Development process for preliminary aircraft sizing methods with regard to new technologies

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Abstract

Purpose – The purpose of this study is to develop and describe a process which can be applied to develop new methods in the context of preliminary aircraft sizing in a successful and efficient way.

Design/methodology/approach – The tasks to development new aircraft sizing methods are systematically analyzed. In particular, repeating and nonrepeating tasks and common or unique tasks. Then ordered in a sequence and described generically.

Findings – A development process for new aircraft design methods which are necessary for new technologies or configurations is introduced and explained step by step.

Practical implications – Introducing the capability to deal with new technologies or configurations, aircraft design tools or aircraft concepts requires new sizing methods.

Originality/value – The paper presents a systematic approach which can be used to develop a great amount of new sizing methods with a comparable usability and quality standard in an efficient and effective way.

Keywords Aircraft design, Method development, Aircraft sizing, Process development, Technology implementation

Paper type Technical paper

1. Introduction

Reliable and reproducible analytical methods are essential throughout the preliminary aircraft design process. Unconventional configurations, new technologies in terms of aircraft structure, systems, propulsion and fuel require new estimation methods for the preliminary aircraft sizing. Moreover, with new technologies, completely new physical and geometrical parameters play a role in the design process. Existing statistical methods and tools cannot handle these parameters, neither predict nor determine them for the sizing process. Therefore, new calculation methods have to be developed to address these new aspects. Furthermore, developing new methods and techniques can help improve the efficiency of aircraft design. By implementing new methods, designers can reduce the time and effort required to design an aircraft while also improving the accuracy of the design. Method development can also lead to new innovations in aircraft design. By exploring new approaches and techniques, designers can come up with new ideas that can improve the performance, safety and reliability of aircraft. By streamlining the design process through the availability of methods, designers can save time and money, resulting in lower development costs.

Method development consists of three main stages:

1 Feasibility – where it is determined whether the method will work with the specific design task;
2 Development – where the method is established and optimized; and
3 Validation – where the optimized method is validated.

Furthermore, methods should have a reasonable degree of flexibility, built in during early development stages, to allow easy translation or transformation of the requirements and input parameters, thus potentially reducing time and costs throughout the aircraft sizing process. Successfully developed (and validated) analytical methods have the potential to reduce overall aircraft developing time.

In this work, a process for effective and efficient development of methods shall be introduced, ensuring quality, flexibility and robustness of preliminary aircraft design methods adapted to the new challenges in this field.

2. Definition of an aircraft design method

An aircraft design method is used to estimate or determine important parameters in aircraft sizing, such as geometrical data or mass data.

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The methods consider the relevant physical relationships and requirements, for example, from the certification regulations or for the mission. Aircraft design methods are mostly mathematical equations consisting of physical and geometrical parameters and factors for the purpose of scaling, differentiating between options or unit conversions. As an example, the below-stated equation (1) is a method to estimate the wing weight of a conventional airplane in an early stage of the aircraft design process (Raymer, 2012):

$$W_{wing} = 0.0051(W_{dg}N_z)^{0.557} S_W^{0.649} A^{0.5} (t/c)_{root}^{-0.4} (1+\lambda)^{0.1} * \cos(\Lambda)^{-1} S_{csw}^{0.1} \tag{1}$$

The wing weight of sailplanes of equation (2) (Gerard, 1998) can be calculated with a modified version of equation (1):

$$W_{wing} = 0.0038(W_0 N_z)^{1.0} S_W^{0.2} A^{0.3} (t/c)^{0.1} (1+\lambda)^{0.2} \tag{2}$$

Such modifications for different aircraft types need to be developed and emphasize the necessity of efficient method development processes.

3. Motivation and goals

Aircraft design is on the brink of another technological revolution. The urgent need for less climate-effective emissions in aviation paves the way for several key technologies (European Commission, 2012).

Especially for using energy sources like batteries, liquid hydrogen, methane or sustainable aviation fuel, which all have the potential to come from sustainable or renewable sources and therefore reduce emissions. New energy sources for aircraft require modified or even new propulsion systems and power trains. Moreover, there is a continuous introduction of new materials into aviation. New materials allow for completely new structural concepts or the possibility to add new functionalities to the structure. The development of aircraft systems is mainly driven to make aviation safer, for example, by reducing the workload of pilots in a more and more demanding airspace due to increasing air traffic. Further, systems development is driven to increase reliability and comfort. Anyhow completely new approaches in terms of aircraft propulsion and energy sources require completely new systems which have not been a part of aircraft before. The new technologies itself and their combinations are increasing the aircraft design space like rarely seen before. This leads to a demand for unconventional overall aircraft configurations which have better synergy potential and efficiency with the new technologies than the conventional tube and wing configuration. Finally, new business cases like urban air mobility can be developed from the newly available technologies, which further increase the design space and accelerate the dynamic of the technological revolution. Aircraft design methods involve multiple engineering disciplines, such as aerodynamics, structures, materials and propulsion. Research in aircraft design methods can explore ways to integrate these disciplines more effectively to optimize the design process and improve overall performance.

A multidisciplinary technological revolution generates significant changes in the aircraft design process. For example, the introduction of new parameters, i.e. the volumetric energy density of liquid hydrogen, which needs to be processed in the aircraft design process. Furthermore, new units like watts per cubic meter for the volumetric power density of batteries need to be treated, interpreted and transformed during aircraft sizing. Revolutionary technologies often come along with new dependencies which need to be considered. For example, the power density and energy density of batteries. The utilization of the full synergy potential of new technologies causes new interfaces of aircraft systems, for example, a combustion engine or gas turbine and generator interface. To deal with the new parameters and units, new references and assumptions from industries, so far not related to aircraft, need to be found, interpreted in terms of aviation circumstances, evaluated and integrated into the aircraft sizing process.

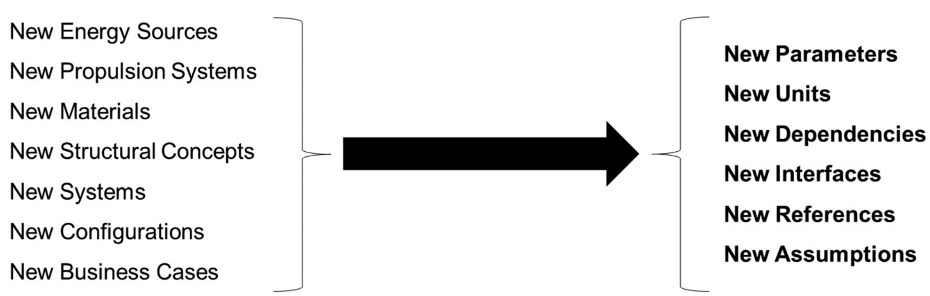
In summary, technology revolutions are having a major impact on aircraft design in two ways. On the one hand, the use of new technologies means that other physical laws and mathematical and physical relationships come into play, which means that many new parameters and units have to be considered. This is summarized in Figure 1.

On the other hand, there are more possible combinations of technologies during the design process, which must be determined and evaluated to find an optimal solution. This means quick and precise estimation methods are necessary throughout the preliminary aircraft design process to compare solutions and to make and support design decisions.

3.1 Why is a process for method development necessary?

In this work, a process which can be applied to develop aircraft sizing methods shall be introduced. For good reasons, processes

Figure 1 Impact of technology revolutions



Source: Figure by authors

are not very common in research because they tend to prevent creativity and the thinking out of the box, which is needed for a scientific problem-solving approach (Amabile, 1998).

Usually, processes are established in rather big companies to coordinate businesses, ensure the same quantity and quality of an output, and to make things understandable and workable for a wide spectrum of employees with different knowledge and experience. Anyhow, science becomes more and more commercialized nowadays which means more effectiveness and efficiency is needed (Funk, 2019). In addition, there are tendencies for a growing number of scientists working together since the projects get more complex and the timeframes more competitive (Funk, 2019). Processes help to make collaborative work more efficient and effective, and they can help to prevent doing the same things twice.

The following simplified example shows why a process for developing aircraft sizing methods can be useful.

Assuming that for a preliminary aircraft design, the following components have to be dimensioned:

- Overall aircraft configuration.
- Energy storage.
- Propulsion system.
- Structural concept.

If there is only one possible technology to use for each of these components, four methods are needed to define/dimension the components for the preliminary aircraft design (Figure 2).

If there are three different technologies available to use for each of the components in the example, the number of method permutations increases up to 81 to define/dimension the components. Due to the omnipresent dependencies in an aircraft design and to consider the effects of one technology to the other, each method for each technology needs at least an adaption to work in the context of the chosen set of technologies (Figure 3).

As it can be seen from the simple example, a very large number of methods needs to be developed or modified to make the new technologies usable in a preliminary aircraft design. A process can help to develop the methods efficiently on the one hand and to meet certain quality requirements on the other. In addition, a process also ensures a certain level of equivalence in the level of detail, precision and computational effort when using the method. Since it makes less sense to put in results of very rough estimation methods in a high-fidelity method to eventually use these results in another estimation method for a final component size. Finally, research in aircraft design methods can explore ways to automate and optimize the design process using tools such as artificial intelligence and machine learning. This can improve the efficiency and accuracy of the design process while reducing costs and time-to-market.

4. Definition of terms

Regarding aircraft design methods, it is important to be familiar with the definition of the following terms:

- robustness;
- flexibility; and
- resilience.

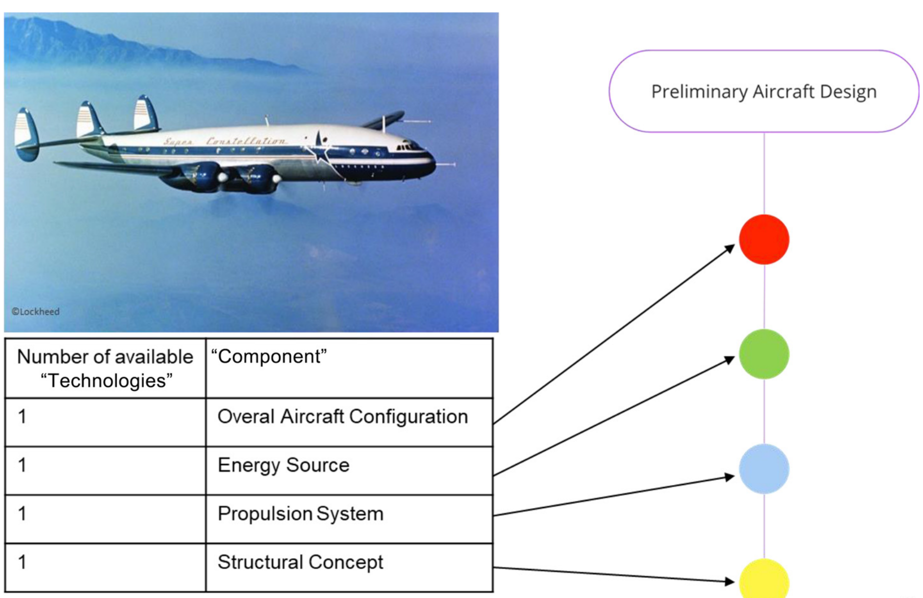
They are tools for minimizing risks for the quality of the output by considering how to deal with uncertainties in achieving a goal.

A robust system can accommodate uncertainty in a way that the initially desired output can still be generated or achieved. There will be no change of the track the system proceeds. It basically endures foreseen and unforeseen changes without adapting (Husdal, 2004).

A flexible system has the ability to react to uncertainty by changing the track which is proceeded in a preplanned manner to generate or achieve the initially desired output (Ku, 1995).

A resilient system allows pushbacks caused by uncertainty but it has the ability to recover quickly and survive the foreseen

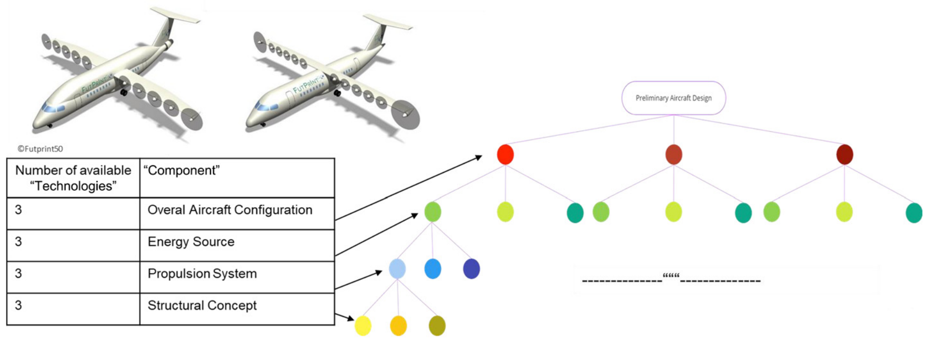
Figure 2 Number of methods depending on available technologies – past



Number of available “Technologies”	“Component”
1	Overal Aircraft Configuration
1	Energy Source
1	Propulsion System
1	Structural Concept

Source: Figure by authors

Figure 3 Number of methods depending on available technologies – nowadays



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and unforeseen events. The main difference to robustness is that not all types of disruptions are anticipated beforehand so that they are not affecting the system but to allow the disruption, go through it quickly and minimize their impact Slovic and Fischhoff, (1988). Figure 4 visualizes robustness, flexibility and resilience in an abstract way how a system behaves when it is affected by disruptions.

Processes can help to introduce robustness, flexibility and resilience to an aircraft design method by conducting some optimization which is explained later in this work.

5. What should a method be capable of?

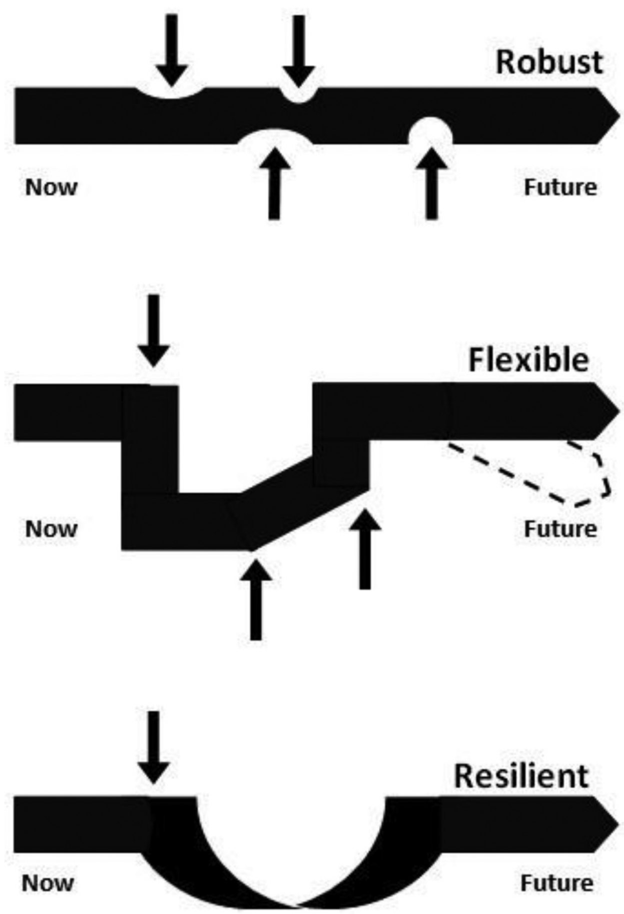
Effective aircraft design methods should be capable of producing a safe, reliable and efficient aircraft that meets the operational requirements while also considering environmental and human factors, as well as affordability and manufacturability. In addition to the calculation of variable aircraft parameters, design methods should also have other functions in aircraft preliminary design. They should show possibilities, for example, for reiterations and where it would make sense to increase the accuracy. Methods are also used to consolidate goals and simplify them if necessary.

By generating and evaluating different alternatives using methods, potential for improvement in the previous design can be uncovered. Methods should have an accuracy and level of detail appropriate to the level of sophistication of the aircraft design. The acceptance of a design method increases if it can be used without conversions of the units, which are customary in the industry for the respective parameters. The methods should also be based on the higher-level aircraft design process so that the most important input parameters of a method are already calculated in the previous steps of the iterative aircraft design process (Venners, 1998).

6. Method development process

The method development process is presented in the following chapters. A process transforms an input into an output. In the present case, the input is information and defined goals – the output, after carrying out the process steps, is a design method. The process is divided into various individual activities that can be grouped into the initial steps, technology investigation, build, validation, optimization and verification.

Figure 4 Visualization of robustness, flexibility and resilience



Source: Husdal (2004)

6.1 Initial steps

The first step in the method development process is to define use cases for the method to be developed. Use cases are a list of actions defining the interactions between an actor and a system to achieve a goal. Use cases are very helpful to identify, clarify and organize requirements because of the multidisciplinary perspective they are regarded with (Bittner and Spence, 2003).

For example, an aircraft engineer wants to use a sizing method for component or system development. A manager instead wants to use the method for reviews. Students want to use the method to understand, for example, parameter interconnections on different levels. All use cases should be stored in a use case book which can be used to transform and derive requirements for the method. The second activity in the initial steps is a trade-off whether a completely new method shall be developed or if a modification of an existing one might be suitable. In the process chart (Figure 5), this activity is followed by a decision node. Criteria to regard for this trade-off are, for example, the units, assumptions for the method, the limits of existing methods, the sensitivity to parameters and the physics in general. For the trade-off itself, various methods for decision-making with defined rules and processes exist. For example, the different variations of decision matrices. The trade-off and decision-making processes shall not be described further in this work. A good overview of decision-making is given in Slovic and Fischhoff (1988).

A method modification is suitable for technology evolutions or if a newer technology still has the same physical background. Usually, method modifications are done quicker due to the head start in terms of validation, verification and assumptions needed. Moreover, the whole mathematical structure of the equation does not need to be developed from scratch. Method modifications are usually done by introducing and quantifying calibration factors or scaling factors to an already existing equation to adapt for the technology evolution.

New methods are usually developed for technology revolutions, such as boundary layer ingesting propulsion, which means either large upgrades or completely new technologies that have not existed or been available for aircraft before. For new methods, a completely new mathematical structure based on the physical behavior needs to be developed. Moreover, new appropriate assumptions need to be found or transformed from other applications to the relevant scale to reduce the complexity and "costs" of the method. Costs can be the number of parameters in the method or the computing power needed to apply and solve. In the work of Seitz *et al.* (Seitz *et al.*, 2021) both method modification and new methods have been developed in a great number to conduct their proof of concept study for fuselage boundary layer ingesting propulsion.

6.2 Technology investigation

The next step in the process, the technology investigation, involves the process of understanding, analyzing and evaluating technological systems. The goal of this process step is to describe a mathematical-physical model of the technology. This is often done by laboratory investigations with computer-aided tools or test equipment. The process flow chart and the actions included in this step are stated in Figure 6.

Before starting the modeling, the quality in terms of accuracy, which shall be achieved with the method, needs to be defined by choosing the level of detail to which the technology is investigated. After that, a parameter sensitivity study needs to be done to identify the primary influencing physical parameters of the new technology. The studies of the technology are then done with various tools depending on the technology but with special regard to the most sensitive parameters in the modeling of the technology. This plays a major role if a more simpler replacement model is used to investigate the technology more generically.

The tools for the technology investigation must be capable to collect the relevant data from modifications of the most sensitive parameters of the technology. Depending on the parameter, these tools can be computer-aided design (CAD), computational fluid dynamics (CFD), finite elements method, wind tunnel tests, scaled demonstrators or even realistic demonstrators, which are used to measure the relevant parameters and collect data. In the following, the technology investigation is explained in detail with a morphing wing as an example for the revolutionary technology, which shall be investigated to find design methods for the wing mass, lift and drag estimations and power/energy requirements of the morphing system. For further background about morphing wings, the work of Barbarino *et al.* (2011) is recommended which gives an extended overview about the technology. A tool for the numerical calculation of flows is used to investigate the lift and drag behavior of a morphing wing. If there is a need for high accuracy of the method, CFD tools should be used for the investigation. Flow solvers based on vortex lattice methods can also be used for lower accuracy. This is followed by the modeling of an object that can depict the technical properties of the morphing wing. For example, the ability to change the airfoil camber, thickness, location of maximum thickness or the

Figure 5 Initial steps process chart

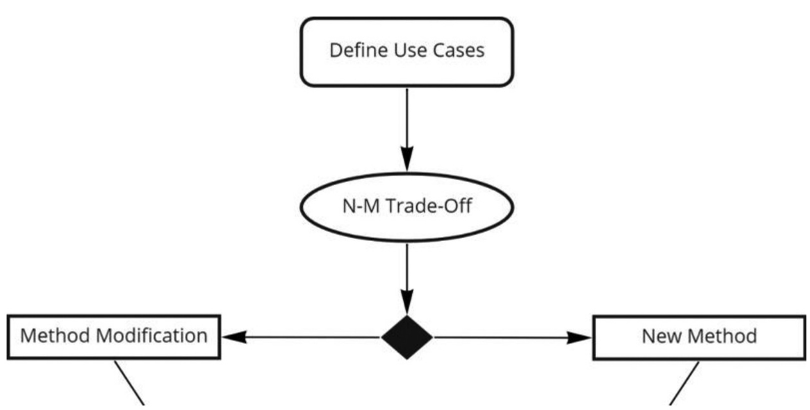


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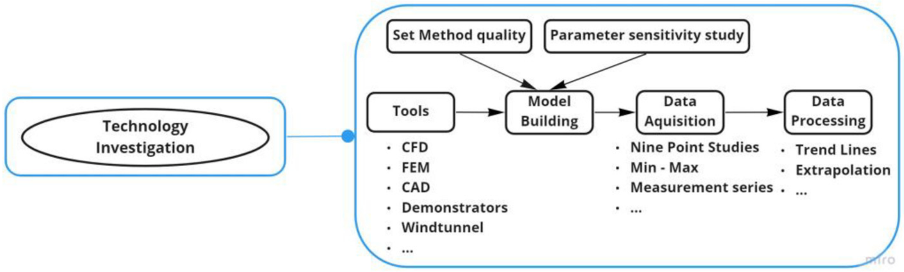
Figure 6 Technology investigation process chart



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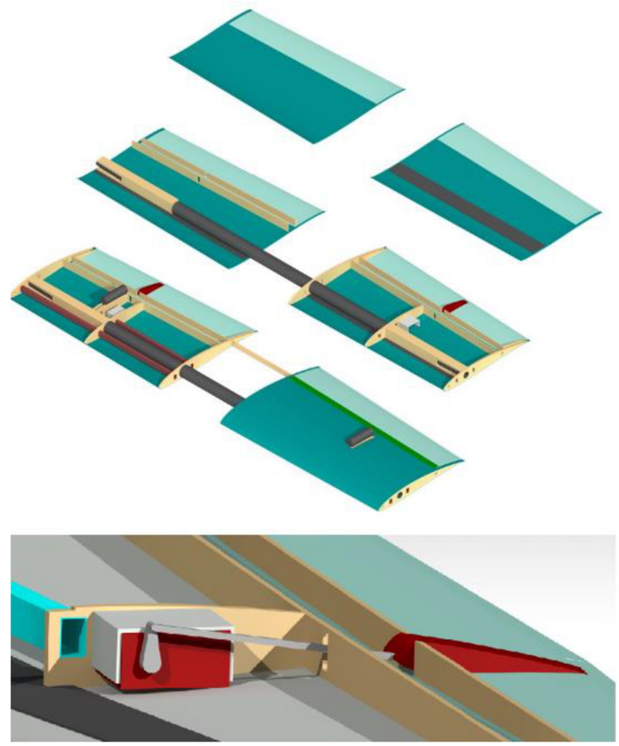
nose radius. The maximum airfoil change achieved with the morphing wing concept serves as a limit. The technology is then measured, i.e. the effects of these properties on the parameters lift and drag are examined, considering the loss of mass during flight or extreme take-off and landing conditions (hot and high). This allows further knowledge to be gained, for example, on the effects of the technology on the required wing area, from which a modification or new method for determining the wing area when using morphing wing technology can be derived. After examining the model, a defined data acquisition for a reference case takes place, i.e. the effects on lift and drag of the morphing wing technology are quantified for a specific aircraft type with regard to size, flight altitude and flight speeds. Data acquisition can be extended further using certain techniques such as nine-point studies (Jenkinson and Marchman, 2003) or examining a series of reference cases. As a result, the flexibility and robustness of the new method can be determined later in the process and, if necessary, increased. In the case of a high computing effort for the consideration of further reference cases, an extended data basis can be created with methods for processing data such as extrapolation (Brezinski and Redivo Zaglia, 1991), trend lines or rising or falling channels of data.

CAD software can be used to derive a mass estimation method for a wing using morphing wing technology. For this purpose, a wing that is as realistic as possible is modeled with the technology. It does not depend on details such as the exact mapping and connection of mechanical components but on the most realistic possible distribution and mass allocation of simplified replacement components with which the wing model is built. In Figure 7, a simplified wing model to derive a mass estimation method can be seen.

The mass of the wing can then be determined in the CAD tool by assigning material parameters or masses. It is not always necessary to construct a complete model of the component to be examined (here, the wing) with the new technology. Rather, a generic design can be modeled and measured for a representative portion of the wing. For the collection of the data, from which the method is then to be derived, the determined parameters from the construction are then scaled to the size of the component (here wing) that is actually to be examined for the method development. As described before, data processing methods, as outlined in Hadley (Wickham, 2014), can be used to handle the data and increase the database

Figure 7 Wing model with simplified components



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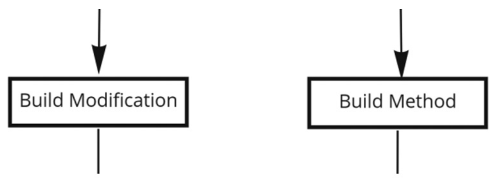
necessary for the method development and to increase robustness and flexibility.

To deriving a method to estimate the power and energy demand of the system which drives the morphing wing, yet again, data needs to be collected. This can be done with a simulation tool for systems and their behavior, i.e. AMEsim (Simcenter Amesim). The main focus is to find an adequate substitute for the system with less single components to reduce complexity and computing time.

6.3 Method building

As seen in the process chart (Figure 8), the next step of the method development process is the building of a method modification or a new method. This is done from the data acquired during the technology investigation.

Figure 8 Method building process chart



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When developing a new method, the simplest possible equation with which the collected data can be reproduced shall be found. In the case of a new method, building the introduction of assumptions or absolute parameters instead of variables might be necessary to reduce complexity.

In the case of a method modification, factors for the existing equation are introduced to better match and reproduce the data sample of the technology investigation. Moreover, it needs to be checked if the former assumptions of the existing method are still valid.

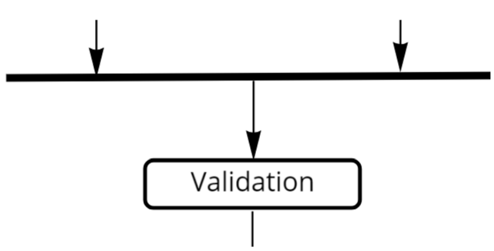
Finally, the scope of the method needs to be identified. This includes identifying the intended use of the aircraft, such as commercial or military, and the desired performance characteristics, such as speed, range, payload capacity and fuel efficiency. The scope of the design method should also outline the steps involved in the design process. Furthermore, setting limitations for the cases the method cannot reproduce the acquired data anymore must be identified and considered.

6.4 Method validation

After building or modifying the new method, it needs to be validated (Figure 9). Validation is the process of evaluating the performance and accuracy of the method using a separate set of data that was not used during the method development (FDA, 2011). The goal of validation is to ensure that the model or system is reliable and generalizable and can be used to make accurate predictions or decisions on new tasks. Validation is a crucial step in the development and evaluation of methods. It helps to ensure that the results obtained from the model or system are robust, accurate and applicable to new data. Validation is also the provision of evidence that a process or system, in the case here an aircraft design method, continuously produces a product that meets the previously defined specifications and quality characteristics.

This means that a comparison must be made with the use-cases and requirements for the method defined at the beginning of the process. Therefore, the validation proofs that the developed method technically fulfills the scope which was intended to cover. Furthermore, the limits of the method need to be validated with some test cases near the limits of the method. The use of the method in those test cases can uncover some potential for optimization of the method, which leads to the next process step.

Figure 9 Method validation process chart



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6.5 Method optimization

The penultimate step of the process is the optimization of the method. So far, the process was quite static, with one step leading to the other. There are several goals of the optimization, and most of them are not correlating. This means the better one goal is reached, the worse other goals might be reached.

The major goals of optimization are as follows:

- increasing the accuracy of the method;
- extending the possible scope where the method gives a solution;
- increasing of real-world behavior of the technology; and
- reducing complexity.

The noncorrelating behavior requires an iterative loop of the optimization to get a well-balanced method in terms of the major goals and also in terms of robustness, flexibility and resilience (Figure 10).

Continuous development is a key to resilience. While tried and tested methods can be the best, in many cases adding backup features can support solving the sizing tasks in difficult conditions such as the unavailability of adequate references for assumptions.

A continuous development in terms of simplifications and transparency of how the method has been developed creates better process knowledge of how to use the method. This enables more people to be familiar and work with the method which helps reskilling resources quickly in cases of unforeseen changes, hence increasing resilience. Adding parameters with less sensitivity on the calculated output increases real-world behavior.

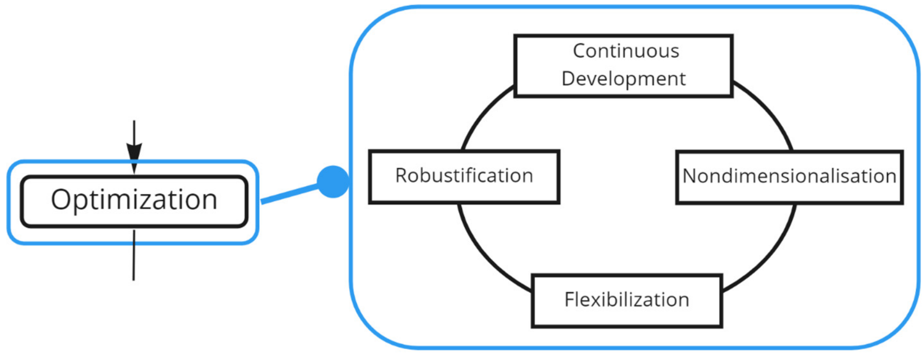
Nondimensionalization means replacing parameters in the method by others without a physical unit. For example, lift or moment coefficients or the Reynolds number. This minimizes the potential for errors caused by using wrong physical units.

For a higher flexibility of the method, parameter substitutions can be introduced which means replacing parameters by an equation or set of different parameters with the same result. For example, replacing the Reynolds number by the respective equation leads to a higher flexibility since more parameters can be used and variated for a specific design task solved with the method.

With method derivatives, the flexibility can also be increased which means slightly different equations of the method for a specific parameter range of the most sensitive parameter in the method. For example, an equation for small aspect ratios and one slightly different for high aspect ratios.

Parameter assumptions which are part of the method have a high potential for uncertainty. Therefore, robustification means to take care of these assumptions by making them more precise or reducing the amount of assumptions necessary. In general, reducing the number of parameters by discarding the ones with little or no effect decreases uncertainty and therefore increases robustness of the method. Moreover, unstable parameters

Figure 10 Method optimization process flow chart



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within the method, which are defined by only a minimum of experimental data should be minimized for a robust aircraft design method.

6.6 Method verification

The final step in the process is the method verification which means an establishment of the correctness of the method to create acceptance and release the method. The verification is the final review and approval for the method and should not be done by the developers themselves (Figure 11).

Verification can be done by comparing the results with a conventional reference where the new technology is not used, but it can be seen if the change made by the technology and determined by the new methods are plausible. If there are references available where the technology is used, it can be checked if the new method delivers these reference results which are realistic. Finally, an inspection and review by experts can also give an approval for the new aircraft design method.

6.7 Final method development process

The single process activities, so far explained, shall finally be put together as a complete process (Figure 12). A path from the optimization activities leads back to the method building/modification to make sure the optimization is done accordingly the method building requirements and standards. The changed design method also needs to be validated again before going into another optimization loop or directly to the verification.

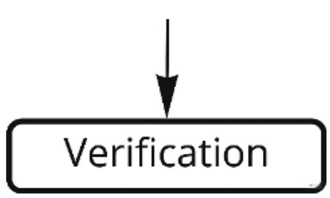
7. Organizing methods in a knowledge base

As a final process step in method development, the transfer to a method database should take place. Databases are knowledge and experience-securing tools that are used to make structured amounts of information quickly accessible.

A database helps establish a common knowledge base for all those involved and facilitates the dissemination of information. Setting up a knowledge base to archive and conserve the design methods, their constraints and the data they have been derived from is helpful to keep an overview of the already developed method. Further method optimizations or modifications can be made quicker with the data of the technology investigation already available and open for further investigations. A knowledge base is a digital repository of information, data and knowledge that is organized, stored and searchable for easy access and retrieval. It is designed to capture and organize knowledge in a way that can be easily shared and reused (Li *et al.*, 2019).

The tool digital data communication (Williams and Vukelich, 1979) is widely used in the aerospace industry as a knowledge base, particularly for preliminary design studies and for estimating the performance of existing aircraft. The Engineering Sciences Data Unit (ESDU) provides verified engineering design methods, data and software tools to support the aerospace, defense and related industries as a knowledge base ESDU provides a wide range of engineering information and tools, including handbooks, technical reports and software that are designed to help engineers and designers make informed decisions during the design process.

Figure 11 Verification process chart



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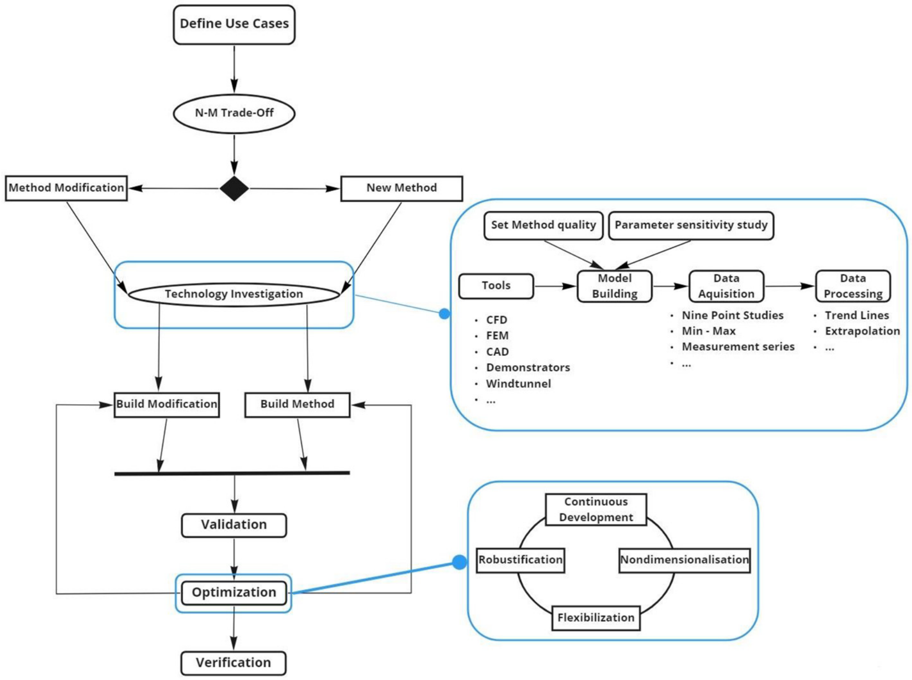
8. Validation of the method development process

Validating the method development process involves ensuring that the process itself is effective, reliable and capable of producing the desired outcome. Within the UNIversity Conceptual Aircraft Design and Optimization project (UNICADO), a project within the Federal Aeronautical Research Program (LuFo VI-1) (DLR, 2020), several aircraft sizing methods have been developed according to the development process. UNICADO is an aircraft design and optimization software which is currently extended to offer the possibility to design and size blended wing body aircraft and hydrogen aircraft. Dealing with these new technologies and configurations, new sizing methods for the mass calculations (wing mass, tank mass, MTOM, OME, etc.) have already been developed according to the process and have been implemented in the UNICADO software. Due to the increased amount of requirements and necessary standards to fit the sizing methods in

Figure 12 Method development process chart



Source: Figure by authors

the software framework, the presented method development process showed effectiveness and reliability.

Moreover, a validated and verified aircraft sizing method which is developed according to the suggested method development process can be regarded as validation of the process itself since the output of the process fulfills the initial method objectives and requirements.

9. Conclusion

In this work, a process was presented with which new methods for aircraft design can be developed. The technological developments of the past few years, especially with regard to electric drives and alternative energy sources, are about to change aviation. However, such technological revolutions always bring with them a certain degree of uncertainty since there are few or no comparison/reference objects.

In addition, there are new physical relationships and dependencies that cause further uncertainties since their interdisciplinary effects are not yet fully understood, and there is no fully thought-out standard. In order for the new technologies to be available for aircraft design, methods must be developed that bring the new technologies into a mathematical–physical relationship with the requirements of the aircraft design.

Even if processes somewhat limit the creativity in method development, they still help to minimize the effects of the aforementioned uncertainties and to manage the high demand for new methods effectively and efficiently. The process presented is a guideline for method development to build a common understanding so that work can be done collaboratively and to meet certain requirements such as robustness, flexibility, validation and verification. The detailed investigations from which the data for the method development emerge differ greatly depending on the technology and are not explained in more detail in this work. Likewise, how complex the new technologies are considered, e.g. whether only a method for the aerodynamic effects of the technology or also a method for the effects on the mass or the power requirement should be developed, is at the discretion of the conducting party. Depending on the availability, skills and preferences for certain tools, the data output and the time required is highly dependent on the developer.

The LuFo VI-1 project UNICADO which is currently highly in need for new aircraft design methods is used for validation and optimization of the presented aircraft sizing method development process. The process shows strong and reliable outputs in the applied science of the aircraft design software development.

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