Developing a Cybersecurity Architecture for Extensible Traffic Management (xTM)

Extended Abstract

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Background:

In the not-too-distant future, the skies above us will look vastly different than they do now. More specifically, the change will occur with the traffic that makes up the National Airspace System (NAS); consequently, the cybersecurity that protects it must change too. Currently, the bulk of the NAS is made up of manned traditional fixed wing aircraft and rotorcraft, from both the public and private sectors. Technology has allowed for the proliferation of cheaper and more advanced methods of flying vehicles, this in combination with the expanse and prevalence of aircraft that were traditionally utilized by governments becoming more readily available to private industry, is contributing to creating a new economy. This new economy will create a paradigm shift in the way air traffic is utilized both in function and its makeup. Part of how this environment will change will be the types of vehicles that people will see and use. Some of these vehicles will take the form of unmanned aerial systems (UAS), also known as drones, changing how people interact with businesses in their everyday life. The planed increased usage of these aircraft is also being born out of the fact that modern roadways are increasingly becoming denser and more congested, causing increased wait times and bottlenecks with the movement of people, goods, and services. To alleviate this, UASs have the expected interactions and changes with the public, initially through two main methods - drone package delivery and Urban Air Mobility (UAM) or air taxis. With UAM being a concept that proposes to develop short-range, point-to-point transportation systems in metropolitan areas using vertical takeoff and landing (VTOL) or short takeoff and landing (STOL) [1]. These new vehicle interactions will transform how traditional airspace operates.

Operating Environment:

Currently traditional aircraft, unless under certain areas or classes of airspace, communicate with a Federal Aviation Administration (FAA) air traffic controller (ATC) for

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various permissions and directions the entire time the aircraft is operated. Under this future environment, UAM vehicles and various UASs, unless under special circumstances within specific FAA controlled airspaces, will not have any direct communication with FAA ATC. To add to this new air traffic model, in addition to the other vehicles that will be flying (mentioned above), a lesser used portion of the NAS which operates above the traditional commercial airspace (60,000 ft above ground level and above), one that is currently mainly used for military and weather services, is planned to be more readily utilized [2]. This airspace has the intended function of accommodating a new generation of high-altitude aircraft meant to efficiently satisfy research objectives, demands for broad coverage services, and supersonic passenger flight [2]. To further complicate this already tight balancing act of airspace coordination, in recent years the space economy has also taken off with a significant uptick in both governmental and private space industry operations. The operating environment of how these aircraft operate in and around launch facilities can be significantly impacted by rocket launches. Currently, for example, when there is a planned rocket launch, significant portions of the surrounding NAS is closed off and aircraft must find alternative routes which create knock-on effects like increased flight times and passenger delays. While each of these components already pose a clear challenge for coordination efforts, the difficulty compounds, with the fact that all of these different and novel aircraft will be flying amongst each other. Consequently, it reveals the desperate need for these vehicles to be able to coordinate amongst each other. Given this need for coordination and the fact that it will be done mostly in absence of FAA ATC coordination, NASA has decided to research this emerging area with three major objectives, each converging to the understanding of interactions with traditional airspace traffic. One of the objectives involves developing and testing cooperative operating practices aimed to study conflict and flow management of air traffic. The second objective is to identify requirements for a secure digital integrated operational picture that supports diverse and increasingly autonomous operations. Taken altogether, the novel vehicle concepts described above can be divided into three traffic management categories. Package delivery drones or UAS, is to be categorized as Unmanned Aircraft System Traffic Management (UTM) that is 400 ft above ground level (AGL) and below [3]; VTOL and similar "air taxi" type aircraft designed to fly over urban centers is categorized as Urban Air Mobility (UAM) that is up to 4,000 ft AGL [4]; and lastly Upper Class E Traffic Management (ETM) that is 60,000 ft AGL and above. With traditional airspace operations sandwiched between the UAM and ETM operating environments. When referring to these three environments, the term Extensible Traffic Management (xTM) is used for the overarching term of traffic management approaches and/or associated services that address the operation of select new entrants within flexibly allocated, designated airspace [5]. To illustrate the connectedness of xTM and its various entities and actors, figure 1 provides a high-level architecture of a potential xTM environment.

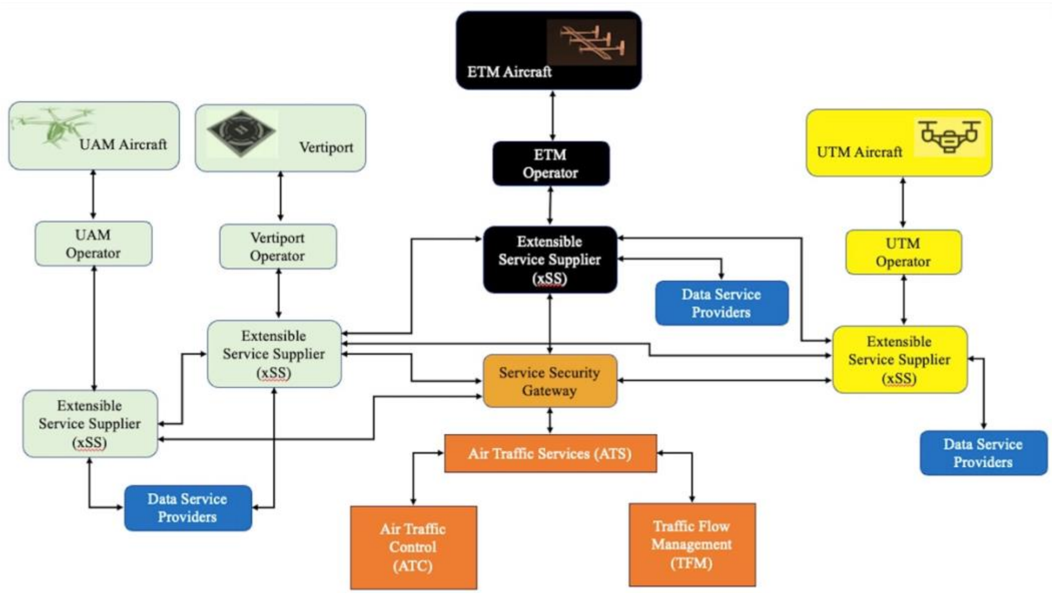

Figure 1 – Notional xTM Environment

Objectives:

Given the complexity of the coordination necessary for these vehicles to not only fly but to fly over urban centers, know one another's position and be able to handle conflicts absent traditional conflict measures supplied via FAA ATC; the exigency of cybersecurity becomes blatant and extremely pertinent. This brings to light the third research objective for the subproject – making sure this is all accomplished securely. Cybersecurity mechanisms will be researched that ensure the confidentiality, integrity, and availability of xTM systems and data exchanges. To accomplish this, the research team has sought out to develop an xTM Security Architecture. The development of the xTM Security Architecture is meant to be the initial step in understanding the cybersecurity implications for this research area through dissecting and decomposing the various components of flight across the three domains that make up xTM. The development of the security architecture will utilize use cases that will be informed through industry knowledge of the NAS and air traffic management. This information will then be distilled through a cybersecurity filter to develop methods to mitigate cybersecurity risks and provide a foundation for security control recommendations to regulators and industry.

The security architecture identifies the common characteristics of flight across xTM, comprising of - pre-flight, departure phase, enroute, arrival and post flight. Each of these phases of flight are combined with actors and use cases and then further broken down utilizing the STRIDE Threat Modeling approach. The STRIDE threat model focuses on the impacts of spoofing, tampering, repudiation, information disclosure, denial of service and escalation of privileges [6].

This paper seeks to document the creation of a security architecture for the xTM environment. Included in this as a key component, this paper will identify and catalogue threats that can lead to risks, vulnerabilities, and weaknesses within the xTM environment. Through a detailed decomposition of the phases of flight, the research team will provide analysis and recommended security controls to minimize risks identified that could lead to collision, major operational instability, or unauthorized data disclosure throughout the various phases of flight. With the critical safety implications understood and a major motivator; the development of this architecture seeks to understand and explain the unexplored interactions and implications of the cross-domain environment that makes up this emerging xTM ecosystem. While concurrently, seeking to understand its interactions and effects within the existing NAS.

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