Risks, vulnerabilities and safety of unmanned aircraft transport systems used in industry

S.O. Johnsen, SINTEF
T.E. Evjemo, SINTEF

Introduction

1) Unmanned Aircraft Systems (UAS) - expanding, annual growth rate 100%

2) Used in tasks being dangerous, dirty or dull

3) Issues/ RQ
   - Planned use of drones in industry
   - Major risks of UAS
   - What is needed to improve safety and resilience of UAS operations?

Approach

- Literature review – Use/ Safety and security of Unmanned Aircraft Systems
- Interviews of regulators, pilots and flight controllers
- Review of research and innovation from the research database of the Norwegian research council – search using key-words

Methods

Method – broad based - Human, Technology and organizational issues (i.e. rules ; regulation;)

- Learn from actual use i.e. incidents
  - "Human in the loop challenges" and need for meaningful human control
  - Based om Human Factors (HFACS)

- Explore governance and emerging/ new risks … (O. Renn)

- Assess design and control issues –
  - New approaches – i.e. STAMP

Autonomy - Levels of automation

Automated: Deterministic; does exactly what it is programmed to do

Autonomy: A non-deterministic system; freedom to make choices

Levels of automation - Society of Automotive Engineers (SAE):

0-No automation;

1- Driver assistance;

2-Partial automation;

3-Conditional automation;

4-High automation;

5-Full automation

Levels of Automation

Automotive SAE Levels	Railways Grades of Automation	Aircraft Levels of Automation	Driver Resp.	Vehicle Resp.
L0 No automation ABS, stability control	GoA-0 Sight train operation	Level 1 – Raw data, no automation at all	All	Warns Protects
L1 Driver Assistance Park assist Cruise contro	GoA-1 Manual train operation Automated Train Protection	Level 2 - Assistance Flight director Auto-throttle	Drives	Guides Assists
L2 Partial Automation (longitudinal & lateral) Traffic jam assist	GoA-2 Semi-automatic train operation (STO) Automated Train Op (ATO)	Level 3 – Tactical use. Autopilot (CWS)	Monitors all time	Manage movement within limits
L3 Conditional Automation Highway traf. jam system	GoA-3 Driverless train operation (DTO) Automated train control (ATC) Some control by attendant: operating doors, emergencies	Level 4 – Strategic Flight management system	Ready to take back control	Drives itself but may give back control
L4 High Automation (specific use cases) Valet parking		Uninterruptible auto-pilot project (Boeing) Drones (unmanned)	May not take back control	Drives itself with graceful degradation
L5 Full Automation (all situations)	GoA-4 Unattended train operation (UTO) Automated Doors Platform screen doors		Not required	All time

Table 1: Comparison of automation levels in automotive, railways and aeronautics.

Scope: Unmanned aviation systems

The system (Power plant/Sensors/…)

External control

interaction
with other actors

Industrial use of UAS

In general – replacing dangerous, dirty operations – moving from manned aviation to unmanned aviation – less pilots than road/sea

- Cinematography and aerial photography
- Speedy delivery of critical supplies - (Blood in Rwanda from 2016)
- Inspection of equipment (to avoid dangerous work/ improve quality)- power lines/ storage tanks/ Flame towers (oil and gas)
- Monitoring and surveying farmland/ seaways/ borders/ sea (Ice monitoring)/"oil spill management",)
- Illicit transportation (Smuggling/ Drug delivery/ to prisoners)
- Disaster support (overview of damages/ find people/ deliver critical equipment/ status feed)
- Fire-fighting (overview, deliver water/ Chemicals close to fire)

Manned & Unmanned Aircraft Systems (UAS)

Manned aviation (highly automated but human-in-the-loop)

- "Ultra high safety" – None IATA accidents 2012 & 2017
- More automation but need "Human In the Loop" – when automation cannot cope
- New accidents due to automation - Boeing Max

Unmanned Aircraft Systems (UAS)

- From large "industrial drones" (DoD):
  - DoD UAS: 50-100 incidents for each 100,000 flight hours vs DoD pilot - 1 incident pr 100,000 flight hours
  - DoD – UAS: Poor Human Factors design of control systems

- **MTBF** – 1,000 hours between accidents - 100 times more than in aviation

Unmanned Aircraft Systems (UAS)

Type of accidents

- Loss of control; UAS Crash/ fall down- and consequences of impact
- Collision with regular flights; Ignition of gas ; New types of accidents

Distribution of 1000 accidents (safety)

- Power plant (411) failure; Ground Control system (273); Navigation system (146)
- Electronics (67); Mainframe (54); Payload (53)

Security issues

- Take over control - GPS spoofing (Iran landed USA drone) , Backdoor (Boeing 787)
- Drone Crash/Collision (hacking/DoS)
- Loss of communication – lock out user/ manipulate video control
- Loss of data (pictures, video) – (data may be stored elsewhere - China/USA…)
- Halt/Impact regular air transport
- Illicit transportation /Smuggling (across borders/ to prisons)
- Drone Attacs cheaper (i.e. As in Saudi-Arabia 2019)

Mitigation of some of the challenges

Privacy

- Registry of owners and UAS id (name-tag)
- Systems for drone detection

Accountability

- Liability to owners (and software producers)
- Insurance

Control/Regulation

- Drone tracking
- Ability to go to a safe/secure state (safe landing)
- Definition of aerial bounds (Geofencing); and stop the drone
- Regulation more in sync with technology development

Likelihood and consequences

Depends on Operational Design Domain- (ODD) – what/where/how

Likelihood - Higher (dependent on operation and procedures)

- Immature technology – MTBF (100 times) higher than manned aviation
- Replace operations with higher likelihood of accidents (such as road transport)
- More resilient design – parachute; UAS 16 motors –(less single point of failure)
- New issues: Need more data related to safety – Security: Likelihood of cheap attack on critical infrastructure– USD 1500 to mount flame thrower on UAS (critical oil and gas ?)

Consequences – Lower

- Less weight and impact consequences (but dependent on weight/ height/speed ...) falling drone: – 1% of fatality (250 gr) – 50% fatality (600 gr)
- Less fire (Batteries – no fuel)
- Removing human exposure of pilot
- New consequences – critical infrastructure

Existing UAS Research

Increasing research funded by Norwegian Research Council

- 2008-2012: 3,6 Mill EUR
- 2013-2017: 5,7 Mill EUR
- 2018-2021: 12 Mill EUR

Areas of focus

- Maritime/offshore research – Ice monitoring/ UAS heavy load transport/ Remote operations of fish farms
- Technology improvements – Better motors/ batteries; Better Air control systems
- Improvements of inspection (Power lines; control of buildings; Bridges)

Missing areas

- Improved safety (improved MTBF); Improved security; Resilience
- Human Factors issues in interfaces / Meaningful human control
- Best practices of local rules, procedures and regulations
- Societal and ethical issues

Conclusions

Main challenges and benefits

- UAS immature – need to be industrialized – improved MTBF needed
- May reduce human exposure in dangerous operations
- May save life by getting better information/ deliver key resources

More knowledge and research needed

- Systematic learning from operations and incidents of UAS;
- More pilot projects in critical areas to speed up learning and development

- Certification schemes to raise quality, human factors issues and safety
- Expert group of regulators, industry users, operators and developers should work together to speed up development of systems, regulation and best practices (i.e. risk assessment) to reach high level of safety, reliability and security
- Societal and ethical issues of drones

Q/A

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