Multilateration (MLAT) - How it Works, and Why You Should Care

Articles

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One of the technologies mentioned in last month's newsletter in the article "Flight Tracking Tech 28," is multilateration (or MLAT). While ADS-B technology is currently considered "state of the art" as far as secondary radar monitoring goes, there is an earlier preceding technology called "Mode S" that emits some of the same information as ADS-B (i.e. altitude, vertical speed, squawk code, ICAO code), but is noticeably missing GPS positioning of aircraft.

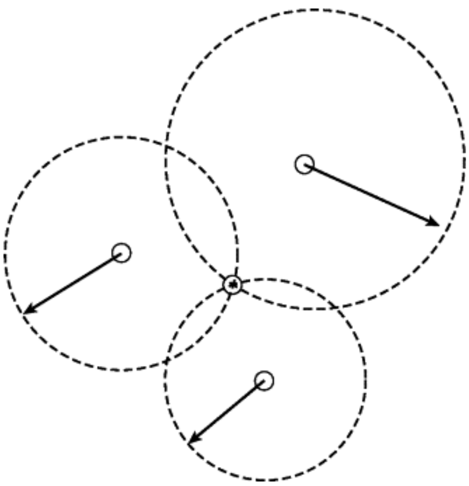
While the position is missing, Mode S packets still emit the "six-digit ICAO hex code" that is uniquely assigned to every aircraft. Calculations on the time these packets are received can be performed to deduce the location of the aircraft via multilateration.

Multilateration (MLAT), as it relates to aircraft tracking, is a technique used to determine the position of an aircraft by measuring the time difference of arrival (TDOA) of a signal from the aircraft to several ground-based receivers. Here's a step-by-step explanation of how it works:

1. Signal Transmission: The aircraft transmits a signal, such as a radio or transponder ping, which is received by multiple ground-based stations. These stations are ideally located to cover a wide area and ensure that signals from aircraft can be received from different angles and distances.
2. Time Difference of Arrival (TDOA): Each ground station receives the signal at slightly different times due to the varying distances between the aircraft and each station. The exact moment the signal is received at each station is precisely recorded.

Since it can be difficult to coordinate clocks precisely enough, an ingenious technique is used to tackle this problem. A "common" aircraft broadcasting ADS-B is used to coordinate the time differences. Since we know the position of the ADS-B aircraft, and the relative time it takes light to travel to each receiver (since we also know the receiver positions), we can measure the time difference between the ADS-B signal and the Mode S signal, and use the ADS-B signal as the "common" timekeeping data. Receipt of a common ADS-B target that can be used in this way is shown as lines connecting receivers on this MLAT map:

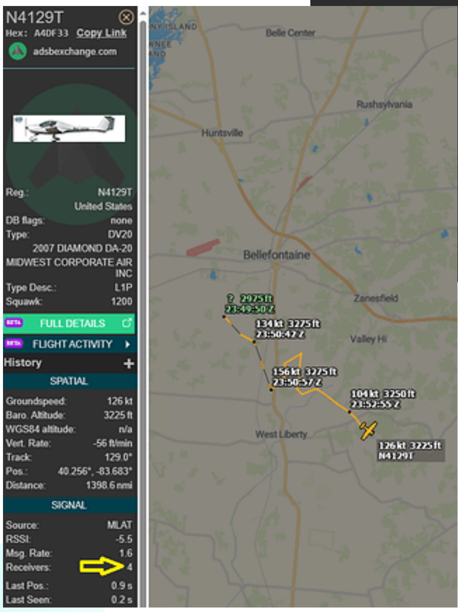
https://map.adsbexchange.com/mlat-map/ 149



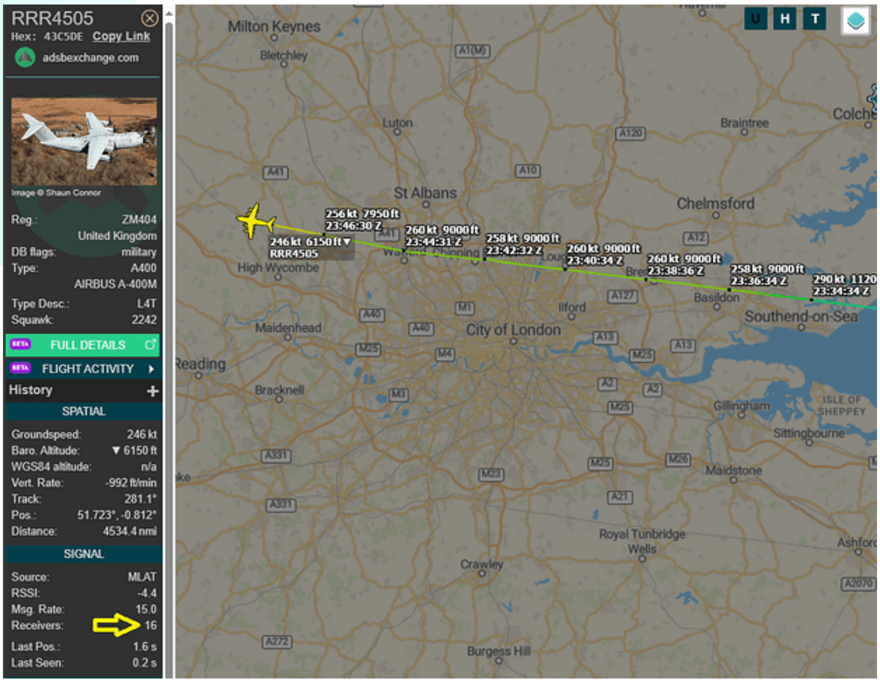
3. Calculating Distances: The time differences in signal reception are used to calculate the difference in distances from the aircraft to each station. Since the speed of the signal (usually the speed of light for radio signals) is known, the difference in arrival times can be converted into spatial differences.
4. Position Determination: With at least three ground stations (the minimum required for 2D positioning), the system can calculate the exact position of the aircraft by solving a set of

mathematical equations that describe hyperbolic curves. Each pair of stations provides a hyperbola on which the aircraft must be located, and the intersection of these hyperbolas gives the aircraft's position. While this is technically possible with 3, we require at least 4 to ensure a reasonable level of accuracy. The more stations receiving the aircraft, the more accurate the position will be.

For example, the track for the aircraft below is jagged and unreliable because there are only 4 receivers providing data.



In contrast, this aircraft has a very straight track line due to the more accurate calculations possible with 16 receivers.



Multilateration can also be done on ADS-B signals, which could serve to validate the coordinates being broadcast and identify "spoofing" attempts in the event the aircraft was not where it claims to be.

So, what does all this mean for the end-user? The more stations participating in multilateration, the more chance of being able to locate non-ADS-B aircraft. ADS-B Exchange has, by far, the largest group of MLAT receivers producing unfiltered results for the aviation enthusiast: ADSBexchange.com Feeder Coverage 149

Multilateration (MLAT) is an essential technology for tracking aircraft, especially useful for locating those that don't broadcast their GPS position. It works by measuring the time difference of arrival of an aircraft's signal at various ground stations. The process involves a bit of clever coordination using ADS-B signals to synchronize timing across the stations, enabling the calculation of an aircraft's position even without direct GPS data.

The key to MLAT's effectiveness is the number of ground stations involved. More stations mean more accurate tracking, as evidenced by the smoother flight paths obtained from denser networks of receivers. This technology is not only helpful for tracking but also for verifying the accuracy of ADS-B data and detecting possible spoofing.

ADS-B Exchange stands out by hosting a large network of MLAT receivers, offering detailed and unfiltered tracking data. This is particularly beneficial for aviation enthusiasts and professionals who rely on accurate flight tracking information. The collaborative effort in expanding this network plays a crucial role in improving air traffic surveillance and safety.