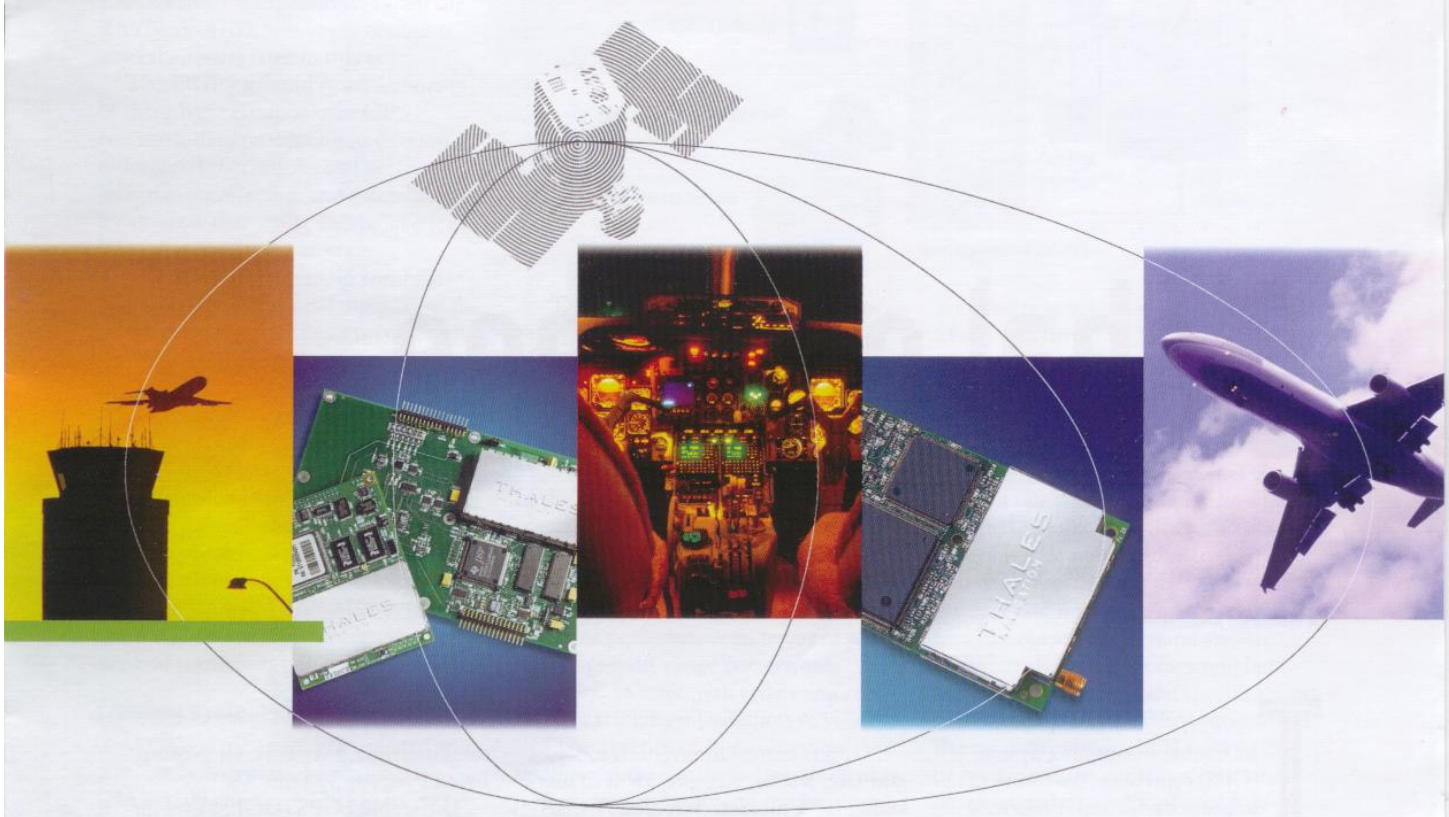


GLOBAL COVERAGE

The global positioning system tells 21st century navigators exactly where they are, anywhere in the world.

by Dr. Mohamed Abousalem
Director of Marketing
THALES Navigation

Reprinted from Flight Deck International, May 2001

THALES
NAVIGATION

Global coverage

The global positioning system tells 21st century navigators exactly where they are, anywhere in the world

Dr Mohamed Abousalem

The Global Positioning System (GPS) represents the future of aviation navigation. Embraced by the US FAA and ICAO, GPS offers a safe, efficient, low-cost global satellite navigation system. The efforts of aviation technology providers such as Universal Avionics, Raytheon and Park Air Systems, and GPS experts such as Magellan Corporation, are critical to the further development of this technology to meet the needs of civil aviation.

Existing ground-based navigation aids provide limited coverage due to obstacles such as terrain, and the majority of instrument approaches do not offer vertical guidance due to the high cost of instrument landing systems (ILS). Civil aviation authorities see that a satellite-based navigation system is needed to provide global coverage and support precision approach operations at most runways. Vertical guidance on an approach, available through augmented GPS, greatly reduces landing risks.

"GPS is critical for aviation today," said Don Berlin, vice-president of marketing for Universal Avionics. "Inertial reference systems are very expensive and Loran-C has a limited area of coverage. GPS is the great equalizer when it comes to navigation systems – it's affordable enough to be installed in all navigation systems and it provides excellent accuracy."

According to the FAA's *Guide for the Approval of GPS Receiver Installation and Operation*, "GPS accuracy is much greater than that of any other en route navigation system. In the future, GPS will allow reduced separation en route, optimized routes and shorter flight paths, and improved access to remote airports that do not support radionavigation by aids such as VOR."

"Differential GPS has been recognized by the aviation community as the core technology on which the next generation of space-based and ground-based augmentation systems for GPS shall be realized," explained Atle Berge Kristiansen, development manager, satellite landing systems, for Norway-based Park Air Systems AS.

Differential GPS (DGPS) uses differential techniques to improve position accuracy and provide integrity information to assist pilots with precision approaches. DGPS uses data from a land-based receiver to determine and transmit corrections to the aircraft. Data can be transmitted over a small geographic area, up to about 20-50 miles, through a local area augmentation system (LAAS), or over a broad geographic area by a wide area augmentation system (WAAS). LAAS data is normally transmitted via VHF from a ground-based site at an airport and WAAS broadcasts are transmitted via geostationary communication satellites to cover almost an entire hemisphere.

GPS has become the navigation technology of choice because of its many considerable advantages. "One of the advantages of the GPS system is the economics," confirmed Tim Katanik, program manager for navigation and landing systems at Raytheon Company,

the developers of the ground-based precision landing equipment that has been designed to work with the airborne GLS-1250 system from Universal Avionics. "The current technology of instrument landing systems requires an expensive piece of equipment for each runway end. We predict that an airport could install a ground-based LAAS GPS system that would support all runway ends at that airport for less than the cost of installing one instrument landing at one runway end – and even get higher performance as well."

The FAA points out that the cost benefits of using GPS lie in the associated user equipment costs and the expected cost benefits from reduced flight times and fuel consumption because aircraft can be routed to their destinations more efficiently. The FAA estimates that GPS could save airlines up to one percent in fuel costs and two percent in flight time each year.

LAAS will augment WAAS by providing Category 1, 2 and 3 landing capability. The FAA is currently developing the LAAS technical specifications, which will cover at least a 23-mile radius around each designated airport, and expects to begin buying and installing LAAS ground stations at major US airports in 2002-2003. Some Category 1 ILS systems are scheduled to be decommissioned as early as 2005, and within 10 years WAAS and LAAS will work together as the primary means of navigation for all phases of flight down to and including Category 3 precision approaches.

"One of the constraints on today's use of airspace is based on the limitations of the current navigation systems," said Katanik. "The strategy developed by ICAO and the FAA is to migrate navigation functions to be based on satellite navigation because the precision information – everywhere, all the time – facilitates much greater flexibility in structuring the air space and the efficient movement of aircraft."

Free flight is a long-range objective that changes the whole philosophy of aviation and fosters an environment that gives the flight crew much more discretion over the routes they choose and their real-time selection of alternate routes to get around weather situations or other constraints safely. The implementation of GPS through the WAAS and LAAS initiatives is an important enabler of the free flight concept.

FAA requirements

Based on the current and emerging FAA guidelines for GPS, and the migration of the aviation industry as a whole towards GPS-based navigation, aviation technology providers have already developed GPS-based flight management systems and are currently developing and testing precision approach landing systems based on DGPS.

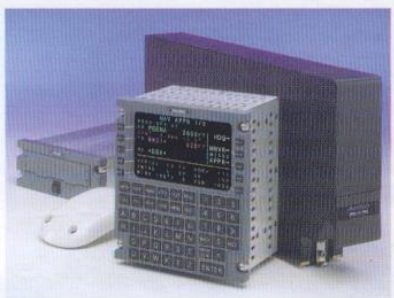
Magellan Corporation, a leading provider of global positioning systems, has developed the Ashtech GG12, a receiver designed to meet all the current requirements of aviation navigation and precision approach. The Ashtech GG12 OEM Board is a 12-channel L1 C/A code and carrier GPS+GLONASS receiver designed explicitly for aviation applications. It is suited for integration within Technical Standard Order flight management systems, ground-based reference stations for GPS aircraft landing systems and other avionics. It comes in GPS-only and GPS+GLONASS configurations and operates in autonomous and differential modes, making it useful for all phases of flight, including precision approach. The GG12 also features RF interference-resistance capabilities.

"GLONASS supplements the GPS system," explained Berlin. "We have our 24 satellites in the US system. The Russian GLONASS system's additional nine satellites supplement our system in mountainous terrain or where there might be some blockage of satellite signals. It adds a certain amount of accuracy to the solution, which increases safety and allows for less rerouted, abandoned or canceled flights."

GPS integrated with FMS

Earlier Ashtech GPS devices and the new Ashtech GPS+GLONASS technology have enabled Universal Avionics to become the first company in the industry to provide pilots with GPS and GPS+GLONASS navigation and non-precision approach capability.

"We include an Ashtech GPS unit as standard in every UNS-1 flight management system," explained Berlin. "We have embedded the GPS receiver right into our nav computer. The GPS receiver in our FMS navigation system gives us a very accurate latitude/longitude position and the navigation systems use that data."



Precision approach landings

Universal is also in the process of integrating the GG12 receiver into its GLS-1250 GPS landing systems for SCAT-I precision approach. "Because of software criticality requirements for our GLS-1250 landing system, we chose to use the Ashtech GG12 which includes the level B software required for landing systems," explained Berlin.

"Right now we have very accurate navigation systems using the Ashtech Sensor II GPS receivers from Magellan," Berlin continued. "The next step is to use the GG12 and datalink with the aircraft so that every pilot knows the location of every other aircraft. Another advantage of the datalink is that it enables controllers to communicate with the aircraft electronically and eliminate voice communications, which sometimes result in misunderstandings."

"The aircraft must have a datalink receiver that is compatible with the ground system transmitter; its own GPS receiver; a means of applying the differential corrections from the ground side to develop a corrected position in the aircraft; and a means of translating those 3D positions into deviations of above, below, right or left of the desired approach track," said Katanik.

Raytheon's ground-based system is the DIAS-3100, built to RTCA's DO-217 standard for SCAT-1. The FAA has established a replacement standard DO-245/6 intended to be fully interoperable worldwide with parallel ICAO standards. "Both the FAA and the international community have migrated to a new set of standards," Katanik noted, "to be able to certify and sell an interoperable DGPS landing system over a broad market, the DIAS-3100 is currently undergoing the necessary design changes to upgrade it to current standards such as FAA-E-2937A and the ICAO GNSS SARPS Annex 10 amendment to be published later this year.

Raytheon's current version of DIAS-3100 employs the Ashtech GG12 and has undergone system trials in Norway, Sweden, Indonesia and Australia, as well as several sites in the US and for

some military applications. Initial units that have been upgraded for LAAS/GBAS compatibility, called the RAYNAV-4100, will begin testing at several airports later in this year.

The DGPS ground system consists of three basic components: GPS receivers, data processing to develop differential corrections and perform integrity monitoring, and a datalink transmitter that sends the signal over a VHF datalink to the aircraft.

The airborne system, in combination with the differential input from the ground system, provides a precise position laterally as well as vertically. The DGPS base station measures the pseudo-ranges to GPS satellites, makes corrections based on known positions and datalinks those corrections to an aircraft, which then applies those corrections through the GLS-1250 and achieves much more accurate positioning. Driven by safety requirements, the highly redundant DIAS-3100 system uses two separate GPS receivers, antennae and processors per system.

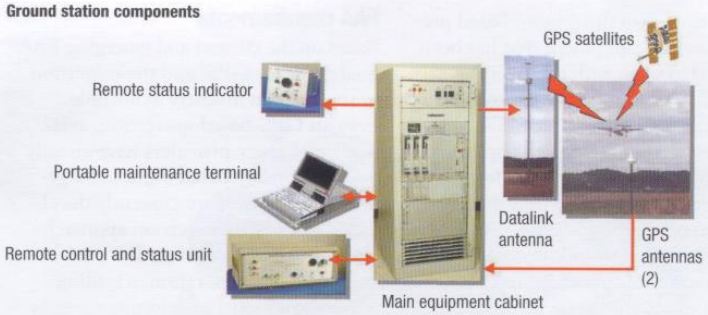
Landing systems in Norway

Two GPS stations are being tested at airports in Norway – Raytheon's DIAS-3100 and the NORMARC 8005 from Norway-based Park Air Systems AS, in collaboration with the Universal Avionics GLS-1250 airborne system and Wideroe Airlines. These companies are working towards a certification program with the older standard, while their development teams are concurrently upgrading their technology to meet the new LAAS standards.

"Norwegian aviation authorities have been active in promoting the implementation of advanced solutions in the domestic air traffic services," said Kristiansen. "NATAM (Norwegian Air Traffic and Airport Management) has determined that precision approach solutions for domestic regional air traffic shall be realized based on the GPS satellite system."

Norway is the ideal country in which to test these systems. There are more than 20 regional airports in mountainous and snowy areas, but they do not have the instrument landing systems that provide precision guidance to 200ft and half-mile visibility, commonly used in larger airports, because the older types of directional radio signals do not work properly in mountainous territory due to multipath problems and reflections off the mountains.

Ground station components



"DGPS would immediately improve safety and operational efficiency for Norway's airports," Katanik pointed out. "No other technology available could accomplish those objectives."

The Norway tests are also providing excellent feedback on the performance of the Ashtech GG12 in these critical precision approach applications. In Raytheon's flight testing of its DIAS-3100 DGPS Landing System ground station in Norway, the GG12 showed excellent performance in terms of accuracy of pseudo-range corrections, reduction in multipath errors and reliability in tracking all satellites in view.

"The absence of high-elevation satellites in the northern latitudes makes it important to be able to track rising and setting satellites as low on the horizon as possible," Katanik explained. "The GG12 showed exceptionally strong performance in such locations. The excellent multipath rejection characteristics of the GG12's Edge Correlator provided differentially corrected vertical navigation system errors that were typically in the 1-2m range.

"During testing of the GG12 several test pilots commented on the stability of the DGPS guidance compared with a typical ILS and stated that they occasionally made some intentional deviations to verify that the indicator was not frozen in the centered position."

The GG12 is also an important component in the NORMARC 8005 Differential Ground Station for aircraft approach and landing developed by Norway-based Park Air Systems. The NORMARC 8000 family builds on a common modular hardware platform that can be configured to realize the current RTCA SCAT-I standard DO-217, as well as the LAAS standard and the corresponding international ICAO GBAS standard.

"Tests of NORMARC 8005 Ground Station performance have been carried out and these tests, accompanied by availability simulations, show that SCAT-I accuracy and availability requirements will be satisfied," said Kristiansen. The NORMARC 8005 Ground Station is now undergoing the FAA SCAT-I Type Approval process.

"The Ashtech GG12 is a vital element in our landing system," he added. "We have employed this receiver as part of our equipment due to the fact that Magellan decided to realize this product and work with system integrators like ourselves – ground station manufacturers and avionics suppliers – to create the requirement specifications and to certify it as an OEM product for the aviation community. I believe this in itself is a great contribution to the development of satellite-based solutions for precision landing systems."

Conclusion

The use of GPS in aviation will continue to grow as new standards are confirmed and new technology is innovated. GPS is already being used in flight management systems and its place in precision-approach technology has already been realized – it is just a matter of aviation authorities hammering out the details.

Due to the benefits and economics, we will see a DGPS ground station at nearly every airport that currently has an instrument landing system that uses the more conventional radio beam technology, as well as many additional airports. Companies such as Magellan Corporation, Universal Avionics, Raytheon and Park Air Systems are paving the way for this implementation by developing cutting-edge technology that not only meets specified standards, but also provides the performance necessary to ensure safety and efficiency for aircraft around the globe.

❖ *Dr Mohamed Abousalem is director of marketing at Magellan Corporation, based in Santa Clara, California, USA*