AIR NAVIGATION IN THE BRAVE NEW WORLD

By Capt Myron Papadakis JD

The times have changed in the last ten years to such a great extent that you, in the world of air transport, must slow the progress down so that machinery can catch up to avionics and computers. The fact remains that in the new digital age you as consumers have moved from PC to lap tops to I Pods to remote offices facilitated through the internet. Every two or three years you discard the old for the new. Technology is moving that quickly but Air Transport aircraft and the air navigations system is so expensive and long lived that the system can not change at the same rate as technology advances.

Truth is the 100 million dollar, 600mph toys of the 1970s such as the Boeing 727 and early version Boeing 737-200 and the early version Boeing 747 are all antiques almost relegated to the desert bone yards.. Their avionics reflect the past. The FAA controllers that run the airspace system are caught in upgrades of antiquity awaiting the future which is upon us and we in Air Transport could not respond because of training, budget, uniformity and politics constraints.

Politics yes. For years and years our military new precisely where aircraft were as they crossed the North Atlantic but airlines relied on World War II technology and a route track system that was used simply to keep some controllers employed moving aircraft by hand on a plotting boards. It was never quite that bad, but I do remember a near miss between two air carrier aircraft, one of which was 100 miles off course. The investigation was steeped in he said, she said arguments because the airlines relied on piloting skill and truthfulness in the void of the North Atlantic Track.

In a show of one-upsmanship the Kremlin suggested they could provide proof where each plane was because their tracking capabilities extended to cover the North Atlantic. Let it be said that the military had both accurate Inertial Navigation before the airlines as well as earlier and more accurate Ground Positioning satellite capabilities. That remains true today, but the airline industry is on the verge of catching up and utilizing this technology to a very sufficient and extensive degree.

GPS and Satellite Navigation

When it works, and its reliability is very high the advantages are wonderful, when it fails what is the back up?

The GPS system is a conglomerate of approximately 24 satellites (now greater than 30) positioned so at least 5 are line of sight visible to a person anywhere on earth..(The number now may be as high as 32). Of course the

distances are too great to actually see the satellites. Each satellite provides highly accurate position, accurate velocity and accurate time information to any user around the world. The user must be equipped with proper receiving equipments. Now just about every household with a mid range cell phone has GPS capability. Every cab in New York does and every rent a car can have one at little extra cost. You can buy GPS at Sam's Club and Costco. Every soldier worth his salt has a private one for survival purposes. Being lost is a thing of the past. In addition you can purchase children and pet finders as well as auto alarm systems. Every cop car in the free world has GPS.

There is little to suggest that GPS is not the single best system to handle cross country navigation and cross aviation navigation for global aviation. If GPS can be used to target a cruise missile to fly cross country at 1,000 mph and hit a target within a few meters if not inches then it can easily replace every navigational system utilized in the past 100 years.

There are a few drawbacks. One is speed of operation. It is far less important to know the exact position of a car or a person during a 1 second interval. The automobile changes location at about 88 feet a second a person walks at about 5 feet a second. Thus the acquisition data stream for a slow item is not as sophisticated as for a fast mover. (Airplanes, in cruise, are moving at 800 feet per second)

There are two levels of users of the initial system begun in 1984 this was divided into security use (read national defense or military) and a lesser accuracy for civilians.

To provide location the system ranges and triangulates between three known signals from three best satellites, each transmits a specific unique code. The satellite monitors and transmits its own health as part of its unique course acquisition coding.. Each receiver has preprogrammed the ability to recognize the 24 satellite codes by comparing codes to those installed in the receivers. Thus the process begins for the receiver to gain knowledge of where it is simply by acknowledging which of the 24 satellites it is receiving from.

The receiver measures how long the satellite took to arrive at the receiver in parts of a second and it needs to know the exact position of the satellite in space. This is simplified as the satellite sends its position as part of its own specific coded message. Each receiver must have three satellites to triangulate position and it utilizes a fourth for an extra time hack. Each satellite sends weather and its health data to verify its capability due to conditions in the ionosphere.

Are there failure modes discernible at the receiver? –Yes and no…. Three working satellites working properly provide valid position information. However, if one of the three satellites is sending a corrupt code the receiver must be in line

with 5 or more satellites to recognize which of the original three satellites is sending such a corrupted code.

From a National security standpoint, which is highly classified, it is very important that these satellites remain in operation above the world. Because reliance on these systems has become so great, a loss of several satellites in a single time frame could be extremely harmful.

To utilize GPS for primary navigation the aircraft must be equipped and certified. The operation must be conducted in accordance with an FAA approved flight operations manual the aircraft and crew must be prepared and capable of reverting to regular equipments and procedures. If the aircraft is not currently equipped to revert to full IFR using older methods.. Notams will include GPS satellites not operational. In addition both the airline and flight crew members must be trained in GPS approach procedures called for in their companies Ops Specs.

An airplane can receive satellite data but how and where it displays such data is also a function of the aircraft installed systems. Used frequently is the digital map mode display installed and provided by several well known manufacturers. An onboard computer that has senses various data streams such as heading speed, altitude can then plot and display the selected route of flight and can compute flight paths to known positions (called waypoints) or a pilot can create a way point by simply typing in Latitudes and Longitudes.

With such a computerized and memorized system the navigation bag of the past, the maps and the approach plates will become a back up to the installed capabilities. That is right up until the system fails. Today (2009) Maps, VOR stations, and non precision and precision instrument approaches still rely on VOR and ILS equipments as primary approach methods. They are still a requirement.

The times however are changing and properly equipped and trained pilots have been allowed to shoot non-precision GPS approaches at specified airports when an approved approach plate has been issued. This has been true since the late 80's and early 90's. The rules in 1992 were that some GPS approaches could be used in the United States if approach plates were issued. The Airline had equipment had trained in the equipment and had procedures in their flight manuals. Any extra territorial GPS approach had to specifically and individually be approved.

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Newer upgrades to the GPS civilian system became fully on line in 1995. That is roughly the date that everyone began using GPS in everyday life. The aviation Wide Area Augmentation System became available to the aviation National Airspace system. in July 2003. As such authorized WAAS equipment installed allows use for vertical navigation, point to point navigation and approaches. In short if

parameters are met the aircraft can be flown Navigated climbed, descended and landed while using GPS data. . A complete rundown on this system can be obtained by obtaining a dated Aeronautical Information Manual (AIM). If one is looking at a particular airline their manuals and Op specs will have such information concerning their operating limitations and allowances.

It is very noteworthy that WAAS information and in particular vertical altitudes shown on Published STARS, SIDS and Approach Plates may not be identical to data seen and loaded into aircraft computer and FMS systems by systems by ITO navigation providers. Thus it was still incumbent on the pilots to carry Brain Bags stuffed with Paper maps and approach plates. These heavy black bags may be a thing of the past as the world goes ever more paper free. However, currently approved approach procedures are still paper and either government issued or Jeppesen provided.

When appropriate WAAS equipment and certification has occurred [(TSO)c-145a] through installation of capable equipment and flight crew training then an airline, at certain airports can now legally use GPS for low minimum approaches. That is the wave of the future and the ILS systems will become back ups and eventually relics of aviation past. (That may take another 30 years) In fact if an aircraft has WAAS equipment the rule does not require the aircraft to be equipped with other navigation equipment usually used on the route to be flow, This is a stand alone certification. Of course most airlines use and have other navigation systems installed and so WAAS will be a retrofit on top of existing navigation capability

GPS based navigation, Climb, descent, approach and departures are now possible to implement. On board FMS are now modified to accept, use and display such data. Soon entire flight kits will be available and paper plates and maps will be relegated slowly to no longer be required.

This system WAAS system was short lived in its original FAA format ideas has transitioned to two segments which are named RNAV and RNP (which stand for terminal and en route applications) of Satellite capabilities for navigation within specific areas. Let it be said that the Minimum approaches allowed using GPS are Cat One 200 and ¾ ILS is still required Currently the ILS system is still predominant approach especially when very low minimum approaches are required. CatII, III, IIIA and those to 100 meters RVR are all currently the old standby ILS. The rules for low minimum ILS require the airplane, the pilots, and the airport to be CatII or Cat III qualified and that **all** required equipment must be operable before such low visibility approaches may be conducted.

With Satellite communications and internet it will be, is possible to interface immediately with all archived manuals relevant to the aircraft such as MEL, AMM, Wiring diagrams and more. Be advised that air Navigation of Transport airplanes

carrying passengers has failure mode potentials for catastrophic results. As such it is incumbent on designers of such systems to show the system is Fail safe. One way that can be accomplished is through back up or redundant systems. Thus this author expects to see continued use and reliance on in place proven systems for a good while longer. [Albeit inertial systems (INS) or auto tuned VORS)]

When the Satellite system is fully adopted it is envisioned that many countries will allow the VOR navigation systems to deteriorate or to be terminated altogether. Implementation of Pegasus GPs system to be added to existing aircraft displays will superimpose GPS on the existing system and then chose best available data to navigate by..In the existing Pegasus display the failure of satellites is annunciated but the system still operates using other navigational aids (auto tuned VORS)

There are three variants of GPS

GPS (the original 24 satellite military system initiated in 1978) GPS upgrade or GNSS Global navigation Satellite System. Now greater than 32 satellites and GALLILEO system, which is reaching completion in the European Union Theatre of operations.

The Most Current system is RNP

RNP is now in place it is a navigation system based on Satellite GPS and modern (updated) flight computers. This allows the aircraft to follow reselected company flight plans, which are loaded into the computers (FMS systems). This usually includes the capability to climb and descend –fly the select course fly departures and select arrivals and even shoot some specific non precision approaches. These programs still being refined provide most direct flight routes and can produce immense fuel savings. The system is backed up by integration of inertial nav systems and existing VOR receptions. Eventually VOR input will be removed.

The system and variants are in implemented in China, Australia, New Zealand the USA and Canada ICAO and the FAA as well as the European Union are working to create a system that will be adaptable and universal in nature. The new Buzz word for making the situation global in nature is Harmonization of procedures and terminology. Such work takes time but the next generation is expected no later than 2010

To fully understand the system you must acquire ICAO RN AR MANUAL, and the ICAO PBN manual. The equivalent FAA documents are (AC) 90-101 and FAA Order 8260.52

One standard for the next decade is the Honeywell Pegasus system that is GPS compatible and it, infect, uses satellites to update Inertial data while still incorporating and capable of utilizing VOR display capability. Expect this system or similar upgrades to be the industry standard for the coming technology advances.

NEXT GENERATION AIR TRANSPORTATION SYSTEM (known as NextGen). FAA 2018 Next Generation Implementation Plan.

The FAA plan merges and changes the National Airspace System from a ground based system for Air Traffic Control into a Satellite based system of air traffic management and . As envisioned the system is planned to be potentially ready for the year 2018. It will replace the current ground based radar controllers as inefficient and aircraft separation will be accomplished through Satellite GPS positioning and data transmission both digital and voice through satellite communication. The ground system of control will be very much changed and diminished if not abolished. The system may require as little as Ground and tower control if not Approach control. Note the words of art Air Traffic control changes to Air Traffic **MANAGEMENT**

The US plan involves co ordination and co operation of several Federal agencies to include NASA .NOAA, White House Science and Technology, DOD and Homeland security as well as a myriad of corporate stakeholders.

The new system envisions changes in aircraft tracking methodology ,where radar and ground controllers are replaced, aircraft 3 dimensional navigation LNAV and VNAv based on satellite positioning , and satellite voice and digital communication. For the most part cross country navigation is envisioned to incorporate mostly point to point direct flights. As opposed to preplanned routing over select VOR stations.

The goals for 2018 suggest that the next generation system will handle more traffic, more efficiently, safer, at less cost, with less delay and with cost efficiencies. In combination of the fuel savings with increased efficiencies and because of gas efficient engines the negative Environmental impact should also be decreased

EUROPE and ATM PLAN

The European countries have banded together and are moving toward a system for air Traffic Management that may be further advanced than the United States. One thing that is seemingly different than the American plan is the fact that in Europe there seems to be a greater willingness to shut down airspace usage to general aviation aircraft not equipped to fly in the restricted airspace.,

The European Union has a similar Air Traffic Management Plan for the year 2020, In many aspects the plan is more advanced , better coordinated and further along, on paper, than is the US plan, They are similar in nature except their plan requires the co ordination of many Union countries rather than a single nation. The European plan is a consortium heavy on industry input. It is to be implemented in 2020

In paraphrase the European Plan incorporates

> "*• Enable a 3-fold increase in capacity which will also reduce delays, both on the ground and in the air;*
> *• Improve the safety performance by a factor of 10;*
> *• Enable a 10% reduction in the effects flights have on the environment and;*
> *• Provide ATM services at a cost to the airspace users which is at least 50% less".*
>
> *Technology will incorporate*
>
> *• Communication systems using digital/data*
>
> *Full integration of terrestrial and satellite networks*
>
> *• The primary navigation system will be satellite based, with a fall back solution to mitigate against a potential blackout of satellite navigation services;*
>
> *• New ADS-B based surveillance systems will increasingly provide improved 4D-position information (accurate position and time*

SOURCE: **Google Euro Control European ATM Master Plan**

A note about aircraft investigations. Just as air navigation changing, so too must aircraft accident investigations change focus. No longer will an investigator be looking to retrieve pointers and dials from old steam gauge systems. No longer will an investigator search to see what frequencies the pilot tuned in navigation devices. The glass cockpit and automation will require the forensic expert to rely on data retrieved to the Digital Flight Data recorder" The BLACK BOX" and upon Non Volatile computer memory and flash drive retrievals to gain forensic data suitable to reconstruct the navigation portions of the flight data. Obviously you need a very special breed of investigator –More Geek than tin kicker.