Preparing for Potential Closure of European Airspaces due to Re-entering Space Objects

Enrico Spinielli, Rainer Koelle and Quinten Goens

***Abstract*—The risk of collision of re-entering space debris with aircraft is increasing due to both increasing number of airborne flights and re-entries. National and international authorities need to balance safety and economic impact of adopted measures. We asses airspaces density as flown by commercial airlines distinguishing seasonal and hourly patterns. We base our hourly density estimation on (enhanced) flown trajectories as recorded by EUROCONTROL's Network Manager (NM) binned over Uber's H3 gridding system. Impact risk probabilities will then calculated based on work from [1]. This combined with a buffered area along the the path of re-entry, can provide risk impact probabilities for deciding on safety measure such as airspace closures and/or re-routings.**

I. Introduction

We base our hourly flight density estimation on (enhanced) trajectories flown by Instrument Flight Rules (IFR) commercial aircraft as recorded by EUROCONTROL's NM[1] and overlapped on Uber's H3 gridding system at different resolutions [2], see Fig. 1 for resolution 2 which corresponds to hexagons of average area 86801.78 km^2 and average edge length of $182.51km$.

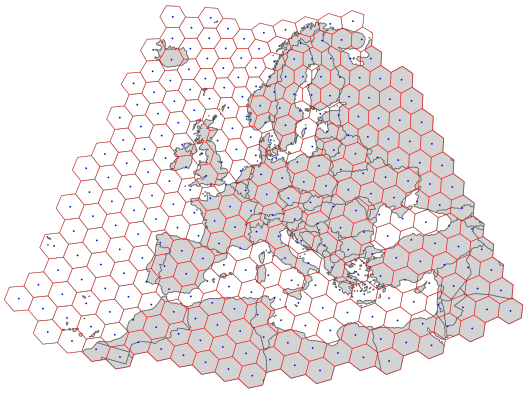

Fig. 1: H3 cells (red) at resolution 2 and their centers (blue) covering EUROCONTROL Area.

We characterise densities on an hourly basis for representative days in summer and winter.[2]

We expand on the works of [1], [3], [4] and provide a reproducible example for States, Agencies or relevant authorities to build upon.

[1]NM coordinates Air Traffic Flow and Capacity Management (ATFCM) operations on behalf of EUROCONTROL's 42 Member States and 2 Comprehensive Member States covering almost all European Civil Aviation Conference (ECAC) States.

[2]We will consider representative days in International Air Transport Association (IATA) summer 2024 and winter 2025 season.

Fig. 2 provides a promising result in the hourly flight density calculation which at least shows expected outcomes such as cells at zero density for war or no-fly zones such as Ukraine, Libia or Syria.

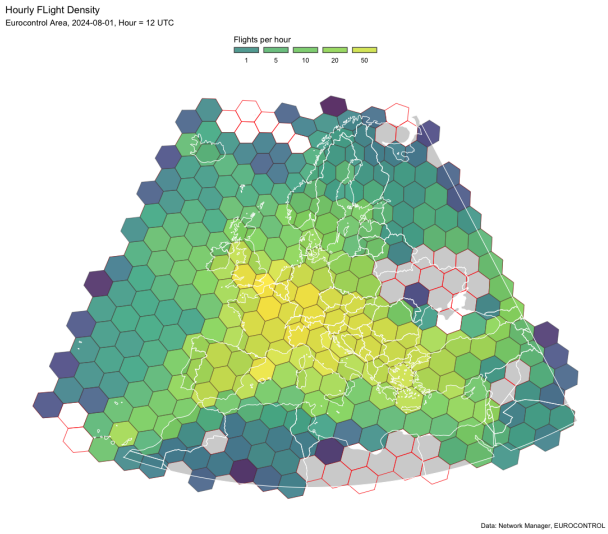

Fig. 2: Flight density on 2024-08-01T12 for H3 cells at resolution 2 covering EUROCONTROL Area.

II. Conclusion / Outcome

We show how National and/or International authorities could prepare for the more and more likely and frequent occurrence of uncontrolled reentry of space objects that could pose a safety concern on civilian aviation. The techniques we implemented on realistic data and sound algorithms can contribute to the bag of tools in the hands of technical and political entities aiming at guaranteeing the utmost safety and minimal economic disruption to civil aviation in Europe.

III. References

[1] R. Patera, "Risk to commercial aircraft from reentering space debris," in *AIAA atmospheric flight mechanics conference and exhibit*, 2008 [Online]. Available: https://arc.aiaa.org/doi/abs/10.2514/6.2008-6891

[2] "Tables of Cell Statistics Across Resolutions | H3." [Online]. Available: https://h3geo.org/docs/core-library/restable. [Accessed: 07-Feb-2025]

[3] E. Wright, A. Boley, and M. Byers, "Airspace closures due to reentering space objects," *Sci Rep*, vol. 15, no. 1, p. 2966, Jan. 2025 [Online]. Available: https://www.nature.com/articles/s41598-024-84001-2. [Accessed: 06-Feb-2025]

[4] W. H. Ailor, "Large Constellation Disposal Hazards | Aerospace Center for Space Policy and Strategy," The Aerospace Corporation, Jan. 2020 [Online]. Available: https://csps.aerospace.org/papers/large-constellation-disposal-hazards. [Accessed: 07-Feb-2025]