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Roger C. Matteson

IS FREE FLIGHT A REALITY OR MYTH?

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During the past ten years, air navigation has made great strides. With an introduction of Global Positioning System (GPS), the Air Traffic Control (ATC) system has seen a massive leap forward in technology. There has been talk of eliminating the current en route and approach navigation system utilizing VORs, NDBs and ILSs. That approach may have been premature. The new projected target date for initiating Phase I of the Wide Area Augmentation System (WAAS) is September 2000 (Eldredge, 1999). This is an extension of 14 months from the original target date.

WAAS is the backbone of Free Flight. Without WAAS, Free Flight cannot achieve its goal of turning the current ATC system into more of a management role versus a control role. The theory behind Free Flight is that aircraft can go directly to their destination without relying on ground-based navigation aids and ATC to guide them along the route. Users are allowed more freedom in selecting routes. In addition, pilots will not have to rely solely on voice communications and will have increased latitude to make altitude and heading corrections based on improved situational awareness to avoid other traffic (Iler & Planzer, 1999). For short distances this would not be an advantage, but for long flights, savings in time and fuel could be significant.

Presently, it is possible for pilots to fly direct to their destination with Inertial Navigation System (INS) and GPS navigation however, the current ATC system is not set up to handle such a role. It becomes difficult for ATC to monitor and control the traffic without aircraft utilizing the established airways. The Free Flight concept incorporates technology into the cockpit to allow the pilot to detect possible traffic conflicts. The ATC work station will have the same information displayed to the controller.

What is Involved in the Free Flight System

As stated above, Free Flight consists of different components. The following are the major components that are being proposed and tested:

1. WAAS is a series of GPS reference stations that are strategically placed around the target area.
These ground reference stations monitor GPS signals and relays information to a master station. The master station assesses signal validity, computes corrections and creates the WAAS message. It sends this to a ground uplink station which relays the information to ATC and the aircraft. The WAAS correction signal allows the aircraft receiver to compensate for any errors and time delays that were transmitted to the aircraft directly from the satellite (Bowie, 1997). These WAAS corrections signals will increase the accuracy of the GPS receiver in the aircraft to Category I precision approach minimums.
2. Local Area Augmentation System (LAAS) is intended to complement WAAS. In areas where WAAS does not provide coverage, LAAS will provide navigation and landing information. LAAS also will have the capability to provide Category I, II, III precision approaches. The technology that LAAS uses is similar to WAAS. Whereas WAAS uses satellites to broadcast its information, LAAS will use a Very High Frequency (VHF) radio datalink from a ground-based transmitter that is strategically placed near the airport (Federal Aviation Administration, 1998).
3. Automatic Dependent Surveillance - Broadcast (ADS-B) allows pilots and air traffic controllers to see other aircraft within about 100 miles, with more precise information than conventional radar. ADS-B utilizes GPS technology to upload information and then send out the data via digital data-link to other aircraft and air traffic controllers. Some of the information that is transmitted is airspeed, altitude, and whether the aircraft is turning, climbing or descending (Ott, 1999).
4. The cockpit display will utilize the ADS-B information provided by data-link utilizing the Mode-S transponder, weather satellite, High Frequency (HF) or VHF communications. The digital data-link will digitally transmit standard information to the pilot (such as speed, altitude, and heading assignments) from the controller keyboard to a

display in the cockpit (Perry, 1997). The information will be displayed on a multifunctional display (MFD), such as a Cockpit Display of Traffic Information (CDTI), and can be integrated with other displays such as weather radar and Enhanced Ground Proximity Warning System (EGPWS) (Federal Aviation Administration, 1998). Eventually, these displays will be integrated into present Electronic Flight Information System (EFIS) displays in the cockpit. This information is used by the pilot to increase their situational awareness of the traffic around the aircraft out as far as 100 miles (Proctor, 1999).

There are advantages of using ADS-B over the Traffic Collision Avoidance System (TCAS). ADS-B is more affordable than TCAS, since it uses GPS information and does not require the additional equipment that TCAS utilizes. (Proctor, 1999). The displays will be able to advise the pilot on conflict predictions and resolutions well in advance of the present TCAS system.

5. The Traffic Information Services-Broadcast (TIS-B) will be used at the ground controller station. The TIS-B will present to the air traffic controller the same information that the pilot displays in the cockpit. The display that the controller will see will reduce the blind spots that are common on conventional radar displays (Proctor, 1999). Non-radar areas will be reduced by placing the low cost ADS-B ground stations in those areas that radar cannot cover.

Human Factors Involved with Free Flight

Although the theory of Free Flight sounds like a simple concept, implementing it may be more difficult. Besides integrating all of the avionics involved with Free Flight, the human factor must be considered. The role reversal from the pilot to controller and the air traffic controller to manager, may be the biggest hurdle to achieve. Studies over the last few years have addressed these problems. Some of the major human factors issues surrounding Free Flight include the following:

1. Can controllers be expected to perform a monitoring and separation assurance role?
2. What information will air and ground exchange? Will they withhold information?
3. What happens when equipment fails? Can controllers serve as backups to automated conflict problem/resolution functions.
4. What are the workload implications of information uncertainty?
5. Will underloading/overloading present problems? (e.g., in terminal areas)?
6. Will memory demands or situational awareness decrements present problems?
7. What are the best ways to design displays and algorithms, so as to facilitate information sharing between air and ground?
8. Are there behavioral bases for defining intervention strategies, airspace structures, resolution time horizons, etc?
9. How should Traffic Flow Management (TFM) handle potential "gaming" of arrival intent information?
10. Will pilots/controllers accept the concept of Free Flight?
11. How should future personnel be selected and trained (National Aerospace Laboratory, 1998)?

The above questions bring out additional concerns that need to be addressed before Free Flight can become a reality. Such questions include the type of training for pilots and controllers, how to transition to Free Flight, and the risks associated with changes in technology and procedures.

From the controller's perspective, the current ATC system can be seen as an orderly, efficient, and predictive flow of traffic. There are only a limited number of areas where conflicts could be a problem. Under Free Flight, the controller would have to be more diligent in the prediction of potential conflicts.

Potential Benefits of Free Flight

In the February 1998 issue of the RTCA Digest, the Free Flight Select Committee listed the following potential benefits of Free Flight:

1. Increase daily flights.
2. By exchanging real-time information, pilots and controllers can help resolve ground delays.
3. Reducing the 200 nautical mile restriction on SIDS and STARS around major airports to allow more flexible routing.
4. Eliminating 145 Published Preferred IFR Routes, allowing for more flexible routing.
5. Removing the 250 knot restriction in Class B airspace below 10,000 feet.
6. Reducing frequency congestion be utilizing data-link when receiving ATIS, airport information, and taxi clearance.
7. TCAS will allow pilots to select a more efficient

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cruising altitude by using the early aircraft to aircraft separation.

8. Final approach spacing tool which will provide runway assignment and sequencing information to the manager (Federal Aviation Administration, 1998).

GPS as Sole Navigation

As the development of Free Flight continues, GPS is continuously being scrutinized. Without GPS, Free Flight probably will not happen. The only remaining question is "will GPS become the only navigation tool in the ATC system?" If Free Flight becomes a reality, it may become difficult to keep the present VOR navigation system. Due to increased traffic and ATC workload, having two national navigation systems may be impossible to maintain without compromising safety. At first look, it seems GPS can do all navigation functions that the present system does. This would include ground navigation and taxi, takeoff and transition from departure to enroute navigation, and through the arrival and landing phase. WAAS and LAAS have the potential to handle all of the non-precision and precision approaches to all airports in the world; so why should the Federal Aviation Administration (FAA) keep VOR, NDB and ILSs?

Two approaches can be used in answering the question of GPS as a sole means of navigation. The first area of concern is general aviation. If we eliminate the current form of navigation, it will force most general aviation aircraft owners to buy new GPS equipment. This would probably include aircraft that already have GPS receivers. The new technology with WAAS and LAAS, utilizes ground based GPS stations in conjunction with satellite information. Older GPS receivers may not be able to receive the information from the ground stations. Cost of the new GPS receivers could be prohibitive and cause the general aviation community to force the FAA to keep the current navigation system.

The second area of concern is the reliability of GPS. A study released in January 1999 by Johns Hopkins University Applied Physics Laboratory refutes the use of GPS as a sole-means of navigation. The study concluded that unaugmented GPS will not meet the needs of the present and future ATC system. However, the study does point out that "GPS with appropriate WAAS/LAAS configurations can satisfy the required navigation performance as the only navigation system installed in the aircraft and the only navigation service provided by the FAA" (Nordwall, 1999).

The reasons that the study does not recommend GPS as the only means of navigation are:

1. Possible intentional jamming of the GPS signal from the satellite.

2. Unintentional interference.

3. Ionospheric variations that can distort the signal (Nordwall, 1999).

With the ground stations storing the GPS data and geographically correcting errors, using GPS with these ground stations would be more reliable. But to achieve the Category 1 precision approaches, the WAAS ground stations will need to be increased from the planned two to four per instrument approach (Nordwall, 1999). This will increase the reliability and accuracy of the GPS signal to conform to the requirement set forth by the National Airspace System.

Even with WAAS, there has been concern that solar activity could degrade the GPS signal. With the presence of a geomagnetic storm, there is a possibility that the ionosphere will not be stable enough for the ground stations to receive reliable information from the GPS satellite (Nordwall, 1997). A possible correction to this problem would be to increase the number of planned WAAS ground stations. The theory is that with more ground stations to receive information from the satellites, the better the stations can reduce any error or interference that may be transmitted by the satellite or in the atmosphere.

Can Free Flight Benefit General Aviation

General Aviation (GA) will need to be included in the forthcoming decisions as to whether Free Flight will be integrated into the ATC system. If Free Flight is only used for transport type aircraft, the FAA will need to keep the ATC structure similar to what it is today. This would mean that most of the time ATC will be controlling GA aircraft. This would leave very little time monitoring transport aircraft. Although the theory of Free Flight is to allow aircraft to manage themselves, there still needs to be a safety monitor on the ground as a back up for any problems the aircraft may have regarding traffic conflicts or emergencies.

If cost drives the FAA to adopt only one ATC system, the question arises "can GA aircraft adopt to the Free Flight navigation system"? The FAA would have to address the cost factor in equipping the GA fleet. Although the cost of the avionics needed to equip GA cockpits has been reduced significantly over the past few years, the FAA may not be able to expect the GA group to comply with the new technology (Iler & Planzer, 1999). Also, what additional training will be required by currently rated IFR pilots and who will pay for this training?

A more likely scenario will be similar to what we have today. A high and low ATC directed system. The high system will be dedicated to transport type aircraft (currently called Jet Routes), and the low will remain similar to what we have today (Victor Routes). Another problem that will need to be addressed with GA aircraft is the use of GPS as the sole means of navigation for the low structure. Again, cost of equipment and training will need to be answered before any decisions can be made.

On-Going Tests

There are several of these systems that are currently being tested to see if they can be incorporated into the Free Flight concept. Phase 1 of the ADS-B is being tested by UPS Aviation Technologies in conjunction with the Cargo Airline Association from early 1999 to late 1999. U.S. cargo carriers Airborne Express, Federal Express and United Parcel Service have installed the ADS-B equipment in 12 jet aircraft (Ott, 1999). The pilots will see traffic on a CDTI. The controllers on the ground will utilize the TIS-B and will see the information supplied by the ADS-B on their traffic display screen along with other radar targets. The purpose of Phase 1 is to:

1. Evaluate CDTI using ADS-B technology for safety enhancement and operational benefit as a pilot tool to enhance see and avoid applications.

2. Determine the final configuration for fleetwide installation based on an analytical comparison between three data-link technologies, and

3. Conduct a Human Machine Interface (HMI) evaluation of the CDTI, controls, and indicators to determine fleetwide equipage design (Shapero, 1999).

By late 1999, the CAA hopes the second-phase of the ADS-B implementation will be on track. Phase 2 objective is to upgrade the ADS-B system with conflict detection capability. The software involved with phase 2 will allow pilots visual and audible cues to avoid possible collisions with other aircraft. The software is suppose to increase detection range from current collision avoidance equipment. The improvements will allow the pilot to make avoidance maneuvers in time to prevent sudden and abrupt maneuvers (Shapero, 1999).

Phase 1 of WAAS was supposed to start in 1999 but has been delayed to September 2000. The delay was caused by technical problems, budget reductions, and a requirement to reduce overall risk to the program (Eldredge, 1999). Technical problems were directly associated with software development and safety processors. Budget reductions involved a cut of $25 million in fiscal 1999 from the WAAS program. The FAA decided that more time was needed to accurately access any problems that may be inherent when developing a new program like WAAS. The reduction in risk dealt with that issue to ensure there was more time to evaluate any problems that may arise during development (Cole & Nickla, 1999).

WAAS Phase 1 will evaluate three fundamental principles:

1. Safety;
2. Functionality;
3. Usability (Cole & Nickla, 1999).

During Phase 1, WAAS will be evaluated on:

1. The system supporting departure, enroute and terminal navigation;

2. The system providing the existing GPS nonprecision approaches; and

3. The system providing precision approaches at a limited number of airports (Cole & Nickla, 1999).

Conclusion

The concept of Free Flight has many advantages that could propel aviation into the 21st century. With the FAA predicting up to a 75 percent increase in air traffic over the next 15 years the need for a more economic, efficient and safe system of navigation is paramount (Speelman, 1998). The design characteristics of Free Flight are solid and should be explored to see if it can work. However, the components involved with the system are having problems.

WAAS is behind schedule and there is still the question of GPS being reliable enough to support navigation as a primary means. Human factors issues have not been thoroughly addressed to resolve some of the major questions. Training of controllers and pilots to accept their new role in the Free Flight environment needs to be examined. General Aviation has not been considered thoroughly enough during this process to see if they can adapt or if there is any resistance to the new navigation system due to training and equipment costs. The FAA needs to decide which system or systems will be needed for the future of air navigation. There is also the question of world navigation. What system will other countries be utilizing. Some countries are still using NDBs as their primary means of air navigation.

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In researching Free Flight, the conclusion drawn seems to be that there are too many unanswered questions. The FAA needs more time to resolve these problems before they can begin to transition to Free Flight. □

Roger C. Matteson holds both MBA in Aviation and Bachelor of Science in Aeronautical Science degrees from Embry-Riddle Aeronautical University. He is a retired Air Force pilot with over 5,000 hours and 3,500 hours of instruction time. He has a Master CFI designation from the National Association of Flight Instructors and is currently an Assistant Professor in Aviation at Central Washington University.

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