very beginning of the design process.

However, the related shift of complexity at the beginning of the design cycle is also associated with a new set of challenges faced by the design team, such as:

- An increased number of parameters, and design variables, associated to the setup and execution of the analysis;
- The initialization of a higher number of details to be provided, and leading to an increased number of effects to be included in the design process;
- Ensuring the integration of multiple disciplinary expertise already during large space exploration activities.

Hence, the main effort by the design team is to guarantee a “coherent binding” of modeling details, type of phenomena accounted in the analysis, search and optimization techniques chosen. The properties of the individual solvers and the algorithms involved play a key role as well in the decision of the MDO architecture, but those are task specific dependent.

Under this perspective, every MDO system can be abstracted to basic functional elements which are required for the deployment of the design and optimization environment. The elements can be identified as:

- **Analysis:** determining the behavioral properties of the product. The underlying models may be physics based or empirical, and provide analysis results via a direct calls or precomputed responses.
- **Optimization:** includes the optimization algorithms, such as gradient based or evolutionary, and all the corresponding searching and converging strategies.
- **Modeling:** concerns the representation of the product itself, its parametrization, and abstractions.

Each of the traditional design phases can be characterized by a certain complexity level for each of the main elements. This concept is illustrated in Figure 6.

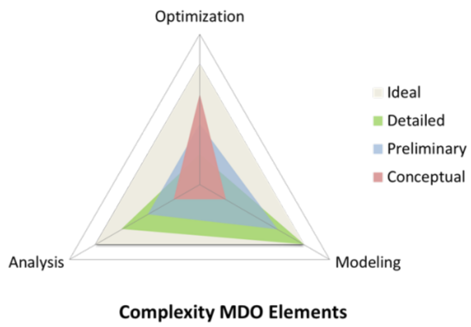

Figure 6 Elements of MDO in OAD phases

The selection of the MDO architecture will need to account for the type and the properties supported by each of the functional elements (e.g. details and characteristics of simulation models) in order to choose the most effective one for the problem at hand. Furthermore, the design system would need to support the designer also during the setup the appropriate interdisciplinary couplings according to the models available.

3.2 Competences Levels

In the same surveys on the MDO potentials and future requirements, it is advocated the need to apply MDO for applications with increasing "difficulty" [40], which is also typically associated to "higher fidelity", or "complexity", and eventually make use of variable fidelity techniques in a single design process addressing all the design stages via a "multi-level" structure. However, these properties, or attributes, are not uniquely defined, and cannot be chosen to set quantitative requirements. Most of the time the term fidelity is purely associated with the computational time which is necessary to retrieve a solution by a certain analysis model. Other times it refers to the source of the representation behind a models (i.e. empirical based, or physics based) [41]. In other domains the fidelity of a model refers to the degree of discrepancy of the product's properties between the simulation and the reality (e.g. the mass estimation for a certain component).

It is clear that definitions chosen depend on the specific domains of interests, or are influenced by pre-knowledge and experiences with the simulation models available within the different design phases. Hence, the formalization domain will need to be extended to provide a quantitative answer to the following question:

"For a given design task, set of disciplinary capabilities, cost and time constraints: Which products' characteristics the MDO environment will be able to account in the optimization process? And at which (quantifiable) depth these will be addressed?"

A key enabler is the definition of a formalized set of attributes referring to the analysis layer which extend beyond the time\costs metrics, and provide a link with the formalization of the MDO architecture. A previous classification is discussed in [42] to identify disciplinary levels, and a representation is illustrated in Figure 7. The classification provides a qualitative measure of time, level of simplification of the physics phenomena, but it could not serve to quantify properties on quality and depth of the analysis provided.

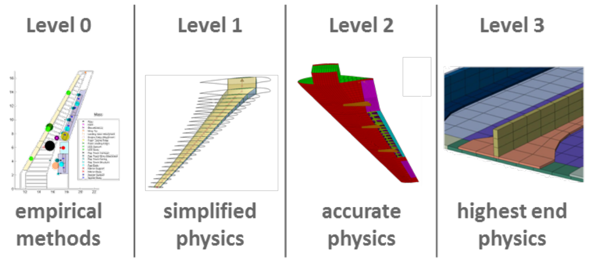

Figure 7 Disciplinary Levels

Hence, a further step is proposed by formulating the following clustering of Competence Levels in the following classes, in Table 1:

Table 1 Competence Levels

Level	Modeling Details	Physics Representation	Phenomena Type
0	No geometry	Empirical	Design rule
1	Reference quantities	Linear	Static, Steady
2	Analytical	Non linear	Dynamic, Unsteady
3	Numerical	Non isentropic	Transient

Additional attributes can be linked to each class. It is not intended to provide here the description and the details on the ontology which is under development, but to rather highlight the needs for such formalization. Such a description is intended to be used in combination with the available formalization of the MDO architectures, to provide a metrics which could account for the "depth and quality" of the analysis called, during the trade-off and selection of a specific architecture. A few representative examples of common analysis which are utilized in different phases of OAD development are listed in Table 2.

Table 2 Examples of Design Competence

Design Competence	Modeling	Physics	Phenomena
Wing aero DLM	2	1	2
Stiffeners Buckling FEM	3	2	2
Aircraft aero Euler	3	2	1

4 AGILE Project

Many of the open challenges mentioned in the previous sections are currently tackled by AGILE (Aircraft 3rd Generation MDO for Innovative Collaboration of Heterogeneous Teams of Experts) [43], an EU funded project under the research schema Horizon 2020 and coordinated by the German Aerospace Center (DLR). AGILE is developing the next generation of aircraft Multidisciplinary Design and Optimization processes, which target significant reductions in aircraft development costs and time to market, leading to cheaper and greener aircraft solutions. To meet the challenges of the AGILE project a team of 19 industry, research and academia partners from Europe, Canada and Russia are collaborating together. The composition of the Consortium reflects the heterogeneous structure that is characteristic for today's aircraft design teams.

AGILE ambition is to advance the state of the art in solving complex, challenging design problems, such as large scale optimization of novel aircraft products, by integration of MDO techniques, collaboration and knowledge based technologies. The involvement of many disciplinary analyses ranging up to high levels of fidelity, and agile workflow management are considered to be state-of-the-art and starting point for AGILE.

Understanding complex systems and products as aircraft and the underlying design process depends highly on the exploitation of knowledge. New technologies to exploit and/or re-use available engineering knowledge have become available with the potential to substantially accelerate the multidisciplinary aircraft design optimization process.

The project has started on June 2015, and it will end in June 2018.

4.1 AGILE Objectives

AGILE is implementing the 3rd generation of multidisciplinary design and optimization through efficient collaboration among international multi-site aircraft design teams.

AGILE has set ambitious performance targets to achieve by the end of the project in 2018: a reduction of 20% in time to converge the optimization of an aircraft and a 40% reduction in time needed to setup and solve the multidisciplinary optimization in a team of heterogeneous specialists. This will lead to improved aircraft designs and a 40% performance gain, compared to aircraft in service today, is expected for large passenger unconventional aircraft configurations.

AGILE is set also to quantify benefits of different optimization approaches for systems with a high number of heterogeneous analysis modules, with multiple levels of fidelity ranging from empirical correlations till high fidelity analysis codes, in all the disciplines. Since the measure of the achievable improvement in aircraft performance by MDO techniques is also a function of aircraft concept maturity, the multiple design campaigns setup in AGILE target aircraft concepts with a diversified maturity level to demonstrate the impact of the developed AGILE technologies on medium-term, and long-term aircraft products, as shown in Figure 8. All the results from the AGILE use cases extend the knowledge on the configurations with high relevance for future applications.

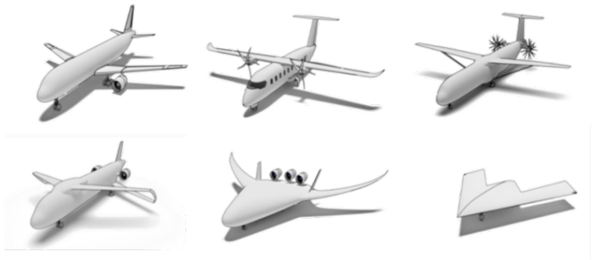

Figure 8 AGILE Design Cases

4.2 AGILE Structure

AGILE is structured into three sequential phases, targeting design campaigns with increasing levels of complexities, and addressing different aircraft configurations and dedicated MDO techniques. The overall structure is shown in Figure 9. In a first phase (Initialization), a reference aircraft configuration is optimized using state-of-the-art techniques. The reference MDO problem is then used to investigate and benchmark novel optimization techniques individually and later in smart combinations (MDO test bench). Finally, the most successful approaches are applied to significantly different aircraft configurations (Novel Configurations). The three sequential phases are embedded within two enabling layers, as show in Figure 8. The first enabling layer (Collaboration techniques) targets the development of the technologies enabling distributed collaboration, comprising the process of collaboration between involved specialists, collaborative pre- and post-processing, visualization and the enhancement of existing framework. The second enabling layer (Knowledge enabled technologies) develops the information technologies, which support the management and the formalization of knowledge within an MDO process. The parallel activities are clustered in Design Campaigns, with increasing complexity from use case perspective (progressing from conventional aircraft to novel configurations), and MDO environment perspective (from the current state-of-the-art to the 3rd generation system). During each design campaign, the design system is enhanced by a step forward the realization of the 3rd generation MDO environment.

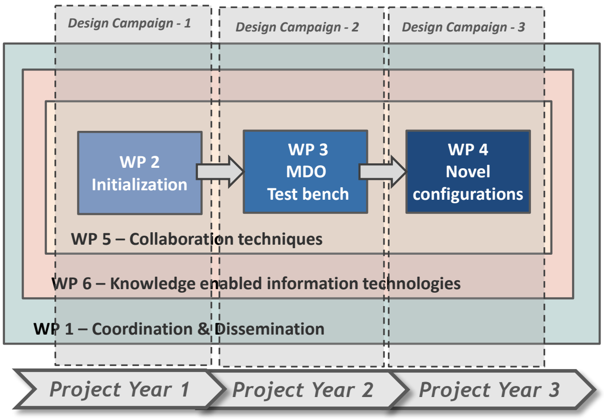

Figure 9 AGILE Project Structure

4.3 AGILE MDO Environment

From the discussion in the previous sections, assembling a distributed and collaborative aircraft design process within such a Consortium, poses additional challenges to the mere technical interfacing of the multiple design modules to a common data model. Main essential features which are under development within AGILE project will enable the setup and the operation of a real cross-organizational MDO collaborative environment:

1. Enable the communication of design capabilities available at the Partners' sites within the same optimization process, even when hosted in different Companies' networks;
2. Integration of human based activities and simulation based workflows;
3. Formalization of the knowledge required to setup, execute, and solve the MDO task.

5 Current Status and Outlook

The paper introduces the background and addresses the needs for the deployment of the next generation MDO systems. The paper introduces an overview of the evolution of the MDO environments, and the open challenges, such as the formalization aspect. The ongoing EU funded project AGILE is currently running, and it was formulated to answer most of the open challenges presented in the paper. At the current status the Initialization phase of the project has been concluded. This includes the formulation and the setup of a state-of-the-art MDO system, and the solution of a reference design and optimization task. The environment at the current stage already provides all the technical means required to operate a design process which is distributed among multiple organizations and networks. All the details and the results on the project will be disseminated in future studies, and dedicated sessions by the AGILE Consortium.

6 Acknowledgements

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