

# Human Factors in the Maintenance of Unmanned Aircraft Systems



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# The Cost of Maintenance Error

- 20% to 30% of airline in-flight engine shutdowns at a cost of US \$500,000 each<sup>1</sup>
- 50% of airline flight delays due to engine problems at a cost of US \$10,000 per hour
- 7 of 14 recent US airline accidents<sup>2</sup>



# Typical Maintenance Errors

- Parts not installed, incomplete installation, wrong locations, cross-connections <sup>1</sup>
- Incomplete installation, incorrect assembly or location, vehicle/equipment contact, foreign object damage (FOD) <sup>2</sup>



# Project Objectives

- How does the maintenance of small UAVs differ from maintenance of conventional aircraft?
- What are the skills and training requirements for UAV maintenance?

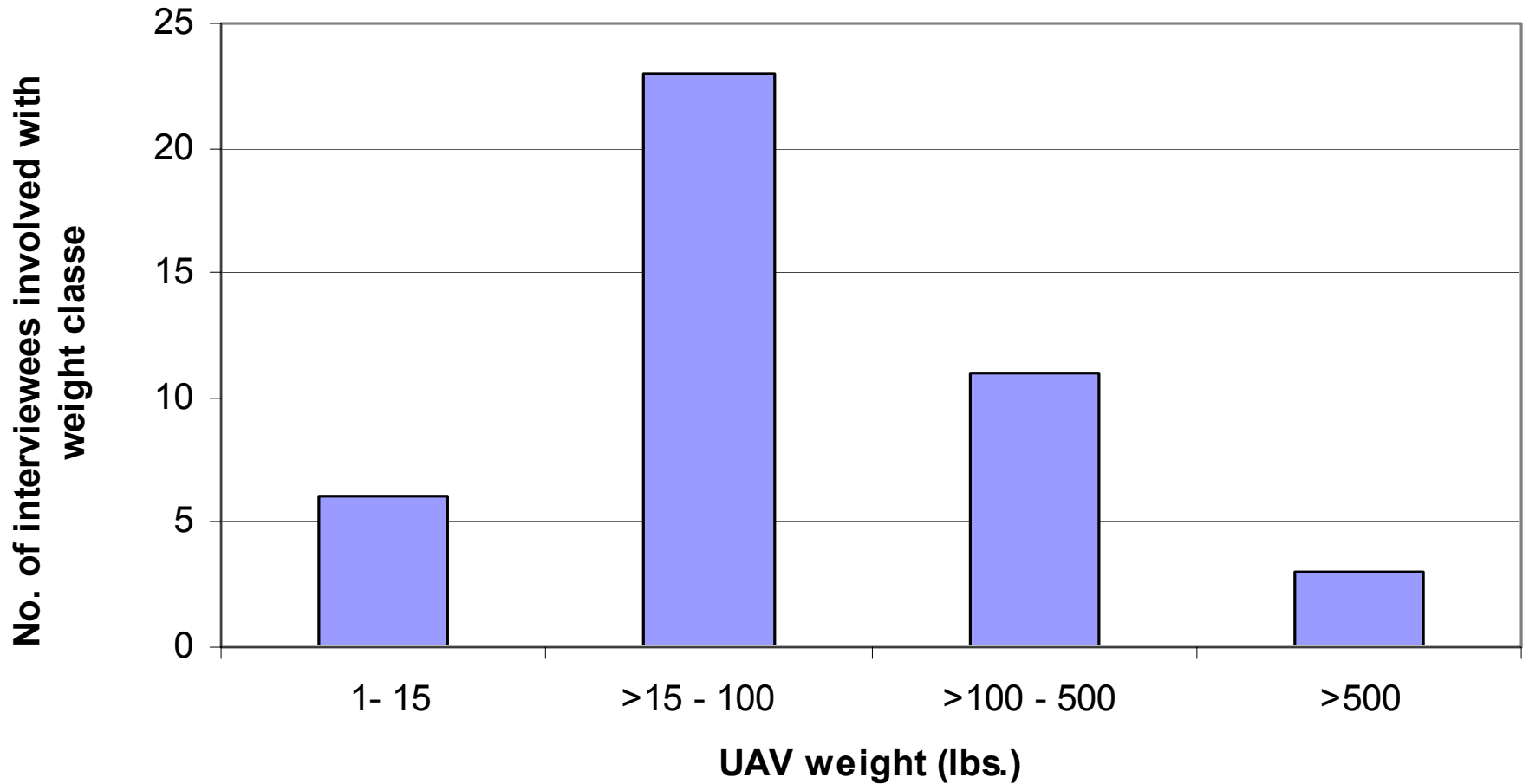


# Approach

- Literature review
- Focus on UAVs < 500 lbs
- Structured interviews with 31 UAV operators
- Discussions with subject matter experts, site visits



## Weight classes of UAVs



Documents



Hardware



Computer systems



Personnel



Personnel

# Hardware-Personnel issues (1)

- Total system includes vehicle, ground station, transmitter, launcher
- Packing, transport & assembly
- Distinction between payload and aircraft
- Salvage decisions
- Modularity & “repair by replacement”
- Return to manufacturer





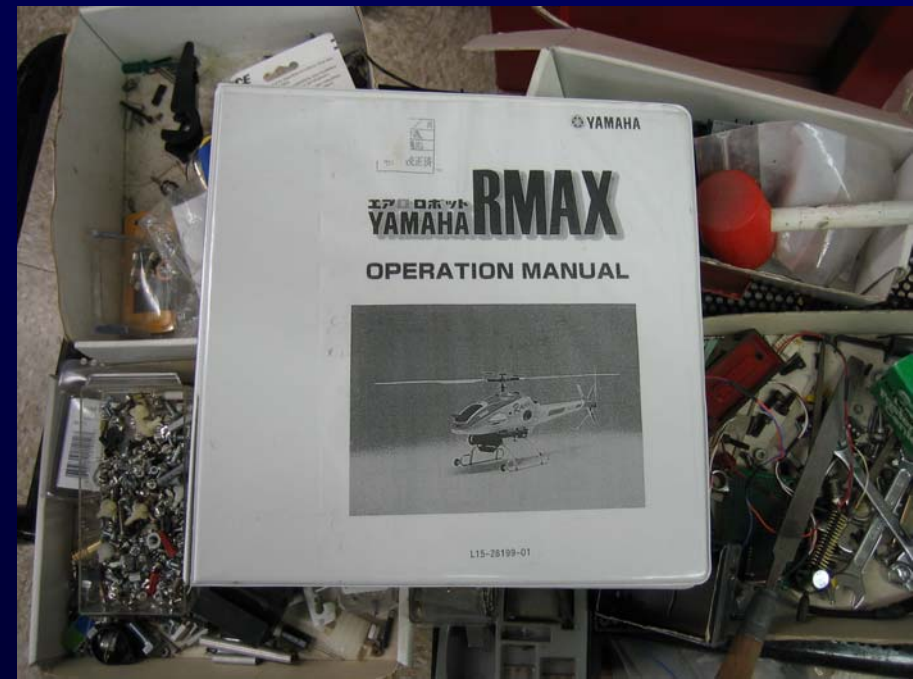
# Hardware-Personnel issues (2)

- Absence of information on component failure modes & rates
- Lack of parts numbers
- Recording of flight hours
- The “woodman’s ax” problem
- Access difficulties & small size of components
- Unconventional propulsion systems
- Battery maintenance
- Composites
- Fuel mixing & storage



# Documentation-Personnel issues

- Lack of maintenance documentation
- Poor standard of documentation
- Lack of reporting systems



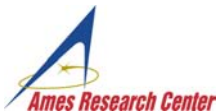
# Computer-Personnel issues

- Extensive use of computers
- Need to understand software
- Autopilot software management
- Increased reliance on computer records of flight



# Personnel issues

- Operator and maintainer may be the same person
- Emphasis on software, radio transmission, electronics
- Need for wide skill set
- Lack of direct pilot reports
- “Model aircraft culture”
- Potential for complacency



# Conclusions (1)

- UAV industry 2006 = Automobile industry 1906?
  - Diversity makes it hard to specify requirements
- Large UAVs generally maintained to same standards as conventional aircraft
- UAV maintenance is more than just the aircraft
- Laptops now an item of flight hardware
- For small UAVs, DOD approach vs RC hobby approach



# Conclusions (2)

- Manufacturers involved in maintenance
- Information management challenges
  - Need for a UAV incident reporting system
  - Component failure rates
  - Improved maintenance documentation
- Miniature aircraft may need very little maintenance
  - *“No user-serviceable parts inside”* ?



# Contact us

We welcome de-identified reports of UAV maintenance incidents, case studies, & comments.

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