Advances in the Use of NAS Infrastructure and GBDAA for UAS Operations

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Abstract—
A Ground Based Detect and Avoid (GBDAA) system, derived from the Terminal Automation Modernization Replacement (TAMR) system, the terminal air traffic control (ATC) automation system currently in use in US National Airspace (NAS) continues to evolve to provide enhanced detect and avoid decision making for unmanned aircraft (UA) operating in the NAS. GBDAA capabilities have been developed as a partnership between the USAF, State of Ohio, DOT Volpe Center, MITRE and Raytheon. The system displays airborne tracks provided by a collection of sensors for situational awareness and proximity alerts to crew and mission planners. Large and small unmanned aircraft systems (sUAS) operations are supported using both fixed and mobile facilities.

The GBDAA system allows the pilot to make decisions about flight maneuvers without using ground observers or chase planes during day and night operations. Recent enhancements include the use of a separate GBDAA Operator (GO) display, synchronized with the UA’s Pilot in Command’s (PIC) display to allow for the safe passage of the UA throughout its operational airspace. The GO supports the PIC with alert prioritization and maneuver recommendations, allowing the PIC to focus on piloting tasks and reduce the time needed for avoidance maneuvers.

Several types of UAS operations are described that include:
- Table top sUAS operations at a small airfield
- Medium sized unmanned aircraft (UA) Ground Control Systems (GCS) such as those used for Predators/Reapers and mobile cart technology.
- Larger UAS operations such as those used for the Global Hawk with a separate mission operations center
- Airspace utilization, such as transit corridor operations, transition from terminal operations to Class A airspace, and free flight considerations

The availability of surveillance coverage and the size of the UAS operational airspace that can be supported can be determined based on available surveillance assets and airspace environment at each location. In many cases, existing surveillance assets are used to provide the information needed on the airspace being monitored. New radar equipment and modifications to existing surveillance assets can be used to augment existing ATC sensors and close surveillance coverage gaps.

GBDAA decision making is provided by new software and the use of multisensor fusion tracking software that supports the display of track information for both cooperative and non-cooperative targets. These are displayed to both the GO and PIC using a common situation display showing the operational airspace. Several ever increasingly urgent levels of proximity alerts are displayed to both flight crew members as they perform their respective tasks.

This paper describes important aspects of the development of a mobile facility as the team integrated access to FAA surveillance radar assets, radio and telecommunications gear to create a complete set of GBDAA services that can be installed at different sites. The necessary airport field work, integration of surveillance, radio and phone connections and the installation of a fully functional GBDAA system into a 36-foot modified recreational vehicle is described. This “GBDAA Bus” provides a working environment to support operations for sUAS stakeholders carrying out different missions for both AFRL and the State of Ohio’s UAS Center.

Where no access is available to certified FAA/DoD, airport surveillance and long-range radar sensors, several different types of towable sensors can be used, some even offering elevation approximation for non-cooperative targets.

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1. INTRODUCTION

Continued government and industry research and operational experience has helped to evolve the capabilities of the US Air Force (USAF) GBDAA system. GBDAA uses ground based surveillance, tracking and other capabilities derived from an FAA Standard Terminal Automation Replacement System (STARS) pedigree, to provide a detect and avoid capability for the UAS crew. In this paper, we focus on the 2nd version of the GBDAA system and provide details unique new mobile capabilities.

The Government and Industry team involved includes the USAF Life Cycle Management Center (AFLCMC), Air Force Research Labs (AFRL), the Ohio/Indiana UAS Test Center, Raytheon Company, DOT Volpe Transportation Center, the MITRE Corporation and others.

GBDAA provides the UAS flight crew situational awareness while transiting civil airspace. Without GBDAA, ground spotters or chase aircraft are positioned prior to UA flight to see and avoid for other traffic throughout operations. The GBDAA system replaces ground or airborne observers and enables a shared situational awareness between the members of the flight crew. Newly developed capabilities allow a GO to participate from a different location than the PIC. Now the GO can be located at a separate facility while the flight crew use separate synchronized displays to guarantee both are observing identical situational views. During operations, the PIC responds to alerts by maneuvering the UA to maintain separation from other traffic.

The GBDAA system uses multiple sensor feeds that are processed in a multisensor tracker to fuse the data into a single integrated air traffic picture. Airspace traffic information and several different GBDAA alerts are controlled and visualized to aid in maneuver decisions. For sUAS vehicles that are not detected by available sensors, a datalink from the Ground Control System (GCS) is available to provide UA position, identity and altitude information.

Earlier GBDAA work (see reference [1]) showed that the system meets a target level of safety of \( \leq 10^{-7} \) midair collision (MAC) events / flight hour. Using modeling, simulation, and collected data it was concluded that “…the target level of safety \{ … \} will be met with significant margin ….” Furthermore, “it can be concluded therefore that GBDAA provides at least an order of magnitude improvement in safety as compared with ground observers.” [2]

2. ENHANCED GBDAA OPERATIONS

GBDAA systems are employed as a non-intrusive addition to UAS GCS that is platform agnostic and not integrated with the UAS avionics. The system includes redundant computer, networking and data recording hardware, GBDAA Version 2.0 software, site-specific adaptation and configuration data, surveillance and telecommunications feeds and radio equipment.

The GBDAA system displays weather, track and map data overlaid on a view of the local operational environment. Alerts are displayed in the data block of tracks involved and are heard over headsets or speakers. Both Visual Line of Sight (VLOS) and Beyond VLOS (BVLOS) operations are supported but BVLOS requires GBDAA use during flights.

GBDAA detect and avoid alerting includes: 1

- Dynamic Protection Zone (DPZ) alerts - Alerting logic that uses UAS and intruder velocity projections to determine potential threats. The DPZ moves with the UA being monitored. It adjusts in size and orientation based on the UA’s flight characteristics. The DPZ displays configurable alert thresholds that represent the time in seconds that the UA could travel at its current ground speed.

- Static Protection Zone (SPZ) alerts - 3D airspace volumes that allow the GO and PIC to visualize the operational airspace, transit corridors and other regions required. The SPZ alerts inform the crew of threat aircraft within their operational airspace. Each site is configured to the needs and environment of the region they operate in. SPZ audible alerts are distinct from the more urgent DPZ alerts. Predicted track lines are displayed for all aircraft involved in the encounter.

Both fixed and mobile GBDAA facilities can be installed depending on operational requirements which may include:

- A mobile facility as shown in Figure 1 in support of sUAS flights.
- A fixed facility with a shared GO and PIC display either integrated into a Launch and Recovery Element (LRE) or Mission Control Element (MCE) or provided using specialized mobile carts that are moved to the GCS.
- A fixed facility with a remote operations center hosting the GOS while the PIC positions are located at different LRE and MCE shelters at the site.

![Figure 1 GBDAA Mobile Facility](image)

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1 Reference [1] provides a detailed description of GBDAA alerting.
3. SMALL UAS OPERATIONS

The GBDAA system installed for the Ohio/Indiana UAS Test Center and AFRL is an example of a mobile facility used for sUAS operations. The system is not configured to address all UAS and sites, airframes and operations, but it is a model of how such a system can be implemented at a test site.

Figure 2 shows a view of UAS operations at the Springfield-Beckley Municipal Airport in Ohio. This site is used by the UAS Test Center and AFRL to train and study different sUAS equipment and procedures. This figure shows a 3-D operational volume (green border) surrounded by a SPZ to provide intruder alerts for traffic near and within their operational airspace. BVLOS operations are carried out within this pre-defined airspace.

Springfield Airport UAS operations are performed in accordance with the “Concept of Employment (CONEMP) Ground Based Detect and Avoid Operations at Springfield-Beckley Municipal Airport” [2]. Surveillance is provided by two short range Airport Surveillance Radars (ASR-9) augmented by input from the local Common Air Route Surveillance Radar (CARSR). Automatic Dependent Surveillance – Broadcast (ADS-B) surveillance can be integrated, if needed.

Figure 3 GO Positions in Mobile Facility

The GBDAA Mobile Facility houses most of the equipment and two GO positions, shown in Figure 3. The GBDAA Bus receives the local radar data along with the UA position data from the GCS. The vehicle is powered using available shore power connections on the airfield or using an onboard
generator. Each GO position is “linked” to a PIC position located either adjacent to the vehicle or some distance away at fixed sites on the airfield. All critical equipment is backed up by an uninterruptable power supply (UPS).

The PIC position is often setup on a set of tables. This equipment may be located several thousand feet from the mobile platform, with cockpit intercom, PIC workstation data and own-ship sUAS position information traveling on single-mode optical fiber. Power is supplied by small portable generators, operating in parallel, with a UPS provided should the generators fail. Either generator may be refueled while the other carries the electrical load. The PIC position hosts separate radio and telecommunications equipment cases with tactical fiber optic cable adapter connectors mated to the bus via fiber optic cable patch panels located at several hand holes on the airfield. For redundancy, the mobile platform and the PIC position table are fitted with separate, FAA-certified Air-Ground aircraft radio transceivers. Both radios work into collinear VHF antennae to optimize radio coverage. At the PIC (GCS) location, A-G radio and UAS telemetry / Global Positioning System (GPS) antennae are mounted on two separated folding tripods connected to appropriate GCS equipment.

GBDAA Version 2.0 enhancements allow the GO and PIC positions to be synchronized to insure a common operating picture is shared. While the PIC focuses on piloting and sensor duties, the GO, in communication with the PIC, observes nearby traffic, acknowledges GBDAA alerts and consults with the PIC on threats to safe operations. The PIC has the final authority on maneuvers made.

GBDAA voice communications between the PIC, GO, other aircraft and the Columbus (CMH) Terminal Radar Approach Control (TRACON) facility is provided with multiple levels of redundancy. The GBDAA Bus incorporates a digital cockpit interphone, Technical Standard Orders - compliant Very High Frequency radios, terrestrial telephone, hand-held Land Mobile Radios (LMR) and cellular phones. The cockpit interphone system provides high quality audio communications between the GCS air crew and the GO on the bus. A dedicated communications rack houses much of the equipment and is the input for fiber optic cabling supporting voice and data communications and raw radar data from three radar sensors.

The GO communicates with the PIC via the cockpit interphone, an LMR or cell phone. Both communicate with other aircraft via VHF radio. Via a Letter of Agreement with the CMH TRACON, they will provide broadcast of emergency declarations only to regional aircraft on behalf of the UAS crew to ensure broadcast coverage. Both the GO and PIC can communicate with local traffic and advisory calls and general situation updates are issued when required.

The GO communicates with CMH via a shout-line requiring no dialing or a 2-digit party line (secondary backup), or lastly cellular phone. The dedicated, party line can also be used by others on the line (such as controllers) to contact the crew if required. Identical capabilities are provided for the PIC to communicate with the TRACON or GO if needed.

Critical power standards are met on the bus via having access to shore power and an onboard, 8 kW diesel generator set. All workstations and communications gear operate from dedicated UPS equipment, ensuring no interruption of power, should power have to transition from shore power to genset, or vice versa. The vehicle power distribution, grounding, bonding, shielding and lightning protection meet FAA and DoD Standards for Communications Electronics / Air Traffic Control Facilities.

### 4. UAS Track Data Link

For sUAS operations, the drone aircraft may have a radar cross section that is too small for consistent detection by the system’s primary surveillance radars. Furthermore, the vehicle may have neither a secondary surveillance radar transponder or ADS-B to provide cooperative surveillance. In such cases, an interface has been developed to support consistent and accurate tracking by the GBDAA system.

For several different classes and types of sUAS, surveillance information is provided from an AFRL-developed track datalink application that sends UA position data from the GCS to the GBDAA system. This application runs on a dedicated workstation that conveys sUAS position in the All-Purpose Standard Eurocontrol Radar Information Exchange (ASTERIX) Category 062 track data message once per second. This UA Position Report interface evolved from work done during earlier FAA and DOD funded NextGen programs. Data is recorded on redundant continuous data recording equipment for analysis and playback.

CAT062 UA Position Reports [1] that are received from the datalink adapter are processed to display an associated geodetic track that is shown as an "external" track to the flight crew. This track is displayed with a yellow fused position to highlight it as the UAS being monitored.

### 5. Medium Sized Fixed Installations

An earlier IEEE Paper “Unmanned Aircraft Sense and Avoid: Leveraging ATC Infrastructure” [2] describes an operational system used by the USAF for Predator and Reaper UA flights in the NAS. For these Remotely Piloted Aircraft (RPA), the GO and PIC man positions adjacent to one another in the GCS and share the same operational view on a single situation display. While transiting civil airspace during BVLOS operations, the GO acknowledges alerts and monitors traffic to assist the PIC by queuing encounter threats to be avoided and collaborating on appropriate avoidance maneuvers.

In this system configuration, the GBDAA controls and display are mounted in an LRE that may be located in a containerized shelter or mounted on a mobile cart. The GBDAA mobile cart hosts a situation display, speaker and
controls that are mounted on a wheeled cart, derived from existing medical cart technology. These carts allow the flight crew to install GBDAA as needed at different GCSs. The GCS may be located within a small transportable shelter or setup using containerized equipment. Carts are connected via network or fiber cables, depending on the distance from the GBDAA equipment room at the site. The carts can be moved from one GCS or another as operations dictate.

6. LARGE SIZED FIXED INSTALLATION

For large installations, such as those controlling the Global Hawk; the GO, PIC and GBDAA equipment room may be separated by considerable distances. A small set of qualified GO personnel may service a larger team of PICs operating from different GCS shelters. In these sites, the GO is located in a mission operations center that supports numerous remote LRE or MCE shelters.

In this configuration, a GO links to a PIC position that is being supported during a mission. Each GO is linked to a single PIC and the GBDAA display is synchronized throughout the flight. The PIC is located at an LRE or MCE depending on operational requirements.

In larger installations, the GBDAA equipment room, often located in the local Air Traffic Control Tower, is connected to the UAS’s operating center where the overall mission is managed and the GO positions are located. Control of what PIC position a particular GO links to is handled by a Keyboard Video Mouse (KVM) matrix switch. The GO uses an application running on a tablet PC to connect their position to the PIC they are supporting. The GO and PIC connections can be changed between flights but at no time is any GO connected to more than one PIC. As operations do not involve more than one flight at a time, this approach provides a way for the GOS to support different flights, controlled at different GCSs, as operations dictate.

7. GBDAA ALERTING CONSIDERATIONS

The GBDAA systems allow each site to tailor their configuration to their operational needs. System settings are preconfigured during installation and no complex setup is required prior to a flight. Alert settings can be changed but only by users with proper login authority to do so. Checklists are provided to insure settings are not inadvertently changed. Alert timings for the DPZ and the SPZ size and shape may differ between sites as operational and safety requirements dictate. SPZ size is a function of terrain, mission needs, population centers, where the flights originate, etc. Based on a configurable setting, SPZ intruder alerts can be setup to warn of any target entering the SPZ or just to alert on non-discrete beacon or primary only targets. At some sites, aircraft with discrete Mode 3A beacon codes are not alerted upon as ATC provides separation services. This is not always the case, as at the Ohio GBDAA Bus, any aircraft entering the SPZ will cause an SPZ intruder (INT) alert. Operational settings are defined by requirements specified for each site that are preconfigured during the installation process.

The types of BVLOS operations supported to date include:

- Horizontal Transit Corridor – used as a conduit between Class D airspace and VLOS operations to a BVLOS transit into a restricted area where the GBDAA system is used to monitor the transit through a corridor of civil airspace to get back and forth from the airport and an operating area cleared of traffic by ATC. The SPZ surrounds the corridor to provide alerts for traffic within a preconfigured distance.
- Vertical Transit Corridor – used where a large UA, such as a Global Hawk, is spiraling to/from high altitude through the NAS to Class A airspace. In this case the SPZ is an oval surrounding the flight paths to the runways at the site.
- Limited Free Flight – used where operations cover a large BVLOS area. Figure 2 illustrates this airspace covering a significant region of Ohio adjacent to the Springfield-Beckley Municipal Airport.

8. GBDAA SURVEILLANCE CONSIDERATIONS

Surveillance sensors able to detect cooperative and non-cooperative aircraft are used by the GBDAA system. These sensors include long and short-range primary and secondary radars that can also provide weather information for display to the flight crew. ADS-B and multilaterated surveillance are also supported. The GBDAA System uses FAA approved NAS interfaces via existing Federal Telecommunications Infrastructure (FTI) Service Delivery Points sources at local FAA TRACONs or DOD Radar Approach Control (RAPCON) facilities. Direct radar surveillance feeds from a radar sensor located at a GBDAA site are also utilized when available.

Both research work and demonstrations have been conducted for the use of the Raytheon Sentinel radar, the use of multiple Raytheon Low Power Radar (LPR) nodes has been demonstrated and ongoing work with the Northeast UAS Airspace Integration Research Alliance (NUAIR) is working to certify the use of this new radar in the NAS. The GBDAA Program has also studied the development of a Syracuse Research Corp. LSTAR radar interface. Earlier work with the Edwards AFB ASR-11 and a mobile ASR-11 demonstrated the use of concurrent beam processed primary radar data to provide an altitude estimation from an existing primary surveillance radar for GBDAA operations.

Many of these sensors can be transported with the GBDAA Bus to provide a self-contained UAS operations facility. Predefined locations could be identified to access the FAA FTI to allow for GBDAA coverage that could be setup for use as needed.
9. GBDAA SAFETY CASE

The safety case for the GBDAA system relies on site-specific analysis of the system performance, regional NAS environment, and alignment to the operational procedures. The process is tailored to the DOD risk assessment criteria and authorities using standard DOD practices; such as the use of the Mil-Std 882E, DOD system safety process for risk level determination. For each site, over 30 technical and operational artifacts are produced to develop a consistent and defendable case for the operations planned at that location. For the initial operational capability at Cannon AFB, this included a site-specific audit of the system software against Mil-STD 882E SwC13. As part of the development of new operational artifacts are produced to develop a consistent and defendable case for the operations planned at that location. For the initial operational capability at Cannon AFB, this included a site-specific audit of the system software against Mil-STD 882E SwC13. As part of the development of new sites to support multiple operational models, the audit has been performed on a single software baseline, allowing local configuration changes for different operational models.

The foundational operational artifact developed for the GBDAA safety case is a local CONEMP that describes the operational mission being supported and the basic architectural methodology for GBDAA to provide services to the aircrew. This single core description of the system’s capabilities and utilization serves as a jumping off point for the other artifacts developed for the safety case. Beginning with a general description of the operational need, the CONEMP then provides a detail description of the planned use of the airspace, including both the route structures of the UAs in use (e.g. waypoints from Class D to Class A in vertical transition) to define the operational volume of interest, the surveillance volume expectations, and intruder alerting volumes (specifically the SPZ) required of the site.

Based on the high-level utilization of the airspace, the CONEMP then provides background on the GBDAA architecture planned for use at the site and the implementation of SPZ and DPZ constructs for the aircraft involved. From the operational perspective, the CONEMP provides background on the UA procedures in the airspace, contingency procedures for the UA in BVLOS conditions associated with GBDAA, and examples of “worst case” scenarios during specific operational segments, such as arrival/departure. These scenarios serve only as initial perspective, and are validated by the unit safety organization and others identified during the development process.

The implementation of the operational procedures for the site in official risk authority documentation (such as a local Operational Instruction) are inherent to and required by the safety case structure developed for GBDAA. This relationship between technical/operational analysis and codification of operational procedures is fundamental to the structure that has been developed through this process.

Radar Characterization

Based on its site-specific design, the operational volume for GBDAA is bound by the performance of radar systems in use. In support of initial CONEMP development and as formal definition of the approved operational volume, the performance of the radar systems supporting GBDAA are modeled and flight tested for Probability of Detection (Pd) performance. While the modeling and simulation of the radar systems in use serves as input to the CONEMP, validation and verification (V&V) of the model for radar systems not previously used with GBDAA is performed using flight test data to set the final operational and surveillance volumes.

In a typical configuration, GBDAA uses local radars to provide surveillance coverage although infill or mobile radar systems are supported by the architecture. Each sensor is evaluated on its ability to detect and track, with high probability, all potential collision threats to the UAS during operations within the targeted operational volume. To do this, and baseline simulation model is established for 1 square meter Radar Cross Section (RCS) targets using the Navy Advanced Refractive Effects Prediction System (AREPS). The AREPS results are then further analyzed and visualized using the MITRE Sense and Avoid Modeling and Simulation Evaluation Toolset (SAAMSET) to provide the boundaries (lateral and vertical) of the surveillance coverage provided by each sensor (see example in Figure 4).

![Figure 4 Radar Modelling and Simulation Sample](image)

Predicted coverage results are used to evaluate the detectability of horizontally separated and pop-up intruders and serve to define the boundaries for flight test. The performance of the GBDAA system tracker is also integrated with the results to determine appropriate track initiation altitudes in the operational volume to define the volume’s vertical floor. The flight tests are performed using manned aircraft equipped with standalone GPS position data loggers to provide V&V of the simulation results. Based on the results of this process, the final operational and surveillance volumes are set as part of the GBDAA site configuration.

Airspace Characterization

GBDAA airspace characterization utilizes a modification of an existing FAA document template to detail the operational area and describe the geographic, environmental, and air-traffic limitations in and around the specific site of interest. The Airspace Characterization documents geographic, environmental, and air traffic factors in the regional area that

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2 Previous public release USAF 66ABG-2018-0020
may impact the utilization of GBDAA in support of BVLOS operations to provide background in support of the determination that UA flights in the operational area can be performed with a reasonable level of risk. This based on the premise that the “likelihood” of acceptable conditions for a given UA operation depends upon the impacts of the environment and air traffic for a given volume and time. This “likelihood” theoretically could be used to rank multiple options for specified missions and times, or to evaluate the desirability of a given volume of airspace for a given time.

The second purpose of this document is to provide data that is used to qualify and quantify the risks and hazards of operations due to geography, weather, other aircraft, etc. Specific airspace research and analysis includes:

- Geography (topography, population, structures, etc.)
- Environment (weather, electromagnetic interference, bird routes, etc.)
- Air traffic and its management (airports, airspace classes and special areas, Air Traffic Management [ATM] services, air traffic distributions, etc.)

The Airspace Characterization serves to set context by describing geographic boundaries and limitations of the operational site and surrounding airspace. Building on the geography, this document also describes the constraints that the environment and air traffic could impose on operations. The document enables the operational unit to fully understand the regional airspace environment, and make appropriate plans to integrate in that region in a safe manner.

Data Analysis and Safety Level Determination

The Data Analysis and Safety Level Determination provides the results of analysis of the expected level of safety of each site-specific GBDAA deployment developed through modeling and simulation. The level of safety is expressed in terms of MAC per hour and is calculated based upon GBDAA operators following the recommended mitigations as described in this paper when encountering air traffic determined to be intruders.

Characterization of site-specific airspace safety level requires modeling the UA’s intended routes, routes associated with typical air traffic, and analyzing the effect of prescribed mitigation strategies on the likelihood of Near Midair Collisions (NMACs) between the UA and local traffic. This analysis does not consider interactions between the UA and other unmanned aircraft, e.g. hobby drones. In this case, the UA is considered to have equal likelihood of being at any point along routes within the operational volume.

The result of this analysis is a determination of system level of safety, expressed in terms of MACs per flight hour. Results are derived from a model that simulates UAs traveling along the defined route structures with operators following the recommended mitigations as described in this paper when encountering air traffic determined to be intruders.

Figure 5 Airspace Safety Characterization Methodology

Depending on the planned operations at a site, UAs can be modeled at different operational velocities and across a range of potential turn rates to assess the effect of maneuverability on safety. The surveillance volumes (SPZ and DPZ) are modeled as implemented for the local airspace, both statically and dynamically. An overview of the analysis methodology is provided in Figure 5.

The likelihood of collision is determined by running thousands of encounter scenarios between UA and intruder trajectories and calculating the number of NMACs in the set. The NMAC volume is defined as a 500-foot horizontal radius from an aircraft and 100 feet above and below an aircraft. The number of NMACs per flight hour is then converted to MACs per flight hour using an NMAC to MAC ratio [4] of 10 to 1.

The results of the analysis, as well as any operational constraints required to achieve those results, are then compared to existing target level of safety guidelines such as those from the 2011 FAA Sense and Avoid workshop recommended that such systems meet a target level of safety of at most 1e-7 midair collision events per flight hour.
10. GLOSSARY

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<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>ADS-B</td>
<td>Automatic Dependent Surveillance – Broadcast</td>
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<td>AFB</td>
<td>Air Force Base</td>
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<td>AFLCMC</td>
<td>Air Force Life Cycle Management Center</td>
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<td>AREPS</td>
<td>Advanced Refractive Effects Prediction System</td>
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<td>ASR</td>
<td>Airport Surveillance Radar</td>
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<td>ASTERIX</td>
<td>All Purpose Structured Eurocontrol Radar Information Exchange</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<tr>
<td>BVLOS</td>
<td>Beyond Visual Line of Sight</td>
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<td>CARSR</td>
<td>Common Air Route Surveillance Radar</td>
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<td>CAT62</td>
<td>ASTERIX Category 062 message</td>
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<td>CMH</td>
<td>Columbus TRACON</td>
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<td>CONEMP</td>
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<td>DOD</td>
<td>Department of Defense</td>
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<td>DOT</td>
<td>Department of Transportation</td>
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<td>DPZ</td>
<td>Dynamic Protection Zone</td>
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<td>FAA</td>
<td>Federal Aviation Administration</td>
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<td>FTI</td>
<td>Federal Telecommunication Infrastructure</td>
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<td>GBDAA</td>
<td>Ground Based Detect and Avoid</td>
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<td>GCS</td>
<td>Ground Control System</td>
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<td>GO</td>
<td>GBDAA Operator</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>INT</td>
<td>Intruder</td>
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<td>KVM</td>
<td>Keyboard Video Mouse</td>
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<td>LMR</td>
<td>Land Mobile Radio</td>
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<td>LRE</td>
<td>Launch and Recovery Element</td>
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<td>MAC</td>
<td>Mid-Air Collision</td>
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<td>NAS</td>
<td>National Airspace System</td>
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<td>NMAC</td>
<td>Near Mid-Air Collision</td>
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<td>MCE</td>
<td>Mission Control Element</td>
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<td>MIL-STD</td>
<td>Military Standard</td>
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<td>Pd</td>
<td>Probability of Detection</td>
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<td>PIC</td>
<td>Pilot in Command</td>
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<td>RAPCON</td>
<td>Radar Approach Control Facility</td>
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<td>RCS</td>
<td>Radar Cross Section</td>
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<td>RPA</td>
<td>Remotely Piloted Aircraft</td>
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<td>SAAMSET</td>
<td>Sense and Avoid Modeling and Simulation Evaluation Toolset</td>
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<td>STARS</td>
<td>Standard Terminal Automaton Replacement System</td>
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<td>UPS</td>
<td>Uninterruptable Power Supply</td>
</tr>
<tr>
<td>USAF</td>
<td>United States Air Force</td>
</tr>
<tr>
<td>V&amp;V</td>
<td>Validation and Verification</td>
</tr>
<tr>
<td>VHF</td>
<td>Very High Frequency</td>
</tr>
<tr>
<td>VLOS</td>
<td>Visual Line of Sight</td>
</tr>
</tbody>
</table>

11. REFERENCES


12. BIOGRAPHIES

Robert Stamm is a Technical Director working for Raytheon’s Intelligence, Information and Services Division. He has over 30 years of systems and software architecture experience. Bob has been the Technical Director for the development of several STARS prototype systems for fusion tracking of radar, multilateration and Automatic Dependent Surveillance – Broadcast sensors. He was also the TD for several FAA, DOD and NASA funded programs that implemented some of the first SWIM services demonstrated for NextGen. Bob is currently the GDSAA Technical Director for the STARS Program.

Bob’s career includes medical imaging research and development work at Brookhaven National Laboratories, radar tracker development for US Navy Carrier ATC and other air and vessel traffic control systems along with enterprise management R&D at both Computer Associates International and Raytheon. Bob holds a MS Degree in Computer Sciences, Polytechnic University of New York, a BS Degree in Computer Science from Empire State College, State University of New York and a BS in Biological Sciences from the State University of New York at Stony Brook.

Jason Glaneuski is a Program Manager and Operations Research Analyst in the Air Traffic Management Systems Division at the Volpe National Transportation Systems Center (Volpe Center) in Cambridge, MA. His Division applies information technology and operations research disciplines to enhance the capacity, safety, and security of the National Airspace System. A key component of this work is developing concepts and designing automated decision-support tools and capabilities that provide solutions to existing and anticipated traffic flow issues. Mr. Glaneuski has experience both performing and managing technical work in the areas of traffic flow management (TFM), time-based flow management (TBFM), and unmanned aircraft systems (UAS) sense and avoid (SAA), among others. Mr. Glaneuski is a graduate of Daniel Webster College in Nashua, NH, where he received his B.S. in Aviation Management and Flight Operations. Prior to joining the Volpe Center in 2001, Mr. Glaneuski worked for the FAA’s Free Flight Program Office in Washington, D.C.

John M. Belanger is Group Leader for Global Flight Operations in MITRE’s National Security Engineering Center (NSEC). He is also a MITRE Principal Systems Engineer and is currently the Chief Engineer for the GBDAA program for the United States Air Force (USAF), Lifecycle Management Center, Aerospace Management Systems Division.

John’s career spans over 20 years in systems engineering and technology development. This includes semiconductor equipment and SEMATECH standard development for the Intel Corporation; engagement of small businesses to Fortune 500 companies in the development of B2B and consumer-facing online presences for Auragen Communications; and advanced technology planning for the USAF with AT&T Government Solutions and Mantech Corp. Prior to working in Global Flight Operations at MITRE, he led the company’s support of the analysis and integration of national lab and venture capital technologies into the USAF acquisitions process.

John received the B.S. degree in Mechanical Engineering from the University of Rochester, Rochester, NY, USA, and the M.S. degree in Materials Science and Engineering focusing on photovoltaic materials from the University of Illinois Urbana-Champaign, Illinois, USA.

Peter Kennett is the GBDAA Program Lead Engineer from the DOT Volpe Transportation Center’s Infrastructure Engineering & Deployment Division. Mr. Kennett is a Registered Professional Electrical Engineer in Massachusetts, Mr. Kennett’s management and design activities have centered around real-time control / automation, power systems, facilities, communications, navigation, semiconductor manufacturing equipment and process control systems. Military experience included shipboard engineering, marine propulsion systems and navigational radars.

Mr. Kennett was an original member of the award-winning Volpe National Air Space (NAS) Upgrade Project Team, supporting the Department of Defense since 1999 in the upgrade of antiquated air traffic control sub-systems within the NAS and overseas. He currently supports military unmanned aircraft systems.