ISO Standards – A Practical Appplication

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1 Scope

The purpose of this document is to analyse how the ISO 21384 series of international safety and quality standards could be applied against a number of real-life issues presented by Network Rail.

2 Introduction

The current design authority regulations for UAS is not fit for purpose. The industry is saturated with manufacturers from around the world with a huge number of commercial platforms becoming available on the market with no dedicated product standards available by which to measure their suitability for task in terms of safety and quality. Many platforms continue to advance, introducing further unstandardized technology to enhance safety or performance. Sadly, the CAA is not able to keep pace and so the regulations rely purely on a manual assessment of the pilot's competence and technology's suitability for commercial use. This approach relies on CAA officers having an intimate knowledge of all emerging technology which, in an under-funded, over-stretched organisation, is neither practical or realistic.

2.1 Operational Challenges

The following specific issues are real-life consequences of not having an Acceptable Means of Compliance for UAS Operations.

2.1.1 Maintenance of Airworthiness

Unlike the military environment, guidance on maintenance of airworthiness for civil UAS is entirely lacking in current UK regulations and guidance. This is causing significant issues for operators who need to ensure:

- The fitness of aircraft and sub-systems for operations
- The fitness and suitability of UAS pilots

2.1.2 Operational Approval Process and Licensing

The current approval process is normally single use case and is too long and drawn out for limited application, only utilised for singular drones per operator (drone in a box/swarm technology hindered) and often set out and approved for limited timeframes, specific dates afforded and within some form of segregation (TDA) which affect the potential of the platforms operating envelopes and normally placed in a benign environment where the goal isn't easily achievable or realistic.

2.2 ISO 21384-3 – UAS Operations standards

ISO 21384-3 – UAS Operations has extensive guidance for operators of all classes of UAS and could be used by Government as an acceptable means of compliance. Indeed, CAP 722 could now be reduced in size, existing as a set of exceptions and exclusions to ISO21384-3 and its sister standards which are developing to cover the training of UAS Pilots, maintainers, monitors and operators. This would save valuable CAA time and resources, leaving the industry to rapidly evolve the acceptable means of compliance.

2.2.1 Currently, ISO 21384-3 covers

- Safety management system requirements
- Safety policy
  - Requirements for Operators conducting UAS operations in VLOS or EVLOS
  - Additional requirements for Operators conducting UAS operations in BVLOS at VLL
  - Additional requirements for operators conducting UAS operations in controlled airspace, above VLL and under IFR and for C2CSP
  - Tasks of the Compliance Monitoring Officer (COMO)
  - Tasks of the Safety Officer (SAFO)
- Security
  - Requirements for Operators conducting UAS operations in VLOS or EVLOS
  - Additional requirements for Operators conducting UAS operations in BVLOS at VLL
  - Additional requirements for Operators conducting UAS operations in controlled airspace, above VLL and under IFR and for C2CSP
  - Tasks of the Security Officer (SECO)
- Data protection — operator requirements
- Operator Documentation
  - Documents held by the UAS operator
  - Documents to be available at the point of operations
- Insurance requirements
- Airspace
  - Compliance with airspace regulations
  - Airspace information
- Operations above 500 ft (150 m)
- Special zones above flight level (FL) 600
- Facility and equipment and requirements
- Registration
  - UA identification
  - Compatibility
- Operations
  - Flight operations
  - Operational plan — Flight planning
  - Flight preparation
  - Pre-flight inspections
  - Communication planning
  - In flight operations
    - Responsibilities of the remote pilot in command (RPIC)
    - Operational limitations
    - Transfer of functions and responsibilities
    - Multiple UA operation
    - Autonomous operations
    - Communication and airborne functions for UTM
    - Operations at night
    - Surface/ground operations
    - Journey log
    - Abnormal and contingency procedures
  - External services
    - UAS functions interacting with UTM
    - Oversight of contracted service providers
    - C2 Communication Service Provision (C2CSP)
  - Personnel qualification and management
  - Maintenance
  - Hardware updates
  - Software updates
  - Service release
  - Configuration management
- Conflict management
- Separation provision and Collision Avoidance
- Operational procedure

2.3 Product Challenges

The following specific issues are real-life consequences of not having an Acceptable Means of Compliance for UAS Products.

2.3.1 Noise

Noise is a significant concern during operations not just over the rail or by night but within all sectors and to all operators and the public. However, no guidance as to acceptable levels of noise for commercial operations. Coupled with the issue of a lack of minimum product standards for UAS, it is impossible to know what UAS are suitable.

2.3.2 Data Security

Network Rail faces a significant threat from loss of data to other countries and doesn't truly understand where this is captured, recorded or how it is utilised. As the rail infrastructure is Critical National Infrastructure (CNI) this is very important issue.

2.4 ISO 21384-2 – UAS Product standards

ISO 21384-2 (Parts 1 & 2) covers the safety and quality requirements for manufacturers of UAS (aircraft and sub-systems). This standard has been created to provide an AMC for manufacturers of aircraft and subsystems and, while it is not exhaustive, it includes a number of subsystems including tether technology, attachments requirements and, as per 21384-3, is under constant review so, if it does not cover what you need, I would again urge you to engage with the work ISO WG2 and WG6 are conducting to ensure that it does.

The benefit of complying with these standards is that the CAA will (in time) accept your compliance at this level as an AMC for the technology that you are using. This is, of course, a gross oversimplification and we have some way to go but, if you wish to simplify the processes that you are facing in time, this is the way forward. Not engaging in this work won't mean that it will not be accepted as an AMC by the CAA, it just means that you will not have had an input to it. I hope that makes sense, but I am happy to explore this with you if you would like to discuss it in more detail.

2.4.1 Areas covered by ISO 21384-2 Part 1 & 2 currently covers:

- General design requirements
  - Function and Reliability
    - Design
    - Components
  - Maintainability and supportability
    - Design
    - Documentation
    - Support
  - Fatigue durability
  - Transportation, storage and packaging
- Aircraft Structures
  - General requirements
    - Fatigue evaluation and damage tolerance
    - Conspicuity
    - UA Construction
    - Moving parts
    - Attached parts
  - Aircraft identification
- Propulsion
  - Propulsion risk management
  - Engines and motors
    - General requirements
    - Mounting and Installation
    - Combustion engines
    - Electric motors
    - Electronic speed controller (ESC)
  - Thrust mechanisms
    - Propellers and Rotors
    - Turbine and fans
- Electrical systems
  - General
  - Electrical Safety
  - Ground electrical systems
    - RPS power system
    - Labelling
- Energy sources
  - Batteries
    - General

        - Protective measures
        - Precautions
    - Fossil fuels
    - Fuel cells
        - General requirements
        - General safety requirements
- Avionics
    - Avionic equipment - general
    - Flight control systems
        - General requirement
        - Flight Control Hardware
        - Flight Control Software
        - Course accuracy
        - Airspeed
    - Flight control actuator
    - Diagnostics
    - Navigation Systems
        - General
        - Global Navigation Satellite System (GNSS) Receiver
        - Real Time Kinematic (RTK) Augmentation
        - Inertial measurement unit (IMU)
        - Magnetic compass
    - Attitude Sensors
        - Altimeter
        - Airspeed sensor
        - Optical sensor
    - Redundancy
        - Hardware redundancy
        - Software redundancy
    - Failure modes
- C2 Link
    - Antenna module design
    - C2 Link
        - Operations
        - C2 Link Security
        - C2 Link protocol
    - Data Features
        - UA status Data
        - Delay requirements
    - Reliability Requirements
    - Security Requirements
- Remote Pilot Station
    - Features
        - Data monitoring systems
    - Design requirements
        - System
        - Structure
        - Ergonomics design
    - Functional requirements
    - Mission planning
    - Data Link control
    - Flight Control Commands
    - Displays
        - Instrumentation
        - Readability
        - Accuracy
        - Warnings, cautions, and advisories
        - Display/interface failures
        - Track and parameter display
        - C2 Link status display
        - Telemetry parameter record
    - Performance requirements
        - Environmental adaptability
        - Reliability
    - Safety
    - Collision avoidance (CA) systems
- Payload
    - General requirements
    - Payload safety marking
        - Wiring design
        - Payload power supply
    - Storage requirement
- Airworthiness
    - Documentation
        - Instructions
        - Manuals and handbooks
        - Process changes
    - Composition of an operator's manual
        - Flight performance
        - Aircraft weights
        - Flight control accuracy.
        - Dimensions
        - Atmospheric and other environments adaptability
        - Mechanical Environment adaptability
        - Electromagnetic compatibility considerations
        - Noise
    - Self-testBuilt-in test and monitoring
    - System safety program
        - Selection of design materials
        - Properties and processes
        - Corrosion
        - Material limitations
        - Design considerations
        - Equipment separation

- UAS software
  - Software architecture and design
    - Safety
    - Security
  - Software compliance
  - Software development life cycle
- Other considerations
  - Ground Support Equipment
  - Multi-vehicle control
  - Jamming and spoofing
- Automation
  - General
    - Software development lifecycle
    - Remote pilot intervention
    - System data collection
  - Automation risk assessment
  - Automation system architecture

Annexes
Software risk management (informative)
Electromagnetic environmental effects (E3) (informative)

2.4.2 ISO/24356:2021(E) - Tethered UAS Systems (in final stages of publication), covers:

- System general requirements
  - General requirements
  - Composition of tethered UAS
  - Design for long-duration reliability
- Operator's manual requirements
  - System performance
  - Weight limits
  - Electrical characteristics
  - Environmental characteristics
  - Fatigue endurance and life characteristics
  - Paintings and markings for tethered UAS safety
  - Lighting
  - Others
- Airborne monitoring system
  - General functions
  - Monitoring software
  - Wireless data transmission module
- Propulsion and electrical system
  - Propulsion system
  - Electrical system
    - Airborne electrical system
    - Uninterruptible power system (UPS)
    - Ground electrical system
- Power transportation system
  - Tethering cables
  - Automatic winches
- Remote Pilot Station (RPS)
- Test verification
  - Test purposes
  - Test content

3 Conclusion

Over the last few years, the CAA has not had the resources to keep pace with the unprecedented evolution of UAS technology. In general aviation, the military environment and for operations where manned aviation certification is required, maintenance of airworthiness and product requirements are well-documented, and an approval process exists. While this process would not be suitable for operations and technology in the specific class, a comparable Acceptable Means of Compliance is required and the ISO Safety and Quality standards provide an opportunity to achieve this while, at the same time, easing pressure on the CAA.

As has been mentioned in the main paper, changing regulations is difficult at the best of times but, with the CAA not able to cope with demands from a rapidly evolving industry, regulations may never be in a position to support viable commercial operations which could destroy inward investment, driving it instead to those countries who have established more flexible approaches.

4 Supplementary Information

4.1 About the Authors

Rikke Carmichael is Head of Air Operations at Network Rail and leads a specialist team that manages aerial data surveys using helicopters and drones. This valuable data is used to improve rail safety, plan preventative maintenance and help identify potential issues before they can impact the rail infrastructure.

A native of Denmark, Rikke has extensive experience in aviation. As a professional helicopter pilot in the USA, she flew for various operators and from a business perspective, she spent six years with Boeing Defence UK. During this period, she played a significant role in the development of the training programme for the C17 Globemaster III. Later, as a Campaign Manager, she successfully secured the through-life training contract with the RAF. Rikke has been with Network Rail since 2018 and is always exploring opportunities to improve and implement new technologies that can benefit aerial data capture and exploitation.

Rikke is a member of the following drone groups:

- BVLOS Operations Forum
- Drone Delivery Group (DDG)
- Drone Industry Action Group (DIAG)
- EIM WG Drones (European Rail)
- National Infrastructure Drone Strategy Group (NIDSG)

Robert Garbett is a qualified aeronautical engineer who served as the senior engineer for Army Special Forces Helicopters and, later in his career, was responsible in the development of many of the tri-service policies for aircraft maintenance across all three services which included all military UAS. Later, as Airworthiness 1 for the Defence Logistics Agency (DLA) he was the lead for the development and maintenance of the airworthiness policies for all British military aircraft including military UAS.

Since leaving the Army, Robert has been appointed to the following positions:

- **British Standards Institute (BSI) -** Chairman of ACE20 which is responsible for UK UAS and Counter UAS safety and quality standards.
- **International Standards Organisation (ISO) -** Convener of TC20/SC16 Working Group 3 responsible for the creation of the International Standards for the operation of UAS and member of the Committee Leadership Team.
- **European Committee for Standardization -** Committee member of the Aerospace and Defence Industries Association of Europe (ASD-STAN) Domain 5 responsible for the development of European Certification Standards for UAS.