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Agenda Item 4: **Aeronautical Mobile Service**
Agenda Item 13: **Review developments, research, trial and demonstration relating to CNS/ATM**

STATUS OF SAFE FLIGHT 21

(Presented by United States of America)

SUMMARY

Safe Flight 21 is a cooperative government/industry program to evaluate capabilities to improve aviation safety, efficiency, and capacity. It focuses on a manageable set of operational capabilities that are important to the user community. This paper discusses those operational enhancements made possible through the collaborative plans of the aviation industry and FAA to demonstrate, evaluate, and measure the operational benefits, and mitigate the risks of implementing those capabilities that prove beneficial.

REFERENCES

RTCA/DO-242 Minimum Aviation System Performance Standards (MASPS) for Automatic Dependent Surveillance Broadcast (ADS-B), February 19, 1998.

1. INTRODUCTION

1.1 The FAA, working with RTCA (an advisory group to the FAA), recognized that new communications, navigation, and surveillance (CNS) capabilities were needed to increase capacity, improve efficiency, and resolve safety problems. In 1998, the RTCA Free Flight Steering Committee comprised of members from aviation industry, FAA, and RTCA recommended to the FAA Administrator a strategy to resolve risks associated with the new CNS systems before these capabilities could be implemented. Under this strategy, the Safe Flight 21 Program was formed to address the CNS issues and provide information to the FAA and industry so that they could make decisions about implementing these systems. Safe Flight 21 is a cooperative government/industry program to evaluate capabilities for Free Flight. It focuses on a manageable set of operational capabilities that are important to the user community. These include the cockpit display of traffic, weather, and terrain information, improved information for controllers, and improved surface situational awareness. The new technologies are based on the use of Global Positioning System (GPS), Automatic Dependent Surveillance-Broadcast (ADS-B), Traffic Information Service-Broadcast (TIS-B), Flight Information Services-Broadcast (FIS-B), and the use of a multi-functional display in the cockpit and enhanced controller displays.

2. Safe Flight 21 Objectives

2.1. The Safe Flight 21 objectives are to identify, evaluate, and mitigate the risks associated with the selection, implementation, and integration of planned CNS capabilities and corresponding procedures. In mitigating these risks, the program will:

- Enhance safety,
- Increase system capacity and efficiency,
- Maximize user operational benefits,
- Minimize user equipage costs and FAA operational costs,
- Address pilot and controller human factors issues,
- Develop and assess new operational procedures and associated training,
- Streamline certification processes and procedures,
- Develop a cost-effective avionics and National Airspace System (NAS) infrastructure, and
- Define a realistic NAS transition path supported by the user community.

3.0 **Operational Enhancements**

3.1 The Safe Flight 21 Program operational enhancements were identified by the operational users through RTCA. The operational enhancements are as follows:

1. Provides weather and other information to the cockpit
2. Affordable means to reduce controlled flight into terrain
3. Improved capability for approaches in low visibility conditions
4. Enhanced capability to see and avoid adjacent traffic
5. Enhanced capability to delegate aircraft separation authority to the pilot
6. Improved capability for pilots to navigate airport taxiways
7. Enhanced capability for controllers to manage aircraft and vehicular traffic on airport surface
8. Provides surveillance coverage in non-radar airspace
9. Establish ADS-B separation standards.

Each of these operational enhancements is further defined in terms of operational applications.

3.2 Operational Enhancement 1 - Provide Weather and Other Information to the Cockpit

- Initial Flight Information Services –Broadcast (FIS-B) based on today's available next generation weather radar (NEXRAD) graphics, aviation routine weather report/aviation selected special weather report (METAR/SPECI), terminal forecasts (TAFs), significant meteorological information (SIGMETs), pilot reports (PIREPs) and severe weather forecast alerts.
- Add products such as notices to airmen (NOTAMs), lightning, icing, turbulence, real time special use airspace (SUA), and volcanic ash.

3.2.1 There is a significant amount of data in the National Airspace System that, if the pilot could have access to in the cockpit, would make the flight safer through improved situational awareness (e.g., weather information) or more cost effective (e.g., knowledge of special use airspace (SUA) restrictions).

3.2.2 This operational enhancement will use the Flight Information Services-Broadcast (FIS-B) to receive current and forecasted weather and weather-related information as well as the status of special use airspace. The enhanced weather products will be available to pilots and controllers, allowing them to share the same situational awareness. The information will be displayed in text and graphics to the pilot.

3.2.3 The expected benefits of this operational enhancement are: increased availability of flight services, increased timeliness and quality of data on weather and system status, increased access to airspace, and reduced flight times and distance.

3.3 Operational Enhancement 2 - Affordable means to reduce controlled flight into terrain

- Low cost terrain situational awareness
- Increased access to terrain constrained low altitude airspace.

3.3.1 There have been many fatal accidents involving controlled flight into terrain (CFIT) due to poor situational awareness. This operational enhancement will increase the pilot's situational awareness by providing a cost/effective terrain database and display in the cockpit.

3.3.2 The expected benefits of this operational enhancement are: reduction in the CFIT rate and increased access to low altitude airspace where terrain imposed restrictions exist.

3.4 Operational Enhancements 3 – 9

3.4.1 Operational enhancements 3 – 9 are based on the use of ADS-B and are included in the RTCA/DO-242 Minimum Aviation System Performance Standards (MASPS) for Automatic Dependent Surveillance Broadcast (ADS-B), February 19, 1998. The MASPS describes the operational applications for each of these enhancements, operational requirements, system level performance standards, interfaces, and minimum system test procedures to ensure that performance meets system level performance standards.

3.4.2 Improved terminal operations in low visibility

- Enhanced visual approaches (visual acquisition with existing procedures, ADS-B only)
- Enhanced visual approaches (with new procedures using ADS-B only)
- Enhanced visual approaches (with new procedures using ADS-B and TIS-B)
- Approach spacing (for visual approaches)
- Approach spacing (for instrument approaches)
- Departure spacing/clearance (visual meteorological conditions (VMC) in radar).

3.4.2.1 During approach operations there are a number of operational problems that limit efficiency. On visual approaches, it is often difficult to identify the aircraft to follow. It is also difficult to judge the distance and speed of the aircraft to follow.

3.4.2.2 ADS-B, Cockpit Display of Traffic Information (CDTI), and Traffic Information Service-Broadcast (TIS-B) could be used during low visibility approach operations to enable the crew to better identify the aircraft to follow and accomplish approaches at lower minimums, thus maintaining VFR throughput longer. The crew will also be able to maintain better spacing during VFR and IFR approaches.

3.4.2.3 The expected benefits of this operational enhancement are: increased access to airports, increased arrival rates, reduced arrival and departure delays, increased predictability of arrival times, and increased flexibility of arrival scheduling.

3.4.3 Enhanced see and avoid

- Enhanced visual acquisition of other traffic for see-and-avoid (using ADS-B only)
- Enhanced visual acquisition of other traffic for see-and-avoid (ADS-B and TIS-B)
- Conflict detection enhanced see and avoid
- Conflict resolution.

3.4.3.1 There are limitations with today's system of "see and be seen". This results in safety and efficiency issues. It is advantageous to increase safety for all aircraft by maintaining situational awareness of the traffic around them, in instrument meteorological conditions (IMC) and VMC.

3.4.4 ADS-B, CDTI, and TIS-B could provide traffic information to the cockpit. This will enable the pilot to maintain situational awareness of surrounding traffic.

3.4.4.1 The expected benefits of this operational enhancement are: increased pilot access to traffic information for situational awareness resulting in greater safety.

3.4.4.2 Enhanced en route air-to-air operations

- Pilot situational awareness beyond visual range.

Today's separation standards and procedures provide limited efficiency due to the lack of, and/or limitations associated with the radar-based surveillance.

CDTI and ADS-B could allow delegation of separation authority to the cockpit, resulting in increased efficiency.

3.4.4.3 Expected benefits: increased access to airspace, reduced flight delays and distances flown, increased predictability of flight times and distances flown, and increased flexibility in routes flown.

3.4.5 Improved surface surveillance and navigation for the pilot

- Runway and final approach occupancy awareness (using ADS-B only)
- Runway and final approach occupancy awareness (using ADS-B and TIS-B)
- Airport surface situational awareness.

3.4.5.1 It is difficult for pilots to navigate the taxiways of an airport especially in low visibility. Under reduced visibility conditions, the pilots may not be able to see other traffic.

3.4.5.2 A moving map display would enable pilots in the cockpit and the operators of equipped vehicles on the airport surface to "see" all the other traffic, resulting in safer and more efficient surface operations. Aircraft can use augmented GPS navigation and maps and Local Area Augmentation System (LAAS) in extremely low visibility conditions.

3.4.5.3 The expected benefits of this operational enhancement are: reduced runway incursion incidents, reduced taxi delays, and increased predictability of taxi times.

3.4.6 Enhanced surface surveillance for the controller

- Enhance existing surface surveillance using ADS-B
- Surveillance coverage at airports without existing surface surveillance.

3.4.6.1 Under low visibility conditions, it is difficult for the tower controllers to manage aircraft and other vehicular traffic on the airport surface.

3.4.6.2 Equipage of aircraft and ground vehicles in the airport movement area with ADS-B using augmented GPS-derived positions will allow the local and ground controllers in the tower to monitor the position and speeds of all the traffic in the movement area.

3.4.6.3 Expected benefits: reduced runway incursion incidents, reduced taxi delays, reduced arrival delays, increased predictability of taxi times, and increased departure/arrival rates.

3.4.7 ADS-B surveillance in non-radar airspace

- Center situational awareness with ADS-B
- Radar-like services with ADS-B
- Tower situational awareness beyond visual range.

3.4.7.1 Today's system contains areas of airspace that are outside of radar coverage. The lack of surveillance information limits a controller to the use of procedural separation to provide separation services. This type of separation limits both airport and airspace capacity.

3.4.7.2 ADS-B can provide additional surveillance coverage and fill gaps in radar coverage.

3.4.7.3 Expected benefits: increased access to airspace, increased arrival and departure rates, reduced flight delays and distances flown, increased predictability of flight times and distances flown, reduced deviations from the intended route, and increased flexibility in the routes flown and increased safety.

3.4.8 Establish ADS-B separation standards

- Radar augmentation with ADS-B to support mixed equipage in terminal airspace
- Radar augmentation with ADS-B to support mixed equipage in en route airspace.

3.4.8.1 Current automation is limited in providing benefits to users based on existing radar accuracy. ADS-B data can be integrated with radar and conflict alert to determine if separation standards can be reduced. Ultimately ADS-B will be integrated with advanced decision support automation.

3.4.8.1 The expected benefits of this operational enhancement are increased efficiency and maintained or increased safety.

4.0 Safe Flight 21 Demonstration and Evaluation

4.1 Safe Flight 21 demonstrates and evaluates the benefits of the applications described above. Prior to committing the FAA and the users to a full-scale implementation of these enhancements, there will be a consensus of the feasibility and business case for the enhancements among the stakeholders. The FAA and industry will jointly define, develop, and evaluate the enhancements.

4.2 The Safe Flight 21 Program Office will demonstrate and evaluate the benefits of this new technology. This will include operational and procedural issues, as well as cost/benefit matters. The review of operations and procedures will ensure that pilot, controller, operator, FAA air traffic maintenance, and flight standards issues are addressed. The cost/benefit activity will define the cost of the data link and quantify and qualify the economic and safety benefits derived from each capability.

4.3 In 2000, the Safe Flight 21 program conducted an Operational Evaluation in Louisville, Kentucky to demonstrate the efficiency and safety benefits of using ADS-B and to evaluate air traffic controller use of ADS-B in the terminal area environment. In addition, tests were conducted to develop and evaluate avionics and procedural modifications to improve the following applications: departure spacing, approach spacing, runway and final approach occupancy awareness, and airport surface situational awareness. The tests provided more data supporting the potential for using ADS-B avionics in the cockpit in combination with revised procedures to improve aircraft spacing and enhance surface safety.

4.4 In 2001, the Safe Flight 21 program conducted an air traffic modernization forum in Memphis, Tennessee to demonstrate newly installed multilateration surveillance capabilities and the use of on-board moving map displays for monitoring surface aircraft and vehicle movement. Multilateration infrastructure was also ordered for the Louisville, Kentucky test site. Other efforts included the award of four contracts for avionics development and evaluation, the development of a visual concept of use for surface moving map displays, and initial development of a surface moving map database to support this effort.

4.5 In 2002, the multilateration system was installed at Louisville, Kentucky, and a new automation platform for that facility to support on-going ADS-B test and evaluation efforts was procured. Development and evaluation continued on avionics and the procedural modifications needed to improve surface situational awareness to enhance existing surface surveillance using ADS-B. Interoperability and shakedown testing of avionics capable of transmitting and receiving ADS-B messages, receiving TIS-B messages, and displaying the combined ADS-B and TIS-B information to flight crews was conducted in April and May at Memphis International Airport. This data collection effort was designed to demonstrate the end-to-end functionality of the TIS-B infrastructure installed at Memphis, and provided data that will assist in the validation of the avionics. It also provided an opportunity to document the air-to-air and air-to-ground surveillance performance of ADS-B. A vehicle tracking system test bed was established in Memphis with the installation of ten surface moving map displays in airport operation vehicles and initiated evaluation activities. 36 digital airport surface moving maps were published as part of a prototype database available to industry for product development. The FAA ADS-B link decision was made in July 2002 and approved two data links. The 1090 MHz extended squitter ADS-B data link is to be used by air carrier and private/commercial operators operating in the higher altitudes, while a universal access transceiver (UAT) ADS-B link will be used by the typical, general aviation users. The Universal Access Transceiver (UAT) Minimum Operational Performance Standard (MOPS) has been approved. A series of simulations were conducted on the cockpit display of traffic information (CDTI) electronic flight rules (CEFR) to determine pilot/controller suitability, acceptance and human factors. In partnership with UPS, 107 ship sets of ADS-B avionics for installation on UPS 757/767 were procured and will support evaluation of enhanced visual approach applications.

4.6 In 2003, the Safe Flight 21 program is continuing to conduct CEFR simulations, survey and deliver new airport digital maps to the surface moving maps database (up to 56 digital surface maps) and expand the vehicle tracking evaluation in Memphis (additional vehicles) and established a vehicle tracking test bed in Louisville, Kentucky. RTCA Steering Committee SC-186 (ADS-B) approved the 1090 MHz ADS-B Minimum Operations Performance Standard (MOPS), Rev A, and approved the Traffic Information Service Broadcast (TIS-B) Minimum Aviation System Performance Standards (MASPS). A demonstration to evaluate the integration of ADS-B on the STARS automation system was conducted and human factors evaluations begun. In partnership with Embry-Riddle Aeronautical University (ERAU) the Safe Flight 21 program will procure ADS-B ground stations. ERAU has procured 104 sets of ADS-B avionics for their training aircraft in Prescott, AZ and Daytona Beach, FL. Based on ERAU’s commitment, the FAA will establish the two pockets of ADS-B implementation in the lower 48 states of the continental U.S. This will enable broadcast service (traffic/weather) applications and flight

following for ERAU. Building on the ADS-B pocket of implementation established in Daytona Beach, FL and the test infrastructure currently operating in Frederick, MD, McLean, VA and Atlanta City, NJ, a plan has been established to provide ADS-B coverage to support broadcast service applications along the east coast of the US by installing additional ADS-B ground stations. ADS-B demonstrations are occurring in the Gulf of Mexico in partnership with NASA, Petroleum Helicopter Inc. and Continental Airlines. ADS-B ground stations have been installed on oil platforms to demonstrate surveillance applications in a non-radar environment.

4.7 In 2000, under the Capstone initiative, the FAA equipped approximately 80 aircraft (out of 150 planned) with avionics equipment that includes a Global Positioning System (GPS), ADS-B using the Universal Access Transceiver (UAT) data link, and a terrain database to aid in terrain situational awareness. An ADS-B ground infrastructure consisting of one ground-based transceiver was established in the Bethel area (Yukon-Kuskokwim Delta region) of southwestern Alaska. Nine of eleven standalone GPS approaches were published for smaller village airports in the surrounding delta region. Two of ten Automated Weather Observation Systems (AWOS's) were installed. In addition, the MicroEARTS automation system at the Anchorage Air Route Traffic Control Center (ARTCC) was modified so controllers can track and monitor ADS-B-equipped aircraft. Based on the completion of these initial Capstone activities, on January 1, 2001, controllers in Anchorage began providing ADS-B "radar-like" services to aircraft in the Bethel area, the first use of non-radar surveillance for control purposes in the United States. The same data link that transmits target data to Anchorage also provides weather text and graphics information to the pilots in the Bethel area.

4.8 In 2001, Alaska continued "radar-like" service coverage in the Bethel area. One additional GPS approach was published, and eight weather systems were installed. In addition, the FAA installed ADS-B avionics on sixty additional aircraft operating in the area. While the Bethel avionics have been approved for Instrument Flight Rules (IFR) radar-like services, initial equipage has been for VFR use only, to allow pilots to adjust to equipment capabilities as well as to fully develop the operational concepts for using ADS-B under IFR conditions. These operational enhancements will be implemented incrementally in the area, based on their potential for improving safety and addressing user requirements. Additional air traffic control planning and procedural development is underway to enhance air traffic services in the Bethel area.

4.9 A plan to extend the Capstone initiative to southeastern Alaska was initiated in 2001 to enhance flight safety and provide a useable IFR infrastructure. This included avionics suites with upgraded certification for IFR applicationsand an IFR area navigation (RNAV) infrastructure using GPS for primary means of navigation in Southeast Alaska. Operators equipped to receive the wide area augmentation system (WAAS) signal would automatically begin to receive lateral navigation (LNAV) information also. Approximately 200 commercial service airplanes and helicopters operating in the area would be equipped with the upgraded ADS-B systems.

4.10 In 2002, Alaska Capstone program completed installation of remaining ground transceivers, weather systems, and ADS-B avionics in the Bethel area, to expand ADS-B "radar-like services". In addition, development of the low-level IFR route infrastructure for southeast Alaska continued. A contract was awarded for 200 primary flight and navigation displays that will be incorporated in the upgraded avionics suites and installations began. A contract for a Minimum Operational Performance Standards (MOPS)-compliant ADS-B avionics transceiver was awarded to demonstrate a useable system in 2003.

4.11 In 2003, the Alaska Capstone program conducted the first commercial flight using an "optimized" RNAV Special FAR 97 route structure in conjunction with enhanced Capstone Phase 2 avionics that includes a GPS/WAAS receiver certified under TSO 145a, in airspace inaccessible with

conventional avionics. An additional 41,000 feet of airspace along 1,521 nautical miles of the existing route structure in Southeast Alaska is now available for aircraft with Capstone Phase 2 avionics. A Request for Offer (RFO) was released for ADS-B capable ground based transceivers (GBT) and is currently being evaluated. The RFO requires Universal Access Transceiver (UAT) as the data link with a migration path to a dual link (UAT/1090 MHz) GBT and includes up to 250 units for Alaska and an option for up to 1,000 units for the lower 48 states of continental U.S. Capstone Phase 2 avionics are continuing to be installed. The Bethel approach control plan was approved and will use ADS-B as a surveillance source. Evaluation of wide area multilateration to provide additional aircraft position to other pilots, air traffic controllers and flight service specialists was initiated. Capstone also began testing the use of the Iridium satellites to augment ADS-B data transfer.

5. CONCLUSION

5.1 As a result of Safe Flight 21demonstration activities in Alaska and the Ohio River Valley, progress is being made toward implementing operational enhancements and applications related to the use of Global Positioning System (GPS), Automatic Dependent Surveillance-Broadcast (ADS-B), Traffic Information Service-Broadcast (TIS-B), Flight Information Services-Broadcast (FIS-B), and the use of a multi-functional display in the cockpit and enhanced controller displays. Pockets of ADS-B implementation in Alaska, along with the establishment of ADS-B ground infrastructure in Prescott, AZ and Daytona Beach, FL will allow users to take advantage of a variety of initial ADS-B benefits. The avionics market place is now recognized the potential for ADS-B applications and benefits and has begun to offer products that incorporate ADS-B capability to a variety of commercial and general aviation customers. The NAS Modernization 2002 update approved by the Administrator in October 2002 and the FAA ADS-B link decision recognize a national deployment of 900 ADS-B ground based transceivers by 2012. The Safe Flight 21 program continues to evaluate and demonstrate potential applications to take full advantage of the ADS-B, TIS-B and FIS-B technology.

5.2 Meetings participants are requested to note the material presented in this information paper and consider its applicability to improve safety and efficiency of civil aviation operations within the Asia-Pacific Region. The members are also invited to visit the FAA's Safe Flight 21 websites at:

http://www.faa.gov/safeflight21 and
http://www.alaska.faa.gov/capstone