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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  $\rightarrow \Box$  changes
- Certification is an integral process
  - Can't do it "at the end"

#### (UN)MANNED CERTIFIED INTELLIGENCE July 2019 NUMBERED DOCUMENTS. DO-385 Supplements. DO 385 Volume I and II, Minimum Operational Performance Standards for Airborne Collision A X (ACAS X) ACAS Xa and ACAS Xo) ... DO-378, Minimum Aviation System Performance Standard (MASPS) for Coexistence of Wireless A Intra-Communication Systems within 4200-4400 MHz ... DO-377, Minimum Aviation System Performance Standards for C2 Link Systems Supporting Operation Unmanned Aircraft Systems in U.S. Airspace. DO-375, Minimum Aviation System Performance Standards (MASPS) for a Combined Vision Systems for DO-374, Safety, Performance and Interoperability Requirements Document Defining Takeoff Minima by Use DO-373, MOPS for GNSS Airborne Active Antenna Equipment for the L1/E1 and L5/E5a Frequency Bands... 31 DO-372, Addressing Human Factors/Pilot Interface Issues for Avionics. DO-371, Minimum Aviation System Performance Standards (MASPS) for Aircraft State Awareness Synthetic DO-370, Guidelines for In Situ Eddy Dissipation Rate (EDR) Algorithm Performance.. DO-369, Guidance for the Usage of Data Linked Forecast and Current Wind Information in Air Traffic DO-368, Minimum Operational Performance Standards for GPS/GLONASS (FDMA + antenna) L1-only Airborne DO-367, Minimum Operational Performance Standards (MOPS) for Terrain Awaranoce and Woming DO-367, TAWS MOPS Suppler Page 5 of 258

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

- 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, ...

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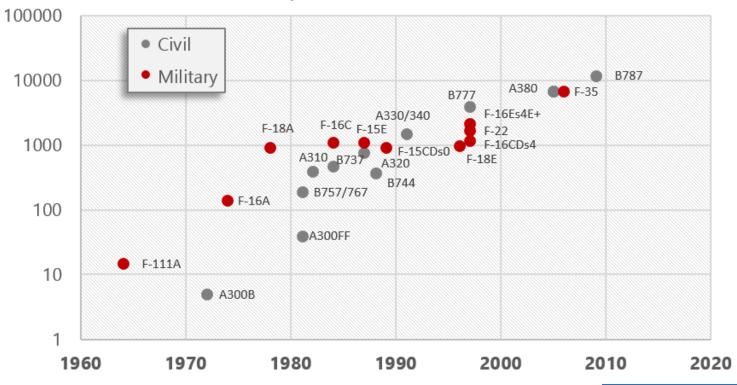
#### Existing Aviation Issues – Rise of Software

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)



#### 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

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### Existing Solutions

### Unforgiving

100% ELECT

YONIVA .

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

- 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

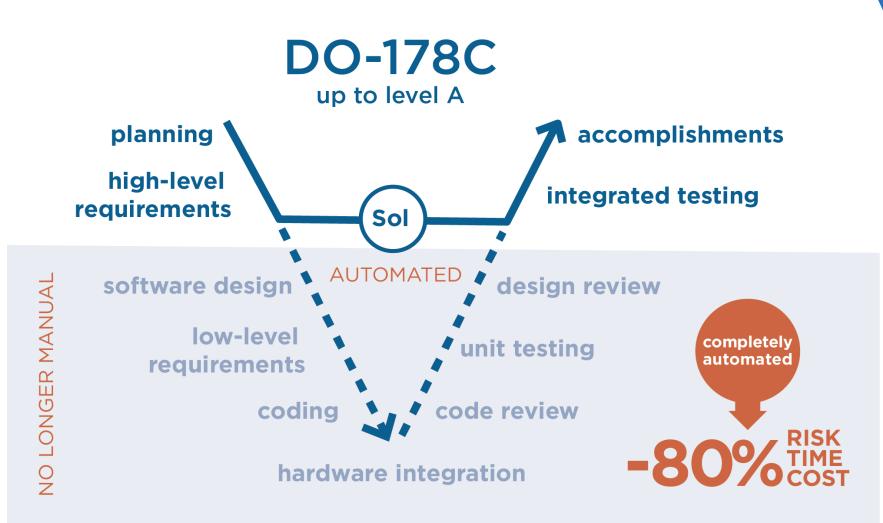
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### New expectations from aircraft

- 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

### (UN)MANNED certified intelligence

### 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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PROTOTYPE

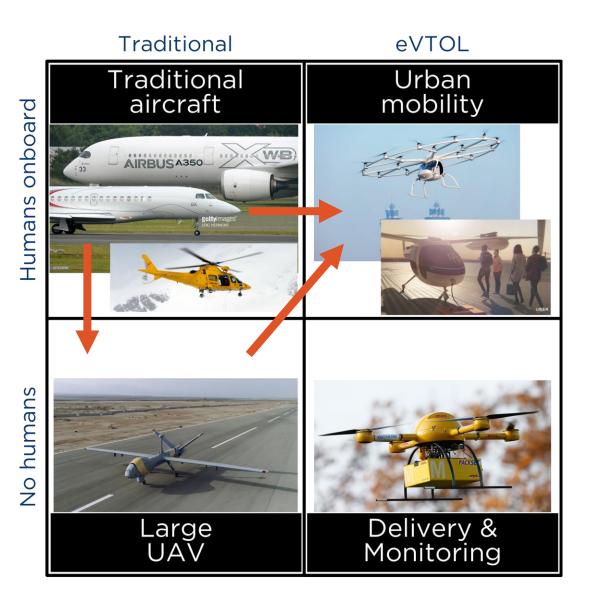
SolRack-1 Duo

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Sol Unit B

- 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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