

DELIVERABLE D 1.13

AGILE OPEN MDO SUITE

Author(s): **Pier Davide Ciampa, Luca Boggero**
WorkPackage N°: **WP1**
Due date of deliverable: **30.11.2018**
Actual submission date: **27.11.2018**
Document ID: **AGILE_D1.13_v1.0.docx**

Grant Agreement number: **636202**
Project acronym: **AGILE**
Project title: **Aircraft 3rd Generation MDO for Innovative Collaboration of Heterogeneous Teams of Experts**
Start date of the project: **01/06/2015**
Duration: **42 months**
Project coordinator name, title and organisation:
Björn Nagel, DLR - Institute of System Architectures in Aeronautics | Aircraft Design & System Integration
Tel: **+49 40 2489641-302**
E-mail: bjoern.nagel@dlr.de
Pier Davide Ciampa, DLR - Institute of System Architectures in Aeronautics | Aircraft Design & System Integration
Tel: **+49 40 2489641-322**
E-mail: pier.ciampa@dlr.de
Project website address: www.agile-project.eu

DOCUMENT INFORMATION

Document Name			
Document ID	D1.13		
Version	1.0		
Version Date	25.11.2018		
Author	P. D. Ciampa		
Security	0		

APPROVALS

	Name	Company	Date	Visa
Coordinator	Pier Davide Ciampa	DLR	25.11.2018	
WP Leader	Jan Vos	CFSE	21.11.2018	

DOCUMENTS HISTORY

Version	Date	Modification	Authors
1.0	25.11.2018	Revised Version	P. D. Ciampa, L. Boggero

LIST OF AUTHORS

Full Name	Organisation
Pier Davide Ciampa	DLR
Luca Boggero	DLR

DISTRIBUTION LIST

Full Name	Organisation
AGILE Consortium	
Externals	

TABLE OF CONTENTS

1 AGILE OPEN MDO SUITE	5
1.1 The implementation of the AGILE Paradigm	5
2 ORGANIZATION OF THE AGILE OPEN MDO SUITE.....	6
2.1 Introduction	6
2.2 Web-access interface	6
2.3 Virtual Machine	7
2.4 Individual open technologies.....	8
3 CONCLUSION AND OUTLOOK	10
4 REFERENCES	10

LIST OF FIGURES AND TABLES

Figure 1 AGILE Framework 5
 Figure 2 Main page of the MDO System Interface 6
 Figure 3 Desktop of the Virtual Machine..... 7

GLOSSARY

Acronym	Signification
AGILE	Aircraft 3 rd Generation MDO for Innovative Collaboration of Heterogeneous Teams of Experts
CMDOWS	Common MDO Workflow Schema
CPACS	Common Parametric Aircraft Configuration Schema
KADMOS	Knowledge- and graph-based Agile Design with Multidisciplinary Optimization System
MDO	Multidisciplinary Design and Optimization
OpenLEGO	Open-source Link between AGILE and OpenMDAO
RCE	Remote Component Environment
SMR	Surrogate Model Repository
SSBJ	SuperSonic Business Jet
VISTOMS	VISualization TOol for MDO Systems
VM	Virtual Machine

1 AGILE OPEN MDO SUITE

1.1 The implementation of the AGILE Paradigm

The EU funded AGILE project 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 more cost-effective and greener aircraft solutions. 19 industry, research and academia partners from Europe, Canada and Russia are developing solutions to cope with the challenges of collaborative design and optimization of complex products. In order to accelerate the deployment of large-scale, collaborative multidisciplinary design and optimization (MDO) processes, a novel methodology, the so-called “AGILE Paradigm” [1] has been developed. The AGILE Paradigm ambition is:

- Accelerate the setup and the deployment of distributed, cross-organizational MDO processes
- Support the collaborative operation of design systems: integrate specialists and tools
- Exploit the latest technologies in collaborative design and optimization

The AGILE Paradigm is defined as a “blueprint for MDO” guiding the deployment and the execution of collaborative “MDO systems” for complex products practiced by cross-organizational design teams, distributed multi-site, and with heterogeneous expertise. Therefore, as blueprint, the AGILE Paradigm provides a methodology which prescribes a series of questions and practices to facilitate the deployment of an MDO system, it indicates how to structure the development of a complex product, it defines the roles of all the stakeholders engaged in the development, and it indicates how to streamline the interfaces and the interactions within the entire supply chain (data, models, and resources involved). Furthermore, the AGILE project has developed a set of technologies enabling the implementation of the AGILE Paradigm approach. The collection of all the technologies constitutes “AGILE Framework”, as illustrated in

Figure 1.

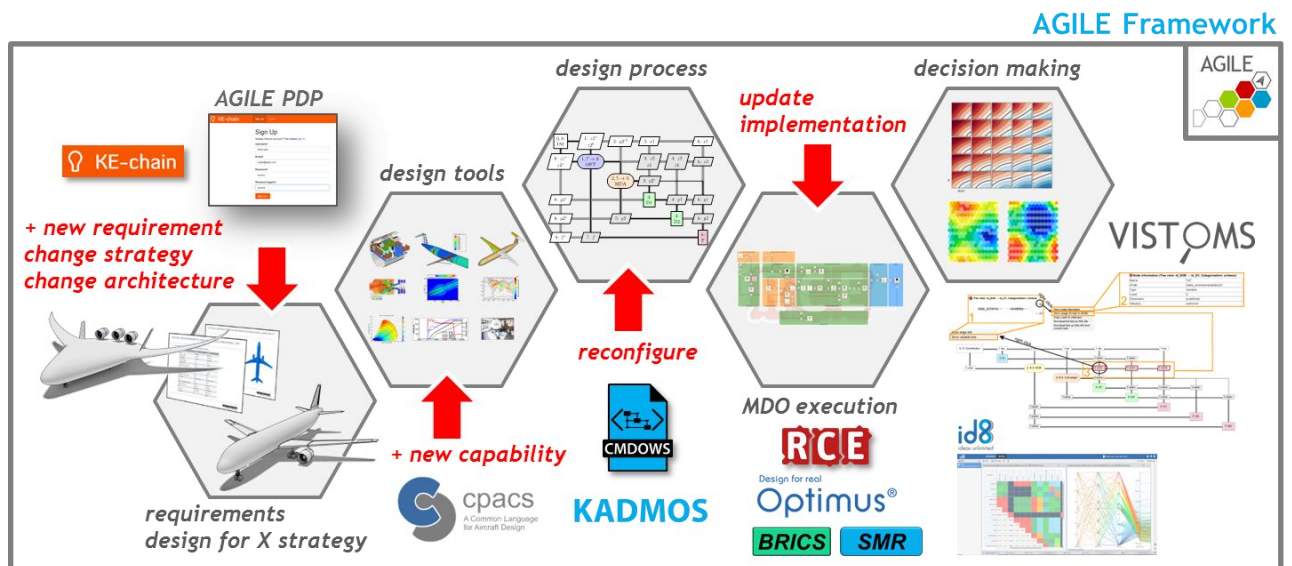


Figure 1 AGILE Framework

One of the main outcomes from the AGILE project is the delivery of the “AGILE Open MDO Suite”, a packaging of AGILE developed open-access technologies, made available outside the AGILE Consortium and enabling the implementation of the main AGILE Paradigm principles. The AGILE Open MDO Suite is accessible via the AGILE portal: <https://www.agile-project.eu/open-mdo-suite/>. The AGILE Open MDO suite also contains documentation, examples, and tutorials. The current document briefly describes how to access the AGILE Open MDO Suite, and the main contents.

2 ORGANIZATION OF THE AGILE OPEN MDO SUITE

2.1 Introduction

In order to maximize the usability of the AGILE technologies, three versions of the AGILE Open MDO Suite have been released by the end of the project. Each one targeting a different typology of user.

1. Web-based MDO interface (Section 2.2): it provides a way to quickly formulate, visualize and/or manipulate design and optimization workflows strategies. As this solution is web-based, no installation is required.
2. Virtual Machine AGILE environment (Section 2.3): a fully configured operative system, containing all the AGILE open technologies already installed and properly set up. In addition to the workflow formulation, the VM enables the design and optimization workflow execution.
3. Individual AGILE technology (Section 2.3): each of the enabling open technologies can be individually accessed, to setup a customized design and optimization environment. This last version of the AGILE Open MDO Suite is addressing experienced users.

2.2 Web-based MDO interface

Target audience: quickly access and experience AGILE open technologies.

Capabilities: MDO workflows generation, visualization and manipulation.

Features: web-based, no installation required.

A web-based version of VISTOMS package [2] has been connected to the KADMOS system [3] and made available outside the AGILE Consortium. This merging is named as MDO System Interface, and it allows the user to inspect and manipulate simple or complex MDO workflows in a user-friendly way. The MDO System Interface can be accessed through any browser at <http://mdo-system-interface.agile-project.eu/>.



Figure 2 Main page of the MDO System Interface

The MDO System Interface gives the user the possibility of creating his own MDO problem from scratch, collecting all the available design disciplines (in terms of CPACS input/output files and metadata), combining and managing them, and imposing an MDO architecture needed to solve the MDO problem. Two examples of MDO problems are provided, with the aim of supporting the user in using the MDO System Interface. The first MDO example is the Sellar Problem, which is typically considered as a benchmark MDO problem. The other example is the SuperSonic Business Jet (SSBJ), which has been implemented at ONERA.

The web-based interface includes:

- ④ MDO System Interface (VISTOMS/KADMOS integration)
- ④ Tutorials and workflows for the visualization and manipulation of example use-cases: the Sellar Problem and the SSBJ example (including CMDOWS files)

Additional details and information about the MDO System Interface can be found in [4]. Moreover, a tutorial video explaining the SSBJ example can be downloaded from the web-access interface.

2.3 Virtual Machine AGILE MDO Environment

Target audience: a deeper insight of the AGILE open technologies.

Capabilities: MDO workflows generation, visualization, manipulation and execution.

Features: stand-alone, fully configured OS and AGILE MDO environment. Low effort installation.

A Linux-based Virtual Machine can be downloaded from the AGILE Project website. This option of AGILE Open MDO Suite combines all the open technologies developed or exploited in AGILE. As all the tools and libraries are installed and properly set up, this solution can be considered as a fully integrated and ready-to-be-used AGILE environment.



Figure 3 Desktop of the Virtual Machine

The Virtual Machine contains the following technologies, already setup and ready to be used:

- ④ MDO System Interface (VISTOMS/KADMOS integration)
- ④ Remote Component Environment (RCE), for the execution of MDO workflows
- ④ TiX\TiGL libraries for the manipulation of CPACS files
- ④ Tutorials and workflows for the visualization and the execution of example use-cases: the Sellar Problem and the SSBJ example (including CMDOWS files and corresponding RCE workflows)

The software Oracle VM VirtualBox is required to execute the Virtual Machine. The software can be downloaded from <https://www.virtualbox.org/wiki/Downloads>. The Virtual Machine can be imported by clicking on **File** and **Import Appliance**. If required, the Virtual Machine password is **agileEU**.

Additional setup instructions are available from the AGILE portal directly.



2.4 Individual open technologies

Target audience: experienced user with medium-high IT skills

Capabilities: all the AGILE open technologies

Features: customizable MDO environment. Possibility of select which technologies to be installed

The last version of the AGILE Open MDO Suite collects all the open AGILE technologies that can be accessed individually, enabling the ad-hoc setup and customization of AGILE MDO environments. The list of all the open AGILE technologies with relative descriptions is provided hereunder.

<u>Technology</u>	<u>Description</u>	<u>Download/Access from</u>
KADMOS	KADMOS (Knowledge- and graph-based Agile Design with Multidisciplinary Optimization System) is an open-source, Python-based package that can be used to formulate, inspect and manipulate MDO systems. The package is based on a graph-theoretic formalization of MDO systems. This formalization enables the description of these systems throughout the different stages of the set-up phase in any collaborative project: tool repository, MDO problem, MDO process. In AGILE, KADMOS is used “under the hood” in applications that aim at supporting design teams to set up MDO systems, such as VISTOMS and KE-chain. KADMOS can also read and write CMDOWS files.	kadmos-repo.agile-project.eu
	CMDOWS (Common MDO Workflow Schema) is the open-source, XML-based storage format for MDO systems. The schema describes a data structure that can be used to store any MDO system at different stages throughout the set-up phase: tool repository, MDO problem, MDO process. In AGILE, the format is at the heart of the AGILE development framework and is used to exchange information about the MDO system between different supporting applications, such as KADMOS, VISTOMS, SMR and KE-chain. In addition, MDO workflow blueprints stored as CMDOWS files can be automatically instantiated as executable workflows in different platforms: RCE, Optimus.	cmdows-repo.agile-project.eu
	OpenLEGO (Open-source Link between AGILE and OpenMDAO) combines the strengths of KADMOS and OpenMDAO. Thanks to OpenLEGO, one can manipulate MDAO workflow blueprints at an abstract level using KADMOS, store them as a CMDOWS file, and then automatically generate and run the blueprint as an OpenMDAO workflow. In AGILE, OpenLEGO is one of the three options, next to RCE and Optimus, to automatically instantiate executable workflows.	https://github.com/daniel-de-vries/OpenLEGO



CPACS (Common Parametric Aircraft Configuration Schema) is a data definition for the representation and the modeling of aeronautical systems. In AGILE CPACS is the “common language” chosen by the partners, enabling the effective exchange of information between their design and simulation tools. It is therefore a driver for the execution of large-scale collaborative MDO processes. All the AGILE aircraft configurations are modeled using CPACS, and all the partners’ simulation tools are CPACS compliant.

github.com/DLR-LY/CPACS



VISTOMS (VISualization TOol for MDO Systems) is the graphical user interface that allows the easy setup, inspection and modification of MDO systems. This is done by using the KADMOS functionalities “under the hood”. The two technologies are combined in a free web service called “MDO System Interface”. All of the obtained MDO systems data can be stored and downloaded in the CMDOWS format.

kadmos-repo.agile-project.eu



The Brics technology (protocol plus supportive middleware) enables the establishment of cross-organization collaborative aircraft design workflows as an integrated set of expert workflows and tools located in the domains of the collaborating partners. As such, it fosters multi-partner MDO studies, thereby complying with the prevailing security constraints while dealing gracefully with technical security measures as firewalls.

Contact collaboration@nlr.nl



RCE (Remote Component Environment) is an Open Source distributed, workflow-driven integration environment. It is used by design teams to “compose and execute” simulation-based MDO processes of complex systems (e.g., aircraft) by integrating their own design and simulation tools. In AGILE RCE can automatically generate MDO workflows stored as CMDOWS format, and execute cross-organizational MDO processes by leveraging Brics technology.

rcenvironment.de



The Surrogate Model Repository (SMR) is a central broker for registration, storage, deployment, sharing, and usage of surrogate models. The SMR facilitates sharing and reuse of the surrogate models available in AGILE among collaborating partners in a knowledge-based way. It enables partners to publish and provide simplified versions of their models to support efficient optimization while protecting the IP of the detailed models.

Contact collaboration@nlr.nl



A small example repository with the SuperSonic Business Jet (SSBJ) is provided as benchmark case of the AGILE technologies

bitbucket.org/imcovangent/ssbjkadmos

3 CONCLUSION AND OUTLOOK

With the aim of making available the AGILE Paradigm to the aviation community, an AGILE Open MDO Suite has been prepared for further exploitation of the developed technologies. The AGILE Open MDO Suite is distributed through a dedicated webpage of the AGILE Project website (<https://www.agile-project.eu/open-mdo-suite/>).

The three versions of the AGILE MDO Suite will be constantly kept updated by the AGILE Consortium, improving the AGILE technologies.

4 REFERENCES

- [1] P. D. Ciampa and B. Nagel, "AGILE the Next Generation of Collaborative MDO: Achievements and Open Challenges," in 19th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, Atlanta (US-GE), 2018.
- [2] B. Aigner, I. van Gent, G. La Rocca, E. Stumpf and L. Veldhuis, "Graph-based algorithms and data-driven documents for formulation and visualization of large MDO systems," *CEAS Aeronautical Journal*, vol. 40, pp. 1-6, 2018.
- [3] I. van Gent, G. La Rocca and L. Veldhuis, "Composing MDAO symphonies: graph-based generation and manipulation of large multidisciplinary systems," in 18th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, AIAA AVIATION Forum, Denver, 2017.
- [4] B. Aigner, R. Lombardi and P. Della Vecchia, "D5.5 - Collaborative pre-/post processing tools," AGILE Project deliverable, 2018.