ANPC

Frequently Asked Questions

TLS/TTLS Transponder-Based Landing Systems

USA 800-228-1857
GLOBAL +1-541-386-1747

www.anpc.com

489 North Street #203
Hood River, Oregon USA 97031

Table of Contents

Introduction 4

What is ANPC's Background and Value Proposition? 4

What is the TLS Transponder Landing System? 4

What are the primary benefits of the TLS vs. SBAS or a conventional ILS? 4

Why can the TLS be used where ILS systems cannot? 5

Does the TLS meet ICAO specifications? 6

Is the TLS approved by the FAA? 6

What design criteria are used to develop TLS approaches? 6

Operation 6

How many aircraft can the TLS detect and track simultaneously? 6

How many approaching aircraft can the TLS service in an hour? 6

What transponder code does the TLS use to provide guidance to aircraft? 6

What types of transponders are supported by TLS? 6

Does the TLS use the Mode C altimeter data? 7

How does TLS provide SSR and PAR functionality? 7

How is multilateration accomplished? 7

How does the TLS display guidance to ILS needles in the cockpit? 7

What is multipath calibration? 7

Compared to TLS, how does multipath affect an ILS signal received on the aircraft? 8

How can the TLS support offset and non-linear approaches? 8

How does the TLS integrity monitor work? 8

What do “integrity” and “continuity” mean? 9

What is the basic “landing procedure” scenario? 9

How much power does the TLS require, and what is the input voltage? 9

What are the TLS power options (off grid)? 9

What are the transportable TLS options and how long do they take to install? 9

What is the flight inspection procedure for the TLS? 9

How many simultaneous PAR approaches can the TLS support?............................. 10

How does the TLS base station communicate with ATC?... 10

Does the TLS support remote maintenance monitoring?... 10

Technical Comparisons 10

How does the TLS compare to a PAR? 10

How does the TLS compare to GNSS augmentation (e.g. GBAS, WAAS)? 11

How does the TLS compare to RNP?.. 11

How does the TLS compare to ILS? 12

How does the TLS compare to WAM?... 12

How does the TLS compare to ADS-B?... 13

How does the TLS compare to VOR?.. 13

How does the TLS compare to DME? 13

Introduction

What is ANPC's Background and Value Proposition?

Advanced Navigation & Positioning Corporation is a privately held aerospace company based in Hood River, OR, USA.

ANPC was founded in 1991 by a former Lockheed Skunkworks engineer with specific expertise in sensor fusion, which he applied to his work on the Joint Strike Fighter program initiated by the U.S. Department of Defense and its allies to replace prominent but aging tactical aircraft. His vision for ANPC was to combine data collected from multiple discrete data sources to create a sophisticated and highly accurate picture of all air traffic activity in a given terminal service volume, in real time and with superior accuracy, that could be applied to a number of applications critical to the safety, reliability, and economic viability of commercial and defense aviation.

This scalable sensor fusion platform was to utilize proven RF technology and methodologies and widely installed airborne avionics prevalent at the time, in an open architecture that could serve the current market but also evolve with the development and market adoption of new technologies designed to solve the inevitable challenges of a growing aviation industry and broader customer base.

This early work at ANPC culminated in the development of an advanced secondary surveillance system that uses multilateration techniques to compare measurements from IFF transponders found on all IFR-equipped aircraft to calculate their precise location in 3D space. The first product based on this core architecture is the TLS Transponder Landing System, which translates aircraft positioning data into instrument approach guidance that allows pilots to safely land in all weather conditions. The TLS remains ANPC's flagship product and provides the foundation for several derivative solutions for diverse applications.

What is the TLS Transponder Landing System?

The TLS is a precision approach system designed for use at airports where rough terrain or real estate constraints make conventional Instrument Landing System (ILS) installation infeasible or cost-prohibitive. TLS calculates the aircraft's position in space from signals emitted by the aircraft's transponder, using time, amplitude, and angle measurements at ground-based sensors. A signal is then transmitted from the ground to the aircraft to give horizontal and vertical guidance indications in the cockpit that are identical to an ILS. The pilot can then fly a precision approach to Category I minimum decision heights. TLS performance meets all FAA and ICAO Annex 10 requirements for a Category I precision approach.

The TLS is also a secondary surveillance system that detects and tracks all cooperative aircraft with active transponders within its service volume. It functions identically to an SSR and surveillance data may be displayed on the TLS operator console or an ATC console through ASTERIX video feed.

What are the primary benefits of the TLS vs. SBAS or a conventional ILS?

- Precision approach guidance over terrain that prohibits traditional ILS localizer or glide slope equipment
- The TLS has no reliance on GPS or any satellite-based navigation services, which are unavailable or unreliable in many parts of the world, and vulnerable to natural or intentional disruption

- The TLS is not susceptible to false glideslope or localizer captures that are increasingly common with an ILS
- Area surveillance to a range of 100 nm for airfields that lack radar facilities
- Occupies a small footprint adjacent to or astride the runway
- Precision Approach Radar display for ground-controlled approach (GCA), a procedure in which the approach guidance is provided through radio communications between the pilot and a controller on the ground. GCA procedures have long been used by defense organizations to keep flight operations covert and less detectable, and to facilitate all-weather landings where ILS avionics are missing or inoperable
- Significant cost savings by avoiding expensive ground conditioning, including grading and other earthworks or property purchases that are required to install a traditional ILS
- Siting flexibility that minimizes the impact of critical and sensitive areas on airport operations
- TLS requires no additional avionics in IFR-equipped aircraft or flight training for IFR-certified pilots
- TLS can support multiple and varied instrument approach procedures at a single location
- TLS will support approach procedures with steeper and variable glideslope angles for rotary-wing operations or those in extreme terrain environments
- TLS can support non-linear (segmented or curved) approaches

Why can the TLS be used where ILS systems cannot?

The ILS is a static system that continuously transmits guidance signals from antennas physically aligned with the desired approach path, and the localizer course is dependent on the runway length and antenna placement. To meet ICAO requirements, the ILS localizer antenna must be installed over 2000 meters from the approach threshold.

The accuracy of ILS localizer and glide slope guidance also requires even and graded terrain free of obstacles underneath and alongside the service volume of the guidance signals. Finally, several marker beacons are required between 0.5 – 7 nm from the runway approach end to inform pilots of their distance to the runway.

This all means that ILS installations require substantial and properly prepared real estate at both ends of the runway, often beyond airport property limits. Such real estate does not exist at many of the world's airfields, particularly those with short runways that end in water, obstacles, or uneven terrain.

In contrast, the TLS is a dynamic system that provides guidance only when an aircraft has been cleared for TLS approach, and which is based upon its precise location. The TLS guidance antennas therefore need not be physically aligned with the approach path, and have none of the aforementioned ILS siting requirements.

Using "virtual emanation points" configured in software, the TLS transmits guidance that appears to emanate from the exact location where an ILS antenna would be, but from antennas that are physically located at the approach end of the runway roughly abeam the threshold on a small footprint of airport property. The virtual emanation points for the localizer and glideslope are simply a set of coordinates entered into the TLS system, and the TLS can inherently support offset and non-linear approaches where a straight-in approach is infeasible due to noise abatement or obstacle clearance issues, without affecting the equipment installation site. This technology also allows TLS to comply with ICAO requirements regardless of runway length or obstacles at either end.

The TLS provides audible marker beacon tones to the pilot identical to ILS beacons but without any equipment installed off airport property.

http://en.wikipedia.org/wiki/Transponder_landing_system

Does the TLS meet ICAO specifications?

Yes, the TLS meets all ICAO performance requirements for a CAT I Instrument Landing System (ILS) as documented in ICAO Annex 10, Volume I under the category of Radio Navigation Aids.

Is the TLS approved by the FAA?

Yes, the TLS was originally granted FAA Type Certification in 1998 and modified in 2004 to account for system software upgrades.

What design criteria are used to develop TLS approaches?

TLS instrument approach procedures may be developed by authorized IAP designers using FAA TERPS criteria for a CAT.I ILS or ICAO PANS-OPS criteria for a CAT.I ILS, at the discretion of the designer or airport authority.

Operation

How many aircraft can the TLS detect and track simultaneously?

Currently the TLS can track up to 100 aircraft simultaneously within a range of 100 NM

How many approaching aircraft can the TLS service in an hour?

A TLS installed with a single guidance transmitter can land approximately 6-15 aircraft per hour, depending on the length of the approach, considering that a typical approach takes about 4-10 minutes. Up to four transmitters can be purchased with TLS to support up to four simultaneous aircraft approaches, increasing its throughput to approximately 60 landings per hour.

What transponder code does the TLS use to provide guidance to aircraft?

The TLS will track all active and transmitting transmitters within its service volume. To fly a TLS approach, the pilot must first obtain approach clearance from the regulatory authority in control of the airspace and tune the transponder to the assigned code. To initiate guidance, the TLS operator will enter this code and instruct the system to “acquire” the aircraft, at which point the TLS will begin transmitting guidance to the CDI or HDI instrumentation in the cockpit. Confirmation of the approach clearance and valid guidance is provided via localizer morse code, as it is for an ILS.

What types of transponders are supported by TLS?

The TLS will track all transponders that respond to Mode 3/A interrogations. This includes Mode 3/A, C, S, and 5. All such transponders will respond by broadcasting the identification code that the pilot has selected on the transponder panel. Future iterations of the TLS will support Mode S selective interrogation as well as Mode 5 encrypted interrogation for DoD and NATO operations.

Does the TLS use the Mode C altimeter data?

Yes, the TLS uses the Mode C for aircraft surveillance but not for guidance as Mode C elevation data is not accurate enough to support a precision approach. For instrument or GCA guidance,
, the TLS determines the altitude geometrically from transponder response signals
received at sensors adjacent to the runway to provide the highest accuracy glideslope.

How does TLS provide SSR and PAR functionality?

The TLS is a surveillance and tracking system that provides the same information to ATC and other users as an SSR does, but with greater accuracy and data that's obtained through multiple sensors and multilateration vs. a single scanning radar antenna. TLS surveillance data is sent to a standard ATC display via ASTERIX-compliant video feed.

PAR functionality is achieved simply by sending the surveillance and tracking data to a standardized display that can be used by a ground controller to verbally guide pilots via radio along a precision approach path to touchdown.

How is multilateration accomplished?

The TLS interrogates from a single omni-directional antenna and receives signals at three omni-directional antenna locations on the ground; the Azimuth Sensor Assembly (ASA), Elevation Sensor Assembly (ESA), and Alternate Time-of-Arrival (ATA) antenna. The signal received by the ASA allows TLS to determine a solution somewhere on a circle at the range that corresponds to the time of arrival measurement. The signal at the ESA narrows the location to where the two range circles intercept, and the ATA signal adds a third range circle which determines the unambiguous location of the aircraft.

How does the TLS display guidance to ILS needles in the cockpit?

First, it is helpful to have a preliminary understanding of how a traditional ILS displays guidance in the cockpit. An ILS transmits static radio signals modulated with two tones that overlap along the desired approach path. Depending on which side of the beam the aircraft is on, one tone is louder (has greater amplitude) than the other. When the aircraft is centered on the beam, both tones have equal amplitude. The ILS receiver detects the relative amplitude of the two tones and drives the needles on the aircraft's CDI (course deviation indicator) or HSI (horizontal situation indicator), which show the pilot which direction to steer (up/down or left/right) so that both tones have equal amplitude, indicating that the aircraft is horizontally and vertically aligned with the desired approach path.

Unlike ILS, the TLS is a tracking system that identifies the aircraft's exact location in space based upon its transponder reply. The TLS compares the aircraft's known position to the pre-programmed approach path, then transmits ILS tones in the correct ratio, driving the needles to positions that direct the pilot onto the correct approach path.

What is multipath calibration?

After installation of the TLS equipment but before flight inspection, a TLS calibration process is conducted. The process takes about one hour using one aircraft and two technicians at the TLS. One technician will be stationed at a precision optical measuring instrument, called a theodolite, positioned adjacent to the runway and near the touch-down point. The other technician will be at the TLS electronics shelter. A data cable connects the theodolite to the TLS electronics shelter. During the process the pilot will steer the aircraft visually onto the approach centerline and fly level so that the theodolite operator is able to track the aircraft visually through the entire glide slope volume from 1 degree to 7 degrees above the horizon. Data from the theodolite is recorded at the TLS electronics shelter while the TLS also tracks the aircraft position. Post-processing this data takes about 5 minutes, after which the data is stored as a "calibration table" that allows the TLS to compensate in real time for multipath (multiple signals arriving directly through line-of-site and also reflected off of the ground) that affects the transponder signal. At this point the calibration process is complete and the TLS is ready for flight inspection.

Compared to TLS, how does multipath affect an ILS signal received on the aircraft?

ILS transmits from multiple antennas and the distance to the aircraft takes a different length path for each antenna. The ILS glide slope has typically three antennas at three different heights, the reflection of the signal off the ground combines with the direct path at the aircraft ILS receiver to form the glide slope. The signal received from a traditional ILS at the aircraft is therefore a combination of the direct signal and the multiple reflected paths that the signal traversed to arrive at the aircraft ILS antenna. This means that the position of the traditional ILS antennas is crucial to create the needle deflection content of the ILS signal received at the aircraft. For a traditional ILS localizer transmitting through 16+ individual antennas, the paths to the aircraft ILS receiver all vary slightly in distance, and horizontal reflectors (e.g. airport terminals) can cause adverse effects to the needle deflection information as received at the aircraft. The physical placement of the antennas and the spacing of the antenna elements is crucial for creating the needle displacement information of a traditional ILS localizer.

These signals are handled very differently by TLS. For TLS the transponder reply bounces off the ground and combines with the direct path at each TLS receive antenna. The composite signal formed by the direct path and the reflected path is characterized and compensated through the calibration process mentioned above. The needle deflection content of the TLS uplink for both localizer and glide slope is modulated within the guidance transmitter. This signal is then broadcast through a single localizer antenna and a single glide slope antenna. Since the signal contains the needle deflection information (Difference Depth Modulation - DDM), reflections cannot change the content of the needle deflection signal received at the aircraft. This is also the key reason why TLS localizer equipment is not placed at the transitional location of an ILS localizer.

How can the TLS support offset and non-linear approaches?

Since the TLS is a dynamic tracking system, the approach profile for TLS is not a consequence of alignment between the approach path and antennas like a traditional ILS that radiates the signal without tracking the aircraft position. Approach procedures for TLS are instead configured in software and can be tailored to any desired approach path.

How does the TLS integrity monitor work?

The TLS built-in Integrity Monitor provides assurance that the signals remain within ICAO CAT. I tolerances throughout an approach. If the Integrity Monitor detects an out-of-tolerance condition, TLS guidance is stopped, and the pilot sees "flags" on the ILS receiver in the cockpit and will execute a missed approach. The TLS will begin transmitting guidance again as soon as the Integrity Monitor detects that the out-of-tolerance condition has been resolved. This can occur within seconds or may take minutes.

The integrity monitoring has been designed in accordance with system safety principles from ARP 4754 that are applied to airborne navigation systems. Potential hazards resulting from hardware/software or system failure modes have been eliminated or mitigated by implementing self-test and redundant systems.

What do “integrity” and “continuity” mean?

Integrity is commonly understood to be the global risk factor for the failure of the monitoring subsystem that may result in guidance exceeding the accuracy tolerance during an approach. By international agreement, ICAO sets the maximum probability of a failure of integrity at 1x10-7 per approach, implying that 1 out of 10,000,000 approaches may have an integrity failure resulting in guidance that is beyond the
required tolerance. An integrity failure can occur if radiation of a signal which is outside specified tolerances is either unrecognized by the monitoring equipment or the control circuits fail to remove the faulty signal. Clearly not all integrity failures are hazardous in all phases of the approach and an integrity failure does not necessarily result in the aircraft losing obstacle clearance.

ICAO also set the maximum rate of interrupted guidance with a continuity specification of 1x10-4 per 15 seconds. This continuity requirement acknowledges that there is a trade-off between achieving the required accuracy and maintaining the integrity while monitoring the guidance in such a way as to avoid alarms that interrupt the guidance excessively.

TLS integrity and continuity of service far exceed the basic requirements for a CAT I system.

What is the basic “landing procedure” scenario?

Pilot calls ATC to request TLS approach:

Pilot: “[Airport] Tower, this is Cessna November 2674 requesting TLS approach for runway 25.”

ATC: Enters N2674 transponder code into TLS RCU and presses “acquire.” “November 2674, you are cleared for TLS approach on runway 25.”

Pilot: Tunes receiver to localizer frequency and confirms via morse code. “Roger, Cessna November 2674 cleared TLS runway 25 approach.”

How much power does the TLS require, and what is the input voltage?

The TLS requires 1.8 kilowatts for the electronics plus 3 kilowatts more if air conditioning or heating as required. The input voltage is single or two phase 220 vac, 50 to 60 hz.

What are the TLS power options (off grid)?

Diesel generator with auto switch-over capability and solar.

What are the transportable TLS options and how long do they take to install?

Mobilized options include a 20-foot CONEX container that also functions as the TLS base electronics shelter. Trailers and alternate container configurations can also be provided. A palletized configuration will be available in 2021.

What is the flight inspection procedure for the TLS?

TLS flight inspection is very similar to ILS flight inspection. It is the evaluation process, using properly equipped aircraft to confirm the continuity, integrity and accuracy of significant parameters from navigation aids and procedures, to comply with international standards. There is a current published FAA Order for flight inspection of the TLS/TTLS.

With TLS, ATC must press "acquire" on the TLS remote control unit in order for guidance to be transmitted to the flight inspection aircraft. Also, the TLS signal does not fade in or fade out as the aircraft travels toward or away from the TLS at the volume edges; the TLS signal is either on or off.

How many simultaneous PAR approaches can the TLS support?

Up to 4 independent PAR consoles are provided with TLS from which 4 controllers working independently can talk down 4 aircraft simultaneously.

How does the TLS base station communicate with ATC?

The communication of data can be using fiber optic cable or wireless Ethernet bridge.

Does the TLS support remote maintenance monitoring?

Yes, remote maintenance and monitoring is provided with TLS using internet connection through a VPN switch and router or a satellite system such as BGAN. Remote access of approach data and LRU status can be achieved using the TLS remote monitor.

Technical Comparisons

How does the TLS compare to a PAR?

Precision approach radar (PAR) is a type of radar guidance system designed to provide verbal lateral and vertical guidance to an aircraft pilot for landing, until the landing threshold is reached. After the aircraft reaches the decision height (DH) or decision altitude (DA), the landing is completed visually and guidance is advisory only. Controllers monitoring the PAR display observe each aircraft's position and issue verbal instructions over the air band radio to the pilot that keep the aircraft on course and glidepath during final approach. It is similar to an instrument landing system (ILS) but requires verbal control instructions.

The signal strength for the TLS is not attenuated by rain since the transponder frequency is within the long-range L-band (1090 and 1030 MHz); therefore a TLS-based PAR console does not experience rain fade. The TLS has an operational range of 120 nm, whereas a traditional PAR has a limited range of 10 to 20 miles using primary radar frequencies. The TLS PAR console display of aircraft position is based on 25Hz update rate while the PAR equipment update rate is only 1Hz. A traditional PAR uses antennas that mechanically move and have higher failure rates associated with moving parts while a TLS has stationary antennas. A traditional PAR flight inspection procedure is performed without a navigation signal available to compare directly to a truth reference. A traditional PAR is flight inspected by comparing written notes between two observers, one taking notes at a truth reference system such as a theodolite and the other observer taking notes while observing the radar console, and coordinating with the pilot by radio. See ICAO Document 8071 for the full procedure.

The TLS non-traditional PAR can transmit an ILS signal that corresponds to the aircraft position relative to the precision approach. Therefore, the graphical depiction can be directly verified using Instrument Landing System (ILS) flight inspection techniques. This direct measurement removes error from the PAR flight inspection process and results in a more accurate approach for the pilot.

More reading at http://en.wikipedia.org/wiki/Precision_approach_radar

How does the TLS compare to GNSS augmentation (e.g. GBAS, WAAS)?

Augmentation of a global navigation satellite system (GNSS) is a method of improving the navigation system's attributes, such as accuracy, reliability, and availability, through the integration of external information into the calculation process. There are many such systems in place and they are generally named or described based on how the GNSS sensor receives the external information. Some systems transmit additional information about sources of error (such as clock drift, ephemeris, or ionospheric delay); others provide direct measurements of how much the signal was off in the past, while a third group provides additional vehicle information to be integrated in the calculation process.

A satellite-based augmentation system (SBAS) is a system that supports wide-area or regional augmentation through the use of additional satellite-broadcast messages. Such systems are commonly composed of multiple ground stations, located at accurately-surveyed points. The ground stations take measurements of one or more of the GNSS satellites, the satellite signals, or other environmental factors which may impact the signal received by the users. Using these measurements, information messages are created and sent to one or more satellites for broadcast to the end users. SBAS is sometimes synonymous with WADGPS, or wide-area DGPS.

Each of the terms ground-based augmentation system (GBAS) and ground-based regional augmentation system (GRAS) describe a system that supports augmentation through the use of terrestrial radio messages. As with the satellite-based augmentation systems detailed above, ground-based augmentation systems are commonly composed of one or more accurately surveyed ground stations, which take measurements concerning the GNSS, and one or more radio transmitters, which transmit the information directly to the end user. Generally, GBAS networks are considered localized, supporting receivers within 20 kilometers (12 mi), and transmitting in the very-high frequency (VHF) or ultra-high frequency (UHF) bands. GRAS is applied to systems that support a larger regional area, and also transmit in the VHF bands.

All GNSS variations have low signal strength that can be interrupted with low-cost emitters on the ground. The GNSS systems are also distorted by daily ionospheric changes, especially in the low latitudes within about 20 degrees of the equator. And of course, all GNSS require new equipment on the aircraft, pilot training, and maintenance checks. And, GNSS variations are all controlled by various political organizations, with each country that has put forth a system having final control over its operation.

TLS by contrast is ground-based with all equipment located within a 100-meter footprint on airport property, owned and controlled by the sponsor with high signal strength and a proven ILS signal technique that has been trusted for over 50 years. TLS does not require new equipment on the aircraft and is completely independent from GPS position and timing signals. Therefore, TLS availability is completely independent of those failure modes that effect GPS.

How does the TLS compare to RNP?

Required navigation performance (RNP) is a type of performance-based navigation (PBN) that allows an aircraft to fly a specific path between two 3D-defined points in space. RNAV and RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting. A navigation specification that includes a requirement for on-board navigation performance monitoring and alerting is referred to as an RNP specification. One not having such a requirement is referred to as an RNAV specification.

RNP also refers to the level of performance required for a specific procedure or a specific block of airspace. An RNP of 10 means that a navigation system must be able to calculate its position to within a circle with a radius of 10 nautical miles, 95% of the time. An RNP of 0.3 means the aircraft navigation system must be able to calculate its position to within a circle with a radius of 3 tenths of a nautical mile, 95% of the time.

TLS does not require new equipment on the aircraft and is completely independent from GPS position and timing signals, and therefore its availability is completely independent of those failure modes that effect GPS. TLS accuracy at the decision height is close to 0.3m (1 foot), while RNP accuracy is measured in tenths of miles. TLS is much more precise than RNP, allowing the use of ILS PANS-OPS and TERPS for the approach design. TLS has built-in test verification of integrity to a 1x10-7 level, whereas RNP has a 1x10-5 level and 5% probability of exceeding the required accuracy.

How does the TLS compare to ILS?

An instrument landing system (ILS) is a radio beam transmitter that provides a direction for approaching aircraft that tune their receivers to the ILS frequency. It is a ground-based instrument approach system that provides precision lateral and vertical guidance to an aircraft approaching and landing on a runway, using a combination of radio signals and, in many cases, high-intensity lighting arrays to enable a safe landing during instrument meteorological conditions (IMC), such as low ceilings or reduced visibility due to fog, rain, or blowing snow.

An instrument approach procedure chart (or approach plate) is published for each ILS approach to provide the information needed to fly an ILS approach during IFR (instrument flight rules) operations. This chart includes the radio frequencies used by the ILS components and associated navaids (VOR, DME) and the prescribed minimum visibility requirements. Radio-navigation aids must provide a certain accuracy determined by ICAO; to ensure this accuracy, flight inspection organizations periodically check critical parameters with properly-equipped aircraft to calibrate and certify ILS precision. TLS accuracy is the same or better than ILS accuracy and can have approaches designed using the same PANS-OPS or TERPS criteria as an ILS. TLS is flight checked using the same tolerances as an ILS, and TLS approach charts are identical to ILS approach charts. Since TLS is also a multilateration system, an important functionality that TLS provides but ILS does not, is the ability to see the aircraft position on the ATC console. The surveillance accuracy of TLS matches that of a radar, and the TLS records the position of all area aircraft, which an ILS does not.

How does the TLS compare to WAM?

Wide-area multilateration (WAM) is a cooperative aircraft surveillance technology based on the same multilateration principle used by TLS. WAM is a technique where several ground receiving stations listen to signals transmitted from an aircraft; then the aircraft's location is mathematically calculated - typically in two dimensions, with the aircraft providing its altitude via Mode C transponder reply. Aircraft position, altitude and other data are ultimately transmitted through an Air Traffic Control automation system to screens viewed by air traffic controllers for separation of aircraft. It can and has been interfaced to terminal or en-route automation systems. WAM sensors are spread out over 10s of miles normally on existing cell phone towers or hill tops where power and communications need to be accessed. However, compared to TLS-based surveillance, WAM is more expensive and difficult to site. WAM operates at lower interrogation rates and sometimes uses a passive mode relying on interrogations from other systems to supply the transponder replies. In this situation, WAM surveillance accuracy and coverage can be greatly reduced. WAM is usually dependent on GPS for time synchronization.

TLS always uses active interrogation to guarantee the best rates and coverage. All the TLS equipment can be placed within about 100 meters on the airport property and provides surveillance coverage to 120nm. TLS is a precision landing system; WAM is not a precision landing system and does not provide any guidance to the pilot.

How does the TLS compare to ADS-B?

Automatic dependent surveillance – broadcast (ADS–B) is a cooperative surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked. The information can be received by air traffic control ground stations as a replacement for secondary radar. It can also be received by other aircraft to provide situational awareness and allow self-separation. ADS–B is "automatic" in that it requires no pilot or external input. It is "dependent" in that itdepends on data from the aircraft's navigation system. ADS–B is an element of the US Next Generation Air Transportation System (NextGen) and the Single European Sky ATM Research (SESAR). ADS–B equipment is currently mandatory in portions of Australian airspace. The United States requires some aircraft to be equipped by 2020 and the equipment has been mandatory for some aircraft in Europe since2017. The system relies on two avionics components—a high-integrity GPS navigation source and a datalink (ADS-B unit). There are several types of certified ADS-B data links, but the most common ones operate at 1090 MHz, essentially a modified Mode S transponder, or at 978 MHz. TLS provides area surveillance to a range of 120nm, using transponder replies. TLS determines the position of the aircraft by triangulation. TLS is completely independent of GPS position and timing services.

How does the TLS compare to VOR?

VHF Omni Directional Radio Range (VOR) is a type of short-range radio navigation system for aircraft, enabling aircraft with a receiving unit to determine their position and stay on course by receiving radio signals transmitted by a network of fixed ground radio beacons. It uses frequencies in the very high frequency (VHF) band from 108 to 117.95 MHz. VOR signals provide considerably greater accuracy and reliability than NDBs due to a combination of factors. Most significant is that VOR provides a bearing from the station to the aircraft which does not vary with wind or orientation of the aircraft. VHF radio is less vulnerable to diffraction (course bending) around terrain features and coastlines. Phase encoding suffers less interference from thunderstorms. VOR signals offer a predictable accuracy of 90 m (300 ft), 2 sigma at 2 nm from a pair of VOR beacons; as compared to the accuracy of un-augmented Global Positioning System (GPS) which is less than 13 meters, 95%.

VOR's are commonly used for non-precision approaches to airport runways and they provide no vertical guidance. The TLS provides precision horizontal and vertical guidance with accuracy of about one foot (1/3 meter) at the decision height of a Category I approach.

How does the TLS compare to DME?

Distance measuring equipment (DME) is a transponder-based radio navigation technology that measures slant range distance by timing the propagation delay of VHF or UHF radio signals. The accuracy of DME ground stations is 185 m (±0.1 NM).DME can be used in conjunction with VOR to provide a non-precision approach without vertical guidance. This is very different from TLS of course which provides precision horizontal and vertical guidance that conform to the Category I standard.