DOES THE AIR TRANSPORT MARKET NEED "UNCONVENTIONAL AIRCRAFT CONFIGURATIONS"?

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Abstract

In the past the engineering spirit and imagination was the driver for new aircraft developments, combined with new technologies, which have led to new aircraft programmes, each new programme showing at least a 10% economical benefit to its competing flying aircraft. During the last two decades technological progress seems to have decelerated or – in other words - the aircraft industry has achieved a high technical standard and has become a mature industry.

There are however a lot of new technical concepts like Flying Wing, Tandem Wing, Three Surface Aircraft Concepts etc. where the inventors claim enormous advantages compared to today's conventional airliners. But does the market need these new vehicles?

The Institute of Aeronautical Engineering at the Technische Universität München has initiated a scenario process with students and experts from industry to establish and analyse a series of air transport scenarios for the year 2030 out of which the market possibilities for future civil transport aircraft have been identified.

In all scenarios, most of the market requirements could be fulfilled by conventional configurations, but sometimes with some stringent requirements like for example noise requirements. Some of the requirements however lead to configurations in unconventional layout.

In a next step these unconventional configurations have been further analysed with respect to additional needs in new technologies, development methods and tools and operational requirements. Based on these additional demands from all scenarios, a fairly robust technology strategy can be developed.

The paper will shortly describe the scenario process, will develop the methodology to define the robust technology strategy and will use a typical, possible scenario to demonstrate and validate the proposed method.

1 Introduction

In the past the engineering spirit and imagination was the driver for new aircraft developments, combined with the introduction of new technologies, which had led to new aircraft programmes showing at least a 10% economical benefit to its competing aircraft flying already. During the last two decades technological progress seems to have decelerated. But it could also be argued, that the commercial aircraft industry has achieved a high and efficient technical standard and has become a technically mature industry. A typical sign of a mature industry is the fact that market forces are dominant to technological progress and innovation. Another fact which supports the thesis of a mature industry can be the fact, that most of the aircraft flying today are looking more or less the same. The payload is transported in a circular cross fuselage, the necessary aerodynamic lift is generated by a pair of wings which are fixed in the middle of the lower part of the fuselage, the wings are moderately swept, aircraft control is assured by the empennage and their control surfaces at the end of the fuselage, the main undercarriage is fixed to the wing and can be retracted into the fuselage, the engines are installed symmetrically under the wings. There are only few exceptions to this configuration, which has proven to be successful. If we compare the latest designs from Airbus and Boeing, i.e. the A330 versus the B777, or the A321 vs. the B757, it is difficult even for specialists, to differentiate which type of aircraft it might be. It can be concluded that today's aircraft look all very similar and even the new concept for a 500-seater from Airbus, the A380, has selected this configuration concept. This configuration is called the "Conventional Configuration" (CC), which has evolved over the past decades as the optimal design for an efficient economical passenger transport aircraft.

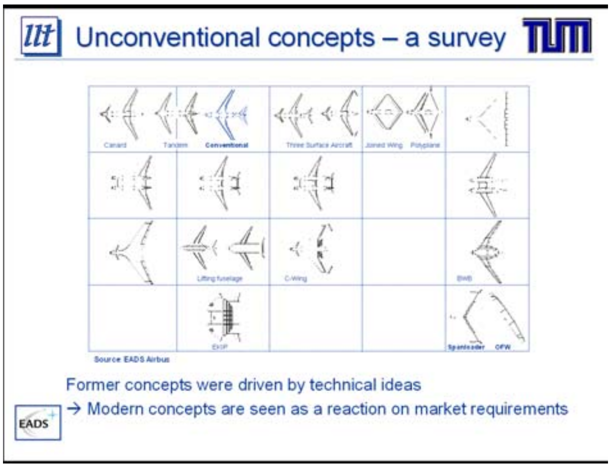

Figure 1

Nevertheless there are a lot of good ideas for new aircraft configurations (see fig.1 and [1]), which look fairly unconventional compared to the flying aircraft today. The so called "Unconventional configurations" are designed and promoted by various highly qualified engineers, who all claim, that their configurations have a lot of specific advantages compared to the conventional designs.

There is however no consistent view, which of these "Unconventional Configurations (UcC) may be viable for a certain task and/or market segment and which not. There are normally two camps. The engineers from the aeronautical industry, who all have a lot of good arguments, why these UcC can not work and a lot of "killer arguments" against the UcC are provided such as: emergency evacuation will never be possible; airport infrastructure will not fit; the aerodynamic interference from a moveable foreplane will be counterproductive to the main wing etc., etc. The engineers from the scientific community have a lot of positive arguments in favour for the UcC, such as: a better aerodynamic L/D; better structural concept with a weight saving potential; less trim drag and the strong argument, that the industry is becoming far too conservative and new ideas are no longer investigated.

Figure 2

The Institute of Aeronautical Engineering in Munich follows and has accepted a change in paradigm and proposes a new system approach, where the operating environment and the market will define the aircraft need and hence the necessary technology level (see fig 2) instead of the technical and technological driven approach.

Being conscious, that market forces will decide in the future, the need to start from a market perspective becomes obvious. The time focus for the market scenario should be rather long (30 years) in order to take into account the long large development cycles in the aeronautical industry. Therefore a market scenario for the year 2030 and later (called 2030+) was chosen and the best methods to be used were investigated.

The use of the scenario methodology has the big advantage that very different views and pictures of the future will be developed, but always a clear path is outlined, how to get from today into this particular scenario. In addition the participants in such a process learn a lot about the more and less important parameters in a scenario process, they get a better understanding, which parameters can be influenced by an actor in the complex market and which are driven by market dynamics and can not be influenced directly.

2. Scenario technique and process in air transport

The use of scenarios to look into the future and develop several different views of the future is a well established tool and methodology for better understanding future market requirements. Several references are describing the scenario methodology [2] – [5] (see fig. 3).

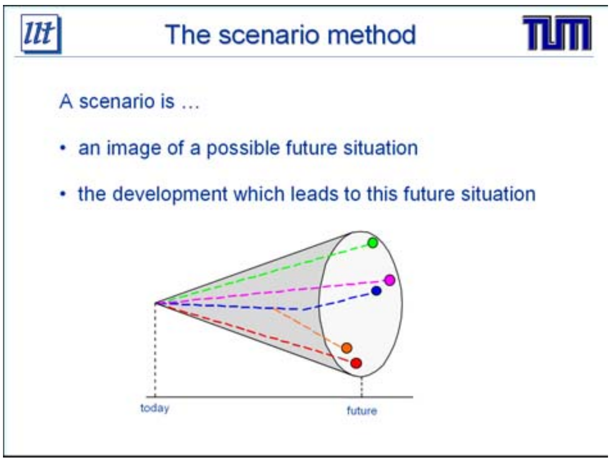

Figure 3

It should however be mentioned, that the best understanding about the methodology and the usefulness of scenarios is in participating directly in a scenario process and discuss and elaborate together with other specialists the future market environment. As part of the educational training programme in Aeronautics, the Institute of Aeronautical Engineering is offering each year a specific course in Scenario technique to their students. Each year the subject is changing and normally, the subjects are selected together with an industry partner who provides the thematic and timely focus and supports the course with some specialists from industry. 5 different scenario workshops have been conducted up to now with a high appreciation from industry about the good contribution and motivation of the students and the good quality of the results [6],[7],[8].

The use of scenarios in the conceptual aircraft design focuses in three different aspects [9]. The results of the scenario process are used to develop from the future market environment a technical product idea and determine from them design requirements. Another possibility is the identification of mandatory and/ or useful technologies which are mandatory or supportive for the new configurational concept. The third aspect is related to the development of evaluation criteria. These aspects are outlined in ref. [8],[9] and [10]. The five basic steps of the scenario method are outlined in fig. 4.

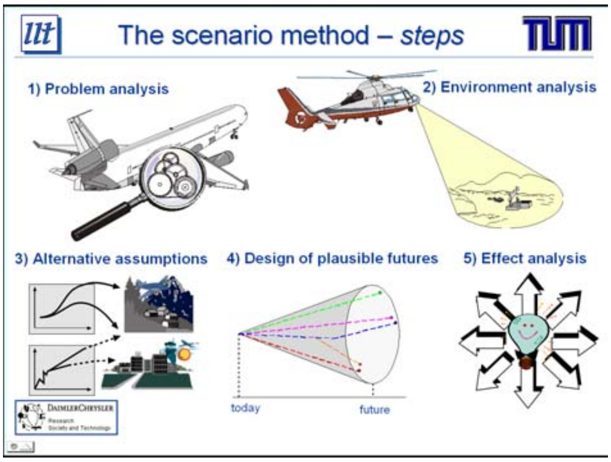

Figure 4

Figure 5

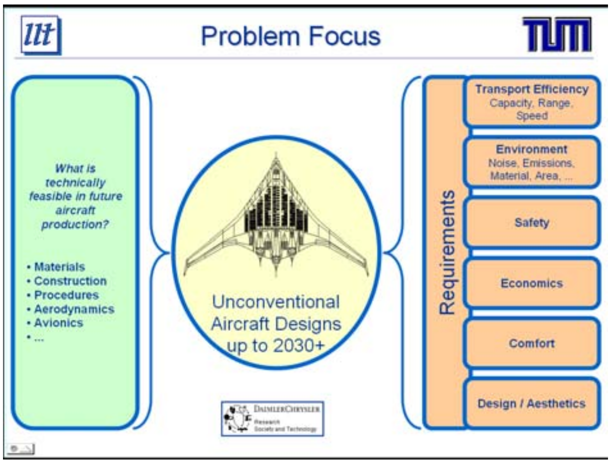

Figure 6

3 The scenario process " Unconventional Aircraft Configurations 2030+"

For this project, a time horizon of 30 years has been chosen. If we bare in mind, that the configuration concept of the future A330/A340 programme from Airbus has been developed already in 1976 and certification has started in 1992, this indicates that new concepts have to be developed fairly early before any chance of realisation will occur. On the other hand, a time horizon of 30 years is fairly long for a scenario process and all results are coupled with a very large uncertainty and risk. Therefore the framework had to be defined before. The following key questions had to be answered before the process (see fig. 5).

From which conditions and requirements in the global air transport business up to the year 2030 will it depend that a future aircraft concept will be of a conventional or can be of an unconventional type (see fig.6)?

How could the spectrum of requirements develop in alternative scenarios?

First of all, the air transport system of today had to be carefully analysed to better understand the interrelationship of all participating partners. On the aircraft industry side factors like ability and willingness to invest, time of development, development cost, accessibility to basic technologies and airline structure had to be investigated. These factors had to be analysed and structured and the most important had been defined.

For these factors a careful description and reasonable assumptions for the probable future development had to be defined. An analysis of the dependency between the different assumptions builds the frame for the different scenarios. Out of these multiple scenarios, some (in the a.m. scenario process only three) typical and different scenarios had to be selected.

All three scenarios have been outlined in detail in [8], but are described with their main features in fig. 7. In this paper we will only show the principle procedure in the context of one scenario, which was called "A Flying World" and shows a fairly positive environment for the aeronautical industry.

Fig. 8 indicates in a cartoon, how the students have characterised the scenario of a "Flying World".

Fig. 9 gives more details about this scenario. In terms of society, economy and politics, the scenario A is described by high mobility, ecological sensibility and increasing depletion of oil resources, leading to high fuel prices and the search for alternative energies. In the airline world, main aspects are strong airline competition, growing airspace capacity with more point to point connections and a sound airline economical basis, where small airlines prove to be more flexible than big alliances. With regard to aircraft manufacturers and their products, many new aircrafts with new technologies will appear on the market, rising development costs and time can be partly compensated with modern tools and methods, and smaller manufacturers can overcome the existing duopoly from Airbus and Boeing.

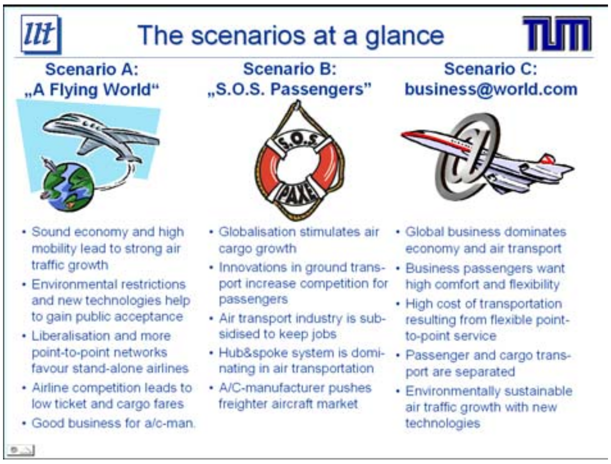

Figure 7

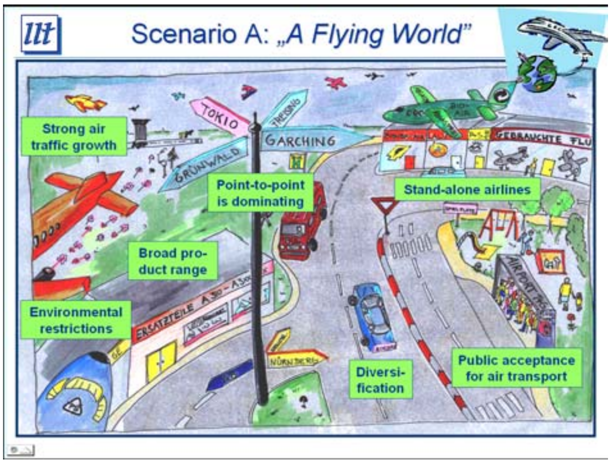

Figure 8

Figure 9

For each of these scenarios a set of requirements for aircraft configurations has been developed. These "Standard and requirement" documents are per se neutral with respect to a configuration. But in these documents, unconventional demands are included which will influence and have impact on today's configuration and also those requirements which only can be met by new and unconventional designs.

The deduced configurations are in so far not pushed by their technical concept but pulled by market needs and requirements.
These requirements are derived by different actors in the air transport scene as airlines , passengers, airports, air traffic control, from the regulating bodies and political demands and conditions and finally from the aeronautical industry with respect to economy and product strategy.

For each scenario a list of criteria had been formulated with regard to passenger and cargo transport like

- transport performance, range, capacity, speed;
- economy for the airline
- safety for passengers and cargo
- environmental aspects like noise, emissions, recyclable materials, etc.
- requirements to turnaround, development potential and image

A specific payload range diagram had been generated for each scenario showing all interesting areas for intra- and intercontinental ranges (fig. 10). After these general considerations a requirement document has been generated for each aircraft category, deduced strictly from market needs (Fig. 11). Later on configuration proposals have been developed for each requirements document. First it was investigated, whether the requirements could be reasonably met by conventional configurations. If this was not possible unconventional solutions and appropriate configurations have been considered and discussed. Most of the requirement profiles could be fulfilled by conventional configurations, which is fairly obvious. However some requirements could only be met by unconventional configurations.

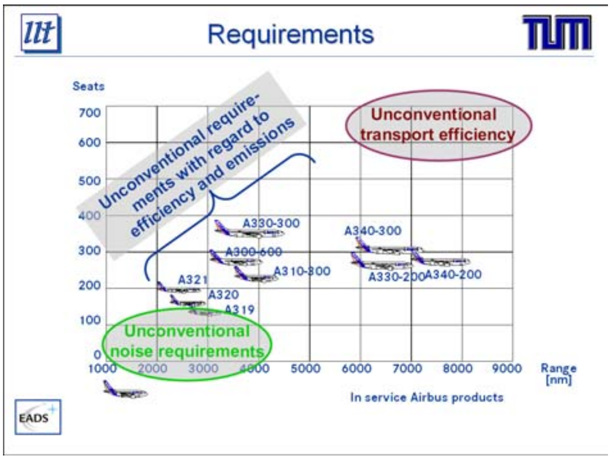

Figure 10

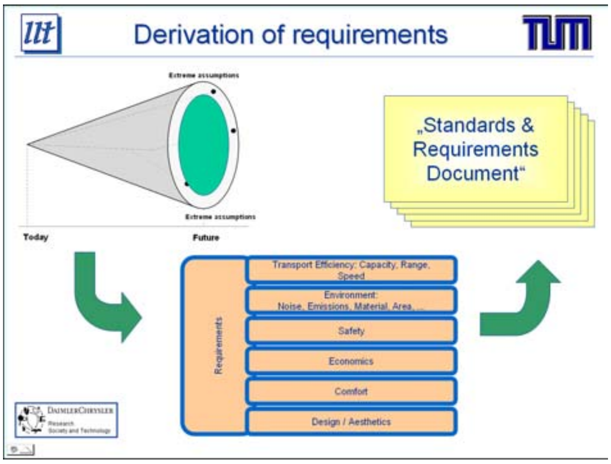

Figure 11

4 Definition of a robust strategy

The next step in the process is the selection of different “unconventional configurations” out of the different scenarios. For each configuration, the standard and requirement documentation exists and has to be properly described.

Figure 12 gives a general overview of this step. In the above mentioned scenario process, six possible new configurations have been identified, where unconventional features could be important for the success of the concept. Fig. 13 shows a typical example of the market applications for scenario A . It should be mentioned, that the requirements for the new freighter aircraft in scenario A will not automatically lead to a “Blended-Wing-Body” configuration. But at least the need for a fast Turnaround time leads to a new concept with nose- or rear-loading door possibilities [15].

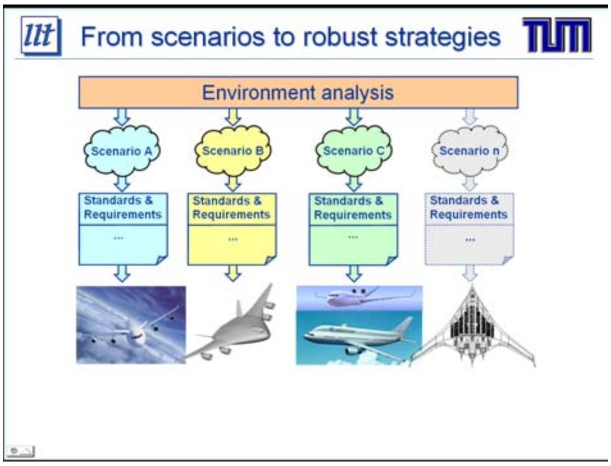

Figure 12

In Scenario A the need for two new concepts has been identified i.e. the “Green SR People Mover” and the “BWB Freighter family”. Under the so called “green aircraft” two different aspects are combined, i.e. the “low noise aircraft” and the “alternative fuel aircraft”.

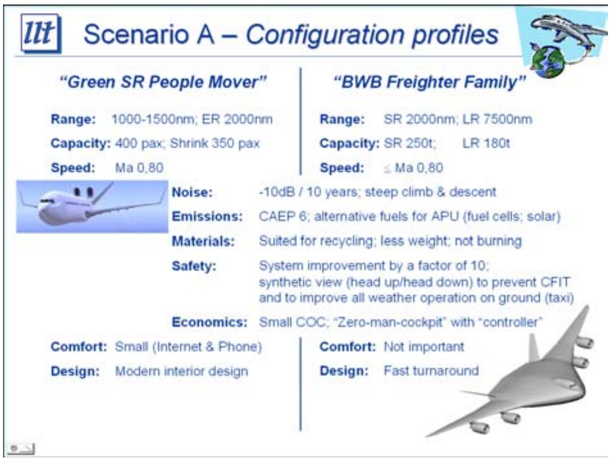

Figure 13

These requirements or configuration profiles are answers to different possible future developments. But as it is unclear which scenario will happen or is more likely to happen, a common set of requirements out of different scenarios has to be derived. The goal for a robust strategy is achieved when out of a variety of scenarios common requirements can be obtained which lead then to configurations which are not optimal for individual scenarios, but fairly robust and the best compromise to meet the needs for a broad range of scenarios.

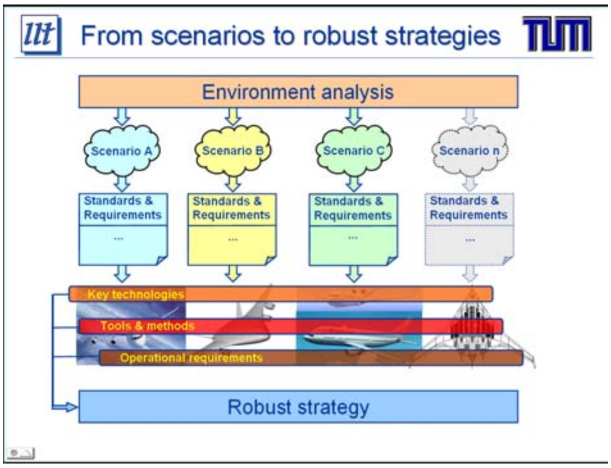

Figure 14

Fig 14 shows the principle procedure for the development of a robust strategy.

However , the goal of a scenario process for students is less the development of a robust product strategy but more the demonstration of the process and the definition of a set of different possible new concepts, which fulfil the future market needs or at least may be of interest for specific market niches. Six principle new concepts (see fig. 15) are the result of the scenario process and are of interest for further investigations. Each concept is based on a set of requirements, which was typical for a specific scenario.

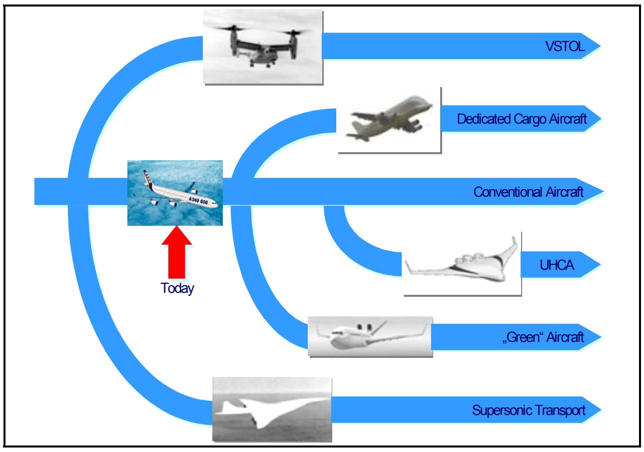

Figure 15

As a general result from the scenario process, it can be stated, that some of the different scenarios lead to requirements, which can not simply be met by conventional configurations. There is room for new concepts in specific market niches.

One of the objective of a scenario process may be the definition of a robust product strategy for the next 30 years. But normally it will be more appropriate to define a robust technology strategy. The development of new technologies and especially the development of those technologies, which fit to several project needs and are most efficient and applicable in different scenarios is an obvious target for scenario processes [9],[11],[12]. Technologies need a much longer time for their development and their readiness for application. It is very important to have the most efficient and most cost effective technologies available, when the market will need and require new products [14].

6 Summary

Assuming a time horizon of thirty years and more, as it is assumed for the development of completely new aircraft concepts, there are a lot of uncertainties and deficiencies about the development of market, customer needs and requirements and necessary technologies. The paper outlines, in which way scenario processes could be used to reduce these uncertainties in a systematic and methodological way. Different outputs can be obtained from scenarios, i.e. requirements, evaluation criteria and technologies.

With the proposed process, the future strategy will be based upon detailed market analysis and a global analysis of market related factors. This procedure will not replace the classical marketing tools like market forecast etc. but will be helpful to reduce the risk of uncertainties in a systematic and methodological way, which is always connected to long term forecast. Another important fact is the participation and discussion during a scenario process, as the complex environment will be carefully structured and the useful discussion between different experts improves the understanding for the global market. This will help considerably to increase the confidence level of a robust product strategy.

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