TRAJECTORY BASED OPERATIONS OVER VDLM2

Improving operations through effective collaboration

SITA's existing datalink service enables Eurocontrol MUAC to gain operational benefits from the first implementation of Trajectory Based Operations (TBO) features.

CONVENTIONAL FLIGHT PLANNING

Today, airspace users capture their intention via filed flight plans which crudely specify where, when, and how they would like to fly. For several reasons, aircraft rarely follow these plans very closely:

- Air traffic controllers give clearances to aircraft according to guidance from their own procedures and ground systems, which are not always efficient because ground systems are not aware of all the information needed to calculate an optimal trajectory.
- Controllers sometimes need to give tactical clearances to deconflict a flight from the path of other flights.
- Flight plans typically assume a trajectory going from point to point along the filed route. In practice, the traffic situation often allows controllers to give tactical clearances (known as Directs or DCTs), resulting in shorter routes.
- Optimal trajectories are much more complex than what can be specified in the conventional flight planning formats.
- Changing environmental conditions (e.g., wind) means that the most optimal trajectory can change mid-flight.
- Not all constraints are known when the flight plans are filed.

These limitations result in some negative operational impacts:

- Flown trajectories are not optimal in terms of fuel consumption/Co2 emissions/climate impact.
- Short-term predictability is limited; controllers must observe each aircraft very closely, which can result in higher workload.
- Aircraft are not closely following their filed plans, and so long-term predictability is compromised. This makes it very hard for ANSPs to properly match capacity to demand.
- The development of advanced controller tools and other forms of ATC task automation is held back by this lack of predictability.
- Controllers can be asked to provide aircraft to a particular point within a time-window to support functions such as runway sequencing. However, with predictability being low, the interventions can only be carried out very late in the trajectory of the flight, resulting in inefficient measures such as holding patterns.

WHAT IS TBO AND HOW DOES IT IMPACT ATC OPERATIONS?

The high-level concept of TBO is that an aircraft creates an efficient and detailed, four-dimensional trajectory that is then coordinated with the ground actors. Air traffic controllers then attempt to facilitate that plan where possible.

Therefore, the foundation of the TBO concept is a mechanism that allows the aircraft and Air Traffic Service Units (ATSUs) to agree and then synchronize a very accurate, four-dimensional trajectory. This trajectory is then maintained throughout the flight in the avionics of the aircraft and the air traffic control systems on the ground. The trajectory is also shared over the ground network so that all ground actors, including downstream ATSUs, can incorporate it into their predictions.

Systems onboard aircraft can calculate highly efficient trajectories, far more efficient than the trajectories used in ground systems. In the TBO concept, controllers will, where possible, allow the flight to remain on this optimal trajectory which leads to a significant reduction in fuel burn and Co2 emissions.

Having a synchronized trajectory greatly increases both short-term and longer-term predictability. For the controller, short-term predictability (i.e., knowing what an aircraft will do before it does it) brings obvious safety benefits. It also reduces the number of potential conflicts, which reduces their workload. Better short-term predictability means that sector capacity can safely increase, partially because it enables the horizon of controller tools like conflict alerting and conformance monitoring to be much longer.

The increase in longer-term predictability can be used to improve demand/capacity balancing within the current ATSU and all the way down the flight path, allowing ANSPs to deploy their resources more efficiently.

In addition to trajectory coordination, TBO also allows aircraft to be issued with time constraints. The aircraft first provides an achievable window for the chosen point. Once accepted, the avionics of the aircraft will automatically make the necessary adjustments to the trajectory so that the aircraft will comply with the constraint to a high level of accuracy (+5 to -10 seconds). Being able to reliably and accurately specify when an aircraft will be at a point provides some advanced benefits. As the adjustments to the trajectory are made early in the flight, they are extremely subtle and have a minimal impact on efficiency. This technique can reduce holding, which is a highly inefficient way of solving the same problem. The source of these (time or speed) constraints can be an airport Arrival Management (AMAN) system, which enables ANSPs to provide airports with correctly sequenced flows with minimal additional effort.

MUAC IMPLEMENTATION

Eurocontrol MUAC is one of Europe's most innovative ANSPs, so it is no surprise to see them leading the way when it comes to the operational implementation of TBO features. MUAC has been involved in validations and pre-operational trials of the TBO concept for several years. In December 2020, some TBO features became part of a long-term operational trial, involving their primary systems and a group of normally rostered controllers:

Air-Ground Trajectory Coordination
When an aircraft approaches MUAC airspace, the aircraft's trajectory is downloaded and compared to the controller's expectations. If there is a two-dimensional discrepancy, an agreed trajectory is coordinated and then synchronized between the pilot and the controller. This brings far better predictability on the ground and in the air, and discrepancies are solved much earlier.

Supporting Efficient Trajectories
By sharing their desired path through MUAC airspace, the pilot has been able to influence this synchronized trajectory to ensure that it is as efficient as possible within any known constraints provided by the ground. The MUAC controllers will then attempt to facilitate that trajectory when other traffic allows. As a four-dimensional trajectory is synchronized, the controllers can see the optimal levels, speeds, and the vertical profile. For example, the controller is shown the optimal point at which to start the descent of the aircraft (ToD) and so can give the associated clearance at the right time. These procedures result in considerably more fuel-efficient trajectories.

Lateral Conformance Monitoring
As the trajectory is continuously downloaded from the aircraft when it is in MUAC airspace, the MUAC system can automatically check that it matches the controller's expectations. If the system detects that the aircraft is planning to do something unexpected, for example, in the case of a human error, a warning is presented to the controller. Thus, scenarios that might have previously led to reductions in safety can be avoided before they occur. MUAC has made a number of these scenarios public so the ANSP community can benefit from their experience.

Even though this is not a complete implementation of the TBO concept, it is already allowing MUAC to achieve safety, operational efficiency, and trajectory efficiency gains.

MUAC implementation of further TBO features (e.g., flying to time and/or speed constraints) is expected to come in the near future and will bring more efficiency gains.

> "For Maastricht UAC, the interoperability between the air and ground via ADS-C as well as the enhanced set of CPDLC v2 message set (the ATS-B2 baseline of March 2016) is providing a cornerstone for Trajectory Based Operations (TBO). The validations and demonstrations over the last years under SESAR and the still ongoing operational trial have proven for MUAC it is ready for the next step, deployment over a wider area. At MUAC specifically, an evolution will soon start to introduce the use of this data in more ATC-tools and for the further automation of ATC."

– MUAC ADS-C TEAM

TBO REQUIREMENTS

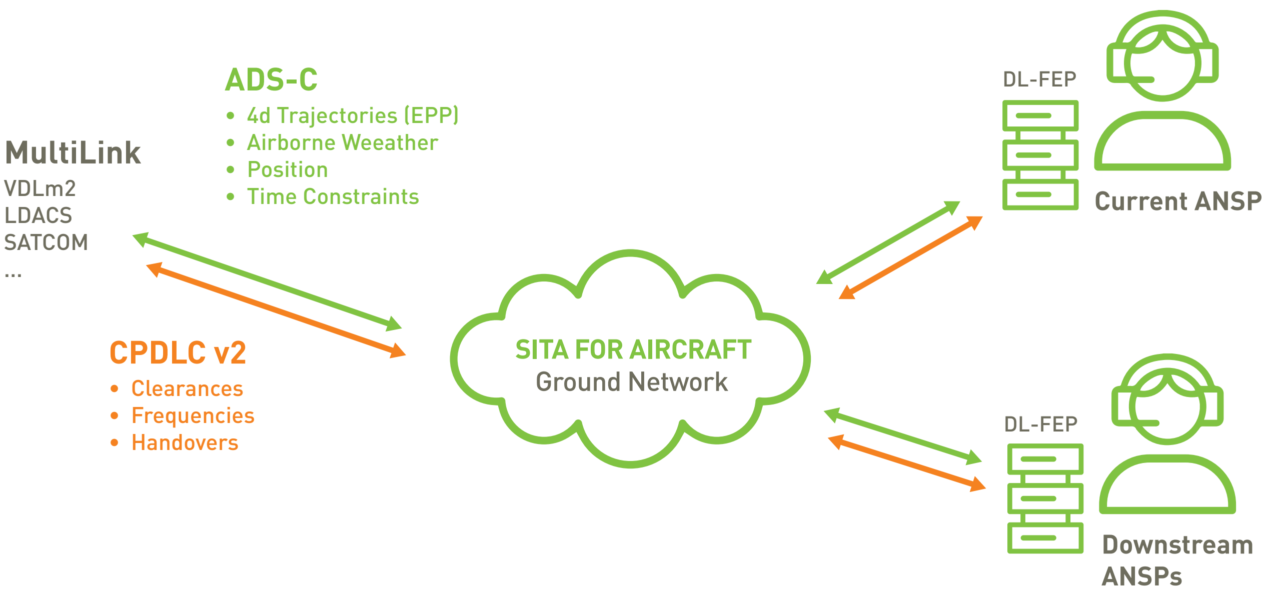
For an ANSP to enable TBO features, some elements must be in place:

Aircraft Equipage
The standard for the air to ground connection used to enable TBO is called ATS-B2 and consists of CPDLC v2 and ADS-C (Automatic Dependent Surveillance - Contract), not to be confused with the FANS ADS-C used in the oceanic environment for some years or ADS-B, an entirely different interface. Only aircraft that have had the necessary avionics upgrades to ATS-B2 can perform TBO use cases.

There are presently around 100 aircraft equipped with ATS-B2, with this number expected to increase dramatically in the coming years. The use of ATS-B2 has become part of a European mandate (Common Project 1) that will enforce its wide use from 2027 for forward-fit aircraft and all upper-area ATC centers. The benefits associated with TBO can be achieved per flight and do not require a minimum level of equipage.

Current ATS-B2 Connectivity
The SITA FOR AIRCRAFT ATN Service has been able to offer ATS-B2 connectivity since 2019, making use of our VDLm2 network. It is this service that MUAC has used to make the progress described above.

Future Datalink
As the mechanism behind TBO involves frequent downloads of the aircraft's trajectory, TBO operations are likely to consume around four times the bandwidth of a conventional datalink connection. When this is added to traffic growth expectations and likely increases in AOC data throughput, it creates bandwidth requirements for the long-term future that the existing VDLm2 datalink networks will not be able to meet.



SITA is investing in innovation to ensure that its future datalink service will be more than sufficient for the future needs of ANSPs. This includes new terrestrial (e.g., LDACS) and non-terrestrial (e.g., SATCOM) technologies that will provide greater functionality, bandwidth, and security. It also includes a concept referred to as MultiLink, which will provide ANSPs and airspace users with a choice of air-ground connections. Such a choice will provide redundancy and allow customers to balance their needs for performance against cost.

ANSP Enablers

ANSP DL-FEP

To receive and integrate datalink information into their systems, ANSPs employ a system called the Datalink Front End Processor (DL-FEP). Since 2019, SITA, in partnership with Thales, has offered ANSPs a DL-FEP product that fully supports ATS-B2 communications. It is this version that MUAC employs in their deployment of TBO use cases.

HMI

Changes are required on the human-machine interface of the controller to integrate the information associated with TBO use cases.

FDP

Work may be required on the Flight Data Processor of the ANSP to allow it to receive and process the new trajectory information.

Operational Procedures and Training

TBO enables new, more efficient ways of working, so controllers and flow management staff may require new procedures and training.

CONCLUSION

There is definite momentum behind the deployment of TBO in Europe; this is apparent from the public strategy of the SJU, Airbus, SITA, various industry players, and ANSPs like Eurocontrol MUAC. The recent mandate of ATS-B2 has set a maximum timescale for this deployment.

SITA is already able to offer the connectivity components necessary to support TBO operations.

Demands for the improvement of air traffic efficiency will make TBO an industry standard, accelerating the deployment of future datalink capabilities worldwide. We believe that other ANSPs could benefit from the early adoption of this concept, as Eurocontrol MUAC has done, long before the mandate makes this compulsory in Europe.

SITA AT A GLANCE

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