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NEW GENERATION SPACE VEHICLE OPERATIONS IN THE UNITED ARAB EMIRATES – AN AIRSPACE AND RISK ASSESSMENT

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Abstract

The objective of this study is to better understand how New Generation Space Vehicle Operations (NGSVO) may impact a highly dense and compact airspace when operating from and to a United Arab Emirates (UAE) spaceport. The National Space Sector is a main pillar of the UAE's long-term strategic plan towards a knowledge-based economy and a sustainable scientific society. Besides several short and long-term initiatives spearheaded by the UAE Space Agency and the Mohammed Bin Rashid Space Centre (MBRSC), commercial space vehicles using the nation´s own spaceport for launch, re-entry and landing is foreseen. NGSVO will have a significant impact on existing Air Traffic Management (ATM) operations, negatively affecting levels of safety, fuel consumption, and carbon dioxide footprint of regular air traffic.

Given the future expected rise in NGSVO, the traditional means of protecting civil aviation traffic from Space Vehicle Operations needs to be addressed and a new more efficient method developed to satisfy the safety requirements related to the insertion of these proposed NGSVO into the civilian ATM environment. Airspace closure is an antiquated method that addresses only one aspect of safety associated with previous debris dispersion model in case of an in-flight breakup or explosion. By applying more advanced ATM concepts such as Trajectory Based Operation (TBO), Advanced Flexible Use of Airspace (AFUA), and dynamic sectorization, and by making smaller adjustments to the aircraft during its ascent/descent phase, the NGSVO would efficiently utilize the surrounding airspace more effectively without hindering other operations. This would lead the way to integration, rather than segregation. However, to establish a benchmark for future comparisons, the current study applies the traditional approach of temporarily restricting a portion of UAE airspace to accommodate a specific type of space vehicle operations. Results of future studies applying more sophisticated and advanced ATM concepts can then be compared to results in the current study to identify operational gains. Proper coordination with the UAE's military agencies would further support efforts to protect civil aviation traffic from future NGSVO.

Keywords: Space Vehicle Operation, Space Port, Environment, Risk Assessment, Air Traffic Management, Trajectory Based Operation

1. Introduction and Generals

The here applied approach consists of using a simplified air traffic event model calculation to assess the impact of NGSVO on several UAE air traffic parameters; the analysis of such parameters will provide information of how many flights will be affected, and to what extent, by the space vehicle passing over and through the airspace. The calculations incorporate elements of the UAE airspace and airway route network, while integrating space vehicle trajectories and the potential spaceport location. Furthermore, the calculations include the application of the relevant hazard protection areas associated with the space vehicle for separation purposes against regular air traffic. These hazard areas are based on recognized risk assessment methods.

Ultimately, the objective of such research will be to understand how today's ATM environment is affected and how ATM systems and ATC controllers could cope with NGSVO, which requires intensive dynamic re-routing of the prevailing air traffic with a minimum of detrimental effects.

Initial results show that a seamless implementation of next generation space vehicles in today's ATM is a considerable challenge. However, horizontal launches of space vehicles from a carrier airplane that have already been demonstrated as part of new operating concepts are also an interesting control tool. In particular, the navigational performance of the glider during descent, approach and landing continues to be a challenge for a safe and efficient operation that does not threaten and obstruct other airspace user. This applies even more to highly frequented air spaces such as those on which this investigation is based.

It had to be determined on what data basis the investigation should be based. To make assumptions as realistic as possible, publicly available radar data was used [10], since pure flight plan data do not represent the route actually flown. For this initial investigation, the consideration was focused on an exemplary traffic hour. In terms of a worst-case scenario, an hour with the maximum number of flights was selected. Due to the ongoing COVID19 pandemic, data from 2019/2020 were not considered representative. After analyzing the available data, December 19, 2018 from 6:00 p.m. to 7:00 p.m. was selected as a traffic hour with a very high number of flights within the UAE airspace (peak hour). The data used in the further course are shown in Figure 1.

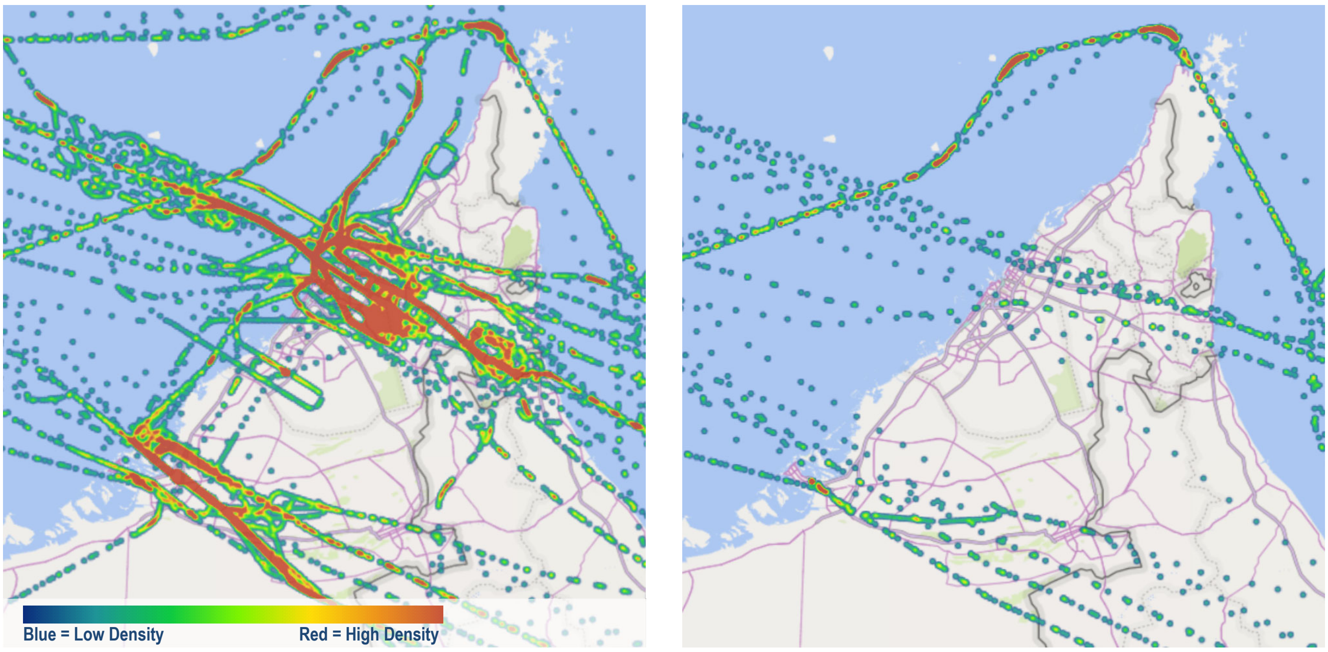

Figure 1: Heat Map - Density of Air Traffic (Qualitative) in the Reference Period (Peak Hour) All Flights (left); Only UAE Overflights (right)[1]

[1] Unmodified position data was used for Figure 1. A higher density of air traffic (red color) generally means that, among other things, higher impacts from NGSVO can be expected in this area.

A total of 20,740 data sets were evaluated, which could be assigned to 233 different flights within the reference hour. In addition to position data (latitude/longitude) the altitude and the direction of flight, the data also contained the Callsign, the ADS-B identifier and the flight number.

It must be considered that approx. 5% to 10% of the flights actually conducted are not included in the data [8][9]. This can be due to missing or non-functioning or inactive ADS-B equipment of the aircraft or insufficient receiver coverage on the ground. From this it follows that the total Air Traffic can also be around 5% to 10% higher during the selected peak hour. For the analysis discussed here, however, this is noncritical. In the further course of the project, the database is to be expanded to include official ATC data.

2. Impact on Civil Aviation Airspace

The traditional means of protecting civil aviation traffic from Space Vehicle Operations is to close the airspace affected by the passage of the vehicle [26], from slightly before until slightly after the planned time of operations [22]. The dimensions of the airspace closure typically depend on the type of space vehicle operations and the associated debris dispersion model in case of an in-flight breakup or explosion. This approach of blocking a relatively large portion of airspace for a period of time is highly restrictive for civil aviation and may result in significant rerouting and delays of commercial passenger flights. If space vehicle operations becomes frequent in the long-term, such restrictive closures will eventually become unacceptable. More advanced ATM concepts must be considered to eventually integrate SVO into the UAE airspace, rather than segregate. However, to establish a benchmark for future comparisons, the current study applies the traditional approach of temporarily restricting a portion of UAE airspace to accommodate a specific type of space vehicle operations. Results of future studies applying more sophisticated and advanced ATM concepts can then be compared to results in the current study to identify operational gains.

2.1 Methodology of Airspace and Air Traffic Assessment

The most common approach of quantifying the impact of space vehicle operations on air traffic is to conduct an airspace analysis using a dedicated fast time simulation platform along with comprehensive datasets made available by relevant air navigation service providers or other major ATM organizations [14]. While future studies will make use of such resources, the current approach uses a simplified air traffic event model calculation to simply determine the number of commercial passenger flights affected by the temporary closure of a portion of UAE airspace. A flight is “affected” if the airspace closure coincides with its usual passage through that airspace, forcing the flight to be rerouted, delayed, or subjected to other air traffic flow management measures.

2.2 Aeronautical Data

The primary input parameter used for analysis includes historical UAE airspace flight data provided by the Flightradar24 internet-based aircraft flight tracking service. This system collects data using a large ADS-B network with over 20,000 connected receivers. Flightradar24 also combines this ADS-B data with other sources such as MLAT, radar data, as well as schedule and flight status data [9].

From this primary data source, along with data available in the UAE Aeronautical Information Publication (eAIP), several parameters may be derived, including aircraft position, points of origin/destination, ATS routes flown, as well as bearing and distance to/from key points such as the reference spaceport location.

As for the space vehicle trajectory and flight parameters, two data sources are used. The first is a study describing the results of a simulation campaign of nominal SS2 flights [18], in which distance flown, altitude, and speed of simulated nominal flights are provided, among other data. The second source is the flight data recorded on Flightradar24 during SS2’s test flight in California on July 11, 2021 [9].

2.3 Hazard Areas and Space Vehicle Trajectory

As mentioned earlier, air navigation service providers have historically opted to temporary block a large portion of airspace to protect civil aviation traffic from the passage of space vehicles. The dimensions of the temporary airspace closure typically depend on the flight characteristics of the specific type of space vehicle and the nature of the operation. More specifically, the temporary airspace closure must be large enough to account for non-nominal events such as the inflight breakup or explosion of the space vehicle, leading to a debris field spanning relatively large areas. Some studies have used debris models derived from actual inflight breakups of space vehicles, such as the Space Shuttle Columbia. However, the application of a debris dispersal model based on the Space Shuttle Columbia accident is not appropriate in this case since the flight characteristics of SS2 differ significantly. For example, while the Space Shuttle would reach speeds above Mach 20 and required relatively long reentry trajectories, SS2's launch and reentry flight trajectories are much steeper and max speed remains near Mach 3 [17].

One study considers potential horizontal launch activities originating at Cecil Spaceport in Florida [22]. According to the Cecil Spaceport website, an airspace operating range has been defined to accommodate horizontal launch operations, in addition to a designated horizontal launch corridor connecting the spaceport to the range [4]. The operating range is a trapezoidal area spanning over 7,000 square nautical miles over the Atlantic Ocean, around 45 NM east of the spaceport. The range is shown in Figure 2.

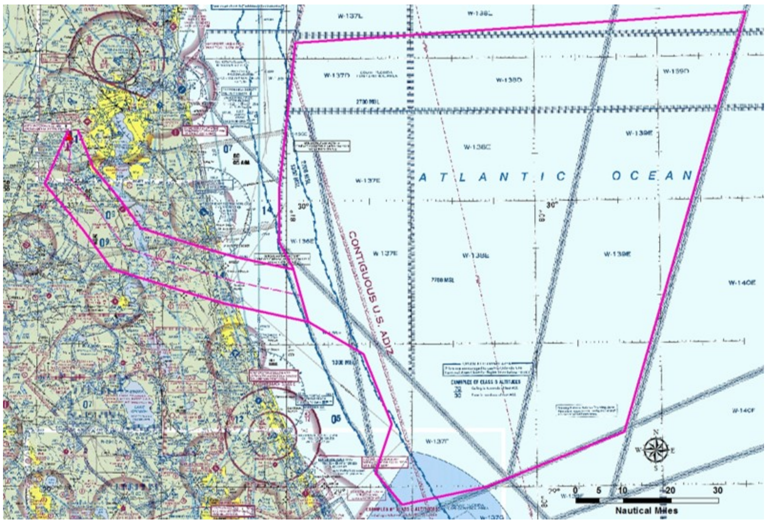

Figure 2: Cecil Spaceport Airspace Operating Range [4]

That study seeks to quantify the impact on commercial passenger traffic of closing the entire trapezoidal operating range from a certain time prior to launch to a certain time following the launch. In one of the study's scenarios, the designated horizontal launch corridor was excluded from the impact analysis since the type of space vehicle studied was not considered to pose extraordinary safety risks during either the takeoff procedure or the return to the spaceport. The space vehicle was described as a reusable launch vehicle that launches horizontally from a carrier aircraft above 40,000 feet and eventually returns to the spaceport as a glider. This characterization adequately describes the use case of the current study, Virgin Galactic's SpaceShipTwo.

The following scenario will be considered for this case: SS2 will be transported by the carrier aircraft from the future Al Ain Spaceport to a launch point around 100 NM southwest of the spaceport, within the OMR 54 restricted area, and will be released above 40,000 feet for the secondary launch. Upon its return, SS2 will enter the glide phase at around 49 NM from the launch point, and around 50 NM from the Spaceport. The distance of 49 NM represents the maximum distance flown by the SS2 between the launch point and the top of glide during a simulation campaign in one study [17]. SS2 will then return to the Spaceport as a glider. Since a debris dispersal model for SS2 was not available for the current study, a circular airspace closure having a similar surface area of the trapezoidal operating range near Cecil Spaceport will be defined, centered at the mid-point of SS2's trajectory (between the secondary launch from the carrier aircraft and the top of glide). Furthermore, the hypothetical horizontal launch corridor between the Al Ain Spaceport and the launch and reentry operating area in OMR 54 will be excluded from the impact analysis based on the same rational presented in the study mentioned above. While this overall approach borrows an airspace configuration defined specifically for the operating context near Cecil Spaceport, it serves as an adequate approximation for the UAE scenario and allows to derive some preliminary insights. Figure 3 shows the proposed SS2 trajectory (red segment), the airspace closure (blue circle), and OMR 54 restricted airspace (white trapezoid).

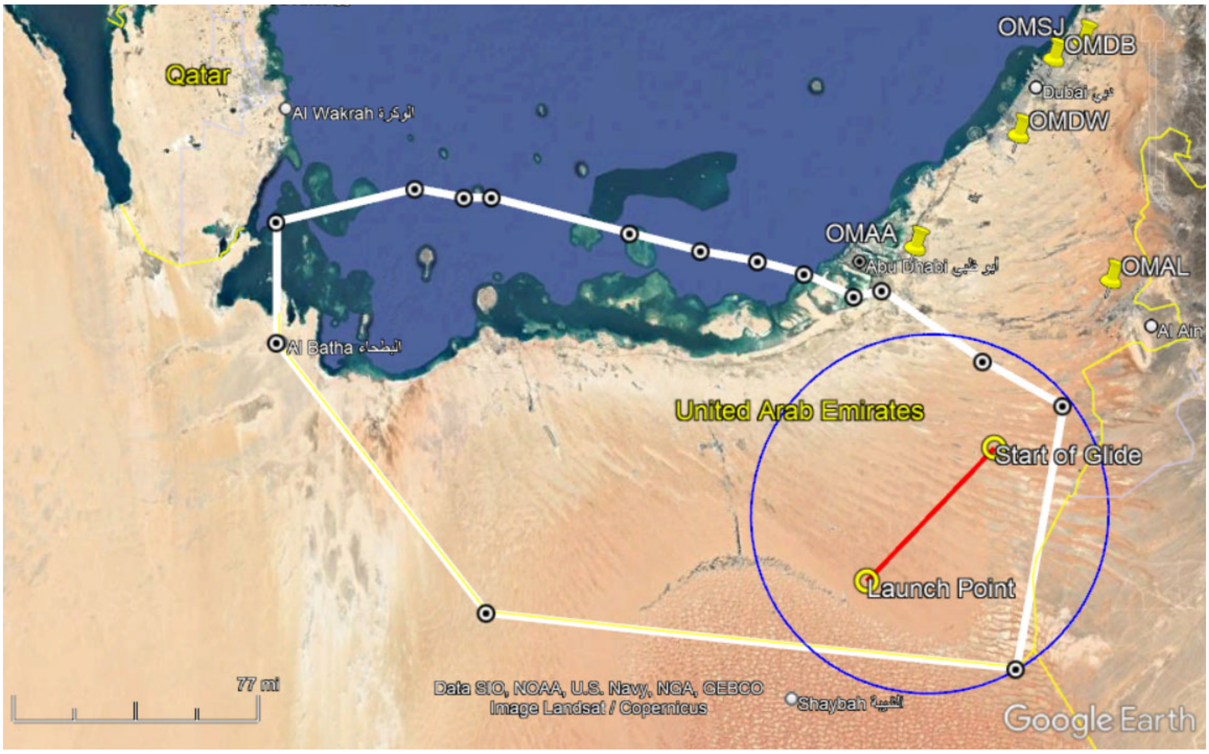

Figure 3: Proposed SS2 Trajectory (red) and Related Assessment Area (blue)

2.4 Analysis and Results

2.4.1 Total UAE Airspace

A total of 233 fights were counted in the UAE airspace during the defined peak hour. This includes 61 overflights through the UAE airspace, 78 departures from UAE airports, and 94 arrivals into UAE airports. Here, “UAE airports” refers to Abu Dhabi International Airport (OMAA), Dubai International Airport (OMDB), Al Maktoum International Airport (OMDW), and Sharjah International Airport (OMSJ) only.

These figures provide an initial general idea of traffic demand and controller workload during the defined peak hour. By analyzing the traffic demand within the defined assessment area, we can begin to understand the impact on specific flights.

2.4.2 Assessment Results

An estimated 12 flights passed through the assessment area shown in Figure 3 during the peak hour. None of these flights were departing from or arriving to UAE airports. All 12 flights were overflights passing through the UAE airspace. While this is a favorable result for UAE terminal traffic, it may indicate that overflights would need to be rerouted.

Table 1 shows the affected flights.

Operator	Call Sign	Aircraft	From	To
Air India	AIC975	A320	GOI	KWI
Air India Express	AXB321	B738	CCJ	RUH
Air India Express	AXB773	B738	CNN	DOH
Jet Airways	JAI524	B738	BOM	RUH
Jet Airways	JAI552	B738	BOM	DOH
Jet Airways	JAI560	B738	BOM	DOH
Jet Airways	JAI566	B738	TRV	DMM
Oman Air	OMA673	B788	MCT	JED
Oman Air	OMA677	B738	MCT	MED
Saudi Arabian Airlines	SVA3759	A332	DEL	JED
Saudi Arabian Airlines	SVA705	B772	KHI	JED
Saudi Arabian Airlines	SVA773	A333	BOM	JED

Table 1: Flights affected by the proposed airspace closure

Table 2 below lists the ATS routes that intersect the assessment area:

Affected ATS Routes	Affected Flights
LUDID-M628-RIGIL-M628-PEKEM	AXB321 OMA673 SVA3759
M628-RIGIL-M628-PEKEM	SVA705 SVA773
RIGIL-M628-PEKEM	JAI524
SODEX-ELUDA-N563-NOBTO-N563-PARED-SIGMO-N563-TAPTO-N563-VUXOD-N563-KUGTO-N563-BOSEV-L565-UKUVO-G462-OXARI-G462-PURLI-G462	AIC975
SODEX-N563-ELUDA-N563-NOBTO-N563-PARED-N563-SIGMO-N563-VUXOD-N563-P899-LAGVU-P899-MEKRI-P899-VATIG-P899-KUMSI	AXB773
SODEX-N563-ELUDA-N563-NOBTO-N563-PARED-N563-SIGMO-N563-VUXOD-N563-RUKOS-P899-LAGVU-P899-MEKRI-P899-VATIG-P899-KUMSI-MEKMA	JAI552
SODEX-N563-ELUDA-N563-NOBTO-N563-PARED-SIGMO-PUVUT-N563-VUXOD-N563-ORMID	JAI566
SODEX-N563-ELUDIA-N563-SIGMO-N563-VUXOD-N563-P899-LAGUV-P899-VATIG-P899-KUMSI-P899-MEKMA	JAI560

Table 2: Affected ATS routes

The above analysis assumes that the entire assessment area would be closed to regular air traffic during the peak hour. This implies that appropriate ATFM measures (mostly rerouting) would need to be applied to all 12 flights identified above. On the other hand, the launch point location and the flight direction were chosen strategically to ensure that most of the assessment area falls within the OMR 54 restricted airspace. This is categorized as a permanent restriction from ground level to unlimited, for military purposes. Although civil aviation aircraft are occasionally permitted to transit through OMR 54 on pre-agreed ATS routes, it wouldn't be unusual for these routes to become unavailable on occasion, forcing aircraft to adopt alternate routes. In conclusion, although the impact is not negligible, this scenario most likely does not represent a significant impact on traffic movements and controller workload. This scenario also assumes that the UAE military would agree to allowing commercial space vehicle operations within OMR 54.

It should be noted that the proposed assessment area overlaps the airspaces of Oman and Saudi Arabia, albeit to a minimal extend. This potentially increases the complexity of the operation since it would require the cooperation of the national aviation authorities and air navigation service providers of both affected countries. One solution would be to adjust the location of the launch point and the direction of flight in order to contain the assessment area entirely within UAE airspace. However, this would most likely lead to a much higher impact of civil aviation traffic, especially in the vicinity of Abu Dhabi International Airport. Given the current levels of congestion in the UAE airspace, this may potentially represent a significant impact on traffic movements and controller workload.

3. Impact on Flight Safety

3.1 Risk Assessment Methodology

Governments across the globe attempt to control the commercial spaceflight industry with heavy regulation to slow the progression of these activities that are deemed dangerous [25]. With the advancements in current technologies and with companies backed by the likes of Sir Richard Branson of Virgin Galactic, Elon Musk of SpaceX, Jeff Bezos of Blue Horizons, the SVO industry have been working towards sustained suborbital operations. It is the operations of these SVO and their integration into the current airspace system that creates risks that must be understood and mitigated before safe integration can begin. The process of integration must be flexible and should demand recurring evaluations to ensure that benchmarks are met and that they satisfy the evolution of these vehicles as well as growth in the surrounding areas of the launch site.

Risk tends to follow a step function in which the risk is constant until changes in the design, process, or operation are addressed. Conventional theory suggest that risk can increase when trading safety margin for perceived gains such as, increased performance which ultimately increase the risk for the underlying areas of the launch vehicle.

Before diving into some of the risks associated with high-risk recreational activities, we must first define risk. Risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard. It may also apply to situations with property or equipment loss, or harmful effects on the environment [3]. The risk assessment process includes:

1. Identify the hazard
2. Identify who or what might be harmed
3. Evaluate the risks
4. Identify control measure
5. Evaluate remaining risks
6. Record the finds in the risk assessment
7. Make contingency plans for residual risks
8. Review and revise.

Further guidance on risk assessment methodology can also be found in the ICAO Safety Management Manual Doc 9859 [11].

3.2 Adopted Approach for SpaceShip Two

In the case of SS2, the assessment follows:

Procedure	Task
1. Identify the Hazards/Risks	• SS2 takeoff to predetermined altitude and separation process. • SS2 does not separate from the transport vehicle. • SS2 does not ignite for the next phase of flight due to computer glitch. • Separation is outside normal parameters/or identified launch area. • Loss of one or both aircrafts • Equipment functional failures • Structural failures • Human errors
2. Identify who or what might be harmed	• Loss of occupants of both aircrafts • Colliding with another aircraft during the separation and return phase of orbiter. • Debris field beyond containment area • Civilian harm or injury below • Environmental damage from fuel or the aircraft
3. Assess the risks arising from the hazard – Initial risk assessment	• Initial take-off process • Conflicting traffic might force the mated ships beyond initial launch area • Integration of the space vehicle into the surrounding Airspace is burdensome. • Catastrophic loss of one of both aircraft
4. Determine the control measures required	• Ensure manual control of ignition system if necessary. • Automate the drag system to reduce human error • Coordinate with ATC to facilitate the liftoff and separation process
5. Assess the remaining risks arising from the hazard	• Possible environmental contamination due to flammable/explosive fuel leakage or wreckage • Environment (or external) events, such as Orbital Debris impacts dispersion
6. Make contingency plans for the residual risks	• The contingency plan would be to reduce the various manual inputs to the system by the pilot. • Expand the underlying area below the separation point beyond 40 NM.

Table 3: Adopted Risk Assessment Process

With the use of Temporary Flight Restrictions (TFRs), SpaceShipTwo could be segregated from the other arriving or departing traffic, ensuring that there is a slight modification to the flight structure to protect both spaceship two and the overlying traffic. As suggest for future studies, the dynamic opening and closing of the surrounding airspace might be a temporary but viable solution for the future growth of SVO. Any integration solution must include characteristics associated with the suborbital launch platform. Some of the characteristics identified includes, launch system reliability, timing, and trajectory [24].

3.3 Refinement of Assessment Scenario

To better understand the status of the current airspace in Al Ain and the surrounding areas within the UAE, we must first look at the current use of the current airspace. Reviewing the flight data available including takeoffs and landing as well as overflights, points the project in a direction that will provide the data necessary to aid in the integration of SVO. Mitigation strategies must be incorporated to ensure that in the event of an unforeseen catastrophic failures, the debris field will be contained within the specified NM buffer zone on either side of the launch trajectory but could be expanded as needed. During liftoff from the designated spaceport the mated aircraft will be under the guidance of air traffic control and will follow the proper established procedures as it attempts to get to its designated altitude for separation above 50,000 ft. During the initial ascent, there should be no other commercial traffic above Spaceship two ignition altitude, where the aircraft would have no problems getting to its position to begin the weightlessness phase before its return. During the return phase of Spaceship two, the craft should still follow the same parameters coming back in once below 50,000 feet. Although now a glider, it should be able to circumnavigate whatever aircraft might be in the vicinity with the help of Air Traffic Control (ATC) to get back to its landing position at Al Ain Spaceport. This can only be done through coordinated information sharing between managers of the airspace and launch providers.

At this point, the authors are aware that the currently effective airspace rules do not recognize the type of glider described here (see ICAO Annex 2; Chapter 3.2.2) [12]. As a result, suitable supplements, preferably at the ICAO level, must be defined. The aviation law issue to be derived from this is not part of this technical paper and will be examined separately.

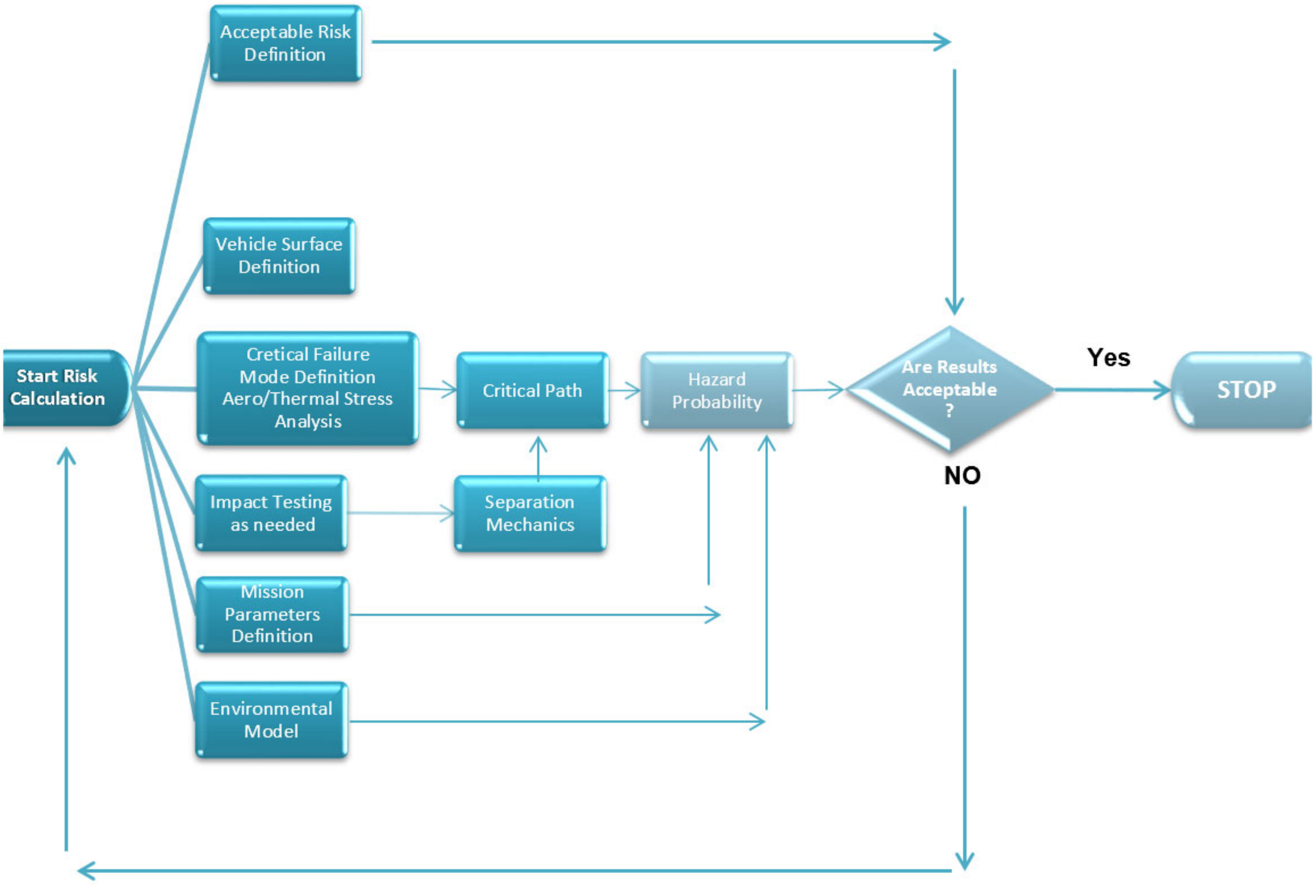

Table 4: On-orbit impact analysis methodology [5]

In a recent white paper submitted by Air Line Pilot Association (ALPA) to one of their annual conferences,

> “the challenge to date has been to develop a data-exchange mechanism to pass this information to the other parties involved. The FAA’s space data integrator (SDI) under development is a move

in this direction and would serve as a testbed for what could potentially be used in the UAE to facilitate suborbital space launches in and around the region. According to reports, SDI would provide controllers and traffic managers with situational awareness of a spaceflight mission through real time data on vehicle state and operational status, calculate the location and extent of potential hazard areas, and provide visibility into mission progress. SDI will afford the capability for FAA and, by extension, other airspace users to benefit from a detailed level of knowledge of a space mission as it progresses through shared airspace. In addition, the real-time, detailed view provided by SDI allows alert and execution of contingencies if off-nominal events occur" [2].

There are multiple risk assessment strategies to choose from across varying industries. The risk assessment associated with spaceship two and the transport aircraft comes from a complex set of systems that if not implemented correctly, would affect not only other users within the airspace, but could negatively impact the surrounding environment.

Launch & reentry operation window as short as possible –

- Avoid peak traffic times
- Optimize launch & reentry trajectories as far as possible
- Optimize air space usage alongside restricted areas which could include military operation areas (MOA).
- Ensure real time monitoring and direct communication, connecting all involved stakeholders with ANSP managers and ATC facilities [15].

Analysis and optimization of SVO scenarios and concepts regarding air traffic impacts as suggested by Kaltenhaeuser et al can be seen below:

- Improved ATC procedure design
- Support of Spaceport site evaluation
- Integration of SVO Mission management and ATM
- Improved SVO implementation into AIM (e.g. System Wide Information Management)
- Provision of adequate evaluation and validation capabilities [15].

4. Conclusion

The next stage of our study will require a more precise definition of the space vehicle's 4D trajectory within the UAE airspace, as well as a more precise definition of flight restriction areas along the SV trajectory. These restriction areas are based on traffic separation criteria for such high-risk operations as well as hazard areas relating to abnormal events such as the inflight breakup or explosion of the space vehicle, leading to a debris field spanning relatively large areas. A primary objective during this next stage is the application of a more accurate debris dispersal model to define more precise hazard protection areas. This will allow for a less conservative approach, possibly leading to reduced impacts on regular air traffic within the UAE airspace.

Regarding the risk assessment, the methodology presented in our initial research will be further expanded to incorporate analyses of both internal and external risks relating to NGSVO within UAE airspace [16]. This paper presented one possible further solution to this burgeoning problem to finally integrate SVO traffic with normal commercial traffic into the UAE airspace.

5. Outlook

However, future research will involve the use of a fast-time simulation platform and a more comprehensive dataset allowing for a more detailed analysis of the UAE airspace and the impact of inserting NGSVO trajectories. We will then be able to consider how modern and emerging ATM concepts such as Trajectory Based Operation (TBO), Advanced Flexible Use of Airspace (AFUA), dynamic sectorization, and the role of aircraft-ground datalink requirements could support the situation. The impact of reroutings on overall fuel consumption and CO2 emissions of the air traffic in UAE airspace will also be investigated.

6. Acknowledgement

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8. Copyright Statement

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10. Abbreviations

ADEK........ Abu Dhabi Department of Education and Knowledge (UAE)
ADS-B ...... Automatic Dependent Surveillance – Broadcast
AFUA .... Advanced Flexible Use of Airspace
AIP........... Aeronautical Information Publication
ALPA .... Air Line Pilot Association
ANSP........ Air Navigation Service Provider
ATC .... Air Traffic Control
ATFM........ Air Traffic Flow Management
ATM.......... Air Traffic Management
CCOHS .... Canadian Center for Occupational Health and Safety
FAA .... Federal Aviation Authority
ICAO......... International Civil Aviation Organization
MBRSC .... Mohammed Bin Rashid Space Centre
MLAT........ pseudo-range Multilateration
MOU .... Memorandum of understanding
NGSVO .... New Generation Space Vehicle Operations
NM........... Nautical Miles
OMAA....... Abu Dhabi International Airport
OMAL .... Al Ain International Airport
OMSJ .... Sharjah International Airport
SDI .... Space Data Integrator
SS2 .... Scaled Composites Model 339 SpaceShip Two (The Spaceship Company)
SV .... Space Vehicle
SVO.......... Space Vehicle Operations
TBO.......... Trajectory Based Operation
TFR .... Temporary Flight Restrictions
UAE.......... United Arab Emirates

11. Definition

“Dwell time” means the period during which a launch vehicle’s instantaneous impact point is over a populated or other protected area.

“Launch vehicle” means:

a) a vehicle built to operate in, or place a payload or human beings in, outer space; and
b) a suborbital rocket.

“Protected area” means an area of land not controlled by a launch operator that is a populated area, is environmentally sensitive or contains a vital national asset.

“Suborbital trajectory” means the intentional flight path of a launch vehicle, reentry vehicle, or any portion thereof, whose vacuum instantaneous impact point does not leave the surface of the Earth.

“Suborbital rocket” means a vehicle, rocket-propelled in whole or in part, intended for flight on a suborbital trajectory, and the thrust of which is greater than its lift for most of the rocket-powered portion of its ascent.

“United Arab Emirates” means the seven Emirates of the United Arab Emirates [20].