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## Some thoughts for revisiting Aircraft Concept Design

Rob Vingerhoeds  
23 october 2017

Concept design of aircraft?

And what if we would start from a white sheet of paper?

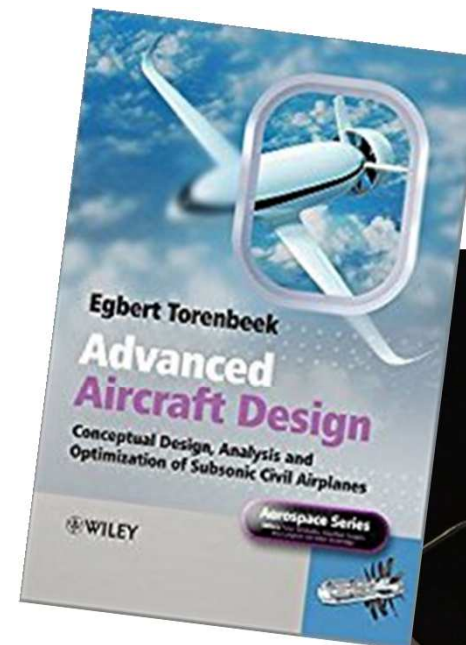
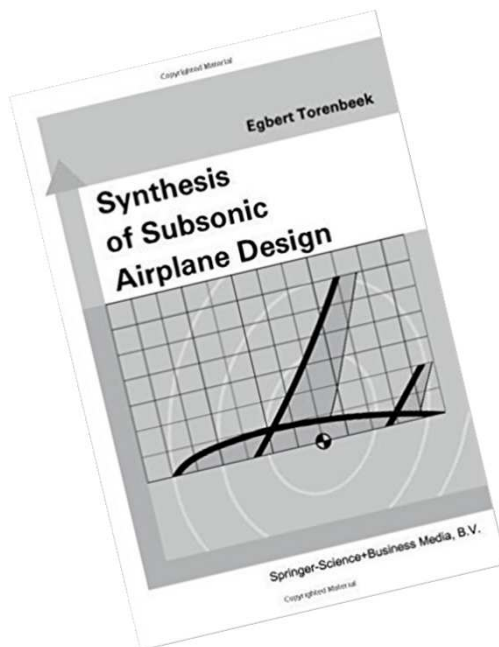


Concept design of aircraft  $\equiv$   
designing a complex system?

# We are not the first to ask ourselves these questions...

Farewell lecture of Prof. Egbert Torenbeek (TU Delft) in 2010:

Let's take a clean sheet of paper and start again



# We are not the first to ask ourselves these questions...

- **New (societal) evolutions appear at the horizon**
  - We will no longer use fossil fuels in half a century
  - Does that mean the end of aviation based on gas turbine propulsion?
  - And what is the alternative?
  - Do not fly anymore?
  - How to travel over long distances?
  - ...
- **Without mentioning important technological progress in several technical domains**
- **To prepare good answers for the future, a new way of thinking has to be prepared**



# Example « legacy carry-over »

## Cockpit Evolution



Avia Av-14T (1950)



Airbus A310 (1980's)



McDonnell Douglas  
DC-8-63 (1960)



Airbus A380 (2000's)



Boeing 747-200 (1970)



Airbus A350 (2010's)

Same basic features, especially integration?  
Some new features



Are there no other solutions?  
What about the Walkman and the iPhone?

# Let's talk about those...

Walkman – iPod



1980



2000



“Local optimisation” or “Reuse” would not have led to these new products...



How to allow creativity?  
How to look at other concepts?

# Let's talk about those...

iPhone



2006+



“Local optimisation” or “Reuse” would not have led to these new products...

How to allow creativity?  
How to look at other concepts?



# Let's talk about those...

iPhone

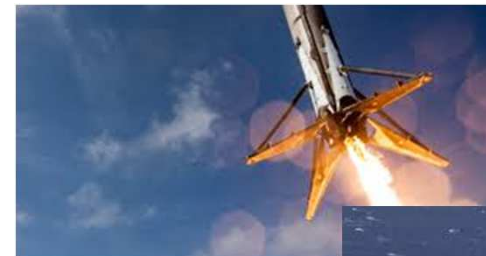
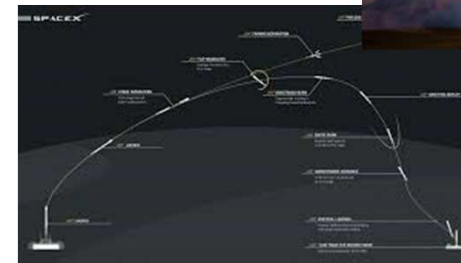


“Local optimisation” or “Reuse” would not have led to these new products...



How to allow creativity?  
How to look at other concepts?

# Surely this does not apply in aerospace... Right?



New approach with aim at reducing  
(operational) cost



Can we learn from this?

# We are not the first to ask ourselves these questions...

Enders: Airbus has to change

## Why these changes?

Airbus sees two established, world-leading businesses, satellite launchers and helicopters, suddenly threatened by disruptive developments.

The Ariane 5 launcher is the world's most reliable launcher of satellites. It hasn't missed in the last 79 launches. Its follow-on is the cheaper Airane 6. It cost half as much as Airane 5 per launch. It's a fundamental improvement, but not fundamental enough.

Elon Musk's SpaceX has moved the goal posts. The reusable Falcon rocket is still cheaper to launch, from a company that didn't exist 15 years ago and which is not working in the traditional way.

Airbus Helicopters sees drone/UAV companies growing up like mushrooms the world over. There are over 230 UAV companies in China alone, with the world's largest producer, DJI, now covering 70% of the global consumer drone market. The company that didn't exist 10 years ago is now turning over \$1.5bn per year.

With multiple electrical thrusters the UAVs circumvent the complicated helicopter gearbox and rotor head technology. The UAVs turn the table on the barriers to entry for vertical flight.

Airbus helicopters will now launch electrical UAVs for urban Taxi service at next week's Paris Air Show.

Enders fears that if these two businesses can be subject to disruptive market changes, why is the civil aircraft business safe? It accounts for 70% of the group's turnover.

This is behind the push of digitalization, new organization forms and a change of leadership for Airbus Innovation.

- **Trends**

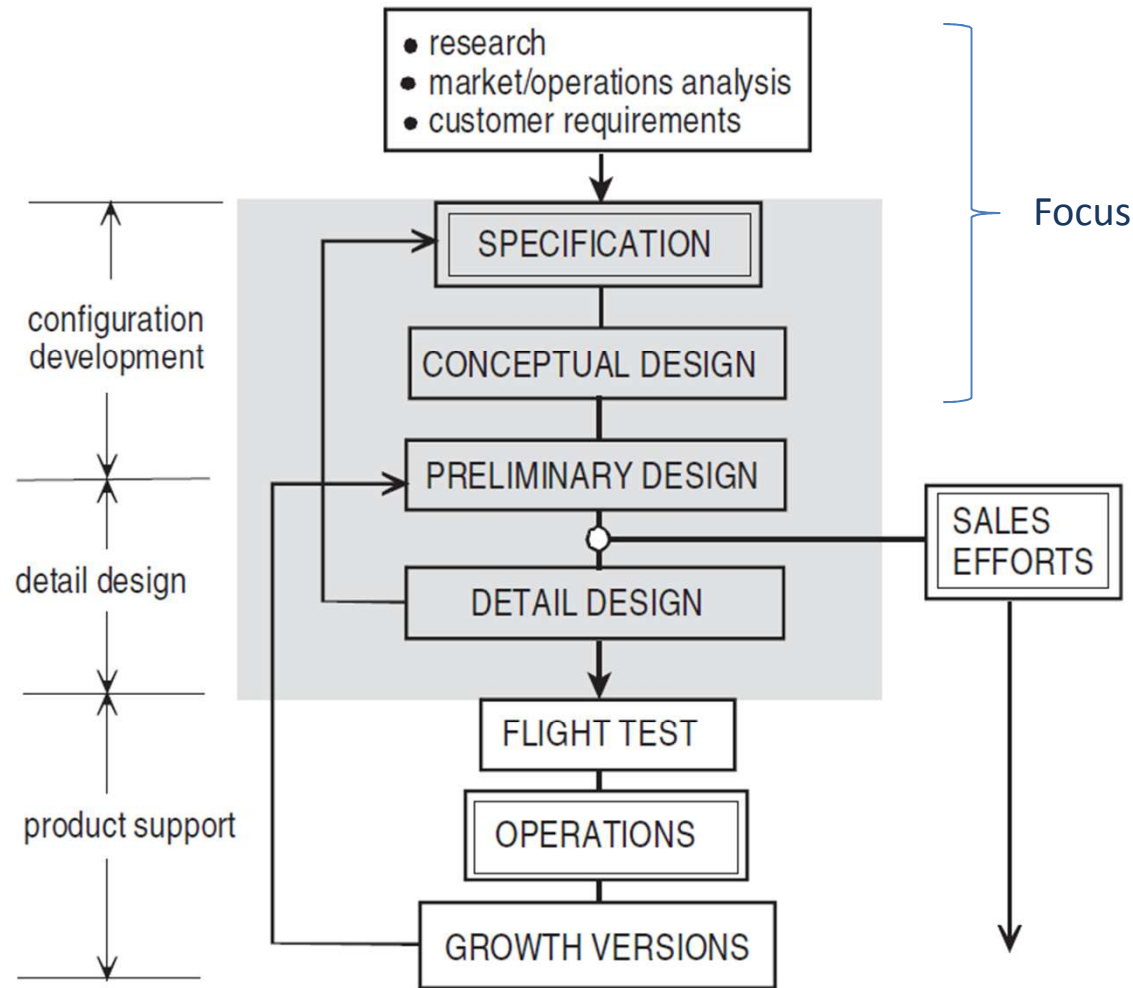
- complexity of systems is rapidly increasing
- quality of the products and their developments are expected to increase
- cost of the system is expected to reduce
- project management becomes more important
- innovation accelerates

**Mastering complexity, quality, development time and cost poses serious constraints to the development of modern systems**

- **Systems engineering offers good possibilities to address these challenges**

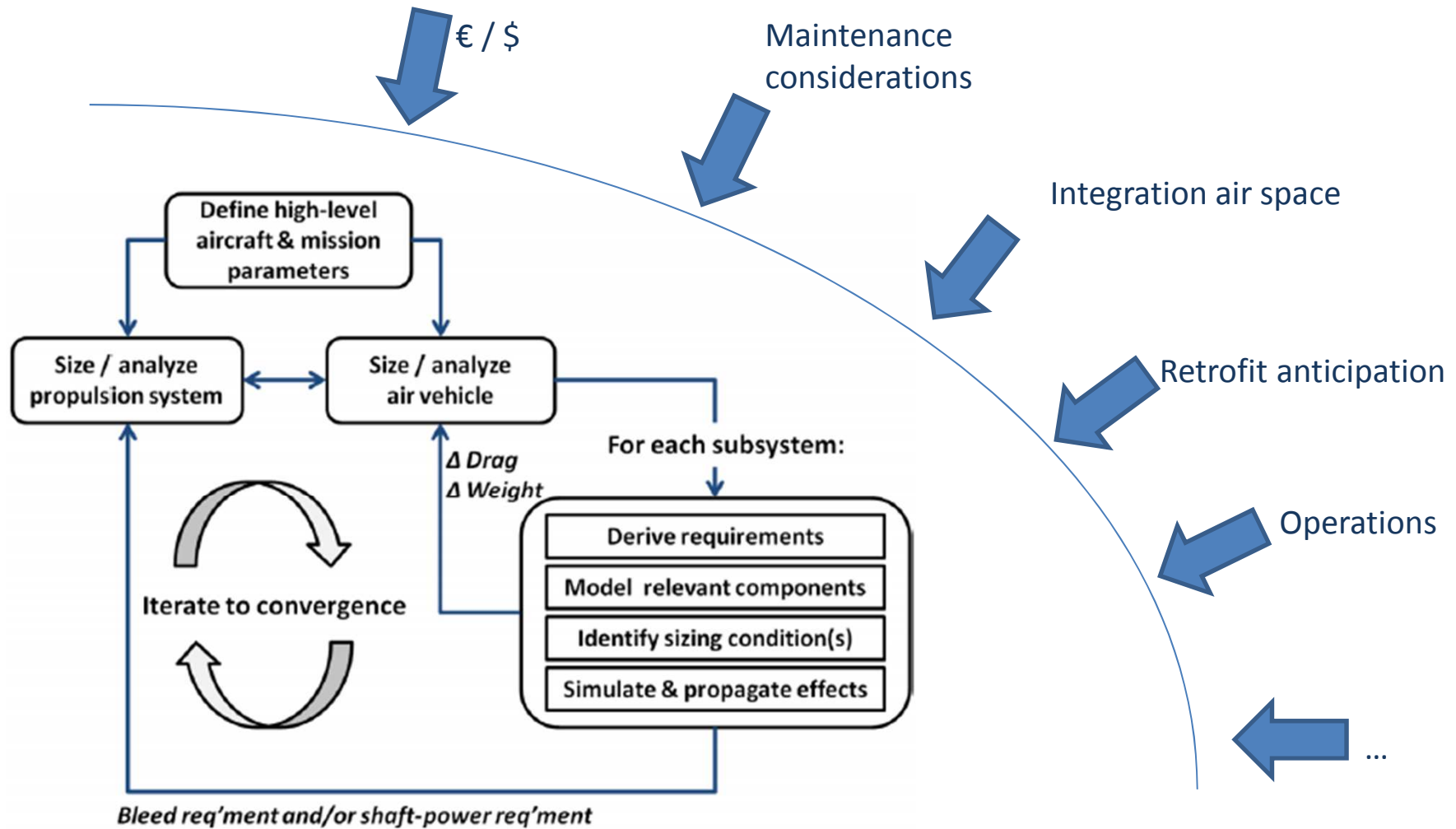
- **New approaches to development based on model-driven systems engineering are needed for**
  - better consideration of requirements and alert on breaches of constraints,
  - multidisciplinary approach,
  - prediction of systems behavior in terms of functionality, as a whole and of the components in their environment, ...
  - allow to concentrate on the different components of the systems,
  - support
    - the individual technical skills for each discipline,
    - optimization and reuse,
    - multi-technology concurrent engineering,
    - intuitive use,
  - better integrate project management tools,
  - support and integrate new approaches, such as agile development,
  - ...

# Aircraft concept design loops



Schedule of the civil airplane development process [40]. Courtesy of J.H. McMasters

# Factors influencing aircraft concept design loops



## a systems engineering approach

- Not just to apply a very structured approach, but foremost to favour creativity and innovation, taking into account the use, maintenance, ..., taking into account other aspects, for example airports, corridors in the air, ...
- Or, as indicated by Airbus Customer Services during the preparation of the "Maintenance" round table at the Paris Air Show:

**It is necessary that the engineers develop without taboo a good financial understanding of things and can consider the \$, like kg, or lbs of push!**

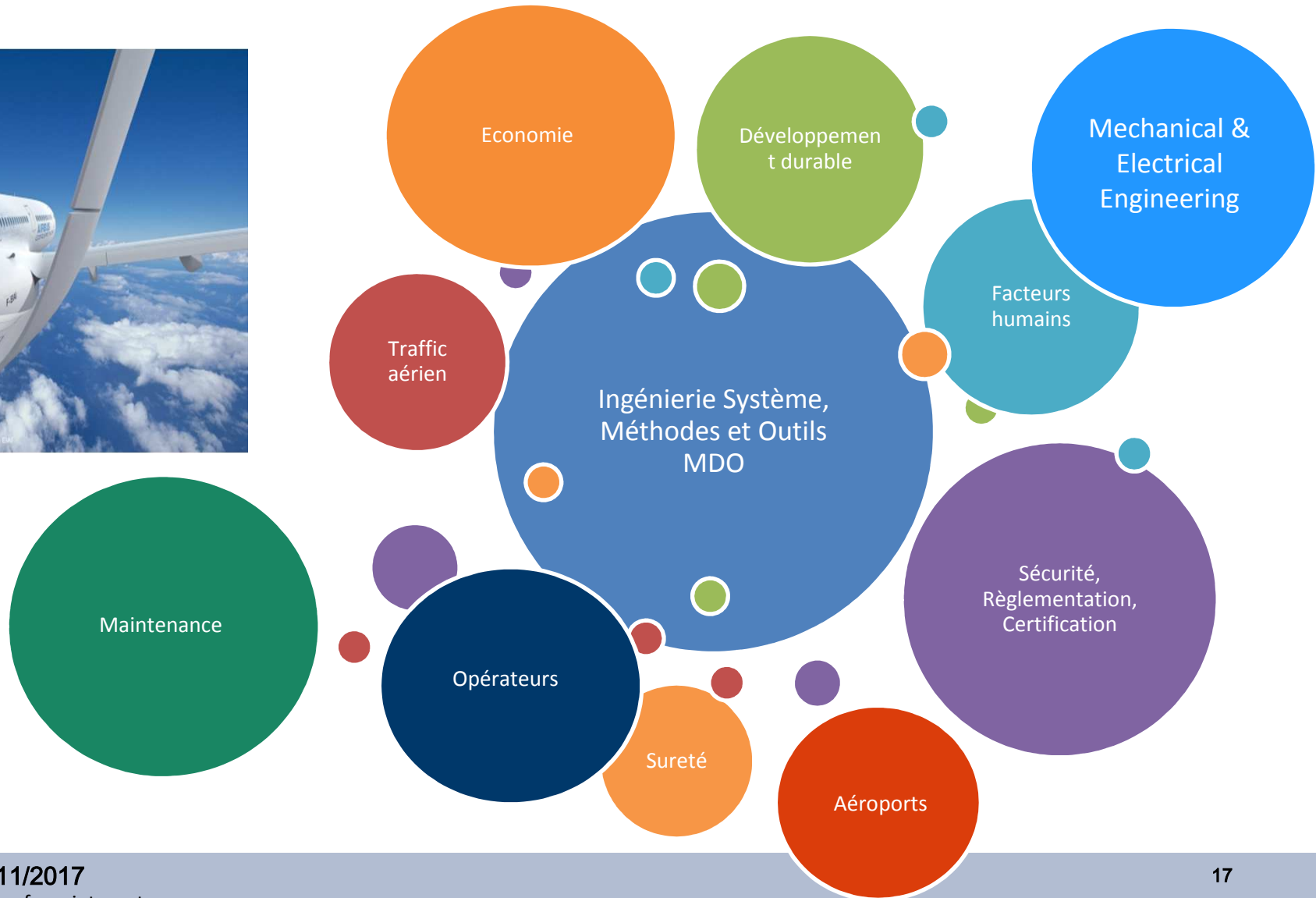
- So:
  - Understand the problem before trying to solve it
  - Translate the problem into measurable requirements
  - Consider all possible alternatives before choosing one
  - Ensure that the total life cycle of the system is taken into account
  - Be sure to test the total system before delivering it.
  - Document everything.



- **Problem definition** - high level description of functions, most mandatory and desirable requirements must be traceable to this description.
- **Study alternative solutions** - Alternative solutions are created and evaluated based on their performance and maturity, timing, costs and risks.
- **System model** - For most alternative solutions. The preferred solution model will be used to help manage the system throughout its lifecycle.
- **Integrate** - Gather things together so they work together.
- **Launch System** - Run system to evaluate results. The preferred solution is designed in detail and the necessary processes are developed.
- **Assess performance** – Figures of merit, technical performance measures and measurements are used to assess performance.
- **Re-evaluate** - At any time re-evaluate the solution against the requirements expressed, help manage systems and improve their performance.

# Global Vision

Concept design of aircraft : taking into account the overall context



## Our short term objectives

This project will allow us to derive scientific research orientations on two main streams:

- Concept design of aircraft and the associated technical disciplines
- Systems engineering and the associated tool chains

Over the coming period the following has to be realized :

- Identification of a main approach
- Identification of individual technical / scientific blocks for the concerned domains
- Work on the scientific roadmap
- Valuing multidisciplinary design as a discipline in its own right
- Definition and consolidation of a common tools platform
- Mutualization of efforts and knowledge capitalization

**Bringing together aircraft concept design activities in an innovative framework will allow to advance on this topic AND on different disciplines individually.**

Many thanks for your attention



Any questions ?