

# IVHM FOR UAVs FOR FUTURE MRO – OPERATIONAL FRAMEWORK, REQUIREMENTS, AND GAP ANALYSIS

Ann-Kathrin Koschlik, Hendrik Meyer, Jan Torben Dohmen and Florian Raddatz

German Aerospace Center- Institute of Maintenance, Repair and Overhaul

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Knowledge for Tomorrow

# Importance of MRO for UAV

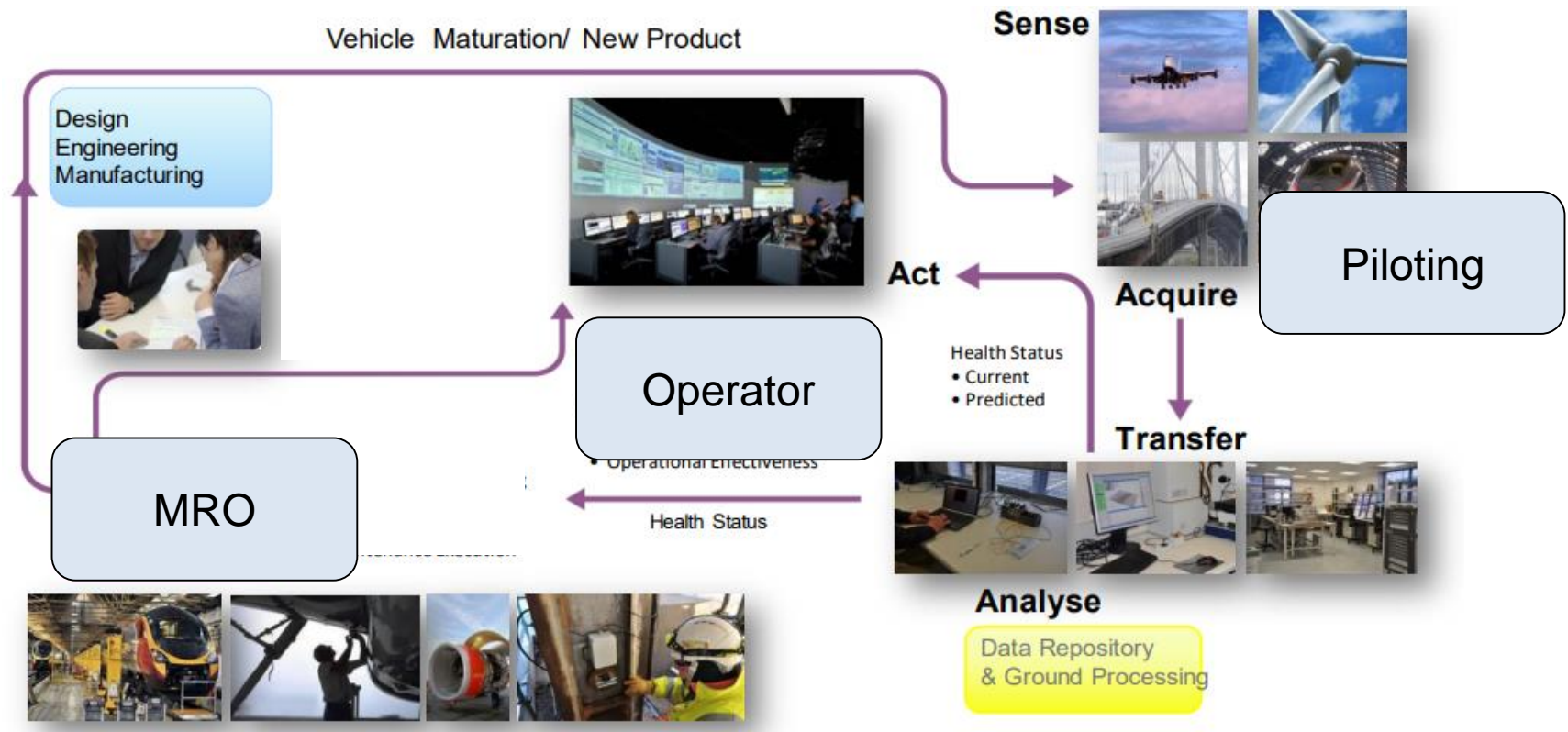


UAV crash close to skier Marcel Hirscher 22.12.2015



# IVHM in Product Life Cycle

- Integrated vehicle health management (IVHM)
- Capability of systems to assess current and future state of member system health
- Framework of available resources and operational demand [Jennions 2011]

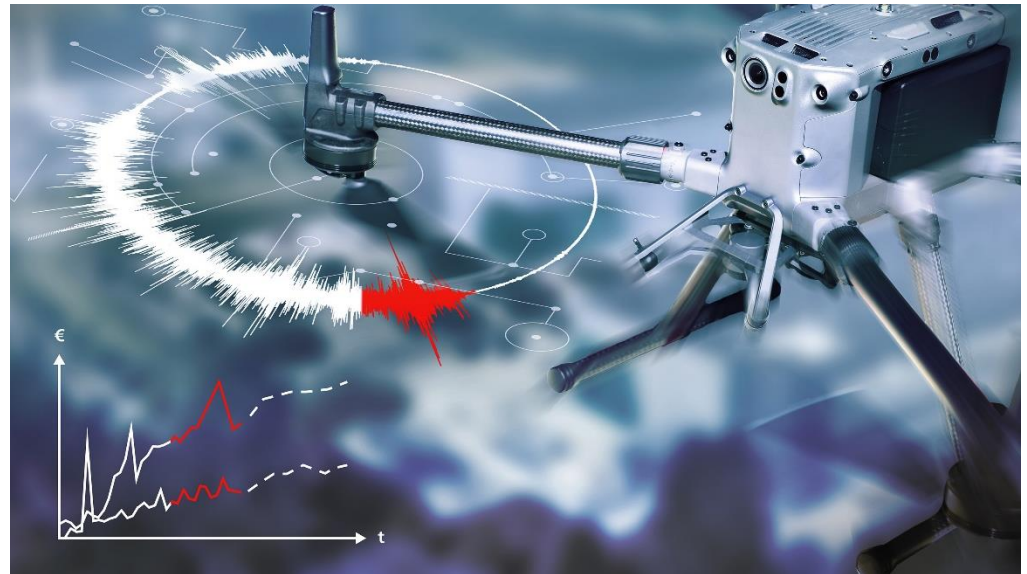


# Research Questions

- *What are current regulations concerning the MRO of UAVs in order to enable highly automated operations in urban area?*
- *And what is the impact on the IVHM design?*

## Agenda

1. Introduction & IVHM concept
2. Operational framework for UAV
3. Regulations for operations
4. IVHM strategies
5. Conclusion

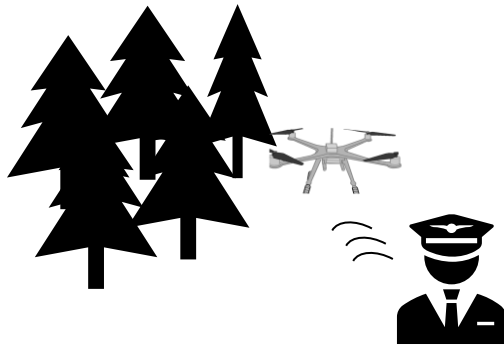




# Three operational use-cases

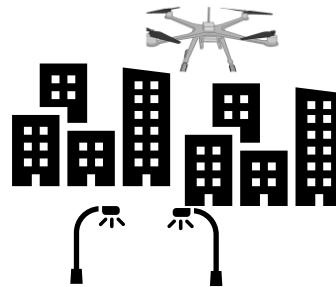
- The EU regulations 2019/947 [3] and EASA 2019/945 [4] introduces three classes
  - Open category (no-approval)
  - **Specific category (higher risk)**
  - Certified (~manned operation)

## Scenario I



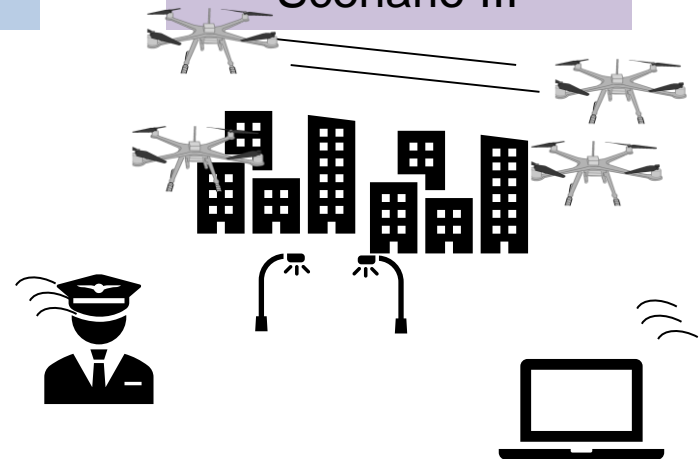
# Sparsely operated area  
# manual control  
# BVLOS

## Scenario II



# Urban area  
# manual control  
# BVLOS

## Scenario III



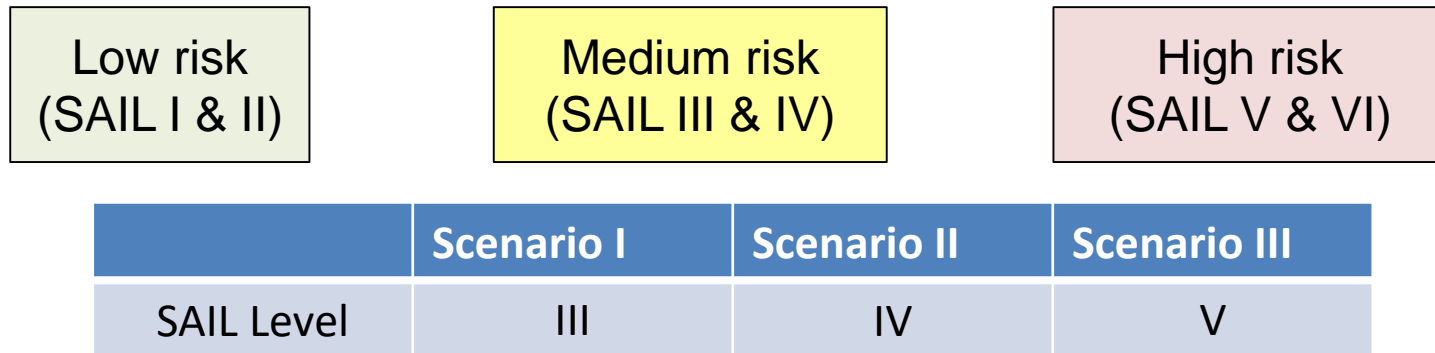
# Assembly of People  
# autonomous flights  
# BVLOS



# Certification of UAS – Specific Category

## Specific Operations Risk Assessment (SORA)

- Multi-stage process of risks (ground and mid-air collision)
- Resulting in Specific Assurance and Integrity Level (SAIL)



[AMC and GM to Commission Implementing Regulation (EU) 2019/947]

## Operational Safety Objectives (OSO)

- In total 24 OSOs
  - 4 categories:
    - Technical issue with the UAS
    - Deterioration of external systems supporting UAS operations
    - Human Error
    - Adverse operating conditions
- } 5 relevant OSOs identified



# #OSO 03 - UAS maintained by competent and/or proven entity

SAIL	I	II	III	IV	V	VI
	L	L	M	M	H	H

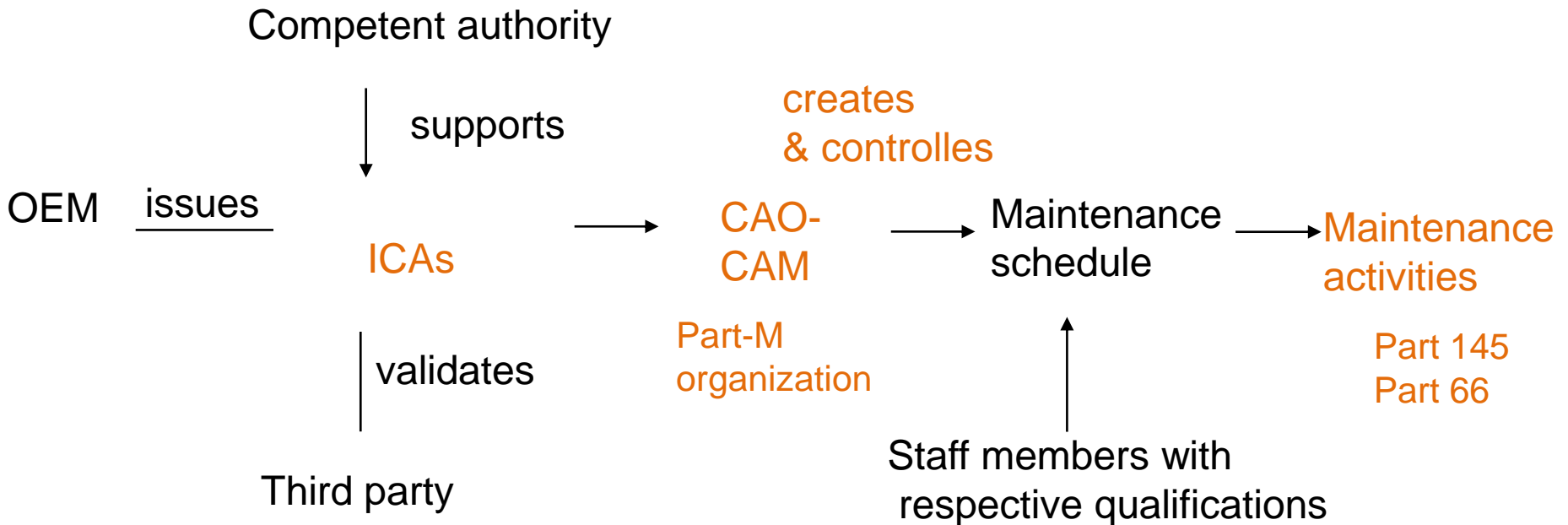
Level of integrity	Task/ Item	Details	Realized by	Released/ supported by
<b>Low level</b>	Maintenance instructions	Maintenance routines	Authorized maintenance staff	OEM
<b>Medium level</b>	Maintenance programme	Scheduled Maintenance activities + Documentation of maintenance activities	Staff members with respective qualifications	The respective competent authority
<b>High level</b>	Maintenance procedure	Detailed description for the maintenance tasks	Similar to medium	Third party



# #OSO 03 - UAS maintained by competent and/or proven entity

## Derived MRO concept

- Non-complex motor powered aircraft (CMPA) [5]
- Light A/C
- Commercial Use



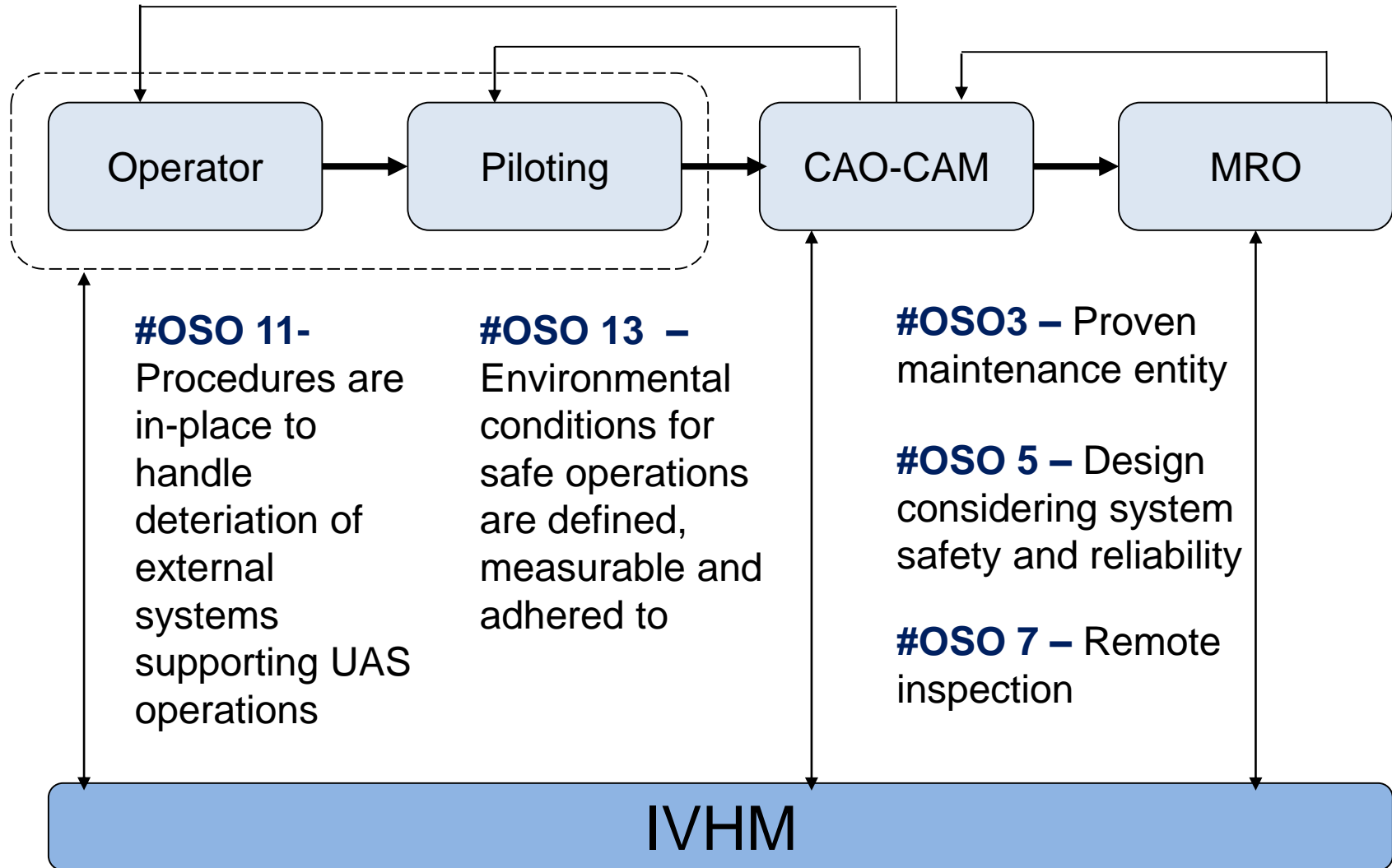
ICAAs := Instruction for continuous Airworthiness

CAO-CAM (not formal denomination) := Part-CAO organization with continuing airworthiness management privilege.





# IVHM for future MRO



# Conclusion

- Currently MRO not sufficiently considered for small-scaled UAVs
- Future demand expected for certified as well as for specified category
- Need for Continuous Airworthiness & Maintenance Organization (CAMO)
- Promising concept of IVHM in order to bridge the gap for efficient and holistic MRO processes



# Thank you for your attention!



# Bibliography

## References

- [1] Infront Sports & Media AG. Updated Statement – regarding FIS Alpine Ski World Cup, slalom race, on 22 December 2015. <https://www.infront.sport/en/news/updated-statement-regarding-fis-alpine-ski-world-cup-slalom-race-on-22-december-2015> (accessed June 22, 2022).
- [2] Jennions, I. K. *Integrated Vehicle Health Management: Perspectives on an Emerging Field*; SAE International: Warrendale, PA, 2011.
- [3] EASA. *Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Commission Implementing Regulation (EU) 2019/947: Annex I to ED Decision 2019/021/R*, 2019.
- [4] Office, P. *COMMISSION DELEGATED REGULATION (EU) 2019/945: on unmanned aircraft systems and on third-country operators of unmanned aircraft systems*, 2019.
- [5] European Commission. *COMMISSION REGULATION (EU) No 1321/2014: on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks*, 2014.

