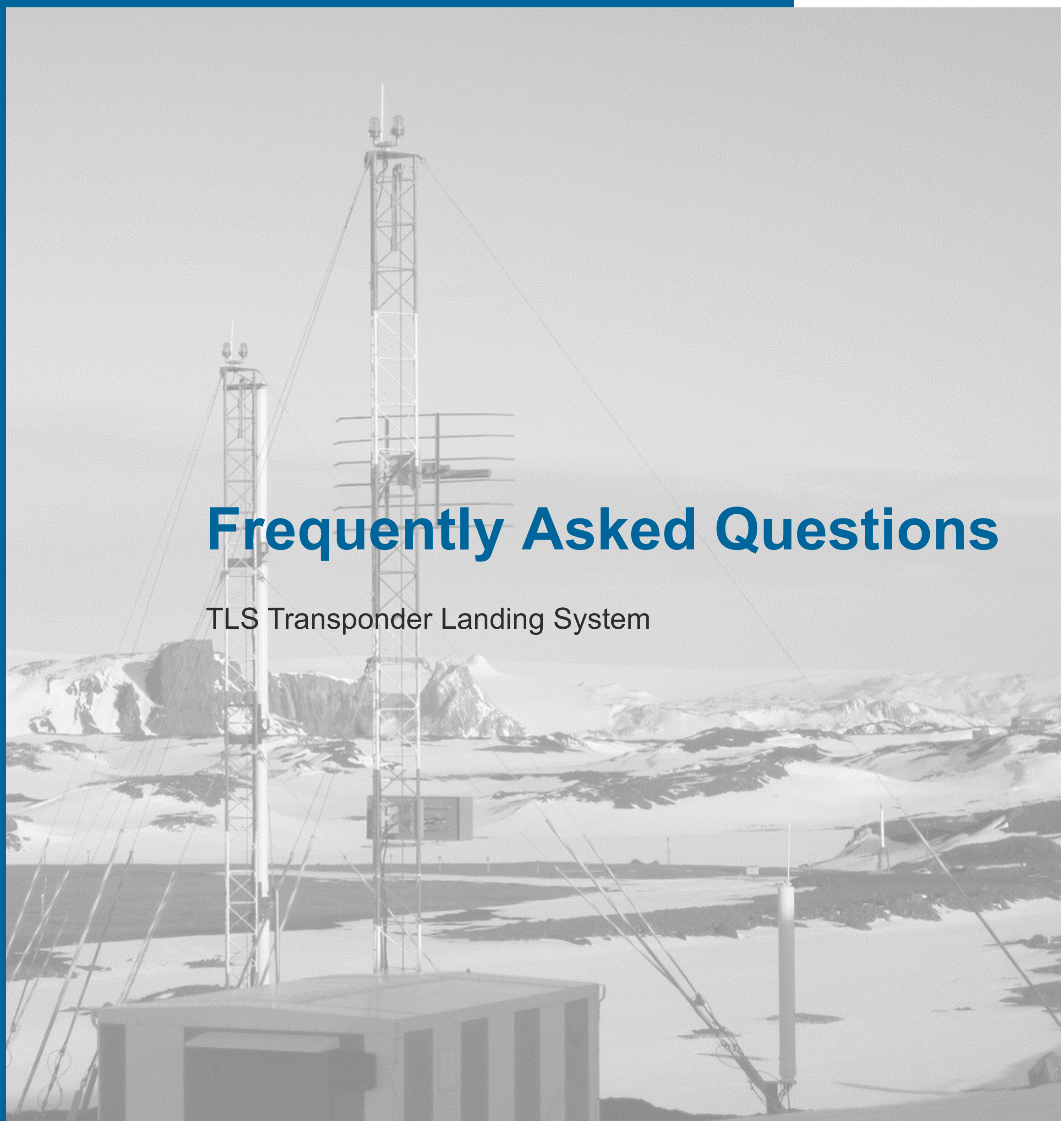
Frequently Asked Questions

TLS Transponder Landing System



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Introduction

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 Instrument Landing System (ILS) installation 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.

Benefits of TLS include:
• Precision approach guidance over terrain that prohibits traditional ILS localizer or glide slope equipment.
• Area surveillance to a range of 120 nm.
• Precision Approach Radar display for ground-controlled approach.
• Significant cost savings by avoiding expensive ground conditioning, including grading and other earthworks or property purchases that are required to install a traditional ILS.
• Frangible equipment design allows safe placement within obstacle clear areas adjacent to runways and taxiways. Siting flexibility also helps position critical areas (areas that must be protected from unrestricted aircraft and vehicular traffic) to minimize their impact on airport operations and maintain the highest level of airport efficiency.

How does the TLS work?

ANPC's technology uses transponder multilateration with ground-based sensors to track an aircraft's precise location in vertical position (elevation), horizontal position (azimuth), and range, with very high accuracy. This is done by measuring the arrival time and phase of radio signals transmitted from the aircraft's radar beacon transponder. The transponder is the same device used by Air Traffic Control radar systems to track aircraft during flight, and every aircraft equipped to fly in Instrument Meteorological Conditions (IMC) must have one installed. TLS is compatible with transponder Modes 3/A, Mode C, Mode S, Mode 4, and Mode 5. This precise location data is then converted to guidance signals which are transmitted to aircraft cleared for TLS approach, and appear to the pilot as needle movements on the course deviation indicator in the cockpit that are identical to an ILS and can be flown down to the minimum descent height or altitude.

The TLS is a ground-based system designed to provide precision approach guidance utilizing the aircraft ILS localizer, glide slope, and transponder equipment. The aircraft does not require any new or modified equipment to be able to fly a TLS approach.

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 whenever the system is operational, without knowledge or tracking of any aircraft on approach. The localizer course width for a traditional ILS is always dependent on the runway length and localizer antenna array placement, but is specified by ICAO to be no greater than 6 degrees and ideally 213m (700 feet) wide at runway threshold to ensure that all ILS approaches appear similar to pilots in terms of needle deflection as a function of distance to the runway. This requires that ILS localizer antennas 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 the majority of the world's airfields, particularly those with short runways that end in water, cliffs, or other obstacles.

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 Point Technology, 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. This "virtual emanation point" is 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.

Also see:
http://www.anpc.com/short-runway-solution/
http://www.anpc.com/solution-to-false-capture/
http://en.wikipedia.org/wiki/Transponder_landing_system

How do I get a TLS?

The Transponder Landing System is a sole-source system manufactured only by Advanced Navigation & Positioning Corporation in the United States of America. It is a commercial product without export restrictions.

Contact information:

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Operation

How many aircraft can the TLS handle 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.

Does the pilot need to switch to a fixed transponder code assigned to the base station?

Not unless ATC or the approach controller decides to assign a fixed code to the approaching aircraft. In most cases, ATC will obtain the pilot's squawk code, enter it into the TLS console, and confirm with the pilot that the aircraft is cleared for TLS approach. When approach control is not staffed, an automatic mode is available with the TLS that allows the TLS guidance to be initiated automatically when the aircraft has tuned to the TLS localizer frequency and its transponder code is acquired and being tracked by the system. Confirmation of cleared approach and valid guidance is provided via ILS localizer morse code.

Does the TLS guidance uplink through the transponder?

No, the TLS guidance is broadcast on standard VHF/UHF frequencies used by ILS facilities.
The pilot tunes into the TLS guidance using the ILS receiver in the cockpit. No new or modified equipment is required on the aircraft.

How many aircraft can be on a TLS approach at one time?

Up to four aircraft can be on TLS approach simultaneously, depending upon the purchased configuration. With an IAF of 15 miles and 3nm spacing this implies that an airport throughput of about 60 aircraft per hour can be supported by the TLS. The number of aircraft supported is a purchase option and at most TLS airports, one or two transmitters are sufficient to support the maximum throughput desired.

Does the airport need to have a ground operator available 24-hrs a day for round-the-clock access to the TLS approach?

No. The TLS can be operated in a staffed or automatic mode. Most airports desire to have a controller clearing and monitoring the approaches, but the system can also be placed in an automatic mode for operations when staff is not available.

What types of transponders are supported by TLS in civilian or military aircraft?

All transponders that respond to Mode 3/A interrogations. This includes Mode 3, C, 4, S, and 5. All such transponders will respond by broadcasting the identification code that the pilot has selected on the transponder panel.

Does the TLS use the Mode C altimeter data?

Yes, the TLS uses the Mode C only for aircraft surveillance plots. For precision approaches, the TLS determines the altitude geometrically from transponder response signals received at sensors adjacent to the runway to provide the highest accuracy glideslope. Mode C responses have an error budget that is of insufficient accuracy for vertical approach guidance.

How does TLS provide SSR and PAR functionality?

At its core, the TLS is a surveillance and tracking system. The TLS uses active interrogations to initiate transponder replies throughout an airport’s service volume. Ground-based sensors receive the transponder replies and determine the location of each aircraft. The TLS ground antennas are all stationary and use a process called multilateration to combine and compare measurements to determine precise aircraft location. Accuracy down to the nanosecond at each antenna facilitates surveillance tracking of all aircraft to a distance of 120nm, with accuracy equal to or better than an SSR.

The TLS sensor tower known as the Elevation Sensor Assembly (ESA) provides time-of-arrival measurement processing with accuracy in the picoseconds, made possible by using carrier phase tracking. This facilitates tracking of aircraft elevation with accuracy far superior to the elevation provided by Mode C transponder replies.

SSR and PAR functionality are achieved simply by translating the surveillance and tracking data into standardized displays that can be used by ATC to track and separate aircraft (SSR), or by a ground controller to verbally guide pilots via radio along a precision approach path to touchdown (PAR).

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 using 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 a "clearance" signal?

ILS approaches are conducted with the pilot viewing two needles that move according to the position of the aircraft relative to the approach path. The needles move proportionally and correspond directly to the relative position of the aircraft from the approach centerline or glide path up to a maximum deflection from centerline or glide path. The maximum deflection for the localizer is typically reached at 3.0 degrees from either side of the runway centerline; beyond that angle, the localizer needle in the cockpit will display full-scale deflection (all the way left or right) and does not move further. This full-scale deflection depicted outside of the maximum 6-degree course width is referred to as a "clearance" signal, and is required from the maximum extent of coverage which is typically 35 degrees from runway centerline at 17 nm from the threshold.

For glide slope, the full-scale fly up clearance signal is typically required from 0.9 degrees to 2 degrees above the horizon. From 2 degrees to the glide slope angle (typically 3.0 degrees) and then above the glide slope to 4 degrees, the needle movement is proportional to aircraft displacement from the glide slope. Above 4 degrees and up to 7 degrees, the full-scale fly down clearance signal is transmitted.

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.

Are offset approaches supported by the FAA and ICAO?

Yes, offset approaches with glide slope are supported by PANS-OPS and TERPS design criteria. The intersection of the extended runway centerline with the centerline of the approach is kept at a distance that facilitates the final turn of the aircraft to align with the runway. Usually this point is not closer than 1,800 meters from the runway threshold.

How are offset approaches possible with an TLS signal?

Since the TLS is a tracking system, it can inherently support offset and non-linear approach procedures where a straight-in approach is not feasible due to noise abatement or obstacle clearance issues. 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.

How does the TLS integrity monitor work?

The TLS built-in Integrity Monitor provides assurance that the signals remain within CAT I tolerance 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 happens during a transportable TLS (TTLS) installation?

During deployment, the Transportable TLS equipment is unpacked from the mobilizer and antennas are setup at predetermined points near the runway. Fiber optic and power cables are deployed between antenna components and the TLS electronics shelter. Antennas are connected to sensors, a precision survey of antenna positions relative to the runway is completed (10 minutes) and then the system is powered on. After 10 minutes of configuring survey data and the integrity monitor, the TLS will be in surveillance mode and be able to track aircraft to 120 nm and display their position on the ATC console. The TLS is now ready for a calibration flight to fully configure the precision guidance. The two calibration approaches and a series of verification approaches take less than two hours and then TLS is fully operational. The entire installation process takes less than 2 days with two men. TTLS can be setup in 4 hours by four men.

How long does it take to install a fixed-base TLS and what civil works are required?

It takes less than two weeks for the civil works to be completed at a normal site with standard tools. The civil works required for a TLS include trenching to bury cables (absent existing conduit) and the installation of concrete foundations for the antenna components. There are 5 concrete foundations required and 4 concrete piers for the TLS electronics shelter. Installation of grounding for surge and lighting protection requires the use of welding shots and molds which are provided with the TLS installation kit.

At some airports, vegetation should be cleared to achieve the largest service volume possible. The minimum service volume required by ICAO is +/- 10 degrees on either side of the approach centerline.

What is the flight inspection procedure for the TLS, and how does it differ from an ILS?

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.

Aircraft equipped with Automatic Flight Inspection Systems have dedicated antennas, receivers/transceivers and sensors to collect (usually real-time acquisition) data from navigation aids under inspection. The data received by this equipment are decoded by flight inspection computers and compared with the *real* aircraft position, in which accuracy is essential. This position can be calculated by several devices and techniques (GPS, inertial systems, barometric systems, landmark systems...) or sent to the flight inspection aircraft by external (usually optical) devices. This process results are displayed on operator/inspector workstations, also installed in the aircraft.

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.

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 airband 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 are 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 it depends 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 since 2017. 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 is the standard air navigational system in the world. 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 nmi).

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.

Requirements

What are the approach design standards for the TLS?

ILS PANS-OPS or TERPS are used to design TLS approaches using Cat I precision approach criteria or RNP 0.1 or RNP 0.3 criteria.

How flexible are the TLS equipment siting requirements?

In general, the TLS siting criteria offers greater flexibility than ILS, as follows:

	TLS	ILS
Ground equipment placement limits	Siting requirements can be measured within hundreds of feet and customized to meet specific airport requirements	Siting requirements must be measured within a few feet
Sloping terrain limits	Can be installed on a significant slope, up to 10%	Grading criteria requires that the ground be smoothed within +/- 6” of the average grade
Antenna placement restrictions	All antennas may be sited roughly abeam the threshold adjacent to or astride the runway	Localizer antennas must be physically aligned with the runway centerline and installed 2000+m from threshold

Capabilities

Is it possible to have distance-to-threshold displayed in the cockpit, similar to a DME?

TLS does not display distance to the pilot in the cockpit, but it does emulate marker beacons over the localizer audio, and three beacons can be configured: outer, middle and inner.

What is the maximum landing speed supported by the TLS?

TLS approaches have been conducted by an F-5, F-18, an F-15, and an AV-8B Harrier intercepting localizer at 220 knots, slowing to final approach speed of 180 knots. The F-15 was equipped with an ILS receiver and reported normal, stabilized automatic approaches. A PAR-like graphic display was used by a ground controller to give radio commands to the pilot of the F-18. Business jets have also conducted high speed, fully coupled automatic approaches using the TLS. TLS has been flight inspected at 200+ knots using a Hawker with an automatic flight inspection system.

Is the TLS sensitive to jamming devices?

Like an ILS, illegal VHF/UHF broadcasts or interference due to incomplete frequency analysis can interfere with the uplink guidance, but the resulting guidance would clearly be interference-related to the pilot (jumping needles, occasional flags, indistinguishable Morse identification). The TLS is significantly less susceptible to jamming than GPS-based solutions and is completely independent of GPS. Furthermore, the TLS guidance is only transmitted when providing approaches to aircraft, reducing its RF signature and raising tactical security.

Can the TLS have back-up and automatic fail-over?

Hot spares are provided with the TLS with dual electronics racks and a manual switch-over that can pass control in less than 10 seconds.

Installations

Where has the TLS been installed and operated?

Afghanistan – Herat Air Base
Antarctica – Teniente Marsh Airport
Antarctica – McMurdo Station
Australia – various air bases
Brazil – Manaus Ponta Pelada Air Base
Brazil – Santa Cruz Air Base Rio De Janeiro
China – Ghanghan Airport, Sichuan Province
Italy - Cervia Air Base
Peru – Lima Las Palmas Airport
Philippines – Subic Bay
Spain – Getafe Air Base
Spain - Sevilla Air Base
Spain - Salamanca
UAE - Al Dhafra Air Base

UAE – Assab Air Base, Eritrea
UAE – Remah Air Base
UAE – Sas Al Nakhl Air Base, Abu Dhabi

What types of aircraft have flown TLS approaches?

All types of fixed-wing and rotary-wing aircraft have used TLS. Any type of IFR-equipped aircraft may fly a TLS approach.