SURVEILLANCE DATA PROCESSING TRADE-OFFS

Trade-offs are a defining feature of all forms of work, whether in operations or in system development and implementation. The trade-offs faced by others are not always clear to us. In this article, **Ceca Bunjevac** explains four trade-offs in support of air traffic controllers.

KEY POINTS

- **Optimising tracking systems involves a number of compromises and trade-offs in development.**

- **The size of the search space for aircraft position updates affect track accuracy.**

- **Multiple radars can increase the quality of position measurement, but only up to a limit.**

- **Different surveillance technologies bring many considerations and trade-offs for tracking.**

- **Nuisance alerts are invaluable diagnostic tool for tracker settings but they cause frustration for ATCOs.**

As a controller, having a short-term conflict alert (STCA) is invaluable. There is no need to see it in action to provide adequate separation between aircraft; just knowing that the safety net is there feels good. It is like an acrobat walking the rope in a circus, with a net stretched beneath the rope. The net is present, but the acrobat still needs to walk the rope. You are doing your job and if an unexpected problem arises, the system gives you a visual or an audio-visual alert.

Then at some point, you start noticing STCAs for aircraft that are not in conflict, and your frustration grows. Nuisance alarms start to affect trust, and loss of trust changes your practice (crying wolf syndrome). But the STCA reacts to the set of criteria given to it and it does this every single time the criteria are met. So the alarm is correct as per the system settings but it is 'false' as per the traffic situation – there is no need for the alert. Nuisance alerts are created between

correct and false tracks and the word 'false' is appropriately used in this case.

Following around 15 years as an operational air traffic controller in Europe, along with operational supervisory and training roles, my first employment in EUROCONTROL was as a surveillance data processing and automated support tools specialist. I was part of a team working on the implementation of two automated

operational systems. Bridging the worlds of operations and system implementation brings some of the trade-offs of tracking systems into focus, in a way that was never so clear to me as an operational controller. Here are four of those trade-offs.

The first trade-off: The search-space trade-off

An aircraft track is formed after a small number of consistent aircraft position indications (plots) have been registered. These can come from a single surveillance source or from various sources. A track is a calculation of a small space, which the tracker opens to search for the plot update.

If the space to search is too big, more than an original aircraft response could fall inside the search space. If the space is too small, the real-life position update could fall outside and slightly left, right, behind or in front of the search space.

Mathematically, it is very easy to enlarge the update search area or to calculate the future position of an aircraft as a

Figure 1: Position update search area

Where is the aircraft now?
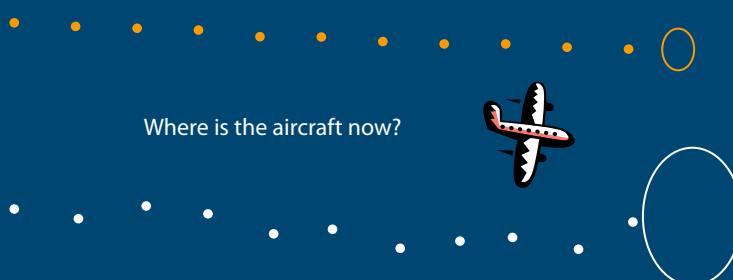
single dot in space. Both situations adversely affect the accuracy of the track and in both cases the above trade-offs have to be made.

The second trade-off: The multi-radar trade-off

Even if there are 10 radars covering the same specific portion of the airspace, the track quality will not increase in direct proportion to the number of measurements obtained. This is known as the law of diminishing returns.
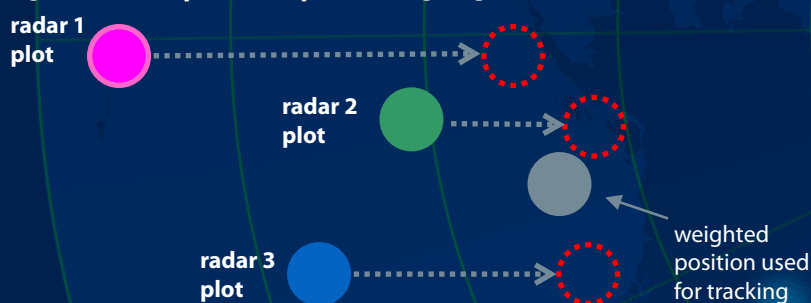
Using more than x number of radars to calculate a track costs a significant amount of processing power and time, without proportionally improving the track accuracy. The value of the x has to be carefully calculated and the trade-off must be made (processing time invested against accuracy improvement gained).

Figure 2: Multi position update weighing

radar 1 plot
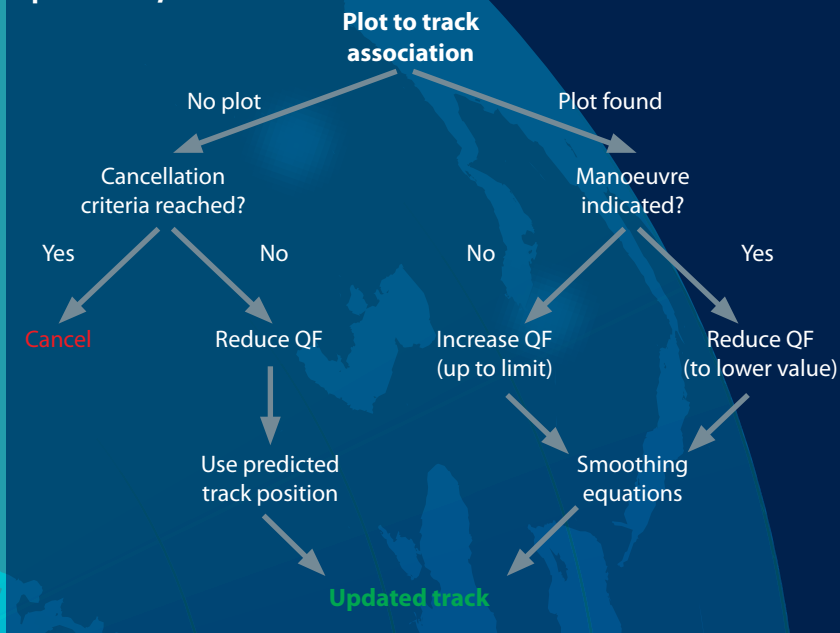radar 2 plot
radar 3 plot
weighted position used for tracking

The third trade-off: The surveillance mix trade-off

We have ground-based radar surveillance (notably, primary and secondary), ground-based non-radar surveillance (multilateration), and air- or satellite-based surveillance (ADS-B). Only primary radars give us aircraft positions without the need for on-board cooperation. There is a significant difference in the purchase cost of different systems, and in the positioning requirements for the systems to work properly. Additionally, different surveillance systems contribute to different degrees of accuracy and with different amounts of processing needed to calculate a track.

Trade-offs have to be made. The type of terrain to be covered (e.g., Switzerland, Malta or Italy, with corresponding topography), legacy systems, resources available, and the nature of surveillance required (civil, military, mixed, approach, etc.) must all be taken into the equation. We cannot create an environment free of nuisance-alarms. This is because we do not have tracking systems that are free of false tracks. Consider the following examples:

An aircraft that made a turn is shown to be in conflict with an aircraft on its previously registered path, which has not been updated to reflect the new path of this aircraft. This is a possible indication that the tracker response to military aircraft turn performance is delayed. This is a normal situation in civilian operations environment, but a possible problem in mixed-mode operations environment.

Two aircraft that are 5 NM apart are in conflict even with 7000ft vertical distance. One (or both) aircraft is not transmitting Mode C information (vertical position). In this scenario, the system uses only horizontal proximity to indicate an alert, or does not alert at all. Alternatively, a system could alert and allow for manual inputs for vertical parameter alert triggers by the system user, or trigger no automatic alert but allow for manual inputs for vertical parameter alert triggers.

There is a conflict indicated between two different tracks, but you only have one aircraft. This is a possible result of reflections (e.g., the sea surrounding Malta or the snow covered surfaces in Switzerland). Adapting the tracker map of reflection prone areas where tracks should not be initialised might help.

Bridging the worlds of operations and system implementation brings some of the trade-offs of tracking systems into focus, in a way that was never so clear to me as an operational controller.

Figure 3: QF – quality factor, trust in track forecast accuracy on previous cycle

How many nuisance alerts can be tolerated for the data processing system to be helpful, and at what number does it hinder operational staff?

The fourth trade-off: The nuisance alert trade-off

The three previous trade-offs are of a technical nature. They happen at every ATC unit with surveillance tracking systems. While nuisance alerts are a useful metric to improve tracking performance, how many nuisance alerts can be tolerated for the data processing system to be helpful, and at what number does it hinder operational staff?

If it was down to a numerical value, the equation would have been available by now, but the number does not exist in isolation. It depends on:

- the number of operations – in a sector with two aircraft, one nuisance alert is too many from the machine point of view but the controller might find it acceptable
- traffic complexity (including traffic mix and route layout)

- company operations (including sufficient staff and appropriately managed rostering), and individual stress and fatigue.

Conclusion

Surveillance data processing systems are not free of false tracks and the nuisance alerts are useful diagnostic metrics to keep improving system performance and reducing the number of false tracks. The issue remains though, that ATCOs already stressed by the traffic volume or the shift roster will be even more tested by possibly frequent nuisance alerts. Equally, given time to provide as details concerning nuisance alerts, ATCOs are a vital link to fine-tune the system parameters. This is only one example of how technology improvements are dependent on improving conditions for the people who use the technology. ⑨

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