CONTROLLER BLIND SPOT

EUROCONTROL Network Manager Top 5 Operational Safety Review

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1 Definition

What is controller blind spot and why should we be concerned about it?

In air traffic control a phenomenon known as “Controller Blind Spot”, refers to the failure to detect a potentially conflicting aircraft usually straight in the controller’s field of view. It is a human performance issue. Specifically, controller blind spot loss of separation events are typically characterised by the controller not detecting a conflict with the closest aircraft when clearing or instructing another one. Since the aircraft are, by definition, close there is very little (or no) time to react to such a conflicting clearance and most of the conflicting clearances result in an incident. There are a variety of scenarios that can lead to this negative consequence.

Controller blind spot has been a EUROCONTROL Network Manager Top 5 operational safety priority dating back to 2012. Recent Safety Functions Map (SAFMAP) barrier analysis, encompassing data from 2015-2020, shows that during this 6-year period, controller blind spot incidents account for an average of 36% of all analysed A and B incidents in European en-route airspace.

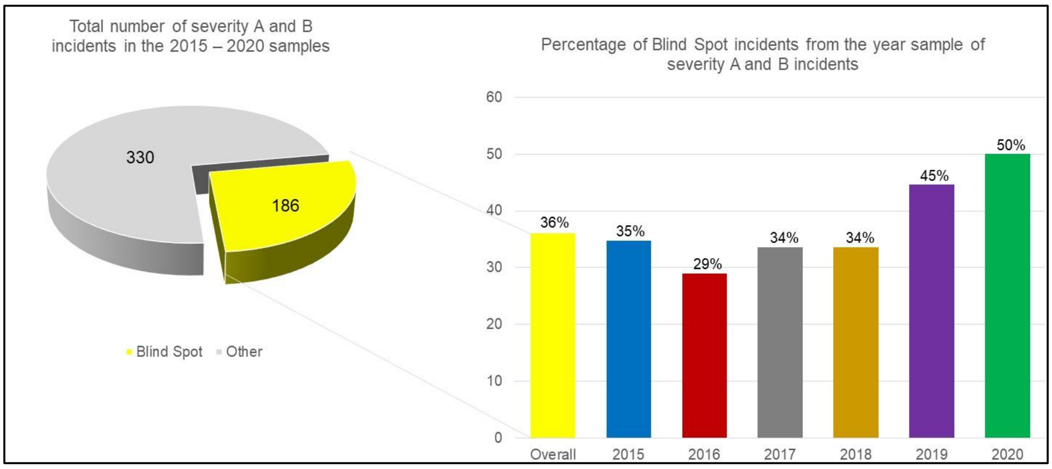

Figure 1 Blind Spot Incidents 2015-2020

This is a significant percentage and is trending up year over year. This suggests all ANSPs would be well served by evaluating the incidence and risk of controller blind spot events in their area of control. (Note: 2020 is considered an anomalous year due to the significant operational impacts of the COVID-19 pandemic)

2 Understanding blind spots

Since controller blind spot incidents are, by definition, a human performance issue, we will never be able to eliminate them entirely. When it comes to controller blind spot, the causal factor is, essentially, inadequate visual detection. The psychological mechanism involves perceptual discrimination and 'layered situation awareness'.

Perceptual discrimination is the cognitive ability to accurately perceive information and to accurately differentiate amongst types of information in a situation involving several information elements. For example, this is the ability to see the conflicting aircraft with track label filtered out or displayed in unconcerned colour on the controller surveillance screen.

Layered situation awareness relates to the need to handle the demands of traffic against a background of other traffic. The controller focuses on traffic that has short-term demands while at the same time planning the traffic management in the future time horizon. The controller therefore mentally suppresses or, in the extreme case, 'filters out' aircraft. However, they may not only filter out aircraft with track label displayed in unconcerned colour, but also certain aircraft with track label displayed in normal colour for traffic in the sector. These aircraft are akin to blind spots – they are not seen. This approach to controlling traffic arises from a proactive approach which is continually looking ahead, using a more complex strategy perhaps, than in lower workload situations.

This way of working would carry over into low and/or medium workload times after a busy period, when the vigilance 'resources' of the controller are lower or even depleted. Therefore, this filtering or suppression process becomes 'second nature', and so is more likely to continue to operate when the controller is tired or the normal required vigilance level drops (and the controller is 'under-stimulated'). It is as if the controller has certain aircraft that are in focus, whereas the others are out of focus. The ones in focus are in the working memory, and the rest are not (at least they are not 'active' – they are treated as 'noise' rather than signals). When tired or preoccupied, it is possible for 'secondary' aircraft to fall out of focus too, even if the traffic level has dropped, since there is little demand to stimulate the controller.

So, does this mean there is nothing we can do about controller blind spot incidents? Absolutely not. While we may not be able to prevent all controller blind spot incidents, we can manage the risk associated with them. With proper understanding of the risk of such incidents in your operation, and the barriers that can affect a controller's attention and ability to recognize such conflicts and act to resolve them, it is possible to reduce the frequency of controller blind spot incidents and the severity of such events when they do happen.

To put it another way, you won't be able to eliminate them, but you can manage them.

To do this, we need to understand the human performance factors at play in controller blind spot incidents and the barriers that can be put in place to provide controllers with safety nets, tools and strategies to reduce the likelihood, or severity, of such incidents.

3 Our approach

There are several operational scenarios that are prevalent when examining past controller blind spot incident data. While we will discuss those in depth later, it does begin to help us understand when and where controller blind spot events may happen. This also points us to where we should strengthen barriers, introduce decision support tools and what manner of strategies can assist controllers with reducing blind spot incidents.

Ideally, we could prevent the triggers that result in these scenarios developing. However, this is not always operationally feasible. It is unrealistic to believe that we could prevent every possible scenario by preventing its trigger from occurring. The system is simply too complex for that. Complete prevention is not a realistic approach, but reduction is. If we can reduce the likelihood of the triggers occurring in these scenarios, we should be able successfully reduce the number of controller blind spot incidents.

Every incident also has contributing/contextual factors, although these are not necessarily specific to controller blind spot but instead are systemic factors across many incident scenarios. Preventing any of the other contributing/contextual factors, even if possible, would not reliably prevent the blind spot incidents, but could potentially reduce the chance of them happening.

Once we understand the scenarios, the contributing and contextual factors around controller blind spot issues we can then begin to put in place and strengthen effective barriers.

4 Operational scenarios

Annually, EUROCONTROL Network Manager conducts a series of dedicated workshops with multiple ANSPs, serving a large part of European air traffic (the Network Manager Top 5 process). Comprehensive barrier models – Safety Functions Maps (SAFMAPs) - are populated with data from the participating ANSPs and analysed. The incident data is comprised of high severity (classified as 'A' and 'B') events, which are both thoroughly investigated and highly informative because the incident scenarios 'tested' the majority of the available safety barriers. In the next sections, we present information based on the EUROCONTROL Network Manager SAFMAP data.

Analysis has identified four operational scenarios (triggers) that are prevalent when controller blind spot incidents occur. While there may be others in any specific ANSP or operation, addressing these four, if mitigated appropriately, may lead to a significant reduction in controller blind spot incidents. The scenarios are as follows:

4.1 Issuing a vertical clearance after a pilot request

This scenario occurs when a pilot makes a request for climb/descent. This diverts the attention of the controller whose focus was elsewhere. There is a perceived need to deal with the request as quickly as possible so that the limited attention resource can be returned to other tasks. The controller does not detect the potential conflicts and agrees to the request. The clearance leads to a conflict with another aircraft in close proximity. This scenario includes first clearance and any subsequent re-clearance that take the fight away from the filed vertical profile of the flight plan route.

Below is an example of this type of scenario:

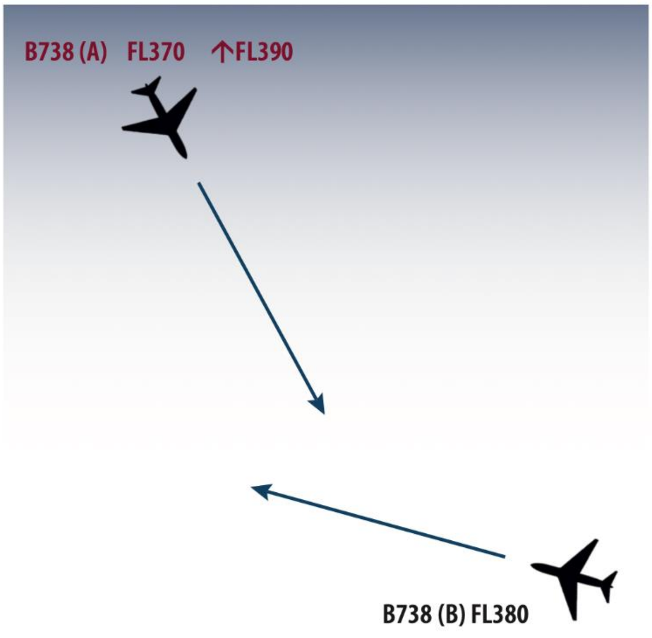

Figure 2 Scenario 1

B738 (Aircraft A) was heading 160° at FL370. B738 (Aircraft B) was heading 300° at FL380. B738 (A) was following the airway, B738 (B) was flying a direct route. The pilot of B738 (A) requested any ride reports at FL390 and on being informed that there was no reported turbulence, he requested climb to FL390. The sector was being controlled by a trainee controller, who cleared B738 (A) to FL390.

The instructor did not hear the clearance as he was engaged in coordination with the Planning controller. The instructor became aware of the conflict about one and half minutes later and took over the R/T. He considered that the B738 (A) would pass to the south of B738 (B) so instructed it to turn right 180°. He then gave B738 (B) traffic information, who responded with "TCAS RA". The two aircraft passed 4 nm abeam with B738 (A) 300ft higher.

Standard strip production would not show the aircraft as being in the same place. B737 (B) would normally have been heading 330°and pass well north of the track of B738 (A). However, it had been given a direct routing to a waypoint, which had the effect of turning it left towards the path of B738 (A).

4.2 Instruction to meet constraints

This scenario incudes descending flights for closely situated destination airport and clearance after a pilot request to follow the vertical profile of the flight plan route (i.e., to climb/descend to the filed requested flight level).

Airspace design for en-route and TMA sectors has become complex. To accommodate the various constraints, such as the transfer of control, the task is increasingly governed by silent handovers either by standing agreements or individual electronic acceptance. The controller's attention turns to a requirement to climb/descend an aircraft to meet these constraints and does not recognize the potential conflict ahead. Since the system contains information about these constraints, this type of scenario may be entirely predictable. However, the challenge is bringing this information to the attention of the controller in a timely and usable manner.

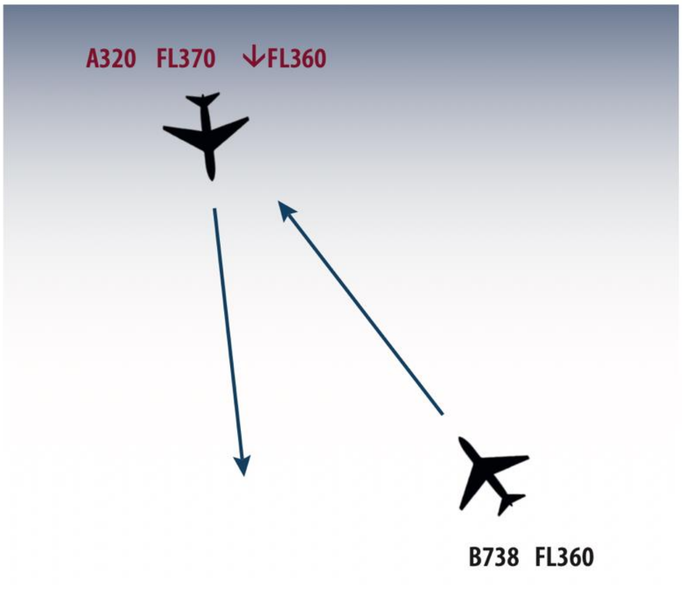

Figure 3 Scenario 2

Below is an example of this type of scenario:

The A320 was southbound, maintaining FL370 and had been co-ordinated out of the sector at FL310. The B738 was northbound, maintaining FL360. When contact was made with the sector the A320 was approximately 50nm in front of the B738.

The controller began a sequence of instructions to various aircraft, climbing and descending, to achieve the levels coordinated out of the sector. The last instruction was to the A320 to descend to FL360. This was due to another aircraft crossing the sector at FL350. The B738 was now 10nm directly ahead of the A320.

STCA alerted the controller to the conflict. The B738 was instructed to turn right 60° and the A320 was instructed to climb back to FL370. Both aircraft reported visual with each other, and both had TCAS TAs. The aircraft passed 2nm apart with the A320 at FL364 and the B738 at FL360.

4.3 Clearance not following the horizontal Flight Plan Route

This scenario involves instruction or clearance from the controller that results in lateral deviation from flight planned route. This encompasses the first clearance, and any subsequent clearance, before the aircraft re-joins the Flight Planned horizontal route, including the instruction to resume own navigation after vectoring. Contemporary Flight Data Processing (FDP) systems are designed to highlight the planned routing of aircraft. This may be via paper or electronic strips, or by information overlaid onto the radar display. When flights do not tactically follow the pre-planned flight profile, the information gleaned from the FDP system may no longer highlight the potential conflict.

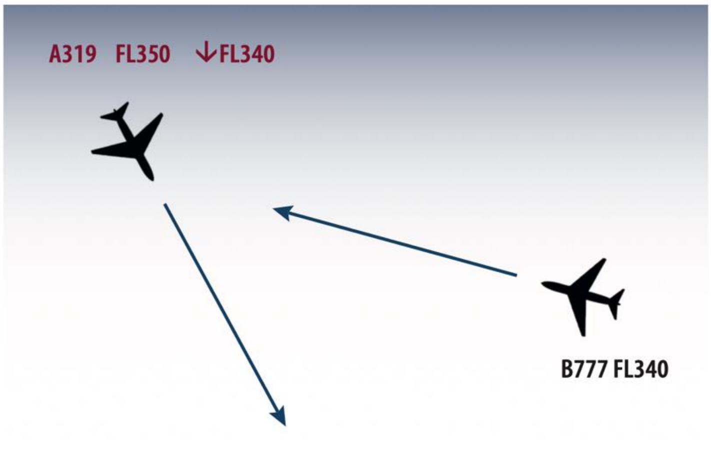

Figure 4 Scenario 3

Below is an example of this type of scenario:

The B777 was at FL340, on its own navigation, heading 300°. The A319 was at FL350, on its own navigation, heading 150°. Both aircraft were slightly off the normal tracks.

Another aircraft on a crossing track at FL360 needed descent. With the B777 directly ahead by 15nm, the controller cleared the A319 to the same level, FL340, to facilitate this descent. The controller instructed the B777 to turn 10° right to resolve a potential confliction with another aircraft. The turn decreased separation from the A319. Shortly afterwards, as the A319 passed FL345, the B777 reported a "Traffic TCAS". The controller responded by instructing the A319 to continue its descent to FL310. The B777 passed 4.5nm north of the A319 at the same level.

The controller had only been in situ for 5 minutes and described the handover as good. The B777 had not spoken to him since the handover. As both aircraft were on direct routes, the confliction was not obvious from the strips. He became aware of the confliction when the B777 reported the TCAS.

4.4 Conflict resolution instruction for vertical manoeuvre

This scenario includes issuing instructions for vertical manoeuvres to solve a potential conflict and not detecting that the implementation of the instruction will result in another conflict. This scenario is often combined with a controller forgetting a previous action and therefore not taking the related aircraft manoeuvre into account.

A significant proportion of a controller's attention is directed towards future situations (e.g., situations that will develop in 5 min). Immediate issues are dealt with and filtered out as "complete" and attention is focused elsewhere. Hence, the controller may not identify the resultant new conflict that was created by the initial implemented conflict prevention action.

Below is an example of this type of scenario:

This event occurred during a handover. First contact was made by the F900 heading north-west at FL350. The outgoing controller cleared the F900 to FL330 at more than 1000ft per minute to solve a potential conflict with another aircraft.

The B757 was heading southwest at FL330 and had been given a direct routing by the adjacent ACC. The controllers were not aware of this change in routing.

Within one minute of the new controller taking over, STCA triggered. The F900 was crossing in front of the B757 left to right and approaching FL340.

When the conflict was spotted, ATC instructed the F900 to stop descent at FL340. The F900 did not reply. ATC repeated the instruction and the F900 answered he was cleared to FL330.

ATC instructed the F900 to maintain FL340 because of traffic. The F900 responded that he was already maintaining FL340 and that he had the traffic on TCAS and in sight, passing behind him.

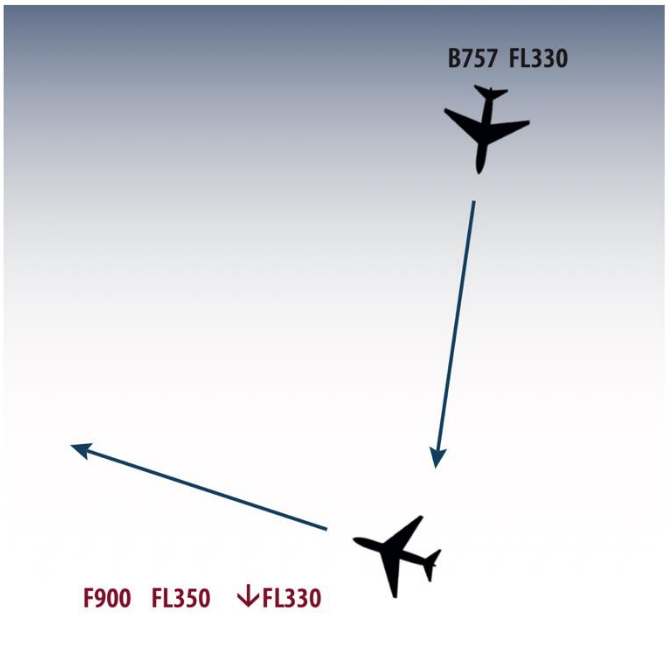

Figure 5 Scenario 4

5 Barriers

As with most safety issues in complex air traffic control systems, there is no single barrier that can efficiently and universally prevent all the scenarios of controller blind spot incidents. Analysis has shown that a combination of strategies, practices, tools, and safety nets seems to deliver the most reliable protection to reduce the frequency and severity of losses of separation due to controller blind spot incidents.

5.1 Prevention Barriers

Many barriers were examined during the analysis to identify possible ways to reduce incidents due to controller blind spot or mitigate the consequences. Not all barriers are relevant to all situations and their adoption by aircraft operators or ANSPs as a group may not necessarily be appropriate, or feasible. It may also be possible to identify more potentially useful barriers than are included here. However, the following preventative barriers seemed to show the most positive impact for reduction of incidents:

5.1.1 Routine structured scan

Scanning is a basic building block in ATC training. Prior to making an executive decision the controller should scan all the appropriate information (the situation display, the flight data (strips), the co- ordinations agreed), evaluate immediate situation, and consider any future implications. However, scanning is an inherently weak barrier. As described in Section 1, blind spot incidents involve conflicting aircraft usually straight in the controller's field of view. In these situations, it is not the scanning that is going to help but addressing the mechanisms of perceptual discrimination and layered situation awareness.

There are situations where information may be suppressed or diffused. Track labels may be obscured, and flight data displays may not be arranged in such a way to highlight a conflict. Time pressure and workload may erode the attention that the controller is able to give to each piece of information.

A controller may not recognize a conflict even when observing the involved aircraft. Working knowledge may then become layered and filtered. When a controller is under pressure, a "return to basics" such as using a structured scan before making an executive decision can reduce the likelihood of controller error. However, scanning techniques need to be enhanced to facilitate better focus and overcome these cognitive filters.

5.1.2 Use of velocity vectors

Velocity vectors achieve a very simple task of making the dynamic characteristics of aircraft on a controller's display visually available. Velocity (speed) vectors help controllers anticipate in what direction aircraft tracks are about to move and where they would be positioned in the near future.

Current ATC automated systems support display of velocity vectors, with typically up to 5 min look-ahead time, selectable in one-minute intervals. Without such visualisation the controller can be under a heavy cognitive burden, having to rely on past experience of the target dynamics (memory or history dots, if available) and integration of a large number of circumstantial factors to predict a targets trajectory into the future.

5.1.3 Operational Team Resource Management

This barrier relies on available, vigilant, and proactive colleagues. It can be both a preventative and a mitigating barrier. Proactive teamwork may involve making a mistake less likely by encouraging/suggesting a plan to a colleague, pointing out potential conflicts or building in assured safety coordination. It may also prevent a loss of separation by alerting a colleague to an apparent error or misjudgement before separation minima have been compromised. However, this is an inherently weak barrier. Concepts such as multi-sector planner make it difficult to monitor executive controller clearances and degrade the effectiveness of this barrier even further. Unlike flight crews, that are working in similar time horizons and continually monitoring each other, planning and executive controllers are working on different tasks, often in different time horizons and cannot be as efficient in monitoring each other.

5.1.4 Predictive Separation Alert Tool (e.g., MTCD)

Most medium-term separation violation tools work using the filed flight plan data with tactical updates made by the controller (e.g., route or level changes). However, some medium-term conflict prediction systems have tactical update facility, i.e., their data is updated according to downloaded aircraft headings and selected flight levels. Such tools have the potential to reduce losses of separation caused by controller blind spot.

5.1.5 Short Term Conflict Probe

There are various assessment tools available to probe the safety of a potential level change. Generally, the controller inputs the intended clearance into the ATC system without communicating it to the flight crew. The ATC system processes the information and checks for conflicts. Analysis of the data from 2015-2020 shows that this tool, when correctly used, had the potential to reduce 90% of the losses of separation caused by controller blind spot, except for scenarios of clearance not following the horizontal flight planned route, as existing probes are predominantly what-if tools for vertical manoeuvres. The advantage of the probe is that it is purely preventive barrier to be used before any instruction or clearance is given. This hypothetical element may also be considered a drawback by some controllers and affect their willingness to use it.

5.1.6 Safety Nets (e.g., STCA) with ATC intentions inputs like Cleared Flight Level (CFL)

CFL allows the predictive STCA to identify vertical conflicts in a timelier manner and may identify them even before the crew start the execution of the conflicting clearance. Analysis has shown that this safety net, when available and correctly used, had the potential to prevent 33% of the losses of separation caused by controller blind spot, in the incidents between 2015 and 2020. This barrier is less efficient in proactively identifying potential conflicts due to unplanned horizontal manoeuvres towards a nearby aircraft. The effectiveness of this barrier may be affected by the consistency of inputting the Cleared Flight Level (CFL) information in the system.

5.1.7 Safety Nets (e.g., STCA) with flight crew intentions inputs like the downlinked Final State Selected Altitude (FSSA or Selected Flight Level)

Some short-term conflict prediction systems have tactical update facility. The system starts with the FPL routing but updates it tactically when the aircraft deviates from that route. The display is updated according to downloaded aircraft headings and selected flight levels. Additionally, for added efficiency it may be updated with CFL inputs by the controller. Analysis has shown that this safety net has the potential to reduce losses of separation caused by controller blind spot.

5.1.8 Safety Nets (e.g., STCA) without ATC intentions inputs

STCA without CFL or SFL input will provide an alert of a potential or actual infringement of separation minima and should allow the controller to take a remedial action before the separation minima have been violated and/or the next barrier (i.e., ACAS) is activated. Arguably, this barrier is less efficient in proactively identifying potential conflicts than STCA with CFL or SFL inputs; however, it may be more efficient in detection of unplanned horizontal manoeuvres toward a nearby aircraft.

5.2 Mitigation Barriers

When analysing controller blind spot incidents, a variety of mitigating barriers exist. However, these barriers are generic in nature (i.e., not specifically designed to mitigate a particular risk). Their presence and effectiveness are independent of the blind spot as a reason for the loss of separation. The following, non-exhaustive, list of mitigation barriers may reduce the negative consequences of a loss of separation due to controller blind spot incidents:

- ❑ Operational Team Resource Management (TRM) – colleague warning
- ❑ Medium Term Conflict Detection
- ❑ Short Term Conflict Alert (STCA)
- ❑ Airborne Collision Avoidance System (ACAS)
- ❑ See and Avoid
- ❑ Providence (geometry of encounter)

The above-mentioned mitigation barriers will nominally trigger in the order as listed.

6 Contributing factors

Apart from the prevention and mitigating barriers, there are several contributing/contextual factors that have been identified in controller blind spot incidents.

Addressing these factors may help reduce the frequency and/or severity of such events. The following is a non-exhaustive list of possible contributing factors:

- ❑ Distraction e.g., focus of attention elsewhere
- ❑ Controller workload issues – high workload or under-load
- ❑ Controller fatigue
- ❑ Obscured track labels:
  - other colour and intensity for tracks that are still within the controlled airspace but that are not anymore, or are not yet, under control of the sector
  - Overlap of the track labels, or a track label and other information that makes some of the information partially or completely obscured.
- ❑ Recent hand-over, sector split or sector collapse impacting the quality of the mental 'traffic picture'
- ❑ Flight data display not updated to show direct routing
- ❑ Production pressure
- ❑ Inadequate training

7 What does data say?

The EUROCONTROL Network Manager, as part of its Top 5 safety prioritisation process, performed a SAFMAP risk and resilience analysis on the following sample:

- 6 year sample (2015 2020).
- The analysed 6-year sample includes 516 separation minima infringements of severity A or B in the en-route phase of flight, collected during the dedicated sessions with ANSP representatives.
- The data sample includes 186 incidents blind spot incidents of severity A or B.
- The sample is representative (by size and geographical coverage) for the European operations.
- The sample is representative for information about risk scenarios, contributory factors and resilience potential.

The distribution of the controller blind spot scenarios and the maneuver direction are illustrated in Figure 6.

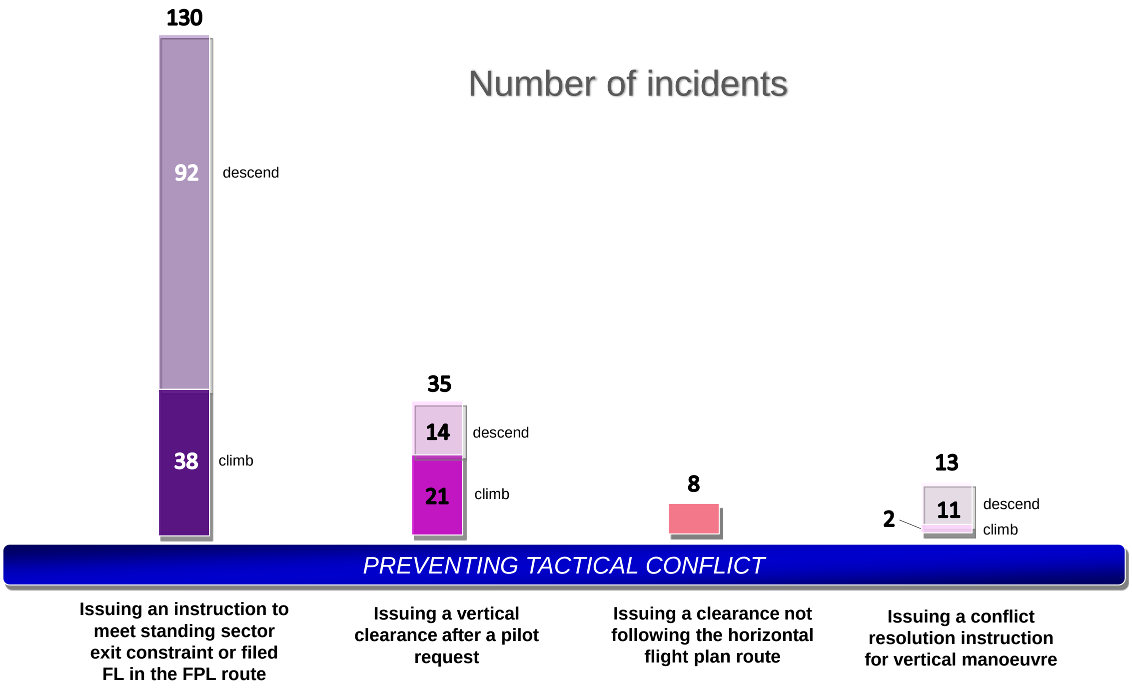

Figure 6 Blind Spot Scenarios Data

The SAFMAP barrier resilience to the different "Controller blind spot" scenarios is illustrated in Figure 7. To the left of the barriers is indicated the number of incidents prevented by a barrier and to the right – the share of prevented incidents from the analysed sample of events.

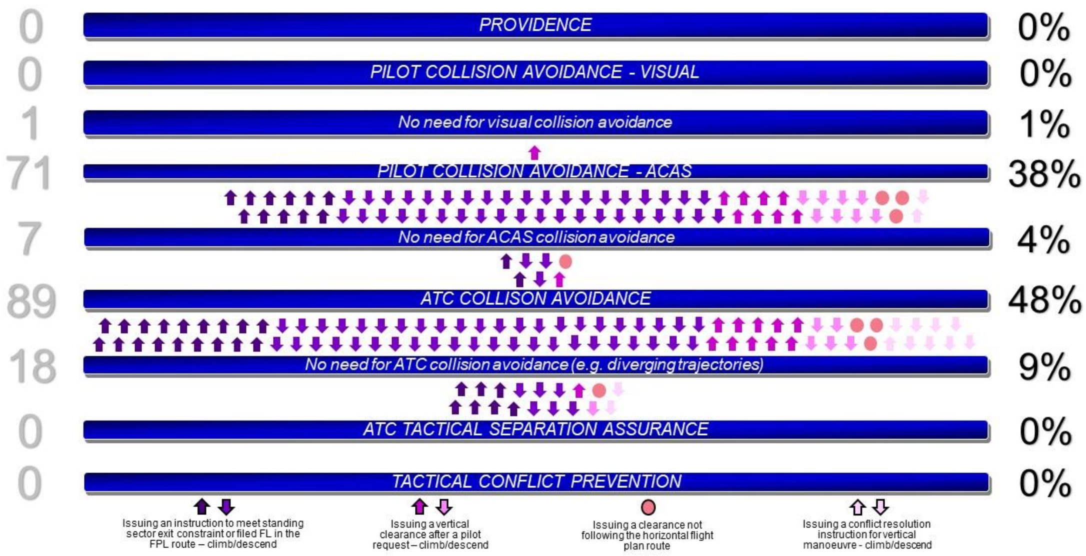

Figure 7 Barrier Performance

Here are some of the main findings of the 6 year SAFMAP study:

- ❑ 36% of the European severity A and B sample of incidents for the years 2015-2020 involved a conflict generated by "Blind spot" – ATCO overlooking a potentially conflicting proximate aircraft when clearing or instructing another one.
- ❑ Blind Spot scenario "issuing an instruction to meet standing sector exit constraint or filed FL in the FPL route" accounts for 70% of the incidents in the sample.
- ❑ 66% of the vertical manoeuvre blind spot incidents in the sample involved instruction to descent.
- ❑ 90% of the incidents in the sample could have been prevented by available and correctly used conflict probe functionality.
- ❑ 33% of the incidents in the sample could have been prevented by available and correctly used enhanced STCA functionality
- ❑ 34% of the incidents in the sample involved conflict between aircraft vertically separated by 1000ft
- ❑ For 20% of the incidents in the sample controller high workload was reported as a factor
- ❑ 58% of the incidents with reported geometry of encounter involved opposite direction conflicting aircraft.
- ❑ 29% of the incidents with reported information about controlling sector involved conflict between aircraft not controlled by one and the same sector.
- ❑ 20% of the incidents in the sample involved conflicting aircraft with track label filtered out or displayed in unconcerned colour on the controller surveillance screen.
- ❑ For 11% of the incidents in the sample controller distraction was reported as a factor.

The ANSPs are encouraged to review these findings and review their relevance for their specific operations.

8 How can you identify/assess blind spots in your operations?

We have covered what the data on a larger scale has shown, but what about your particular operation? Every operation is unique and has elements that may prove more, or less, resilient to any given safety issue. As discussed earlier, current data (2015-2020) shows that controller blind spot incidents have predominantly been trending up since 2015. A thorough review of your ANSP's data around controller blind spot may be wise. Even if you have it well managed, we know that human behaviour does drift, and controller blind spot is a human performance issue.

The important questions to answer are:

- ❑ What types of scenarios are you most likely to see?
- ❑ Where are you most likely to see them?

Answering these questions will help you understand where to focus your mitigation efforts.

9 A process to evaluate the risk in your operation

9.1 Collate blind spot incident data

It is necessary to start with information about incidents that have occurred in your operation over the past few years. Identify any that fit the scenarios defined above. The Blind Spot Baseline Information Gathering Canvas (Appendix 1) developed by the SAFOPS group is a very useful tool to help you narrow your data.

9.2 Validate the data with investigation reports

Review the investigation reports associated with the events you have identified. Make sure the findings are consistent with controller blind spot incidents to ensure you are using the right information for your analysis.

9.3 Review your operational environment

You may not have enough data in your reported incidents, or there may be other factors in play in your operation. Perhaps controller blind spot scenarios are present but not resulting in negative consequences yet. The study team should examine the operation and attempt to identify the prevalence of controller blind spot scenarios.

9.4 Blind Spot Scenarios

Identify the blind spot scenarios present in your operation. The four listed below are the most frequent but be open to other scenarios that may be present and may be unique to your operation.

- ❑ Overlooking potentially conflicting aircraft when issuing a vertical clearance after a pilot request.
- ❑ Overlooking potentially conflicting aircraft when issuing an instruction to meet standing sector exit constraint or filed FL in the FPL route.
- ❑ Overlooking potentially conflicting aircraft when issuing a conflict resolution instruction for vertical manoeuvre.
- ❑ Overlooking potentially conflicting aircraft when issuing a clearance not following the horizontal flight plan route.

10 How can you manage controller blind spot incidents?

After you have identified and validated your controller blind spot incidents and scenarios, review the barriers in place that may help reduce the frequency or consequences of blind spot incidents

- ❑ Review the list of safety barriers described above and select those that are relevant or could be relevant to your operational environment.
- ❑ Determine if your organisation has other barriers not provided in the list.
- ❑ Discuss if there are other barriers, not in the list and not used by your organisation but that are feasible to be implemented.
- ❑ Consolidate your list of barriers.

Once you have identified a list of barriers, assess your vulnerability to controller blind spot and the potential effectiveness of each barrier identified. Some questions to consider:

- ❑ Would this barrier be ineffective, or not intended to address controller blind spot?
- ❑ Would this barrier be partially effective or effective only under certain conditions?
- ❑ Would this barrier be an effective and efficient barrier?

After you have reviewed all your data, identified your controller blind spot scenarios, and reviewed your barriers for effectiveness:

- ❑ Identify your scenarios that have less effective barriers
- ❑ Review and address contributing/contextual factors that are negatively impacting your barriers.
- ❑ Review and strengthen any barriers, if needed. This may also involve putting additional barriers in place.

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