

# Multilateration takes off in Europe

**Multilateration – a system that can track aircraft and ground vehicles at airports, provided they are equipped with RF-emitting transponders – has been winning its European spurs by monitoring surface movements at the continent’s busiest airports. But now air navigation service providers see that this technique could also be an important surveillance tool for ATC in the terminal area and en-route as a substitute for secondary surveillance radar (SSR). The EUROCONTROL Agency has recognised this development and actively supports its stakeholders with the introduction of Multilateration techniques.**



**By Dr Werner Langhans, Chairman of the EUROCONTROL Multilateration Task Force, and Head of Technology Development, Austro Control GmbH**

Multilateration has been winning support in Europe and other leading regions of the aviation world with its ability to enhance control of aircraft and vehicle movements on the ground at airports. Improving on the coverage traditionally provided by surface movement radar and providing the possibility to identify aircraft unambiguously is a pressing need.

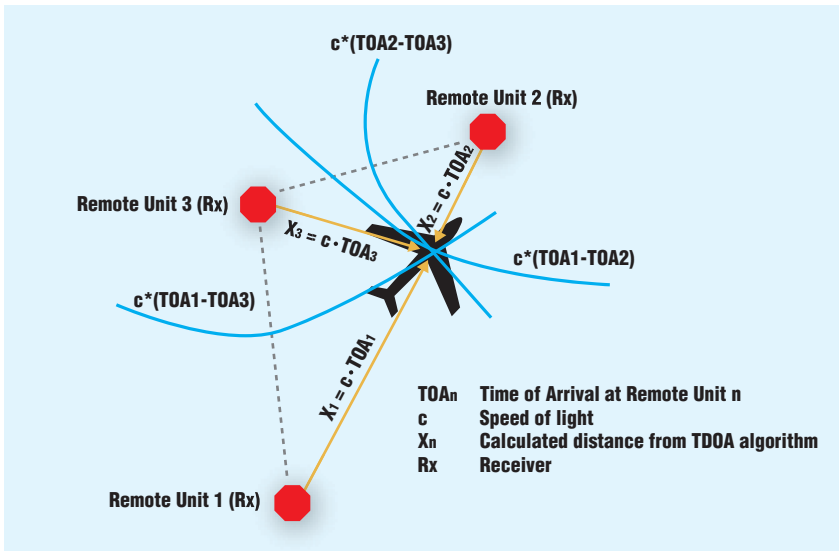
Given the continent’s inexorable growth in air traffic, European aviation authorities regard such improvement as essential in maximising airport throughput and efficiency, maintaining operations in low visibility and ensuring safety – not least by preventing runway incursions. But certain forward-looking air navigation service providers (ANSPs) are going one step further. Austria, the Czech Republic and Germany, for instance, are showing that the technique can be extended beyond airport boundaries into the third spatial dimension and can be applied to air traffic control within the terminal area and en-route. As a result, Wide Area Multilateration (WAM) has already taken off.



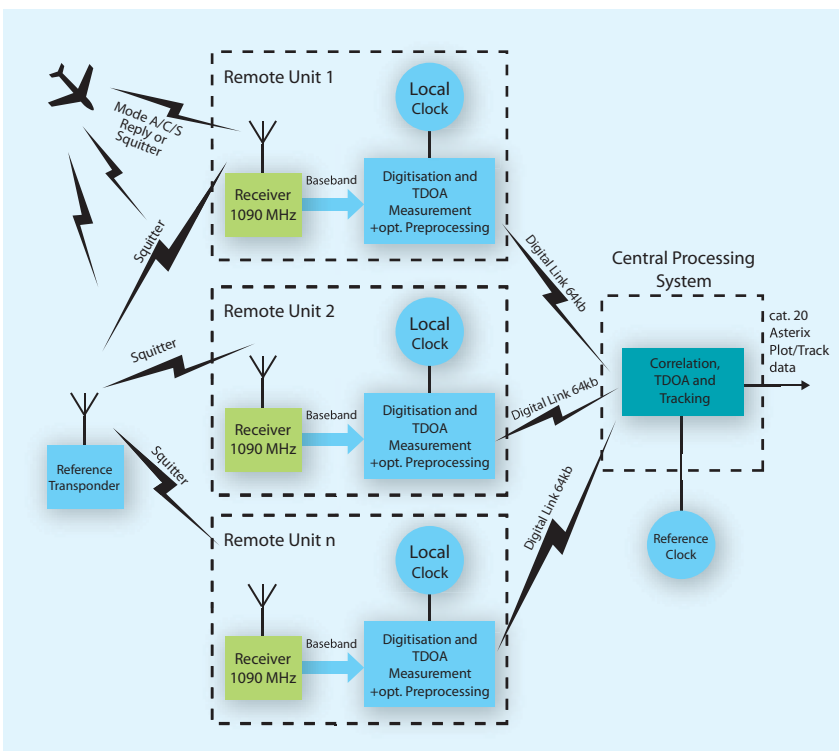
The Multilateration systems are based on a well known measurement technique, the so called Time Difference of Arrival (TDOA). The reader can think of this as “inverted GPS”. Instead of having moving satellites transmitting their time stamp signals and the receiver calculating its own position from these signals, Multilateration triangulates on a moving transmitter – like the aircraft SSR transponder – by detection and time stamping of the transponder squitter or reply signals at well known, fixed receiver stations. A set of equations at a central processing site derives the accurate position of the aircraft transponder. This calculation is performed more than once per second, a measurement update rate a conventional SSR never can achieve. The principle of the TDOA technique is shown in Figure 1.



**One of the nine Remote Unit Antennas of the Innsbruck Wide Area Multilateration System**



**Figure 1:** The principle of the Time Difference of Arrival (TDOA) technique used in passive Multilateration Systems requires the exact information of all Remote Unit (RU) Receiver positions at the central processing system. The arrival time of the Reply/Squitter signal from the aircraft is measured at each receiver and a system of equations is solved to calculate the intersection point of the hyperbolas between each pair of RUs [ $c \cdot (TOAx - TOAy) = \text{constant}$ ]. The solution is the point where the aircraft transponder is located. To derive a two-dimensional position three RUs are needed, to compute a three-dimensional solution four RUs are needed.



**Figure 2:** Transponder synchronised Wide Area Multilateration (WAM) is used in the Innsbruck surveillance system. The SSR transponder reply/squitter-messages transmitted from the aircraft are digitised, time stamped and pre-processed in the remote unit receivers (RU). Via narrow band digital data links each RU is connected to the central processing system (CPS), where the position of the aircraft is calculated. The output of the CPS is a standardised ASTERIX Data format which contains plot or track information of all aircraft in the coverage area, together with accuracy information. Each RU has its own system-clock. To synchronise the time stamping of the individual RUs, the squitter signals of a well known Reference Transmitter (RT) are used to calculate the necessary timing offsets.

**Note:** For areas where no interrogation signal triggers a Mode A/C only transponder, the Innsbruck WAM system uses integrated omni-directional interrogator signals at 1030MHz which can also transmit all the Mode-S uplink messages.

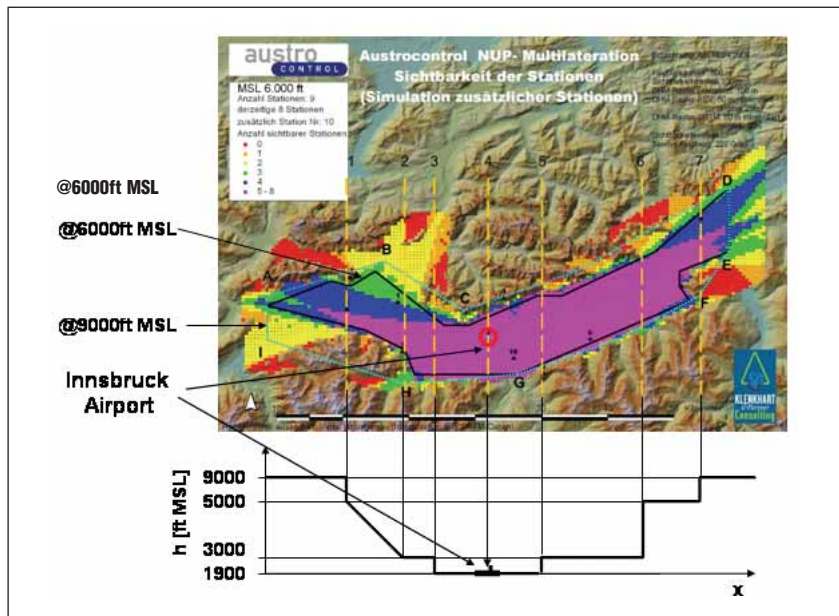
For Multilateration purposes, the time synchronisation precision of the received signals is of great importance. There are several synchronisation methods being used by the different manufacturers, all having their advantages and drawbacks. The technique used in the TMA of Innsbruck Airport, Austria, is depicted in Figure 2. The main advantage of this transponder based synchronisation is its independence from GPS signals.

The accuracy of this type of system is determined by the geometric dilution of precision and the ground station receiver front end electronics. At airports, accuracies of 3-7m and in Wide Area Multilateration (WAM), 10-50m easily can be achieved.

Another benefit of the Multilateration surveillance technique is its independence from the airborne navigation and the use of the existing airborne equipment without the need of any retrofit. Analogous to SSR Mode-S radar, Multilateration enables all kind of basic, elementary and enhanced surveillance capabilities as foreseen in the EUROCONTROL Mode-S Programme. Furthermore, Multilateration equipment does not only support the Mode-S Programme's applications, also the ground element of the ADS-B Programme's applications are automatically provided by the Multilateration system hardware. And, thinking innovatively again, Multilateration offers to be the complementary surveillance technique for ADS-B to overcome its airborne navigation dependability issues in high complexity European core airspace.

Last but not least, Multilateration also promises to be a cost-effective solution in comparison to SSR, being under detailed investigation in Europe. Austro Controls WAM System in Innsbruck with nine remote stations and a fully redundant central processing system, for

1 - Automatic Dependent Surveillance - Broadcast



**Figure 3: Horizontal and vertical coverage area of the Innsbruck WAM System at 6000 and 9000ft MSL. The coloured dots represent the number of remote units visible at 6000ft MSL. Green, blue and pink colours have three or more sensors in their visibility, thus the central processing station can calculate at least a 2D-position. The simulation was run on a GIS system with a 50m grid size terrain model.**

instance, only cost approximately €1.5 million for the planning, investment, implementation and testing with actual operating cost less than €150,000. A comparable solution built on standard SSR would have cost about €13 million, taking into account the difficulties for logistics and coverage requirements of the Inn valley making two radar stations necessary. In addition, such an investment would have faced enormous environmental political difficulties and technical difficulties caused by multipathing and reflections from steep mountain faces.

In the course of last year, EUROCONTROL gave considerable impetus to the wide spread introduction of Multilateration in Europe by the creation of the Multilateration Task Force. This task force coordinates the standardisation and the necessary fact-finding activities within Europe and ICAO. It brings together the interested stakeholders and acts as a platform for information exchange. The Surveillance Domain has already initiated detailed

studies into the error behaviour, the standardisation, the surveillance data processing issues and some specific items determined by the Task Force.

EUROCONTROL, together with some innovative stakeholders, has embarked on the exploration of the benefits of this surveillance technique. It is engaged in the standardisation at protocol level (ASTERIX), ICAO level and in EUROCAE<sup>2</sup>, it considers Multilateration in the operational concepts, the strategy and the architecture work.

On a sensor level, the Multilateration has matured a lot in the last decade. The integrated EUROCONTROL surveillance data processing product (ARTAS) and the associated data analysis tools are still somewhat behind this development. It is of utmost importance for the airspace users, that they can make operational use of such ground based technology as early as possible, and thus the full surveillance chain needs the capability to accommodate data from this sensor technique.

Austro Control has been using a WAM system for ATC purposes fully operational in the TMA and en-route airspace surrounding Innsbruck since November 2004 with great success. The Innsbruck surveillance system exhibits an update rate of 1.5 updates per second in a coverage area shown in Figure 3. The probability of detection is better than 99.4% when counting gaps larger than 4s and the position accuracy was measured to be 13m mean error and 22m rms error. All of these WAM performance parameters are much better than any SSR radar station could deliver.

To build on this experience and to explore the behaviour of Multilateration in super wide areas of more than 400km x 700km, Skyguide, DFS and Austro Control have started a feasibility project, called CEWAM (Central European WAM), based on coverage from Zurich via Nürnberg, Salzburg to Innsbruck. This project that will last for the next 24 months will analyse the safety, technical engineering aspects as well as the commercial aspects of WAM-intercell-coupling.

It can be concluded that the use of Multilateration systems at airports and for surveillance for en-route purposes is considerably gaining momentum in Europe. EUROCONTROL invites all stakeholders interested in the coordinated international introduction of Multilateration techniques to actively contribute to the Multilateration Task Force activities and to bring forward ideas, concerns and proposals to this forum. ■

#### Further reading:

[www.eurocontrol.int/surveillance](http://www.eurocontrol.int/surveillance)

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2 - European Organisation for Civil Aviation Equipment Manufacturers