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Automated Selection of the Optimal On-board Systems Architecture within MDO Collaborative Environment

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The on-board systems are having even more importance in aircraft design since the continuous research for a competitive, more optimized and less costly aircraft. In addition, the introduction of new technologies related to the More Electric Aircraft and All Electric Aircraft concepts have raised the interest on on-board systems discipline giving the option of analyzing different architectures. The present paper would enhance the selection of the best on-board systems architecture introducing a new workflow, which is able to identify the best architecture in terms of procurement and operating cost. Since the importance of fuel required providing the secondary power, the effect of each specific architecture on engine performance is particularly considered including a detailed engine module. The workflow is implemented in Optimus framework within a collaborative and multidisciplinary environment and it is open to be integrated with additional modules increasing the fidelity of the analysis. To explore the capability of the defined workflow, the H2020 AGILE regional jet is identified as test case.

Nomenclature

AEA = All Electric Aircraft
AGILE = Aircraft 3rd Generation MDO for Innovative Collaboration of Heterogeneous Teams of Experts
APU = Auxiliary Power Unit
CPACS = Common Parametric Aircraft Configuration Schema
DOE = Design Of Experiment
ECS = Environmental Control System
EPGDS = Electric Power Generation and Distribution System
FMU = Functional Mock-up Unit
IPS = Ice Protection System

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MDO = Multidisciplinary Design Optimization
MEA = More Electric Aircraft
MTOW = Maximum Take-Off Weight
OEW = Operating Empty Weight
PIDO = Process Integration and Design Optimization
RSM = Response Surface Methodology
SFC = Specific Fuel Consumption
SOTA = State Of The Art
TLAR = Top Level Aircraft Requirement

I. Introduction

At present, the competitiveness and the environmental constraints in the field of civil aeronautical products have boosted the need for optimized designs that target above all low operating cost. Aerospace engineers and researchers are focusing their attention towards a more integrated design between the different disciplines: aerodynamics, structure design, propulsion and on-board systems [1]. Previously, during conceptual design phase, the on-board systems have been considered merely for their weight using parameterized formulas based on literature data [2]. Only from preliminary design phase, the on-board systems architectures, the power required and their volumes are taken in consideration. In order to obtain a more integrated and optimized design, all parameters, usually considered in preliminary design, are now evaluated also in conceptual design. In this way, a real MDO can be carried out from the very beginning of the project considering, in more details, a large part of the aircraft empty mass, acquisition and operating cost represented by on-board systems.

Furthermore, on-board systems have other significant effects on aircraft overall design, the most important are: the additional fuel weight needed to supply them, the volume required for installation, aircraft reliability and safety. The on-board systems require electric, hydraulic and pneumatic power to operate. These powers are produced by engine as non-propulsive power, hence the engine will require additional fuel just to supply energy to the sub-systems as well as dedicated interfaces to extract and convert the mechanical power into more suitable forms. Different quantities of power off-takes and bleed air extraction produce an effect on engine SFC also [3] [4]. Fuel consumption is furthermore increased by augmented induced drag, consequence of systems weight, and by the up-scaled friction drag related to larger air intakes and fairings [5]. The systems architectures have also an effect on global aircraft reliability and safety. The increase of number of redundancy lines for electric, pneumatic and hydraulic power systems should increase the safety level reducing logistic reliability.

Over the past few years, the on-board systems have been differentiated into several types of architecture, from standard technology to more or all electric. As shown in Figure 1 (a), for SOTA architecture, the utilities systems use hydraulic, electric and pneumatic power. Thus, electric and hydraulic powers are derived converting the mechanical power gathered from the engine by accessory drive gearbox. The pneumatic power is generated using bleed air from engine compressor stages. The innovative architecture presented in Figure 1 (b) is similar to the one installed on the Boeing 787 [6], however it represents only one example of the several "more electric" architectures that can be designed. In this example it is possible to observe that electric, hydraulic and pneumatic users are still present; the mechanical power taken from the engine is exclusively transformed in electric power. Hydraulic and pneumatic users are powered by electric power generation and distribution system by means of respectively electric turbo-compressors and electric motor driven pumps. Engine cycle efficiency could be increased and power generation could be optimized removing the engine air bleed off-takes [4] and engine driven hydraulic pump. Other innovative architectures could include electric flight control system actuators, partially or entirely removing the hydraulic system. Moreover, other system architectures can be derived from a combination of the two described ones.

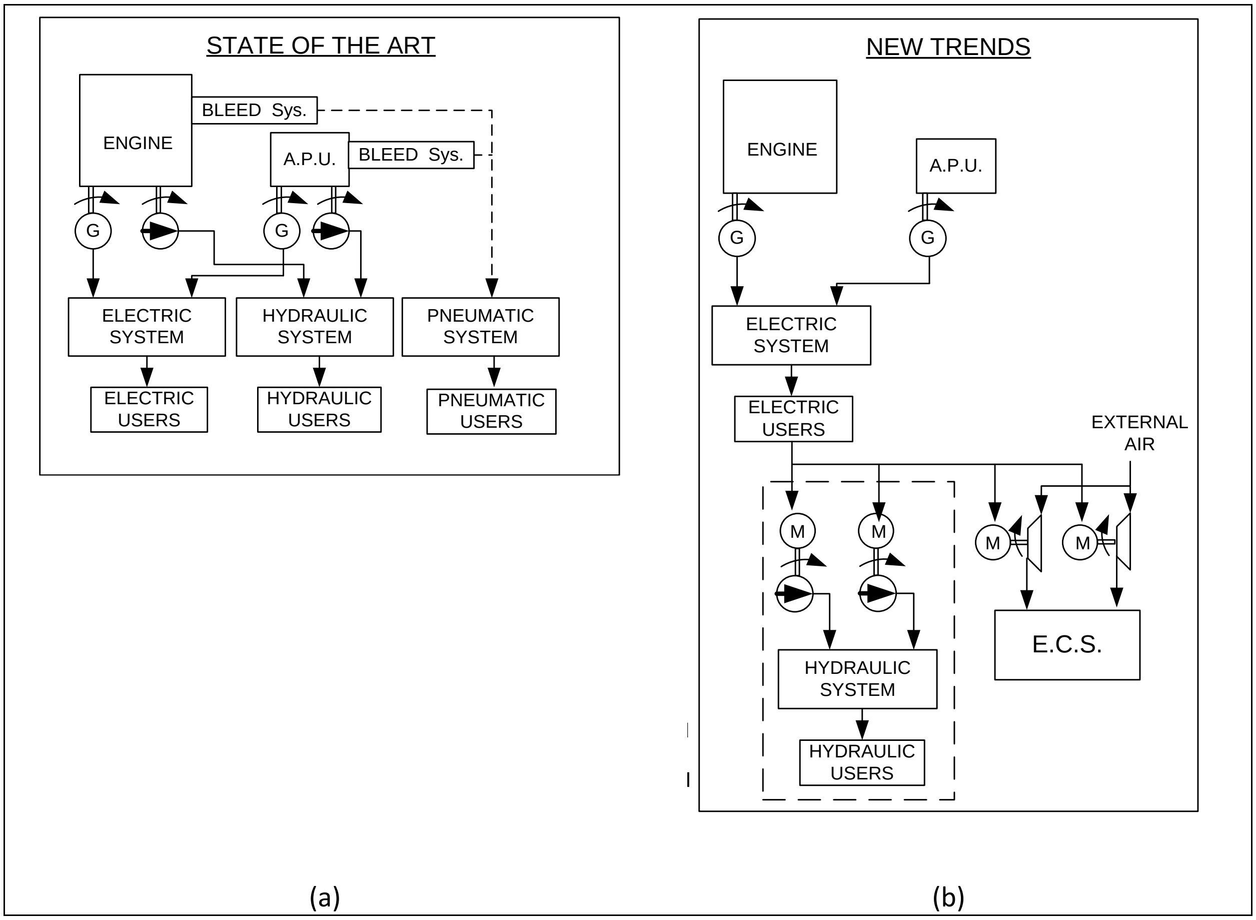

Figure 1: Example of state-of-the-art and "more electric" systems architectures.

Seeing the effects of on-board systems and their architectures in overall aircraft, it is essential to define the optimal one to improve the aircraft performance. The present paper is focused on a novel methodology to automatically select the optimal (i.e. that minimize cost and weight) sub-system architecture considering the impacts of the architecture itself on the overall aircraft design. In particular, the proposed procedure takes into account the effect of fuel required by on-board systems, as well as the systems' cost and weight. The "snow ball" effect of fuel and systems weight obtained with the further design iteration is not accounted, otherwise several additional disciplinary design modules should be necessary. This should not be a limit of the present study since the first outcome proposed is an algorithm for the automatic definition and selection of the best subsystems configuration. Other researchers have focused their attention in the selection of more suitable system architecture obtaining optimal results [2]. Additionally, in the present work, the model proposed and its implementation are compatible with a collaborative design, using the commercial PIDO Optimus by Noesis Solutions [7], and it is a little more comprehensive extending the analysis to the cost discipline with the aim to define the best systems solution.

II. Automated model for subsystem architecture selection in a MDO workflow

The workflow sketched in Figure 2 concerns systems design to define masses, required fuel and costs for several system architectures. The balance between the three types of non-propulsive power, the schema used to generate them, and the served utilities, determine the hardware configuration. Conventional systems directly extract both mechanical power (converted to electric and hydraulic) and high pressure gas from the engine whereas other solutions could have staged conversions (mechanical to electric to hydraulic). As an example an AEA thanks to the lack of hydraulic and pneumatic systems will have an overall heavier but more fuel efficient architecture.

Three design modules are integrated within the workflow. The main integrated module is represented by the tool ASTRID [8], in-house software conceived and realized by Politecnico di Torino, aimed at the preliminary design of the aircraft sub-systems. The results of the model are represented by system masses and engine shaft power off-takes and bleed off takes required to supply energy to on board systems. These results are input of a second integrated module focused on engine design.

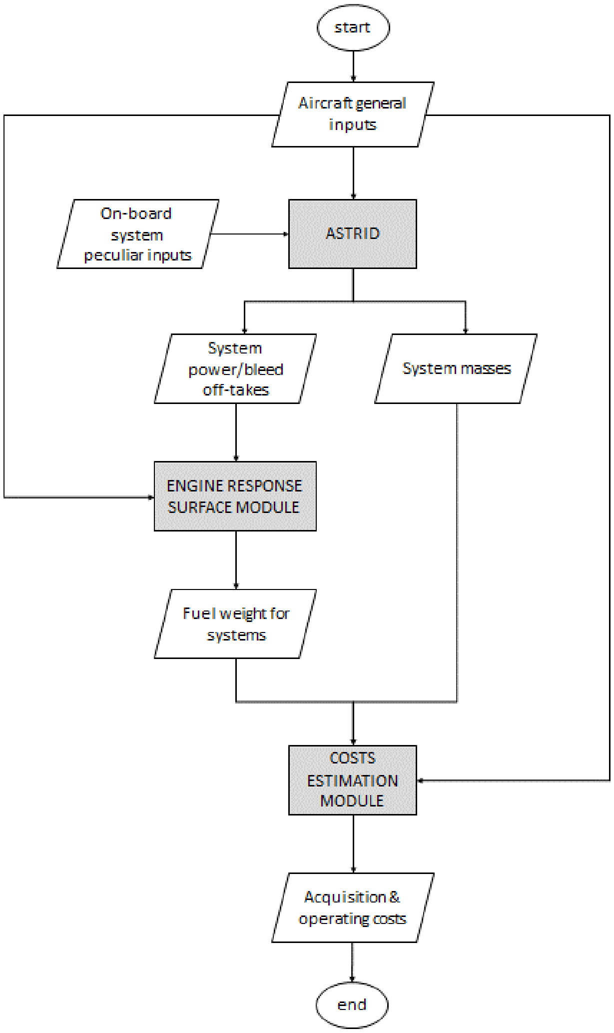

Figure 2: Flowchart of the workflow including systems sizing, engine and cost estimating modules

This module assesses the effect of on-board system on engine SFC and it is used to calculate the fuel flow required to supply power to the systems and to produce thrust. The last module is the cost model, which, given the results of systems weight and fuel quantity for secondary power, estimates the acquisition and operating costs of each system architecture.

More in details (see Figure 2), the aircraft general inputs, such as TLARs, airplane dimensions and geometries (e.g. fuselage length, wing area), design weights as MTOW, OEW and other generic considerations (e.g. type and position of engines) are given to the on-board systems design module, ASTRID. The software receives additional inputs related to the sub-systems. These groups of data allow for a detailed description of each on-board system (as instance the number of wheels of the landing gear, the pressure of the hydraulic system and the number of redundant equipment). The specific inputs characterize the different system architectures. ASTRID estimates the masses and the mechanical shaft power off-takes and bleeded air requirements of the following systems: avionics, Flight Control System, landing gear (i.e. retraction, steering and braking sub-systems), IPS, ECS, Fuel system, APU System, furnishing, Pneumatic System, Hydraulic System and Electric System. Different methodologies are implemented to evaluate masses and secondary power requests of both conventional and innovative systems, such as MEAs and AEAs. Other details about ASTRID and the implemented design modules are reported in Chiesa et al. [8].

Systems weight results, together with aircraft generic information, such as mission profile and engine deck (performances, thrust levels, fuel consumption), are inputs of the Engine Module. Engine module is based on the commercial tool GasTurb v12 [9] [10] for engine design and performances simulation. GasTurb v12 is a comprehensive code for the preliminary design of propulsion and industrial gas turbine engines. It encompasses design point and off-design performance, based on extensive libraries of engine architectures and component performance maps, all coupled to impressive graphics. The engine component maps can be presented in the engine model in a different ways from generalizations up to approximation of rig test data. Engine module technology constraints and design rules are used in engine cycle design, off-design simulation and engine overall geometry and mass assessment. Technology constraints and design rules were applied to generate extended engine deck consistent with specified technology. Engine analysis module evaluation is based on the operational assumptions, Entry into Service time, engine configuration, power off-take/overboard bleed. The module provides engine installation losses, engine flight envelope, intake pressure recovery description, thrust reverser ability, engine technical deliveries, engine performance for different operating conditions, engine dimensions description, engine sizing rules, automatic handling of air bleed. More details on the applied engine model are described in the Kurzke, 2015 [9].

Additionally, although a single run of the ASTRID tool takes a few seconds, the Engine Module involves much more complex and time demanding operations. To this end, a RSM has been applied to speed up the optimization process without sacrifice the accuracy. From the analysis of the input at aircraft level, it is possible to derive the range of the inputs at Engine Module level, like maximum and minimum power off-take.

With the now know expected inputs range of the Engine Module, through an independent design of experiment is possible to identify the input-output correlation of the Engine Module for an arbitrary set of inputs combinations that embrace the whole design space. The data are used to build an interpolated model whose accuracy is validated against the available DOE points. Upon validation and within the limits of the inputs range used to create it, the RSM can be used as a surrogate of the Engine Module. Specifically, the response model has been embedded in a FMU, a standardized xml-described interface that allows storing of a complex simulation system as a software library.

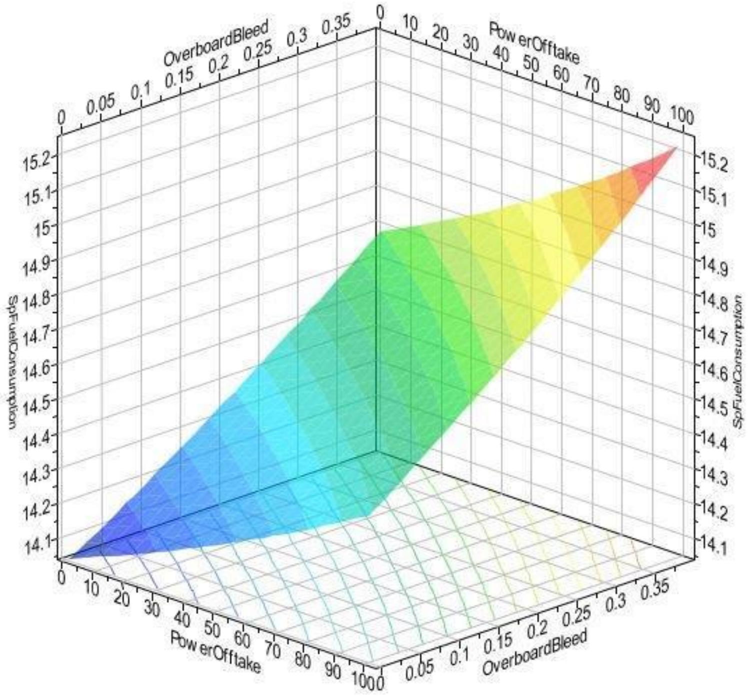

Figure 3: Response Surface Model of representative engine. (Unit of measure: Power Offtakes [kW], Overboard Bleed [kg/s], Specific Fuel Consumption [mg/Ns])

The fuel weight calculated through the Engine Module and the systems masses obtained through ASTRID become an input for the Costs Estimation Module [11]. This model is based on the costs estimation methodology proposed by Beltramo [12] modified to consider the inflation, the cost of novel technologies (i.e. MEA and AEA equipment). It allows the estimation of the procurement cost of each subsystem in a preliminary phase of the aircraft design process. This represent the systems purchasing costs and they depend on the technology level of the sub-system, their "quantity per aircraft" (generally expressed in terms of mass), and the number of production units (meant as number of aircraft to be produced with each type of system architecture). Concerning the operating cost, the implemented module evaluates only the fuel cost overlooking the other items of the direct operating cost (DOC) in this preliminary design phase. To balance the acquisition cost with the operating cost, the model is set to calculate the operating cost considering the entire life cycle (about 120000 flight hours).

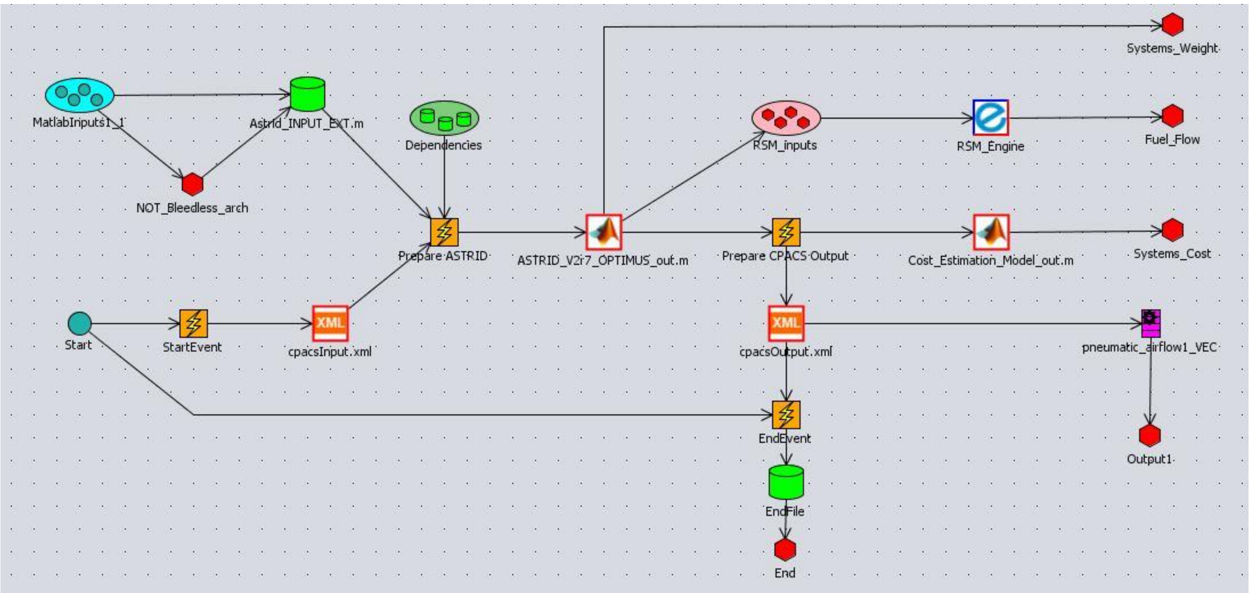

Figure 4: Workflow integrated within Noesis Optimus showing the building blocks (i.e., inputs, files, analyses, outputs) required to link the design variables to the system responses and the connection between these items.

The workflow so far described is implemented using the commercial PIDO Noesis Optimus, as represented in Figure 4. In this workflow, inputs are discrete variables that describe the configuration of the on-board systems; they are resumed in Table 1. They are either controlled directly by the user to investigate specific system architectures or by the DOE/optimization method to explore the design space and search for a quantifiably "better" solution. The input variables are written on file by the "infile" block (light green icon) to be fed to ASTRID. The engine RSM is integrated in the workflow as a local sub-workflow that embeds the surrogate model. The engine RSM has been previously defined as an interpolated surface based on data from a DOE. Systems and cost modules are Matlab® files called using a dedicated interface that allows for the execution of external programs.

Table 1: Workflow Input variables

Input Variable Name	**Value – Meaning**
FCS_Power_Supply	0 – the Flight Control System is supplied by electric power 1 – the Flight Control System is supplied by hydraulic power
LND_GEAR_RETRACTION_Power_Supply	0 – the retraction of the landing gear is supplied by electric power 1 – the retraction of the landing gear is supplied by hydraulic power
LND_GEAR_STEERING_Power_Supply	0 – the steering of the nose landing gear is supplied by electric power 1 – the steering of the nose landing gear is supplied by hydraulic power
LND_GEAR_BRAKING_Power_Supply	0 – the braking of the main landing gear is supplied by electric power 1 – the braking of the main landing gear is supplied by hydraulic power
Brake_Hydraulic_pressure	207 – Hydraulic pressure [bar] of the landing gear braking system

	344 – Hydraulic pressure [bar] of the landing gear braking system
Hydr_Pressure	207 – Pressure [bar] of the hydraulic system 344 – Pressure [bar] of the hydraulic system
Primary_Electric_voltage	2 – Primary generated electric voltage: 115 V AC (400 Hz) 5 – Primary generated electric voltage: 235 V AC wf
Primary_Electric_Machine	1 – Type of electric generator: Integrated Drive Generator 4 – Type of electric generator: Permanent Magnets Alternator + AC/DC
Bleedless_architecture	0 – Conventional pneumatic architecture (with air bleed) 1 – Innovative pneumatic architecture (bleedless)

III. Case Study: the AGILE regional aircraft

The workflow previously presented is under development within a European funded Research Project named AGILE – H2020 [13]. This project involves several worldwide aerospace partners from academia, research centers and industries. 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 cost-effective and greener aircraft solutions.

A conventional reference regional jet (see Figure 5) has been selected within the AGILE Consortium as case study to set-up and operate the AGILE state-of-the-art Design System. The Top TLAR and the main airplane specifications obtained from the preliminary design are listed in Table 2. Several subsystem architectures are identified and designed as case study of the workflow. The reference aircraft is comparable with an Airbus 319 in terms of range, cruise speed and payload capacity.

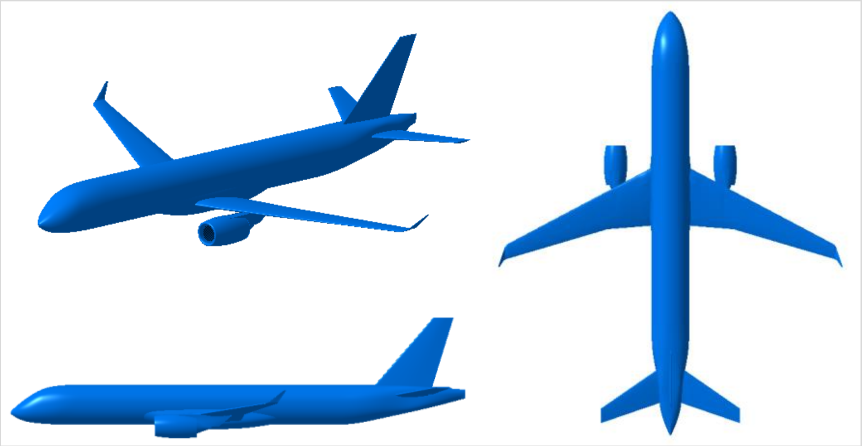

Figure 5: Notional geometry of the reference aircraft.

Table 2: AGILE state-of-the-art reference aircraft: TLAR and main specifications.

Range [km]	3500
Design payload [kg]	9180
Max. payload [kg]	11500
Number of passengers	90
Cruise Mach [-]	0.78
TOFL @ ISA, SL [m]	1500
Wing Area [m2]	84,3
Wing Span [m]	28,4
MTOM [kg]	45046
OEM [kg]	27421

Considering the main design parameters, several on-board system architectures have been identified, varying:

- the power supply of the different users systems (e.g. FCS and landing gear actuation), selecting between electric and hydraulic power.
- the hydraulic pressure, selecting between 207 bar and 344 bar.
- the electric voltage, 115 VAC and 235 VAC.
- the pneumatic system architecture, selecting between the presence of bleed air off-take and the bleedless configuration.

The authors in [2] have proposed several other variables, as instance the typology of actuators (linear vs. rotary, hydraulic vs electric). Comprehensively, from a purely mathematical point of view, over 13 millions of combinations could be defined: not all of them are realizable or possible from a logical or engineering point of view. As instance, if the system architecture is characterized by the absence of the centralized hydraulic system, the presence of hydraulic actuators representsan infeasible solution.

A DOE has been performed on the complete workflow to investigate a set of 512 possible combinations that have been identified analyzing the inputs listed in Table 3. These inputs are in fact a subset of more generalized input list from [2]. An additional preprocessing has been performed manually to screen out the few surviving non feasible configurations. As instance, in an all-electric architecture nothing changes if the variable “Hydr_Pressure” assumes the values 207 bar or 344 bar, as no hydraulic pressurized fluid is present inside this configuration. At the moment, the 16 unfeasible solutions have been discarded by hand, with the future goal to automate this process.

In Table 3 is reported an extract of the preliminary list of system architectures, ordered from the most affordable to the most expensive ones. As the reader can notice, the solutions with a lower cost are those characterized by the bleedless configuration. The acquisition costs of these architectures are higher respect to conventional solutions (at least at the moment, as only 2 models of bleedless turbofan engine are in use on airliners) because of the innovative technology and higher complexity but this is paired.by the lower fuel required to power the bleedless systems, attaining an important reduction of the overall operating costs.

Table 3 – Synthesis of the 512 system architectures (inputs and results)

Num exp.	FCS power (hydr/elec)	lnd gear retracion power (hydr/elec)	lnd gear steering power (hydr/elec)	lnd gear braking power (hydr/elec)	Hydraulic pressure [bar]	Primary electric voltage	Bleedless architecture (y/n)	Systems weight [kg]	Systems fuel Weight [kg]	Sys+fuel weight [kg]	Total Cost
239	hydr	hydr	hydr	elec	344	235 VAC wf	y	8175,592371	53,21153481	8228,80391	$ 10.788.312
247	hydr	hydr	hydr	hydr	344	235 VAC wf	y	8175,592371	53,21195922	8228,80433	$ 10.788.325
227	hydr	hydr	hydr	elec	207	235 VAC wf	y	8295,529605	53,21153481	8348,74114	$ 10.803.731
251	hydr	hydr	hydr	hydr	207	235 VAC wf	y	8295,529605	53,21195922	8348,74156	$ 10.803.743
199	hydr	hydr	elec	elec	344	235 VAC wf	y	8175,592371	53,20773164	8228,8001	$ 10.842.884
223	hydr	hydr	elec	hydr	344	235 VAC wf	y	8175,592371	53,20815606	8228,80053	$ 10.842.896
229	hydr	hydr	hydr	elec	344	115 VAC (400 Hz)	y	8279,327797	53,21153481	8332,53933	$ 10.858.188
253	hydr	hydr	hydr	hydr	344	115 VAC (400 Hz)	y	8279,327797	53,21195922	8332,53976	$ 10.858.201
203	hydr	hydr	elec	elec	207	235 VAC wf	y	8295,529605	53,20773164	8348,73734	$ 10.858.302
211	hydr	hydr	elec	hydr	207	235 VAC wf	y	8295,529605	53,20815606	8348,73776	$ 10.858.315
…	…	…	…	…	…	…	…	…	…	…	…
7	elec	elec	elec	elec	-	235 VAC wf	y	8119,365281	52,32393801	8171,68922	$ 11.203.602
11	elec	elec	elec	elec	-	235 VAC wf	y	8119,365281	52,32393801	8171,68922	$ 11.203.602
103	elec	hydr	hydr	elec	344	235 VAC wf	y	8382,692797	52,32778751	8435,02058	$ 11.262.613
127	elec	hydr	hydr	hydr	344	235 VAC wf	y	8382,692797	52,32821167	8435,02101	$ 11.262.625
107	elec	hydr	hydr	elec	207	235 VAC wf	y	8502,630031	52,32778751	8554,95782	$ 11.278.031
115	elec	hydr	hydr	hydr	207	235 VAC wf	y	8502,630031	52,32821167	8554,95824	$ 11.278.044
1	elec	elec	elec	elec	-	115 VAC (400 Hz)	y	8237,753309	52,32393801	8290,07725	$ 11.283.348
13	elec	elec	elec	elec	-	115 VAC (400 Hz)	y	8237,753309	52,32393801	8290,07725	$ 11.283.348
79	elec	hydr	elec	elec	344	235 VAC wf	y	8382,692797	52,3239862	8435,01678	$ 11.317.184
87	elec	hydr	elec	hydr	344	235 VAC wf	y	8382,692797	52,32441036	8435,01721	$ 11.317.197
67	elec	hydr	elec	elec	207	235 VAC wf	y	8502,630031	52,3239862	8554,95402	$ 11.332.603
…	…	…	…	…	…	…	…	…	…	…	…
255	hydr	hydr	hydr	hydr	344	235 VAC wf	n	8070,876508	120,4415145	8191,31802	$ 12.619.333
245	hydr	hydr	hydr	hydr	344	115 VAC (400 Hz)	n	8081,281718	120,4415145	8201,72323	$ 12.626.342
231	hydr	hydr	hydr	elec	344	235 VAC wf	n	8092,599806	120,4410893	8213,0409	$ 12.633.954
243	hydr	hydr	hydr	hydr	207	235 VAC wf	n	8190,813741	120,4415145	8311,25526	$ 12.634.752
249	hydr	hydr	hydr	hydr	207	115 VAC (400 Hz)	n	8201,218951	120,4415145	8321,66047	$ 12.641.761
237	hydr	hydr	hydr	elec	344	115 VAC (400 Hz)	n	8112,741728	120,4410893	8233,18282	$ 12.647.521
235	hydr	hydr	hydr	elec	207	235 VAC wf	n	8212,537039	120,4410893	8332,97813	$ 12.649.372
225	hydr	hydr	hydr	elec	207	115 VAC (400 Hz)	n	8232,678962	120,4410893	8353,12005	$ 12.662.939
215	hydr	hydr	elec	hydr	344	235 VAC wf	n	8074,306701	120,4377046	8194,74441	$ 12.676.215
221	hydr	hydr	elec	hydr	344	115 VAC (400 Hz)	n	8086,739436	120,4377046	8207,17714	$ 12.684.590
207	hydr	hydr	elec	elec	344	235 VAC wf	n	8092,599806	120,4372795	8213,03709	$ 12.688.525
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Focusing on cost results, it is possible to define the following relation concerning the on-board system technologies:

- The FCS actuators technologies have a rather effect on on-board system procurement cost
- The operating cost is strongly related with pneumatic system technology (with bleed or bleedless)

Concerning the weight, the following relations can be observed:

- The FCS actuators technologies produce a notable effect on the overall on-board systems weight.
- High pressure and voltage power generation reduces the systems weight.
- The bleedless configuration weights more, but it requires less fuel to operate.

With the aim to usefully compare the results obtained, four of the most prominent systems architectures are selected and compared.

- Conv, Conventional architecture (Figure 6): all flight control system (FCS) and landing gear (LG) actuators use hydraulic technology, powered by 3000 psi (≈207 bar) hydraulic system. The IPS is aerothermal using the hot bleed air tapped from aircraft engines. The ECS that regulates the cabin air pressure and temperature is conventional and it is supplied by pneumatic power bled by aircraft engine. The electric system generates 115 V AC 400 Hz by integrated drive generators (IDG). Then electric power converted to 28 V DC for low voltage users.

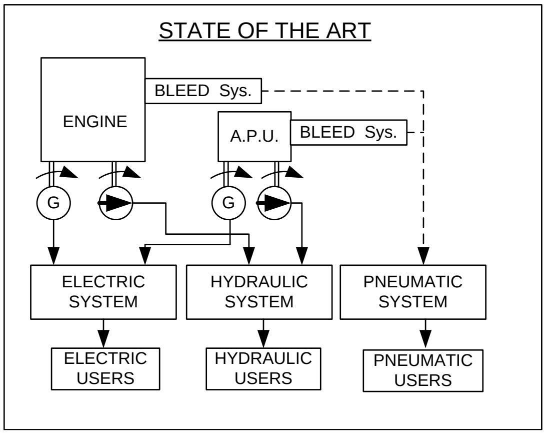

Figure 6: Conventional on-board systems architecture.

- MEA1, More electric architecture, first configuration (Figure 7): All actuators (FCS & Landing gear) are electric, powered by high voltage electric system. The IPS is aerothermal (hot bleed air tapped from engines).The air conditioning system (ECS) is conventional (bleed air tapped from engines) is regulated in pressure and temperature. Hydraulic system is not present. Electric system generates 235 V AC wild frequency by Alternator. Then electric power converted to 270 V DC, 115 V AC and 28 V DC.

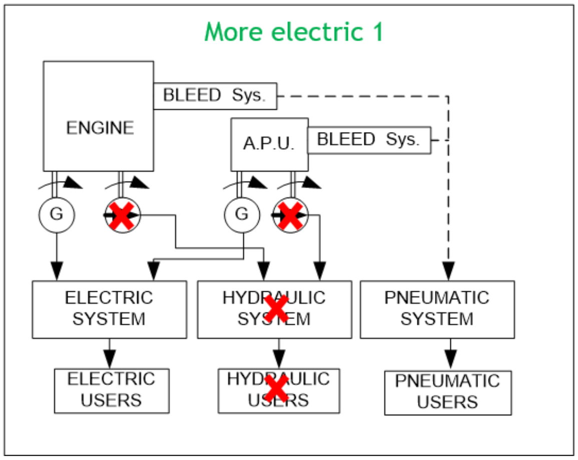

Figure 7: More electric on-board systems architecture, first configuration.

- MEA2, More electric architecture, second configuration (Figure 8): all actuators (FCS & Landing gear) are hydraulic, powered by 5000 psi (~345 bar) hydraulic system with electric driven hydraulic pumps. The IPS is electric and it uses high voltage electrical resistance. The ECS is electric. It uses external air, which is pressurized by dedicated compressors driven by electric motors. Electric system generates 235 V AC wild frequency by Alternator. Then electric power is converted to 270 V DC, 115 V AC and 28 V DC.

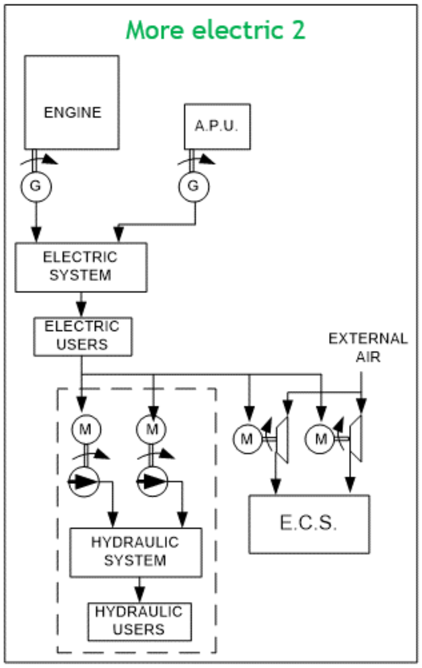

Figure 8: More electric on-board systems architecture, second configuration.

- AEA, All electric on-board system architecture (Figure 9): All actuators (FCS & Landing gear) are electric, powered by high voltage electric system. The IPS is electric with high voltage electrical resistance. The ECS is electrical. It uses external air pressurized by dedicated compressors driven by electric motors. The hydraulic system not present. The electric system generates 235 V AC wild frequency by Alternator. Then electric power is converted to 270 V DC, 115 V AC and 28 V DC.

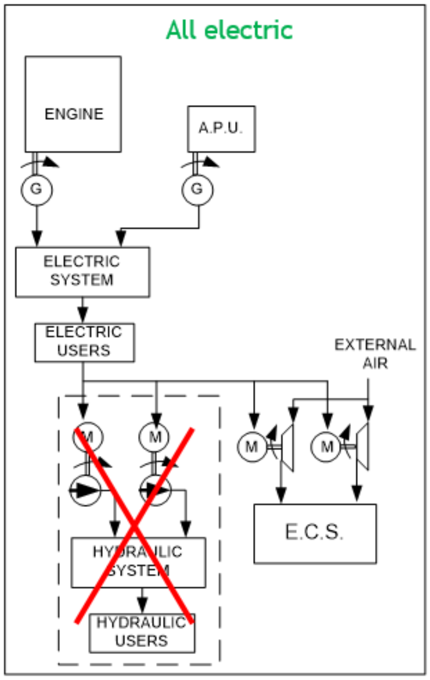

Figure 9: All electric on-board systems architecture.

Figure 10 Weight and Cost comparisons of four on-board systems architectures

Focusing on the total weight (systems plus fuel), as shown in Figure 10, the lightest architectures is the AEA (All electric) with a small edge over the MEA 1 (More electric, first configuration). In both architectures, all hydraulic users, power generation and distribution are replaced with electrical one. MEA 2 (More electric, second configuration) and the conventional architecture both rely on hydraulic system and the drawback is a notable increment of weight. In more details, the reason of the weight difference among the architectures is not the presence of the hydraulic system only. It is worth notice that the FCS that uses hydraulic technology is lighter than the electric one (due to the better force to mass ratio of the actuators). However, the weight of hydraulic power distribution and generation reverses this initial advantage. The pneumatic power generated by using dedicated electric driven compressor gives an additional save in weight for MEA2 and AEA configuration when the fuel weight is considered. Conversely, as seen for hydraulic technology, the architectures, which rely almost totally on electric technology, faced an increment of the electrical power generation and distribution system. However, this increment in weight is well compensated by the weight saved due to the removal of hydraulic system.

Concerning the cost, AEA and MEA2 require less fuel to operate and this reduce the operating cost for these two architectures. The conventional and MEA1 have a reduced acquisition cost, however they require more fuel. Since AEA totally relies on new systems technologies, the acquisition cost is higher than MEA2, which at the moment can be considered the best architecture of the four selected.

IV. Conclusion

As results of the present work, an automated selection of the best on-board systems architecture is achieved using on-board systems, engine and cost modules. The workflow is implemented in a multidisciplinary and collaborative environment open to be extended including all aircraft design disciplines. RSM technique is implemented to the engine design in order to reduce the process run-time and increase its automation. Concerning the AGILE regional jet case study, the results indicate as the best architecture the combination of bleedless engine and conventional FCS that is currently employed in one of the most innovative aeronautical product (i.e. B787 Dreamliner). However, the AEA architecture could become more advantageous favorable if (when) the acquisition cost of the new AEA technologies would decrease as they become more widespread.

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