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Unmanned AEW/ISR Platform
Conceptual design and technology assessment

Christopher Jouannet[1], Kristian Amadori[1], Mathias Emeneth [2], Athanasios Papageorgiou [3]

[1] Aircraft Conceptual Design division, Saab Aeronautics, Linköping, Sweden
[2] PACE America, Inc., Mukilteo (WA), U.S.A.
[3] Linköping University, Linköping, 58183, Sweden

Abstract

This paper presents a notional case design study of an unmanned AEW/ISR platform, aimed to test methods under development at Saab Aeronautics. One of the goals of the methodologies is to provide better insight into technology impact and prioritization with respect to a future aircraft programs, especially in aircraft conceptual design. Therefore, in this work primary focus has been on testing and identifying boundaries of new tools for modelling and simulation that were recently introduced at the Saab. The use case represents a typical technology assessment study, in which the impact on mission and vehicle performance metrics is assessed when different onboard system architectures and technology clusters are applied. The presented way of working will demonstrate how it is possible to trace the impact of technologies at sub-system level all the way to system or system-of-systems mission metrics. The study was carried out in accordance to the methodology developed at Saab for technology assessment which has been already documented in previous publications.

Keywords: technology assessment, aircraft conceptual design, methods

1. Introduction

Within aerospace defense industry, overall development time is long and conceptual design phases start well ahead of planned entry into service dates. Within the conceptual design phase, possible benefits of available technologies and potential gains from new and still immature technologies need to be addressed in order to understand their impact on design and requirements. This needs to be done from a technical and technology maturity level perspective. Addressing maturity levels has been of great focus during passed years [4,5], due to the large impact technology maturation slips may have on the aircraft development and thereby on the overall acquisition cost.

The current work is based on papers by the authors targeting methods for technology assessment [1,2,3,4,5] with linking to aircraft conceptual development and system-of-systems consideration of an unmanned AEW/ISR aircraft.

Since the recent introduction at the Company of Pacelab APD/SysArc as a new aircraft conceptual design tool, the aim of the work presented in this paper is to test the capabilities and find the boundaries of the tools, with particular focus to onboard systems and systems architectures. With the adoption of APD/SysArc it is now possible to have a more detailed representation of the onboard aircraft systems and their impact on aircraft performance in different flight conditions. The aim is to capture more precisely the effect of technologies and technology clusters on aircraft level thanks to the more detailed modelling of the aircraft systems. If possible, this functionality will be used on each technology effect to try making prioritizations and selections among the available technologies based on a better insight than with the previous in-house tool.

2. Case Study

The design case used in the presented work is based on a current research project that explores the possibility of using Unmanned Aerial Vehicles as an AEW/ISR platform. Removing the crew can lead to significant weight savings, which can be then be exploited in order to increase the useful payload (i.e. the radar system) or in order to improve the performance of the vehicle [7]. A pictorial representation of one of the concepts of the AEW/ISR platform at hand is provided in Figure 1, where most onboard systems can also be seen distributed inside the vehicle according to one of the architectures considered.

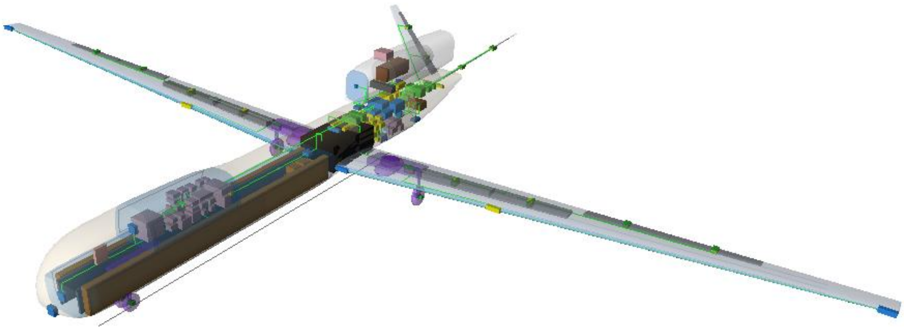


Figure 1 Pictorial view of one AEW/ISR concept

The case study which will be presented in the following pages is based on a typical surveillance mission profile as well as a set of design requirements which correspond to aircraft with a similar operational role (see Figure 2). The mission includes two cruise phases to and from the patrol zone at a fuel-economic speed; a patrol phase in the form of a racetrack pattern at a low speed for the specified endurance time; an escape alternative return route to base at maximum speed; and a number of safety precautions in terms of fuel reserve. As far as the design requirements are concerned, the aircraft must be able to both carry and fit the payload, and in this case, this includes mission items such as the radar aperture and electronics as well as avionic systems such as sensors and cameras, friend or foe interrogators and transponders, communication datalinks, and electronic support measures.

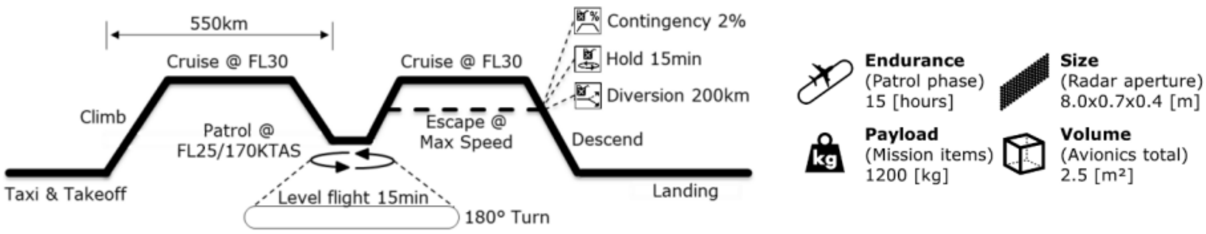


Figure 2 The design mission specifications and the payload/endurance/volume requirements

The notional case study is structured in a three-step approach (see Figure 3). First, an overall exploration of different aircraft configurations is carried out, with the aim of finding suitable designs and to size the aircraft relative to its mission requirements. During this stage focus is on the aircraft configuration and general internal arrangement, so onboard systems are approximated at SWaP (Size, Weight and Power) level. Once the most suitable aircraft concept is selected, in the second step different onboard systems architectures were traded to detail the effects on key performance metrics. The goal was to understand the impact of adopting alternative architectural and technological choices, but maintaining the overall aircraft configuration and dimensions. Finally, one specific architecture is selected and in the third step the focus is on exploring in more details the sub-systems performance, with respect to how the systems are used throughout the different mission segments and also addressing initial system safety questions.

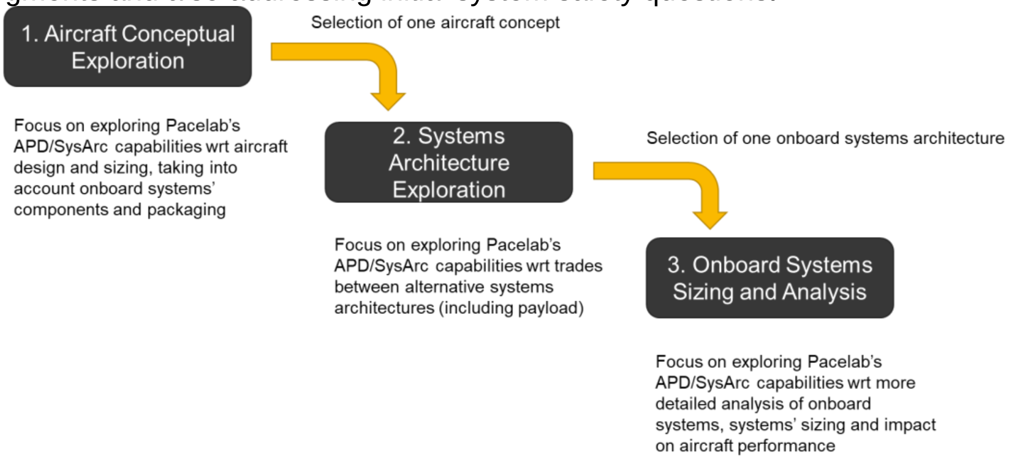


Figure 3 The use case three-steps approach

3. Models set up

3.1 SoS Analysis

The performance of the resulting SoS against the chosen MoEs was simulated with an ABS model which was developed in NETLOGO [20], with further detail in [7]. The simulation model receives as input the specifications of the SoS as well as the needs and desired capabilities in the form of a scenario, and then it computes a set of MoEs which can be used to evaluate each SoS (see Fig. 4). In this model, the systems are represented as “agents” which act according to a set of behavioral rules and tactics, while the operational scenario is represented by a “world” which includes information about the position of military and civilian sites; about the terrain morphology and weather conditions; and about the general movement constraints as well as traffic restrictions.

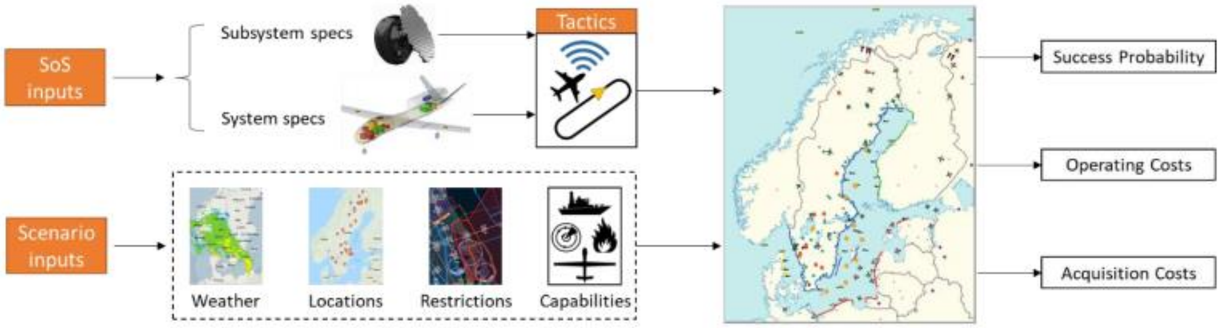


Figure 4 Inputs, outputs and connectivity of the SoS level simulations

3.2 Aircraft Sizing

The aircraft is modelled in Pacelab SysArc. The tool allows to integrate a dedicated model of the primary radar sensor which provides information about both sensor performance and impact on aircraft performance metrics. At a secondary level, the SysArc model represents the onboard electrical system architecture and the propulsion as accurately as possible so that the effects of radar operation can be properly propagated and assessed at a vehicle level (see Figure 1). The rest of the sub-systems are also considered in order to provide a complete overview of the payload, however, those are represented here by means of statistical formulas which can be found in Refs. [13], [14].

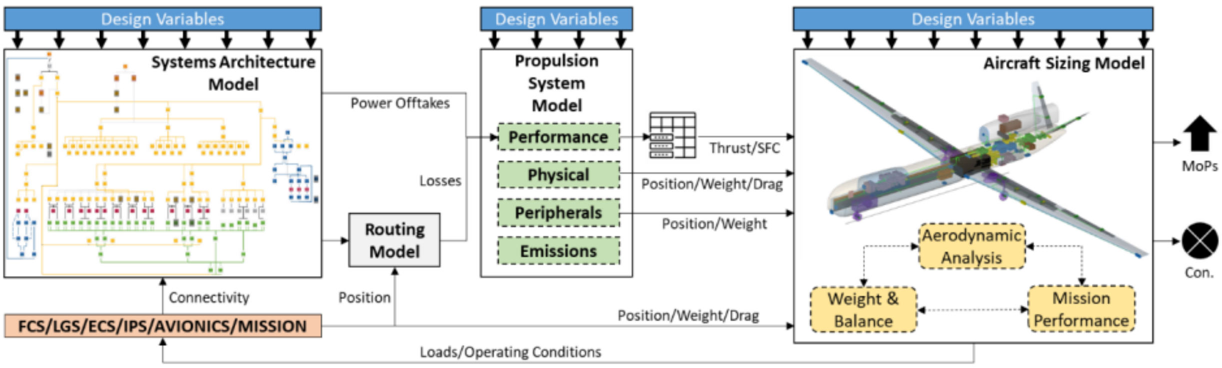


Figure 1 Overview of the framework and the basic model interactions

3.3 System Architecture

The systems architecture is modeled in the Systems Architecture (SysArc) Engineering Workbench [12]. In this model there is a detailed description of the flight critical systems, whereas airframe, avionics, and other mission specific systems are represented only by their mass properties and power demands. The primary input includes the operating characteristics of various types of mechanical, electrical, hydraulic, and pneumatic systems, while in addition to this, the model receives the complete representation of the logical connections and interactions that may exist between the components and the environment. The power demand and associated heat dissipation are modeled and linked to each flight segment, which allows sizing of cooling demand and impact of onboard systems on the engine performance. This opens up for including considerations on onboard systems impact in performance and weight perspective. On the whole, the systems architecture model allows to place the components in their respective 3D spatial location inside compartments in the vehicle, and therefore, it provides a direct exchange of information between compartment and component; it enables a more accurate calculation of the aircraft's mass properties; it helps to identify potential issues associated with inadequate space or placement violations; and it allows to compute the additional weight and the induced losses due to routing and cabling.

In the following sections, the complete list of parameters controlled the assumption sets can't be presented in full detail, since switching between alternatives sets tens of parameters that control size, mass, power and cooling requirements for all the components included in the affected systems.

Flight Control System

The aircraft model is constructed to allow swapping between four different architecture alternatives:

i. AEA (FCS, LGS, IPS, ECS), All Electric Architecture in which all onboard systems are based on electric-based design, in which electro-mechanical or electro-hydraulic actuators are used
ii. MEA (FCS, LGS), More Electric Architecture in which flight control and landing gear systems are based on electric designs, in which electro-mechanical or electro-hydraulic actuators are used
iii. MEA (IPS, ECS), More Electric Architecture in which the ice protection and environmental control systems are based on electric designs
iv. SOTA, State Of The Art architecture which represent the baseline design. In this setup, the flight control and landing gear systems are hydraulically actuated, while the ice protection and environmental control systems are driven by means of pneumatic components.

Auxiliary Power Unit

The auxiliary power unit assumption set is used to choose between three different alternatives:

i. Pratt and Whitney APS-3200
ii. Sundstrand T-62
iii. Pratt and Whitney APS-2300

In addition to size and mass, the selection of one of the APUs automatically scales also performance metrics and fuel consumption.

Radar Configuration

The AESA radar installed on the aircraft is the main functional component of the notional AEW/ISR platform in the study. It can be varied choosing amongst two antenna sizes (called "Short" and "Long"), and two maximum power outputs (called "High Power" and "Low Power") and a fixed antenna installation which then requires an antenna on both port and starboard side of the fuselage (called "Fixed") or a rotating antenna which can swing from port to starboard (called "Rotating"). This corresponds to eight different combinations of alternatives:

i. Fixed/High Power/Long
ii. Fixed/High Power/Short
iii. Fixed/Low Power/Long
iv. Fixed/Low Power/Short
v. Rotating/High Power/Long
vi. Rotating/High Power/Short
vii. Rotating/Low Power/Short
viii. Rotating/Low Power/Long

Avionics System

The avionics systems assumption set is used to choose between two different alternatives:

i. Basic Configuration
ii. Advanced Configuration

The idea with this assumption set is to switch between a more basic avionic system package and a more complex and advanced one. In this case, at modelling level the components and architecture are the same but size, weight and power/cooling requirements are higher when a more capable and complex system is chosen.

3.4 Propulsion System

The propulsion model is integrated in the APD workbench by Pacelab [12], and it is comprised of two parts which represent the "physical" and the "performance" aspects of the engine and its support systems. The physical properties include information about the type, size, number, and placement of the engines as well as their peripherals, whereas the performance specifications are expressed in terms of thrust capabilities and Specific Fuel Consumption (SFC) at various operating conditions. The SFC of the engine can be coupled to the power-outtake of the engine based on the system demands, by that closing the loop between engine performance and system impact. In this study several different propulsion systems are considered and described in Table 1. The propulsion model has been enhanced with a computational component which accounts for the calculation of emissions based on a model developed in Ref [19]. A detailed review of the different engine alternatives has been presented in [6]. The down selected aircraft concept, according to the process described in Figure 3, used a ducted turbofan engine fueled by conventional kerosene.

Table 1 Considered propulsion systems

Propulsion type	Ducted Fan		Push Propeller				
Energy source	Kerosene	Hydrogen	Kerosene	Hydrogen	Keros./Electr.	Keros./Electr.	Keros./Electr.
Hybridization level [%]	N/A	N/A	N/A	N/A	10	20	30
Bypass ratio [-]	5	5	N/A	N/A	N/A	N/A	N/A
Inlet capture area [m^2]	0.58	0.58	N/A	N/A	N/A	N/A	N/A
Jet thrust ratio @ SL [-]	N/A	N/A	0.14	0.14	0.09	0.08	0.07
Propeller coef. @ SL [-]	N/A	N/A	0.75	0.75	0.75	0.75	0.75
Shaft power @ SL [kW]	N/A	N/A	733	733	733	733	733
Battery energy [kWh]	N/A	N/A	N/A	N/A	70	140	210
Battery power [kW]	N/A	N/A	N/A	N/A	74	148	222
Fuel flow @ SL [kg/s]	0.214	0.085	0.134	0.052	0.125	0.115	0.105
Wing fuel tank [m^3]	5.073	N/A	5.073	N/A	4.226	4.226	4.226
External fuel tank [m^3]	N/A	14.457	N/A	13.191	N/A	N/A	N/A
Battery compartment [m^3]	N/A	N/A	N/A	N/A	0.175	0.350	0.525
Nacelle length [m]	3.8	3.8	4.2	4.2	4.2	4.2	4.2
Nacelle width [m]	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Nacelle height [m]	1.1	1.1	1.0	1.0	1.0	1.0	1.0

3.5 Technology Infusion

The last assumption set used in this project controls the adoption of additional technologies that impact different aspects of the vehicle. This was done similarly to the previous publications [1]-[5] using a k-factors, i.e. multiplicative factors that are applied to the available parameters in the aircraft data model that are affected by the technologies. This assumption set was introduced to have a direct comparison with previous work. Eight out of 34 technologies were considered:

i. Tech04: electrical power generation integrated in the aircraft engine, so no mechanical outtake is needed
ii. Tech23: load alleviation system that impacts structure mass
iii. Tech24: Integrated Aero-servoelastic Structures (as described in the NASA N+3 report [[17]])
iv. Tech25: Digital hydraulic for servo actuation (as described in [[18]])
v. Tech26: Full electro-mechanical actuation system
vi. Tech27: Electro-hydraulic actuation system
vii. Tech28: Hydraulic actuation system
viii. Tech29: Vapor-cycle based cooling system.

The selection of one of the technologies automatically sets the value of the pre-defined k-factors. In contrast to the previous studies, in this case only one technology can be selected at the time. It can be noted that technologies 26, 27 and 28 overlap with the flight control system architecture assumptions. This was done to allow comparing the results obtained by applying appropriate k-factors (Step 1) to swapping the more detailed architecture models (Step 2).

4. Aircraft Conceptual Exploration

The multidisciplinary model adopted for aircraft conceptual exploration and sizing includes analysis capabilities for estimating the weight, for evaluating the aerodynamics, for calculating the stability and balance, for assessing the various costs, and for computing the mission performance characteristics. The model can adapt to both morphological as well as topological choices, and therefore, it is possible to automatically generate and subsequently analyze several aircraft types and variants (See Fig. 4). In addition to this, the model offers a visualization of the inner and outer surfaces; simple representations of systems that are not explicitly expressed by higher fidelity models; a computation of the component placement violations. The inputs to the aircraft sizing model are parameters that typically have an impact at an aircraft level, and the three main categories that are encountered here are variables which define the mission profile, variables which affect the system performance, and variables which control the fuselage shape and wing planform.

Figure 5 Examples of investigated aircraft configurations

As shown in Figure 6, the concept models also included the placement of the radar and other sub-system groups. This allowed to compare the feasibility of design alternatives in terms of wing position, fuselage size, empennage layout, engine type, and system placement. For instance, concept to the left in the figure has a long fuselage to accommodate the radar aperture; the wing is placed towards the rear to ensure a good radar FoV; and the engine is mounted near the tail to have a good balance. Accordingly, the right concept has a shorter fuselage since the radar is externally mounted below the fuselage, but on the other hand, this requires longer landing gears to ensure a good ground clearance; it pulls the engine closer to the center to satisfy a good balance; and it leads to a H-tail to avoid having the rudder and elevators inside of the engine's exhaust wake.

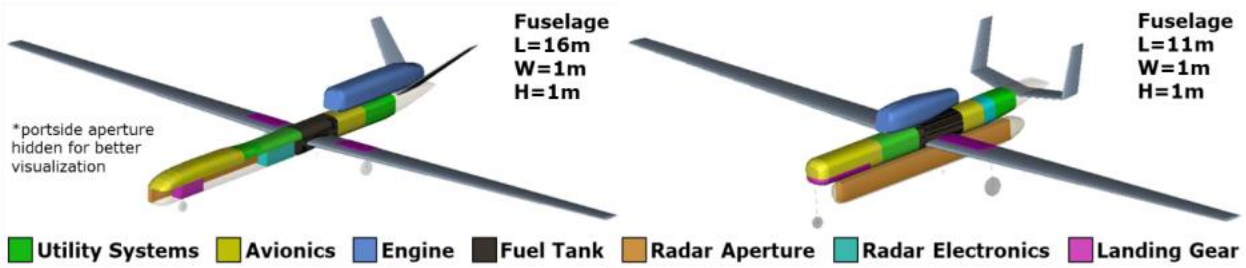
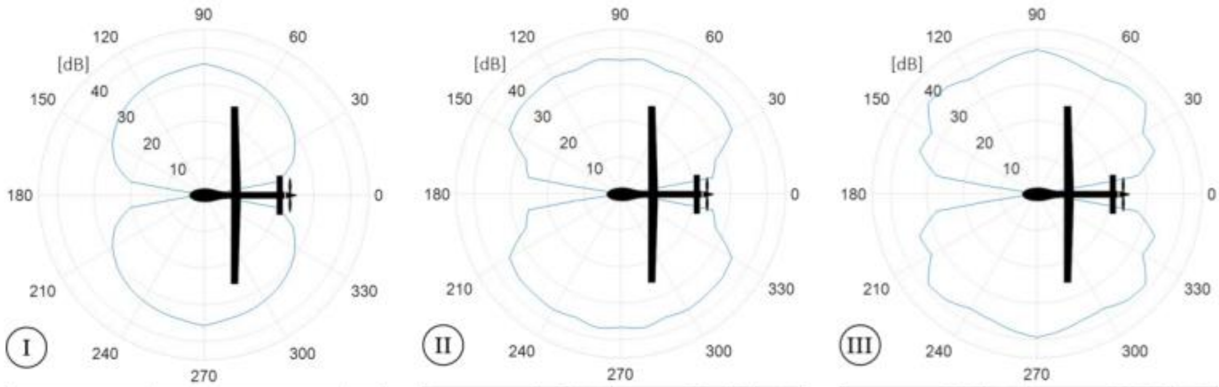


Figure 6 Comparison between two aircraft concepts, showing the position of various system groups

As explained, in addition to flight performance metrics, during this project step attention was dedicated to assessing integration and functionality of the radar arrays. Therefore, different radar designs were generated (see Figure 7), with further detail in [7]. These systems are based on a uniform rectangular slot phased array with a different number of antenna elements, and as a result, they have diverse power requirements and directive gain patterns. For this application, the considered antenna elements have the same radiating pattern, wavelength, pulse width, and pulse frequency; however, they differ in terms of peak power, size, and spacing. The angular coverage of all the radar systems is set to be between -75 to +75 degrees in the azimuth and between -75 to +45 in the elevation plane, and in all cases, this is achieved through an electronic steering of the beam. Overall, the transmitter/receiver modules of the system are designed to be installed in the forward compartment of the fuselage, while the radar aperture is assumed to be integrated in the skin of the aircraft and covered by a nacelle.



System power [kW]	5.0	System weight [kg]	254
Frequency [GHz]	3.0	Max gain [dB]	34.9
Radar length [m]	1.20	Radar height [m]	0.30

System power [kW]	25.0	System weight [kg]	1105
Frequency [GHz]	3.0	Max gain [dB]	37.1
Radar length [m]	3.00	Radar height [m]	0.45

System power [kW]	45.0	System weight [kg]	2059
Frequency [GHz]	3.0	Max gain [dB]	39.5
Radar length [m]	5.60	Radar height [m]	0.60

Figure 7 Specifications of radar systems, showing the directive gain at zero degrees of elevation

From an initial pool of concepts, a reduced number was selected using expert judgement. Then, trade studies and quantitative analysis were performed to assess each concept's potential. Figure 8 shows for instance how design mission fuel weight and turn performance vary as function of aircraft empty weight for one of the concepts that were studied.

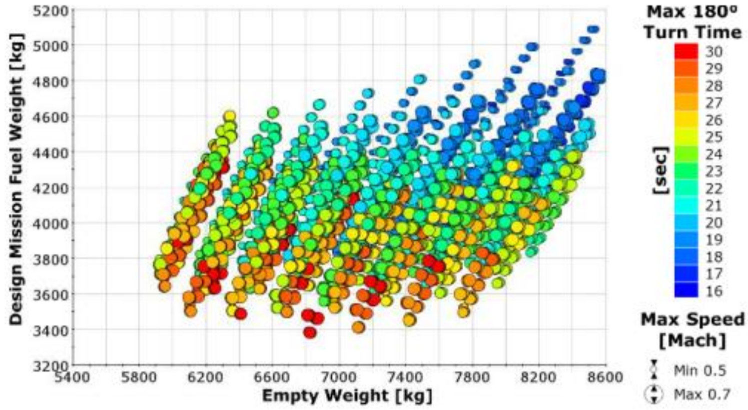


Figure 8 Quantitative design space exploration performed on selected aircraft concepts

Finally, the predicted aircraft performance were used as inputs into the SoS simulations that provided predictions of mission effectiveness metrics, as shown for example in Figure 9. It is important to note that different tactics were tested and that they had a significant impact on the resulting effectiveness. The example in Figure 9 is only showing the probability of success for a given tactics but different SoS compositions. For an in-depth discussion of the topic, the interested reader can find more details in [7].

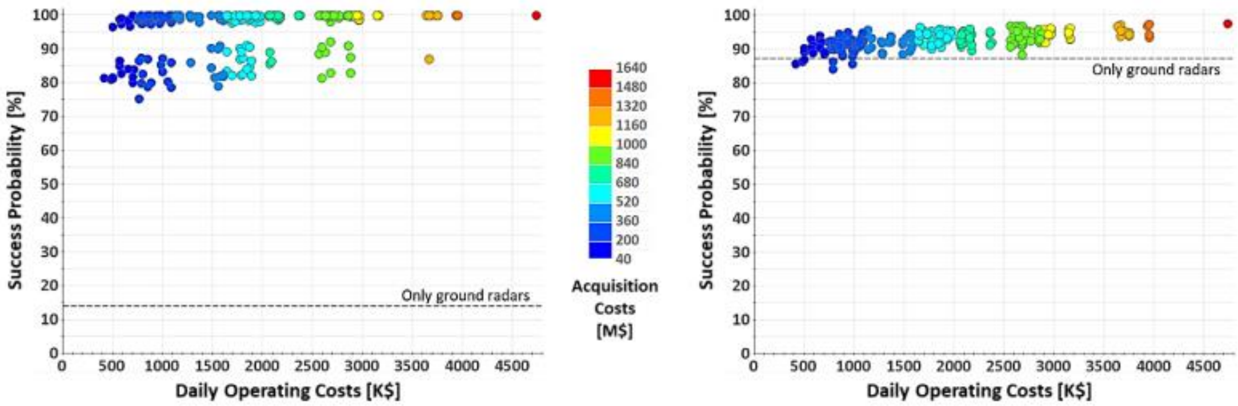


Figure 9 Capability analysis of all SoS in peace-time (left) and crisis-time (right)

The chosen design shown in Figure 1 has a relatively large wing area (66.5 m^2) to ensure good stall characteristics at the expected low patrol speeds, while it was also found that a relatively big engine (34.5 kN) is needed to achieve the desired high altitude and speed capabilities. On the whole, the chosen concept has a relatively low fuel weight as it presented good aerodynamics, but among all the considered configurations, it was not always the best performing. For instance, in comparison with the concept to the right in Figure 6, it has a higher empty weight (+418 kg). Overall however, the metrics are well within the requirements, and it was found that at the most critical requirements were time to turn (18-19 sec), cruising at high altitudes (>42000 ft) even at low patrol speeds, and cruising at high speeds (0.65-0.67 Mach) during the inbound and outbound segments. The chosen concept offered in contrast a better integration of the radar arrays and minimal obstruction to the sensors' field of view, which have both a significant impact on mission effectiveness (see Figure 10). Also, it can be mentioned that propeller solutions were penalized by the limited capability to cruise at high speed during the inbound and outbound segments.

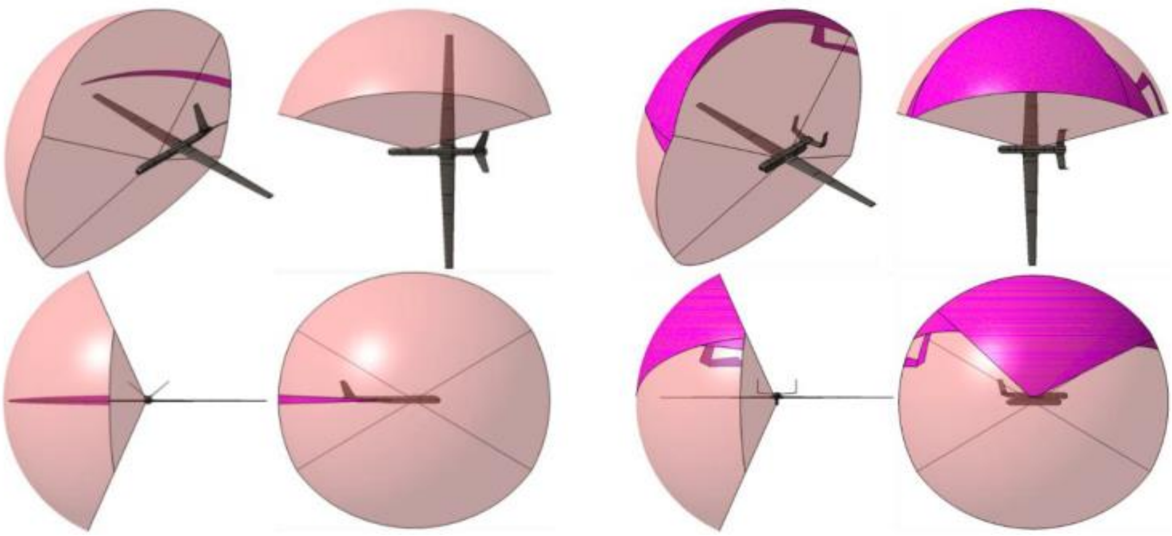


Figure 10 Analysis of the radar FoV for two of the considered concepts

5. Systems Architecture Exploration

Once the overall aircraft configuration was set, the focus in Step 2 shifted towards a more in-depth analysis of the onboard systems introducing models of higher fidelity into the design framework. An overview of the model types and a simplified description of their expected interactions within the framework is presented in Figure 11. Depending on the desired level of analysis accuracy, different parts of the framework can be activated or deactivated to achieve a balance between fidelity and computational speed. As an example, the discipline of aerodynamics can be represented by different models, which include the use of expert inputs, empirical equations, a Vortex Lattice method (VLM), a CFD approach, or a blend of all the above. Accordingly, the entire system level can be described with simple sizing formulas which have been based on statistical regressions or by using a more detailed functional abstraction where each component is considered individually.

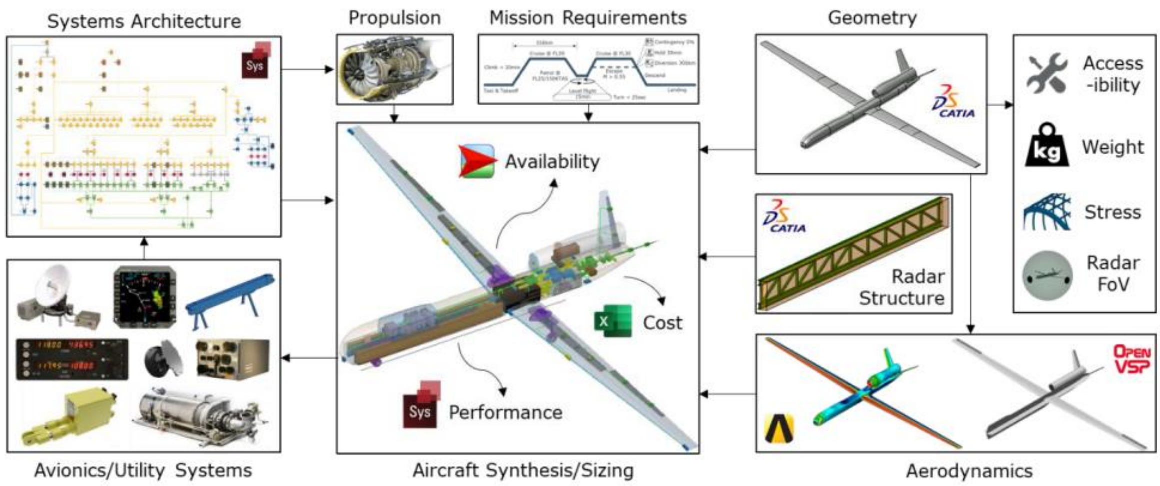


Figure 11 Overview of the models and their interactions within the framework

The input to the architecture model includes the operating characteristics of various types of mechanical, electrical, hydraulic, and pneumatic systems, while furthermore, the model receives the complete representation of the logical connections and interactions that may exist between the components and the environment. Moreover, the model enables the definition of "flight control", "ice-protected", and "temperature regulated" compartments, which in turn can be used as a reference for estimating the maximum needed forces from an actuator system or for calculating the required cooling load from the operation of the avionics. On the whole, the systems architecture model allows to place the components in their respective places on the vehicle as well as within specific compartments, and therefore, it provides a direct exchange of information between the compartment and the component; it enables a more accurate calculation of the aircraft's balance equilibrium; it helps to identify potential issues associated with inadequate space or placement violations; and finally, it allows to compute the additional weight and the induced losses due to routing and cabling (See Figure 12).

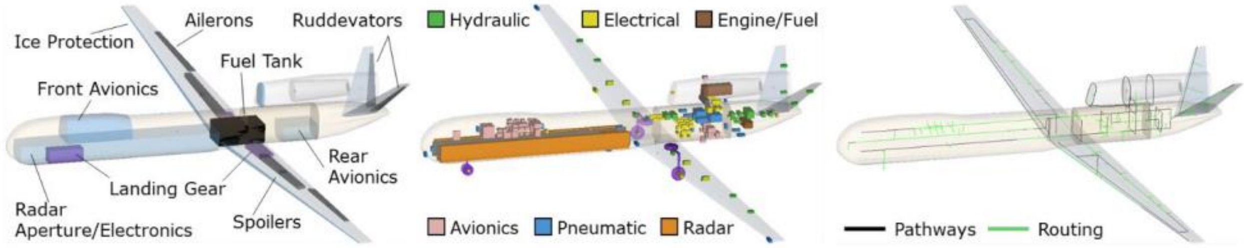


Figure 12 Example of compartments (Right), component placement (Center), and pathways/routing (Left)

In order to allow switching from one architecture to another as described in section 3.3, the concept of "assumption" was leveraged in SysArc. Assumptions allow collecting arbitrarily large groups of parameters, for which pre-defined value can be defined. Subsequently, all parameter values can be assigned at once by choosing the desired assumption set. For instance, all parameters controlling size, position and weight for all the FCS components were collected into an assumption to define the FCS architecture, as described in section 3.3. When switching between the four alternatives, all parameters of all components were changed accordingly. However, it should be noted that no simple ready-to-use way of adding and removing components was found, the replacement of some system components was emulated by assigning mathematically insignificant weight, size and power demand. Figure 13 provides a logical overview of the modelled systems.

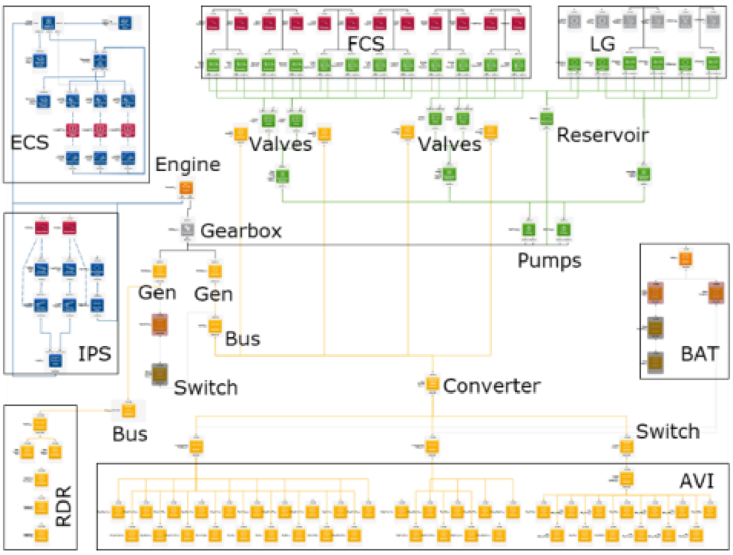


Figure 13 The onboard systems architectures

The model was used to analyze the impact on overall aircraft performance of choosing among the possible combination of assumptions. Within Pacelab APD/SysArc it is easy to define trade studies to explore such design spaces, further details presented in [21]. Per default, these trade studies use full-factorial sampling, which in the presented example yielded 18432 different designs. These have been analyzed taking advantage of the Pacelab Analysis Server, which allows off-loading the analysis burden on a computation server, where sampling points can be analyzed concurrently based on the number of available computation nodes. For the notional problem in this paper, a selection of outputs were defined, comprising for instance maximum take-off weight, operating empty weight, mission block fuel, turn performance at two different reference masses, patrol time, maximum ceiling, etc.

Figure 14 shows a snapshot of the interactive dashboard that was created in Microsoft Power BI to visualize and traverse the results from the study. The charts provided in the dashboard show:

i. Average patrol time changes when different onboard system architectures are chosen
ii. Turn performance worsen for increased required patrol time
iii. Block fuel increases for increased required patrol time
iv. Ramp weight decreases for increasing required patrol time (which is an unexpected and seemingly contraintuitive finding which will be discussed in section V)
v. Tables and lists to enable filtering of data with respect to engines, technologies and radar configurations.

In addition to charting the outputs of the trade study, the dashboard allows filtering and exploring the data, for instance by simply selecting a group of data. As an example, in Figure 15 once one technology and one radar alternative have been selected, the remaining charts are updated to reflect the same selection, so data sets are adjusted and synchronized automatically by the tool. The same type of customized data selection or filtering can be achieved by clicking on a data point or a bar in any plot available in the dashboard.

Figure 16 shows the comparison of turn performance, ramp and block fuel weight estimations in case the onboard systems architecture alternatives are replicated by using appropriate k-factors (top row) or actually modelled in SysArc (bottom row). It can be seen that the use of k-factors tends to have more optimistic predictions, due to the simplified approach that cannot capture as many effects and synergies between systems and aircraft performance.

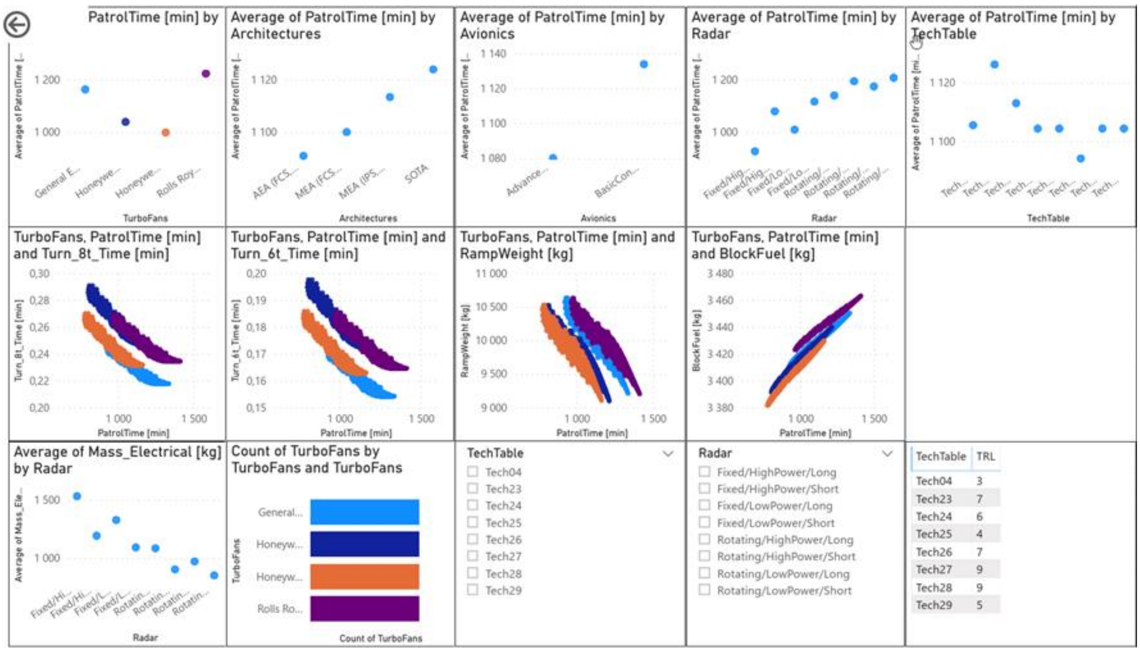


Figure 14 Project interactive dashboard for result exploration

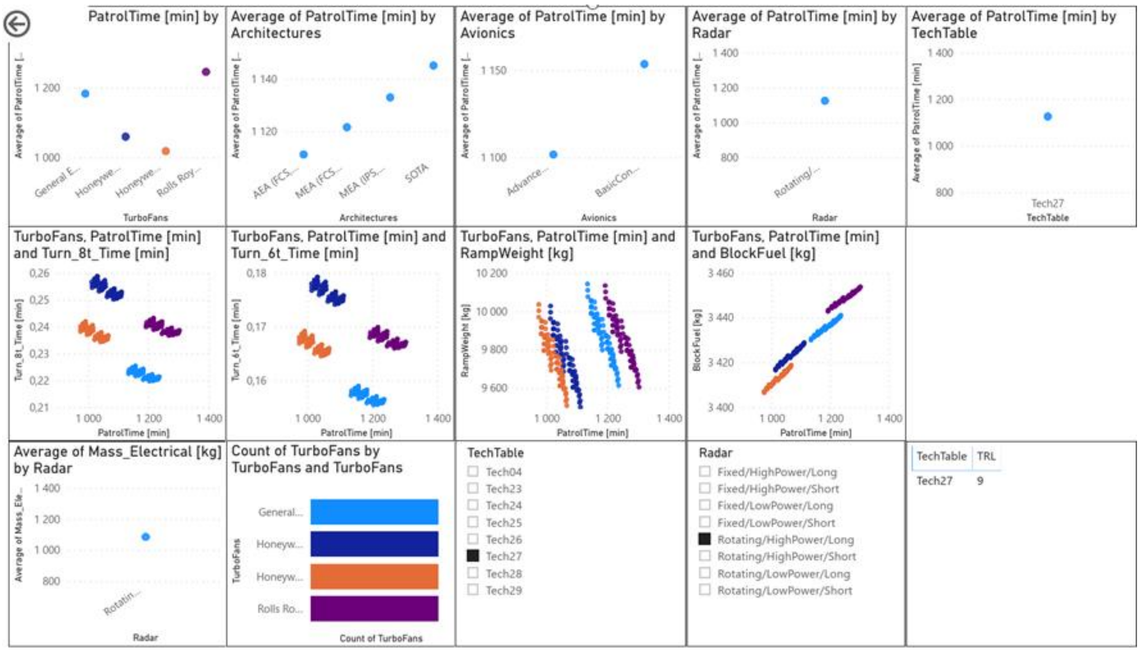


Figure 15 Data automatically filtered by choosing one technology and one radar alternative

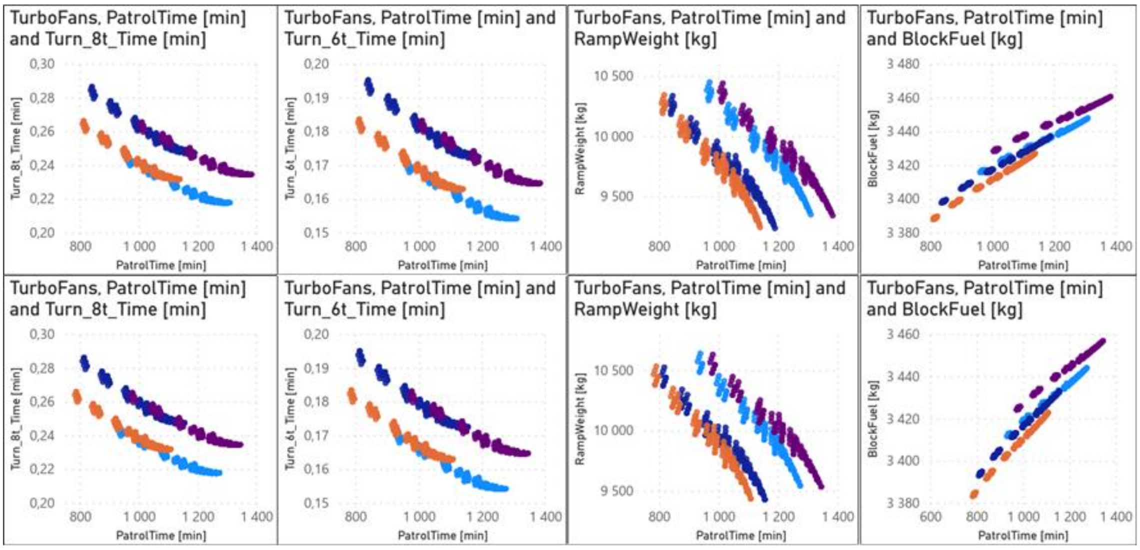


Figure 16 Comparison of performance metrics obtained from swapping architecture models (bottom row) to applying appropriate k-factors (top row)

6. Onboard Systems Sizing and Analysis

The final step of the study entailed an even more detailed analysis of at least one of the onboard systems architectures that had been considered. The goal was to capture the impact of the chosen architecture on the propulsion system and hence on aircraft performance. To this very aim, Pacelab SysArc offers an analysis function that starts from creating a input data set of all the system components loads during each step of the mission profile and then using them to assess the power off-take requirements on the propulsion system (see Figure 17).

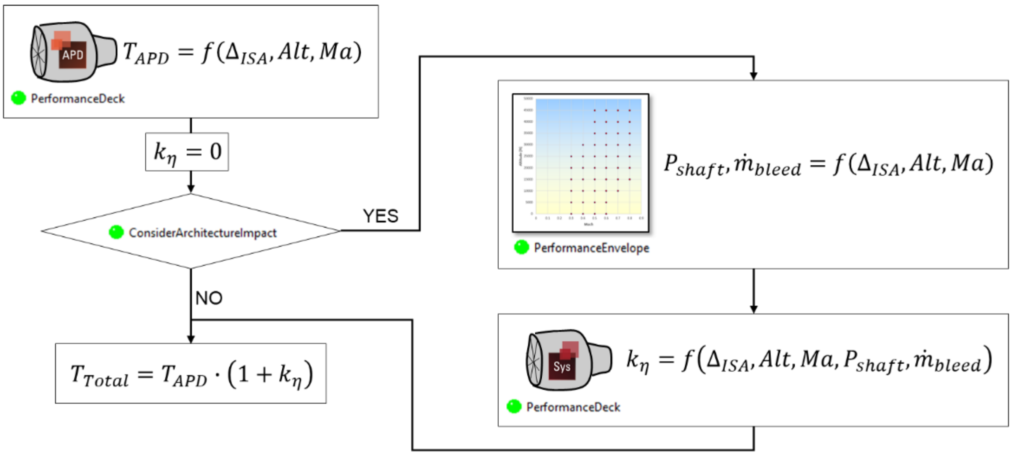


Figure 17 Assessment of onboard systems architecture choices on aircraft performance in Pacelab SysArc

In the process it also sizes the distribution elements (cables and pipes) to provide a more accurate prediction of the system weight. However, since this step is computationally heavier than all the others, it wasn't possible in the time-frame of the project to execute this detailed analysis on all the architectures that were considered in Step 2. Hence, after taking into account the availability of components for MEA/AEA solutions, mostly in relation to actuator size and weight in reference to the selected aircraft configuration, and including risk and TRL considerations, it was concluded that hydraulic-based FCS was the most suitable for Step 3.

Figure 18 gives an overview of all the elements that are included in the analysis. The level of detail at this stage is significantly higher than previously, which also explains why the computational burden didn't allow analyzing the same amount of combinations as in Step 2.

- 26 compartments (volumes, leading and trailing edge devices)
- 58 main system components (generators, busses, motors, switches …)
- 80 loads (50 electric, 23 hydraulic, 1 pneumatic, 6 mechanical)
- 191 distribution elements (78 cables, 83 pipes, 30 ducts)

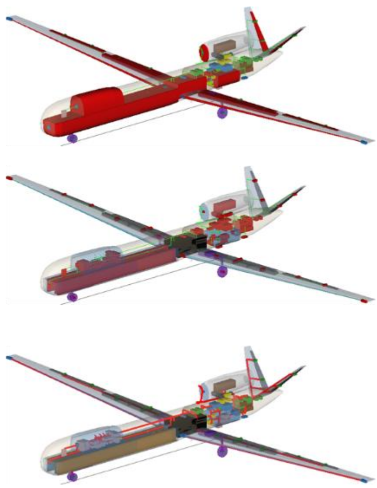


Figure 18 Elements of the detailed onboard system analysis of Step 3

For the architecture that was analyzed and sized it was possible to obtain more detailed mass information, as shown in Figure 19, where both predictions for piping length and weight are available. In this study, the predictions were based on default settings provided in the tool, so they shouldn't be considered as actual results for a real design effort. However, being able to define sizing rules and constraints, the predictions can be tuned to provide significant engineering indications for this early design stage.

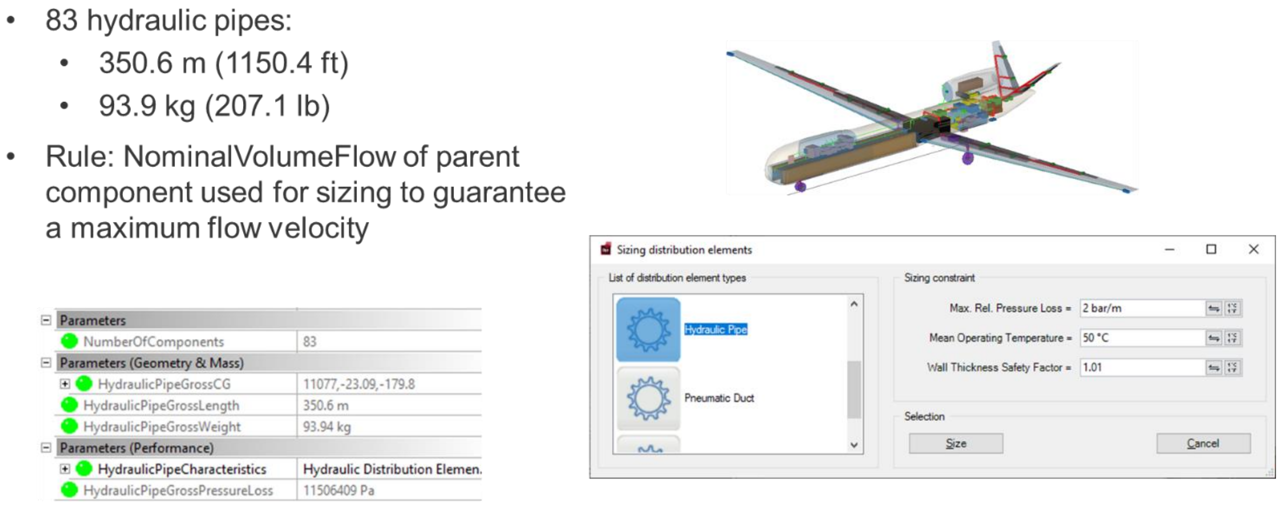


Figure 19 Sizing of hydraulic distribution elements

The end result of Step 3 was the estimation of overall aircraft performance, as shown in Table 2. It can be seen that there is indeed a difference in both weight estimation and aircraft performance. However, the true difference is significantly over-estimated in this study, due to a not realistic setting of the sizing constraints for the ducting of the ECS system. This led to an incorrect mass estimation which in turn over-penalized the aircraft mass and endurance. The inaccuracy was found too late to be corrected, but the table results still show clearly that it was possible to refine even further the predictions, all the way to each system component level and that these had an impact on the previously obtained performance estimations.

Table 2 Comparison of aircraft performance from Step 2 and Step 3

	APD	Using SysArc Masses	Account for power offtakes
TOW	8786 kg (19369 lb)	11559 kg (25482 lb)	11559 kg (25482 lb)
OEW	4919 kg (10833 lb)	7687 kg (16946 lb)	7687 kg (16946 lb)
Distance	4251 NM	2631 NM	2267 NM
Patrol	3651 NM	2031 NM	1667 NM

7. Conclusions

Using the design of a notional unmanned AEW/ISR platform as use case, the present paper builds on the findings from a number of previous projects and demonstrates how to trace the effects of technology choices at sub-system level all the way to aircraft performance and mission effectiveness metrics. Within the project, the newly introduced Pacelab tool framework was tested to identify its current modelling and analysis limitations. To this end, a parametric aircraft model was created. At vehicle level, it permitted to explore a multitude of aircraft configurations, including alternative propulsion systems that varied in size and power, but also from turbofan to turboprops. But the same model included also different radar sensors installations and different onboard systems architectures. To enable controlling and evaluating the changes, the concept of Assumptions was tested within the Pacelab environment and Pacelab Analysis Server was leveraged to offload the computational burden.

All in all, the project demonstrated that the framework permitted to traverse the design space from mission effectiveness metrics at SoS level, all the way to design choices and technology selections at component level within specific onboard system architectures. However, it was found that the parametric aircraft model, although fulfilling its purposes, it overly complicated and it would be recommendable to reduce the model complexity. This could be for instance achieved by creating different models, each with a smaller number of design and technology choices. In particular maintainability and transparency would benefit from such a simplification.

The project also helped identifying gaps in the system components database in Pacelab SysArc that will require addressing in the nearest future.

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9. Contact Author Email Address

Christopher Jouannet Christopher.jouannet@saabgroup.com

Kristian Amadori Kristian.amadori@saabgroup.com

Athanasios Papageorgiou Athanasios.papageorgiou@liu.se

Mathias Emeneth mathias.emeneth@pacelab.com

10. Copyright Statement

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