Network Manager
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EUROCONTROL

Operational Safety Study: Blind Spots

Inefficient conflict detection with closest aircraft

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DOCUMENT APPROVAL

The following table identifies all management authorities who have successively approved the present issue of this documents.

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DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

Edition Number	Edition Date	Reason for change	Pages affected
0.1	06/01/2014	Creation of the Working Draft	All
0.2	04/03/2014	SISG feedback and internal review	All
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0.5	01/10/2014	Internal DNM/NOM/SAF Review	All
1.0	12/12/2014	External review	All

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EXECUTIVE SUMMARY

The EUROCONTROL Safety Improvement Sub-Group (SISG), reporting to the EUROCONTROL Safety Team, was tasked to identify the Top 5 ATM Operational Safety Priorities.

SISG performed a review during summer 2012 and involved a series of dedicated workshops with 6 ANSPs, representing a large part of European air traffic.

Comprehensive barrier models - Safety Functions Maps (SAFMAPs) - were developed and populated with representative data from the participating ANSPs. The incident data is for high severity (classified as 'A' and 'B') events, which are on one side thoroughly investigated and on the other side - highly informative because the incident scenarios 'test' the majority of the available safety barriers.

As a result of the SAFMAP analysis the Top 5 priority areas were suggested, agreed by SISG and endorsed by the Safety Team:

- Risk of operation without transponder or with a dysfunctional one
- Landing without ATC clearance
- Detection of occupied runway
- "Blind spot" – inefficient conflict detection with the closest aircraft
- Conflict detection with adjacent sectors

This purpose of this report is twofold:

- To document the operational safety study on one of the Top 5 Network Manager operational safety priorities for 2013 - "Blind spot - inefficient conflict detection with the closest aircraft".
- To serve as a reference for the Network actors in case they undertake operational safety analysis and improvement activities for Blind spot - inefficient conflict detection with the closest aircraft.

The priorities were reviewed by SISG with SAFMAP analysis of the data for year 2013 and re-confirmed as Top 5 priorities for 2014.

The methodology employed for this operational safety study was as follows:

- Generate a set of generic scenarios that could result in a Blind spot – conflict with the closest aircraft event.
- Consider what barriers exist that if implemented and deployed could prevent a Blind spot - with the closest aircraft event.
- Consider what barriers exist that if implemented and deployed could mitigate the result of a Blind spot - with the closest aircraft event.
- Analysis of each generic scenario against the potential barriers to establish which of these barriers could be the most effective over the whole range of scenarios.
- Review a set of actual events to validate the barriers suggested by the generic analysis in the live environment.
- Review other published study data and conclusions to check upon convergence and source new information and ideas.
- Collate industry best practice in ATC training and system tools .

This study has identified four basic operational scenarios of losses of separation because of blind spot occurrences and six potential barriers to prevent losses of separation because of blind spot occurrences.

This study has identified that a combination of four barriers seems to deliver the best reliable protection to prevent losses of separation because of blind spot events:

- Predictive Separation Alert Tool (e.g. STCA) with ATC intentions inputs like Cleared Flight Level (CFL).
- Short Term Conflict Probe.
- Structured Scan.
- Predictive Separation Alert Tool (e.g. STCA) with flight crew intentions inputs.

This study identified that there are three most frequent contributing factors that influence the losses of separation because of blind spot occurrences, and that offer a good prevention potential if properly addressed:

- Flight Data Display not updated to reflect change of routing or did not highlight confliction.
- Track labels obscured.
- Sector hand over and post sector handover.

It is recommended that ANSPs review the identified preventive barriers and contributory factors in case they undertake operational safety analysis and improvement activities for Blind Spot – confliction detection with closest aircraft.

CHAPTER 1 - INTRODUCTION

1.1 What is the purpose of this document?

Documenting and communicating

This purpose of this report is twofold:

- To document the operational safety study on one of the Top 5 Network Manager operational safety priorities for 2013 – "Blind Spot – inefficient conflict detection with closest aircraft".
- To serve as a reference for the Network actors in case they undertake operational safety analysis and improvement activities for Blind Spot – confliction detection with closest aircraft.

1.2 What are the Network Manager Top 5 ATM Operational Safety Priorities for 2013 and 2014?

Risk of operation without transponder or with a dysfunctional one

Operations without transponder or with a dysfunctional one constitute a single threat with a potential of "passing" through all the existing safety barriers up to "see and avoid".

Landing without ATC clearance

For various reasons, aircraft sometimes land without ATC clearance resulting in Runway Incursions that are often only resolved by 'providence'.

Detection of occupied runway

Some Runway Incursion incidents could have been prevented if controllers had had better means to detect that the runway was occupied at the time of issuing clearance to the next aircraft to use the runway.

"Blind spot" - inefficient conflict detection with the closest aircraft

Loss of separation "Blind Spot" events are typically characterised by the controller not detecting a conflict with the closest aircraft. They usually occur after an incorrect descent or climb clearance.

Conflict detection with adjacent sectors

Losses of Separation in the En-Route environment sometimes involve inadequate coordination with an adjacent sector. These typically involve either an early (premature) transfer of control to or from the neighbouring sector, or the infringement of a neighbouring sector without coordination.

1.3 How did we identify the 'Top 5'?

The Network Manager identifies Network safety issues to enable aviation stakeholders to mitigate existing hazards and anticipate new operational risks

Our ultimate goal is to keep the Network safe and able to increase its capacity and efficiency.

The EUROCONTROL Safety Improvement Sub-Group (SISG), reporting to the EUROCONTROL Safety Team, was tasked to identify the Top 5 ATM Operational Safety Priorities. In 2012, the SISG followed a structured two-step process of operational safety prioritisation. Firstly SISG identified a list of priority areas.

The first step was to define broad priority areas for further prioritisation

The agreed list contains work priority areas addressing operational threats, safety precursors or undesired safety outcomes. The list includes:

- Airspace Infringement
- Runway Incursion
- Loss of Separation
- ATC sector overloads
- Level Bust
- Severe Weather Risk
- Air Ground communications
- Runway Excursion

The list of agreed priority areas contains issues that are too broad to be a part of a focussed work program. There was a need to get more "granularity" and select some of the areas for a detailed review. Based on the availability of reliable safety information, two of the risk areas were selected for detailed review:

- "Runway Incursion" and
- "Loss of Separation En-Route".

The review was performed during summer 2012 and involved a series of dedicated workshops with 6 ANSPs, representing a large part of European air traffic.

The second step was a detailed review with SAFMAPS.

Comprehensive barrier models – Safety Functions Maps (SAFMAPs) - were developed and populated with representative data from the participating ANSPs. The incident data is for high severity (classified as 'A' and 'B') events, which are on one side thoroughly investigated and on the other side – highly informative because the incident scenarios 'test' the majority of the available safety barriers.

As a result of the SAFMAP analysis the Top 5 priority areas were suggested, agreed by SISG and endorsed by the Safety Team:

- Risk of operation without transponder or with a dysfunctional one
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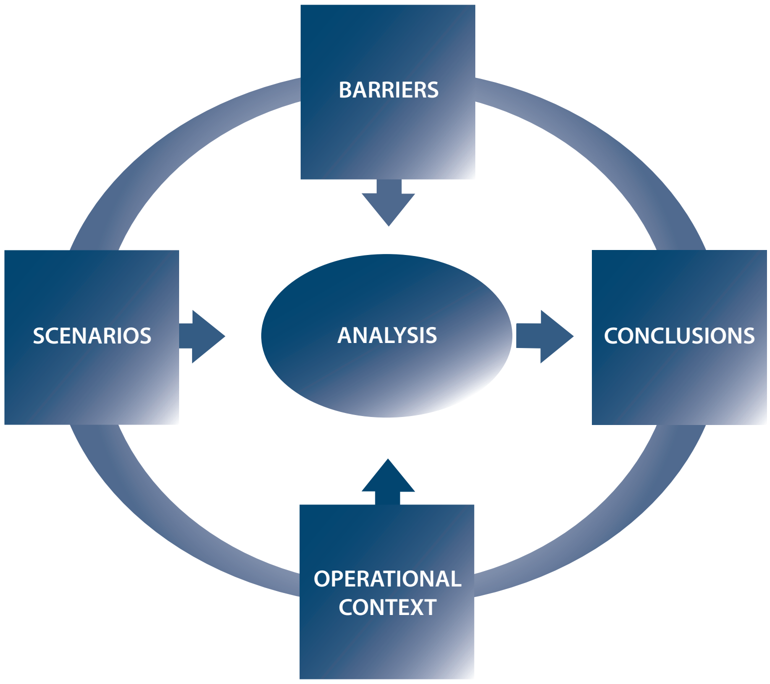
- Detection of occupied runway
- "Blind spot" – inefficient conflict detection with the closest aircraft
- Conflict detection with adjacent sectors

The priorities were re-confirmed for 2014

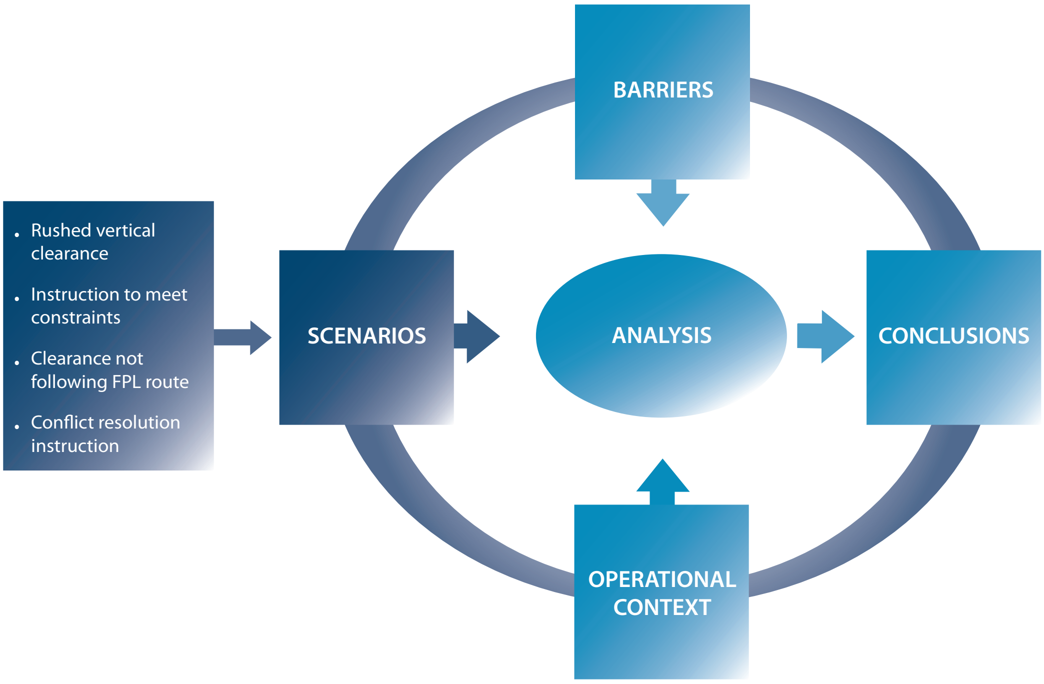
The priorities were reviewed by SISG using the same approach of analysing the high severity incident with SAFMAPs. As a result SISG re-confirmed the Top 5 priorities for 2014.

CHAPTER 2 - THE GENERIC PROCESS: OVERVIEW

The figure below provides an overview of the generic steps in the Operational Safety Study



CHAPTER 3 - GENERIC SCENARIOS



3.1 How are generic operational scenarios defined?

Generic operational scenarios are used to help reduce the complexity of the subsequent analysis. Scenario definition is by "story telling", specific - to help assess the effectiveness of the proposed safety barriers and generic enough - to keep their number relatively small. The scenarios draw upon two sources of information:

Combination of top-down and bottom-up approaches

- A systematic analytical de-construction of each operational scenario into sub-scenarios. This is based on all theoretically possible combinations of scenario (1) sources, (2) mechanisms and (3) outcomes.
- A review of the publicly available information from investigation reports of accidents and serious incidents investigated following the provisions of ICAO Annex 13 and confidentially provided data in respect of less significant incidents.

3.2 Analytical deconstruction of operational scenarios - sources

A review of the case study events identified four types of scenario sources (triggers) that have led to controller Blind Spot occurrences:

Scenario Sources identified

A. **Rushed vertical clearance after a pilot request.**
B. **Instruction to meet constraints** - e.g. sector exit levels.
C. **Clearance not following the horizontal Flight Plan Route.** No conflict detection due to aircraft not following Flight Plan route e.g. Direct routing to Waypoint clearances.
D. **Conflict Resolution Instruction.** Solving potential conflict and not detecting the resultant conflict.

A. Rushed vertical clearance after a pilot request

This scenario trigger occurs when a pilot makes a request for climb/descent. This grabs 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 carry out any structured scan for potential conflicts and agrees to the request. The clearance leads to a conflict.

B. Instruction to meet constraints

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 take into account the potential conflict ahead.

In one of the case studies, the controller was actually aware of the proximity of the aircraft involved and, with defensive controlling, deliberately retained them both on his frequency, instead of an early transfer to the next sector, to guard against the next sector climbing into conflict. He then, himself, descended the aircraft into conflict in order to meet a constraint that needed to be met in 3 or 4 minutes.

C. Clearance not following the horizontal Flight Plan Route

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.

This scenario trigger involves instruction or clearance from the controller that result in horizontal deviation from Flight Planned Route. This includes 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.

D. Conflict Resolution Instruction

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.

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3.3 Analytical deconstruction of operational scenarios - mechanism

The mechanisms as a scenario element describe how the scenario trigger together with the contextual conditions and other contributing factors to result in a blind spit occurrence.

In the case of Blind Spot occurrences the mechanism is basically reduced to only one – **inadequate attention**. This is because the mechanism of the blind spot occurrence by definition is '*controller not detecting a conflict*'.

Attention is a limited resource. There are numerous processes that compete for the limited attention resource. Controllers can only "hold a finite number of balls in the air" i.e. working memory, depending upon the complexity of the traffic situation, their contextual situation and their natural ability.

Only one Scenario Mechanism

For preventing Blind Spot events the needed elements of attention - **vigilance** (maintaining awareness) and **focus** (concentration on the task) will be affected by:

- **Competition** for the attention resources from other tasks, distractions, attempts to remember.
- **Erosions** of the attention resources by filtering mechanisms and physiological factors like fatigue.

In this way one of the four triggers defined as a scenario source, together with other factors, result in inadequate attention. The triggers are necessary elements for the scenario – the occurrence could not have occurred without some of them. Preventing the scenario triggers will reliably prevent the blind spot occurrences, but this may not be operationally feasible.

On the other hand preventing any of the other contributing factors would not reliably prevent the blind spot occurrences but would only reduce the chance of them to happen. Albeit unreliable, these may be one of the most efficient risk reduction strategies.

Non exhaustive list of contributing factors

The contributing factors are not mutually exclusive and they may be dependent. Here is a list of identified contributing factors.

- Distraction e.g. focussing attention elsewhere.
- Controller workload issues – high workload or under-load.
- Controller fatigue.
- Obscured track labels – (1) other colour and intensity for tracks that are still within the controlled airspace but that are not anymore, or are still not, under control of the sector or (2) overlaps of the track labels, or a track label and other information, that make 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.

3.4 Analytical deconstruction of operational scenarios - outcomes

Scenario Sources identified

Three scenario outcomes were identified:

1. Same controller working both aircraft.
2. Controller only working the one aircraft but with immediate means to co-ordinate resolution with the other controller.
3. Controller only working the one aircraft and with no immediate mean to co-ordinate resolution with the other controller.

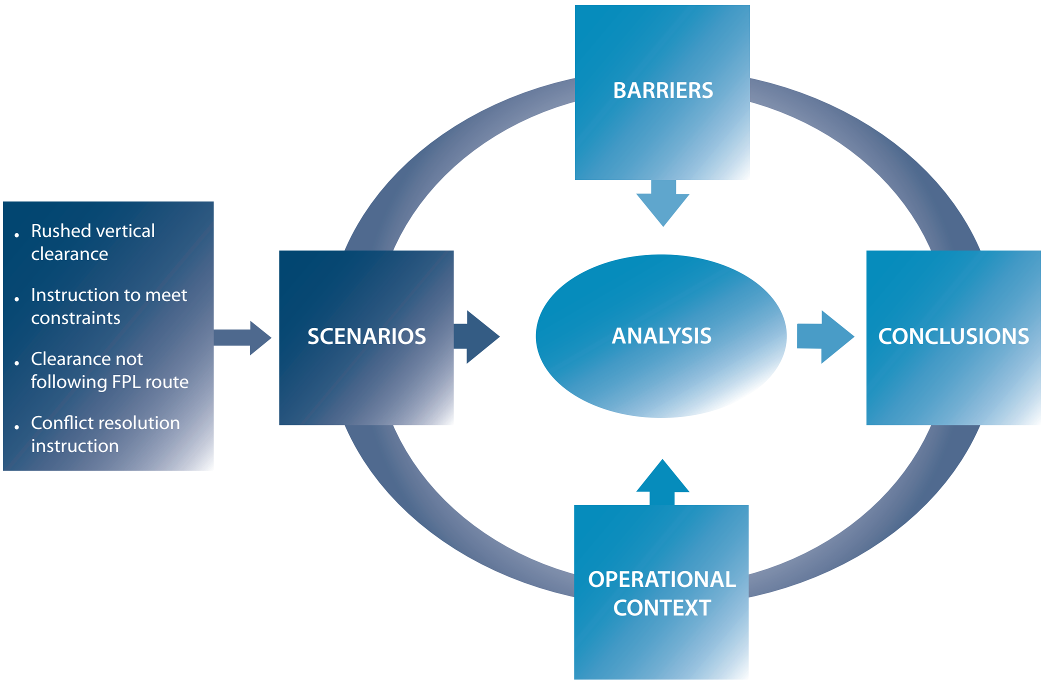
The review of the scenario outcomes revealed that they are not providing any important differentiation of the scenarios in terms of preventing the scenario and are therefore irrelevant for this operational study. The scenario outcomes were not retained further.

3.5 The list of operational scenarios

The resulting list of generic operational scenarios for analysis

A. Loss of Separation due inefficient conflict detection with closest aircraft following a rushed vertical clearance after a pilot request.
B. Loss of Separation due inefficient conflict detection with closest aircraft following an instruction to meet constraints.
C. Loss of Separation due inefficient conflict detection with closest aircraft following a clearance not following the horizontal Flight Plan Route.
D. Loss of Separation due inefficient conflict detection with closest aircraft following a conflict resolution instruction.

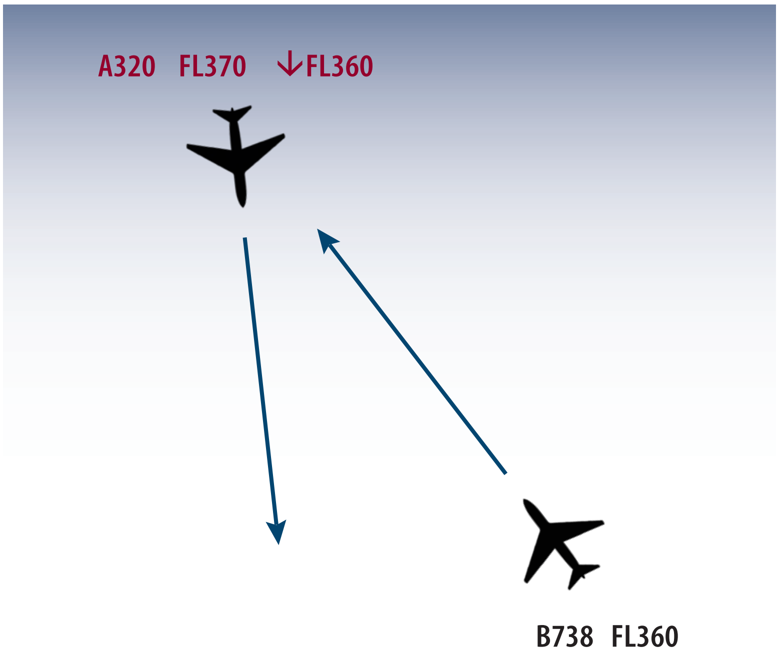
CHAPTER 4 - ACTUAL EVENTS



4.1 Event 1: A320/B738

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 co-ordinated out of the sector**. The last instruction was to the A320 to descend to FL360. This was in respect of another aircraft crossing the sector at FL350. The B738 was now 10nm directly ahead of the A320.



STCA alerted the controller to the event. 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.

The controller considers that she may have missed the more immediate conflict with the B738 for three reasons:

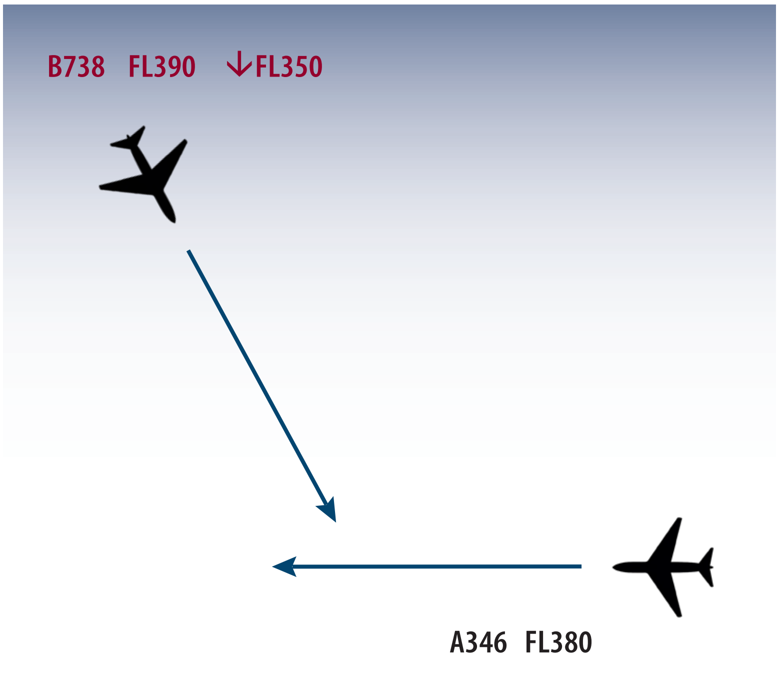
- The B738 had made contact 6 minutes earlier and there had been no requirement to give it any instructions, such that its presence had been forgotten.
- The strip display would normally have shown the two aircraft under the same designator. However, because the B738 was on a direct routing, the strips had become separated.
- The 3-line track label for the B738 was obscured by the track labels of two other aircraft.

Generic Scenarios
B. Instruction to meet constraints

Contributing Factors
No Interaction with High Level Traffic for more than 5 minutes
Track labels obscured
Flight data display not updated to reflect direct routing

4.2 Event 2: B738/A346

The event occurred within 10 minutes of the sector being opened by a new team. The B738 was southeast bound at FL390. The A346 was westbound at FL380. Both aircraft had reported on the previous band-boxed sector before the new sector had been opened. The default position for the track label on this east/west sector is to the north. The track labels can be moved individually and the A346's track label had been moved to the south by the previous controller. In addition the track label for another aircraft at FL330 had been left highlighted in a solid blue square, this has the effect of totally obscuring other track labels within its area. (Note STCA is forced through the solid label). The B738 **had to be descended from FL390 to FL330 before the sector boundary to meet the Standing Agreement** with the next sector. The controller descended the B738 to FL350, without seeing the A346 at FL380 and 10nm in front of it. The controller then moved the track label of the highlighted aircraft directly in between those of the B738 and the A346.



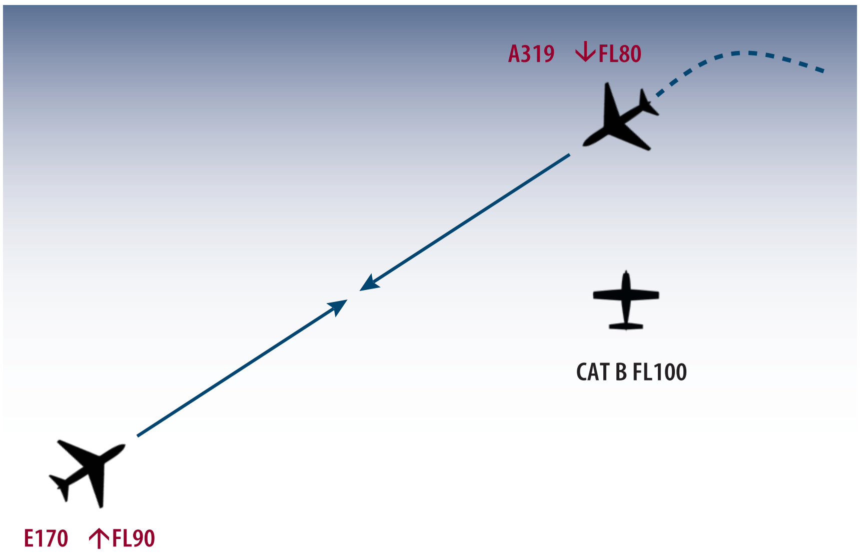
STCA activated as the B738 left FL390, 4 nm ahead of the A346. Almost immediately the A346 reported TCAS RA descent. The B738 also reported TCAS RA. Minimum separation was 650ft when they were 2.5nm apart. As the aircraft passed 1.65nm abeam, vertical separation was 930ft. The controller reported that he had identified a different aircraft at FL380 as being the blocker to the descent of the B738 and once it had passed, he cleared the B738 down. He could not be sure that the A346 was ever included in his mental plan. The strips for the two subject aircraft used different reporting points and did not highlight the confliction. The highlighted label for the aircraft at FL330 had been for a purpose some minutes ago and the controller had not deselected it. The controller stated that the situation display was not set up to his personal preference. There is functionality to return to a global default setting if a controller does not like how a previous controller has set up the picture.

Generic Scenarios
B. Instruction to meet constraints

Contributing Factors
Splitting sector within 10 minutes
Labels and Radar not set up to preference
Track labels obscured
Flight data display not updated to reflect direct routing

4.3 Event 3: E170/A319

The A319 was descending to FL80 westbound. **It had been vectored north of the normal route to resolve a confliction** with a CAT B traffic that was orbiting at FL100. The E170 was heading northeast bound and had been placed on a tactical heading further south than usual, **to resolve a confliction with a fourth aircraft to the north**. The intention being to climb to FL90 and route beneath the CAT B flight. Both flights were in unusual positions and the controller was concentrating on ensuring their individual separation from the CAT B flight (but not between each other). There was a fair degree of distraction from other co-ordination requests and from traffic requesting to enter CAS.



A minor loss of separation would have occurred as the E170 passed behind the A319. However, once the A319 had passed FL90 and to the north of the CAT B flight, the controller cleared it to resume its own navigation. This entailed a left turn of about 40° and directly towards the E170 about 4nm away. The controller returned his attention to the aircraft requesting an airspace join, during which time STCA activated.

The E170 was passing FL72 for FL90 and the A319 was level at FL80. The controller gave a stop climb avoiding action to the E170, which responded with a TCAS RA. Shortly afterwards the A319 reported a TCAS RA. The E170 pilot visually acquired the A319 and reduced its rate of climb, just as TCAS demanded an increased climb. The E170 TCAS reversed to a descend RA. The A319 initially got a descend RA but this was reversed. The E170 descended to FL75 and the A329 climbed rapidly to FL90. Analysis shows that the aircraft were at the same level 2nm apart but by the time that they crossed 0.5nm apart, vertical separation was in excess of 1500ft. The controller reported that when he climbed the E170 to FL90 he did not check the strip display for the A319 as they would normally be separated and in different strip bays. The flight path of the A319 to the north of the usual track would normally have required co-ordination with the Departures controller but, in light traffic, he was performing both tasks. This lost an aide-memoire against the departing E170.

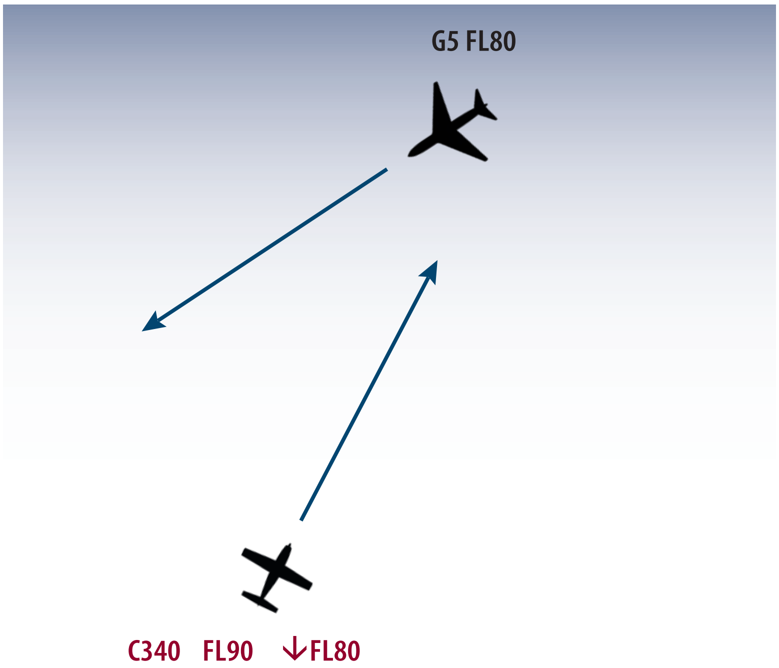
Generic Scenarios
D. Conflict resolution instruction

Contributing Factors
Unusual traffic scenario
Sectors Grouped so the co-ordination that would have been necessary was not done, as controller had both sectors.
Flight data display not updated to reflect direct routing
Sudden workload increase
Incorrect response to TCAS

4.4 Event 4: C340/G5

The C340 was maintaining FL90 on a heading of 010°. The G5 had departed a TMA airfield and had been climbing to 6000ft following the SID. The controller cleared the G5 to climb to FL80 underneath the C340, it was on its own navigation, flying a heading of approximately 220°. At this point the C340 was 10nm south of the G5.

Two minutes later the controller **cleared the C340 to descend to FL80**.



Thirty three (33) seconds later STCA triggered as the C340 was passing FL86. The controller concluded that it was too late to do anything as they were already abeam each other, so chose not to give any Avoiding Action or Traffic Information. The C340 passed 1.67nm to the left of the G5 and 400ft above. Neither pilot received any TCAS warnings nor did either pilot see the other aircraft.

The controller advised that he could have transferred the G5 early to the next sector but chose the retain control to prevent the possibility of them climbing it into conflic-tion with the C340. He needed to descend the C340 by 1000ft within the next 20nm in order for it to pass under holding traffic. This became his priority.

The C340 was not equipped with enhanced Mode S e.g. download of selected Flight Level, so the linear prediction function of STCA was disabled. The reactive element of STCA could not trigger until the C340 vacated FL90. The C340 was exempt from the requirements to carry an enhanced Mode S transponder as it was below the minimum weight (5700kgs).

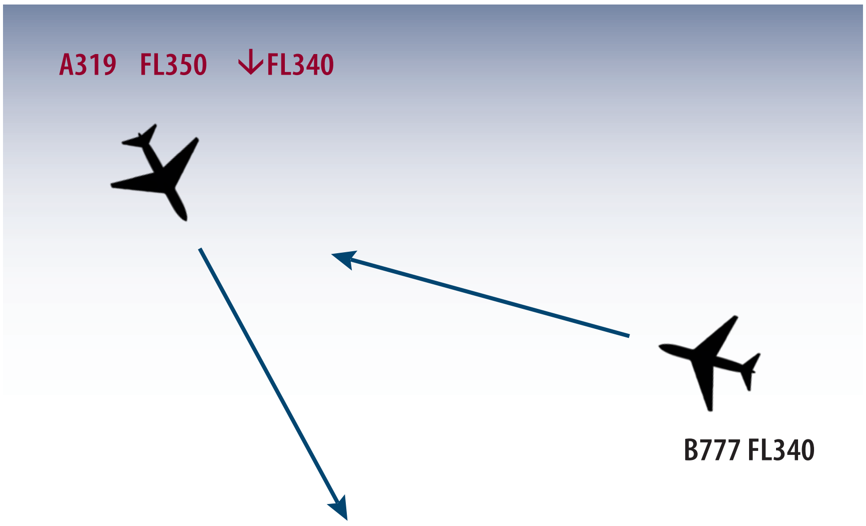
Generic Scenarios
B. Instruction to meet constraints

Contributing Factors
Lack of enhanced Mode S on exempt aircraft

4.5 Event 5: B777/A319

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.

An 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. Fortuitously the turn increased 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.

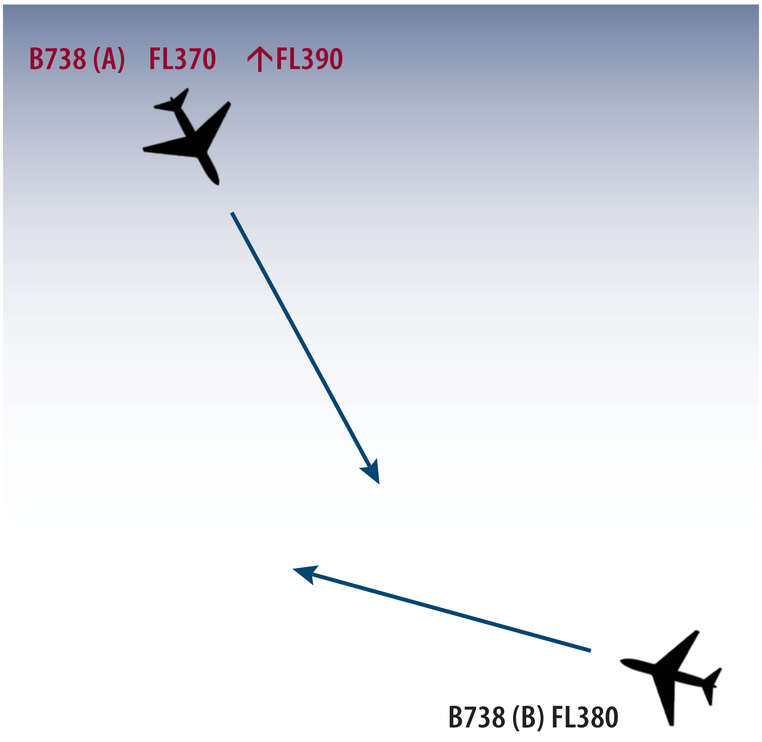
Generic Scenarios
D. Conflict resolution instruction

Contributing Factors
Group sector opened within 10 minutes
No Interaction with High Level Traffic since takeover
Flight data display not updated to reflect direct routing

4.6 Event 6: B738/B738

B738 (A) was heading 160° at FL370. B738 (B) was heading 300° at FL380. Whilst 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 a co-ordination 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 B738 (A).

The instructor reported that he was aware that his trainee had made a transmission but did not know what it was. He was scanning the situation display and strip display to find out, when he saw the conflict. He did not consider asking the trainee.

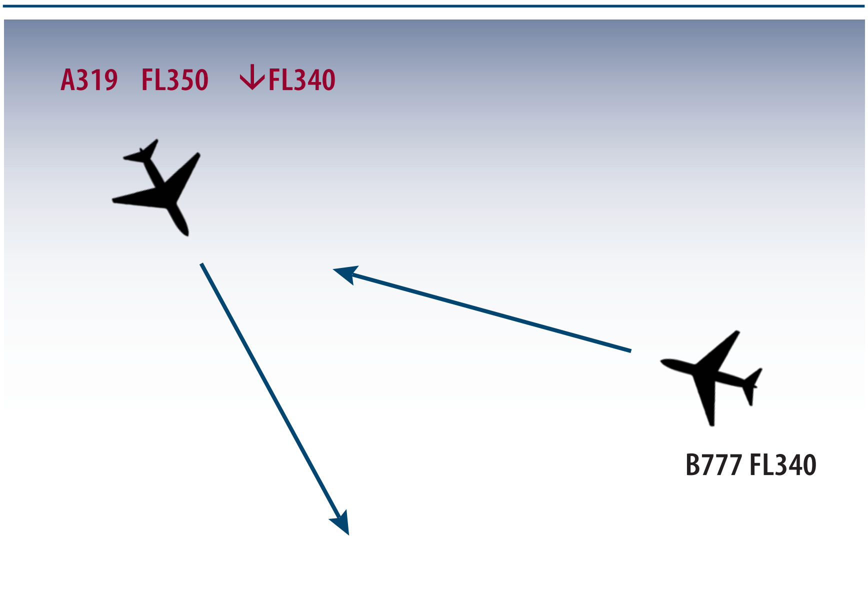
Generic Scenarios
A. Rushed vertical clearance

Contributing Factors
ATC training
Mentor distracted and did not notice error
Flight data display not updated to reflect direct routing

4.7 Event 7: A320/CRJ7

An A320 was routing westbound at FL360, on its own navigation in the centre of the airway, **with a required exit level of FL280**. A CRJ7 was eastbound at FL350 and had been following the centre of an airway immediately to the south at FL350. The track label of CRJ7 was hooked by the controller. This highlighted the aircraft but equally obscured all other aircraft within the track label area. The controller then gave the CRJ7 a direct routeing which effectively turned it left towards the A320.

The A320 was cleared to descend to FL340. The CRJ7 was 10 miles ahead in its 11 o'clock and closing. STCA activated and the controller moved both labels. He gave 10° turns to both aircraft, including the words "Avoiding Action" but neither aircraft replied. He then instructed the A320 to stop descent. Both aircraft then reported TCAS RAs.



A handover had taken place 12 minutes before the incident. The controller described the traffic situation at the time as low to medium. The controller had issued a direct routing to CRJ7 but subsequently reported that it was "possible" that he forgot that he had done so.

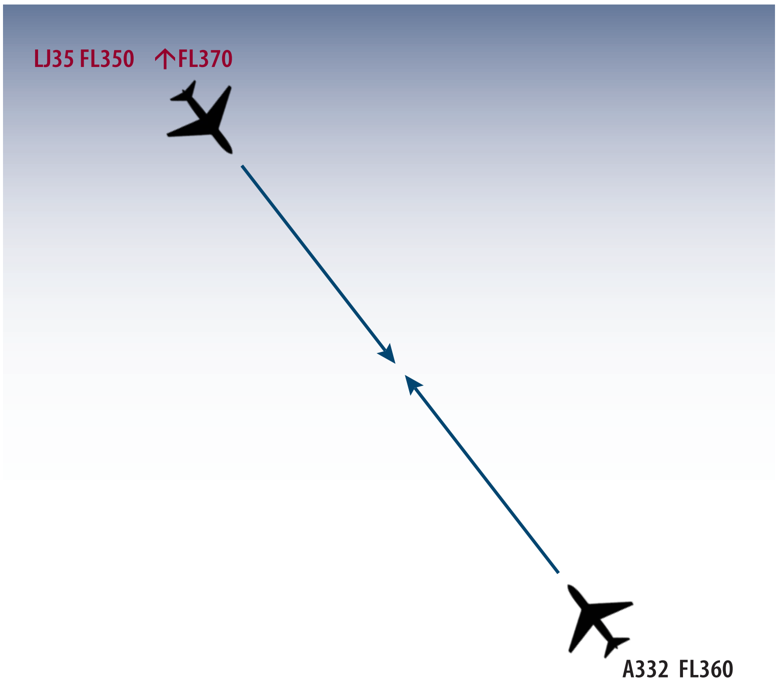
The controller also reported that he had assessed that the only traffic to affect the descent of A320 was a third aircraft, which was behind the CRJ7 at FL330, this was before he had turned CRJ7 direct. On doing so, he reported he had not adjusted his plan to include the CRJ7.

Generic Scenarios
B. Instruction to meet constraints

Contributing Factors
Group sector open for less than 15 minutes
Track Labels obscured
Flight data display not updated to reflect direct routing

4.8 Event 8: LJ35/A332

The LJ35 requested climb from FL350 to FL370 on first call to the sector. This climb was immediately approved by the controller bringing it into conflict with the A332, at FL360, which was opposite direction and 22 nm directly ahead. STCA triggered one minute later, when the aircraft were head-on at 8nm and 600ft apart. The controller twice gave avoiding action turns to the LJ35 but no response was received. He then gave an avoiding action turn to the A332. By now the aircraft were 3nm apart and 500ft. The A332 acknowledged but then immediately reported a TCAS RA.



TCAS reconstruction showed that the LJ35 did not respond to the TCAS instruction to climb. The operator said that the explanation for this was that the pilot was visual with the other aircraft.

The controller had taken over the sector 5 minutes before the incident. Traffic was light and although a Planning Controller was available close by, he took no part in the event. During the handover, the outgoing controller focused the incoming controller's attention to a conflict at the NE boundary and stated that it would need to be dealt with. The controller passed on several reasons as to why he should ensure that this conflict was resolved swiftly. The new controller's attention was focussed on this potential conflict and thus made decisions based on solving this problem. The new controller remembered thinking that giving the LJ35 the requested climb would resolve this future conflict and had not noticed the immediate conflict which was created by climbing the LJ35.

The controller described that in order to build situation awareness or mental picture he would ensure that the situation display was set to a preferred configuration and that the strip bay was organised in way to suit his way of working.

Generic Scenarios
D. Conflict resolution instruction

Contributing Factors
Group sector open for less than 5 minutes
Situation display and strip display not set to personal preference
Underload
Incorrect response to TCAS

4.9 Event 9: A319/A320

The sectors had just been split because of increase in workload.

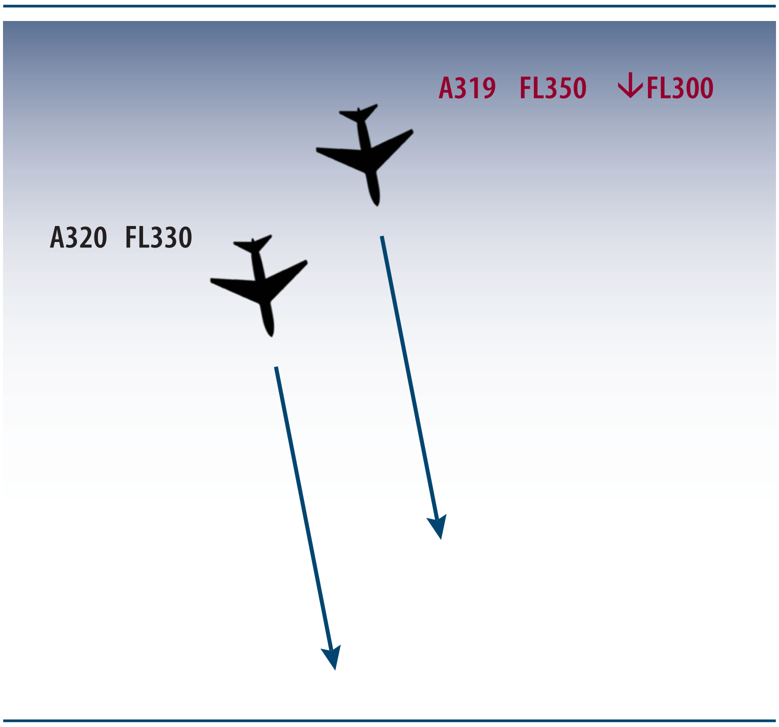
The A319 was southbound and called the sector level at FL350, requesting descent.

The A320 was also southbound but at FL330. It is on a similar track to the A319, about 2 nm ahead and 1 nm to its right.

The controller was concentrating on the "new" lowest level of his "new" sector and cleared the A319 to descent to FL300. He did not see the A320.

The coordinator is busy with coordination and does not detect the conflict.

The A319 takes a good rate of descent. STCA triggers. ATC turns the A319 30° to the left and the A320 30° to the right as avoiding action.



Generic Scenarios
A. Rushed vertical clearance

Contributing Factors
Group sector split within 5 minutes
Distraction due to assimilating to new sector boundaries/levels

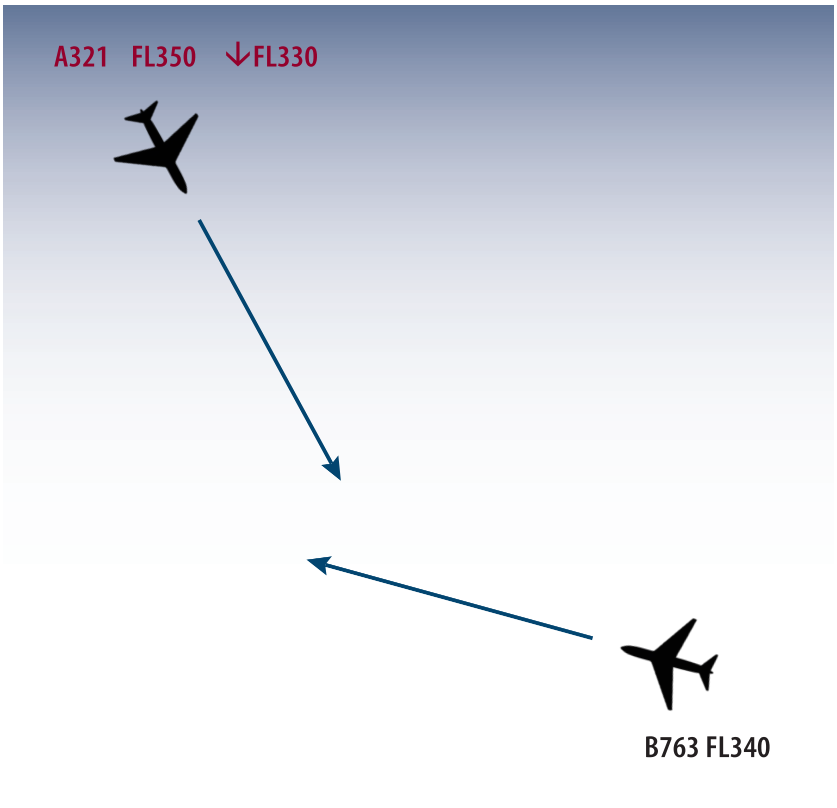
4.10 Event 10: A321/B763

There is turbulence at FL350 and FL370 so the controllers have to deal with a lot of Flight Level change requests which increased their workload.

The A321 was southbound at FL350. Its pilot reports light to moderate turbulence and requests information about the turbulence on its route. One minute later the A321 requests descent to FL330. ATC clears the A321 for FL330. The B763 is westbound at FL340 crossing left to right.

Two minutes later the B763 makes its first contact with the sector. The A321 is just leaving FL350 in its one o'clock position 30nm ahead. ATC gives the B763 it's routing but does not detect the conflict. Almost immediately STCA triggers. ATC turns the A321 30° to the right and the B763 20° to the right as avoiding action.

The controller had detected another potential conflict between the A321 and other traffic requesting a descent to FL350 and this was partly why ATC cleared the A321 to descend out of FL350 to FL330 but the ATC did not detect the conflict between the B763 and the descent of the A321 to FL330.



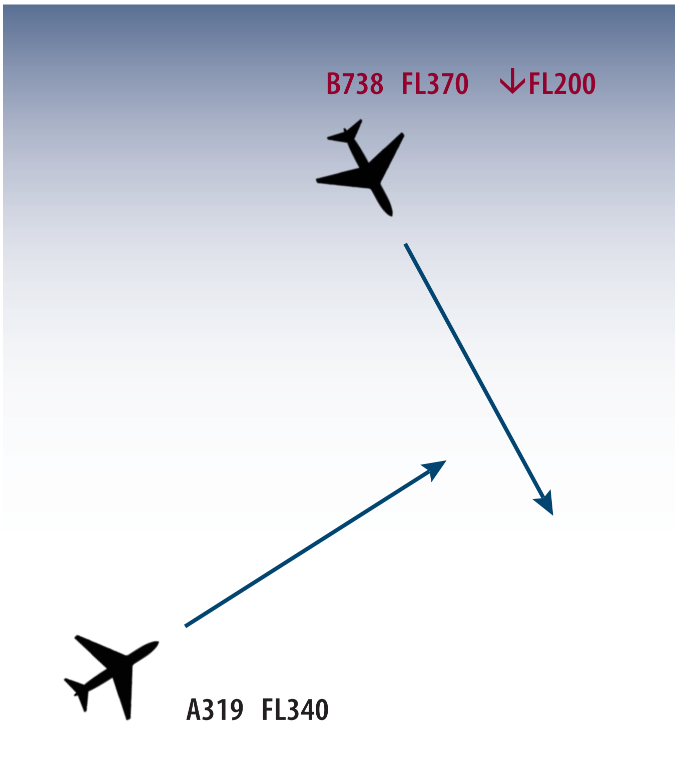
Generic Scenarios
A. Rushed vertical clearance

Contributing Factors
High workload due requests to avoid turbulence

4.11 Event 11: A319/B738

The sector had previously been complex and busy because of the presence of CB's resulting in a lot of requests for Flight Level or a heading change. The incident happened after it had calmed down but the ATCOs were reportedly tired.

The A319 was heading northeast and descending to FL340. An unrelated aircraft at FL360 requests and is cleared to FL380 after ATC momentarily forgetting that the highest level of the sector is FL365. The B738, southbound at FL370 **makes first call requesting descent. ATC immediately clears it to FL200**. As the coordinator was busy with co-ordinations, he did not notice the descent to FL200 given to the B738 until he saw it on the strip later.



The controller was distracted by his mistake and initiates a co-ordination with the Higher sector. A minute after ATC had cleared the B738 to descend from FL370 STCA triggers as it passes FL358 with a high rate of descend. ATC are however still focusing attention on the third aircraft, which following co-ordination, is cleared to FL400. Some 20 seconds after STCA, the controller sees the problem and asks the B738 to maintain FL350. It is passing FL350 and does not reply. ATC try to contact the B738 again, who replies that it passing FL340. ATC instruct it to expedite its descent through FL330. The B738 reports visual with the A319 and turns left, without clearance and levelled at FL340 (the same as the A319).

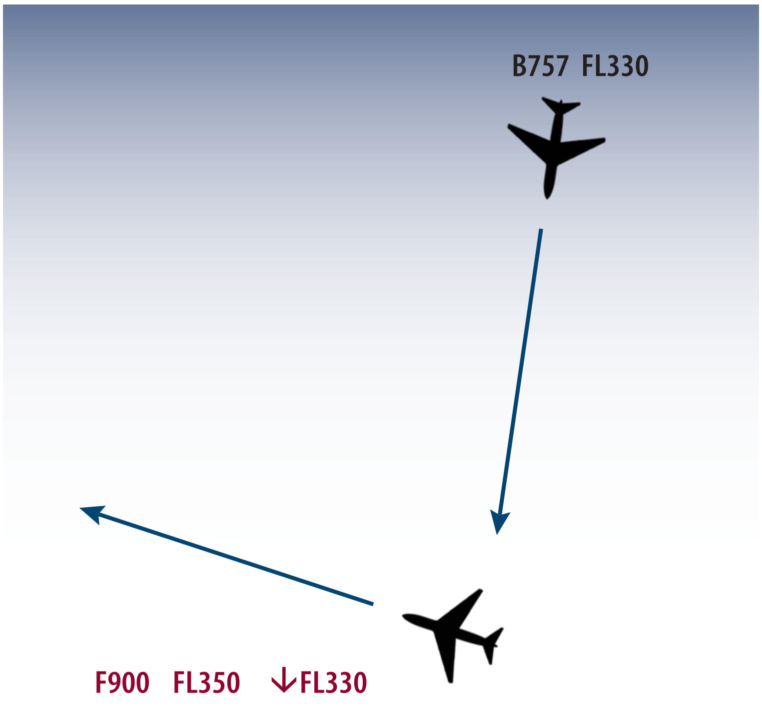
Not expecting the B738 to turn, ATC turned the A319 30° to the right. ATC cleared the B738 to FL200 again. The A319 then reports a TCAS climb RA. The B738 commences a descent at the same time. The B738 crossed 2.5 nm in front of the A319. ATC did not detect the conflict between the A319 and the B738 because, usually there is no conflicting traffic in this area but the A319 is not following his usual route because he is avoiding CBs. The controllers had a large space to cover in the horizontal plan as several sectors were grouped and the third aircraft was located at the west side of the sector while the A319 and the B738 were at the east side of the sector.

Generic Scenarios
A. Rushed vertical clearance

Contributing Factors
Controller fatigue
Distraction from resolving a known error
Flight data display not updated to reflect direct routing
Unauthorised and not notified avoidance turn and levelling aggravated event

4.12 Event 12: F900/B753

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



The B753 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 triggers. The F900 is crossing in front of the B753 left to right and approaching FL340.

When the conflict was spotted, ATC instructed the F900 to stop descent at FL340. The F900 does not reply. ATC repeat the instruction and the F900 answers he was cleared to FL330.

ATC tells the F900 to maintain FL340 because of traffic. The F900 responds that is already maintaining FL340 and that he has the traffic on TCAS and in sight, passing behind him.

Generic Scenarios
D. Conflict resolution instruction

Contributing Factors
Sector hand-over in progress
Direct routing given by adjacent sector not known to controller
Flight data display not updated to reflect direct routing

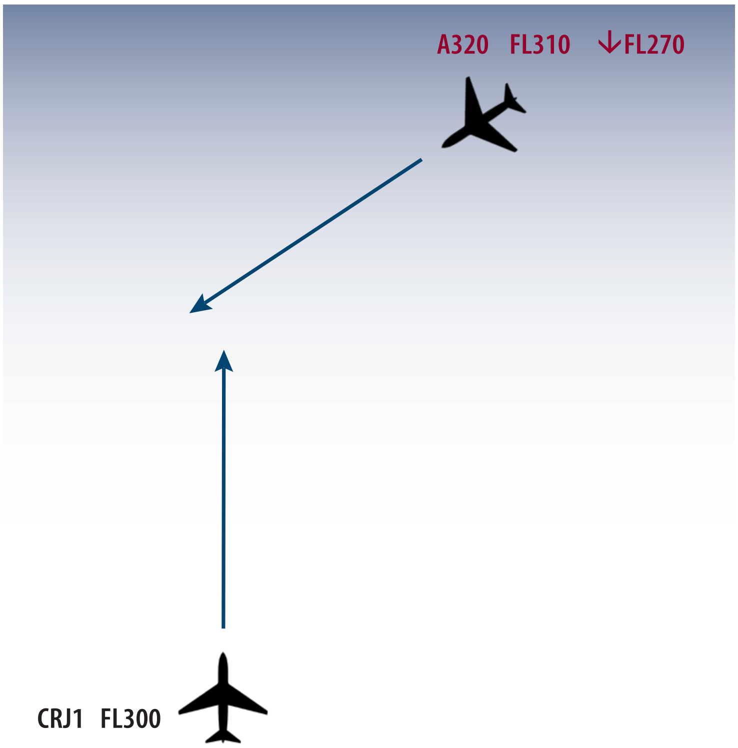
4.13 Event 13: CRJ1/A320

The sector was manned by a trainee, instructor and a coordinator. It was initially decided to split the sector, but as the trainee seemed to manage the situation, the controllers finally decided not to split the sectors. The situation then became more complex and it was no longer possible to split the sectors easily.

The A320 was heading southwest at FL310. The CRJ1 was heading north at FL300. The A320 will pass very close in front of the CRJ1 but 1000ft above.

The Trainee locked the A320 on its heading and cleared it to descent to FL270. 20 seconds later STCA triggered. A further 20 seconds later the trainee instructed the A320 to turn 30° the right. The A320 asks for confirmation of the clearance. The instructor took over the frequency and confirmed the instruction. Both aircraft respond to TCAS RAs.

The conflict between the A320 and the CRJ1 had been detected but the controllers were focused on a conflict between the A320 and a third aircraft and forgot the conflict between the CRJ1 and the A320 as the CRJ1 was just below the A320 and obscured when the controllers cleared him to descend. The CRJ1 had been given a direct routing by the previous sector that had not been coordinated.



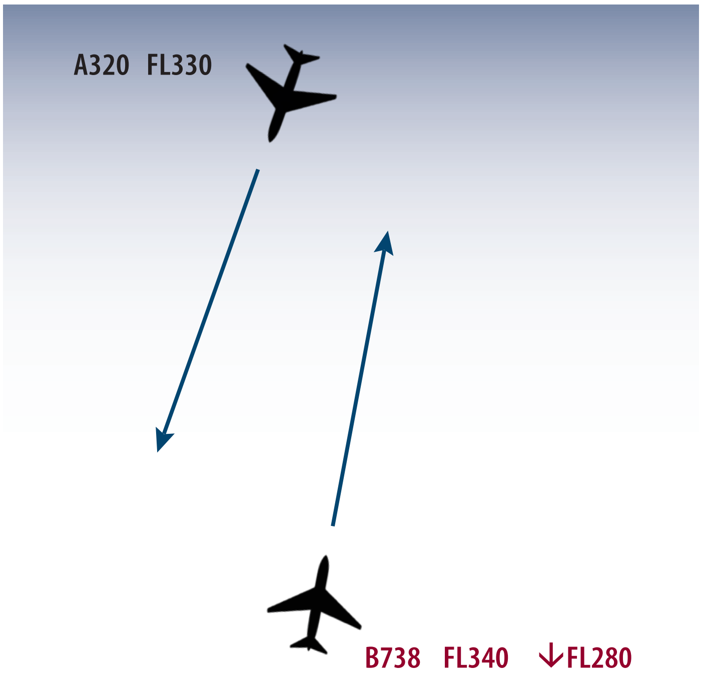
Generic Scenarios
D. Conflict resolution instruction

Contributing Factors
Sector split rejected and then too difficult when traffic increased
ATC training in progress
Mentor did not notice error or STCA
Non co-ordination of direct route from adjacent sector
Flight data display not updated to reflect direct routing
Track label obscured

4.14 Event 14: B738/B772

The sector was quiet. The B772 was heading South-southwest at FL330. The B738 was heading north at FL340 and will pass within 2nm of the B772, 1000ft above. The potential conflict between the B738 and the B772 had been spotted by the controllers while they were entering their sector.

ATC clears the B738 **to descend to FL280 in order to be at the correct sector exit level in time**. The coordinator is busy with coordination and does not hear the clearance given by the radar controller.



30 seconds later STCA triggers. The B738 was passing to the right of the B772 by about 2nm and descending through FL337. ATC turned the B772 left 80° as avoiding action. The B772 did not answer and did not turn. No avoiding action or information is given to the B738.

After the aircraft had passed, ATC asked the B738 if he had a TCAS-TA. The B738 affirms that he did. ATC asks the B772 why he did not turn. The B772 reports that he was handling the TCAS.

The coordinator had put a "warning" on the B772, as he was not answering anything on the frequency, a few minutes before the radar controller gave the clearance to descend to FL280 to the B738. The radar controller had forgotten the potential conflict between the B738 and the B772 and he did not see the B772 when he gave the clearance to the B738.

The radar controller was focused on the Flight Level he had to give to the B738 before the B738 reached the exit point of his sector.

Generic Scenarios
B. Instruction to meet constraints

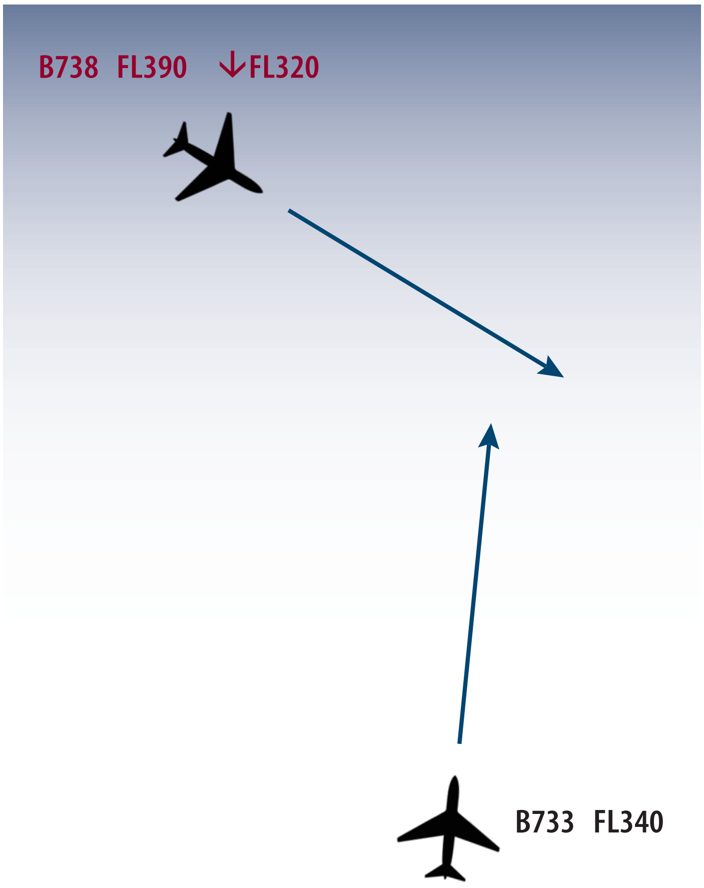
Contributing Factors
Underload

4.15 Event 15: B738/B733

The B738 was heading southeast descending from FL390 to FL350. The B733 was heading north at FL340. There was a spurious STCA alert due to the high rate of descent by the B738.

The B733 is told to contact the next sector (B). The B738 comes on to the sector (A) frequency. ATC clears the B738 to descend to FL320. It is some 15nm north of the B733 (which has been sent to sector B) STCA triggers when the B738 has already passed through the track of the B733 and is passing FL337. Sector B turns the B733 left 20° and gives traffic information. The B733 reports that the traffic is passed. Sector A turns the B738 30° left. He starts to call the B733 but realizes he is no longer on his frequency.

The Sector A controller was focusing on a potential conflict between the B738 and a third aircraft when he gave to the B738 the clearance to descend to FL320 and did not consider the B733 because he had transferred this traffic to sector B forgotten about it.



Generic Scenarios

D. Conflict resolution instruction

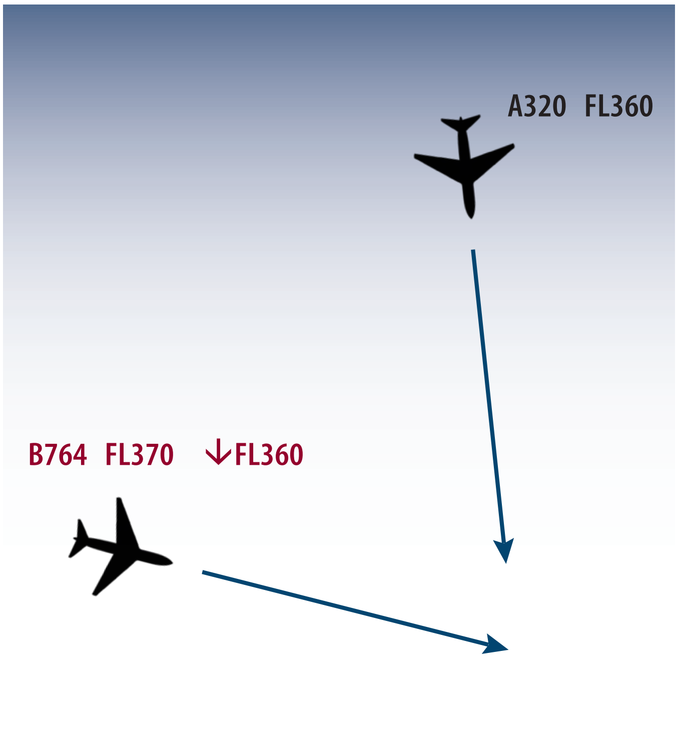
Contributing Factors

Early transfer of traffic out of sector

4.16 Event 16: B764/A320

The B764 was eastbound at FL370. The A320 was southbound at FL360. The aircraft were under the control of a combined frequency configuration of 3 Sectors. The controller instructed the B764 to descend to FL360 as a first step towards its exit level of FL270. The A320 was in its 10:30 position, 10 nm away, crossing left to right.

STCA activated unheeded for almost a minute before the controller reported that his attention was drawn back to his own situation display by the call from the A320 "er Centre, (callsign)", which he described as being in a "questioning tone". He saw the STCA at that point and realised his mistake. He instructed the A320 to descend immediately FL350. The A320 however reported that he was responding to a TCAS RA. The B764 confirmed that it too had responded to an RA.



The controller reported that he was aware from the times on his strips of a potential conflict between the subject B764 and a separate B734 which were both at FL370 on crossing tracks. As the cross was still some considerable way off, he decided no action was necessary at the time but cocked the strips for the two aircraft out as a reminder to descend the B764 in good time.

When the A320 called on his frequency, the controller reported that he identified the B764 as a confliction and therefore climbed the A320 only to FL360. He considered that he had resolved the potential confliction and moved on to other tasks.

The controller was then unable to establish two-way communications with an aircraft elsewhere in the sector despite repeated attempts. He stated that as he was doing this, he became more and more distracted by thoughts about how a loss of communications with this aircraft might impinge on the sector and the actions he may be required to take in order to re-establish contact. The controller considered that the extra attention he gave to this issue increased his overall workload and he reported feeling irritated, particularly as he had previous experience of communication problems with this operator.

The Supervisor decided to split the sector and, in preparation for this, the controller began to transfer aircraft to the correct frequencies within the sector group. When the controller reached the B734 in his handover, **he informed the incoming controller that he had cocked out the strips on B764 and the B734 as a potential conflict existed and that he would descend the B764 now to FL360 to resolve this. He stated that his decision to descend the B764 prior to transferring the aircraft to the incoming controller was influenced by the number of strips that were being put in front of his colleague and he was keen to help. He instructed the B764 to descend FL360 without referring to his own situation** display or the paper flight progress strips, as he was still turned towards his new colleague. He stated that neither the A320 nor the B764 were visible on his colleague's situation display and he had forgotten about the presence of the A320. Although he wrote the descent clearance on the B764 paper flight progress strip, it was not adjacent to that of the A320. The Planning controllers did not detect the conflict as they were busy with their own sector split at the time.

The following learning points were identified with the help of the controllers involved:

The controller considered that the sector split prompted him to descend the B764 much earlier than he would have done otherwise. He tried to be helpful in response to the upcoming traffic load on the adjacent sector by sorting out the potential conflict for the incoming controller. In so doing, although working to a plan he had already constructed to resolve the conflict, he would appear to have made a hasty decision which he also executed in haste.

The controller was distracted by his inability to communicate with an aircraft prior to the handover. This, coupled with the distracting effect of the sector split, reduced the controller's focus on the entire sector.

Generic Scenarios
D. Conflict resolution instruction

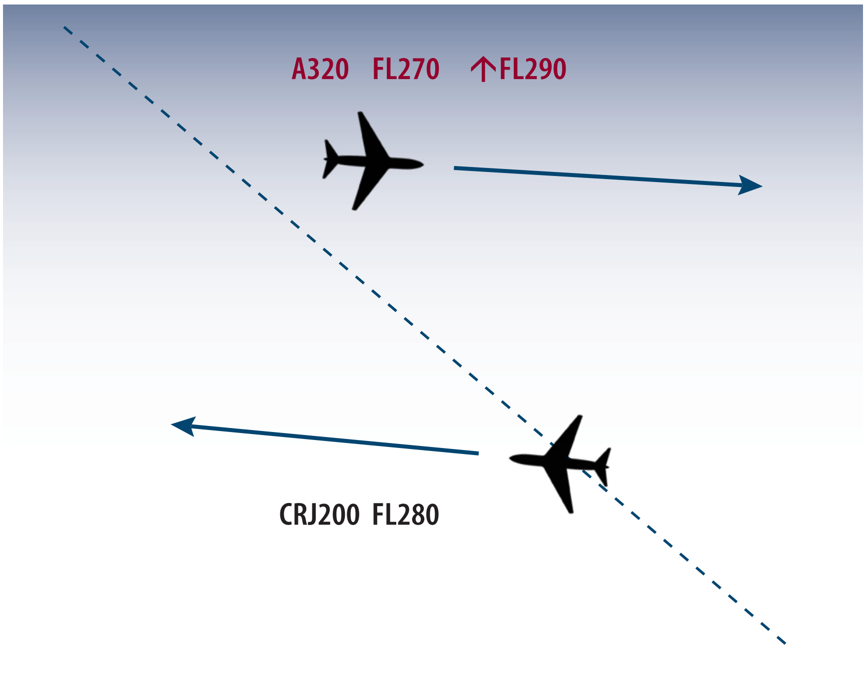
Contributing Factors
Sector split in progress
Over willingness to resolve future problems for new controller without adequate scanning.
Flight data display not updated to reflect direct routing
Distraction due to communications problem with unrelated aircraft

4.17 Event 17 A320/CRJ200

The CRJ200 is sent from Sector A to Sector B very early, climbing to FL280. Because of the Change of Control the label and track of the CRJ200 changes colour from a bright light blue to a suppressed light brown. The A320 is opposite direction and is transferred from Sector B to Sector A near the boundary, climbing to FL270. The label and track of the A320 is in the bright concerned/active state. **The Sector A clears the A320 to continue climbing to FL290**, having forgotten about the CRJ200.

The CRJ200 is tracking several miles north of its normal routing, but the controller has moved its label from the default northeast position to the south and displaced by a line from the target to the label. This effectively places the track label of the CRJ200 to a position where the aircraft would normally be. The A320 is, fortuitously, tracking some 3 nm north of the CRJ200 on a reciprocal heading.

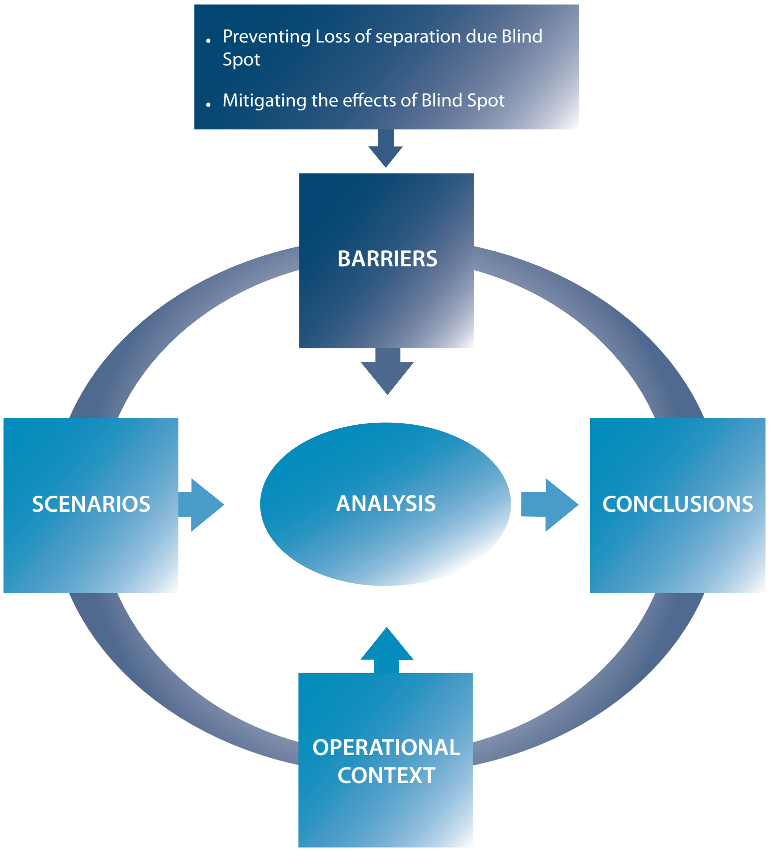
STCA does not trigger as it is just outside its parameters. None of the four ATCOs on the two sectors see the conflict until the pilots query traffic on TCAS.



Generic Scenarios
A. Rushed vertical clearance

Contributing Factors
Early transfer of traffic still within the sector
Track labels obscured
Individual TDB manually re-positioned giving false perception.

CHAPTER 5 - BARRIERS



5.1 Barriers as risk reduction opportunities

The Barriers included in this risk analysis have been identified as possible ways that Loss of Separation due Controller Blind Spot could be prevented or the consequences mitigated. Their inclusion does not imply that they are relevant to all situations and neither does it imply that their adoption by aircraft operators or ANSPs as a group would necessarily be appropriate. It may be possible to identify more potentially useful barriers than are included here.

Opportunity versus responsibility

In order to define the specific barriers it is useful first to define the generic barrier groups for reducing the risk of Loss of Separation due Controller Blind Spot.

The figure below represents a generalised SAFMAP for Mid-Air Collision in En-Route airspace at the top, level 0, of the safety functions.

The Highlighted block under Tactical Conflict is the act of ATC to break that barrier. There is the opportunity to correct the error before any separation minima infringement. When this opportunity is not taken the barriers become collision avoidance barriers. Firstly for ATC, then by pilot resolution with the aid of ACAS. The last barriers are pilot resolution by visual acquisition and when all positive barriers are broken the final collision prevention barrier is providence i.e. good luck.

Mid-air collision en-route SAFMAP v0.8 - Level 0

PROVIDENCE

POTENTIAL COLLISION UNRESOLVED BY VISUAL WARNING

CA_V01 The other aircraft is visible	**CA_V02** Crew observes the visible a/c in time	**CA_V03** Crew initiates action on time	**CA_V04** The avoidance action is correctly implemented and collision is avoided

POTENTIAL COLLISION UNRESOLVED BY ACAS COLLISION AVOIDANCE

ACAS03 Functional ACAS and transponder	**ACAS04** Correct and timely RA	**ACAS06** RA maneuver is possible	**ACAS05** RA is detected and correct, on time collision avoidance is initiated	**ACAS08** The avoidance action is correctly implemented and collision is avoided

ACAS01 - The closest point of approach distance is higher than ACAS trigger (ACAS RA not needed)

POTENTIAL COLLISION UNRESOLVED BY ATC COLLISION AVOIDANCE

CA_ATC02 Opportunity for ATC collision avoidance	**CA_ATC03** The infringement is detectable and ATCO detects it	**CA_ATC04** Effective ATC decision and action	**CA_ATC05** Communication is functional	**CA_ATC06** Adequate Communication	**CA_ATC07** Crew acts on time on the ATC collision avoidance instruction	**CA_ATC08** The avoidance action is correctly implemented and collision is avoided

CA_ATC01 - No need for ATC collision avoidance - ATC Collision avoidance is not challenged - e.g. diverging trajectories

SEPARATION INFRINGEMENT / INADEQUATE SEPARATION

SIP02 Opportunity for ATC tactical resolution	**SIP03** The conflict is detectable and ATCO detects it before the separation infringement	**SIP04** Effective ATC decision and action	**SIP05** Communication is functional	**SIP06** Adequate Communication	**SIP07** Crew acts on time on the ATC infringement prevention instruction	**SIP08** Adequate pilot action and infringement is prevented

SIP01 – No need for ATC separation infringement prevention - ATC Infringement Prevention not challenged – e.g. crew acts

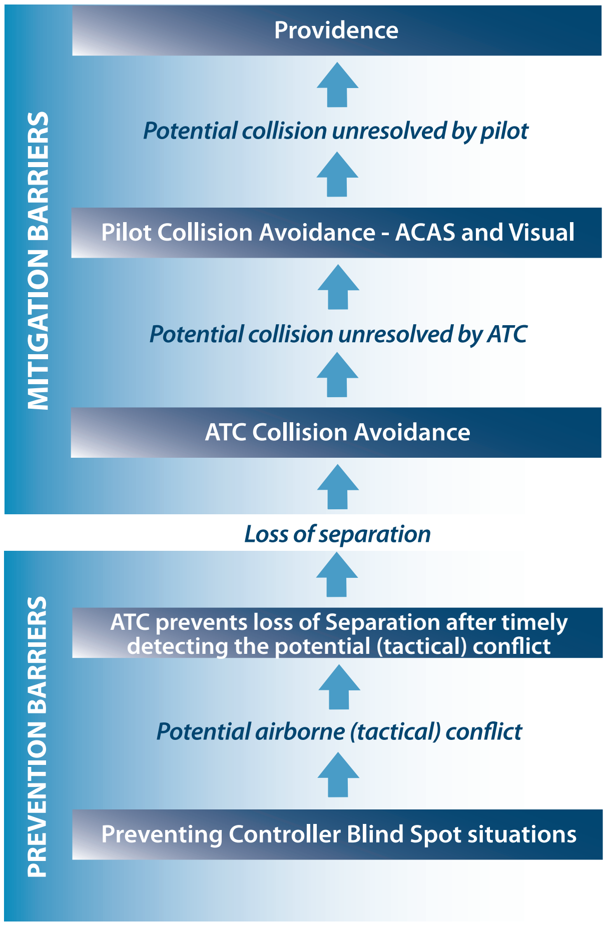
TACTICAL CONFLICT

TCP01 Pre-tactical conflict prevented by ATC tactical planning	**TCP02** Preventing tactical conflict caused by clearance deviation	**TCP03** Preventing tactical conflict caused by airspace infringement	**TCP04** Preventing conflict generated by the ATC plan of work	**TCP05** Preventing conflict generated by AG Communications	**TCP06** Preventing conflict generated by military activity

5.2 Two types of barriers

A barrier model

The straight line route of the barrier failures can be shown more simplistically as the figure bellow.



Balancing preventing and mitigating the risk associated with Loss of Separation due Controller Blind Spot

There are two sets of barriers which can reduce the risk associated with Loss of Separation due Controller Blind Spot. These barriers have been identified from both a wide literature search and from consultation. These are:

- Barriers to prevent the occurrence of a Loss of Separation due to inefficient detection of conflict with the closest aircraft.
- Barriers to mitigate the consequences of a Loss of Separation due to inefficient detection of conflict with the closest aircraft.

5.3 Barriers which may **prevent** a loss of separation due to inefficient detection of conflict with the closest aircraft

Barriers preventing loss of separation

PB1 Medium term conflict prediction tools with route updates (e.g. **MTCD**). These are tools that predict the trajectory of the aircraft in mid-term of up to 20-30 minutes and are usually based on flight plan information, updated with surveillance information about the position and speed of the aircraft and actual and forecasted meteorological information. Considering the aircraft type performance the tools calculate if the aircraft will come into conflict with another aircraft. Some medium term conflict detection tools are equipped with functionality for the controller to update the route of the aircraft should this not follow the flight planned route.

PB2 Routine Structured Scan. Scanning is a basic building block in ATC and Pilot training. Prior to making an executive decision the controller should scan all of the appropriate information, including the situation display and the flight data (strips or other information). It is akin to crossing the road. Listen, check right, check left, check right again. In ATC, it is check situation display, check flight data (strips), check co-ordinations agreed, evaluate immediate situation, and consider future implications – all to be done between "standby" and "affirm".

PB3 Operational Team Resource Management (available, vigilant and proactive colleagues). This barrier can be both preventative and mitigational. Proactive team work may involve making a mistake less likely by encouraging/suggesting a plan to a colleague, pointing out potential conflicts or building in assured safety in co-ordinations. It may also prevent the loss of separation by the alerting of a colleague to an apparent error or misjudgement before separation minima has been compromised.

PB4 Short Term Conflict Probe (What if). There are various forms of "What if" or Level Assessment tools available to probe the safety of an offered level change. To some extent, it fulfils the role of Scanning.

PB5 Predictive Separation Alert Tool (e.g. **STCA**) with ATC intentions inputs like Cleared Flight Level (CFL). CFL allows the predictive STCA to identify conflicts much earlier and to identify them even before the crew start the execution of the conflicting clearance.

PB6 Predictive Separation Alert Tool (e.g. **STCA**) with flight crew intentions inputs like the downlinked Final State Selected Altitude (FSSA or Selected Flight Level) are used by STCA for detecting conflicts early in advance.

Some medium term conflict prediction systems have tactical update facility. This part of their functionality falls within this study description of predictive STCA with flight crew intentions inputs. The NATS Separation Monitor (part of the iFACTS architecture) is such an example. The system starts with the FPL routing but updates tactically when the aircraft deviates from that route. The display is updated according to downloaded aircraft headings and selected flight levels.

Three other Preventative barriers were considered for this study:

Additional barriers

- **Pre-planned 4D Separation**
  Pre-planned 4D is generally aspirational. One form of 4D planned separation has been in use in Oceanic Airspace for many years. Events caused by ATC error, blind spot or otherwise, are extremely rare. The downside is that standard separation is 60nm laterally or 10 to 15 minutes in time. In En-Route airspace 4D planning is a medium term project and excluded from this operational safety study.
- **Removal of non-operational distractions**
  A ban on non op-related distractions was considered and rejected. It would only affect a contributory factor and not the deterministic reasons for the scenarios.
- **Airspace Design**
  Removal of planned congested crossing points. This study considered the safety gains that could be achieved by a re-designing airspace barrier such to remove the possibility of a conflicting traffic in case of other, independent deviation. Although a good guiding principle for airspace design, this was considered not universally feasible.

5.4 Barriers which **may mitigate the consequences** of a loss of separation due to inefficient detection of conflict with the closest aircraft

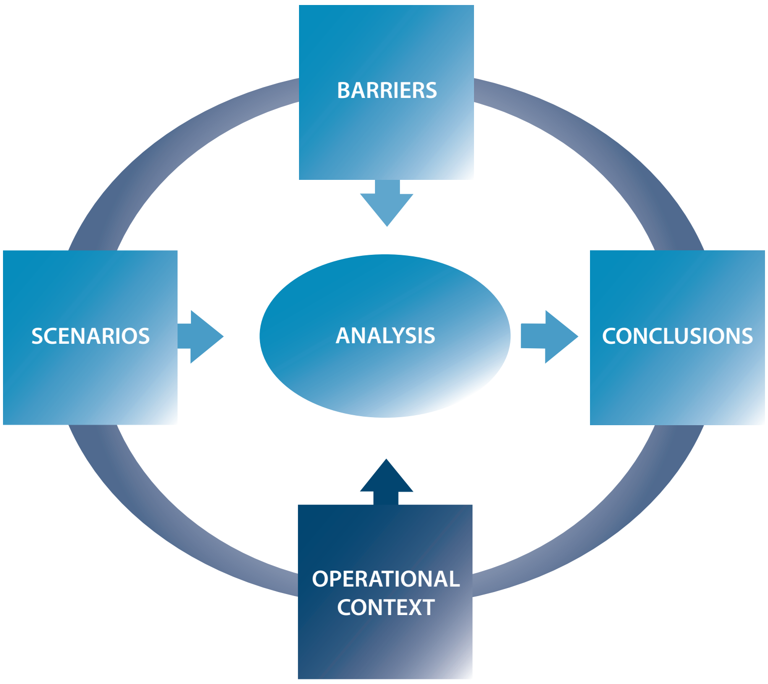
The first step was to define broad priority areas for further prioritisation

Using the SAFMAP barrier model, several barriers were identified which could mitigate the consequences of a loss of separation due to inefficient detection of conflict with the closest aircraft. Between those are:

- Routine Structured Scan.
- Operational TRM – colleague warning.
- Short Term Conflict Alert.
- ACAS.
- See and avoid.
- Providence (geometry of encounter).

The analysis of the mitigation barriers against the generic and actual scenarios led to the conclusion that these barriers are generic. Their presence and effectiveness are independent of the blind spot as a reason for the loss of separation. It was therefore decided not to retain in the analysis a review of the mitigation barriers effectiveness against the blind spot scenarios.

CHAPTER 6 - OPERATIONAL CONTEXT



6.1 Differentiator or not?

No differentiation of Operational Context for the purpose of this study

In the European En-Route environment there is very little variation in Operational Context. Short Term Conflict Alert in one form or another is present virtually everywhere.

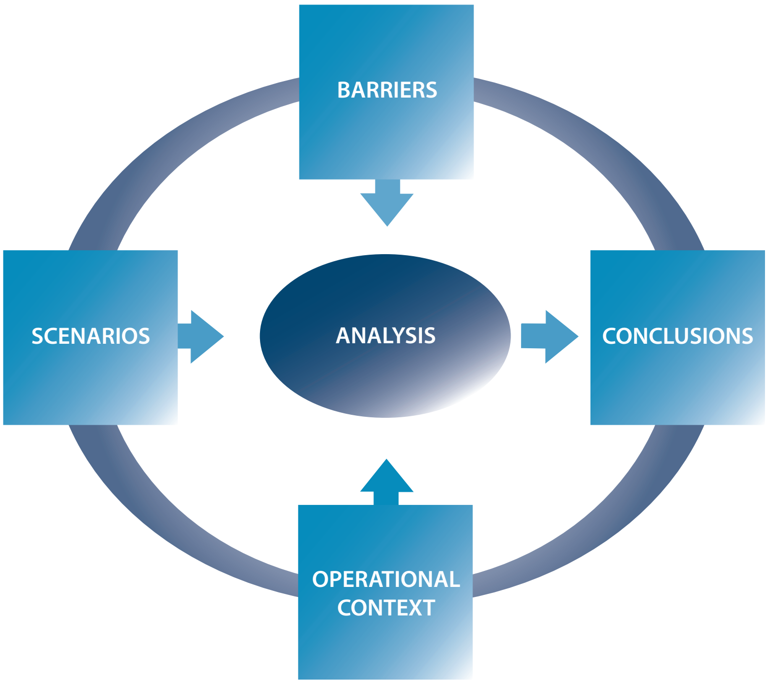
The carriage of TCAS up to Version 7 is a common European requirement. Some States may stipulate more stringent requirements.

Area Control Centres will have some functionality that others do not have, but this study is by nature generic across the European theatre of operation.

It is concluded that there is insufficient cause to consider differing Operational Contexts for this study apart from:

- Time and workload pressures.
- The type of the conflict: horizontal, vertical or both.

CHAPTER 7 - ANALYSIS



7.1 Analysis of Prevention Barriers

OPERATIONAL SCENARIOS:	PREVENTION BARRIERS EFFICIENCY[1]:					
	PB1: MTCD with route update.	**PB2:** Structured Scan, including flight data.	**PB3:** TRM	**PB4:** Short-term conflict probe.	**PB5:** Predictive STCA with CFL.	**PB6:** STCA with FSSA.
A: Rushed vertical clearance after a pilot request	MTCD is used for medium-term planning and is not efficient for tactical conflicts prevention.	Under time pressure and workload it is more difficult to integrate two dimensional information into three dimensional mental picture.	In efficient and cost-effective operations the planner will be busy with his job - concentrating on another time horizon.	The probe is purely preventive compared with STCA, but, as it is hypothetical, will depend on the ATCO willingness to use it.	It is not purely preventive and will depend on the timely provision of resolution instruction and crew comprehending and executing it on time.	Depends on the proximity but will be triggered later compared with the STCA with CFL.
B: Instruction to meet constraints.	MTCD can help to identify and highlight early in the planning some of the potential conflicts if constraints are to be met.	Under time pressure and workload it is more difficult to integrate two dimensional information into three dimensional mental picture.	Depends upon time available and the ability of the operational colleague to become aware of the issue. If a colleague is plugged in on the same frequency as the Executive controller, then there is opportunity	The probe is purely preventive compared with STCA, but, as it is hypothetical, will depend on the ATCO willingness to use it	It is not purely preventive and will depend on the timely provision of resolution instruction and crew comprehending and executing it on time.	Depends on the proximity but will be triggered later compared with the STCA with CFL
C: Clearance not following the horizontal Flight Plan Route.	MTCD can help to identify some of the potential conflicts after the route update.	Easier to detect potentially conflicting traffic on a horizontal plane	Depends upon time available and the ability of the operational colleague to become aware of the issue. If a colleague is plugged in on the same frequency as the Executive controller, then there is opportunity.	Horizontal manoeuvres are not probed for conflicts.	Conflicting horizontal manoeuvres may be highlighted late for proper prevention of the separation loss.	Conflicting horizontal manoeuvres may be highlighted late for proper prevention of the separation loss.
D: Conflict Resolution Instruction.	MTCD is used for medium-term planning and is not efficient for tactical conflicts prevention	Under time pressure and workload it is more difficult to integrate two dimensional information into three dimensional mental picture.	Depends upon time available and the ability of the operational colleague to become aware of the issue. If a colleague is plugged in on the same frequency as the Executive controller, then there is opportunity.	Prevention support only for vertical resolution instructions.	Conflicting horizontal manoeuvres may be highlighted late for proper prevention of the separation loss.	Conflicting horizontal manoeuvres may be highlighted late for proper prevention of the separation loss.

1 Note: Red shading defines either an inefficient barrier or barrier that is not intended for the operational scenario, yellow shading defines barrier that is partially effective or partially efficient for the operational scenario or efficient under certain conditions, and green shading defines barrier that is effective and efficient for the operational scenario.

7.2 Top 4 Potential Prevention Barriers

PB5 Predictive Separation Alert Tool (e.g. STCA) with ATC intentions inputs like Cleared Flight Level (CFL) has the potential to prevent all losses of separation caused by Blind Spot. This barrier is less efficient in proactively identifying potential conflicts due to unplanned horizontal manoeuvres towards a proximate aircraft. The barrier may be affected by the consistency of inputting the Cleared Flight Level (CFL) information in the system.

PB4 Short Term Conflict Probe has the potential to prevent most losses of separation caused by Blind Spot but scenarios of clearance not following the horizontal flight planned route as the existing probes are 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 character can also be considered by some controllers as a drawback and affect their willingness to use it.

PB5 and PB4 have the highest number of Green responses; however PB5 has the highest combined Green/Yellow (always/sometimes) rate.

PB7 Structured Scan has the potential to prevent most losses of separation caused by Blind Spot. There is a caveat that the 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 confliction. Time pressure and workload may erode the attention that the controller is able to give to each piece of information and working knowledge may then become layered and the filtered. When a controller becomes under pressure, a "return to basics" such as using a structured scan before making an executive decision would reduce the likelihood of controller error.

PB6 Predictive Separation Alert Tool (e.g. STCA) with flight crew intentions inputs has the potential to prevent all losses of separation caused by Blind Spot blinds spot. The barrier efficiency will depend on the proximity of the conflicting aircraft and will be triggered later compared with the STCA with CFL inputs. On the other hand this barrier will not depend on the controller consistency in inputting the CFL into the system. The cases of flight crew manually manoeuvring the aircraft before entering the FSSA will be less frequent.

The best prevention strategy

The analysis reveals that there is no single barrier that can efficiently and universally prevent all the scenarios of blind spot. A combination of PB2, PB4, PB5 and PB6 seems to deliver the best reliable protection to prevent losses of separation because of blind spot events.

7.3 Analysis of contributing factors apparent in actual events

Preventing the contributing factors will not prevent the blind spot occurrences but would only reduce the chance of them to happen Although probabilistic; there is considerable prevention potential in addressing some of the most frequent contributing factors.

The analysis reveals that the highest prevention potential is associated with addressing the following contributing factors:

The 3 most frequent contributing factors

- **Flight Data Display not being effective in highlighting conflicts**, particularly where one or both aircraft were not following the Flight Plan route, was a contributing factor in more than half of actual events studied.
- **Track labels being obscured**, either by function or by manual selection, was a contributing factor in a significant minority of actual events studied. This involves labels overlaps but also situations when the label was in other, unconcerned colour that makes it less visible. These include situations when the aircraft was in the volume of controlled airspace but was not under control. Some ANSPs has successfully adopted a new functionality that displays part of the track label (the Aircraft Identity) still in concerned colour in case the aircraft is not anymore under control but is still in the physical volume of controlled airspace, extended with some additional airspace buffers.
- **Sector hand over or a short-time post sector handover** were contributing factors in a significant minority of the actual events studied.

An important observation

An important observation/assumption was made by two ANSPs that the use or not by Controller of the velocity line of the track labels is correlated with some of the blind spot occurrences.

Indeed, if we assume a layered situational awareness of the controller, one layer will be fixed in "now" time and one layer – in a future time horizon of some minutes ahead time (depends on the size and complexity of the sector). What would be "left", is some "gap" in the time for the next, up to a minute or two, time horizon. This "gap" in time can be expressed as a "hole" or a "blind spot" around the aircraft. The use of a velocity leader could help bridging this gap.

Currently there is no empirical evidence to confirm this assumption.

CHAPTER 8 - OTHER STUDIES AND REFERENCES

8.1 NATS

Post-incident discussions between controllers and Human Factors specialists in NATS quote controllers describing that in order to build situation awareness (SA) or mental picture they would ensure that the situation display was set to a preferred configuration and that the flight data/strip bay was organised in way to suit their way of working.

Note: *A question must be why do individual controllers feel the need to vary away from the pre-set bi-modal operation to operate at their perceived peak efficiencies?*

Secondly, following the thrust of Safety II (see 7.5) does this individuality enhance the frequency of getting it right most of the time or is it a Threat?

Recent visual scanning research carried out within NATS has revealed that the visual scanning patterns within the first fifteen minutes after a handover is substantially different to the visual scanning patterns after this time period. It is therefore highly likely that controllers are still building situation awareness in the first 10 to 15 minutes. This finding aligns with the high percentage of incidents in these early minutes of a control session. Broad research shows that 25% of all incidents occur within 15 minutes after a handover has taken place. This small selective study on "controller blind spot" puts that number above 30% for this type of event.

8.2 EUROCONTROL Experimental Centre - Kirwan Barry - Incident reduction and risk migration. Safety Science 49 2011

An analysis of blind spot incidents at a European ACC suggested that they were happening via what may be called 'layered situation awareness'. Layered situation awareness relates to the need to handle the demands of significant traffic against a background of other traffic. The controller, in order to deliver a high capacity and quality service, focuses on traffic that has short term demands, e.g. a need to climb or descend, or to be at a certain lower sector exit flight level, yet wanting to remain at a cruising altitude as long as possible (to conserve fuel). The controller therefore mentally suppresses or 'filters out' aircraft not of immediate concern. He may not only filter out traffic that is no longer under his command, but also certain current aircraft that are relatively 'invariant' in their passage across the sector, e.g. they are staying at cruise level. These aircraft are akin to 'blind spots' – they are not seen. This complex approach, which is partly proactive and partly opportunistic, and is focused on giving good service to aircraft, means the controller is thinking ahead much of the time, as well as focusing on what is on the situation display at the time.

Note: *This thinking ahead to resolve future problems is shown to be the number one generic scenario in this current study.*

This has been evidenced by former studies on what is called the 'mental picture' (or simply, the 'picture'). Controllers retain a mental image of the traffic situation in their heads. Even if the situation display is suddenly switched off, controllers can recall where each aircraft was and at what flight level. Eye movement studies have found controllers looking to where the aircraft were on the situation display prior to blackout.

Staying ahead of the game means the controller may not always be focusing on what is actually there in front of him or her, and hence this allows 'blind spots', with certain signals (considered unimportant for the future picture) allowed to fade into the background.

A small number of events involved a situation of controller 'underload'. Several theories have been put forward as to why controllers have 'underload' events. One such theory, Malleable Attentional Resource Theory (MART), posits that mental underload can lead to performance degradation due to the shrinkage of attentional resources, hypothesising that attentional resource changes in response to the demands of the environment. Extrapolating from these results leads to the suggestion that mental underload can be detrimental to performance, just as mental overload can, due to the diminishing levels of attention. Unused attention could overspill into the perception of unrelated tasks which then act as a distracter and introduces a potential risk to the underloaded controller.

Kirwan posited that the layered filtering methodology developed for use in high workload situations 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, it is suggested that 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').

8.3 ICAO - Threat and error management (TEM)

The Threat and Error Management approach is a component of NOSS (Normal Operations Safety Survey) (ICAO, 2005), and comprises three basic components in its model. The TEM conceptual framework assists in understanding the inter-relationship between safety and human performance in dynamic operational contexts. The TEM model poses that: (1) Threats and Errors are part of everyday aviation operations that must be managed by air traffic controllers; (2) Both Threats and Errors carry the potential to generate Undesired States; (3) There is no linear relationship between Threats, Errors and Undesired States. Managing an Undesired State represents the last opportunity to avoid an unsafe outcome and thus maintain safety margins in ATC operations.

Threat management is the process of detecting and responding to threats with counter-measures that reduce the probability of entering undesired states.

TEM implicitly has as its focus 'normal operations' and so is relevant to the edge of the normal performance envelope, and can be a means of finding out how often such performance envelope edges are crossed, under what circumstances, and how the situations are recovered safely. The focus on normal operations aligns closely with the latest thinking in Europe, which is called from Safety I to Safety II.

8.4 From Safety-I to Safety-II: A White Paper (DNM Safety EUROCONTROL 2013)

The number of global ATM movements more than doubled between 1988 and 2008. An accident is a rare event – the equivalent of one accident for every 500,000 flights in 2012. For Western-built jets, the accident rate is lower still, with six hull-loss accidents in 2012 - equating to one accident for every 5 million flights.
Pilots, controllers, engineers and others have achieved these results because they have been able to adjust their work to match the conditions. Yet when we try to manage safety, we focus on the few cases that go wrong rather than the many that go right. But focusing on rare cases of failure attributed to 'human error' does not explain why human performance practically always goes right and how it helps to meet ATM goals. Focusing on the lack of safety does not show us which direction to take to improve safety.

The current state of affairs represents a common understanding of safety, which we shall call Safety-I.

Safety – I defines safety as "a condition where the number of adverse outcomes is as low as possible".

The Safety-I view does not explain why human performance practically always goes right. The reason that things go right is not people behave as they are told to, but that people can adjust their work so that it matches the conditions. As systems continue to develop, these adjustments become increasingly important for successful performance. The challenge for safety improvement is therefore to understand these adjustments, beginning by understanding how performance usually goes right.

Safety management should therefore move from ensuring that 'as few things as possible go wrong' to ensuring that 'as many things as possible go right'. This perspective is termed Safety-II and relates to the system's ability to succeed under varying conditions. According to Safety-II, the everyday performance variability needed to respond to varying conditions is the reason why things go right. Humans are consequently seen as a resource necessary for system flexibility and resilience. The safety management principle is continuously to anticipate developments and events. The purpose of an investigation changes to understanding how things usually go right as a basis for explaining how things occasionally go wrong. Risk assessment tries to understand the conditions where performance variability can become difficult or impossible to monitor and control.

While many adverse events may still be treated by a Safety-I based approach without serious consequences, there is a growing number of cases, such as Controller **Blind Spot events**, where this approach does not work and leaves us unaware of how everyday actions achieve safety. The way forward therefore lies in moving toward Safety-II while combining the two ways of thinking. Most of the existing methods and techniques can continue to be used, although possibly with a different emphasis. But the transition toward a Safety-II view will also include some new practices to look for what goes right, focus on frequent events, remain sensitive to the possibility of failure, to be thorough as well as efficient, and to view an investment in safety as an investment in productivity.

The solution to this is surprisingly simple: instead of only looking at the one case in 10,000 where things go wrong, we should also look at the 9,999 times where things go right in order to understand how that happens. We should acknowledge that things go right because people are able to adjust their work to the conditions rather than because they work as imagined. Resilience engineering acknowledges that acceptable outcomes and unacceptable outcomes have a common basis, namely everyday performance adjustments.

Look for what goes right. According to this view we should avoid treating failures as unique, individual events, and rather see them as an expression of everyday performance variability. Something that goes wrong will have gone right many times before – and will go right many times again in the future. Understanding how acceptable outcomes occur is the necessary basis for understanding how unacceptable outcomes happen. In other words, when something goes wrong, we should begin by understanding how it (otherwise) usually goes right, instead of searching for specific causes that only explain the failure.

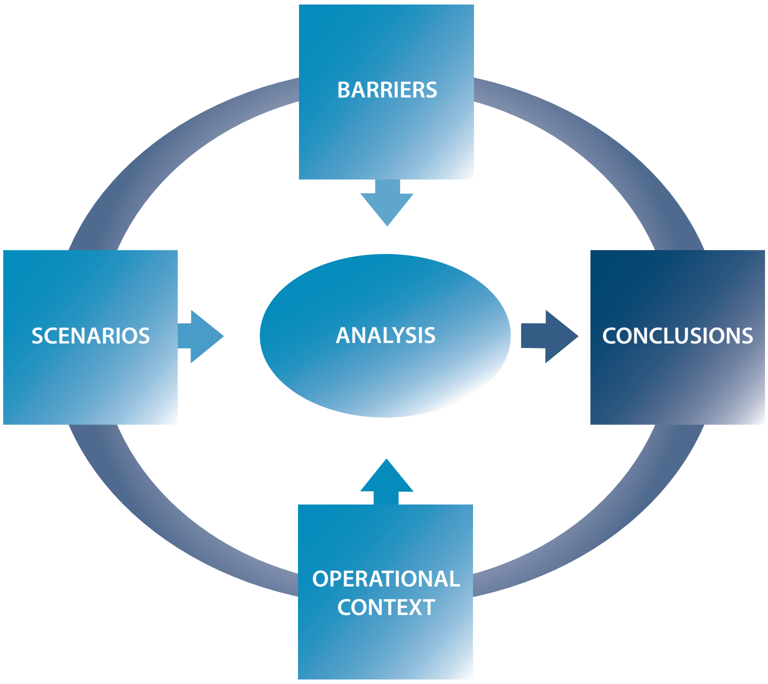
Things do not go well because people simply follow the procedures and work as imagined. Things go well because people make sensible adjustments according to the demands of the situation. Finding out what these adjustments are and trying to learn from them is at least as important as finding the causes of adverse outcomes.

When something goes wrong, such as a **controller "blind spot" event**. It is necessary to understand how such everyday activities go well – how they succeed – in order to understand how they fail. From a Safety-II view they do not fail because of some kind of error or malfunction, but because of unexpected combinations of everyday performance variability.

The basic differences between Safety – I and safety – II are summarised in the table below:

	Safety-I	Safety-II
Definition of safety	That as few things as possible go wrong.	That as many things as possible go right.
Safety management principle	Reactive, respond when something happens or is categorised as an unacceptable risk.	Proactive, continuously trying to anticipate developments and events.
View of the human factor in safety management	Accidents are caused by failures and malfunctions. The purpose of an investigation is to identify the causes.	Things basically happen in the same way, regardless of the outcome. The purpose of an investigation is to understand how things usually go right as a basis for explaining how things occasionally go wrong.
Accident investigation	Accidents are caused by failures and malfunctions. The purpose of an investigation is to identify the causes.	Things basically happen in the same way, regardless of the outcome. The purpose of an investigation is to understand how things usually go right as a basis for explaining how things occasionally go wrong.
Risk assessment	Accidents are caused by failures and malfunctions. The purpose of an investigation is to identify causes and contri-butory factors.	To understand the conditions where performance variability can become difficult or impossible to monitor and control.

CHAPTER 9 - CONCLUSIONS



Conclusion 1	This study has identified four basic operational scenarios of losses of separation because of blind spot occurrences and six potential barriers to prevent losses of separation because of blind spot occurrences. The single most efficient barrier is **Predictive Separation Alert Tool (e.g. STCA) with ATC intentions inputs like Cleared Flight Level (CFL)**. This has the potential to prevent all losses of separation caused by Blind Spot blinds spot but is not equally efficient for all the scenarios.
Conclusion 2	This study combination of four barriers seems to deliver the best reliable protection to prevent losses of separation because of blind spot events: ■ **Predictive Separation Alert Tool (e.g. STCA) with ATC intentions inputs like Cleared Flight Level (CFL).** ■ **Short Term Conflict Probe.** ■ **Structured Scan.** ■ **Predictive Separation Alert Tool (e.g. STCA) with flight crew intentions inputs.**
Conclusion 3	This study identified that there are three most frequent contributing factors that influence the losses of separation because of blind spot occurrences, and that offer a good prevention potential if properly addressed: ■ **Flight Data Display not updated to reflect change of routing or did not highlight confliction.** ■ **Track labels obscured.** ■ **Sector hand over and post sector handover.**
Recommendation 1	**It is recommended that ANSPs review the identified preventive barriers and contributory factors in case they undertake operational safety analysis and improvement activities for Blind Spot - confliction detection with closest aircraft.**
Conclusion 4	An important observation was made by some ANSPs that the use or not by Controller of the velocity leader of the track labels is correlated with some of the blind spot occurrences. Currently there is no empirical evidence to confirm this assumption.
Recommendation 2	**It is recommended that the European stakeholders (including ANSPs and EUROCONTROL) undertake a study to assess further the improvement potential from available controller tools, such as the use of velocity leader lines, in the reduction of controller blind spot events.**

APPENDIX A - REFERENCES

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