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Filip Verhaeghe – (UN)MANNED

Tackling **Airborne Software** Complexity and Safety for **eVTOL**

Aerospace is demanding

- Our focus is on avionics & instruments
- A *lot* more certification than automotive
- Very challenging for start-ups
- Technical development of urban is very impressive, but not enough
- Regulations pre-active audits
- Crash investigation → changes
- Certification is an integral process
  - Can't do it "at the end"

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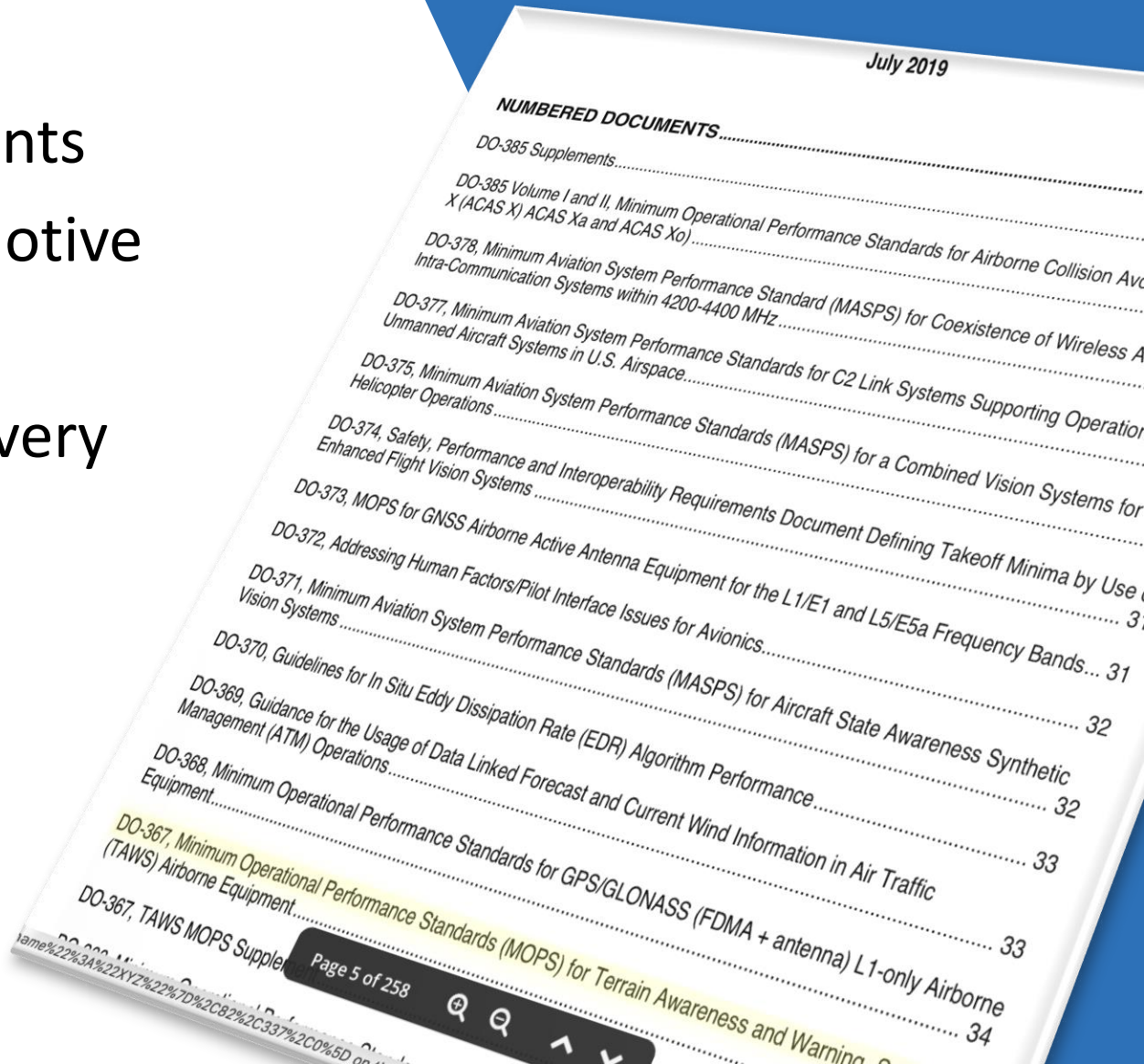

FAA: 14 CFR Part 23 Airworthiness Stds for GA
EASA: SC-VTOL-01 Special Condition for VTOL

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- ARP4754A : Guidelines for Development of Civil Aircraft and Systems
  - DO-254: Design Assurance Guidance for Airborne Electronic Hardware
  - DO-178C: Software Considerations in Airborne Systems and Equipment Certification
    - DO-330/DO-331/DO-332/DO-333/DO-248C
  - DO-160G: Environmental Conditions and Test Procedures for Airborne Equipment
  - ARP5150A/ARP5151, ARP4761
- There are also…
  - Minimum Aviation System Performance Standards (MASPS)
  - Minimum Operational Performance Standards (MOPS)
  - TSO, AC, CS, …

Existing Aviation Issues – Rise of Software

- Manual software development
- Exponential cost increase
- Lack of developers
- Years of delay to market
- But pressure for cost cutting drives development
- Less fuel, less sound, less maintenance, faster turnaround

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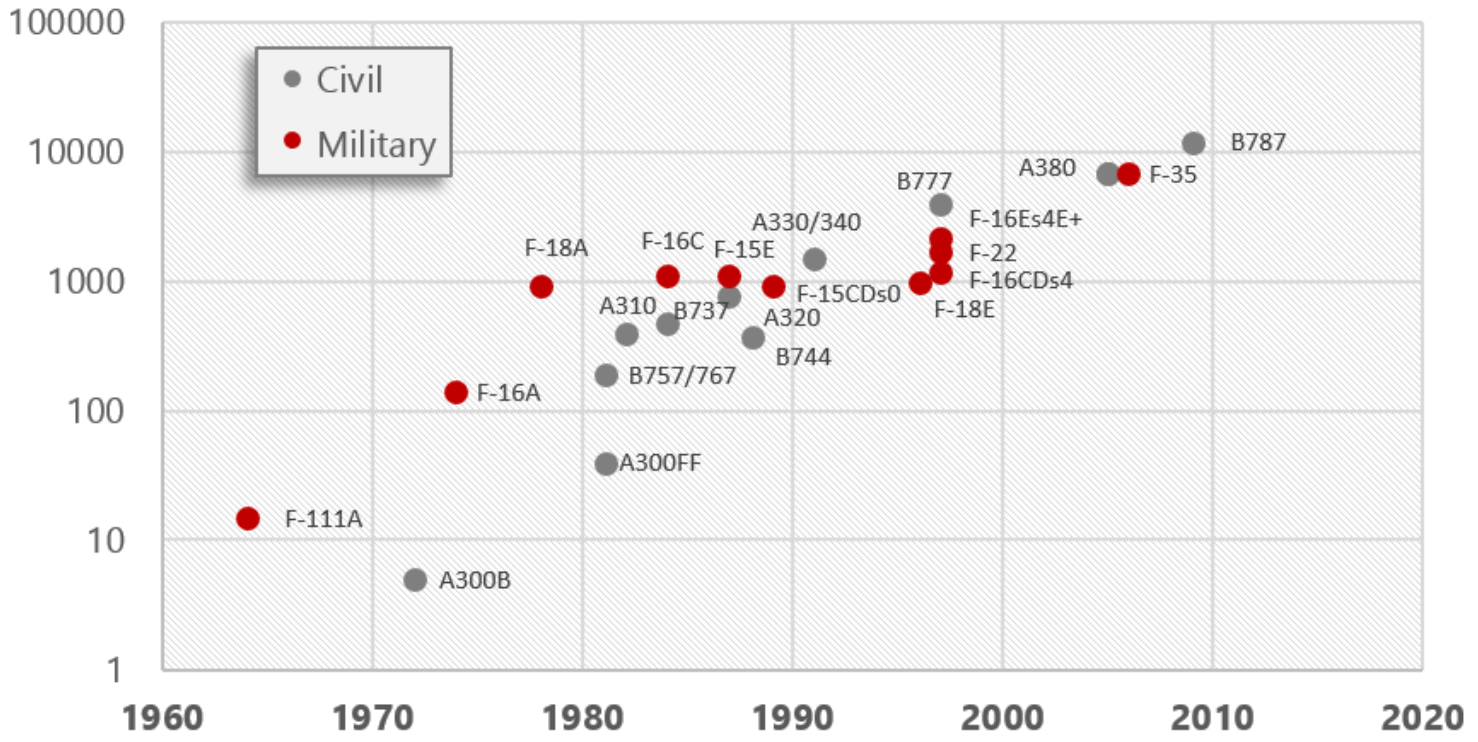
Exhibit 1: Aircraft Software Volume Growth
(airborne system software, K SLOCs)



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Existing Solutions

Custom design

- Usually with existing instruments that are customized to the aircraft
- Slow and extremely expensive, flexible design but slow evolution
- Hard to make up in volume due to the high-cost HW

One size fits all

- One cockpit that serves many aircraft
- No changes of any kind can be made
- Fast and cost effective, but rigid design and slow evolution

Urban mobility needs…

- Fast, cost effective, but flexible and fast evolution

Unforgiving

Reuters: “Norway's First Electric Plane Crash-Lands on Lake”

Expected trends in the urban air cockpit

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- Trend to simplify:
  - From aircraft-specific steep learning curve to automotive style
  - Less dials to turn imply much higher level of autonomy
- Trend to update fast:
  - Today, any avionics change will take years to design
  - Urban Air will require much faster updates
- Trend to offload the pilots to ground:
  - Initially: remote piloted flight
  - Later: semi-autonomous with pilot on standby

Different flight environment

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- From long distance flights to short urban hops
- From high altitude to low altitude
- From large aircraft separation to close proximity
- Much higher concentration of aircraft over cities,
  - Shared with drones!
  - Other urban aircraft, helicopters and large aircraft
- Significant effect of weather on flight safety and operations, including very turbulent wind
- In case of a problem, high risk of ground fatalities

New expectations from aircraft

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- Much higher situational awareness
  - Short-range obstacle detection & response
  - Very fast drone detection and avoidance
  - Dynamic navigation aids with highly connected aircraft
  - Rapid and automated recovery from aircraft *or* pilot errors
- Loss of pilot or remotely piloted aircraft require autonomy
  - At least reduced autonomy to recover from loss of communication
    - Emergency landing over a city
    - Mid-air avoidance maneuvers
  - Full autonomy for maximizing economic potential
    - Mostly autonomous flight, remote pilot intervention only in exceptions
- Amount of software rises dramatically
  - Mostly software that is also hard to functionally certify
  - But all highly safety critical and subject to highest certification levels

Developing certified software

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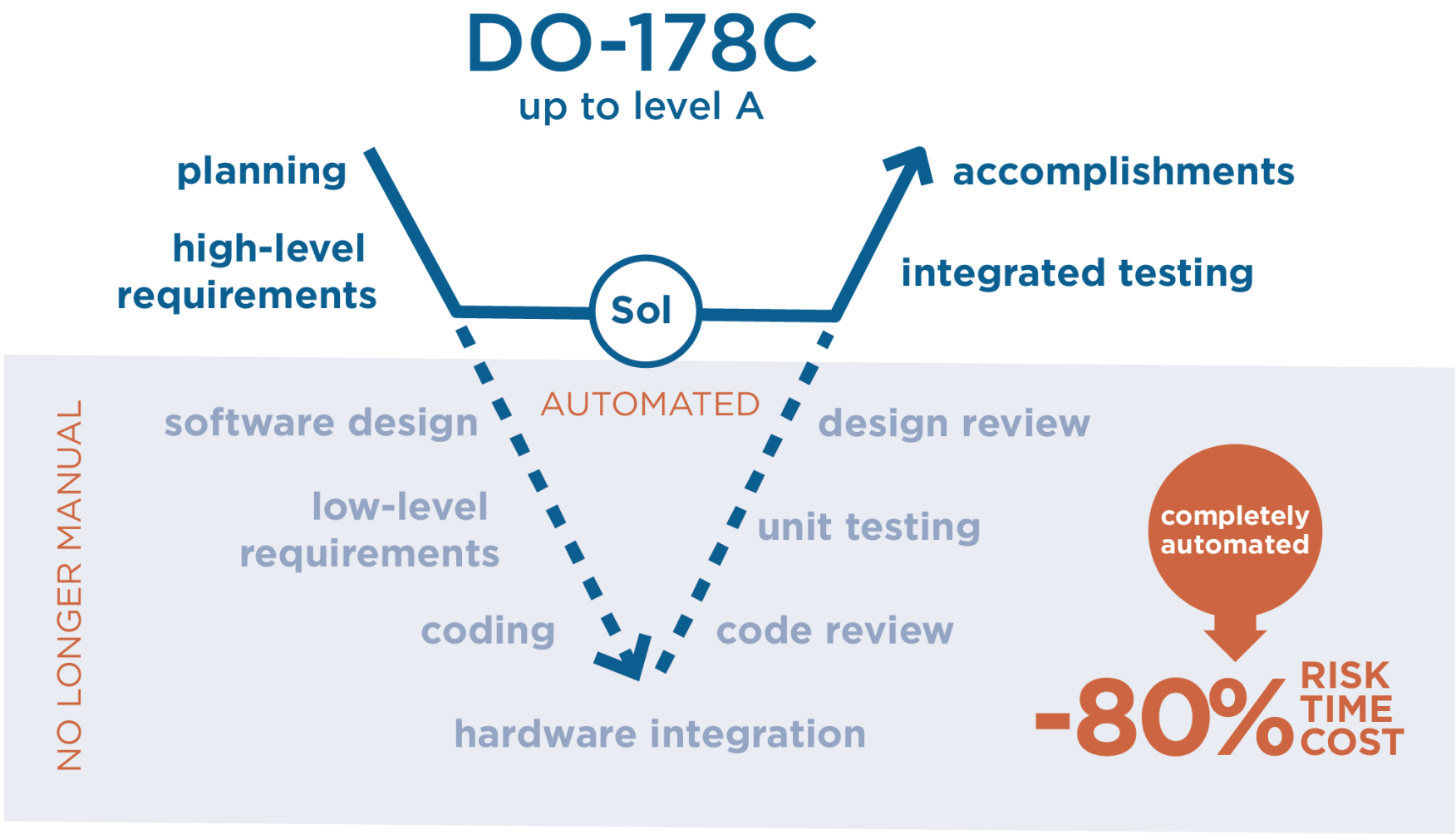

Verification is based on approved higher artifacts
Change analysis on iteration
Design and low-level req. is much more than coding
Verification is a lot more still
Coding = 10-20% of software development
Extremely expensive
Results in rigid code

(UN)MANNED has automated it
No need for software dev
Proven, flying every day
Used by major aerospace

DO-254 certified hardware

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- DO-178C certified software requires DO-254 certified hardware – and is tuned to the hardware's safety features
- For DO-254, the best approach is to re-use the same hardware with different software.
- Available as very powerful but small airborne computer, and for certified ground cockpits.

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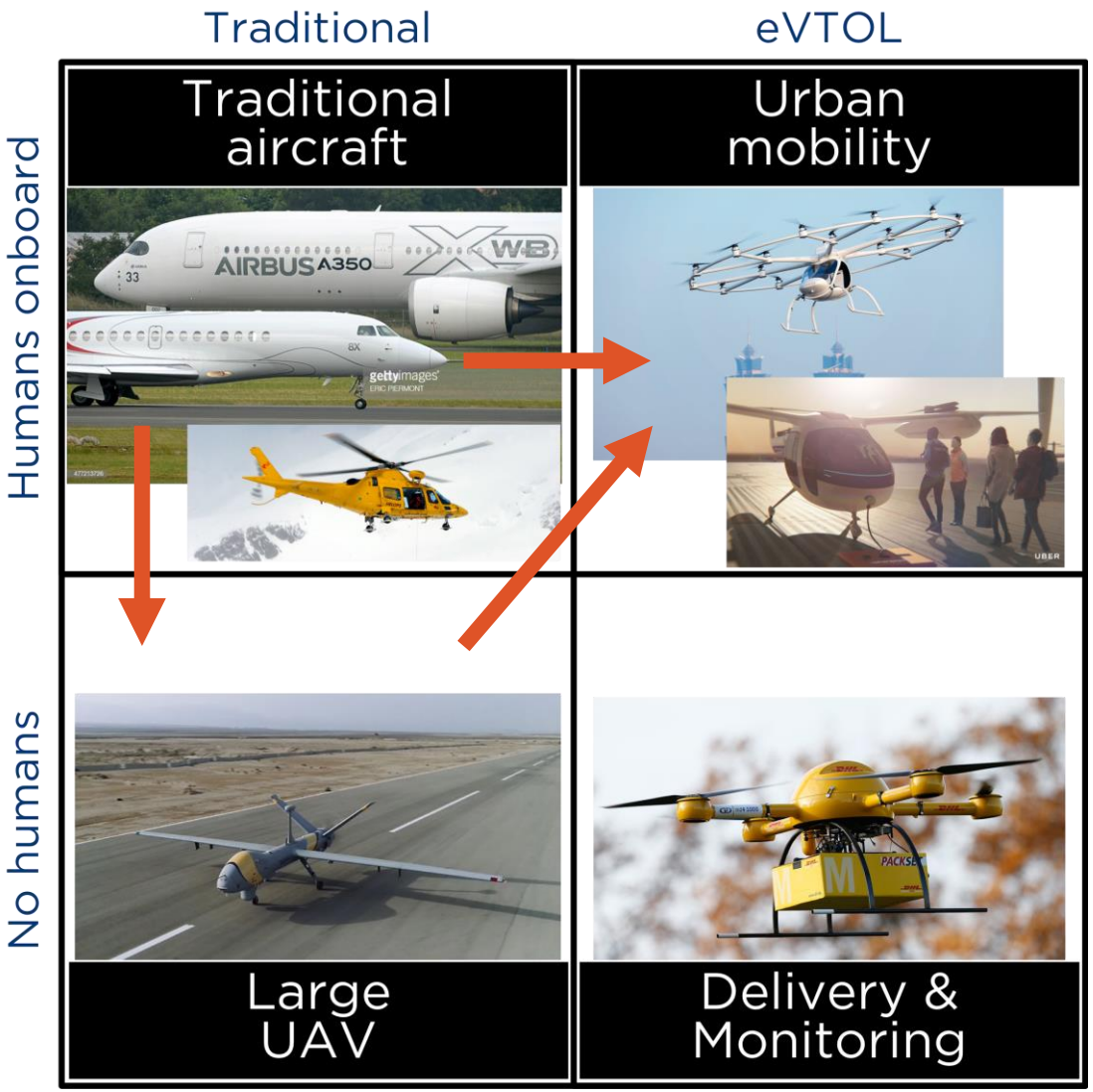

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