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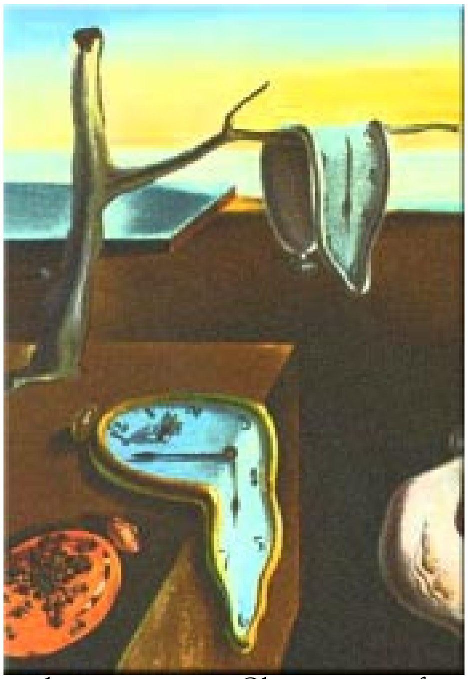
FAA Satellite Navigation Product Teams

SatNav News

In this issue:



From Time to Time

by W.J. Klepczynski, GPS TAC/WAAS Team (AND-730)
Ed Powers, United States Naval Observatory
Rob Douglas, National Research Council of Canada
Pat Fenton, NOVAtel

Historically, navigation systems have depended on time. This was clearly demonstrated by the sailing of Harrison's chronometer on HMS Deptford in 1761, to prove that the instrument allowed navigators for the first time to determine longitude accurately and reliably. Because of this relationship between navigation and time, the time-keeping community has always had a keen interest in the use of navigation systems for the *distribution* of time. Even today, the heart of the GPS rests on a highly evolved clock technology. Unlike navigators, who need four GPS satellites by which to determine their position, timekeepers, who know their position, need only one satellite to determine time. Observations of a single satellite also allow timekeepers to remotely synchronize clocks around the world.

This article summarizes the result of a recent study, which showed that the GPS Wide Area Augmentation System (WAAS), once fully operational, should provide a very stable, continuously-available timing signal. It should also allow the development of more economical timing systems utilizing its signals, the almost instantaneous detection of any pathological behavior in a system providing time, and an extremely robust check for many timed systems. The WAAS is one of the most recent developments in the evolution of navigation systems. While it is similar to other differential GPS systems in concept, the WAAS gives the Federal Aviation Administration (FAA) and air navigation a significantly higher level of performance than other differential GPS (DGPS) systems. Because of the augmentation methods utilized by the WAAS, it provides not only improved accuracy, but also increased availability, integrity, and continuity of service. It does this by continually monitoring GPS transmissions from WAAS Reference Stations (WRSs) and by transmitting an augmented message from several geostationary communications satellites (GEOs). The WAAS is currently in its early stages of development. Current studies on the use of WAAS for time transfer and time distribution indicate that it is already at the level of the GPS Precise Positioning System (PPS). We can reasonably expect improved levels of precision and accuracy as the system matures.

Time and the WAAS

Figure 1 schematically depicts the WAAS process, as it will be once fully implemented. The basic unit is the WAAS Reference Equipment (WRE), consisting of a cesium beam frequency standard, a 12-channel, dual-frequency WAAS-GPS receiver, and a wide- and a narrow-band GPS receiver. Each WRE continuously tracks as many GPS satellites and GEOs as it is able to acquire.

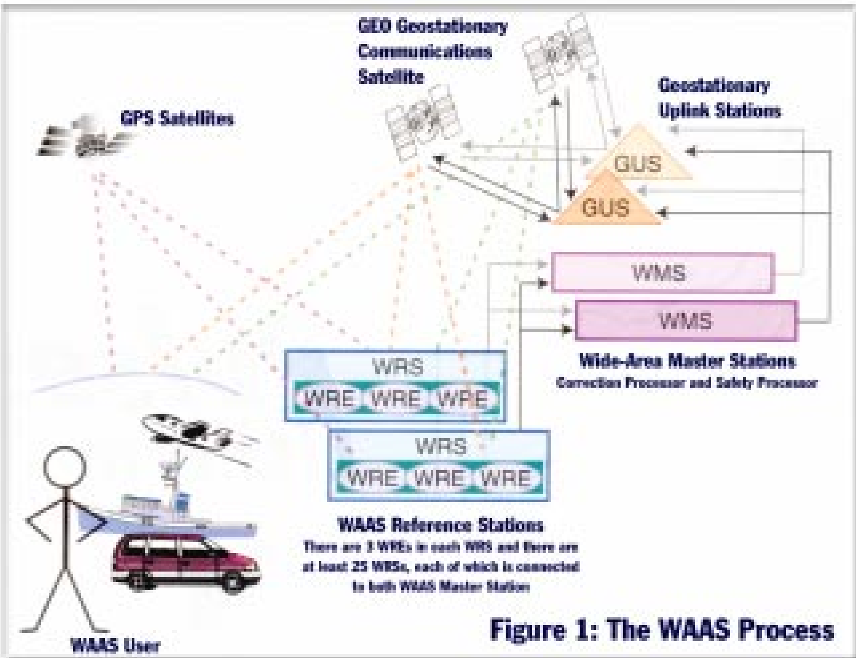


Figure 1: The WAAS Process

Each WRS contains three identical WREs. This redundancy ensures that each WRS will continue to provide data to its WMS in the event that one of the WREs fails. Each WRS, in turn, transmits the data it obtains to two WAAS Master Stations (WMS), which form the WAAS navigation message and WAAS Network Time (WNT). The message contains information on satellite orbits, the current state of the ionosphere, timing information, and system health. Each WMS passes the navigation message to each of, initially, two Geostationary Uplink Stations (GUSs), which upload it to the two Phase 1 GEOs which then transmit it to the user.

WAAS Master Stations

Once per second, all WRSs transmit all their data to all WMSs, which then perform the functions of correction processing, satellite orbit determination, integrity determination, verification, validation, and WAAS message generation, and transmit a formatted 250-bit WAAS message to all GUSs.

WNT Time Scale

In order for the WAAS signal to supplement the GPS navigation signals, the GEOs must synchronize their transmissions with those from the GPS satellites. In other words, WAAS must be on GPS time. The reference for the WAAS is called WAAS Network Time (WNT). Measurements from all WREs at all WRSs are sent to each WMS. The corrections processor at each WMS employs a WNT algorithm to compute a potentially independent WNT time scale from the data received from the WRSs. All "good clocks" contribute to the WRE measurements that a WMS corrections processor receives and uses to form the WNT time scale. This time scale is then steered to GPS time with the same algorithm.

Ground Uplink Stations (GUS) will each have a cesium clock, slaved to WNT. Once per day, the WMS will issue commands to steer the GUS clock in order to reduce any offset it may have from GPS time. The GUS clock controls the synchronization of the WAAS navigation message from the GEO.

WAAS Time Distribution

As a secondary mission, the WAAS provides coordinated universal time (UTC). To this purpose, the WAAS compares WNT, which is synchronized to GPS time, with the UTC provided by the U.S. Naval Observatory (USNO), and transmits the offsets as part of the WAAS navigation message.

Status of WAAS Time-keeping

Data collection commenced at USNO on October 6, 1999. Every 15 seconds, GPS and Atlantic Ocean Region-West (AOR-W) WAAS GEO satellites make pseudorange and carrier-phase measurements. All of the broadcast data from the satellites are now collected for postprocessing.

Time Transfer Capabilities

Fig. 2 illustrates the computed difference between USNO and GPS system time. We included this difference as a common denominator benchmark process. Most GPS timing receivers today use this observable to provide time reference information. Note that selective availability (SA) caused most of the 43-nanosecond standard deviation. On May 1, 2000, the U.S. Department of Defense (DoD) turned off this inten-

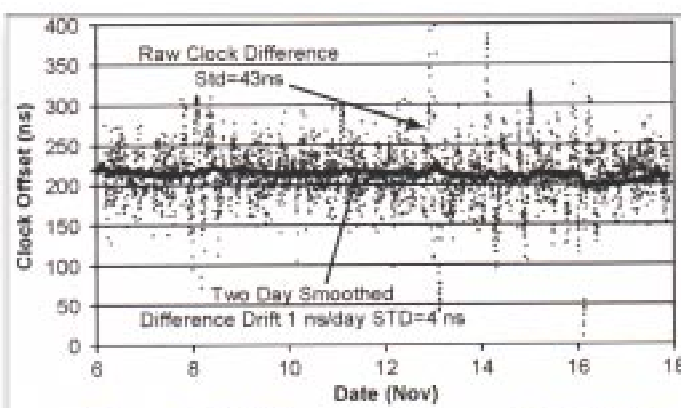


Figure 2: Differences between the USNO Master Clock and GPS Time

tional degradation and performance has since substantially improved.

These results, at this early stage in the development of the WAAS, indicate the future promise of this technique for time transfer and time distribution.

Future Potential of SBAS

The WAAS will contribute to the timing infrastructure of the U.S. by providing time within the National Airspace System (NAS) for the recording of all events. It will also provide a very stable timing signal for the timekeeping community. Because the source remains at the same approximate point in the sky, a high-gain antenna can provide a very good signal to the stationary user. The offset of WNT from UTC will be transmitted within the WAAS navigation message. The signal will be available continuously.

Such a signal provides some unusual capabilities for the timekeeping community. It should allow the development of more economical timing systems utilizing its signals. Cheaper crystals can now be used in systems that rely on atomic standards as their flywheel while they continuously integrate GPS time or UTC using only one geostationary satellite. A user will be able to instantly detect any pathological behavior in a system providing time by comparing signals with another visible GEO. With GPS, one has to wait to see whether the transients are due to anomalous clock behavior in a satellite. The WAAS, on the other hand, provides an immediate redundancy check to anyone who is within the footprint of its two transmitting geostationary satellites. This can be used as an extremely robust check for many timed systems.

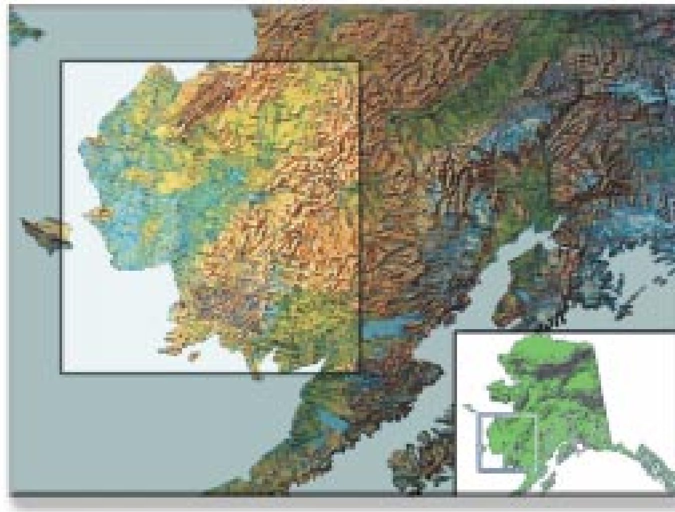
Based on an article originally published in the May 2001 issue of GPS World, Eugene Oregon.

New Technology Benefits Region with High Safety Risks

by Jim Hebert, Capstone Liaison (Contract support for AND-500)

Safety, capacity, and efficiency continue to be a concern for members of the FAA's Alaska Region where airplane accidents are a daily reality. The avionics package offered by the Capstone Program addresses these challenges and offers solutions, and the key to this program is the partnership formed by the FAA and the Alaskan aviation industry.

The Capstone Program, named for its combination of a range of concepts and recommendations, recognizes the need to integrate emerging technologies into the present airspace in order to resolve the hurdles of the Alaskan environment. The initial Capstone challenge focuses on aviation safety in the Southwest Yukon-Kuskokwim (Y-K) and Southeast regions of Alaska. These areas experience a significant number of mid-air collisions, controlled flight into terrain, and weather related accidents. The Capstone effort is working to provide ground infrastructure and avionics in order to address these problems as well as to determine the operational benefits for commercial carrier aircraft operating in these areas. Capstone has equipped up to 90% of the aircraft operating in the Y-K and Southeast regions of Alaska giving the program the ability to measure the anticipated benefits. While Capstone is initially focusing on these two geographic areas, the intention is to leave systems in place that provide a benefit and to expand these ground systems to the rest of Alaska. Capstone technology is being engineered so that it can be deployed to the rest of the National Airspace System (NAS) as needed. The following have been provided in the Y-K area and will migrate to the Southeast in 2002:



- Data link weather and other flight information into the cockpit
- A cockpit display that uses a terrain database to reduce controlled flight into terrain
- Increased number of airports served by GPS non-precision approaches
- Automated Weather Observing System (AWOS) to provide weather for the GPS approaches
- Cockpit display of adjacent traffic
- Radar-like service using Automatic Dependent Surveillance-Broadcast (ADS-B)

The Wide Area Augmentation System (WAAS) has introduced area navigation (RNAV) routes in a region with no existing infrastructure, and has increased aviation safety and airspace capacity while decreasing the cost of the supporting infrastructure and aircraft avionics equipment and systems. WAAS, in conjunction with terrain and traffic avoidance data, offers a practical evaluation that will validate the application and functional capabilities of new technologies and enhance the pilot's ability to operate safely. As a result, the avionics and ground infrastructure in the Southeast will provide this user-identified "useable Instrument Flight Rules (IFR) infrastructure." Narrow approaches into airports bordered by sharply rising terrain will pose less of a threat. Environments with weather patterns that have restricted or even prevented flight due to the route structure will also be more accessible.

WAAS in Review: IRB Report Released

by Hal Bell, WAAS Team Lead (AND-730)

On April 10, 2001, the FAA publicly released the report of the WAAS Independent Review Board (IRB), which was chartered to review and report to the FAA Administrator on system engineering efforts aimed at resolving the technical barriers that were preventing delivery of WAAS to the customer. The full Report and accompanying Executive Summary can be viewed at http://gps.faa.gov/Library/Documents/documents.htm#waas

Background

The Wide Area Augmentation System was originally scheduled to achieve Initial Operational Capability in September 2000. In January of that year, however, FAA certification specialists identified a problem with proving that the system met the stringent integrity requirements specified for the system.

Integrity is the ability of the system to provide timely warnings to users when it should not be used for navigation. For WAAS, integrity means there can be a no greater than one in ten million chance of hazardously misleading information being transmitted to the user without the system notifying the user within six seconds of its degraded status.

To meet the challenge of establishing the parameters of the integrity issue and developing the solution to the problem, in February 2000 the FAA formed the WAAS Integrity Performance Panel (WIPP). Shortly thereafter, the FAA also chartered the WAAS IRB to review the WIPP's efforts and offer additional technical and strategic advice concerning the WAAS Program. The IRB was formed under the auspices of the Institute for Defense Analyses (IDA) in Alexandria, VA to report directly to the Administrator. Its membership is composed of senior scientists and managers from outside the FAA.

IRB Report

The IRB made a number of near, mid and long-term recommendations to improve the WAAS acquisition program. In brief, the IRB validated the WIPP's approach to defining the parameters of the integrity problem and its proposed solution to achieve an initial capability of Lateral Navigation/Vertical Navigation (LNAV/VNAV). It also supported the WIPP's proposed path to achieve the follow-on GNSS Landing System (GLS) capability that will constitute full operational capability for WAAS. The IRB strongly supported the continuance of the WIPP at least through commissioning of the system.

The IRB urged the FAA to make a stronger commitment to the evolution of WAAS, considering how to exploit the possible synergies among WAAS, the Local Area Augmentation System (LAAS) and the U.S. Coast Guard's Differential GPS (DGPS) augmentation system.

The IRB also strongly urged the acquisition of an additional geostationary satellite as soon as possible to mitigate the single thread of failure that exists with the current two-satellite INMARSAT III constellation. The IRB also pressed for the immediate initiation of acquisition efforts aimed at achieving the required end-state constellation of four satellites with autonomous payloads supporting broadcast of three civil signals.

The IRB has provided the FAA a valuable assessment of where the FAA is and where it needs to go to make WAAS, the cornerstone of its future navigation architecture, available to the aviation community as soon as possible. The IRB will continue to provide analysis and advice at least through 2001.

The LAAS Government Industry Partnership: A Complex Approach to System Implementation

by Dieter Guenter, GPS-TAC/LAAS Team (AND-710)

In March of this year, the New York Times published an article discussing FedEx and the airlines' expectations for the ongoing Local Area Augmentation System (LAAS) activities in Memphis. The article focussed on the FedEx / Memphis activities but did not really expand on the complexity of the "Government Industry Partnership" (GIP) driving the development and implementation of the LAAS. The New York Times also made little mention of the other two GIP teams and additional FAA activities, which are equally important for the LAAS success story. The following article intends to bring to light some of the other activities included in the LAAS Government Industry Partnership.

With the GIP, the FAA is pursuing an innovative approach to overall LAAS system development, fielding, testing and evaluation, and operational approval for public use. The GIP approach is a cost-sharing partnership between the government and industry. FAA ("government") is responsible for the development of the system specification, operational documentation, technical support, and certification of the system while private companies ("industry") provide the funds to develop a LAAS Category I system. Honeywell, Raytheon, and most recently, Airsys ATM, presently lead different industry teams, which are made up of airline/aircraft manufacturers, airports, and avionics manufacturers. As part of the FAA GIP program, these teams were formed to start the development of the LAAS Category I system.

LAAS has made tremendous progress due to the work of all the GIP partners. Honeywell prototype ground systems have been established at Chicago O'Hare, Midway, and Memphis. Raytheon is converting its SCAT I system into a prototype LAAS in Salt Lake City, and Rockwell Collins is working on the integration of LAAS into the aircraft avionics within its multi-mode receiver (MMR). These activities and prototype installations provide the FAA and the GIP partners with valuable insight into the development and implementation of LAAS systems.

The FAA's LAAS Product Team (AND-710) is directing research, validation, and implementation of LAAS. The relatively small LAAS team, under the leadership of Steve Hodges, is involved in all aspects of the GIP, coordinating implementation activities, leading the LAAS acquisition process and further development of the LAAS Category II/III systems.

The development efforts of LAAS are focused on two main areas: ground equipment and avionics. Honeywell, Raytheon, the FAA Technical Center, and the University of Oklahoma have developed prototype ground systems. Installing such prototype systems, however, is just one part of LAAS development. Stanford University, Ohio University and MITRE continue to work in different areas of the LAAS ground facility development including Ephemeris, Signal-Quality and Integrity Monitoring, Very High Frequency (VHF) Data Link projects and Multipath modeling. These development efforts, as well as validation of the requirements, are equally crucial to the progress of the final system.

On the airborne/avionics side of LAAS development, the Navy/NAVAIR and the Technical Center both play a significant role. Using LAAS prototype ground systems both are working towards implementing and validating LAAS airborne receiver requirements and are teaming up with Rockwell Collins on the LAAS multi-mode receiver.

In addition to the technical development and validation of the LAAS ground system and avionics, the LAAS team is working with the different FAA disciplines on installation and operational issues for implementing LAAS into the National Airspace System (NAS). FAA's Airways Facilities and the Technical Center are working on LAAS siting criteria (how and where to install LAAS), which constitutes a major undertaking due to the diversity of the system and the individual requirements of each airport. Maintenance, training, and logistics issues have to be identified and worked on as well.

In order to utilize the LAAS signal, specific approach and departure criteria and procedures need to be established to fly LAAS approaches. Flight Standards develops and validates these criteria through flight tests in Oklahoma City with the University of Oklahoma and in Atlantic City with the Technical Center aircraft. Aviation System Standards (AVN) develops LAAS approach procedures and establishes flight inspection criteria for LAAS flight inspections. Other important factors include the coordination and training of Air Traffic personnel and the development of LAAS NOTAM capabilities and specific LAAS air traffic monitor capabilities.

All these activities have to be coordinated for the GIP teams and their systems as well as for the FAA systems. Coordinated activities between the FAA Headquarters, the FAA Regional Offices, Industry, and users are essential for the successful implementation of LAAS into the National Airspace System.

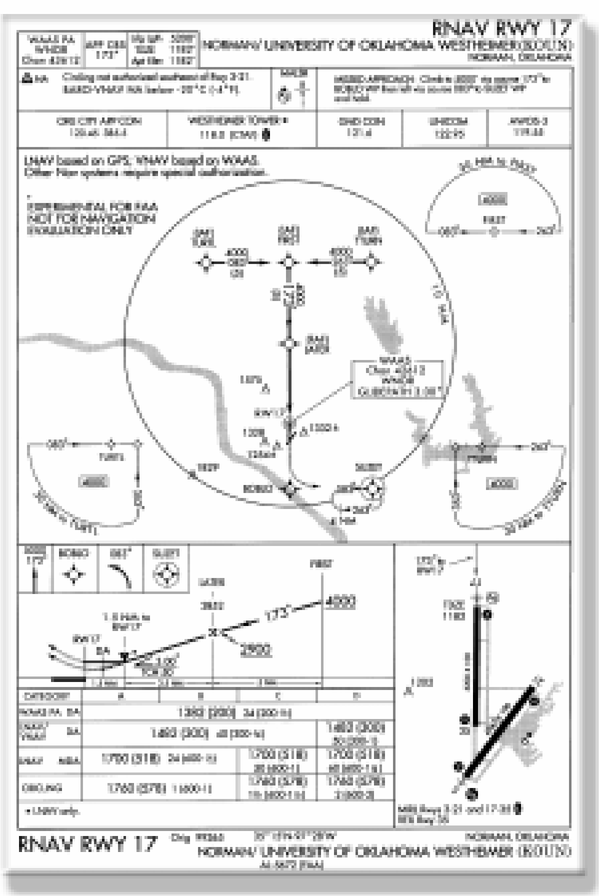
GNSS Procedures Development Initiatives

by Kelly McKee, GPS TAC/NAS Implementation Team (AND-710)

The National Airspace System (NAS) is in a period of unprecedented growth and change. Our national airspace comprises more than 29 million square miles and handles more than 55,000 flights per day that use 12,300 instrument approach procedures. Since 1994, the number of instrument procedures has grown by approximately 50%. Technology improvements, funding levels and other factors will impact the course of the modernization strategy. In addition, global interoperability of technology and harmonization of procedures are essential for continuity of operations and avionics investments. Aviation System Standards (AVN) has the responsibility for designing instrument approach and departure procedures for the 21st Century NAS in accordance with Federal Aviation Regulations (FAR 97) safety standards. A web site developed to assist people in understanding the procedure development process and providing a method for requesting new instrument procedures can be found at http://www.mmac.jccbi.gov/avn/iap/iap_flow.html

As an outgrowth of the general context described above, the Federal Aviation Administration (FAA) participates with the aviation industry on the Commercial Aviation Safety Team (CAST) to reduce accidents, incidents, and delays. One of the efforts of CAST was to form a subgroup to work on precision-like approach implementation. This subgroup has generated a plan with a series of actions for different FAA organizations, including AVN. AVN's strategy is effectively integrated with the (FAA) NAS Architecture and National Airspace Redesign initiative. The AVN strategy also addresses industries' request to fully utilize ground, aircraft, and space- based navigation systems for improved safety, capacity, and operational flexibility. The AVN organization has produced a plan that addresses the CAST's direction toward a 21st Century precision landing system. The AVN plan provides a broad framework of flight procedure production options that are linked to specific funding requirements and provides the opportunity for the FAA to effectively and efficiently deliver the improved safety benefits desired by the CAST. The CAST AVN Implementation Plan can be viewed or downloaded at http://www.mmac.jccbi.gov/avn/home/documents/cast.doc.

The CAST Plan makes several references to area navigation (RNAV), lateral navigation (LNAV), and vertical navigation (VNAV). RNAV is a method of navigation that permits aircraft operation on any desired course within the limits of a self-contained system capability. Many systems also provide vertical guidance. The Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) will expand the availability of LNAV/VNAV instrument approach opportunities to lower weather minimums. To foster and support full and optimum integration of RNAV into the NAS, the FAA has developed a new charting format for RNAV Standard Instrument Approach Procedures (SIAPS). This new format maximizes the information available to the pilot for the safe and efficient conduct of the instrument procedure.



Vertical guidance is provided as a linear deviation from the desired track defined by a line joining two waypoints with specified altitudes, or as a vertical angle from a specified waypoint. Computed positive vertical guidance is based on barometric, satellite elevation, or other approved systems. The desired vertical path may be pilot selectable or may be determined by the VNAV computer with computations based on the altitudes associated with successive waypoints. These instrument approach procedures provide separate minima for LNAV and LNAV/VNAV. The LNAV/VNAV procedure and the LNAV procedure are designed with different obstruction criteria. The flight inspection of RNAV procedures evaluates the soundness of the procedures in accordance with FAA Order 8200.1A, Section 214, and identifies any deficiencies in the procedure. Approach safety and flyability are evaluated as a non-precision approach with and without vertical guidance. The final segment of the flight inspection may require repeated flights for obstacle verification/evaluation.

The AVN production plan schedules and prioritizes procedure development through 2007. The production schedule specifies a "what by when schedule" that enables the aviation industry to plan for the introduction of new instrument approach procedures. In addition, the AVN production schedule is prioritized based upon risk assessment and contains a matrix that displays the priority as directed by the CAST, i.e. first priority Part 139 runways, second priority runways 5,000 feet or longer, and third priority paved public use runways less than 5,000 feet. The plan takes into consideration the available safety risk factors to mitigate accident rates at airports by using National Transportation Safety Board (NTSB) accident data. This production plan also supports Safer Skies objectives.

The first two fiscal years (2001 – 2002) of the production plan contain specific information about the type of procedure that will be published at an identified airport and runway end during each quarter of the year. Beginning in the third year (2003), the schedule identifies the airport and runway end that will be published during the year without a quarterly commitment. The production schedule for the remaining years (2004-2007) contains information on the airport that will be addressed during that fiscal year. The schedule will be a "rolling schedule" whereby specific information on airport runway ends and quarterly publication plans will be available for a continuous two-year period. It is anticipated that the production schedule will be revised every six months, facilitating industry input and assuring that the agency is as responsive as it can be with the resources that are available.

AVN has developed a comprehensive website that allows the flying community to access information about the instrument flight procedure production schedule. The website contains general information about the process of flight procedure production, the current FAA production schedule based upon agency resource commitments, and options for private investment in instrument flight procedure production. Available on the web-site, on a quarterly basis, will be a listing of vertical descent angle (VDA) additions as they are completed and also the accomplishment of renaming the GPS procedures. Finally, the site offers a listing of contacts. You can access the site at: http://www.mmac.jccbi.gov/avn/iap/

The AVN production schedule considers the visual glideslope indicator (VGSI) installation plans of the Airway Facilities organization. Updated information on the adjustment/alignment of the VGSI angles will also be available on the production schedule web-site.

AVN 100 faces many challenges with the resources available. Although the CAST plan is prioritized based on safety benefits, procedure development continues at all airports in the NAS. As of July 2000, AVN has added Vertical Descent Angles (VDAs) to non-precision approaches at 60% of Part 139 airports, 40% of non-Part 139 airport with runways 5000 ft or greater, and less then 10% at all other runways less than 5000 ft. As the number of procedures increase, so does the amount of resources allocated to the maintenance of these procedures.

AVN, in conjunction with other organizations, continues daily support of the CAST initiatives. The initial group of airports selected for airport surveys, procedure development, and implementation are just the beginning, as time goes on, numerous new airports will be added to the list. Procedure development will continue and eventually, almost all airports will have GPS approaches available. Support of this long-term program is imperative as the program continues to grow and expand. We invite you to visit our websites and let us know what you think.

2002 Winter Games: Salt Lake City Uses GPS to Prepare Airspace for Increased Traffic

by Brian Durham (ANM -520) and Paul Ewing (ATP-104) for NAS Implementation Team (AND-710)

The complex flight environment of the Salt Lake City Airport terminal area is overly congested and can pose a significant challenge to VFR pilots. One of the busiest air traffic environments in the nation, Salt Lake City Airport is situated in a valley with high mountainous terrain to the east and west. In preparation of the 2002 Winter Olympic Games next February, the Air Traffic Control facility is also preparing for a substantial increase of both Instrument Flight Rules (IFR) and VFR air traffic in the region.

Two Air Traffic divisions have recently taken a significant step in providing for safer flight in the Salt Lake City area by instituting the use of VFR Waypoints. VFR Waypoints are predetermined geographical coordinates, determined by the Global Positioning System (GPS) and designed to enhance pilot situational awareness, enhance safety, reduce airspace deviations, and increase Air Traffic Control efficiency.

The VFR Waypoint program was developed to aid VFR pilots in navigating into, out of, through, or around terminal airspace areas, special use airspace (SUA), or other areas where VFR navigational assistance is deemed prudent. The Waypoints are graphically displayed on the April 19, 2001 edition of the Salt Lake City VFR Terminal Area Chart (TAC) and are either associated with a VFR Reporting Point, or as a stand-alone Waypoint.

The charting of the VFR Waypoints is a big step in improving VFR flight and airspace efficiency. The FAA has also published VFR Waypoints on VFR TACs at Kansas City, Missouri on November 20, 2000, and Houston, Texas, on March 22, 2001. The benefits to Kansas City are similar to those of Salt Lake City and enable VFR pilots to safely navigate around Class B airspace. The Houston TAC application provides GPS Waypoints to assist pilots in navigating through the Class B airspace by ensuring the correct identification of the flight corridor. The publication of these Waypoints is part of the FAA's commitment to being a good service provider to the flying public and supporting safe VFR flying.

GPS Supports Unique Helicopter Capabilities for Emergency Medical Flights

by Mike Webb, ARINC/NAS Implementation Team (AND-710)

The FAA has aggressively pursued development of new instrument flight rules (IFR) applications of the Global Positioning System (GPS) for civil helicopter operations, which include Emergency Medical Service (EMS) operations.

Facilitating EMS operations to hospital heliports has offered the FAA a unique set of challenges when compared to standard IFR operations into airports. Hospitals are necessarily located within cities, which are, by nature, obstacle rich environments. The necessary land to convert a typical VFR heliport into an IFR facility rarely exists, and obstacles would penetrate into the shallower IFR heliport airspace surfaces. Relocating the hospital heliport is rarely a solution as its mission is to deliver patients to the trauma services of an emergency room as quickly as possible.

FAA standards and orders provide for helicopter point-in-space GPS instrument approach procedures to non-IFR heliports. The standards facilitate IFR operations into VFR heliports with special visual-segment criteria for the transition from an IFR approach to a VFR ground infrastructure. While these FAA efforts permit greater capability for EMS helicopters to complete missions, safety of flight for EMS helicopters is also enhanced by sole reliance on VFR during periods of reduced visibility. The Flight Standards Service is presently in the process of developing new heliport departure criteria for departing VFR heliports under IFR conditions.

In 1998, as part of the solution necessary for meeting the helicopter industry's unique needs, Flight Standard's Service Flight Technologies and Procedures Division (AFS-400) and Aviation System Standards (AVN-1) entered into agreement to participate in a cooperative effort with Satellite Technology Implementation L.L.C (STI) for non-federally developed helicopter GPS approach procedures. Interim Policy, Letters of Agreement, and Letters of Authorization, allow for STI developed approach procedures to be submitted to AVN for Quality Control (QC) and flight inspection, and authorize STI to perform Flight Standards and Flight Procedures Office (FPO) coordination in the Regions. Under this program there have been 107 industry funded Special Helicopter GPS approaches developed to hospitals and 25 more are under development. Applications of these procedures at private locations throughout the country have given populations living in remote areas access to trauma services during the crucial "golden hour".

Additionally, in preparation of the availability of the Wide Area Augmentation System (WAAS) to augment GPS, the FAA's William J. Hughes Technical Center has collected data for WAAS helicopter precision instrument approaches to heliports. These data are currently being analyzed for incorporation into FAA procedures criteria. These criteria should be in place when WAAS is commissioned for IFR use. The Technical Center is also collecting data on GPS lateral navigation and barometric altimeter-aided vertical navigation (LNAV/VNAV) approach capability to heliports. This will permit the use of existing navigation equipment and aircraft avionics to fly a vertical path to a decision altitude (DA), reducing the risk of controlled flight into terrain (CFIT).

The importance of this work cannot be overestimated. The FAA and industry have long touted the unique capabilities of the helicopter. Operations to airport runways seldom call upon these capabilities. Operations to heliports, by definition, demand them. Through this research, the FAA is pushing the envelope to quantify these unique capabilities.

The FAA regional Flight Standards and Air Traffic staffs have been aggressively working to assist helicopter operators in creating private, low altitude GPS enroute infrastructures, a recommendation supported by the FAA Safer Skies Program. In California, the Western Pacific Region recently approved 8 STI developed approaches to hospital helipads and the first helicopter GPS enroute system. This system will greatly increase the use of IFR for EMS operations in northern California. It will also effectively reduce minimum enroute altitudes for REACH Air Ambulance helicopter operations by 50% thereby improving their availability to provide healthcare for local communities in a four county area in Northern California. The RNAV routes are the end result of many months of collaboration and coordination between the various entities in the FAA and STI. Three different air traffic control facilities are involved in providing services: Oakland ARTCC, Sacramento Terminal Radar Approach Control (TRACON), and Bay TRACON. STI developed the routes by using interim criteria provided by the Flight Procedures Standards Branch (AFS-420) and policy from AFS-400. Quality control reviews and flight inspections were completed by AVN prior to final approval by the FAA. The Western-Pacific Regional Headquarters (AWP), including the AWP-Airspace Branch and Operations Branch, the Los Angeles FPO and the AWP AWO to mention just a few involved in making these new GPS routes a reality. STI is currently involved with Erlanger Medical Center, of Chattanooga, Tennessee, and has developed six special GPS-based RNAV routes servicing 17 special helicopter GPS approaches located in Tennessee, Georgia, and North Carolina.

The helicopter has emerged as a solution for point-to-point air transportation, and EMS helicopters are a proven means of transporting trauma patients between medical facilities. Historically, the EMS was rooted in air transportation designed to service airports and lacked the capability for inter-heliport and airport-heliport all-weather air transportation. With the implementation of GPS, an integrated EMS system offers reliable and cost-effective solutions for providing accessible care for populations over a large area. The key to this network lies in establishing affordable, safe instrument approaches using the availability of GPS for low altitude enroute navigation and landing guidance.

Though small in number compared to other segments of the aviation industry, EMS operators have developed in response to improving emergency healthcare for a larger segment of society, while keeping medical costs down. GPS is an integral component in the evolution of this segment of the national healthcare system.

Name of Operator*	Years of Operation**	Number of IFR Flights**
STAT MedVac	2.5	1402
AirEvac for Tulsa	1.5	166
St. Vincent Hospital	7 months	28
Univ. of Wisconsin Hospital	8 months	64
Univ. of Michigan	1	40
Mayo Clinic	2.5	344

*Operator statistics provided by Satellite Technology Implementation, L.L.C.
**Years of Operation and Number of IFR Flights as of July, 2000

Industry Corner

GPS-Based Instrument Approaches Benefit Tool for Estimating Airport Access

by Vince Massimini, MITRE Corporation

One of the principal objectives of WAAS is to improve safety by providing instrument approaches with vertical guidance to almost all instrument capable runways in the U.S. Another important consideration, especially for users, is the airport access benefits that will accrue from WAAS approaches. Airport access can be measured by the height above touchdown (HAT) and the visibility minimum for an instrument approach to a runway end.

It has been difficult, however, to estimate what the airport access benefits would be for the thousands of airports and runways in the U.S. The FAA (AVN-100 in Oklahoma City) currently develops instrument approaches, but the process can take weeks for one runway end. Evaluating thousands of runway ends has just not been practical.

MITRE has developed a computer-based tool that estimates the HAT and visibility minima for GPS instrument approaches using electronic databases of terrain and obstacles. The model is called the GPS Approach Minima Estimator (GAME). GAME uses criteria from the FAA Terminal Instrument Procedures (TERPS) developed for GPS approaches, but can be modified to use different criteria. The design of the model allows the evaluation of a large number of runways, with subsequent analysis of the benefits of a particular approach procedure.

GAME is not intended to replace the procedure developers at AVN. To reduce development, processing, and analysis time, GAME only evaluates a 5 nautical mile straight in final segment. The model does not attempt to optimize for terrain and obstacles, as would a human developer, nor does it consider increased minima that might result from obstacles in the missed approach path. Also, GAME does not use all the data, such as maps, that might be available to a human developer.

However, initial validation results comparing the HAT from GAME to an existing approach are promising. The difference between GAME estimates of the HAT for a GLS approach versus an existing ILS approach to the same runway end have a median of zero and a 75th percentile of only 25 ft. Differences between a GAME estimate of HAT for an LNAV/VNAV approach and the HAT determined by AVN have a median of 12 ft, and a 75th percentile of 5 ft. Similarly, differences between GAME and AVN HATs for LNAV have a median of 30 ft and a 75th percentile of 2 ft.

At present, GAME does not include considerations for airport infrastructure, which can reduce visibility minima (e.g., with approach lights), increase visibility minima (e.g., runway surface composition), or even preclude a category of approach (e.g., runway length). These capabilities, in addition to missed approach considerations, are presently being incorporated into GAME.

Preliminary results for over 5000 runway ends at over 1500 airports are already showing the relative airport access benefits of LNAV/VNAV and GLS approaches. When the airport infrastructure and missed approach considerations are included, GAME will be capable of estimating benefits for existing and future airport configurations.

Another important use of GAME will be to investigate the effects of improved WAAS performance on airport access. For example, if the WAAS Vertical Alert Limit (VAL) can be reduced from 50 to 20 m, and if criteria are developed for approaches using the new VAL, then GAME can estimate the airport access benefits of the reduced VAL.

Contact Les Crane (703 883 7243; lescrane@mitre.org) or Vince Massimini (703 883 5893; svm@mitre.org) for more information on GAME.

Worldwide Adoption of Satellite Navigation

by David Burkholder, Office of International Research and Acquisition (ASD-500)

Interwoven within the FAA's mission is a strong emphasis and commitment to "global leadership." The FAA Research and Acquisitions Office (ARA) is a critical contributor to the execution and success of this global leadership as it facilitates worldwide system compatibility and interoperability of global implementation initiatives with those technologies being fielded for operational use in the U.S. National Airspace Systems (NAS).

One of the technologies that has provided the most impact to international aviation is the Global Positioning System (GPS). The number of countries adopting GPS at least as a supplemental navigation aid has continued to grow at a healthy rate as the safety and efficiency benefits of GPS become clearer to both service providers and the users.

For instance, countries that currently have little or no ground-based navigation infrastructure are realizing the potential safety, efficiency, and economic benefits of using GPS to provide an immediate navigation capability. This type of space-based service also is beneficial to countries and regions that currently have to take extreme measures to safeguard ground-based navigation aids from hostile forces, tampering, or vandalism.

The benefits from basic GPS are clearer than ever. However, many countries and regions are already opting to take steps to progress beyond what the basic GPS constellation can provide. The FAA, represented by the International Research and Acquisition Office (ASD-500) and the Satellite Navigation Product Teams (AND-710/730), is actively involved in providing support to these regional satellite navigation implementation efforts and initiatives that are gaining momentum around the globe.

In North America, we have been working with our counterparts in Canada and Mexico for several years on cooperation towards creating a North American satellite navigation system based on WAAS and LAAS technologies. In March of this year, we brought three Mexico National Satellite Test Bed (NSTB) reference stations on-line, and thus created a true North American WAAS test bed capability (Canada already has three NSTB reference stations). This newly formed architecture provides opportunities to conduct

Efficiencies for the Future: Airport Redesign Raises Airport Standards

by Bob Brekke, GPS TAC/NAS Implementation Team (AND-710)

With the National Airspace Redesign, airspace changes are underway across the United States. Both the Western Pacific Region and the Southwest Region are jointly undertaking one of the newest airspace redesign projects, known as the *Northwest 2000 and Las Vegas Four Cornerpost Plan*, which seeks to achieve the most efficient airspace possible for both system-users and providers.

This comprehensive airspace redesign plan, scheduled for implementation in the fall of 2001, integrates changes in the airspace at the Albuquerque and Los Angeles Centers. It also includes the Phoenix and Las Vegas Terminal Radar Approach Control (TRACON) areas that serve the Phoenix Sky Harbor International and Las Vegas McCarran International Airports. Area navigation (RNAV) arrival and departure routings have been designed to reduce delays, improve efficiency, and reduce complexity while maintaining the highest standards of safety and environmental sensitivity.

Airspace studies have shown that RNAV procedures have the potential for a significant cost savings for systems users. On a recent RNAV arrival-route test-flight into the Phoenix Sky Harbor International Airport the aircraft saved approximately four minutes of flight time and 300 pounds of fuel. Additional benefits include increases in flexibility, predictability, and improved access to the National Airspace System.

more advanced regional analyses on how a North American WAAS can come to fruition.

Latin America is taking monumental steps towards developing its own regional Global Navigation Satellite System (GNSS) architecture. Brazil has initiated an extensive joint project with the FAA to establish a prototype WAAS test bed capability. This Brazilian Test Bed (BTB) should be operational this Fall and will also be a major component of a larger effort to establish a prototype WAAS test bed capability for the entire Latin American region. This Latin American test bed will facilitate the development and implementation of an operational WAAS/LAAS architecture for Latin America that will be interoperable with the systems being fielded in the U.S. NAS in order to create a seamless Western Hemisphere SatNav system.


Brazilian delegates training on a TRS

The success of the Latin American effort has already been recognized by other regions and has become a model and template for these regions to begin a similar GNSS implementation project. The Asia Pacific region is following-up on previous decisions of the Asia Pacific Economic Cooperation (APEC) Transportation Working Group and the International Civil Aviation Organization (ICAO) Regional Office in Bangkok, Thailand to adopt a similar GNSS work project for the creation of a GNSS augmentation test bed capability in South East Asia. Work on this project is just getting underway so look for continued updates in future editions of this newsletter.

As you can see, the momentum of GPS and GPS augmentation implementation around the globe is reaching an all-time high. ASD-500 and AND-710/730 are right in the thick of it and will continue to provide global leadership and assistance to the international community with the implementation of these technologies. As more regions adopt programs for advanced GPS implementation, we collectively inch closer to the original ICAO vision of a seamless Global Navigation Satellite System (GNSS). The momentum of this revolutionary transition is just beginning to heat up.

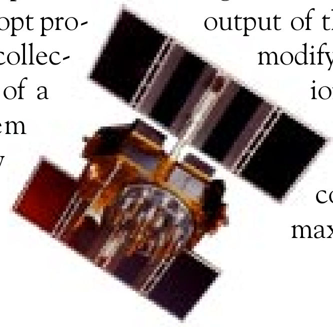
WAAS Arrives in Mexico

by Tom Dehel, NSTB Lead Engineer (ACT-360)

Mexican civil aviation officials, engineers, and pilots of the FAA completed a flight test of Mexico's recently installed National Satellite Testbed (NSTB) equipment. Sr. Oscar Amable, Dirección General Adjunto Servicios a la Navegación en el Espacio Aéreo Mexicano (SENEAM) and several other Mexican officials flew on board the FAA 727 as it conducted multiple precision approaches into the airport at Mérida, Mexico. The test was conducted from March 20 – March 25, 2001.

The NSTB prototype WAAS system is functionally simi lar to the WAAS and was used in the US for the WAAS proof-of-concept. The NSTB is now primarily used to collect data to support WAAS testing in the US and to support test efforts in areas outside the WAAS service volume. In Mexico, US and Mexican officials are cooperating to expand the coverage of the NSTB, as a first step toward investigating the expansion of future WAAS coverage over Mexico. Three NSTB reference stations were installed in Mexico (Mazatlán, Mexico City, and Mérida), and communications lines were provided by Mexico to send the data to the NSTB Master Station at the FAA Technical Center in Atlantic City. The Mexican reference station data was used along with 11 US and Canadian reference stations to generate the WAAS-like correction message, which was sent via the same communication line back to Mérida, where the corrections were broadcast to the aircraft in Mexico. The total testing will include two more flight tests, as well as a year of static data collection and analysis.

One of the challenges facing the global use of WAAS systems is the difference in ionospheric conditions around the globe, especially at the geomagnetic equator. Even in the continental US, ionospheric storms could decrease WAAS safety, and this threat has been specifically addressed by WAAS with new monitoring algorithms. The NSTB master station software used in this test was provided by Stanford University in the 1990's as part of research conducted on the WAAS. In 2001, the NSTB/WAAS Technical Center engineers coded software on a processor connected to the output of the Stanford NSTB master station processor to modify the output according to the latest available ionosphere-monitoring algorithms. In addition to the new software, this test was scheduled to coincide with the worst expected ionospheric conditions – near the equinox in a year of solar maximum conditions.



The testing in Mexico included over 40 precision approaches into Merida as well as two enroute flights across Mexico in order to collect additional ionospheric data. Data analyzed to date has shown that Mexico has similar ionospheric conditions to the continental US, and a similar response to ionospheric storms. Simultaneous data collected from Antofagasta, Chile (which lies closer to the geomagnetic equator than Mexico), however, show much more irregular ionospheric conditions. To continue research in this area, the FAA is providing technical expertise to the Brazilian Testbed effort, continuing cooperative efforts with the Chilean Testbed efforts, and is planning to collect additional flight data in the region affected by the geomagnetic equator near the time of the next equinox, in October 2001.

This test was possible because of the work of both the Mexican officials and engineers, and the FAA officials, pilots, mechanics, and engineers – thanks to all!

http://gps.faa.gov

FAA, India Agree to GPS Cooperation

reprinted from the *FAA Intercom*, May 2001

The FAA has an important new partner in expanding the use of CNS/ATM technology in Asia. A recently signed Memorandum of Cooperation between the FAA and India could lead to the development of an interoperable Global Navigation Satellite System, using GPS and its augmentation systems to significantly enhance air traffic system safety and efficiency of air carrier operations in that region.

An FAA/U.S. Trade Development Agency-sponsored GPS workshop is scheduled for later this summer in India to provide Indian aviation officials with additional information about how to implement GPS in their air traffic control system.

We want your feedback. We encourage your questions, suggestions, and recommendations for improvement. Please e-mail our editor at Ashley.ctr.brott@faa.gov.

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