UK Research and Innovation

Future Flight Initial Safety Framework

egis

University of York

Background

The Future Flight Challenge is a UK Research and Innovation (UKRI) initiative that will support the development, in the UK, of new aviation technologies such as freight-carrying drones, urban air passenger vehicles and hybrid-electric regional aircraft that will transform the way that people and goods fly. The challenge also supports the development of the necessary ground infrastructure, regulation and control systems required to use these new aircraft safely.

Effective management of an increased volume and diversity of aircraft operating in urban, suburban and rural environments will present safety challenges that the current safety management and assessment approaches are unable to fully address. New approaches are therefore required that will enable the safe development and integration of new aircraft types into the existing aviation system and the ongoing development of that aviation system to meet the needs of society moving forward.

Scope

The use cases selected for the project were:

1. Drones, which comprises three sub-use cases:
   a. drones for delivery,
   b. drones for inspection/monitoring/broadcast and
   c. drones that perform robotic functions (e.g. repair, crop spraying)
2. Urban Air Mobility (UAM)
3. Regional Air Mobility (RAM)

To ensure key safety challenges are identified and addressed early in the evolution of UK aviation, transversal themes were identified which are likely to have the greatest impact on safety across all use cases. Four transversal themes were identified for the project:

1. Safety management of complex systems
2. Integrated risk and safety management
3. Role of the human and autonomy
4. Supporting infrastructure

Scenarios

Three scenarios were defined to represent the evolution of the (future) aviation system over different time horizons and represent a realistic progression of the technological, operational and regulatory aspects of the aviation system. The scenarios are represented using an actor/interface diagram approach showing the key service providers, aircraft, vehicles or infrastructure within a single system. Extracts from the short- and long-term diagrams are shown below as examples.

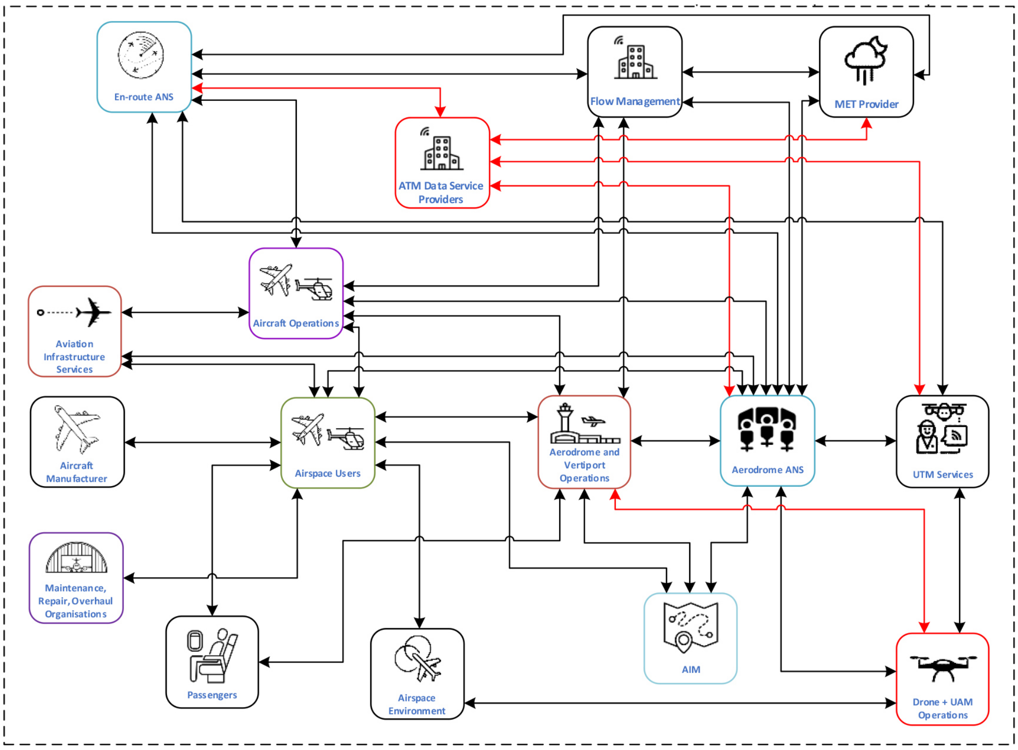

Figure 1 – Short-term actor diagram.

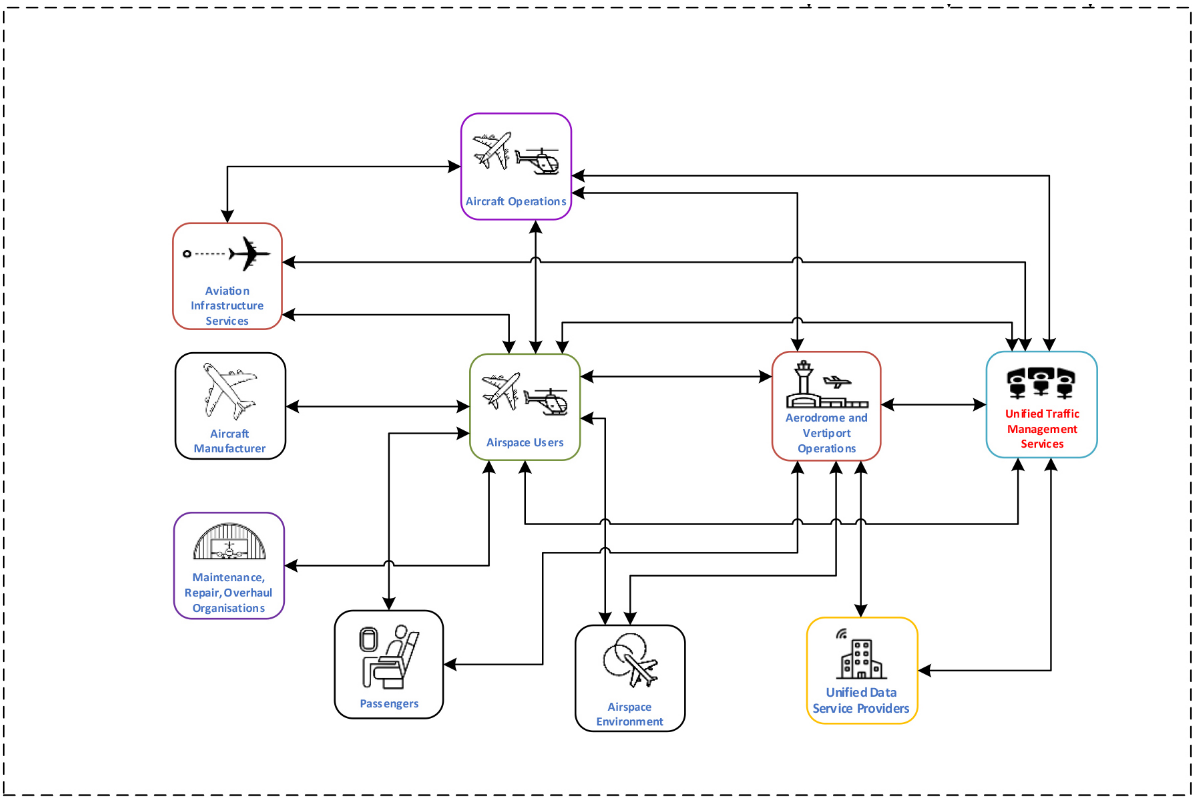

Figure 2 – Long-term actor diagram

Developing the initial safety framework

There were two principal workstreams that contributed to the development of the framework as described below.

- Use of the complex systems framework to develop requirements / approaches relating to management of complex systems – this addressed the "softer" organisational and management system related elements of safety performance.
- Use of bowtie analysis to understand and develop technical requirements relating to hazard/consequence mitigation – this addressed the "harder" technical requirements on the "system" to deliver an acceptably safe performance.

Use of the Complex Systems Framework

The analysis centred on identification of relevant design-time and operation-time controls that mitigate causes and consequences of system complexity and help to manage the safety challenges of complex systems.

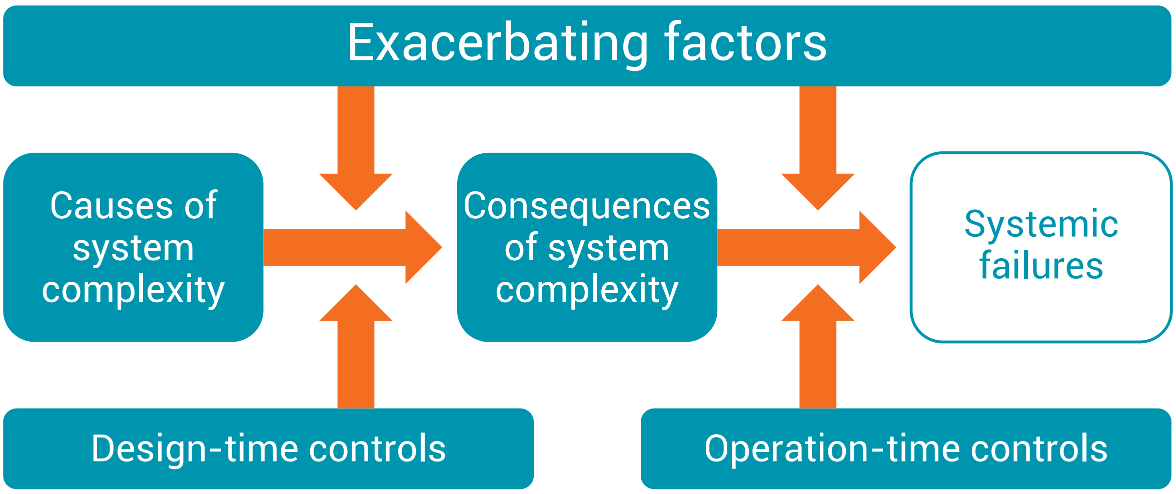

Figure 3 – Safer Complex Systems Framework Elements.

This analysis produced a set of recommendations and activities that were categorised into different stakeholder groups. A summary of these recommendations and activities are shown below:

Governance Organisations (Policy and Regulation) Recommendations

- Development of appropriate standards / regulations / law using either current standards and/or outcome-based standards supported by Acceptable Means of Compliance (AMC)
- Ensure appropriate engagement at all levels of the industry and between regulators and the industry
- Ensure approaches and measures are in place to drive safety performance including derivation of appropriate target levels of safety, proactive incident and accident analysis, operational monitoring and active alerting practices

Standards/Professional Bodies, Industry Organisation Recommendations

- Identify key areas where industry community guidelines would support safety assurance of future flight and produce a roadmap for their development
- Establish means for industry-wide learning from future flight (FF) complex systems incidents and accidents, with a particular focus on smaller FF participants

Supporting Infrastructure Providers Recommendations

- Ensure supporting infrastructure providers publish Concepts of Operation (CONOPS) to enable FF technology development
- Ensure supporting infrastructure has a roadmap for Publicly Available Specification (PAS) development which aligns with FF technology development and associated PASs

New Entrants Recommendation

- Ensure FF new entrants understand and adopt the mature aviation industry safety management practices

New Technology Developer and Future Flight Operator Recommendations

- Ensure new FF technology development has strong engagement with aviation and urban industry stakeholders and is cognisant of the future landscape.
- Ensure appropriate stakeholder diversity and inclusion in FF concept and system development
- Ensure incremental delivery roadmaps are used to strategically work towards radical change in FF operations
- Ensure new technology and systems apply design for assurance principles

Current Aviation Industry Recommendations

- Ensure that all aviation system participants consider the changing aviation system landscape and how FF operations will impact the safety of their operations
- Ensure aviation safety change management practices are adapted to manage the dynamic and complex nature of FF change

Bowtie analysis

The activities included detailed safety analysis of the future aviation system across the three scenarios and use-cases described earlier. It used the bowtie modelling concept to provide a pictorial representation at a conceptual level of the relationship between hazards, top events, causal chains (known as threats) and consequences. An example is shown in Figure 4.

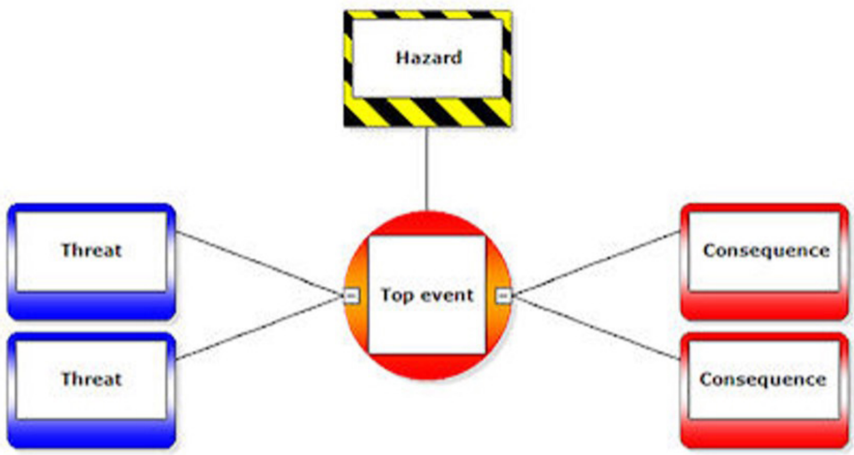

Figure 4 – Example bowtie diagram.

It is therefore ideal as a tool for understanding risk at a conceptual level for programmes early in the development lifecycle hence is well suited to the FF programme.

The bowtie approach has been applied to FF to achieve the following objectives:

- Understand the impact of FF on the risk of existing UK aviation operations
- Understand the new hazards and risks associated with FF

The approach is focused at a strategic level and, for each hazard, identifies the key controls from a preventive and mitigative perspective that can reduce the risk associated with the consequences of each hazard. It is not intended to be an exhaustive or detailed exercise that identifies all potential controls but focuses on identifying the controls that comprise the following strategic defences against aviation risk:

- Design (airspace, aircraft, system) features providing inherent protection against the hazard and/or consequences
- Strategic controls such as flow management as provided by Air Traffic Management
- Tactical controls such as separation provided by Air Traffic Control
- Pilot see-and-avoid (more generically known as detect and avoid in the future)
- ACAS (an automated collision avoidance system)
- Emergency response planning

An example bowtie model created as part of this study is shown in Figure 5 including a number of the strategic defences that have been highlighted.

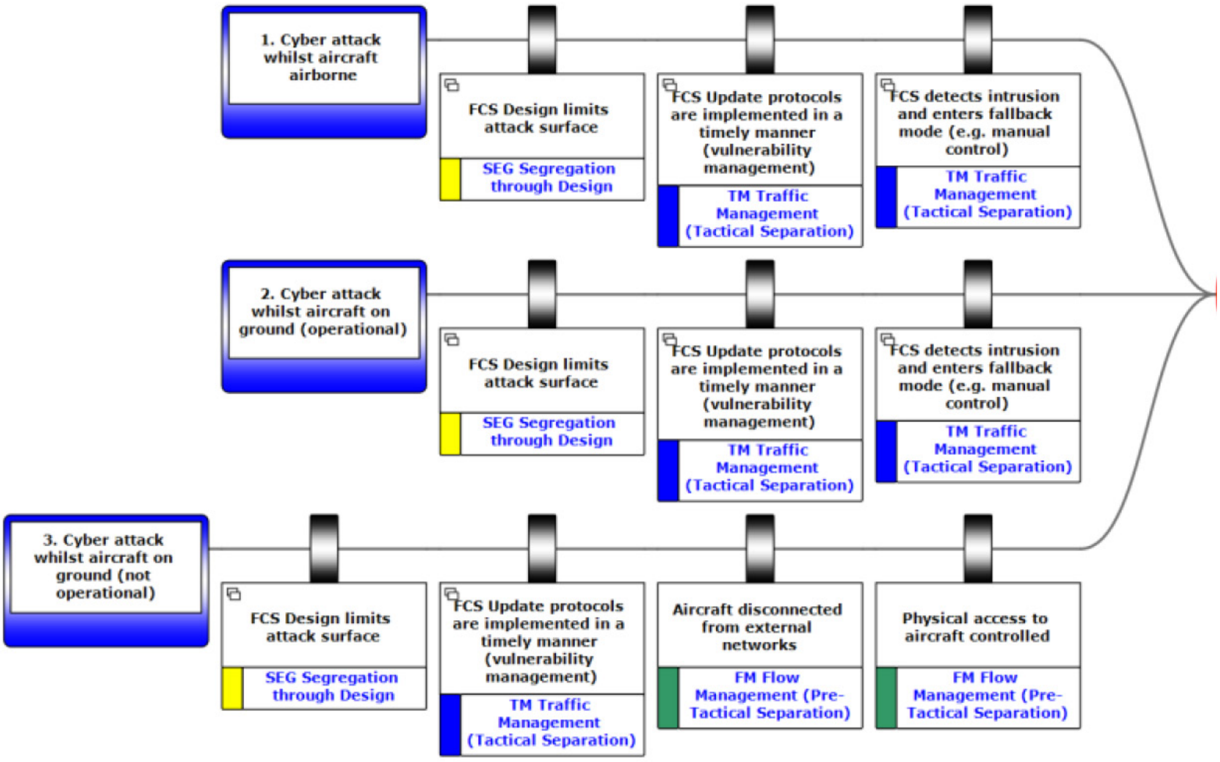

Figure 5 - Bowtie model showing strategic defences.

Conclusions and recommendations

The analysis conducted to date has described the key contextual components for an initial safety framework for FF. This framework is particularly focussed on the top layers of a safety case which sets out the safety argument strategy for demonstrating the overarching goal has been met with respect to FF. Given this is the first iteration of this framework, many of the goals outlined are not yet satisfied with appropriate evidence. The aim of presenting the framework at this stage is to indicate what activities are required to achieve the intent of the overarching safety case. This is similar in nature to the development of an initial safety argument during a safety change management activity, which then can be used to inform safety planning.

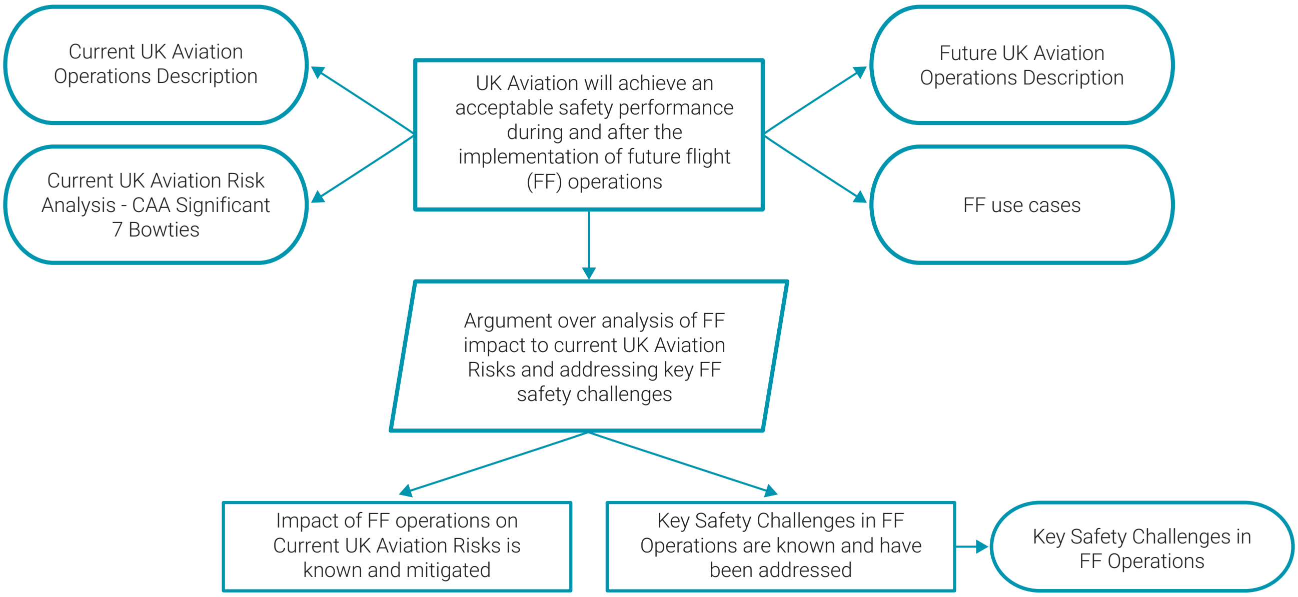

Figure 6 – Top level argument for the FF Aviation Safety Framework.

The analysis identified many recommendations which will contribute to assuring the acceptably safe integration of FF operations into a future aviation system. They relate to all aspects of the system and the stakeholders within it and act as a starting point for further development. The highest priority recommendations are listed below with the remainder listed in the main report.

The priority recommendations are intended to set the basis and an associated programme of work for addressing the many other recommendations in the report. They also provide the mechanism for establishing a form of governance organisation to oversee the associated programme of work and ensure that it continues to meet its objectives as the programme develops.

Recommendation 9.1	Development of a concept of operations for the future aviation system which includes transitional states.
Recommendation 9.2	Establishment of Target Levels of Safety for aircraft operations, including specific FF use cases.
Recommendation 9.3	Establishment of an aviation system risk baseline made up of both the current risk profile and the future expected risk profile, based upon future concepts of operations.
Recommendation 9.4	Prioritisation of the issues and recommendations in the report and the establishment of a safety work program in support of the FF challenge. This should include, amongst other things, a plan for managing the impacts of complex systems at the Governance, Management and Task/Technical layers. This should also include consideration of the many more detailed recommendations in the report. Consideration should be given to placing the responsibility for developing and delivering this plan on a pan-industry body or, establishing one specifically for this purpose.

The following recommendations recognise the importance of wide engagement and consultation across the industry such that coordinated and effective development of the work can take place.

Recommendation 9.5	Presentation of the analysis and recommendations to FF participants and the wider UK aviation community to: • Seek feedback on the completeness of the analysis and prioritisation of issues; and • Inform planning of future work across all aviation stakeholders.
Recommendation 9.6	Expansion of the concepts to the full UK aviation system (including other new aviation concepts such as High Altitude Platforms and autonomous Commercial Air Transport).
Recommendation 9.7	Identification of other additional key safety challenges that can have a critical impact on the success of future UK aviation, both within the scope of FF and other aviation innovation activities.
Recommendation 9.8	Establishment of an international engagement strategy and plan to ensure that the UK remains central to developing and influencing globally harmonised approaches and standards.

The recommendations and actions provided above and in the main report are now the subject of ongoing discussions between industry and the regulator to determine the most effective way forward. These discussions are taking place in parallel with the necessary engagement activities with industry, academia and relevant government agencies.

However, we would value feedback on the study outputs and conclusions to inform the discussions and decision-making on the most effective way forward.

Please send any feedback to:
simon.masters@innovateuk.ukri.org

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