



International Civil Aviation Organization

WORKING PAPER

AN-Conf/13-WP/205

26/9/18

(Information Paper)

English only

THIRTEENTH AIR NAVIGATION CONFERENCE

Montréal, Canada, 9 to 19 October 2018

COMMITTEE A

Agenda Item 5: Emerging issues

5.5: Other emerging issues impacting the global air navigation system including unmanned aircraft systems (drones), and supersonic and commercial space operations

INTEGRATING PUBLIC SAFETY STANDARDS FOR COMMERCIAL SPACE AND AVIATION

(Presented by the United States)

EXECUTIVE SUMMARY

Every day, air navigation service providers (ANSPs) work to safely and efficiently manage a diverse mix of operations in the global airspace. Commercial space launch and re-entry operations are becoming an increasingly more significant part of this mix. Traditionally, ANSPs restrict other airspace users' access to volumes of airspace assigned to a space launch or re-entry to ensure that these other users are kept safely away from the potential hazards. Until recently, the United States Federal Aviation Administration (FAA) applied a target level of safety that evolved from the space industry to size these airspace restrictions. Having evolved at different times and under different circumstances, this space industry target level of safety differs from the aviation industry target level of safety in terms of terminology, numeric value, and relative stringency. Simply imposing the target level of safety of one industry on another would have significant consequences. As such, integration of aviation and space operations goes beyond techniques to manage the airspace, to include the integration of their different safety standards. To address this challenge, the FAA has developed an intermediate solution in the form of an acceptable level of risk approach that applies safety principles from both industries. This paper describes that approach, and its application to space launch and re-entry operations.

1. INTRODUCTION

1.1 In the United States, the commercial aviation and commercial space industries originated and evolved under different circumstances. While some commonality exists across the industries in the approaches used by regulators and safety professionals to ensure public safety, the target levels of safety used in the two industries are not directly comparable. As commercial launches and re-entries are becoming more frequent, more complex, and more global in nature, Air Navigation Service Providers (ANSPs) and civil aviation authorities (CAAs) must consider this difference as they take steps to integrate commercial launch and re-entry operations into the global airspace system.

1.2 Acknowledging that the two target levels of safety are not the same, a simple resolution could involve the imposing of one industry's standards on the other. But in this case, such a resolution could have drastic, negative consequences. Since public safety during launch and re-entry operations is achieved primarily through the use of segregated airspace, increasing the amount of airspace that must be segregated during an operation could be extremely detrimental to the global airspace system's efficiency and capacity. At the same time, an ANSP providing air traffic services to different types of operators operating at different levels of public safety risk could also be very problematic. The FAA has identified and implemented an alternate approach, known as acceptable level of risk (ALR).

2. DISCUSSION

2.1 Public Safety in Aviation

2.1.1 Traditionally, aviation safety authorities have focused on the management of risk to individual aircraft operating in the airspace at a level commensurate with the high number of air traffic operations that occur every day. In the United States, the FAA's Air Traffic Organization (ATO) provides air traffic services to over forty thousand aircraft each day. Accordingly, the ATO has established a target level of public safety for air traffic related hazards of no more than one catastrophic accident per one billion air traffic control (ATC) operations (or flight hours), where a catastrophic accident is defined as an accident that results in a fatal injury to a person on board or a hull loss. In practice, this can mean that no more than one in one billion clearances from an air traffic controller to an aircraft may result in a fatality to a person on board the aircraft or hull loss.

2.1.2 Traditionally, the ATO has not applied a collective risk limit as part of its target level of safety. A collective risk limit would establish a maximum risk to which all aircraft could be exposed in a given period of time.

2.2 Public Safety in Commercial Space Transportation

2.2.1 As the space industry has accumulated data and operational experience, space safety authorities in the United States have employed both individual and collective limits to ensure the protection of the public. Currently, the FAA's Office of Commercial Space Transportation (AST) uses a target level of public safety for individuals of no more than one casualty in one million launch or re-entry operations, where a casualty is defined as a serious injury requiring hospitalization or a fatality. In practice, AST regulations restrict access by the public to locations on the ground, on the sea, and in the air where the risk to a person of becoming a casualty as a result of the launch or re-entry would exceed one casualty in one million operations if a person were present in that location during every operation. A risk analyst identifies these locations by establishing a geospatial grid over an area of interest on a map, and then computing the risk to an individual at each grid point. The analyst encloses grid points of common orders of risk magnitude into geospatial areas known as contours. Generally, risk decreases with increasing distance from the risk source, which in this case is the launch or re-entry vehicle. So a one in ten million contour lies beyond a one in one million contour, a one in one hundred million contour lies beyond a one in ten million contour, and so on. Per regulations, all contours in which the risk to an individual would exceed one casualty in one million operations must be evacuated of members of the public in order for a launch or re-entry to take place. On the ground, these evacuated areas are known as land hazard areas. On the sea, they are known as boat or ship hazard areas. And in the air, they are known as aircraft hazard areas (AHAs). AHAs are often referred to as segregated airspace, since ANSPs provide air traffic control services that segregate operations within an AHA from other airspace users.

2.2.2 AST also imposes a collective risk limit on all launches and re-entries of no more than one public casualty in ten thousand operations. This risk limit is quantified as “expected casualties”. In practice, a risk analyst computes expected casualties based on three factors: the likelihood of an event that could generate falling debris; the area within which the debris generated would create a casualty; and the density of the exposed population. A product of these three factors is computed for all reasonably foreseeable failure events, and the sum of these products represents the expected casualties. Currently, AST applies its collective risk limit only to members of the public located on the ground.

2.3 Comparison of Target Levels of Safety

2.3.1 While the different target levels of safety described above have existed for some time, the increasing frequency and complexity of commercial launch and re-entry operations have prompted the FAA to examine the nature of these differences. Experts from across the FAA put extensive time and effort into this examination, comparing the numerical values and the definitions of the terms used in the respective target levels of safety to determine if they could be aligned or even translated. Key differences exist in the numerical values of the likelihood values (one in a million vs. one in a billion), the limits on consequence or severity (casualty vs. fatality), and the time interval over which the risk is considered (per launch or re-entry operation vs. per ATC operation or flight hour).

2.3.2 Simply increasing the size of an AHA computed at a one in one million probability of casualty to a one in one billion probability of casualty could add thousands of miles to its dimensions. For example, an AHA for a launch from Cape Canaveral computed at the one in one billion probability of casualty could extend uninterrupted from the coast of Florida to the middle of Europe or beyond. The current techniques used to compute AHAs appear to overestimate the actual risk to an aircraft in transit by a factor of ten. Thus, the maximum risk to an aircraft transiting the area at the boundary of an AHA computed at one in one million is actually less than one in ten million. This order of magnitude difference is an order of magnitude below the AST-required limit, but it is still more than an order of magnitude above the ATO-required limit. This difference results from the assumption used in the grid analysis method described above that the exposure of an aircraft at each grid point is constant during the entire launch or re-entry operation, even though its exposure actually varies with time as it transits the area.

2.3.3 The difference between casualty and fatality is not as significant numerically. Physics-based models capable of discerning the level of injury suffered by an individual when struck by debris demonstrate that protecting to a severity level of casualty affords only about 2.5 times more protection than protecting to a severity level of a fatality.

2.3.4 A more significant difference lies in the time interval. A launch or re-entry operation can unfold over a period of several minutes. ATC operation is determined by counting the number of aircraft for which an air traffic facility provides a service, and the service provided follows the guidelines within FAA Joint Order 7210.3, Chapter 12. When considering a time interval in the form of an individual ATC operation, the risk must never exceed the ATO limit, making it considerably more stringent than the AST limit in this context. At the same time, a launch or re-entry lasts minutes and not hours, as does the time required for an aircraft to transit a launch area, meaning a comparison of the time interval in terms of flight hours, which might otherwise allow for averaging, is also not valid.

2.4 Acceptable Level of Risk

2.4.1 Fortunately, a reasonable compromise between the two safety levels can be achieved through procedural changes to the way that the ATO manages air traffic in the vicinity of a launch or re-entry operation. These changes incorporate three key elements: the application of an intermediate

adjustment in individual risk; operational restrictions; and a new collective risk limit. Together, these elements are the basis of the ALR approach.

2.4.2 Recognizing the order of magnitude relationship described above between the risk associated with an AHA computed using a grid analysis method and the risk to an aircraft transiting the area, the FAA has selected a probability of one in ten million as the individual risk limit for use in the ALR approach. This allows the FAA, its safety partners, and the industry to continue their current practice of constructing AHAs at the one in one million risk level as they have done, using a grid analysis method. Air traffic controllers continue their practice of prohibiting aircraft from entering AHAs.

2.4.3 Moreover, FAA analysts use a grid analysis method to compute two additional boundaries of airspace that lie beyond the AHA: a boundary at the one in ten million risk of fatality level and a boundary at the one in one hundred million risk of fatality level. Extensive modelling, under different assumptions, established that the difference between the results of a grid analysis method and a method that models the variation in exposure of a transiting aircraft is roughly one order of magnitude. So here, the one in ten million risk level computed using the grid method relates to a one in one hundred million risk when the aircraft transits the area. Likewise, when an aircraft transits the area associated with the one in one hundred million risk level computed using the grid method, it relates to a one in one billion risk. When computing these risks, fatality is used in place of casualty to retain more commonality between the ALR approach and the ATO target level of safety.

2.4.4 Any aircraft transiting an area beyond the AHA but at a one in one hundred million risk of fatality or higher is still being exposed to risk above the ATO's target level of safety, so the ATO counts it as an exposed aircraft. The ATO applies operational restrictions on exposed aircraft flying in the area beyond the AHA but at a risk higher than one in ten million risk of fatality to minimize the duration of their exposure to this higher level of risk. Exposed aircraft must cross the path of the launch or re-entry vehicle at an angle greater than 30 degrees measured relative to the vehicle's path, and the aircraft must not circle, hover, or otherwise loiter. Thus, not only is each aircraft exposed for a brief period of time, but it is only exposed once per launch or re-entry operation, allowing the ALR approach to be applied on a per launch or per re-entry basis that retains some commonality with the AST target level of safety. In practice, aircraft are not allowed on routes at a relative angle that is less than 30 degrees (parallel or near-parallel to the launch or re-entry vehicle's path), so air traffic control closes those routes during the launch or re-entry operation. Air traffic controllers must also prohibit exposed aircraft from circling, hovering, or otherwise loitering.

2.4.5 Finally, the FAA applied a new collective risk limit to the ALR approach, intended to cap the total number of aircraft that could be exposed in a year to risk above the ATO target level of safety. Seeking to ensure that no fatal accidents occur in the average person's lifetime of 80 years at a 95 per cent confidence level, the FAA set the collective risk limit for the ALR approach to no more than 6 412 exposed aircraft in a rolling 12-month period. The ATO tallies the number of exposed aircraft during each launch and re-entry operation.

2.5 **Moving Forward**

2.5.1 The ALR approach allows the FAA to achieve a higher level of safety during launch and re-entry operations than it has in the past, without drastic increases to the size of segregated airspace and the associated impacts these increases would have on airspace system and capacity. Further, by integrating aspects of both aviation and space industry safety standards, it represents an intermediate step between the two target levels of safety. However, doing so does require the ATO to accept a higher level of risk during launch and re-entry operations than it accepts during other operations, so the FAA intends to apply the ALR approach only temporarily. In the future, purpose-built automation and procedures will

allow the FAA to return to the ATO's target level of safety during commercial launch and re-entry operations.

2.5.2 The FAA is currently researching and developing critical safety technologies such as the Space Data Integrator (SDI) and Hazard Risk Assessment Management (HRAM). The SDI will allow the FAA to integrate available time-accurate data from launch and re-entry operators directly into FAA networks and systems, providing the FAA with the necessary situational awareness to monitor the progress of launch and re-entry operations relative to traffic flows. The FAA has demonstrated in concept that in the event of a vehicle failure or other contingency that may require an air traffic response, the SDI can pass the best available data to the HRAM capability. The HRAM capability will then quickly perform computations that will identify the affected volume of airspace. The result will be used to either confirm that the airspace closed to other users in advance of the operation is still sufficient, or it will be used to identify additional airspace that must be closed to ensure that the ATO target level of safety is met. The boundaries of this airspace will be immediately distributed and displayed on air traffic tools, where decision support will assist in addressing the situation. Technologies like these will allow the FAA to replace the ALR approach with an approach that safely minimizes the amount of airspace that must be closed to other users in advance of the operation, immediately responds in the event of contingency, and quickly releases the airspace back to normal use once it is no longer at risk.

3. CONCLUSION

3.1 As the frequency and complexity of commercial launch and re-entry operations increases, differences in the target levels of safety used in the space and aviation industries become increasingly important. The FAA's ALR approach is a procedural change to the way the Air Traffic Organization manages the airspace in the vicinity of a launch or re-entry that borrows safety principles from both industries. Since it implements an intermediate step between the two safety levels, the ALR approach is intended to be temporary. Ultimately, the FAA will use technologies like those being developed in the SDI and HRAM capabilities to implement the high level of safety in the airspace system on which all of its users rely.

3.2 The Conference is invited to note the content of this paper.

— END —