Alternatives to the instrument landing systems engineering essay

Food & Diet

Pilots have been faced with horrors of not being able to safely carry out the whole flight envelope activities during unfavourable weather conditions. The solution was the idea of somehow aiding pilots with instruments that would help get the job done. The Instrument Landing System (ILS), being the first, did break the ice but its faults and restrictions paved way for alternatives like the MPL, JPAL, IGS and TLS amongst others. It cannot be overlooked though that the ILS is still the most common of all approaches and pilots are tested numerous times on the workings of the ILS during their flight career.

The Instrument Landing System (ILS) is an instrument presented, pilot interpreted, precision approach aid. The system provides the pilot with instrument indications which, when utilised in conjunction with the normal flight instruments, enables the aircraft to be manoeuvred along a precise, predetermined, final approach path. [1] Tests of the ILS began in 1929 and the Civil Aviation Authority (CAA) authorised installation of the system in 1941 at six locations. The first landing of a scheduled U. S. passenger airliner using ILS was on January 26, 1938, as a Pennsylvania Central Airlines Boeing 247-D flew from Washington D. C. to Pittsburgh and landed in a snowstorm using only the Instrument Landing System.[2] The first fully automatic landing using ILS occurred at Bedford Airport UK in March 1964. [3]

1. 1 Overview on the Instrument Landing System (ILS)

The ILS uses two primary signals: a localizer for lateral guidance (VHF) operating between frequencies 108. 10MHz and 111. 95MHz; and a glide slope for vertical guidance (UHF) operating between 329. 30MHz to 335. 00MHz. The localizer provides course guidance throughout the descent path to the runway threshold from a distance of 18 NM from the antenna between an altitude of 1, 000 feet about the highest terrain along the course line and 4, 500 feet about the elevation of the antenna site. [4] On the other hand, the glide consists of two overlapping beam modulated at 150Hz and 90Hz. The centre line of the glideslope signal is arranged to define a glide slope of approximately 3° above ground level with the beam being 0. 7° below the glideslope centreline and 0. 7° above the glideslope centreline i. e. 1. 4° in total. The transmitter is located 750 to 1, 250 ft. down the runway from the threshold, offset 400 to 600 ft. from the runway centreline [5].

1. 2 Limitations facing the ILS

The complexity of the ILS localizer and glide-slope system gives rise to its high installation cost. Also, there are topographic limitations with the ILS because of the complex siting requirements due to the sensitivity of both the localizer and glide slope systems. The localizer's full functionality is limited due to effects from obstructions in the signal broadcast areas like hangers and large buildings and the glide-slope conversely is affected by the terrain in front of the glide-slope antenna. If terrain is sloping or uneven, reflections can create an uneven glide-path causing unwanted needle deflections. Additionally, the ILS only supports straight-in approaches since its signals are pointed in one direction by the positioning of the antennae arrays. Furthermore, the ILS suffers from frequency congestion because of a finite number of available frequencies (only 40 channels in all)[6], and has frequency modulation interference problems in some areas.[7] Also, the fact that it is not easily deployable makes it fall out of favour with the military.

These main facts resulted into the development of the Microwave Landing System (MLS) with one intention only, to replace the ILS.

2. The Microwave Landing System (MLS)

2. 1 History of the MLS

The Microwave Landing System was designed to replace or supplement the ILS. Tests of the MLS began in 1972 in Australia. Most of this work was jointly done by the then Federal Department of Civil Aviation (DCA), and the Radio Physics Division of the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The project was called " Interscan" which was one of the many Microwave Landing System under consideration internationally. Interscan was chosen by the FAA in 1975 and ICAO in 1978 as the format to be adopted. [8] The MLS was standardised in 1988 and approved for use in international civil aviation. [9]

2. 2 Overview and advantages of the MLS over the ILS

MLS employs 5GHz transmitters at the landing place which use passive electronically scanned arrays to send scanning beams towards approaching aircraft. An aircraft that enters the scanned volume uses a special receiver that calculates its position by measuring the arrival times of the beams. The MLS operates in the microwave spectrum of 5. 0-5. 25 GHz/15. 4-15. 7 GHz. It provides azimuth, elevation and distance measurement to aircraft having the necessary components installed. It has various advantages over the ILS as it is more accurate and preferable in providing approach guidance to aircrafts. It is capable of providing fan coverage range of +/- 40 degrees either side of the antennae and a horizontal distance of about 20NM from the runway touchdown point for azimuth approaches and +/- 20degrees fan coverage area from a horizontal distance of 5NM for back azimuth for a missed approach situation. The ILS on the other hand can only accurately provide course guidance of +/- 10 degrees either side of the antennae from a horizontal distance of 18NM for forward azimuth approach and a further +/- 25 degrees fan coverage area (+/- 35degrees in total for azimuth approaches) from a horizontal distance of 10NM for back azimuth on a missed approach. Any area beneath the +/- 35 degrees coverage area, signal may provide incorrect or undesirable readings by the instruments. [10] This statement is graphically represented in figure 1.

Figure 1. The MLS coverage area.

Also, the DME (Distance Measuring Equipment) on the ILS provides a range accuracy of +/- 1, 200ft. as compared with greatly improved version on the MLS called the DME/P (for Precision) which provides a range accuracy of +/- 100feet making it possible for the MLS to guide the extremely accurate CATIII approaches which was previously normally carried out with expensive ground based high precision radar equipment with the ILS.

Furthermore, with the MLS having 200 channels for communication/broadcast operating between 5031 and 5090. 6 MHz (far from FM broadcast frequencies) gives it further advantage through getting rid of jamming and interference problems faced with the ILS because its operational channel frequencies are fairly close to FM broadcast frequencies.

In addition, the MLS antennae are small because it transmits at higher frequencies, cheaper and easy to construct and maintain as it does not employ a Localizer and glideslope transmitter. It can also be placed anywhere as compared to the ILS system that has to be placed at the end of the runway and along the approach path.

Again, it has the advantage of providing precision guidance to V/STOL (Shot Take-off and Landing) aircrafts and helicopters in small areas e. g. roof-top helicopters which is impossible with the ILS.

In addition, it cannot only accommodate straight-in or segmented approaches but also curved approaches as the transmitter does not have to be in direct alignment with the receiver before landing can be possible and this is so because the MLS transmitter signal covers a very large fan-shaped coverage area.

Finally, because of the higher frequency the MLS operate, precisely in a ratio of 50: 1 as compared with the ILS, it therefore requires a smaller antenna. A 1o beam-width antenna for a MLS requires 12ft (3. 6m) antenna while a typical ILS system would require a 600ft (180m) antennae size for the same 1o beam-width losing out again to the MLS to size advantage. [11].

The MLS expectation to replace the ILS was actually the reverse as a lot of airliners were reluctant to converting to MLS because it required them installing and or changing some equipment on board the aircraft and on the ground. Also, at almost about the same time came the invention of the GPS. The GPS required no installations in airports. It never employed placing any antennae along the runway like the ILS and MLS. This eliminates the siting requirements imposed by both initial systems and gave rise to simplicity.

3. The GPS and the WAAS:

The GPS, Global Positioning System, consists of a space-based radio navigation satellite and network of ground stations for controlling and monitoring. The space portion consists of at least 24 GPS satellites orbiting the earth twice in a day at a speed of about 7, 000miles per hour and about 11, 000 miles in altitude from the earth's surface.[12] The GPS provides accurate data of current position. Basically, to get current location using the GPS, data is sent from the object e. g. the aircraft and it measures the time taken for the wave to reach the satellite and return and by means of triangulation using at least three satellites, accurate location can be calculated. The GPS though also has some limitations. It cannot be employed for precision landing since it does not give enough vertical accuracy and as known, vertical accuracy ensures safer landing. The GPS precisely provides a vertical accuracy of about 15meters and even the certification for the least, CAT I landing requires a vertical accuracy of at least 4meters. The inaccuracy is caused by the interaction of the radio signals with large waves in the ionosphere. This interaction slows down the time for the radio signal to be reflected back to its source since even a very small clock error multiplied by the very large speed of light (the speed at which satellite signals propagate) results in a large positional error. These errors aroused the introduction of the WAAS (Wide Area Augmentation System). The WAAS basically employs the same space-based satellite and ground based stations as the GPS but its main difference is that it sends out correctional signal to augment errors in the GPS signal. Two master stations located on either coast collects data from the reference station and a GPS correction message. This correction accounts for GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere. The corrected differential message is then broadcast through one of two geostationary satellites (satellites with a fixed position over the equator). The information is compatible with the basic GPS signal structure, which means any WAAS-enabled GPS receiver can read the signal.

For some users, in the U. S for example, they are not able to receive the corrected WAAS signal because of obstructions from trees and mountains. So plainly speaking, the GPS or WAAS is just not accurate enough to replace the ILS and this further encouraged the manufacture of other precision landing systems. [13]

4. JPALS (Joint Precision Approach and Landing System)

JPALS or the Joint Precision Approach Landing System is an all weather precision landing system developed and mainly intended for use by the military. The crash of a U. S. military transport in Bosnia in 1996, while flying a non-precision approach in adverse weather highlighted the need for a near-term, rapidly deployable precision approach system. As a result, the Air Mobility Command is pursuing an initiative to field a precision approach system to solve problems like the one encountered in Bosnia. In 1992, the Assistant Secretary of Defense for C3I directed a study to analyze existing emerging PALS technologies. Tasking was passed through the Air Force to the DoD Policy Board on Federal Aviation, which chartered the Precision

Landing Study Advisory Group (PLSAG) to produce a JPALS Mission Needs Statement (MNS). The Joint Requirements Oversight Council validated the MNS in August 1995. [14]

JPALS was developed by the military for two main reasons:

1. They needed an all weather precision landing system that is highly mobile and open to most if not all military scenarios, such as landing on ships, rough terrains etc. and

2. They needed a rugged system that would work and withstand any weather and environmental conditions.

JPALS is similar in concept to the civilian Local Augmentation Area System, LAAS. JPALS augments GPS to provide precision approach and landing information for military aircrafts flying in poor weather or low visibility. A typical JPALS system consists of both ground and airborne component. The ground component transmits correctional messages to augment the GPS signal. It also transmits a set of co-ordinate data defining the final approach path. The airborne receiver on the aircraft determines the position relative to the desired approach path or " runway" if you like. This information is displayed on the pilot's PFD.

A single JPALS ground system can support multiple runways in an airport and it can also support different approach path to a single runway. Also, the same JPALS ground system can support approaches to nearby airports within a 10-20miles radius. Furthermore, if a portion of the runway sustains damage, the landing threshold position can be moved further up front the runway. JPALS is divided into two main categories namely the SRGPS and the LDGPS. SRGPS provides highly accurate precision landing for aircrafts aboard ships, S/VTOL, helicopters. LDGPS is further subdivided into three categories. The fixed base used by military for on going operations around the world, the Tactical base designed for short-term critical operations and the Special missions is highly portable and used by Special Forces on special missions. Figure 2 simplifies the subdivisions.

Figure 2. JPALS classifications

A typical Special Missions JPALS system would be carried in two bag packs and can be set up by two airmen within a few minutes. The prototype system consists of a two GPS receiver enclosure, a laptop and a data link transmitter. In November 2007, this system was set up and tested at the FAA's Williams J. Hughes technical centre in Atlantic City, NJ. This man-packed system was tested using the FAA's covey test aircraft and by a C21 aircraft provided by the airforce's Flight Standard Agency. These two aircrafts successfully demonstrated the ability of the man-packed JPALS system to support the CAT1 approach and also further demonstrated its success after the landing threshold position was moved further up the runway in a case of a damaged portion of the runway. [15][16]

5. Conclusion: The ability for aircraft to fly and land under any circumstance is very much important as it ensures safety, integrity to the industry and comfort to passengers. As pilots of the earlier days were almost completely paralysed due to effects from bad weather or worse would crash as it happened to the military transport aircraft in Bosnia urged the need for

solutions. The faults in the ILS paved way for the MLS, GPS, JPALS and others. A Transponder Landing System or the TLS would also work where a typical ILS would not provided there is no paralysis in funds. The latest alternative to the ILS is the Localise Performance with Vertical guidance or the LPV which is also based on the same operation as the WAAS and as of Nov. 2008[update], the FAA has published more LPV approaches than Category I ILS procedures.

Generally, these precision and landing systems have greatly improved the integrity and safety of the Aviation industry, both military and civilian.