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SPACEPORT OPERATIONS IN EUROPE

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Abstract

Commercial Space Transportation (CST) has become an international business and requires landing opportunities all over the world. Hence the integration of space vehicles in airspace other than the United States NAS is an important topic to be considered. The Single European Sky ATM Research Programme (SESAR) is preparing the implementation of a new ATM system in Europe. With the commercialization of Space Operations under way, the number of Space Vehicle Operations is expected to increase significantly in the upcoming years. Areas of operation will expand from the current established and well known spaceports (e.g. Cape Canaveral, Vandenberg AFB, etc.) towards new operational sites. The development of spaceports is not only expected to take place in the United States but in other countries as well. If the expected cost reduction for space vehicle operation can be realized and commercial space operations established independent of national research and space programs, the number of launch and re-entry activities will increase together with the number of possible launch and landing sites. Operating a spaceport in a remote location with low population density might be an adequate approach in the early stages of expanding commercial space operations. However, the business of CST reaches Europe (which has a high density population as well as a busy airspace in most areas) launch and re-entry trajectories of space vehicles will most probably have to interact with air traffic operations. As air traffic has increased over the last decades and is expected to continue its growth, this aspect will gain further importance, and integrating both kinds of operations (ATM and STM) should be as seamless and efficient as possible. A study was conducted at the Air Traffic Validation Center of the DLR using real and fast time simulations. The results show the way in which the impact of space vehicle landing trajectories on other air traffic in the centre of Europe may be minimized by active dynamic planning in order to avoid flight path conflicts without having too great an impact on commercial aircraft operations.

Keywords: Spaceport, Commercial Space, Europe, Validation, Air Traffic Management, SESAR, NextGen

1. Introduction

To briefly summarize the current development of commercial space transportation (CST), the core assumption is that commercialization in space will lead to reduced costs and increased number of operations. This is already reflected by the number of commercial launches from the USA, which has significantly increased over the past decade [1]:

- Commercial launches prior 2008 totalling max. 5/year
- Commercial launches in 2014 = 23, 2017 = 33

As interest in the emerging market of commercial space operations grows, so too does the number of commercial launch sites (so called spaceports) is as well growing on a global level. In 2017 there are already 19 active U.S. governmental and commercial launch and reentry sites, of which 10 are licensed commercial launch sites, with 3 additional non-licensed sites. In addition, 16 non-US orbital launch sites are in operation worldwide [1]. The United Kingdom has recently announced the location of its first spaceport on the Sutherland peninsula in Scotland and explores building additional spaceports elsewhere in the UK, including Cornwall, Argyll and Wales [X1]. Worldwide, additional sites are under consideration or even evaluation, e.g. in Italy, Spain (Lleida Alguaire/Barcelona), Singapore, Curacao, and Germany.

Therefore, the CST industry does and will continue to affect Europe and the high population regions therein. In addition to having an effect on populations and populous regions, these current and future launch and re-entry endeavours will further impact European air traffic.

2. Space Vehicles in Europe

The motivation to operate Space Vehicles from Europe is manifold:

2.1 Increased commercial interest in launching from Europe

Launching "locally" allows locally produced and procured materials and manufactured goods to be placed into space faster and more efficiently than current alternatives. Independent launch opportunities will also allow for greater operational flexibility. Finally, space tourism will be positively impacted with the addition of conveniently located launch and re-entry locations.

2.2 Increased national security interest in launching from Europe

Rapid and independent access to space is a matter of sovereignty. This avoids the reliance on classic launch sites and single operators.

2.3 Increased interest landing reusable spacecraft in Europe

International missions require landing close to research sites with fast access to sensitive scientific materials, i.e. materials for bio science.

2.4 New hypersonic passenger flight concepts

New concepts for transcontinental flights are being developed, allowing passengers flying suborbital from Europe to other continents, i.e. Australia [2, 3]

3. Methods and Means

The impact of increased CST on the air traffic system in Europe has been investigated. This includes operation of Space Vehicles launched from Europe or reaching Europe including trajectories of overflights or landings to defined sites.

3.1 Research questions

In order to obtain results on how to integrate space vehicles (SV) in the European air space, the several topics had to be considered. If SVs have to be integrated, the safety of those involved and affected must first be ensured. The first step would be to design temporarily restricted areas which that may evolve dynamically. In these areas no other aircraft would be permitted. The question here is how the implementation of these restricted areas will influence air traffic during peak hours in the European air traffic management (ATM) system. Is it possible to integrate SV operations in the current ATM? This will lead to the rating of the impact of space flight activities on the surrounding flights. And following this question, which delays may occur as a result of SV operational interferences i.e. by mandating deviations?

3.2 Use case

To access the order of magnitude of the impact, SV operation might have on the European air traffic system, the DLR suborbital point-to-point SpaceLiner passenger transport concept [2, 3, 4] was established as a use case. The SpaceLiner concept has been developed by the Space Launcher Systems Analysis (SART) group of DLR. The basic concept is to enable sustainable low-cost space transportation to orbit while simultaneously revolutionizing ultra-long distance travel between different points on Earth. As a future high-speed intercontinental passenger transport vehicle it is designed as a rocket-propelled, two staged suborbital Reusable Launch Vehicle (RLV), able to service ultra-long-haul distances such Australia – Europe in 90 minutes. Intercontinental destinations between Europe and North-West America could be reduced to flight times of slightly more than one hour.

Fig. 1. The SpaceLiner vision of a rocket-propelled intercontinental passenger transport [2].

The test scenario comprises a trajectory from Australia west-bound to Europe with a flight distance of 17,500 km, and a 75 min flight time. The analysis focuses on the SpaceLiner descent trajectory, passing above and through European airspace, with a horizontal unpropelled landing. The airport of Nordholz in the North of Germany was chosen as a final landing point (ICAO Code ETMN).

Fig. 2. SpaceLiner west-bound trajectory from Australia to Europe [2]

3.3 Modelling

For modeling, the simulation tool AirTOp was used. [4]. The airspace model was created from the DDR2 database of Eurocontrol. It contains several types of ATC sectors: collapse sectors, elementary sectors, area control center group, etc. For each simulation day performed, a suitable airspace model was used.

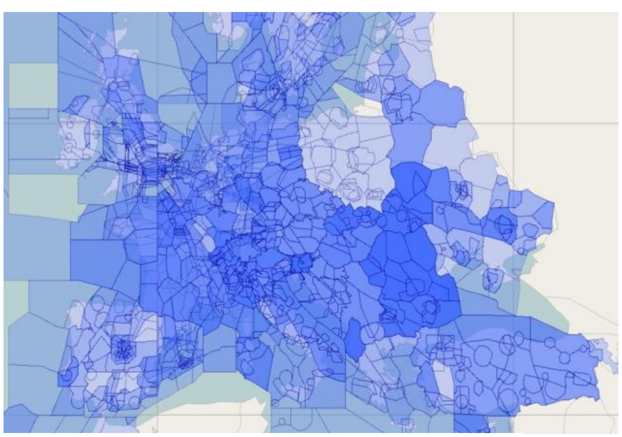

Fig. 3. Airspace model representation in AirTOp

For the simulations runs analysed day and traffic data information from Europe was used. These traffic data includes 24 hours historical air traffic information from March 2015.

Around the descent trajectory a hazard area/volume below the trajectory was defined according NASA's model derived from Columbia space shuttle accident debris data [5]. The hazard area was established for a static time and not modelled dynamically.

4. Results

Fig 4 shows the trajectory with the hazard areas as restricted areas giving a footprint under the current flight position according to the NASA debris model [5].

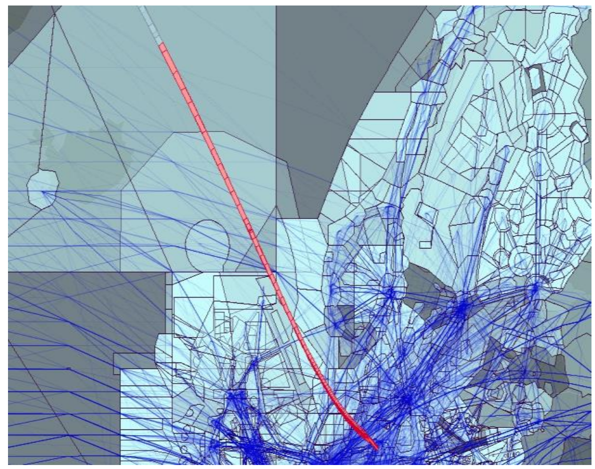

Fig.4. Trajectory of the final approach to Nordholz (ICAO Code ETMN)

Fig 5 summarizes the results of the simulations. Using the models described above, the number of conflicts of the air traffic within the defined hazard areas was measured for a rolling hour through the day using the available historic data. Weather was not been included in the simulations.

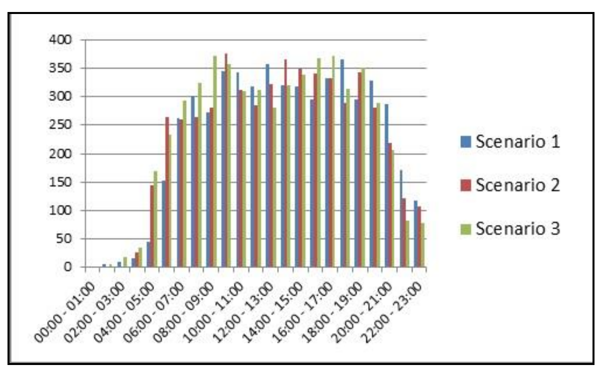

Fig. 4. Entry count for three traffic scenarios during one rolling hour

It can be seen, that through the day, an hourly maximum of 300 - 350 flights were affected, i.e. would enter the hazard areas below the SpaceLiner's trajectory.

As long as the SpaceLiner flies sufficiently high above regular airspace, those Hazard Areas do not necessarily needed to be avoided, but deviations would have to be requested in case of a mishap.

5. Discussion

During simulations, a significant amount of air traffic interacted with the trajectory or the related hazard areas of the SpaceLiner., and the amount was manageable in these scenarios. Considering the conservative approach taken on modelling and operating thise hazard areas (static activation for a whole our during SpaceLiner approach), there is plenty of optimization potential left to be exploited. For the future, a dynamic model has to be developed and used, which minimises the volume and duration of hazard area activation. Hazard areas shall remain open for aircraft in transit as long as possible. It is foreseen to develop a concept of dynamic hazard areas and improve calculations and forecasts of the SpaceLiner trajectory. A key issue here will be the exchange of data between the flight management system of the space vehicle and the air traffic management system (ATM) of the airspaces involved.

Space vehicle operation has to become an integrated part of Air Traffic Management. The nature of space flight and its comparably lower target level of safety compared to commercial air traffic is specifically challenging for such integration. The introduction of trajectory based operations under the regimes of the Single European Sky Air Traffic Management Research (SESAR) and the U.S. Next Generation Air Transportation System (NextGen) can be utilized to address these challenges, as prototypical solutions for a SWIM based integration of space vehicle operations have demonstrated, including a technical setup to achieve interoperability between SESAR and NextGen and a European / U.S. harmonization. To address specific questions about the impact of space vehicle operations to certain air traffic regions and to validate the concepts and technologies to mitigate these impacts, a Space and ATM Operational testbed as well as a traffic impact analysis framework has been developed and established [6, 7].

The trajectory information of the space vehicles as well as of the other airspace users has to be exchanged via an integrated system wide information platform (SWIM). This enables the information of the trajectory consumption as well as a provision of the data in a worldwide secured system [Fig. 5, Fig. 6].

6. Conclusions

The integration of increasing commercial space traffic into traditional traditional airspace is a challenge. However, by carefully selecting the safety and hazard standards and models it should be possible even in the busy airspace of Germany, as well as the entirety of Europe. The trajectory planning should take into consideration traffic flows as well the density of population in nearby regions, depending on the expected hazards. Finally, the implementation of dynamic hazard areas as well low latency data exchange via a SWIM system will further assist in the safe integration of Passenger Spaceflight and Spaceport operations.

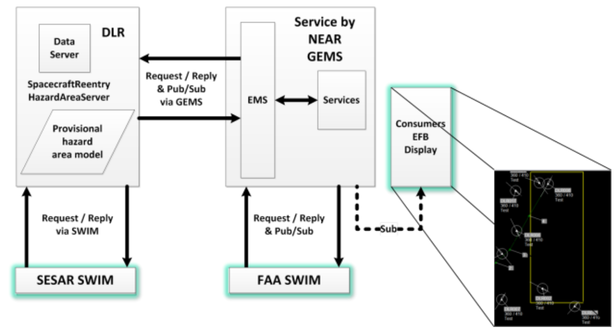

Fig. 5. Interconnection of a SESAR SWIM Spacecraft Reentry Hazard area server with the US NextGen system [6, 7]

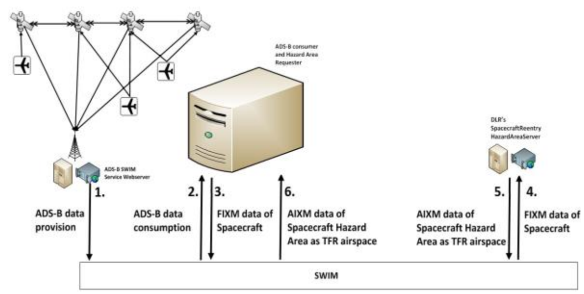

Fig. 6. SWIM system for worldwide provision and consumption of trajectory and hazard zone data.

University, Daytona Beach (ERAU), Florida, USA, for the successful SESAR/NextGen SWIM integration demonstration is acknowledged. The server at DLR was set-up by Peter Jänsch whose work is highly appreciated. Special thanks to Christopher Stockdale from ERAU for revising the correct English of the text.

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