MAKING SENSE OF GOAL CONFLICTS AND TRADEOFFS IN AIR TRAFFIC MANAGEMENT

Organisational decisions and goal conflicts are connected to controller and pilot trade-offs, but these trade-offs are rarely addressed explicitly in procedures and training. In this article, **Stathis Malakis** describes the nature of goal conflicts and trade-offs in air traffic management, with a number of insightful examples.

KEY POINTS

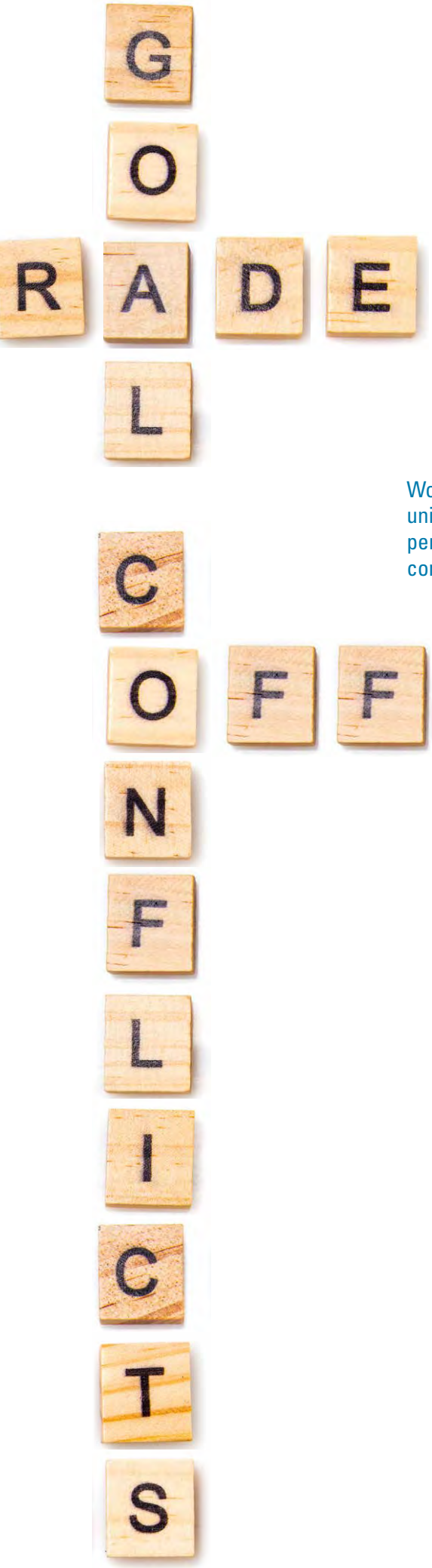
- **Organisational policies, priorities and pressures generate goal conflicts. Operational staff have to respond via trade-offs, workarounds and compromises to compensate for inadequate planning, time or resources.**
- **While individual demands and pressures can be successfully dealt with, in combination they produce multiple conflicts, which make work more difficult.**
- **Systems may be simultaneously cooperative over shared or global goals and competitive when it comes to local goals. Efficient local performance may be at the expense of common goals.**
- **As the window of opportunity gets smaller and smaller, we are forced to choose one option which favours a particular goal.**
- **Trading off goals requires deep knowledge and an ability to discern the range of applicability of options to a wide variety of situations. Developing this competency also involves trade-offs.**

Air traffic controllers know about trade-offs. Economic and performance pressures in the air traffic management system create the conditions for goal conflicts that get resolved with countless trade-offs every day. Work in the ops rooms is bounded by economic, workload, performance and safety constraints. In many cases, controllers have to make several trade-offs between interacting and conflicting goals, as well as between performance indicators placed on different outcomes of work.

Since goal trade-offs are usually not addressed in operating procedures or training, controllers may make operational compromises to compensate for inadequate planning, time or resources. These compromises should have been addressed by the organisation. Organisational policies and priorities generate goal conflicts, and controllers must respond via trade-offs in their work. These trade-offs relate to aspects of efficiency and thoroughness, planning horizon, team roles and work organisation.

A typical example from tower operations is when an aerodrome operator exerts pressures for more capacity. This is usually accompanied by other types of demands regarding changes of runways in use at certain hours of the day, enforcement of preferential taxi routes, and removal of air traffic flow restrictions in order to expedite traffic. The obvious aim of these pressures is to increase the efficiency of aerodrome and airline operations. Even though each individual demand can be successfully dealt with, their combination produces multiple conflicts that cannot be easily reconciled.

For example, if a departing flight is delayed for security reasons in the terminal building and misses its departure slot, the air traffic flow and capacity management system may allocate a new departure slot one hour later due to capacity restrictions at the destination aerodrome. Suppose that tower controllers become busy with a wave of departing aircraft and have to work above their capacity limits. This unexpected situation creates problems for the affected flight crew who need to take off as soon as possible because their destination airport is closing at night. To make things worse, the aerodrome operator informs the controllers that the parking stand of the delayed flight has been allocated



to another flight that just arrived and is waiting on the taxiway. All these economic, capacity and efficiency pressures leave controllers with a narrow space to manoeuvre and make decisions. In the end, the tower controllers would have to negotiate these perspectives and may choose to cancel the restriction to allow the flight to depart earlier and reach their destination aerodrome while it is still open.

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Local and organisational trade-offs

Air traffic management is a domain where goals and constraints are not always well defined and controller trade-offs are very challenging. Hence, systems may be simultaneously cooperative over shared or global goals and competitive when it comes to local goals, which may be in conflict at different units. Working in isolation, different control units may achieve efficient local performance at the expense of common goals. For example, direct routings and vector shortcuts are always welcomed by flight crews and demonstrate the expertise of controllers. However, a controller who expedites arriving aircraft with direct routings to land at a congested airport, where no parking stands are available, is inadvertently exerting unnecessary pressure to tower controllers. Eventually, this can destabilise aerodrome operations. Additionally, safety-sensitive situations are generated by direct routings and vector shortcuts when flight crews end up approaching high and fast to a different runway; not the originally briefed and planned landing.

The window of opportunity

When controllers are not sure how to solve a problem, they may be simultaneously preparing for a few goals. They may have a preferred goal but, as they are not sure if it will work out, they can prepare some backups. As the window of opportunity gets smaller and smaller, they are forced to choose one option which favours a particular goal. For example, approach controllers faced with a complex arrival traffic flow may delay the sequencing of the arrival aircraft until the cost of replanning is too high, or even unsafe.

Similar examples can be drawn from flight crew decisions to divert or fly into adverse weather at the destination aerodrome. In this case, another option may be to choose an alternate aerodrome where the chances of bad weather are lower. Flight crews may try to delay their decision to the last moment in the hope that their preferred option would fall into place (i.e., continue to destination). But at the same time, preparations should be made for the diversion possibility (i.e., after a certain distance travelled to the destination aerodrome, fuel management issues may make a diversion extremely risky).

In the dynamic environment of air traffic management, goal trade-offs may also exist regarding when to commit to a plan of action. Controllers have to decide whether to take corrective action early, or delay their response and wait for more data to come in, to explore additional options and become more reflective. For example, an operational supervisor may delay a decision to accept normal levels of traffic after a surveillance system failure. The supervisor may prefer to work for a while in reduced traffic conditions in order to check the stability of the previously failed system, before resuming normal traffic loads. This is a precautionary tactic that usually pays off when the failure is not well understood and the systems are software intensive. In this sense, the supervisor faces a trade-off between (i) resuming normal operations early and facing a risky complication of the initial failure and (ii) waiting for more information and working with reduced traffic rates. This

latter option will eventually increase the workload of adjacent units, generating delays and route diversions.

Competency for trade-offs

Effective management of trade-offs implies that controllers and organisations are competent in operating in both sides of the spectrum, despite the fact that different goals have their own requirements. Trading off goals requires a deep knowledge of risks and opportunities as well as an ability to discern the range of applicability of different options to a wide variety of situations. Developing this capability, however, comes at an increased cost of training so that controllers can acquire redundant skills for a variety of domains. Broadening the bandwidth of competences may be a good strategy to increase operational and rostering flexibility, for instance, but it also leads to increased demands for training.

In the air traffic management system, organisational activities shape and affect the ways that controllers work and coordinate their efforts.

A characteristic example is the dilemma facing the multisector units when it comes to the training of their controllers in different sectors. A multisector unit may operate with many sectors which are by design incompatible in traffic demands, complexity, de-conflicting strategies, coordination requirements, weather patterns, communication, navigation and surveillance systems, and so on.

The training section – in line with the operational management – has a difficult decision to make concerning whether to train all controllers for all sectors or to provide tailored training between dedicated sector groups and selected controllers. The first option requires extensive training, and makes the progression of the controllers towards acquiring ratings and sector endorsements lengthy. But it provides operational flexibility as all controllers can work in any sector at any given condition. The second option reduces training needs, controllers develop in-depth expertise in their dedicated sector groups, work practices are better developed and communicated, and controller performance may be enhanced. But the margin of manoeuvre of operations becomes significantly lower as rostering gets more challenging. Additionally, system-wide failures and contingency plans can be better managed with the first option while day-to-day operation is smoother with second option.

Safety vs efficiency

In some cases, collision prevention is often in conflict with efficiency of operations. For instance, controllers may maintain a high safety record at the expense of efficiency, forcing airlines to spend more mileage and fuel – and hence also emissions – on their sectors. The result may be more delays and route changes, especially in the cases of bad weather, staffing issues and system-wide degradations.

Air navigation service providers strive to meet increasing pressures for performance and respond to new opportunities while lowering costs. This is usually achieved by transferring pressures to the operations rooms, forcing controllers to work faster, harder and smarter (i.e., relying on tradeoffs, workarounds and circumventions to balance conflicting goals). In the air traffic management system, organisational activities shape and affect the ways that controllers work and coordinate their efforts. Therefore, it is necessary to understand how the system performs as a whole, and how it achieves its goals and functions. Thus, making sense of goal conflicts and tradeoffs is a critical goal for safety, operations and research in the air traffic management system.

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