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Individual and Group Approaches to Human Error Identification: HAZOP and TRACEr-lite Compared for Three ATM Systems (Annex)

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Abstract

An independent comparison of two human error analysis techniques - HAZOP and TRACEr-lite - was performed for three projects: Co-space, Time Based Separation and CORA 2. This annex report presents the detailed analysis performed for each study, and an overview of the studies for Time Based Separation and CORA 2 including recommendations for these projects. A main report accompanies this annex report, which provides an overview of the Co-space study, compares the performance of HAZOP and TRACEr-lite and provides recommendations for the implementation of the techniques in EUROCONTROL.

Keywords

Human Error	Human Error Analysis	System Design	Safety
HAZOP	TRACEr-lite	Task Analysis	Human Factors

Contact Person(s)	Tel	Unit
Barry Kirwan	7886	EEC Safety R&D

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EATMP Infocentre
EUROCONTROL Headquarters
96 Rue de la Fusée
B-1130 BRUSSELS

Tel: +32 (0)2 729 51 51
Fax: +32 (0)2 729 99 84
E-mail: eatmp.infocentre@eurocontrol.int

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CONTENTS

EXECUTIVE SUMMARY

EUROCONTROL commissioned an independent assessment and comparison of two approaches to 'human error analysis' that may support the process of designing for safety. The approaches selected were:

- **(Human) HAZOP** - an established, group-based approach to human hazard identification developed in the chemical industry, and
- **TRACEr-lite** - a relatively new, single analyst-led approach to human error analysis developed for ATM, analogous to the engineering-based 'Failure Modes and Effects Analysis'.

The findings of the study will be used to begin developing a 'portfolio' of alternative methodologies for use on EUROCONTROL projects.

The two methods were tested on three projects: **Co-space**, **Time-Based Separation** and **CORA 2**. The project compares independently the two techniques (by two independent analysts) to show what they can deliver in terms of safety and design insight, and to show the relative advantages of each for human error analysis purposes.

This annex report accompanies the Main Report and contains the detailed HAZOP logsheets, Hierarchical Task Analyses (HTAs) and TRACEr-lite analyses for Co-space, Time-Based Separation and CORA 2, as well as overviews of the Time-Based Separation and CORA 2 studies.

Important Note: This study is methodological in nature. Although the context is the application of two safety analysis techniques to three Eurocontrol projects, the study in no way represents a safety case of these projects, nor even input to safety cases or assessments of these projects that might be used for safety assurance purposes. The study was partial in nature, with limited resources, and was aimed at evaluating the methods of HAZOP and TRACER-lite only, and in particular for example has not considered the safety benefits of the three systems considered. Additionally, while there may appear to be a large number of errors identified for each of the three systems, this is a function of the highly detailed approaches used, and in a formal safety assessment many of these would be 'aggregated' into a smaller set of errors. Lastly, the recommendations made in this Annex should be considered only as examples of the types of solutions these techniques can generate, and are not requirements for consideration by the three projects, due to the reasons in this paragraph (although the projects may independently decide to investigate them further). Therefore, insights on the three projects cited in this Annex and the Main Report should not be taken out of the methodological context of this study.

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1. APPENDIX A.1: TIME BASED SEPARATION STUDY OVERVIEW

The first stage of data collection common to both Human HAZOP and TRACEr-lite was an initial scoping meeting with the project manager. During this meeting, the concept was presented to the HAZOP leader and the TRACEr-lite analyst. It was clear at this stage that the Time Based Separation (TBS) project was in a very early stage of development (concept stage) and that only an initial analysis could be performed.

1.1 HAZOP Approach

Since there were no procedures available for a detailed Human HAZOP, a set of task steps was developed by the contractor (DNV) with the assistance of the project team as part of the HTA and TRACEr-lite process, based on previous work in a related area (see Section 5.2). The top-level tasks were passed to the HAZOP leader for use in the HAZOP session. The Human HAZOP approach described in Section 2 was applied to these task steps. Since there was much uncertainty in terms of how TBS would be implemented, risk ranking was not performed for this session. The HAZOP considered both controller- and pilot-related errors, since all were judged relevant and useful to consider while each delegation phase was being considered.

A one-day session was held at the EEC in Brétigny on Wednesday 4th December 2002. The HAZOP sessions were attended by two of the project team members. Neither a controller nor a pilot was available for the session.

At the start of the HAZOP session, the team was asked to identify which steps they felt needed to be assessed at the current time, in light of the limited time available for the HAZOP. The HAZOP session focused on the following task step:

- **Sequence a/c / Follow AMAN sequence** - issuing sequencing instructions/following Arrivals Manager advice. (HTA task step 1.5.)

1.2 TRACEr-lite Approach

The TRACEr-lite study for TBS proceeded according to the methodology description in Section 3. A second data collection meeting was held with three project personnel. During this two-hour meeting, a generic HTA of air traffic control using TBS was developed based partly on previous task analyses. Following the meeting, the TRACEr-lite analyst further developed the HTA and sent to the meeting attendees for review and comment[1].

The TRACEr-lite analysis was therefore conducted on this HTA. The full HTA is presented in Appendix A.3. The HTA was constructed for

[1] No comments were received at this stage.

the range of controller tasks for Area, Terminal and Final Approach. However, the roles of various controllers that may be involved were not represented separately, since there are variations in task distribution throughout Europe. These tasks reflect the existing tasks in providing a control service to arriving a/c. However, some of the sub-tasks and processes, and the implications of some tasks, will differ. The HTA comprised the 'top-level' tasks in Table A.1.1.

Table A.1.1: Top-level HTA task and implications identified for TBS during Task Analysis

HTA Top Level Tasks	Implications identified for TBS during Task Analysis?
1.1 Take over from off-going controller	Yes
1.2 Receive a/c	Yes
1.3 Maintain traffic separation within sector	Yes
1.4 Hold a/c	No
1.5 Sequence a/c / Follow AMAN sequence	Yes
1.6 Turn a/c onto base leg	No
1.7 Turn a/c onto intercept ILS	No
1.8 Establish a/c on ILS	Yes
1.9 Transfer to next sector / tower / controller	Yes
1.10 Handover control to relief controller	Yes

Seven of the ten tasks were thought to have clear implications for TBS. While a small number of news tasks were identified in the HTA, it was found that most of the tasks represented exist currently. However, certain tasks have different implications for TBS. These involve either:

- new or different potential errors,
- new or different error consequences,
- impacts on recovery and recovery success likelihood, or
- higher task criticality.

1.3 Comparison of Results

This section provides a general comparison of the findings generated by the two approaches. The same difficulties are relevant here as are presented in Section 4.5. Since HAZOP analysed only one of the tasks, this section focuses only on 'Task 1.5 Sequence a/c / Follow AMAN sequence'.

1.3.1 Errors and Issues

The full TBS HAZOP worksheets and recommendations are included in Appendix A.2. HAZOP identified 22 errors and issues for 'Task 1.5 Sequence a/c / Follow AMAN sequence', shown below in Table A.1.1.

The detailed TRACEr-lite analysis for controller tasks related to the implementation of TBS is presented in Appendix A.4. The categories used for analysis in the TRACEr-lite analysis tables were the same as those used for Co-space. TRACEr-lite predicted 16 errors for Task 1.5, but predicted others related to this task (e.g. separation monitoring

tasks), under different high-level tasks. Hence, 21 TRACEr-lite-predicted errors are indicated in Table A.1.2 below, which provides a comparison of the errors and issues identified by HAZOP and TRACEr-lite (jointly and separately) for Task 1.5 Sequence a/c / Follow AMAN sequence tasks.

Table A.1.2: Errors and issues Identified by HAZOP and TRACEr-lite for Task 1.5 'Sequence a/c/Follow AMAN Advisory'.

HAZOP Error/Issue	In-scope HAZOP?	In-scope TRACEr-lite?
Issues identified by both HAZOP and TRACEr-lite		
Controller misreads/misinterprets AMAN display	Yes	Yes
Controller selects wrong clearance (gives radar vector instead of speed reduction) **	Yes	Yes
Controller or pilot confuses whether TBS or Distance Based Separation (DBS) in operation **	Yes	Yes
Controller fails to react to changing weather conditions **	Yes	Yes
Controller does check AMAN display or does not react quickly enough to changing AMAN display	Yes	Yes
Controller does not inform pilot that they are moving to TBS (from DBS) **	Yes	Yes
Controller takes more time due to lack of familiarity of TBS	Yes	Yes
As separations change with weather, controller takes more time to respond due to more tasks	Yes	Yes
Failure of controller / pilot communications (TBS will require more communication)	Yes	Yes
Controller does not tell pilot if in TBS or DBS **	Yes	Yes
Issues identified by HAZOP only		
Controller inappropriately anticipates wind change (could depend on display update frequency)	Yes	Yes
Incorrect information displayed on arrival manager (flight plan information incorrect)	Yes	No
Pilot call sign confusion *	Yes	No
Incompatibility between display and real weather conditions *	Yes	No
Inadequate display *	Yes	No
Pilot does not react to instruction quickly *	Yes	No
Pilot takes more time due to lack of familiarity (e.g. more RT required) *	Yes	No
Forecasting system failure	Yes	No
General system failure	Yes	No
Failure to inform controllers of changed procedure	Yes	No
Met information update too frequently *	Yes	No
Failure to inform all controllers of TBS procedure	Yes	No
Issues identified by TRACEr-lite only		
Controller fails to check approach path / speed	Yes	Yes
Controller mis-sees or misinterpret approach path / speed	Yes	Yes
Controller fails to realise conflict or problem from radar/strips	Yes	Yes
Controller misreads strip	Yes	Yes
Controller fails to check Wake Vortex Separation Requirements	Yes	Yes
Controller mis-reads Wake Vortex Separation Requirements	Yes	Yes
Controller fails to check suitability of AMAN advisory	Yes	Yes
Controller ignores AMAN advisory	Yes	Yes
Controller decides on inappropriate sequence order	Yes	Yes
Controller fails to resequence in timely manner	Yes	Yes
Controller fails to monitor and maintain sequencing and spacing	Yes	Yes

* Failure(s) of associated ATCO hearback or monitoring identified

** Similar or related ATCO errors identified

For Task 1.5 'Sequence a/c/Follow AMAN Advisory', Table A.1.2 shows that 10 errors were identified by both HAZOP and TRACEr-lite. In addition, 12 errors were identified only by HAZOP, 11 of which were within the scope of the TRACEr-lite study. For seven of these 12 errors, TRACEr-lite identified associated failures in the ATCO response (e.g. to pilot errors or equipment problems). TRACEr-lite identified 11 other ATCO errors for this task that were not identified by HAZOP.

TRACEr-lite also analysed nine additional high-level tasks that were not analysed in the HAZOP session due to restriction on time and resource availability. The errors identified for these tasks are not included in this comparison, but can be seen in Appendix A.4. The main tasks affected by TBS in terms of the numbers of TBS-relevant errors predicted were:

- 1.2 Receive a/c
- 1.3 Maintain traffic separation within sector
- 1.5 Sequence a/c / Follow AMAN sequence
- 1.8 Establish a/c on ILS

For the total set of tasks analysed for TBS, the TRACEr-lite analysis revealed 89 detailed errors with implications for TBS. Of these, 31 errors were rated as moderate RSL, 28 were rated as Low-Moderate RSL, and seven were rated as Low RSL.

1.3.2 Consequences

The HAZOP study found the following summarised consequences for the TBS task above.

- Frequency occupancy.
- Potential loss of capacity.
- Increased pilot and controller workload.
- Loss of separation.

Often, these consequences depended upon an increase or drop in headwind.

The initial consequences according to the TRACEr-lite analysis are as follows:

- AMAN advisory may not be appropriate.
- Controller unaware of AMAN sequence.
- Controller has incorrect knowledge of a/c details.
- Controller has incorrect knowledge of approach path and speed.
- Controller unaware of (actual) Wake Vortex Separation Requirements.
- Controller unaware of a/c details.

- Controller unaware of approach path and speed.
- Controller unaware of conflict or problem.
- Headwind and wake vortex would slow a/c significantly.
- Potential mis-sequencing.
- Conflict.
- Loss of spacing/separation.

1.3.3 Safeguards

The safeguards identified by HAZOP were:

- Accurate reliable forecasting system envisaged.
- Accurate reliable system envisaged.
- Airline operator training.
- ATIS and controller training.
- Flight planner and controller training and familiarisation with TBS.
- Fall-back procedures.
- HMI design.
- Pilot Training.
- Radar monitoring.
- Short Term Conflict Alert (STCA).
- Terminology.

The safeguards identified by TRACEr-lite were:

- Radar monitoring.
- RT communication, pilot query pilot.
- STCA.

1.3.4 TBS Recommendations

1.3.4.1 HAZOP-generated

Key recommendations arising from the HAZOP study relating to these errors were:

1. TBS requires higher equipment reliability and there needs to be a review of the resolution of radar display and its accuracy to ensure sufficient support to TBS.
2. More RT is required and hence a need for better RT discipline to minimise extra errors. General tightening up of monitoring needed as TBS requires higher controller vigilance.
3. Investigate how the display flags up changing AMAN information (e.g. visual / audible warnings)

4. Consider data link or new technology if call sign confusion was shown to be high risk issue.
5. Review how warnings of incompatibility between display and real life weather conditions are processed (whether the warnings be from ground equipment, a/c, pilots, etc)
6. Publish guidelines on controller methods under TBS.
7. Post-incident investigation required of problems under TBS.
8. Display information concerning TBS or DBS on the HMI.
9. Robust procedures needed for changeovers between TBS and DBS.
10. Conduct an investigation into controller methods for reacting to significant weather changes.
11. AMAN HMI issues need to be addressed. Warnings need to be provided on the status of failure detection.
12. Ensure AMAN display refresh rate is adequate to prevent need for anticipation.
13. Variable STCA parameters need to be developed (this applies to multiple causes and also to normal TBS operations to ensure that false STCA alerts do not occur too frequently).
14. Intelligent speed vector should be researched to assist controllers in maintaining separation (this applies to multiple causes and normal TBS operations).
15. Investigate warning systems for the controllers to assist them in reacting to changes from AMAN.
16. Provide pilots with TBS information to better understand consequences of their actions.
17. Investigate automatic methods of informing pilots which separation system is enforced (TBS or DBS).
18. Consider more general use of simulators to familiarise controllers and pilots with TBS (consider simulating problems to investigate reaction of controllers and pilots).
19. Conduct investigation into new technologies to reduce RT workload e.g. data link.
20. Investigate the need for a backup forecasting system.
21. Define alternative procedures in case of forecasting system failure.
22. Investigate the need for back-up general system (general system failure might be slightly worse under TBS due to increased a/c in sector).

1.3.4.2 TRACEr-lite-generated

A number of recommendations were also generated by TRACEr-lite that may help to resolve individual errors. These were as follows:

1. The controller must have a correct understanding of a/c on TBS and associated time parameters. This would require robust co-

ordination protocols and perhaps some visual, permanent indication of TBS status.

2. The controller must have a correct understanding of the applicability conditions for TBS, and a clear indication of an a/c's compliance with these conditions.
3. The controller must have a correct situational awareness of the actual and projected time separation. This would require high-quality dynamic radar tools, with a direct indication of TBS (i.e. requiring no interpretation).
4. The controller must have a clear, dynamic display of weather information (particularly headwind)
5. The applicable pilots must be fully aware that TBS (or DBS) is in operation.
6. TBS status must be indicated on flight strips or other record.
7. There must be a clear method of displaying changes to weather conditions
8. Short-Term Conflict Alert must be in operation.
9. TBS and associated controller tools must take into account the effects of headwind on wake vortices.
10. Procedures for resequencing under TBS conditions need to be devised.
11. The off-going controller must clearly point out a/c on TBS and associated time parameters during handover. This may require a handover checklist or protocol and some visual, permanent indication of TBS status.

1.3.5 Discussion

Overall, it can be seen that both HAZOP and TRACEr-lite identified some critical errors that could occur with TBS, including understanding and interpreting weather information, responding rapidly to highly dynamic conditions, and awareness of type of separation and parameters. Both techniques identified similar numbers of issues. For many of the issues predicted only by HAZOP (pilot errors or equipment problems), TRACEr-lite did predict errors in the associated ATCO response.

With respect to the TRACEr-lite analysis, it is interesting to note that the key stages of the error analysis were Task 1.2 'Receive a/c' and Task 1.3 'Maintain traffic separation within sector'. These tasks were not chosen for the HAZOP study. It may be that HAZOP would be useful to use at a high level to give the detailed error analysis a better focus. Both HAZOP and TRACEr-lite predicted a similar number of errors and issues for the task examined above, but the HAZOP analysis included controller, pilot and information/equipment issues, while TRACEr-lite focussed more deeply on controller errors.

It is also interesting that TRACEr-lite identified many more consequences than HAZOP; HAZOP focussed only on the 'bottom line' consequences. However, TRACEr-lite identified fewer

safeguards. This may suggest that TRACEr-lite can produce more 'pessimistic' analyses than HAZOP.

The HAZOP study again identified many more recommendations than TRACEr, for only one of the 10 tasks analysed by TRACEr, confirming the finding of the Co-Space study.

The HAZOP study team felt that it would be useful to the project to use HAZOP again as it helped focus on new issues. They also considered it to be a good introduction to safety methodologies and helped prepare for future work required. Given that the project was at a very early stage with many processes still needing to be defined, it benefited the team to perform a high-level HAZOP. It was seen as useful to conduct a high level analysis of potential problems at beginning of a project, and then go into more detail as more information becomes available and procedures are more defined. At the time of the HAZOP, the project did not have a controller or pilot available to provide a user perspective and this was a gap in the process.

The TBS project team felt that the HTA was also useful to help identify tasks that would be affected by TBS, and where tasks still needed to be specified or considered.

2. APPENDIX A.2: TIME BASED SEPARATION HAZOP WORKSHEET

Table A.2.1: Time Based Separation HAZOP Worksheet

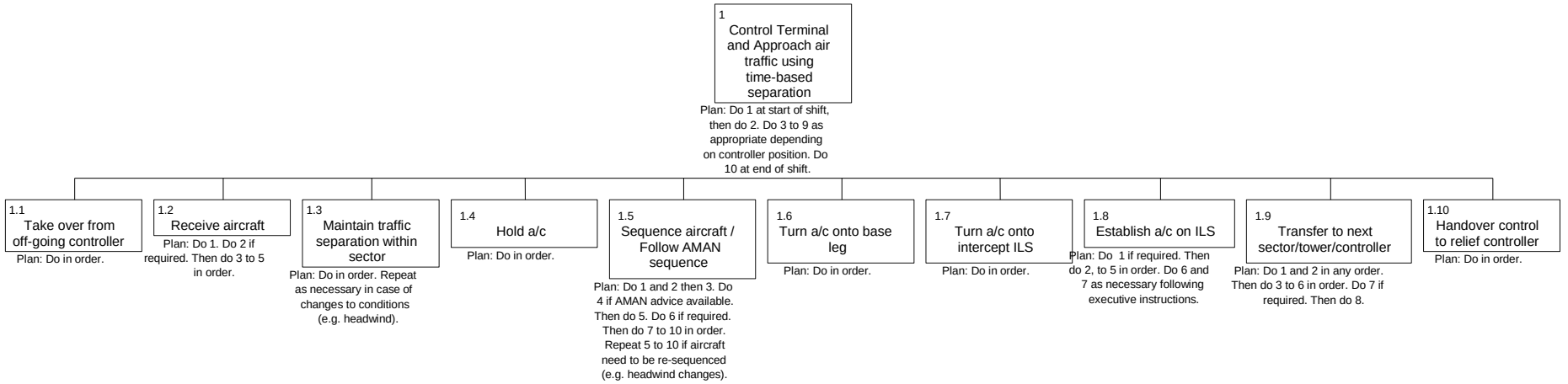
Project: Time Based Separation		**System: Sequence Aircraft following Arrivals Manager advice**		**Recommendations**
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
1. Wrong Action	1.1. Incorrect information displayed on arrival manager. (flight plan information incorrect)	1.1. Higher workload if controller notices. 1.2. Potential loss of separation if controller does not notice.	1.1. Flight planner and controller training. 1.2. Airline operator training. 1.3. Equipment reliability.	1. TBS requires higher equipment reliability and there also needs to be a review of the resolution of radar display and its accuracy to ensure sufficient to support TBS. 2. More RT required and hence a need for better RT discipline to minimise extra errors. General tightening up of monitoring needed as TBS requires higher controller vigilance.
2. Wrong Action	2.1. Controller reads AMAN display incorrectly.	2.1. If controller realises mistake quickly higher workload 2.2. Potential loss of separation if controller does not notice.	2.1. Well designed HIM 2.2. Controller training.	3. How the display flags up changing AMAN information to be investigated (e.g. visual / audible warnings)
3. Wrong Action	3.1. Pilot call sign confusion.	3.1. Higher workload if pilot and controller notices. 3.2. Potential loss of separation if controller does not notice.	3.1. General pilot training.	4. If call sign confusion was shown to be high risk issue, data link or new technology might need to be considered.
4. Wrong Action	4.1. Incompatibility between display and real weather conditions.	4.1. Loss of separation when headwind drops. 4.2. Headwind increases, controller has higher workload.	4.1. ATC detection via radar display.	5. How warnings of incompatibility between display and real life weather conditions are processed need to be reviewed (whether the warnings be from ground equipment, a/c, pilots, etc)

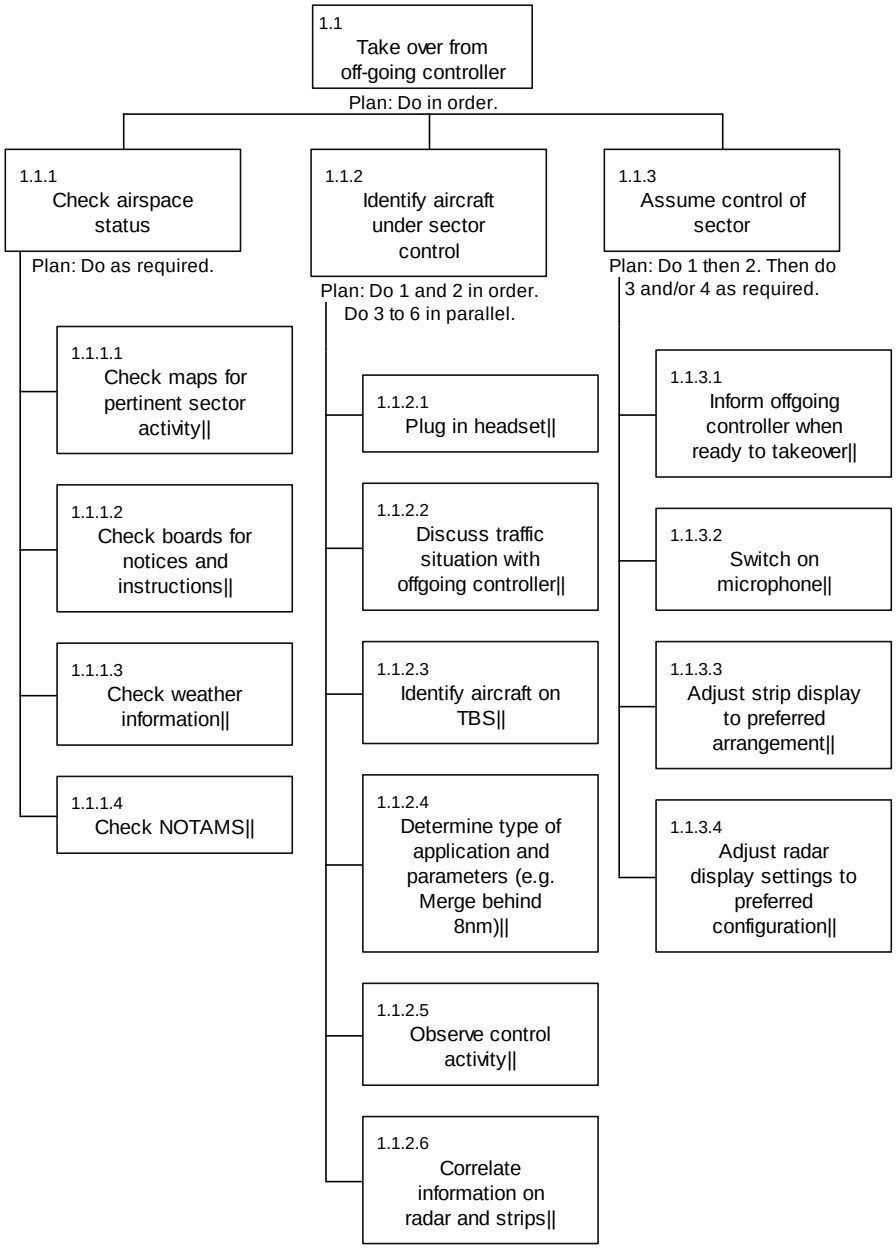
Project: Time Based Separation		System: Sequence Aircraft following Arrivals Manager advice		Recommendations
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
5. Wrong Action	5.1. Controller selects wrong clearance (gives radar vector instead of speed reduction)	5.1. Potential loss of separation. 5.2. Higher workload.	5.1. Controller training.	6. Publication of guidelines on controller methods under TBS will be needed. 7. Controller training will be critical. 8.Post-incident investigation required of problems under TBS.
6. Wrong Action	6.1. Controller or pilot confused whether TBS or Distance Based Separation (DBS) in operation.	6.1. Potential loss of separation. 6.2. More RT	6.1. Right terminology. 6.2. Training.	9. Information concerning TBS or DBS should be displayed in HMI. 10. Robust procedures needed for changeovers between TBS and DBS.
7. No Action	7.1. Failure of controller to react to changing weather conditions.	7.1. Loss of separation when headwind drops / when headwind increases controller has higher workload.	7.1. ATC training.	11. Investigation of controller methods for reacting to significant weather changes should be carried out.
8. No Action	8.1. Inadequate display.	8.1. Loss of separation when headwind drops / headwind increases controller has higher workload.		12. AMAN HMI issues need to be addressed. Warnings need to be provided on the status of failure detection.
9. More Action	9.1. Controller inappropriately anticipates wind change (could depend on display update frequency).	9.1. Potential loss of separation. 9.2. Higher workload.	9.1. Training. 9.2. Short Term Conflict Alert (STCA)	13. Ensure AMAN display refresh rate is adequate to prevent need for anticipation. 14. Variable STCA parameters need to be developed (this applies to multiple causes and also to normal TBS operations to ensure that false STCA alerts do not occur too frequently). 15. Intelligent speed vector should be researched to assist controllers in maintaining separation (this applies to multiple causes and normal TBS operations).
10. Less Action	10.1. Controller does not react quickly enough to changing AMAN	10.1. Potential loss of separation.	10.1. ATC training	16. Investigate warning systems for the controllers to assist them in reacting to

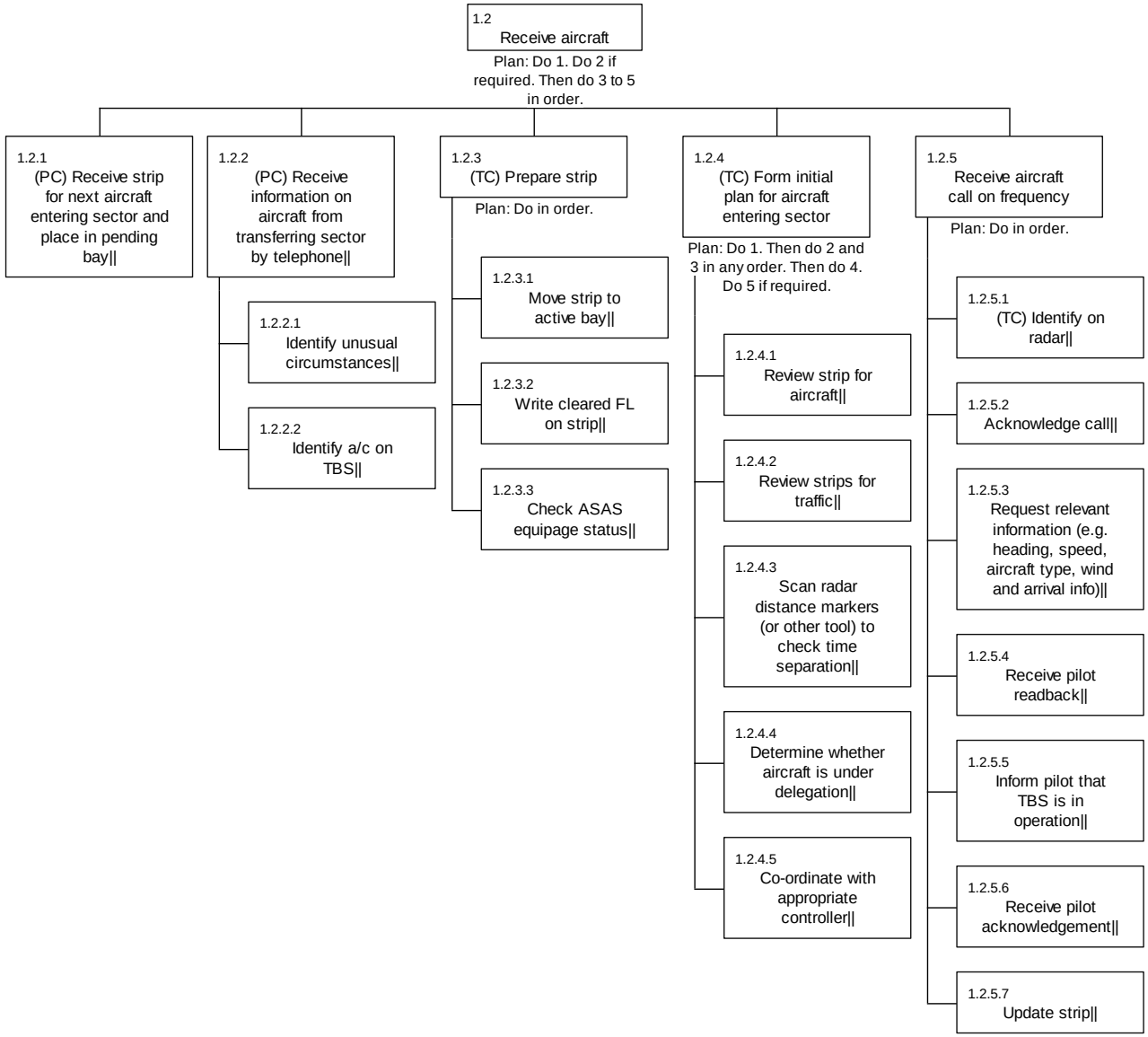
Project: Time Based Separation		System: Sequence Aircraft following Arrivals Manager advice		Recommendations
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
	display.	10.2. Higher workload.		changes from AMAN.
11. Less Action	11.1. Pilot does not react to instruction quickly.	11.1. Potential loss of separation. 11.2. Higher workload.	11.1. Pilot Training	17. Pilot should be provided with TBS information to better understand consequences of their actions.
12. Less Action	12.1. Controller does not inform pilot that they are moving to TBS (from DBS).	12.1. More RT 12.2. More pilot and controller workload.	12.1. ATIS and controller training.	18. Investigate automatic methods of informing pilots which separation system is enforced (TBS or DBS).
13. More Time	13.1. Controller takes more time due to lack of familiarity of TBS.	13.1. Potential loss of separation. 13.2. Higher workload.	13.1. Controller training 13.2. Familiarisation with TBS.	19. Consider more general use of simulators to familiarise controllers with TBS (consider simulating problems to investigate reaction of controllers).
14. More Time	14.1. Pilot takes more time due to lack of familiarity (e.g. more RT required).	14.1. Potential loss of separation. 14.2. Higher workload.	14.1. Pilot Training 14.2. Familiarisation with TBS.	20. Consider more general use of simulators to familiarise pilots with TBS (consider simulating problems to investigate reaction of pilots).
15. More Time	15.1. As separations change with weather, controller takes more time to respond due to more tasks.	15.1. Overall sector workload could increase 15.2. Potential loss of capacity	15.1. Controller training and familiarisation with TBS	21. Conduct investigation into new technologies to reduce RT workload e.g. data link.
16. No Information	16.1. Forecasting system failure.	16.1. Potential loss of separation. 16.2. Higher workload.	16.1. Accurate reliable forecasting system is envisaged. 16.2. ATC detection radar display.	22. Investigate need for backup forecasting system. 23. Alternative procedures in case of forecasting system failure to be defined.

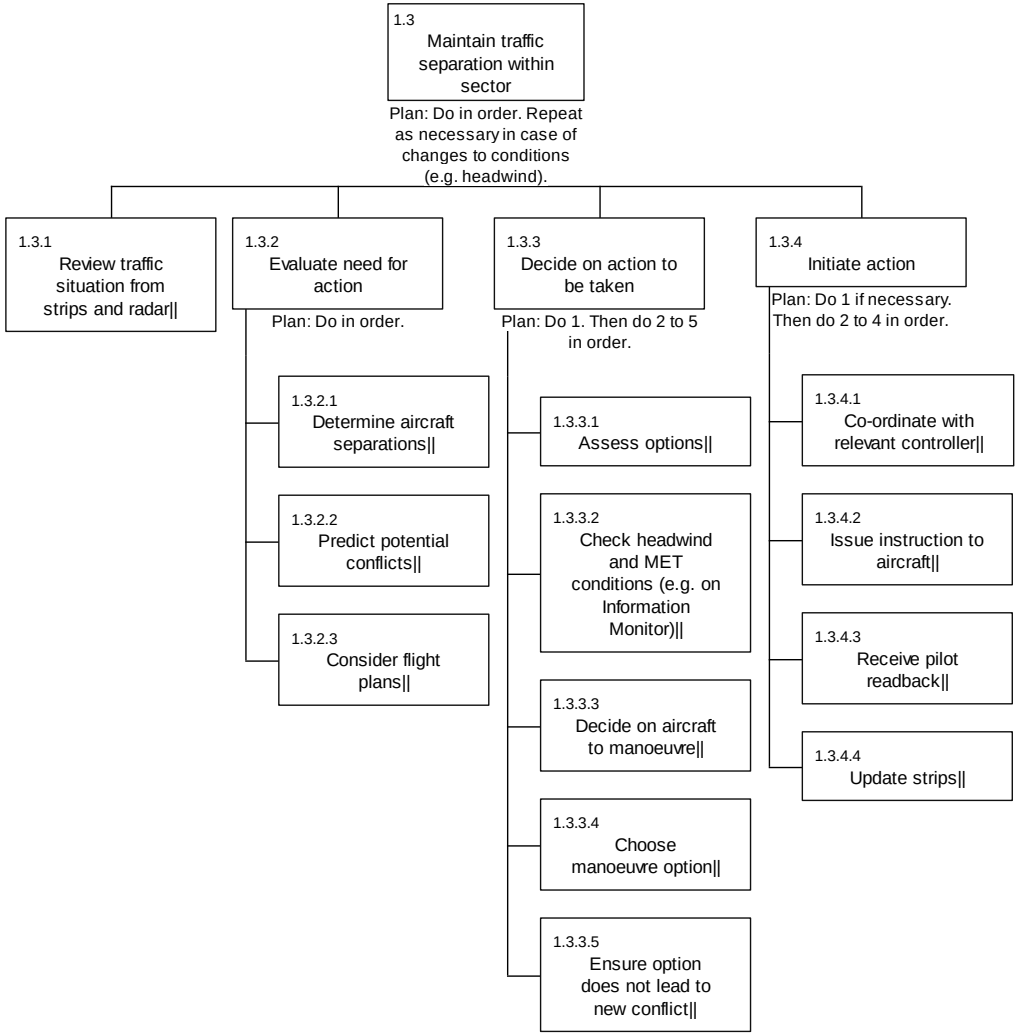
Project: Time Based Separation		System: Sequence Aircraft following Arrivals Manager advice		Recommendations
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
17. No Information	17.1. General system failure.	17.1. Potential loss of separation. 17.2. Higher workload.	17.1. Accurate reliable system envisaged. 17.2. Fall-back procedures.	24. Investigate the need for back-up general system (general system failure might be slightly worse under TBS due to increased a/c in sector). 25. Alternative procedures in case of general system failure to be defined.
18. No Information	18.1. Failure of controller / pilot communications (TBS will require more communication).	Not analysed further		
19. No Information	19.1. Failure to inform controllers of changed procedure.	Not analysed further		
20. More Information	20.1. Met information update too frequently.	Not analysed further		
21. More Information	21.1. controller informing of TBS procedure.	Not analysed further		
22. Less information	22.1. Controller does not tell pilot if in TBS or DBS.	Not analysed further		

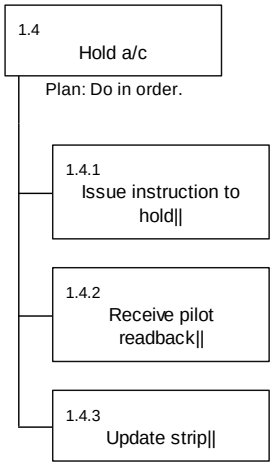
3. APPENDIX A.3: TIME BASED SEPARATION HIERARCHICAL TASK ANALYSIS

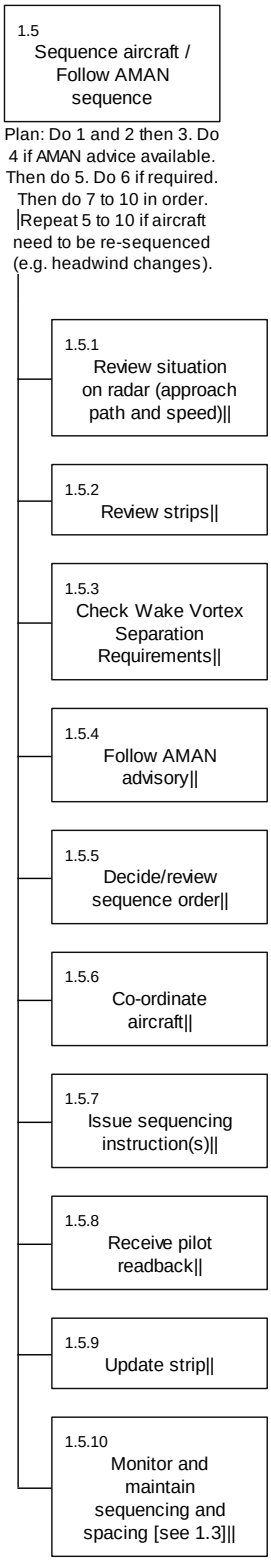


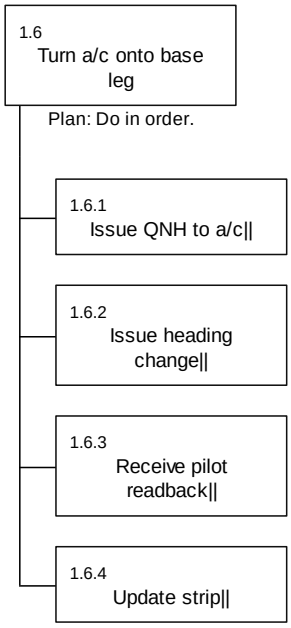

1.1
Take over from off-going controller
Plan: Do in order.
1.1.1
Check airspace status
Plan: Do as required.
1.1.1.1
Check maps for pertinent sector activity||
1.1.1.2
Check boards for notices and instructions||
1.1.1.3
Check weather information||
1.1.1.4
Check NOTAMS||
1.1.2
Identify aircraft under sector control
Plan: Do 1 and 2 in order. Do 3 to 6 in parallel.
1.1.2.1
Plug in headset||
1.1.2.2
Discuss traffic situation with offgoing controller||
1.1.2.3
Identify aircraft on TBS||
1.1.2.4
Determine type of application and parameters (e.g. Merge behind 8nm)||
1.1.2.5
Observe control activity||
1.1.2.6
Correlate information on radar and strips||
1.1.3
Assume control of sector
Plan: Do 1 then 2. Then do 3 and/or 4 as required.
1.1.3.1
Inform offgoing controller when ready to takeover||
1.1.3.2
Switch on microphone||
1.1.3.3
Adjust strip display to preferred arrangement||
1.1.3.4
Adjust radar display settings to preferred configuration||

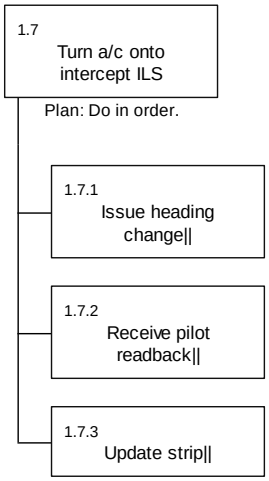

1.2
Receive aircraft
Plan: Do 1. Do 2 if required. Then do 3 to 5 in order.
1.2.1
(PC) Receive strip for next aircraft entering sector and place in pending bay||
1.2.2
(PC) Receive information on aircraft from transferring sector by telephone||
1.2.2.1
Identify unusual circumstances||
1.2.2.2
Identify a/c on TBS||
1.2.3
(TC) Prepare strip
Plan: Do in order.
1.2.3.1
Move strip to active bay||
1.2.3.2
Write cleared FL on strip||
1.2.3.3
Check ASAS equipage status||
1.2.4
(TC) Form initial plan for aircraft entering sector
Plan: Do 1. Then do 2 and 3 in any order. Then do 4. Do 5 if required.
1.2.4.1
Review strip for aircraft||
1.2.4.2
Review strips for traffic||
1.2.4.3
Scan radar distance markers (or other tool) to check time separation||
1.2.4.4
Determine whether aircraft is under delegation||
1.2.4.5
Co-ordinate with appropriate controller||
1.2.5
Receive aircraft call on frequency
Plan: Do in order.
1.2.5.1
(TC) Identify on radar||
1.2.5.2
Acknowledge call||
1.2.5.3
Request relevant information (e.g. heading, speed, aircraft type, wind and arrival info)||
1.2.5.4
Receive pilot readback||
1.2.5.5
Inform pilot that TBS is in operation||
1.2.5.6
Receive pilot acknowledgement||
1.2.5.7
Update strip||

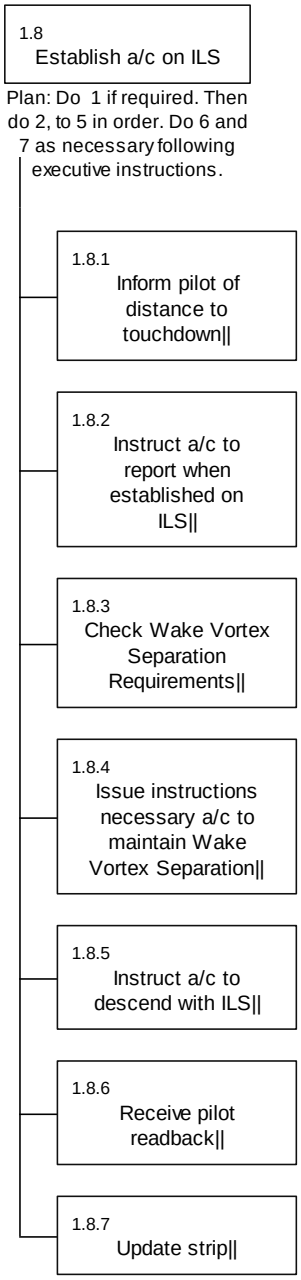

1.3
Maintain traffic separation within sector
Plan: Do in order. Repeat as necessary in case of changes to conditions (e.g. headwind).
1.3.1
Review traffic situation from strips and radar||
1.3.2
Evaluate need for action
Plan: Do in order.
1.3.2.1
Determine aircraft separations||
1.3.2.2
Predict potential conflicts||
1.3.2.3
Consider flight plans||
1.3.3
Decide on action to be taken
Plan: Do 1. Then do 2 to 5 in order.
1.3.3.1
Assess options||
1.3.3.2
Check headwind and MET conditions (e.g. on Information Monitor)||
1.3.3.3
Decide on aircraft to manoeuvre||
1.3.3.4
Choose manoeuvre option||
1.3.3.5
Ensure option does not lead to new conflict||
1.3.4
Initiate action
Plan: Do 1 if necessary. Then do 2 to 4 in order.
1.3.4.1
Co-ordinate with relevant controller||
1.3.4.2
Issue instruction to aircraft||
1.3.4.3
Receive pilot readback||
1.3.4.4
Update strips||

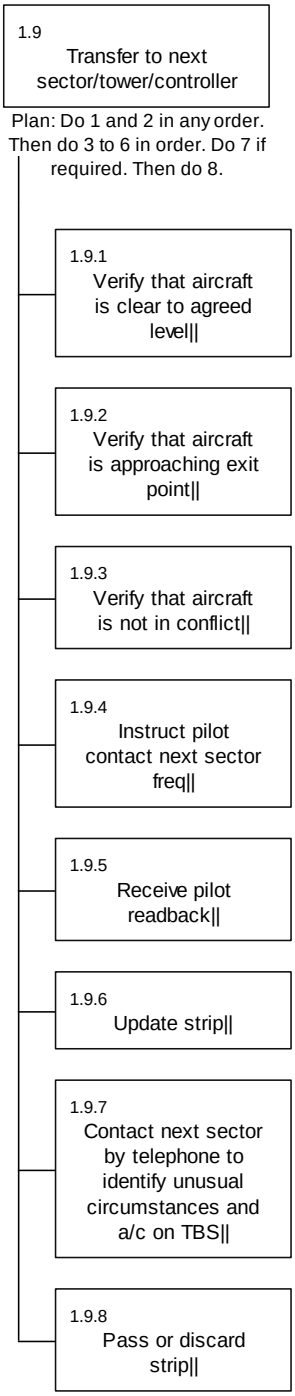

1.4
Hold a/c
Plan: Do in order.
1.4.1
Issue instruction to hold||
1.4.2
Receive pilot readback||
1.4.3
Update strip||

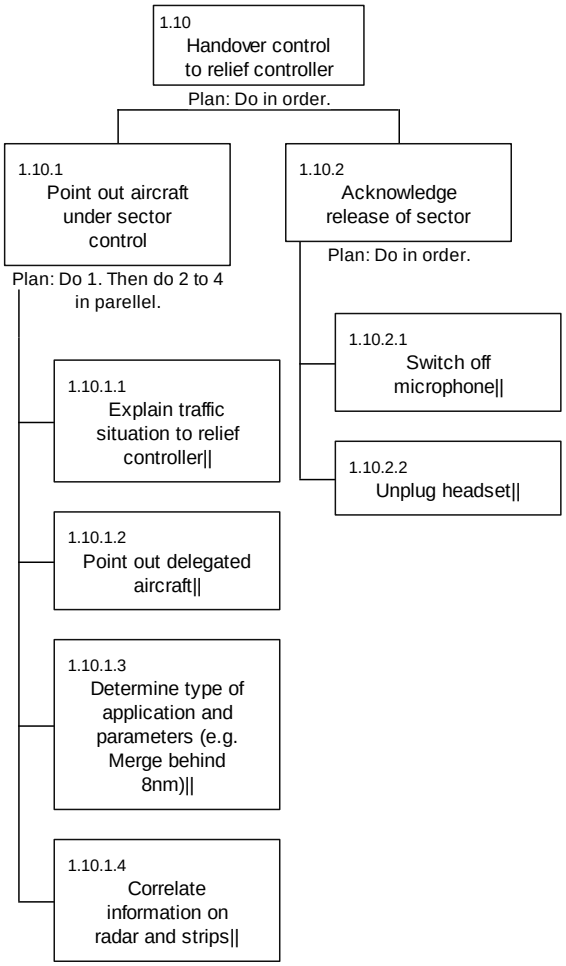

1.5
Sequence aircraft / Follow AMAN sequence
Plan: Do 1 and 2 then 3. Do 4 if AMAN advice available. Then do 5. Do 6 if required. Then do 7 to 10 in order. Repeat 5 to 10 if aircraft need to be re-sequenced (e.g. headwind changes).
1.5.1
Review situation on radar (approach path and speed)||
1.5.2
Review strips||
1.5.3
Check Wake Vortex Separation Requirements||
1.5.4
Follow AMAN advisory||
1.5.5
Decide/review sequence order||
1.5.6
Co-ordinate aircraft||
1.5.7
Issue sequencing instruction(s)||
1.5.8
Receive pilot readback||
1.5.9
Update strip||
1.5.10
Monitor and maintain sequencing and spacing [see 1.3]||


1.6
Turn a/c onto base leg
Plan: Do in order.
1.6.1
Issue QNH to a/c||
1.6.2
Issue heading change||
1.6.3
Receive pilot readback||
1.6.4
Update strip||


1.7
Turn a/c onto intercept ILS
Plan: Do in order.
1.7.1
Issue heading change||
1.7.2
Receive pilot readback||
1.7.3
Update strip||


1.8
Establish a/c on ILS
Plan: Do 1 if required. Then do 2, to 5 in order. Do 6 and 7 as necessary following executive instructions.
1.8.1
Inform pilot of distance to touchdown||
1.8.2
Instruct a/c to report when established on ILS||
1.8.3
Check Wake Vortex Separation Requirements||
1.8.4
Issue instructions necessary a/c to maintain Wake Vortex Separation||
1.8.5
Instruct a/c to descend with ILS||
1.8.6
Receive pilot readback||
1.8.7
Update strip||


1.9
Transfer to next sector/tower/controller
Plan: Do 1 and 2 in any order. Then do 3 to 6 in order. Do 7 if required. Then do 8.
1.9.1
Verify that aircraft is clear to agreed level||
1.9.2
Verify that aircraft is approaching exit point||
1.9.3
Verify that aircraft is not in conflict||
1.9.4
Instruct pilot contact next sector freq||
1.9.5
Receive pilot readback||
1.9.6
Update strip||
1.9.7
Contact next sector by telephone to identify unusual circumstances and a/c on TBS||
1.9.8
Pass or discard strip||


1.10
Handover control to relief controller
Plan: Do in order.
1.10.1
Point out aircraft under sector control
Plan: Do 1. Then do 2 to 4 in parellel.
1.10.1.1
Explain traffic situation to relief controller||
1.10.1.2
Point out delegated aircraft||
1.10.1.3
Determine type of application and parameters (e.g. Merge behind 8nm)||
1.10.1.4
Correlate information on radar and strips||
1.10.2
Acknowledge release of sector
Plan: Do in order.
1.10.2.1
Switch off microphone||
1.10.2.2
Unplug headset||

4. APPENDIX A.4: TIME BASED SEPARATION TRACER-LITE ANALYSIS WORKSHEET

KEY:
☒ = No implications identified for TBS.
🡻 = External Error(s) described in hierarchy below.
a/c = Aircraft
DBS = Distance Based Separation
NOTAMs = Notices to Airmen
RSL = Recovery Success Likelihood (see Table A.4.2 for RSL Scale)
RT = Radio Telephony
STCA = Short Term Conflict Alert
TBS = Time Based Separation

Table A.4.1: TRACEr-lite Analysis Worksheet

Task Step	External Error	Internal Error	Consequences	Detection Means	RSL	Recommendations / Comments
1 CONTROL TERMINAL AND APPROACH AIR TRAFFIC USING TIME-BASED SEPARATION	🡻					
Plan: Do 1 at start of shift, then do 2. Do 3 to 9 as appropriate depending on controller position. Do 10 at end of shift.						
1.1 Take over from off-going controller	🡻					
Plan: Do in order.						
1.1.1 Check airspace status	🡻					
Plan: Do as required.						
1.1.1.1 Check maps for pertinent sector activity ‖	☒					

1.1.1.2 Check boards for notices and instructions ‖	☒					
1.1.1.3 Check weather information ‖	1. Fail to check weather information 2. Misread / misinterpret weather information	1. Forget action, Late or no decision, Poor decision 2. No detection - visual, Mis-see	1. Controller unaware of weather on starting shift 2. Controller has false impression of weather on starting shift	1, 2. Future checks on weather using monitors and pilot reports.	1. H 2. H	More critical for TBS
1.1.1.4 Check NOTAMS ‖	?					
1.1.2 Identify a/c under sector control	🡻					
Plan: Do 1 and 2 in order. Plan: Do 3 to 6 in parallel.						
1.1.2.1 Plug in headset ‖	☒					
1.1.2.2 Discuss traffic situation with offgoing controller ‖	☒					
1.1.2.3 Identify a/c on TBS ‖	1. Fail to identify a/c on TBS 2. Falsely identify a/c on TBS	1. No detection - visual / auditory, Mis-see, Mis-hear, Forget information 2. Mis-see, Mis-hear, Misrecall information	1. Relief controller unaware of a/c on TBS. Provides DBS rather than TBS, Potential loss of separation 2. Relief controller falsely believes a/c are on TBS, Provides TBS rather than DBS. Potential loss of separation	1, 2. Future RT communication, Future check of strip markings	1. M-H 2. M	Assume strip markings indicate TBS? Where will TBS be indicated?
1.1.2.4 Determine time parameter ‖	1. Fail to determine time parameter 2. Confuse time parameter	1. No detection - auditory Mis-hear, Forget information, No decision 2. Mis-hear, Misrecall information	1. Relief controller unaware of time parameter, or assumes time parameter, Relief controller uses wrong time parameter, Potential loss of separation 2. Relief controller uses wrong time parameter, Potential loss of separation	1, 2. Future check of strip markings	1. M 2. L-M	Will time parameter always be the same, and for all a/c? Where will time parameter be recorded?
1.1.2.5 Observe control activity ‖	☒					
1.1.2.6 Correlate information on radar and strips ‖	☒					

1.1.3 Assume control of sector	🡻					
Plan: Do 1 then 2. Then do 3 and / or 4 as required.						
1.1.3.1 Inform offgoing controller when ready to takeover ‖	☒					
1.1.3.2 Switch on microphone ‖	☒					
1.1.3.3 Adjust strip display to preferred arrangement ‖	☒					
1.1.3.4 Adjust radar display settings to preferred configuration ‖	☒					
1.2 Receive a/c						
Plan: Do 1. Plan: Do 2 if required. Then do 3 to 5 in order.						
1.2.1 (PC) Receive strip for next a/c entering sector and place in pending bay ‖	☒					
1.2.2 (PC) Receive information on a/c from transferring sector by telephone	🡻					
Plan: Do 1. Then do 2 and (3&4) in any order.						
1.2.2.1 Answer telephone call	☒					
1.2.2.2 Identify unusual circumstances ‖	☒					

1.2.2.3 Identify a/c on TBS ‖	1. Fail to identify a/c on TBS 2. Falsely identify a/c as being on TBS	1. No detection - auditory Mis-hear, Forget information 2. Mis-hear, Misrecall information	1. Relief controller unaware of a/c on TBS. Provides DBS rather than TBS, Potential loss of separation 2. Relief controller falsely believes a/c are on TBS, Provides TBS rather than DBS. Potential loss of separation	1, 2. Future RT communication	1. M-H 2. L-M	Will TBS be indicated visually on transfer?
1.2.2.4 Determine time parameter ‖	1. Fail to determine time parameter 2. Confuse time parameter	1. No detection - auditory Mis-hear, Forget information, No decision 2. Mis-hear, Misrecall information	1. Relief controller unaware of time parameter, or assumes time parameter, Relief controller uses wrong time parameter, Potential loss of separation 2. Relief controller uses wrong time parameter, Potential loss of separation	1, 2. None identified	1. L-M 2. L	Will time parameter always be the same, and for all a/c? Where will time parameter be recorded?
1.2.3 (TC) Prepare strip	☒					
Plan: Do in order.						
1.2.3.1 Move strip to active bay ‖	☒					
1.2.3.2 Write cleared FL on strip ‖	☒					
1.2.4 (TC) Form initial plan for a/c entering sector	1. Decide to use TBS when not applicable / appropriate	1. Poor plan	1. Controller uses TBS when not applicable / appropriate, Potential loss of separation	1. Radar monitoring, Controller has time to change to TBS, STCA	1. H	What are applicability conditions?
Plan: Do 1. Then do 2 and 3 in any order. Do 4 if required.						

1.2.4.1 Review strip for a/c ‖	1. Fail to review strip 2. Misread strip 3. Confuse strips for a/c on TBS with a/c not on TBS	1. Forget action 2, 3. Mis-see	1. Controller unaware of a/c details and capabilities 2. Controller has incorrect knowledge of a/c details and capabilities 3. Controller uses TBS when not applicable / appropriate	1, 2, 3. Radar monitoring, RT communication	1. H 2. M 3. M-H	What is marked on strip? Which a/c are / are not able to use TBS?
1.2.4.2 Review strips for traffic ‖	1. Fail to review strip 2. Misread strip 3. Confuse strips for a/c on TBS with a/c not on TBS	1. Forget action, No detection - visual 2. Mis-see	1. Controller unaware of a/c details and capabilities 2. Controller has incorrect knowledge of a/c details and capabilities 3. Controller uses TBS when not applicable / appropriate	1, 2. Radar monitoring, RT communication	1. M-H 2. M-H	
1.2.4.3 Use radar distance markers (or other tool) to check time separation ‖	1. Fail to check time separation 2. Misinterpret time separation using markers 3. Misidentify a/c	1. Forget action 2. Misprojection 3. Mis-see	1. Controller unaware of separation 2, 3. Controller has incorrect knowledge of separation	1, 2, 3. STCA	1. L-M 2. L-M 3. L-M	How will distance markers work?
1.2.4.5 Co-ordinate with appropriate controller ‖	☒					
1.2.5 Receive a/c call on frequency	↓					
Plan: Do in order.						
1.2.5.1 (TC) Identify on radar ‖	☒					
1.2.5.2 Acknowledge call ‖	☒					

1.2.5.3 Request relevant information (e.g. heading, speed, a/c type, wind and arrival info) ‖	1. Fail to check wind information 2. Fail to check speed 3. Fail to check a/c weight	1, 2, 3. Forget action, Poor decision	1, 2, 3. Controller unaware of true wind/speed/weight, Potential for misjudgements when using TBS	1. Future check of supplementary monitor, Future RT communication 2, 3. Radar monitoring, Future RT communication	1. M? 2. M-H 3. M-H	How will wind information be updated on supplementary monitor. How frequently will wind information be updated? Will controllers use actual or maximum weight values? How will controller determine actual weight?
1.2.5.4 Receive pilot readback ‖	1. Fail to detect / query erroneous / spurious readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Poor decision, No decision	1. Controller and pilot have different knowledge states, Controller unaware of true wind / speed / heading / etc., Potential for misjudgements when using TBS 2. Controller and pilot could have different knowledge states, Controller could be unaware of true wind / speed / heading / etc., Potential for misjudgements when using TBS	1, 2. Future check of supplementary monitor, Radar monitoring, Future RT communication	1. M 2. M	Same as current, but more critical for certain message elements

1.2.5.5 Inform pilot that TBS/DBS is in operation ‖	1. Fail to inform pilot that TBS is in operation 2. Inform wrong pilot that TBS is in operation 3. Erroneously inform pilot that DBS is in operation	1. Forget action, Poor decision 2, 3. Incorrect information	1. Pilot unaware that TBS is in operation, Pilot may be unwilling or unable to use TBS 2. Wrong pilot thinks TBS is in operation, Intended pilot unaware that TBS is in operation 3. Pilot thinks that DBS is in operation, when controller is using TBS	1. Future RT communication 2, 3. RT readback, Future RT communication	1. L-M 2. M 3. L-M	New task - potential for confusion between TBS and DBS, particularly in transition period
1.2.5.6 Receive pilot acknowledgement ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback 3. Fail to detect pilot refusal to use TBS	1, 3. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot may be unaware that TBS is in operation, Controller and pilot could have different knowledge states 3. Controller attempts to use TBS when pilot is unwilling or unable to use TBS, Controller and pilot have different knowledge states	1, 2, 3. Future RT communication	1. L-M 2. L-M 3. L-M	New task - potential for confusion between TBS and DBS, particularly in transition period
1.2.5.7 Update strip ‖	1. Fail to update strip 2. Update wrong strip 3. Update strip incorrectly	1. Forget action 2. Selection error 3. Incorrect Information, Unclear information, Misrecall information	1. Controller could forget TBS a/c, Failure to transfer information at handover 2, 3. Controller may have incorrect knowledge / recall of TBS a/c, Failure to transfer information at handover	1, 2, 3. Check on strip markings, Handover, Other controller	1. M 2. M 3. M	
1.3 Maintain traffic separation within sector	↓					
Plan: Do in order. Repeat as necessary in case of changes to conditions (e.g. headwind).						

1.3.1 Review traffic situation from strips and radar ‖	1. Fail to review / notice strip information 2. Misread strip 3. Review wrong strip 4. Fail to check / notice radar information 5. Mis-see radar	1, 4. No detection - visual, Forget action 2, 3, 5. Mis-see	1, 4. Controller unaware of traffic situation 2, 3, 5. Controller has incorrect knowledge of a/c details	1, 2, 3. Radar monitoring, RT communication 4, 5. Check on strip markings, RT communication	1. M-H 2. M-H 3. M-H 4. L-M 5. M	Increased radar monitoring burden
1.3.2 Evaluate need for action	↓					
Plan: Do in order.						
1.3.2.1 Determine a/c separations ‖	1. Fail to notice a/c separations 2. Misinterpret a/c separations 3. Confuse separations of TBS and DBS a/c	1, 3. Mis-see 2. Misprojection	1, 3. Controller unaware of a/c separations, Potential loss of separation 2. Controller has incorrect knowledge of a/c separations, Potential loss of separation	1, 2, 3. STCA	1. L-M 2. L-M 3. L-M	Controllers may have difficulty distinguishing TBS from DBS a/c. Clear permanent visual markers would be required.
1.3.2.2 Predict potential conflicts ‖	1. Fail to predict potential conflict 2. Falsely identify potential conflict	1, 2. Misprojection	1. Conflict, Potential loss of separation 2. Workload increase	1. STCA 2. No recovery necessary	1. L-M 2. H	Controllers may have difficulty distinguishing TBS from DBS a/c. Clear permanent visual markers would be required.
1.3.2.3 Consider flight plans ‖	1. Fail to check flight plan 2. Misread flight plan 3. Check wrong flight plan	1. Forget action 2, 3. Mis-see	1. Controller unaware of a/c route / destination / weight, etc 2, 3. Controller has incorrect knowledge of a/c route / destination / weight etc, Possible errors in routing	1, 2, 3. RT communication, Radar monitoring (destination code)	1. H 2. M-H 3. M-H	Critical that controllers are aware of a/c performance capabilities.
1.3.3 Decide on action to be taken	1. Fail to decide on action 2. Decide on action with inappropriate parameter 3. Decide to take action on wrong a/c	1. Forget action, Late or no decision, Poor decision 2, 3. Poor decision	1, 2, 3. Potential loss of separation	1, 2, 3. STCA	1. L-M 2. L-M 3. L-M	Same as current, but less time available for recovery

Plan: Do 1. Then do 2 to 5 in order.						
1.3.3.1 Assess options ‖	☒					
1.3.3.2 Check headwind and MET conditions (e.g. on Information Monitor) ‖	1. Fail to check headwind 2. Mis-see headwind 3. Check headwind too late 4. Fail to verify accuracy of headwind information	1. Forget action, Poor decision 2. Mis-see 3. Forget action, Late or no decision 4. Forget action, Poor decision, Late or no decision	1, 2, 3, 4. Controller unaware of true headwind, Headwind affects a/c performance, Potential loss of separation	1, 2, 3, 4. RT communication	1. M 2. L-M 3. M 4. L-M	How will accuracy and validity of headwind information be indicated on supplementary monitors?
1.3.3.3 Decide on a/c to manoeuvre ‖	1. Fail to decide on a/c to manoeuvre 2. Decide to manoeuvre wrong a/c	1. Forget action 2. Poor decision	1. Potential loss of separation 2. Potential secondary conflict, Potential loss of separation	1, 2. Radar monitoring, STCA	1. L-M 2. M	Same as current, but less time available for recovery
1.3.3.4 Choose manoeuvre option ‖	1. Choose wrong manoeuvre option	1. Poor decision	1. Potential secondary conflict, Potential loss of separation	1. Radar monitoring, STCA	1. M	Same as current, but less time available for recovery
1.3.3.5 Ensure option does not lead to new conflict ‖	1. Fail to ensure manoeuvre does not lead to new conflict	1. Poor decision	1. Potential secondary conflict, Potential loss of separation	1. Radar monitoring, STCA	1. M	Same as current, but less time available for recovery
1.3.4 Initiate action	☒					
Plan: Do 1 if necessary. Then do 2 to 4 in order.						
1.3.4.1 Co-ordinate with relevant controller ‖	☒					
1.3.4.2 Issue instruction to a/c ‖	☒					
1.3.4.3 Receive pilot readback ‖	☒					
(PNF readback instruction)	☒					
(PF execute)	☒					
1.3.4.4 Update strips ‖	☒					
1.4 Hold a/c	☒					
Plan: Do in order.						

1.4.1 Issue instruction to hold ‖	☒					
1.4.2 Receive pilot readback ‖	☒					
1.4.3 Update strip ‖	☒					
1.5 Sequence a/c / Follow AMAN sequence	↓					
Plan: Do 1 and 2 then 3. Plan: Do 4 if AMAN advice available. Then do 5. Plan: Do 6 if required. Then do 7 to 10 in order. Repeat 5 to 10 if a/c need to be re-sequenced (e.g. headwind changes).						
1.5.1 Review situation on radar (approach path and speed) ‖	1. Fail to check approach path / speed 2. Mis-see or misinterpret approach path / speed 3. Fail to realise conflict or problem	1. Forget action 2. Mis-see 3. Misprojection	1. Controller unaware of approach path and speed, Potential mis-sequencing 2. Controller has incorrect knowledge of approach path and speed, Potential mis-sequencing 3. Controller unaware of conflict or problem, Potential mis-sequencing, Conflict	1, 2. RT query by pilot? 3. STCA	1. M 2. M 3. L-M	Same as current, but less time available for recovery
1.5.2 Review strips ‖	1. Fail to review strip 2. Misread strip 3. Review wrong strip 4. Fail to realise conflict or problem	1. Forget action 2, 3. Mis-see 3. Misprojection	1. Controller unaware of a/c details 2, 3. Controller has incorrect knowledge of a/c details 4. Controller unaware of conflict or problem, Potential mis-sequencing, Conflict	1, 2, 3, 4. Radar monitoring, RT communication	1. H 2. M 3. M-H 4. M	Same as current, but less time available for recovery

1.5.3 Check Wake Vortex Separation Requirements ‖	1. Fail to check Wake Vortex Separation Requirements 2. Mis-read Wake Vortex Separation Requirements	1. Forget action, Poor decision 2. Mis-see	1, 2. Controller unaware of (actual) Wake Vortex Separation Requirements, Large headwind and heavy wake vortex would slow a/c significantly, Potential mis-sequencing, Potential loss of separation	1, 2. Radar monitoring, RT communication, STCA	1. L 2. L	Same as current, but more critical
1.5.4 Follow AMAN advisory ‖	1. Fail to check AMAN / check late 2. Fail to check suitability /integrity of AMAN advisory 3. Mis-interpret AMAN advisory 4. Ignore AMAN Advisory	1. Forget action, No decision, Poor decision, Late Decision 2. Forget action, No decision, Poor decision, Late Decision 3. Mis-see Poor decision, No decision 4. Poor decision, No decision	1. ATCO unaware of AMAN, AMAN may have changed 2. AMAN advisory may not be appropriate, Potential mis-sequencing 3, 4. Potential mis-sequencing	1, 2, 3, 4. Radar monitoring	1. M 2. M 2. M 3. M	Same as current, but less time available for recovery
1.5.5 Decide / review sequence order ‖	1. Decide on inappropriate sequence order 2. Fail to resequence in timely manner	1. Poor decision , 2. Late decision	1. Potential mis-sequencing 2. Loss of spacing/separation	1. Radar monitoring 2. Radar monitoring, RT communication, STCA	1. M 2. M	May have to take several a/c out of sequence in strong sudden headwind. How will these be resequenced?
1.5.6 Co-ordinate a/c ‖	☒					
1.5.7 Issue sequencing instruction(s) ‖	☒					
1.5.8 Receive pilot readback ‖	☒					
1.5.9 Update strip ‖	☒					
1.5.10 Monitor and maintain sequencing and spacing [see 1.3] ‖	1. Fail to monitor and maintain sequencing and spacing	1. Forget action, Poor decision	1. Potential mis-sequencing, Potential loss of separation	1. RT communication, STCA	1. M	Same as current, but less time available for recovery
1.6 Turn a/c onto base leg	☒					
Plan: Do in order.						
1.6.1 Issue QNH to a/c ‖	☒					

1.6.2 Issue heading change ‖	☒					
1.6.3 Receive pilot readback ‖	☒					
1.6.4 Update strip ‖	☒					
1.7 Turn a/c onto intercept ILS	☒					
Plan: Do in order.						
1.7.1 Issue heading change ‖	☒					
1.7.2 Receive pilot readback ‖	☒					
1.7.3 Update strip ‖	☒					
1.8 Establish a/c on ILS	🡻					
Plan: Do 1 if required. Then do 2, to 5 in order. Plan: Do 6 and 7 as necessary following executive instructions.						
1.8.1 Inform pilot of distance to touchdown ‖	☒					
1.8.2 Instruct a/c to report when established on ILS ‖	☒					
1.8.3 Check Wake Vortex Separation Requirements ‖	1. Fail to check Wake Vortex Separation Requirements 2. Mis-read Wake Vortex Separation Requirements	1. Forget action, Poor decision 2. Mis-see	1, 2. Controller unaware of (actual) Wake Vortex Separation Requirements, Large headwind and heavy wake vortex would slow a/c significantly, Potential mis-sequencing, Potential loss of separation	1, 2. Radar monitoring, RT communication, STCA	1. L 2. L	Unsure when controller checks Wake Vortex Separation Requirements
1.8.4 Issue instructions necessary a/c to maintain Wake Vortex Separation ‖	1. Fail to issue instruction 2. Issue inappropriate instruction 3. Issue instruction to wrong a/c	1. Forget action 2. Poor decision Incorrect information 3. Incorrect information	1, 2, 3. Potential loss of separation	1. STCA 1, 2, 3. RT readback, STCA	1. L 2. M 3. M	Same as current, but more serious, with less time available for recovery

1.8.5 Instruct a/c to descend with ILS ‖	☒					
1.8.6 Receive pilot readback ‖	1. Fail to detect / query erroneous / spurious readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Poor decision, No decision	1, 2. Pilot may not respond, Pilot may respond inappropriately, Controller and pilot have different knowledge states, Potential loss of separation	1, 2. Radar monitoring, STCA	1. L-M 2. L-M	Same as current, but less time available for recovery
1.8.7 Update strip ‖	☒					
1.9 Transfer to next sector / tower / controller	🡻					
Plan: Do 1 and 2 in any order. Then do 3 to 6 in order. Plan: Do 7 if required. Then do 8.						
1.9.1 Verify that a/c is clear to agreed level ‖	☒					
1.9.2 Verify that a/c is approaching exit point ‖	☒					
1.9.3 Verify that a/c is not in conflict ‖	☒					
1.9.4 Instruct pilot contact next sector freq ‖	☒					
1.9.5 Receive pilot readback ‖	☒					
1.9.6 Update strip ‖	☒					

1.9.7 Contact next sector by telephone to identify unusual circumstances and a/c on TBS ‖	1. Fail to identify a/c on TBS 2. Falsely identify a/c as being on TBS 3. Fail to determine time parameter 4. Confuse time parameter	1, 3. Forget information, No decision 2, 4. Misrecall information, Incorrect information	1. Relief controller unaware of a/c on TBS. Provides DBS rather than TBS, Potential loss of separation 2. Relief controller falsely believes a/c are on TBS, Provides TBS rather than DBS. Potential loss of separation 3. Relief controller unaware of time parameter, or assumes time parameter, Relief controller uses wrong time parameter, Potential loss of separation 4. Relief controller uses wrong time parameter, Potential loss of separation	1, 2. Future RT communication 3, 4. None identified	1. M-H 2. L-M 3. L-M 4. L	Will TBS be indicated visually on transfer? Will time parameter always be the same, and for all a/c? Where will time parameter be recorded?
1.9.8 Pass or discard strip ‖	☒					
1.10 Handover control to relief controller	🡻					
Plan: Do in order.						
1.10.1 Point out a/c under sector control	🡻					
Plan: Do 1. Then do 2 to 4 in parallel.						
1.10.1.1 Explain traffic situation to relief controller ‖	☒					

1.10.1.2 Point out a/c on TBS ‖	1. Fail to point out a/c on TBS 2. Falsely point out a/c on TBS	1. Forget action, Poor decision 2. Misrecall information, Incorrect information	1. Relief controller unaware of a/c on TBS. Provides DBS rather than TBS, Potential loss of separation 2. Relief controller falsely believes a/c are on TBS, Provides TBS rather than DBS. Potential loss of separation	1, 2. Future RT communication, Future check of strip markings	1. H 2. M	Assume strip markings indicate TBS? Where will TBS be indicated?
1.10.1.3 Determine time parameter ‖	1. Fail to determine time parameter 2. State wrong time parameter	1. Forget action, Poor decision 2. Misrecall information, Incorrect information	1. Relief controller unaware of time parameter, or assumes time parameter, Relief controller uses wrong time parameter, Potential loss of separation 2. Relief controller uses wrong time parameter, Potential loss of separation	1, 2. Future check of strip markings	1. M 2. L-M	Will time parameter always be the same, and for all a/c? Where will time parameter be recorded?
1.10.1.4 Correlate information on radar and strips ‖	☒					
1.10.2 Acknowledge release of sector	☒					
Plan: Do in order.						
1.10.2.1 Switch off microphone ‖	☒					
1.10.2.2 Unplug headset ‖	☒					

Table A.4.2: Recovery Success Likelihood Scale

RSL	Detection	Diagnosis	Correction
High	> Easily detected > Immediate, clear, direct feedback of actions/effects > Active involvement and constant monitoring > Independent/third party checks, automatic checks or cues to check	> No diagnosis required or very reliable diagnosis expected > No 'expectation bias'/'confirmation bias'	> Easily corrected, requiring no changes to plan, and causing little or no additional workload > Plenty of time available for recovery
Moderate -High			
Moderate	> Detectable > Feedback available > Regular but intermittent monitoring > Some cues to check or occasional independent checking by third party or automation	> May require some interpretation or diagnosis > Incorrect diagnosis possible > May be some 'expectation bias'/'confirmation bias'	> May necessitate changes to plan or corrective action using practised procedure causing some additional workload > Controller prepared and able to intervene > Some time pressure to recover error
Low-Moderate			
Low	> Difficult to detect > No feedback, or poor, indirect or delayed feedback > No monitoring or passive monitoring > High reliance on memory to check or suspect error	> Hard to diagnose, diagnosis very likely to be incorrect > Strong 'expectation bias'/'confirmation bias'	> Plan modification or difficult or complex correction process required, causing considerable workload > Controller unprepared or not familiar with procedures, with limited ability to intervene > Strong time pressure, or insufficient time available for recovery

5. APPENDIX A.5: CORA 2 STUDY OVERVIEW

The CORA 2 study began with an initial scoping meeting for HAZOP and TRACEr-lite conducted with the CORA 2 Software Engineer. During this meeting, the CORA 2 concept was described and four CORA 2-relevant high-level tasks were identified:

- The controller prioritises the detected conflict situations.
- The controller analyses the focussed conflict situation.
- The controller decides to resolve a conflict/problem in a CORA 2 environment
- The controller acts on the conflict/problem.

5.1 HAZOP Approach

The CORA 2 HAZOP analysis began with a set of task steps developed by DNV with the assistance of the project team as part of the HTA process. The top-level tasks were passed to the HAZOP leader for use in the HAZOP session. The Human HAZOP approach described in Section 2 was applied to these task steps. Risk ranking was not performed for the HAZOP session. The HAZOP considered both controller- and pilot-related errors, since all were judged relevant and useful to consider while each delegation phase was being considered. Additionally, the HAZOP considered other issues related to information availability.

A one-day session was held at the EEC in Brétigny. The HAZOP sessions were attended by three of the project team members (project manager and two software engineers) and an independent safety representative. It was not possible to use obtain a controller, pilot or human factors specialist for the session. A DNV safety consultant facilitated and recorded the analysis. This dual role was possible due to the small-scale nature of this HAZOP.

Due to the limited time available to conduct the HAZOP, the team focused on the following task:

- **Analyse focused situation** – understanding the conflict situation and deciding an action (HTA Task 1.3).

5.2 TRACEr-lite Methodology

Following the initial consultation, various documentation were reviewed, as follows:

- EATMP (2002). *CORA 2 Operational Concept of Use*. ASA.01.CORA.2.DEL01.OCU, V1.0, Proposed Issue.
- EATMP (2002). *Operational Scenario Document*. ASA.01.CORA.2.DEL05-B.OSD, V0.3, Draft.
- EATMP (2002). *CORA 2 HMI document*. V0.1, Draft.

- EATMP (2002). *Model of the Controller-CORA 2 Interaction. The controller's task of conflict resolution in a CORA 2 environment*. Working Draft.

The availability of documentation describing the Human-Machine Interface and Controller-CORA 2 Interaction made it possible to represent the task steps in detail in a preliminary HTA.

A set of data collection meetings was held between 5-7 November 2002. The draft HTA was presented individually to a CORA 2 Software Engineer, a CORA 2 Human Factors specialist and an Air Traffic Controller in a series of consultations lasting 1 to 2 hours. Each project team member helped to shape and modify the HTA until an agreed version was formed. Following the meeting, the TRACEr-lite analyst sent the finished HTA to the meeting attendees for review and comment[2].

The full HTA for controller tasks related to the implementation of CORA 2 is presented in Appendix A.7. The HTA was constructed for the range of tasks involved in resolving a conflict situation using CORA 2. The HTA described in detail the 'top-level' tasks in Table A.5.1.

Table A.5.1: Top-level HTA task and implications identified for CORA 2 during Task Analysis

HTA Top Level Tasks	Implications identified for CORA 2 during Task Analysis?
1.1 Detect conflict situation	Yes
1.2 Prioritise conflict situation(s)	Yes
1.3 Analyse focussed situation	Yes
1.4 Act on focussed situation	Yes
1.5 Check resolution progress	Yes
1.6 Monitor situation	Yes

All six tasks differed from the current method of conflict detection and resolution.

5.3 Comparison of Results

This section provides a general comparison of the findings generated by Human HAZOP and TRACEr-lite for Task 1.3 'Analyse focused situation'. The full HAZOP worksheets and recommendations are included in Appendix A.6. A full list of the 41 potential errors and issues identified by HAZOP is shown in Table A.5.2.

The detailed TRACEr-lite analysis for controller tasks related to the implementation of CORA 2 is presented in Appendix A.8.

It is particularly difficult to compare HAZOP and TRACEr-lite for CORA 2, primarily due to the different grain of analysis produced by the two techniques. Hence, the following analysis excludes from the

[2] One set of detailed comments was received from the Human Factors Specialist, which were incorporated into the HTA.

comparison detailed errors in HMI interaction identified by TRACEr-lite (i.e. over 90 errors in mouse interaction with the Plan View Display, Conflict Detector, Vertical Aid Window and a/c label), and combines a number of errors in order to present a more balanced comparison.

Table A.5.2: Errors and issues Identified by HAZOP and TRACEr-lite for Task 1.3 'Analyse focussed situation'.

Error/Issue	In-scope HAZOP?	In-scope TRACEr-lite?
Issues identified by both HAZOP and TRACEr-lite		
Controller mis-selects resolution from CORA options (different from intention)	Yes	Yes
Wrong resolution not spotted by controller *	Yes	Yes
Controller fails to detect conflict / resolutions	Yes	Yes
Controller fails to select resolution or takes no action (e.g. due to misunderstanding or because of role confusion between PC and TC or between sectors)	Yes	Yes
Controller manually modifies or elaborates a resolution that is not conflict free (not one of CORA options) due to misjudgement	Yes	Yes
Controller manually modifies or elaborates a resolution that is not conflict free (not one of CORA options) due to slip of hand (HMI related?)	Yes	Yes
Controller fail to react to one of the resolutions presented (e.g. decides to wait)	Yes	Yes
Controller reacts late or too slowly	Yes	Yes
Resolution is presented too early to controller (controller then waits and forgets to return to task later)	Yes	Yes
Controller selects two resolutions for one conflict	Yes	Yes
Issues identified by HAZOP only		
Two controllers try to resolve the same conflict (might both be using CORA or one might be doing it manually)	Yes	Yes
No resolutions presented to controller (either HMI or CORA not working) *	Yes	No
No resolutions presented to controller because CORA unable to identify one *	Yes	No
Wrong resolutions presented to controller (could be out-of-date or not conflict free) *	Yes	No
Wrong resolutions presented to controller (ranking incorrect or unexpected) *	Yes	No
Information overload (multiple conflicts on screen or multiple reminders) *	Yes	No
System does not show conflict (e.g. system is too busy calculating resolution) *	Yes	No
System does not show conflict (e.g. a/c has not yet changed course following clearance) *	Yes	No
Full set of resolutions not available	Yes	No
CORA reacts late or too slowly	Yes	No
Reminder sent too early (could be miscalculation or HMI issue) *	Yes	No
Best resolution is very late *	Yes	No
Conflict detected too late for CORA *	Yes	No
Reminder arrives too late (could be miscalculation or HMI issue)	Yes	No
No information from MTCD / TP *	Yes	No
No deviation alerts from MONA *	Yes	No
No environment data	Yes	No
No sequencing constraints	Yes	No
Too many recalculations (too many updates from supporting systems)	Yes	No
HMI overkill (e.g. clock presentation)	Yes	No
Too many reminders (could be linked to HMI)	Yes	No
Too few recalculations (too few updates from supporting systems)	Yes	No
Wrong (incomplete) information from MTCD / TP *	Yes	No
Wrong deviation alerts from MONA *	Yes	No
Wrong environment data	Yes	No
Wrong sequencing constraints	Yes	No

Error/Issue	In-scope HAZOP?	In-scope TRACEr-lite?
Incorrect letter of agreement	Yes	No
Co-ordination for resolution not been identified	Yes	No
Co-ordination for resolution identified when not needed	Yes	No
Treatment of trajectories pending implementation in the air	Yes	No
Issues identified by TRACEr-lite only		
Controller fails to identify a/c involved	Yes	Yes
Controller misidentifies a/c (& FL) involved	Yes	Yes
Controller falsely identifies a/c involved	Yes	Yes
Controller fails to check/misreads FL of a/c involved	Yes	Yes
Controller fails to identify/misidentifies where conflict/problem will occur	Yes	Yes
Controller fails to identify/misidentifies type of conflict	Yes	Yes
Controller fails to assess/mis-projects stability of the trajectories	Yes	Yes
Controller fails to decide/decides wrong level of assistance	Yes	Yes
Controller fails to check suitability of CORA 2 advice	Yes	Yes
Controller fails to decide/decides wrong sequence of manoeuvres	Yes	Yes
Controller fails to display/displays wrong resolution information	Yes	Yes
Controller inadvertently selects resolution	Yes	Yes
Controller fails to request additional resolutions	Yes	Yes
Controller fails to observe/misinterprets effect of a resolution on the PVD	Yes	Yes
Controller fails to modify/modifies wrong CORA 2 proposal	Yes	Yes
Controller fails to elaborate a resolution	Yes	Yes
Controller wrongly assumes notification is false alert	Yes	Yes
Controller fails to consult TC when necessary	Yes	Yes

* Failure(s) of associated ATCO monitoring identified

For Task 1.3 'Analyse focussed situation', HAZOP and TRACEr-lite identified 10 errors or issues in common.

In addition, 30 issues (almost all relating to information display or data/equipment problems) were identified only by HAZOP, only one of which was within the scope of the TRACEr-lite study. For 14 of these issues, TRACEr-lite did identify associated failures in the ATCO response or monitoring.

TRACEr-lite identified over 18 controller errors not identified by HAZOP. Many of these are groups of similar errors, and do not include minor human-machine interaction errors.

TRACEr-lite analysed five additional high-level tasks that were not analysed in the HAZOP session. The errors identified for these tasks are not included in this comparison, but can be seen in Appendix A.8.

5.3.1 Consequences

The HAZOP study found the following summarised consequences for the CORA 2 task above.

- Controller's situational awareness is negatively impacted (wrong picture of future trajectory of a/c).
- Degraded information (unable to depend on CORA).

- CORA overloaded, could fail.
- Distraction/ confusion for controller.
- Increased workload.
- Loss of time or optimum resolution.
- Loss of trust in CORA by controller.
- No automated resolution available.
- Controller does not react until STCA.
- Potential loss of separation.

The TRACEr-lite analysis determined the following impacts consequences for the CORA 2 task above.

- CORA 2 proposal not modified.
- Controller unaware of, or assumes, all a/c involved /type of conflict /where conflict/problem will occur/effect of a resolution.
- Controller implements different resolution to that recorded?
- Controller may have incorrect picture of conflict situation /unaware conflict still exists.
- Controller may modify wrong proposal.
- CORA 2 proposal not modified.
- Erroneous update of trajectory/FL.
- Inappropriate trajectory/FL selected.
- Possibility of erroneous update.
- Resolution not selected.
- Workload increase.
- Possible loss of separation.

5.3.2 Safeguards

The HAZOP study for CORA listed the following key safeguards:

- Alert deviation.
- Clearance history and planned trajectory.
- Conflict free resolutions.
- CORA checks.
- HMI feedback.
- MTCD.
- Prioritisation.
- Recalculation.
- Reliability of CORA algorithms.
- Reminders.

- STCA.
- Tactical controller and verbal communication between PC and TC.
- Visibility of trajectory editor use by other controllers.

The following 'detection means' were identified by TRACEr-lite:

- All resolutions are safe.
- CORA checks and other functionality.
- MTCD.
- Radar monitoring.
- Reminder to act.
- RT communication.
- STCA.
- TC monitoring.

5.3.3 Recommendations

5.3.3.1 HAZOP-generated

HAZOP generated the following recommendations:

1. Design the HMI to minimise chance of controllers mis-selecting a resolution from CORA options.
2. The design of CORA 2 should take account of the possibility that CORA 2 may become safety critical in the future (integrated into controllers' normal working methods).
3. CORA 2 should be monitoring itself and provide alert to controller in case of malfunction.
4. Where CORA 2 is not able to present a resolution to the controller, an alert plus rationale provided to controller.
5. Develop adequate procedures for role definition (PC/TC).
6. Develop adequate procedures for tuning parameters relevant to ranking.
7. CORA 2 requires tuning to ensure that the controller focuses on most import conflict.
8. The CORA 2 display should indicate that a full set of resolutions is not available, along with a rationale.
9. Controller training is required for CORA, as well as the development of working methods.
10. If MTCD or Trajectory Prediction fails, remedial actions and display needs to be clarified.
11. Elicitation of what is a relevant change/update (and hence what causes recalculation) should be defined as part of review of adjacent systems.

5.3.3.2 TRACEr-lite-generated

1. Design Track Data Block symbology and text (i.e. red dot, availability triangle, callsign, XFL, etc.) so that it is easy to select and does not lose focus when the TDB moves. Ensure this task is possible with acceptable performance limits for all screen resolutions/font sizes.
2. Ensure clear feedback is shown when a resolution is selected (e.g. incorporating feedback for a specified time period after the OK button is pressed)
3. Ensure controller can easily change resolutions selected accidentally.
4. Conduct further studies into error rates for forgetting to change label values.
5. Conduct further studies into error rates for forgetting to prepare PAC.
6. Ensure co-ordination rejections, discontinuations and counterproposals are clearly indicated to the controller.
7. Provide means to ensure protected trajectories are not modified again (i.e. following CORA 2 resolution).
8. Provide automatic warnings to indicate problems with data integrity (e.g. where different data sources are not coherent, failure of associated system).
9. Provide training in recovery from CORA 2 failure.
10. Consider periodic continuity training without CORA 2 to maintain controller conflict detection and resolution capability.
11. Conduct an assessment of controller recovery from CORA 2 failures.

5.3.4 Discussion

HAZOP and TRACEr-lite performed in a similar way for the CORA 2 study as for the Co-Space and TBS study. For the one task considered by HAZOP, the two techniques identified a set of errors in common, and both HAZOP and TRACEr-lite identified errors and issues that were not identified by the other technique. HAZOP identified pilot and information/equipment issues that were not considered by TRACEr-lite (outside the scope of the study). TRACEr-lite identified controller errors not identified by HAZOP. These latter errors were, however, within the HAZOP study scope. Again, TRACEr-lite analysed all six tasks while HAZOP only considered one in the time available for the study.

Both the HAZOP and TRACEr-lite analyses identified a similar range of consequences but HAZOP identified more safeguards, reflecting the experience of the HAZOP team members.

Both analyses identified a similar number of recommendations, but again, HAZOP was overall much more productive in this respect, since it only considered one of the six tasks analysed by TRACEr.

The CORA 2 team felt that the HAZOP was of limited use to the project since a similar exercise had been conducted less than a year before as part of the Functional Hazard Assessment. This process uses a comparable group-based process, itself adapted from HAZOP.

6. APPENDIX A.6: CORA 2 HAZOP WORKSHEETS

Table A.6.1: CORA 2 HAZOP Worksheets

Project: CORA 2		**System: Analyse Focussed Situation**		**Recommendations**
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
1. Wrong action	1.1 Controller mis-selects resolution from CORA options (different from intention)	1.1 Controller's situational awareness is negatively impacted (wrong picture of future trajectory of a/c). This knocks-on to future decisions.	1.1. Tactical controller spots error at reminder or RT stage.	*Comment - Any resolution is conflict free.* 1. Design the HMI to minimise chance of controllers mis-selecting a resolution from CORA options.
		1.2. Could impact on workload if corrected in time.	1.2. Verbal comms between PC and TC.	
			1.3. Controller can view clearance history and planned trajectory.	
2. Wrong action	2.1 No resolutions presented to controller (either HMI or CORA not working)	2.1. No automated resolution for new conflicts.	2.1. Controller builds own resolution as they would still see conflict.	2. The design of CORA 2 should take account of the possibility that CORA 2 may become safety critical in the future (integrated into controllers' normal working methods).
		2.2. Controller needs to tidy up existing conflicts.	2.2. CORA 2 is not intended to be safety critical initially.	3. CORA 2 should be monitoring itself and provide alert to controller in case of malfunction.
3. Wrong action	3.1. No resolutions presented to controller because CORA unable to identify one	3.1. No automated resolution for this relevant conflict.	3.1 Controllers build own resolution as they would still see conflict.	4. Where CORA 2 is not able to present a resolution to the controller, an alert plus rationale provided to controller.
4. Wrong action	4.1 Wrong resolutions presented to controller (could be out-of-date or not conflict free)	4.1. If controller selects conflicting resolution could lead to increased workload and higher chance of LOS.	4.1. MTCD will detect any new conflict.	
		4.2. If out of date could lead to	4.2. STCA.	

Project: CORA 2		System: Analyse Focussed Situation		Recommendations
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
		overload or even higher chance of LOS.		
			4.3. Clear definition of timespan for which CORA 2 is relevant (> 2mins before LOS).	
			4.4. Controller should spot wrong resolution.	
5. Wrong action	5.1. Wrong resolutions presented to controller (ranking incorrect or unexpected)	5.1. Controller may not select optimum resolution - could have cost or workload implications (extra complexity if unexpected)	5.1. Reliability of CORA algorithms.	5. Develop adequate procedures for tuning parameters relevant to ranking.
6. Wrong action	6.1. Wrong resolution not spotted by controller	6.1. Related to safeguard above		*Comment - Failures of safeguards not analysed further.*
7. Wrong action	7.1. Controller does not see conflict nor resolutions offered (possibly because HMI breaks down)	7.1. Controller does not react until STCA	7.1. STCA if CORA breaks down.	
			7.2. Reminder to act on best resolution in case of HMI clutter.	
8. Wrong action	8.1. Controller takes no action because of role confusion (either between PC and TC or between sectors)	8.1. Loss of time	8.1. Reminder.	5. Develop adequate procedures for role definition (PC/TC).
			8.2. STCA etc.	
9. Wrong action	9.1. Information overload (multiple conflicts on screen or multiple reminders)	9.1. See above, e.g. loss of time, no reaction until reminder or STCA etc.	9.2. Information about next conflict to act on (intended to help prioritisation).	6. CORA 2 requires tuning to ensure that the controller focuses on most import conflict.
10. Wrong action	10.1. System does not show conflict (e.g. system is too busy calculating resolution)	10.1. Loss of time.	10.1. Performance requirement for time to complete calculation, then alert if time is exceeded.	
		10.2. Loss of trust in CORA 2 by controller	10.2. Conflict will be displayed and controller resolves manually.	

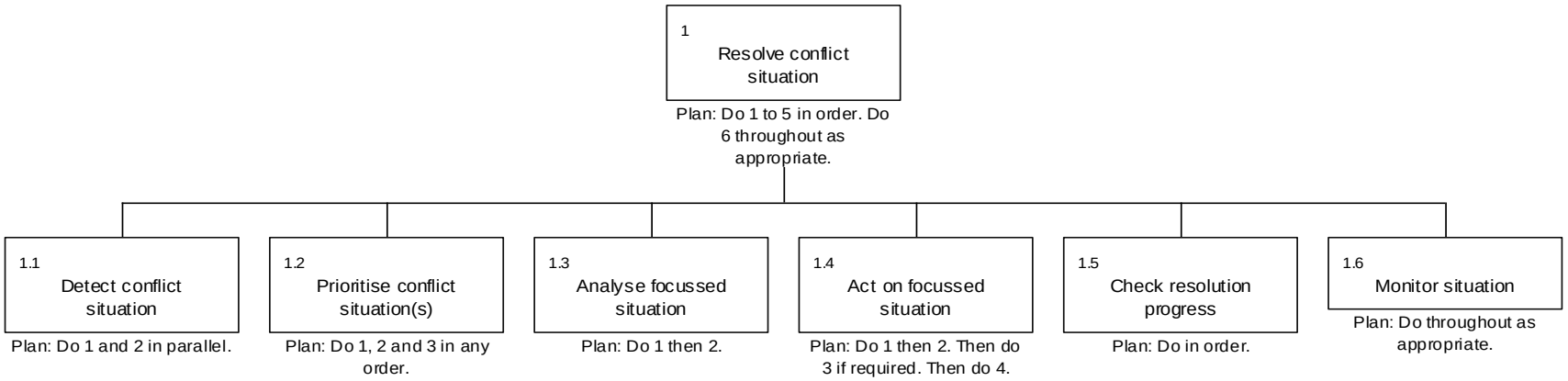
Project: CORA 2		System: Analyse Focussed Situation		Recommendations
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
11. Wrong action	11.1. System does not show conflict (e.g. a/c has not yet changed course following clearance)			*Comment - Open item: when to update system trajectory (when a new plan has been decided or when related clearance has been issued)*
12. Wrong action	12.1. Controller manually enters resolution that is not conflict free (not one of CORA options) due to misjudgement	12.1. Another conflict that will be treated by CORA, loss of time.	12.1. If trajectory is edited via CORA-1, checks are made and immediate feedback given.	
			12.2. MTCD and CORA.	
13. Wrong action	13.1. Controller manually enters resolution that is not conflict free (not one of CORA options) due to slip of hand (HMI related?)	13.1. Another conflict that will be treated by CORA, loss of time.	13.1. If trajectory is edited via CORA-1, checks are made and immediate feedback given.	
			13.2. MTCD and CORA.	
			13.3. HMI feedback.	
14. No Action	14.1. See above for some causes (e.g. CORA or controller not working)			*Comment - Some causes generated under "Wrong Action" would probably better fit under "No Action"*
15. No Action	15.1. Controller does not react to one of the resolutions presented (e.g. decides to wait)	15.1. Loss of time, loss of optimum resolution	15.1. Reminder to act on the best one.	
			15.2. STCA etc.	
16. More Action	16.1. Controller selects two resolutions for one conflict		16.1. Prevented by system.	
17. More Action	17.1. Two controllers try to resolve the same conflict (might both be using CORA 2 or one might be doing it manually)	17.1. Increased workload	17.1. System prevents 2 controllers using CORA-2 from resolving same conflict.	*Comment - Can happen with controllers from different sectors.*
			17.2. When trajectory editor is being used, other controllers can see this.	
			17.3. Within trajectory edition, feedback on change.	

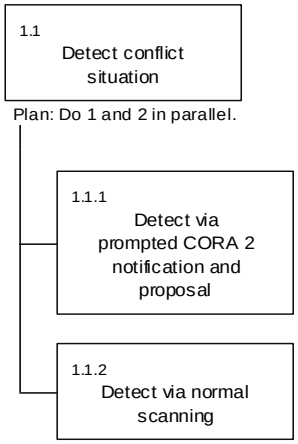
Project: CORA 2		System: Analyse Focussed Situation		Recommendations
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
			17.4. Alert deviation if one controller has used RT and forgotten to update electronically (and vice versa).	
18. Less Action	18.1. Full set of resolutions not available	18.1. Less choice, potential loss of trust.	18.1. Conflict free resolutions still available.	7. The CORA 2 display should indicate that a full set of resolutions is not available, along with a rationale.
19. Less Action	19.1. Controller reacts late or too slowly	19.1. Loss of time, extra workload, higher chance of LOS	19.1. Reminders, prioritisation and recalculation (resolutions are up-to-date)	8. Controller training is required for CORA, as well as the development of working methods.
20. Less Action	20.1. CORA reacts late or too slowly	Not analysed further		
21. More Time	21.1. Resolution is presented too early to controller (controller then forgets)	Not analysed further		
	21.2. Conflict is presented too early and not trusted by controller	Not analysed further		
	21.3. Reminder sent too early (could be miscalculation or HMI issue)	Not analysed further		
22. Less Time	22.1. Best resolution is very late	Not analysed further		
23. Less Time	23.1. Conflict detected too late for CORA	Not analysed further		
24. Less Time	24.1. Reminder arrives too late (could be miscalculation or HMI issue)	Not analysed further		
25. No Information	25.1. No information from MTCD / TP	25.1. CORA 2 can not be relied on (information degrades with time)	25.1. Alert to controller.	9. If MTCD or Trajectory Prediction fails, remedial actions and display needs to be clarified.
			25.2. STCA	
26. No Information	26.1. No deviation alerts from MONA	Not analysed further		

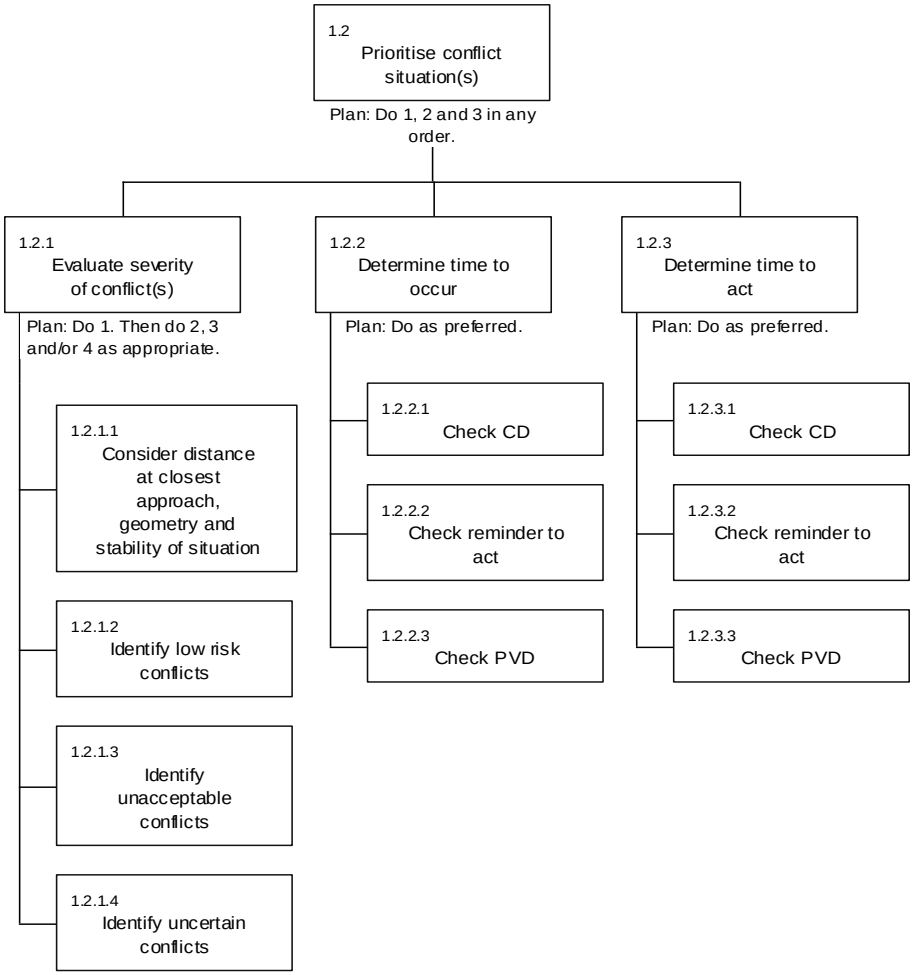
Project: CORA 2		System: Analyse Focussed Situation		Recommendations
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
27. No Information	27.1. No environment data	Not analysed further		
28. No Information	28.1. No sequencing constraints	Not analysed further		
29. More Information	29.1. Too many recalculations (too many updates from supporting systems)	29.1. CORA overloaded, could fail.	29.1. Recalculation is selective and selection parameters are tunable.	10. Elicitation of what is a relevant change/update (and hence what causes recalculation) should be defined as part of review of adjacent systems.
		29.2. Distraction/ confusion for controller.		
30. More Information	30.1 HMI overkill (e.g. clock presentation)	Not analysed further		
31. More Information	31.1 Too many reminders (could be linked to HMI)	Not analysed further		
32. Less Information	32.1. Too few recalculations (too few updates from supporting systems)	Not analysed further		
33. Wrong Information	33.1. Wrong (incomplete) information from MTCD / TP	Not analysed further		
34. Wrong Information	34.1. Wrong deviation alerts from MONA	Not analysed further		
35. Wrong Information	35.1. Wrong environment data	Not analysed further		
36. Wrong Information	36.1. Wrong sequencing constraints	Not analysed further		
37. Wrong Information	37.1. Incorrect letter of agreement	Not analysed further		
38. Wrong Information	38.1. Co-ordination for resolution not been identified	Not analysed further		
39. Wrong Information	39.1. Co-ordination for resolution identified when not needed	Not analysed further		

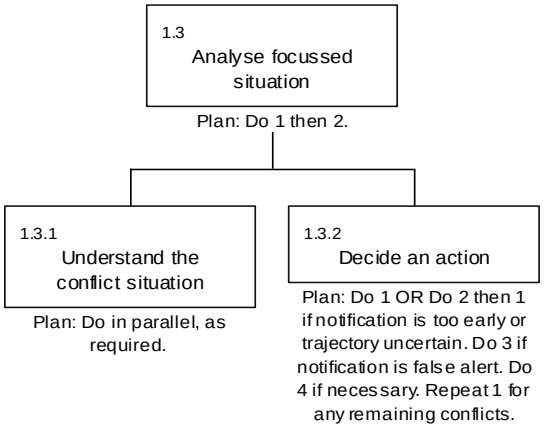
Project: CORA 2		**System: Analyse Focussed Situation**		**Recommendations**
Guideword Deviation	**Causes**	**Consequences**	**Safeguards**	
40. Sequence	40.1. Treatment of trajectories pending implementation in the air	Not analysed further		*Comment - More relevant to task ""Act on focussed situation"*

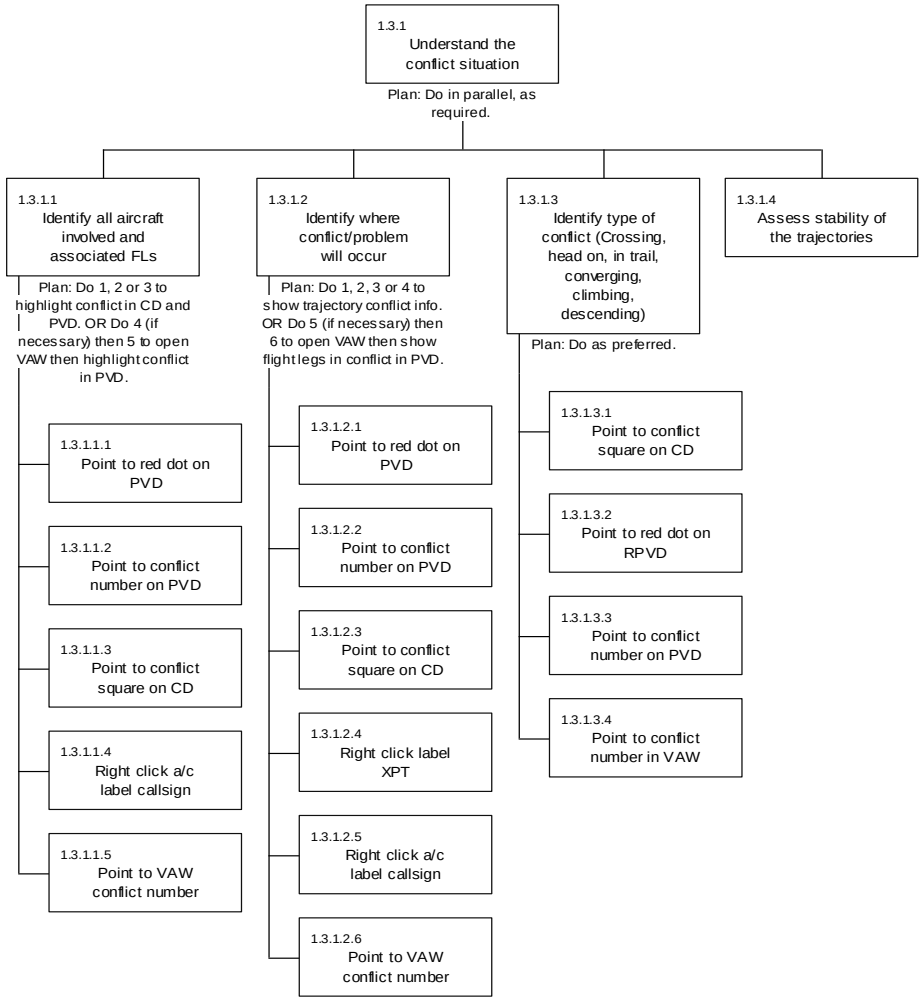
7. APPENDIX A.7: CORA 2 HIERARCHICAL TASK ANALYSIS

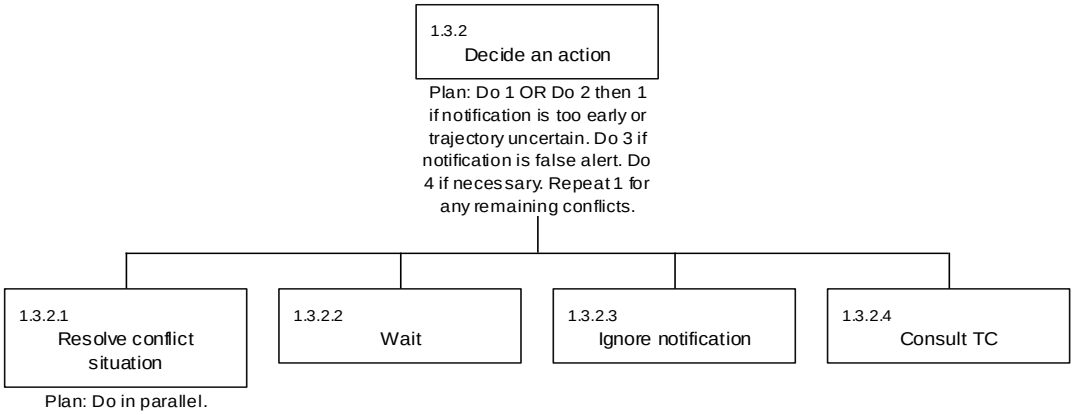


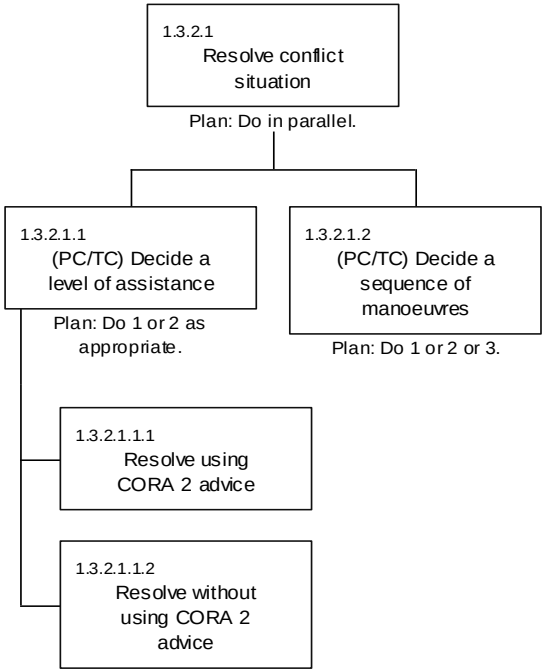

1.1
Detect conflict situation
Plan: Do 1 and 2 in parallel.
1.1.1
Detect via prompted CORA 2 notification and proposal
1.1.2
Detect via normal scanning

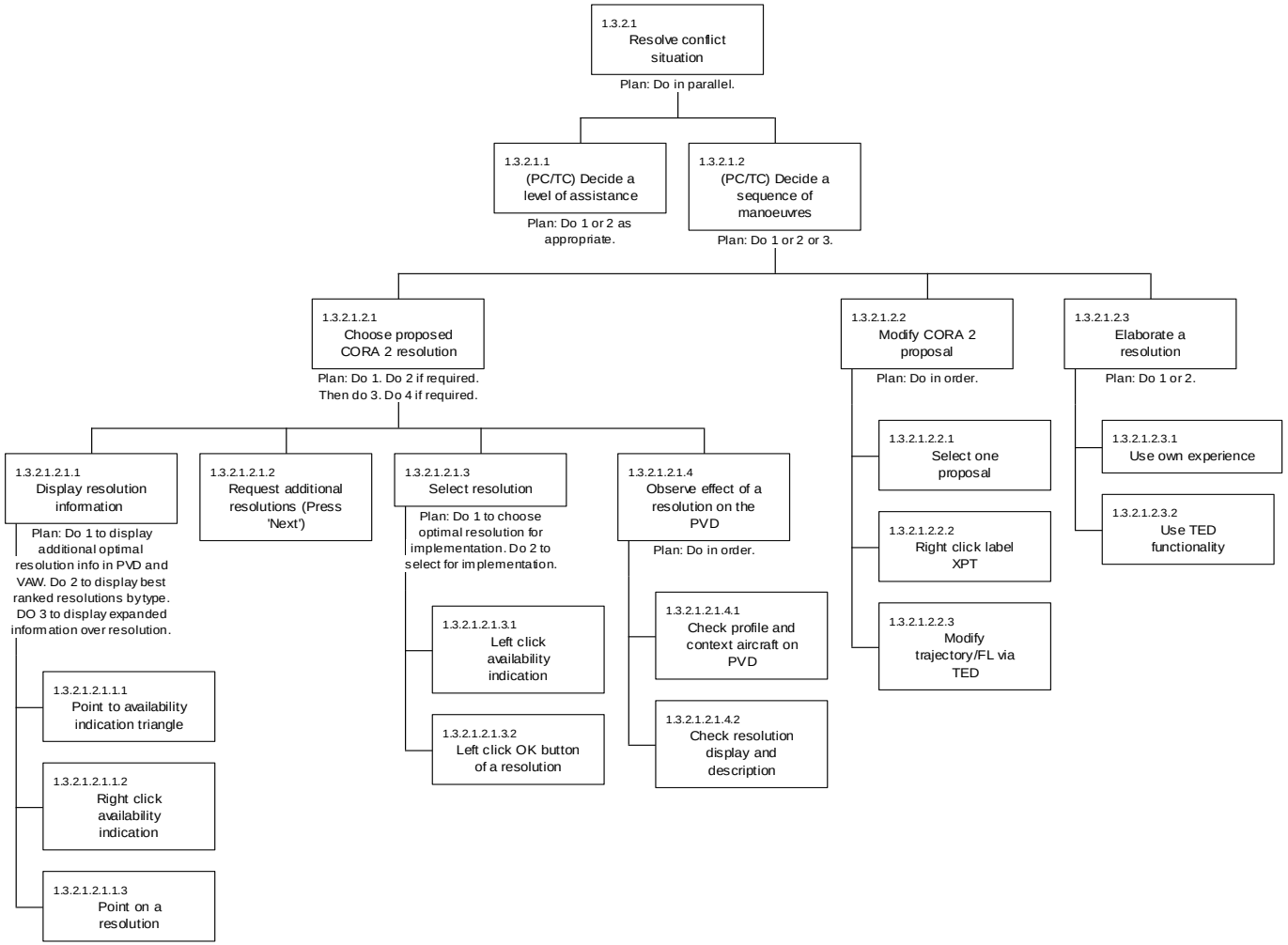

1.2
Prioritise conflict situation(s)
Plan: Do 1, 2 and 3 in any order.
1.2.1
Evaluate severity of conflict(s)
Plan: Do 1. Then do 2, 3 and/or 4 as appropriate.
1.2.1.1
Consider distance at closest approach, geometry and stability of situation
1.2.1.2
Identify low risk conflicts
1.2.1.3
Identify unacceptable conflicts
1.2.1.4
Identify uncertain conflicts
1.2.2
Determine time to occur
Plan: Do as preferred.
1.2.2.1
Check CD
1.2.2.2
Check reminder to act
1.2.2.3
Check PVD
1.2.3
Determine time to act
Plan: Do as preferred.
1.2.3.1
Check CD
1.2.3.2
Check reminder to act
1.2.3.3
Check PVD

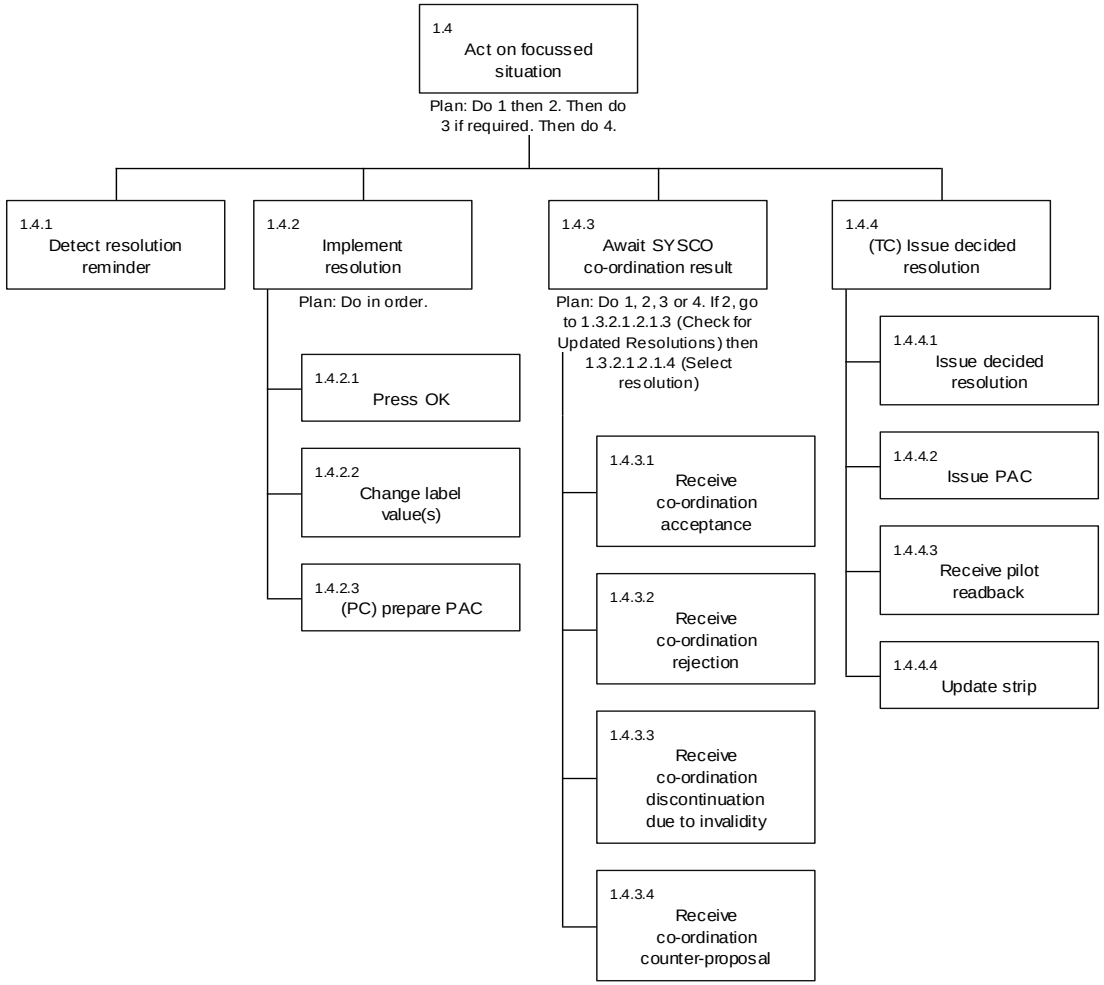

1.3
Analyse focussed situation
Plan: Do 1 then 2.
1.3.1
Understand the conflict situation
Plan: Do in parallel, as required.
1.3.2
Decide an action
Plan: Do 1 OR Do 2 then 1 if notification is too early or trajectory uncertain. Do 3 if notification is false alert. Do 4 if necessary. Repeat 1 for any remaining conflicts.

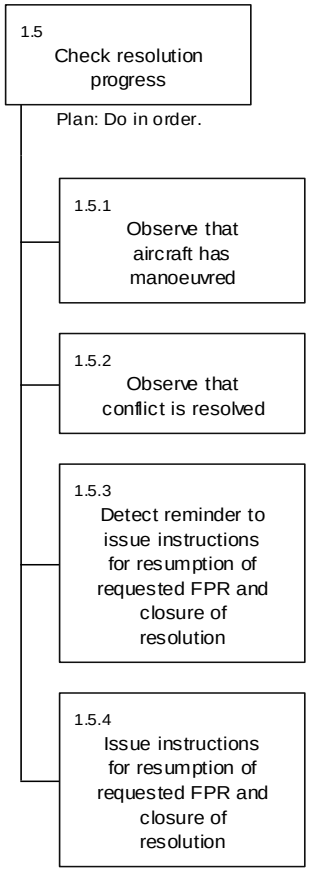

1.3.1
Understand the conflict situation
Plan: Do in parallel, as required.
1.3.1.1
Identify all aircraft involved and associated FLs
Plan: Do 1, 2 or 3 to highlight conflict in CD and PVD. OR Do 4 (if necessary) then 5 to open VAW then highlight conflict in PVD.
1.3.1.1.1
Point to red dot on PVD
1.3.1.1.2
Point to conflict number on PVD
1.3.1.1.3
Point to conflict square on CD
1.3.1.1.4
Right click a/c label callsign
1.3.1.1.5
Point to VAW conflict number
1.3.1.2
Identify where conflict/problem will occur
Plan: Do 1, 2, 3 or 4 to show trajectory conflict info. OR Do 5 (if necessary) then 6 to open VAW then show flight legs in conflict in PVD.
1.3.1.2.1
Point to red dot on PVD
1.3.1.2.2
Point to conflict number on PVD
1.3.1.2.3
Point to conflict square on CD
1.3.1.2.4
Right click label XPT
1.3.1.2.5
Right click a/c label callsign
1.3.1.2.6
Point to VAW conflict number
1.3.1.3
Identify type of conflict (Crossing, head on, in trail, converging, climbing, descending)
Plan: Do as preferred.
1.3.1.3.1
Point to conflict square on CD
1.3.1.3.2
Point to red dot on RPVD
1.3.1.3.3
Point to conflict number on PVD
1.3.1.3.4
Point to conflict number in VAW
1.3.1.4
Assess stability of the trajectories

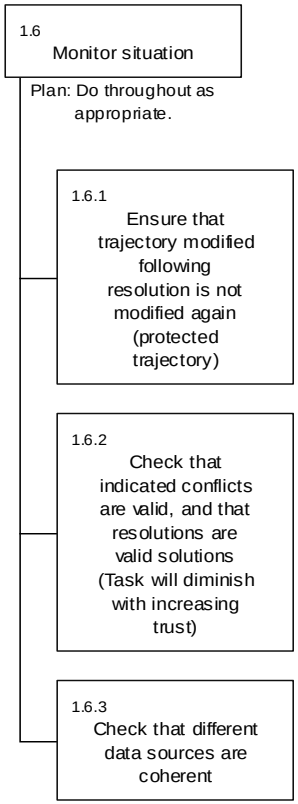

1.3.2
Decide an action
Plan: Do 1 OR Do 2 then 1 if notification is too early or trajectory uncertain. Do 3 if notification is false alert. Do 4 if necessary. Repeat 1 for any remaining conflicts.
1.3.2.1
Resolve conflict situation
Plan: Do in parallel.
1.3.2.2
Wait
1.3.2.3
Ignore notification
1.3.2.4
Consult TC


1.3.2.1
Resolve conflict situation
Plan: Do in parallel.
1.3.2.1.1
(PC/TC) Decide a level of assistance
Plan: Do 1 or 2 as appropriate.
1.3.2.1.2
(PC/TC) Decide a sequence of manoeuvres
Plan: Do 1 or 2 or 3.
1.3.2.1.1.1
Resolve using CORA 2 advice
1.3.2.1.1.2
Resolve without using CORA 2 advice


1.3.2.1
Resolve conflict situation
Plan: Do in parallel.
1.3.2.1.1
(PC/TC) Decide a level of assistance
Plan: Do 1 or 2 as appropriate.
1.3.2.1.2
(PC/TC) Decide a sequence of manoeuvres
Plan: Do 1 or 2 or 3.
1.3.2.1.2.1
Choose proposed CORA 2 resolution
Plan: Do 1. Do 2 if required. Then do 3. Do 4 if required.
1.3.2.1.2.2
Modify CORA 2 proposal
Plan: Do in order.
1.3.2.1.2.3
Elaborate a resolution
Plan: Do 1 or 2.
1.3.2.1.2.1.1
Display resolution information
Plan: Do 1 to display additional optimal resolution info in PVD and VAW. Do 2 to display best ranked resolutions by type. DO 3 to display expanded information over resolution.
1.3.2.1.2.1.2
Request additional resolutions (Press 'Next')
1.3.2.1.2.1.3
Select resolution
Plan: Do 1 to choose optimal resolution for implementation. Do 2 to select for implementation.
1.3.2.1.2.1.4
Observe effect of a resolution on the PVD
Plan: Do in order.
1.3.2.1.2.2.1
Select one proposal
1.3.2.1.2.2.2
Right click label XPT
1.3.2.1.2.2.3
Modify trajectory/FL via TED
1.3.2.1.2.3.1
Use own experience
1.3.2.1.2.3.2
Use TED functionality
1.3.2.1.2.1.1.1
Point to availability indication triangle
1.3.2.1.2.1.1.2
Right click availability indication
1.3.2.1.2.1.1.3
Point on a resolution
1.3.2.1.2.1.3.1
Left click availability indication
1.3.2.1.2.1.3.2
Left click OK button of a resolution
1.3.2.1.2.1.4.1
Check profile and context aircraft on PVD
1.3.2.1.2.1.4.2
Check resolution display and description


1.4
Act on focussed situation
Plan: Do 1 then 2. Then do 3 if required. Then do 4.
1.4.1
Detect resolution reminder
1.4.2
Implement resolution
Plan: Do in order.
1.4.2.1
Press OK
1.4.2.2
Change label value(s)
1.4.2.3
(PC) prepare PAC
1.4.3
Await SYSCO co-ordination result
Plan: Do 1, 2, 3 or 4. If 2, go to 1.3.2.1.2.1.3 (Check for Updated Resolutions) then 1.3.2.1.2.1.4 (Select resolution)
1.4.3.1
Receive co-ordination acceptance
1.4.3.2
Receive co-ordination rejection
1.4.3.3
Receive co-ordination discontinuation due to invalidity
1.4.3.4
Receive co-ordination counter-proposal
1.4.4
(TC) Issue decided resolution
1.4.4.1
Issue decided resolution
1.4.4.2
Issue PAC
1.4.4.3
Receive pilot readback
1.4.4.4
Update strip


1.5
Check resolution progress
Plan: Do in order.
1.5.1
Observe that aircraft has manoeuvred
1.5.2
Observe that conflict is resolved
1.5.3
Detect reminder to issue instructions for resumption of requested FPR and closure of resolution
1.5.4
Issue instructions for resumption of requested FPR and closure of resolution


1.6
Monitor situation
Plan: Do throughout as appropriate.
1.6.1
Ensure that trajectory modified following resolution is not modified again (protected trajectory)
1.6.2
Check that indicated conflicts are valid, and that resolutions are valid solutions (Task will diminish with increasing trust)
1.6.3
Check that different data sources are coherent

8. APPENDIX A.8: CORA 2 TRACER-LITE ANALYSIS WORKSHEET

CORA = Conflict Resolution Assistant
FPR - Flight Plan Route
PAC - Planned Alternative Clearance
PVD - Plan View Display
RCD - Conflict Detector
RSL = Recovery Success Likelihood (see Table A.8.2 for RSL Scale)
RT = Radio Telephony
STCA = Short Term Conflict Alert
TED - Trajectory Editor
VAW - Vertical Aid Window
XPT - Exit Point

Table A.8.1: TRACEr-lite Analysis Worksheet

Task Step	External Error	Internal Error	Consequences	Detection means	RSL	Recommendations / Comments
1 Resolve conflict situation						
Do 1 to 5 in order. Do 6 throughout as appropriate.						
1.1 Detect conflict situation						
Do 1 and 2 in parallel.						
1.1.1 Detect via prompted CORA 2 notification and proposal	1. Fail to detect conflict via CORA 2 2. Misinterpret/ignore notification via CORA 2	1. No detection - visual 2. Poor decision, No decision	1. Controller unaware of conflict; Controller takes no action 2. Controller unaware of conflict; Controller believes conflict is false alert; Controller takes no action	1, 2. Detect via normal scanning; Reminder to act; STCA	1. M-H 2. M	

1.1.2 Detect via normal scanning	1. Fail to detect conflict via normal scanning 2. Misinterpret/ignore conflict situation via normal scanning	1. No detection - visual 2. Misprojection; Poor decision, No decision	1. Controller unaware of conflict; Controller takes no action 2. Controller unaware of conflict; Controller believes conflict is false alert; Controller takes no action	1, 2. Detect via CORA 2 functions; STCA	1. H 2. M-H	
1.2 Prioritise conflict situation(s)						
Do 1, 2 and 3 in any order.						
1.2.1 Evaluate severity of conflict(s)	1. Fail to evaluate severity of conflict(s) 2. Evaluate severity of conflict(s) too late 3. Mis-evaluate severity of conflict(s)	1. Poor decision, No decision 2. Late decision 3. Poor decision	1, 2, 3. Controller unaware of severity of conflict; Controller fails to deal with conflicts in appropriate timeframe; Controller deals with conflicts in inappropriate manner	1, 2, 3. Radar monitoring; Reminder to act; STCA	1. M 2. M 3. M	
Do 1. Then do 2, 3 and/or 4 as appropriate.						
1.2.1.1 Consider distance at closest approach, geometry and stability of situation	1. Fail to consider parameters 2. Misinterpret/Misproject parameters	1. Poor decision, No decision; No action 2. Misprojection	1, 2. Controller unaware of distance at closest approach, geometry and stability of situation; Controller may have false impression of parameters	1, 2. Radar monitoring; Reminder to act	1. M-H 2. M-H	
1.2.1.2 Identify low risk conflicts	1. Fail to consider risk 2. Identify low risk conflict(s) too late 3. Falsely identify conflict(s) as low risk 4. Mis-classify low risk conflict	1. Poor decision, No decision 2. Late decision 3, 4. Poor decision	1. Controller does not prioritise conflicts 2. Minor increase in workload 3. Controller has faulty perception of risk; Controller takes inappropriate or insufficient action, or takes action late; Possible loss of separation 4. Controller takes unnecessary action; Workload increases	1, 2, 4. Radar monitoring; Reminder to act 3. Radar monitoring; Reminder to act; STCA	1. M-H 2. M-H 3. M 4. H	

1.2.1.3 Identify unacceptable conflicts	1. Fail to consider risk 2. Identify unacceptable conflict(s) too late 3. Falsely identify conflict(s) as unacceptable 4. Mis-classify unacceptable conflict 5. Dismiss conflict	1. Poor decision, No decision 2. Late decision 3, 4, 5. Poor decision	1. Controller does not prioritise conflicts 2, 5. Controller takes no/late action; Sudden increase in workload; Avoiding action; Possible loss of separation 3. Controller has faulty perception of risk; Controller takes unnecessary action; Workload increases 4. Controller takes inappropriate or insufficient action, or takes action late	1, 2, 4, 5. Radar monitoring; Reminder to act; STCA 3. Radar monitoring; Reminder to act	1. M 2. M 3. H 4. M 5. M	
1.2.1.4 Identify uncertain conflicts	1. Fail to consider risk 2. Identify uncertain conflict(s) too late 3. Falsely identify conflict(s) as uncertain 4. Mis-classify uncertain conflict 5. Dismiss conflict	1. Poor decision, No decision 2. Late decision 3, 4, 5. Poor decision	1. Controller does not prioritise conflicts 2, 5. Controller takes no/late action; Possible sudden increase in workload; Possible avoiding action; Possible loss of separation 3. Workload increases; No significant consequences 4. Controller takes inappropriate or insufficient action, or takes action late	1, 2, 4, 5. Radar monitoring; Reminder to act STCA 3. Radar monitoring; Reminder to act	1. M 2. M 3. H 4. M 5. M	
1.2.2 Determine time to occur	1. Fail to determine time to occur 2. Determine time to occur too late 3. Miscalculate time to occur	1. Poor decision, No decision 2. Late decision 3. Poor decision	1, 2, 3. Controller unaware of time to occur; Controller fails to deal with conflicts in appropriate timeframe; Controller deals with conflicts in inappropriate manner	1, 2, 3. Radar monitoring; CORA functions; STCA	1. M 2. M 3. M	
Do as preferred.						

1.2.2.1 Check RCD	1. Fail to check RCD 2. Misinterpret RCD 3. Focus on RCD too long - miss other event	1. Forget action; Poor decision, Late decision, No decision 2. Mis-see; Poor decision, Late decision, No decision 3. No detection - visual	1. Controller unaware of time to occur; Controller does not act 2. Controller has wrong impression of time to occur; May take late action 3. Controller misses other event/fails to monitor traffic	1, 2. Radar monitoring; Reminder to act 3. Reminder to act; STCA	1. M-H 2. M-H 3. M	
1.2.2.2 Check reminder to act	1. Fail to notice reminder to act 2. Misread reminder to act	1. No detection - visual 2. Mis-see	1. Controller does not act 2. Controller does not act; Controller takes inappropriate action	1, 2. Radar monitoring; RCD; STCA	1. L-M 2. M-H	Where does this message appear, and in what format?
1.2.2.3 Check PVD	1. Fail to check PVD 2. Misread/Misinterpret PVD	1. Forget action; Poor decision, No decision 2. Mis-see Poor decision, No decision	1. Controller does not act 2. Controller does not act; Controller takes inappropriate action	1, 2. RCD; Reminder to act; STCA	1. H 2. M-H	
1.2.3 Determine time to act	1. Fail to determine time to act 2. Determine time to act too late 3. Miscalculate time to act	1. Poor decision, No decision 2. Late decision 3. Poor decision	1, 2, 3. Controller unaware of time to act; Controller fails to deal with conflicts in appropriate timeframe; Controller deals with conflicts in inappropriate manner	1, 2, 3. Radar monitoring; CORA functions; STCA	1. M 2. M 3. M	
Do as preferred.						
1.2.3.1 Check RCD	1. Fail to check RCD 2. Misinterpret RCD 3. Focus on RCD too long - miss other event	1. Forget action; Poor decision, Late decision, No decision 2. Mis-see; Poor decision, Late decision, No decision 3. No detection - visual	1. Controller unaware of time to act; Controller does not act 2. Controller has wrong impression of time to act; May take late action 3. Controller misses other event/fails to monitor traffic	1, 2. Radar monitoring; Reminder to act 3. STCA	1. M-H 2. M 3. M	
1.2.3.2 Check reminder to act	1. Fail to notice reminder to act 2. Misread reminder to act	1. No detection - visual 2. Mis-see	1. Controller does not act 2. Controller does not act; Controller takes inappropriate action	1, 2. Radar monitoring; RCD; STCA	1. L-M 2. M-H	
1.2.3.3 Check PVD	1. Fail to check PVD 2. Misread/Misinterpret PVD	1. Forget action; Poor decision, No decision 2. Mis-see Poor decision, No decision	1. Controller does not act 2. Controller does not act; Controller takes inappropriate action	1, 2. RCD; Reminder to act; STCA	1. H 2. M-H	

1.3 Analyse focussed situation						
Do 1 then 2.						
1.3.1 Understand the conflict situation	1. Misunderstand conflict situation	1. Poor decision, Late decision; No decision	1. Controller responds inappropriately to conflict	1, 2. All resolutions are safe; Reminder to act; STCA	1. M	
Do in parallel, as required.						
1.3.1.1 Identify all a/c involved and associated FLs	1. Fail to identify a/c 2. Misidentify a/c (& FL) 3. Falsely identify a/c 4. Fail to check FL 5. Misread FL	1. No detection - visual; Forget action; No decision 2, 3, 5. Mis-see 4. Forget action; No decision				Various ways of achieving this sub-goal (information redundancy) Potential for role confusion (TC v PC)
Do 1, 2 or 3 to highlight conflict in RCD and PVD. OR Do 4 (if necessary) then 5 to open VAW then highlight conflict in PVD.						
1.3.1.1.1 Point to red dot on PVD	1. Fail to point to red dot 2. Point to other red dot 3. Point to availability indication 4. Left click availability indication 5. Right click availability indication 6. Right click callsign 7. Right click XPT	1. Forget action 2, 3, 4, 5, 6, 7. Selection error	1. Controller unaware of all a/c involved and associated FLs; Controller (falsely?) assumes s/he knows all a/c involved 2. Conflict information relating to other a/c displayed (often will be the same); No consequence? 3. Additional optimal resolution information shown; No significant consequence 4. Selects optimal resolution for implementation ; May need to change selection?; Workload increase? 5. Displays best ranked resolutions 6. Opens VAW 7. Enables edit flight leg	1. Radar monitoring; Other CORA functionality 2, 3, 5, 6, 7. Instant feedback - see consequences 4. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. M-H 3. H 4. M? 5. H 6. H 7. H	What feedback is shown when a optimal resolution for implementation is selected? How would a controller change a resolution selected accidentally? 'Moving target' - HMI issue and risk of selection errors

1.3.1.1.2 Point to conflict number on PVD	1. Fail to point to conflict number 2. Left click conflict number 3. Right click conflict number	1. Forget action 2, 3. Selection error	1. Controller unaware of all a/c involved and associated FLs; Controller (falsely?) assumes s/he knows all a/c involved 2, 3. No consequence?	1. Radar monitoring; Other CORA functionality 2, 3. No consequence to detect?	1. M-H 2. N/A 3. N/A	
1.3.1.1.3 Point to conflict square on RCD	1. Fail to point to conflict square on RCD 2. Point to availability indication 3. Left click availability indication 4. Right click availability indication	1. Forget action 2, 3, 4. Selection error	1. Controller unaware of all a/c involved and associated FLs; Controller (falsely?) assumes s/he knows all a/c involved 2. Additional optimal resolution information shown; No significant consequence 3. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 4. Displays best ranked resolutions	1. Radar monitoring; Other CORA functionality 2, 4. Instant feedback - see consequences 3. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. H 3. M 4. H	
1.3.1.1.4 Right click a/c label callsign	1. Fail to right click a/c label callsign 2. Point to red dot 3. Point to availability indication 4. Left click availability indication 5. Right click availability indication 6. Right click XPT	1. Forget action 2, 3, 4, 5, 6. Selection error	1. Controller unaware of all a/c involved and associated FLs; Controller (falsely?) assumes s/he knows all a/c involved 2. Highlights all a/c involved, conflict information, and conflict in RCD; No negative consequence 3. Additional optimal resolution information shown; No significant consequence 4. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 5. Displays best ranked resolutions 6. Enables edit flight leg	1. Radar monitoring; Other CORA functionality 2, 3, 5, 6. Instant feedback - see consequences 4. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. H 3. H 4. M 5. H 6. H	

1.3.1.1.5 Point to VAW conflict number	1. Fail to point to VAW conflict number 2. Left click conflict number 3. Right click conflict number	1. Forget action; Poor decision, No decision 2, 3. Selection error	1. Controller unaware of all a/c involved and associated FLs; Controller (falsely?) assumes s/he knows all a/c involved 2, 3. No consequence?	1. Radar monitoring; Other CORA functionality 2, 3. No consequence to detect?	1. M-H 2. N/A 3. N/A	
1.3.1.2 Identify where conflict/problem will occur	1. Fail to identify where conflict/problem will occur 2. Misidentify where conflict/problem will occur					
Do 1, 2, 3 or 4 to show trajectory conflict info. OR Do 5 (if necessary) then 6 to open VAW then show flight legs in conflict in PVD.						
1.3.1.2.1 Point to red dot on PVD	1. Fail to point to red dot 2. Point to other red dot 3. Point to availability indication 4. Left click availability indication 5. Right click availability indication 6. Right click callsign 7. Right click XPT	1. Forget action; Poor decision, No decision 2, 3, 4, 5, 6, 7. Selection error	1. Controller unaware of where conflict/problem will occur; Controller (falsely?) assumes s/he knows where conflict/problem will occur 2. Conflict information relating to other a/c displayed (often will be the same); No consequence? 3. Additional optimal resolution information shown; No significant consequence 4. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 5. Displays best ranked resolutions 6. Opens VAW 7. Enables edit flight leg	1. Radar monitoring; Other CORA functionality 2, 3, 5, 6, 7. Instant feedback - see consequences 4. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. M-H 3. H 4. M 5. H 6. H 7. H	

1.3.1.2.2 Point to conflict number on PVD	1. Fail to point to conflict number 2. Left click conflict number 3. Right click conflict number 4. Point to wrong conflict number	1. Forget action 2, 3. Selection error	1. Controller unaware of where conflict/problem will occur; Controller (falsely?) assumes s/he knows where conflict/problem will occur 2, 3. No consequence? 4. Displays different conflict information	1. Radar monitoring; Other CORA functionality 2, 3. No consequence to detect? 4. Displays different conflict information	1. M-H 2. N/A 3. N/A 4. M-H	Is there any effect of clicking the conflict number?
1.3.1.2.3 Point to conflict square on RCD	1. Fail to point to conflict square on RCD 2. Point to availability indication 3. Left click availability indication 4. Right click availability indication 5. Point to wrong conflict square	1. Forget action 2, 3, 4, 5. Selection error	1. Controller unaware of where conflict/problem will occur; Controller (falsely?) assumes s/he knows where conflict/problem will occur 2. Additional optimal resolution information shown; No significant consequence 3. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 4. Displays best ranked resolutions 5. Displays different conflict information	1. Radar monitoring; Other CORA functionality 2, 4, 5. Instant feedback - see consequences 3. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. H 3. M 4. H 5. M-H	

1.3.1.2.4 Right click label XPT	1. Fail to right click label XPT 2. Point to red dot 3. Right click a/c label callsign 4. Point to availability indication 5. Left click availability indication 6. Right click availability indication 7. Right click wrong label XPT	1. Forget action 2, 3, 4, 5, 6, 7. Selection error	1. Controller unaware of where conflict/problem will occur; Controller (falsely?) assumes s/he knows where conflict/problem will occur 2. Highlights all a/c involved, conflict information, and conflict in RCD; No negative consequence 3. Opens VAW 4. Additional optimal resolution information shown; No significant consequence 5. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 6. Displays best ranked resolutions 7. Displays different conflict information	1. Radar monitoring; Other CORA functionality 2, 3, 4, 6, 7. Instant feedback - see consequences 5. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. H 3. H 4. H 5. M 6. H 7. M-H	

1.3.1.2.5 Right click a/c label callsign	1. Fail to right click a/c label callsign 2. Point to red dot 3. Point to availability indication 4. Left click availability indication 5. Right click availability indication 6. Right click XPT 7. Right click wrong label callsign	1. Forget action 2, 3, 4, 5, 6, 7. Selection error	1. Controller unaware of where conflict/problem will occur; Controller (falsely?) assumes s/he knows where conflict/problem will occur 2. Highlights all a/c involved, conflict information, and conflict in RCD; No negative consequence 3. Additional optimal resolution information shown; No significant consequence 4. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 5. Displays best ranked resolutions 6. Enables edit flight leg 7. No consequence - opens VAW	1. Radar monitoring; Other CORA functionality 2, 3, 5, 6. Instant feedback - see consequences 4. Unsure - what is feedback?; All resolutions are safe 7. No consequence	1. M-H 2. H 3. H 4. M 5. H 6. H 7. N/A	
1.3.1.2.6 Point to VAW conflict number	1. Fail to point to VAW conflict number 2. Left click conflict number 3. Right click conflict number 4. Point to wrong VAW conflict number	1. Forget action 2, 3, 4. Selection error	1. Controller unaware of where conflict/problem will occur; Controller (falsely?) assumes s/he knows where conflict/problem will occur 2, 3. No consequence? 4. Displays different conflict information	1. Radar monitoring; Other CORA functionality 2, 3. No consequence to detect? 4. Instant feedback - see consequences	1. M-H 2. N/A 3. N/A 4. M-H	
1.3.1.3 Identify type of conflict (Crossing, head on, in trail, converging, climbing, descending)	1. Fail to identify type of conflict 2. Misidentify type of conflict					
Do as preferred.						

1.3.1.3.1 Point to conflict square on RCD	1. Fail to point to conflict square on RCD 2. Point to availability indication 3. Left click availability indication 4. Right click availability indication	1. Forget action 2, 3, 4. Selection error	1. Controller unaware of type of conflict; Controller (falsely?) assumes s/he knows type of conflict 2. Additional optimal resolution information shown; No significant consequence 3. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 4. Displays best ranked resolutions	1. Radar monitoring; Other CORA functionality if used 2, 4. Instant feedback - see consequences 3. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. H 3. M 4. H	
1.3.1.3.2 Point to red dot on PVD	1. Fail to point to red dot 2. Point to other red dot 3. Point to availability indication 4. Left click availability indication 5. Right click availability indication 6. Right click callsign 7. Right click XPT	1. Forget action 2, 3, 4, 5, 6, 7. Selection error	1. Controller unaware of where conflict/problem will occur; Controller (falsely?) assumes s/he knows where conflict/problem will occur 2. Conflict information relating to other a/c displayed (often will be the same); No consequence? 3. Additional optimal resolution information shown; No significant consequence 4. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 5. Displays best ranked resolutions 6. Opens VAW 7. Enables edit flight leg	1. Radar monitoring; Other CORA functionality if used 2, 3, 5, 6, 7. Instant feedback - see consequences 4. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. M-H 3. H 4. M 5. H 6. H 7. H	What feedback is shown when a optimal resolution for implementation is selected? How would a controller change a resolution selected accidentally?

1.3.1.3.3 Point to conflict number on PVD	1. Fail to point to conflict number 2. Left click conflict number 3. Right click conflict number	1. Forget action 2, 3. Selection error	1. Controller unaware of type of conflict; Controller (falsely?) assumes s/he knows type of conflict 2, 3. No consequence?	1. Radar monitoring; Other CORA functionality if used 2, 3. No consequence to detect?	1. M-H 2. N/A 3. N/A	
1.3.1.3.4 Point to conflict number in VAW	1. Fail to point to VAW conflict number 2. Left click conflict number 3. Right click conflict number	1. Forget action 2, 3. Selection error	1. Controller unaware of type of conflict; Controller (falsely?) assumes s/he knows type of conflict 2, 3. No consequence?	1. Radar monitoring; Other CORA functionality if used 2, 3. No consequence to detect?	1. M-H 2. N/A 3. N/A	
1.3.1.4 Assess stability of the trajectories	1. Fail to assess stability of the trajectories 2. Mis-project stability of trajectories 3. Misidentify a/c involved	1. Forget action; Poor decision, No decision 2. Misprojection 3. Mis-see	1. Controller unaware of stability of trajectories; May take inappropriate action 2, 3. Controller takes inappropriate action	1, 2, 3. Radar monitoring	1. M-H? 2. M-H? 3. M-H?	
1.3.2 Decide an action	1. Fail to decide an action/decide too late 2. Decide on inappropriate action					
Do 1 OR Do 2 then 1 if notification is too early or trajectory uncertain. Do 3 if notification is false alert. Do 4 if necessary. Repeat 1 for any remaining conflicts.						
1.3.2.1 Resolve conflict situation	1. Fail to resolve conflict situation 2. Worsen conflict situation					
Do in parallel.						

1.3.2.1.1 (PC/TC) Decide a level of assistance	1. Fail to decide a level of assistance 2. Decide wrong level of assistance					
Do 1 or 2 as appropriate.						
1.3.2.1.1.1 Resolve using CORA 2 advice	1. Fail to check suitability of CORA 2 advice	1. Forget action; Poor decision, No decision	1. Potentially unsuitable (but safe) action decided	1. Radar monitoring; RT communication; All resolutions are safe	1. M	This check might be omitted over time. Controllers may become more reactive.
1.3.2.1.1.2 Resolve without using CORA 2 advice	Same as current					It may be useful to work without CORA 2 periodically to retain conflict resolution skills in case of CORA 2 failure.
1.3.2.1.2 (PC/TC) Decide a sequence of manoeuvres	1. Fail to decide sequence of manoeuvres 2. Decide wrong sequence of manoeuvres					
Do 1 or 2 or 3.						
1.3.2.1.2.1 Choose proposed CORA 2 resolution	1. Fail to choose proposed CORA 2 resolution 2. Choose wrong CORA 2 resolution 3. Choose more than one CORA 2 resolution					
Do 1. Do 2 if required. Then do 3. Do 4 if required.						
1.3.2.1.2.1.1 Display resolution information	1. Fail to display resolution information 2. Display wrong resolution information 3. Inadvertently selects resolution					

Do 1 to display additional optimal resolution info in PVD and VAW. Do 2 to display best ranked resolutions by type. Do 3 to display expanded information over resolution.						
1.3.2.1.2.1.1.1 Point to availability indication triangle	1. Fail to point to availability indication triangle 2. Point to conflict number 3. Left click conflict number 4. Right click conflict number 5. Point to red dot	1. Forget action 2, 3, 4, 5. Selection error	1. Controller not provided with resolution information 2, 5. Highlights all a/c involved, conflict information, and conflict in RCD; No negative consequence 3, 4. No consequence?	1. Unable to select resolution 2, 3, 4, 5. Instant feedback - see consequences	1. M-H 2. H 3. H 4. H 5. H	
1.3.2.1.2.1.1.2 Right click availability indication	1. Fail to right click availability indication 2. Left click availability indication 3. Right click red dot 4. Point to red dot 5. Right click callsign 6. Right click XPT	1. Forget action; No decision 2, 3, 4, 5, 6. Selection error	1. Controller not provided with resolution information; Other resolution information may still be on display?; Controller might act on 'wrong' information 2. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 3, 4. Highlights all a/c involved, conflict information, and conflict in RCD; No negative consequence 5. Opens VAW 6. Enables edit flight leg	1. Unable to select resolution 2. All resolutions are safe 3, 4, 5, 6. Instant feedback - see consequences	1. M-H 2. M 3. H 4. H 5. H 6. H	Assume right clicking red dot has same effect as pointing to red dot.
1.3.2.1.2.1.1.3 Point on a resolution	1. Fail to point on a resolution 2. Point to wrong resolution	1. Forget action; Poor decision, No decision 2. Selection error	1. Controller not provided with resolution information 2. Controller provided with unintended resolution information	1. Unable to select resolution 2. Instant feedback - see consequence	1. M-H 2. M-H	

1.3.2.1.2.1.2 Request additional resolutions	1. Fail to request additional resolutions	1. Forget action; Poor decision, No decision	1. Controller not provided with additional resolutions	1. All resolutions are safe	1. H	
1.3.2.1.2.1.3 Select resolution	1. Fail to select resolution 2. Select wrong resolution 3. Select more than one resolution					
Do 1 to choose optimal resolution for implementation. Do 2 to select for implementation.						
1.3.2.1.2.1.3.1 Left click availability indication	1. Fail to left click availability indication 2. Right click availability indication 3. Right click red dot 4. Point to red dot 5. Right click callsign 6. Right click XPT 7. Left click wrong availability indication	1. Forget action; No decision 2, 3, 4, 5, 6, 7. Selection error	1. Resolution not selected; Controller may be unaware conflict still exists 2. Displays best ranked resolutions 3, 4. Highlights all a/c involved, conflict information, and conflict in RCD; No negative consequence 5. Opens VAW 6. Enables edit flight leg 7. Selects optimal resolution for other conflict; Controller may have incorrect picture of new conflict situation; May need to change selection?; Workload increase?	1. Unable to select resolution 2, 3, 4, 5, 6. Instant feedback - see consequences 7. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. H 3. H 4. H 5. H 6. H 7. M	
1.3.2.1.2.1.3.2 Left click OK button of a resolution	1. Fail to left click OK button of a resolution 2. Press 'Close' 3. Select wrong resolution	1. Forget action; No decision 2, 3. Selection error	1. Resolution not selected; Controller may be unaware conflict still exists 2. Resolution display closes; Controller has to reopen resolution display 3. Unintended resolution selected; Controller unaware of resolution; Controller implements different resolution to that recorded?	1. Radar monitoring; Reminder to act; STCA 2. Instant feedback - see consequence 3. Radar monitoring; TC detects reminder to act	1. M-H 2. H 3. M	What feedback is presented when OK is pressed?

1.3.2.1.2.1.4 Observe effect of a resolution on the PVD	1. Fail to observe effect of a resolution 2. Misinterpret effect of a resolution on the PVD					
Do in order.						
1.3.2.1.2.1.4.1 Check profile and context a/c on PVD	1. Fail to check profile and context a/c 2. Misinterpret profile	1. Forget action; Poor decision, No decision 2. Mis-see; Misprojection	1. Controller may be unaware of effect of a resolution; Controller (falsely?) assumes s/he knows effect of a resolution 2. Controller has false impression of effect of a resolution	1, 2. All resolutions are safe	1. M 2. M	Is this indicated via system feedback?
1.3.2.1.2.1.4.2 Check resolution display and description	1. Fail to check resolution display and description 2. Misread resolution display / description 3. Read wrong resolution display / description	1. Forget action; Poor decision, No decision 2, 3. Mis-see	1. Controller may be unaware of effect of a resolution; Controller (falsely?) assumes s/he knows effect of 2, 3. Controller has false impression of effect of a resolution	1, 2, 3. Radar monitoring; All resolutions are safe	1. M-H 2. M-H 3. M-H	What feedback is presented when a resolution is selected?
1.3.2.1.2.2 Modify CORA 2 proposal	1. Fail to modify CORA 2 proposal 2. Modify wrong proposal 3. Modify proposal incorrectly 4. Choose inappropriate trajectory/FL					
Do in order.						
1.3.2.1.2.2.1 Select one proposal	1. Fail to select proposal 2. Select wrong proposal	1. Forget action 2. Selection error	1. CORA 2 proposal not modified 2. Controller may modify wrong proposal; Possibility of erroneous update	1. Unable to select resolution 2. Unsure - what is feedback?	1. H 2. M	

1.3.2.1.2.2.2 Right click label XPT	1. Fail to right click label XPT 2. Point to red dot 3. Right click a/c label callsign 4. Point to availability indication 5. Left click availability indication 6. Right click availability indication 7. Right click wrong label XPT	1. Forget action 2, 3, 4, 5, 6, 7. Selection error	1. CORA 2 proposal not modified 2. Highlights all a/c involved, conflict information, and conflict in RCD; No negative consequence 3. Opens VAW 4. Additional optimal resolution information shown; No significant consequence 5. Selects optimal resolution for implementation; May need to change selection?; Workload increase? 6. Displays best ranked resolutions 7. Controller could modify wrong CORA 2 proposal?	1. Radar monitoring; Other CORA functionality 2, 3, 4, 6, 7. Instant feedback - see consequences 5. Unsure - what is feedback?; All resolutions are safe	1. M-H 2. H 3. H 4. H 5. M 6. H 7. M	
1.3.2.1.2.2.3 Modify trajectory/FL via TED	1. Fail to modify trajectory/FL 2. Mistype trajectory/FL 3. Fail to confirm trajectory/FL 4. Choose inappropriate trajectory/FL	1, 3. Forget action 2. Selection error 4. Poor decision	1, 3. CORA 2 proposal not modified 2. Erroneous update of trajectory/FL 4. Inappropriate trajectory/FL selected; Possible loss of separation	1. Unable to modify trajectory 2, 3, 4. Radar monitoring	1. M-H 2. M 3. M 4. M	
1.3.2.1.2.3 Elaborate a resolution	1. Fail to elaborate a resolution 2. Elaborate resolution inappropriately (poor plan) 3. Elaborate resolution incorrectly (contrary to plan)					
Do 1 or 2.						
1.3.2.1.2.3.1 Use own experience	1. Choose inappropriate trajectory/FL	1. Poor decision	1. Inappropriate trajectory/FL selected; Possible loss of separation	1. Radar monitoring, MTCD, CORA 1 checks	1. M-H	

1.3.2.1.2.3.2 Use TED functionality	1. Mistype trajectory/FL 2. Fail to confirm trajectory/FL 3. Choose inappropriate trajectory/FL	1. Selection error 2. Forget action 3. Poor decision	1. Erroneous update of trajectory/FL 2. CORA 2 proposal not modified 3. Erroneous update of trajectory/FL	1, 2, 3. Radar monitoring, MTCD, CORA 1 checks	1. M-H 2. M 3. M-H	
1.3.2.2 Wait	1. Wait for too long 2. Fail to return to task later	1. Forget action; Poor decision, Late decision, No decision 2. Forget action	1, 2. Conflict not resolved; Sudden workload increase later; Possible loss of separation	1, 2. Radar monitoring, Reminder to act, STCA	1. M 2. M	
1.3.2.3 Ignore notification	1. Wrongly assume notification is false alert 2. Fail to return to task later	1. Poor decision 2. Forget action	1, 2. Conflict not resolved; Sudden workload increase later; Possible loss of separation	1, 2. Radar monitoring, Reminder to act, STCA	1. L 2. L	
1.3.2.4 Pass to TC	1. Fail to consult TC when necessary	1. Poor decision, No decision	1. Potentially inappropriate action taken	1. TC monitoring; STCA	1. M	
1.4 Act on focussed situation						
Do 1 then 2. Then do 3 if required. Then do 4.						
1.4.1 Detect resolution reminder	1. Fail to detect resolution reminder	1. No detection - visual	1. Conflict not resolved; Sudden workload increase later; Possible loss of separation	1, 2. Radar monitoring; TC monitoring; STCA	1. L-M	
1.4.2 Implement resolution	1. Fail to implement resolution					
Do in order.						
1.4.2.1 Press OK	1. Fail to left click OK button of a resolution 2. Press 'Close' 3. Select wrong resolution	1. Forget action; No decision 2, 3. Selection error	1. Resolution not selected; Controller may be unaware conflict still exists 2. Resolution display closes; Controller has to reopen resolution display 3. Unintended resolution selected; Controller unaware of resolution; Controller implements different resolution to that recorded?	1. Radar monitoring; Reminder to act; STCA 2. Instant feedback - see consequence 3. Radar monitoring; TC detects reminder to act	1. M-H 2. H 3. M	What feedback is presented when OK is pressed?

1.4.2.2 Change label value(s)	1. Fail to change label value(s) 2. Change label value(s) incorrectly	1. Forget action 2. Selection error	1. System not updated 2. System updated incorrectly	1, 2. Not known	1. N/K 2. N/K	
1.4.2.3 (PC) prepare PAC	1. Fail to prepare PAC 2. Prepare PAC incorrectly	1. Forget action 2. Selection error?	1, 2. Not known consequence	1, 2. Not known	1. N/K	
1.4.3 Await SYSCO co-ordination result	1. Fail to notice failed co-ordination					
Do 1, 2, 3 or 4. If 2, go to 1.3.2.1.2.1.3 (Check for Updated Resolutions) then 1.3.2.1.2.1.4 (Select resolution)						
1.4.3.1 Receive co-ordination acceptance	None					
1.4.3.2 Receive co-ordination rejection	1. Fail to notice co-ordination rejection	1. No detection - visual	1. Controller gives clearance without necessary co-ordination; Workload increase; Possible loss of separation	1. TC; Next Sector Controller; Other detection means?	1. L-M	How is co-ordination rejection displayed to controller?
1.4.3.4 Receive co-ordination discontinuation due to invalidity	1. Fail to notice co-ordination discontinuation	1. No detection - visual	1. Controller gives clearance without necessary co-ordination; Workload increase; Possible loss of separation	1. TC; Next Sector Controller; Other detection means?	1. L-M	How is co-ordination discontinuation displayed to controller?
1.4.3.4 Receive co-ordination counter-proposal	1. Fail to notice co-ordination counter-proposal	1. No detection - visual	1. Controller gives clearance without necessary co-ordination; Workload increase; Possible loss of separation	1. TC; Next Sector Controller; Other detection means?	1. L-M	How is co-ordination counter-proposal displayed to controller?
1.4.4 (TC) Issue decided resolution						
Do in order.						

1.4.4.1 Issue decided resolution	1. Fail to issue decided resolution 2. Issue wrong/different resolution 3. Issue resolution incorrectly	1. Forget action 2. Mis-recall information 3. Incorrect information transmitted; Unclear information transmitted	1. Conflict not resolved; Sudden workload increase later; Possible loss of separation 2. Actual resolution and CORA 2 information conflict; Workload increase; Possible secondary conflict 3. Actual resolution and CORA 2 information conflict; Pilot takes unexpected action; Workload increase; Possible secondary conflict	1, 2, 3. PC; Recalculation; Reminder; STCA	1. M 2. L-M 3. L-M	
1.4.4.2 Issue PAC	1. Fail to issue PAC 2. Issue wrong PAC 3. Issue PAC incorrectly	1. Forget action 2. Mis-recall information 3. Incorrect information transmitted	1. Conflict not resolved; Sudden workload increase later; Possible loss of separation 2. Actual resolution and CORA 2 information conflict; Workload increase; Possible secondary conflict 3. Actual resolution and CORA 2 information conflict; Pilot takes unexpected action; Workload increase; Possible secondary conflict	1, 2, 3. PC; Recalculation; Reminder; STCA	1. L 2. L 3. L	
1.4.4.3 Receive pilot readback	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory; Forget action; Poor decision, No decision	1. Pilot takes different unexpected action; Workload increase; Conflict may deteriorate; Possible secondary conflict 2. Pilot may fail to take action; Workload increase; Conflict may deteriorate; Possible secondary conflict	1, 2. Radar monitoring	1. L-M 2. M	

1.4.4.4 Update strip	1. Fail to update strip 2. Update wrong strip 3. Update strip incorrectly	1. Forget action 2. Selection error 3. Incorrect Information, Unclear information; Misrecall information	1. Other controller may have out of date picture; May forget resolution; Problems monitoring resolution progress?; Potential problem during future handover 2, 3. Both controllers may have wrong picture; May forget resolution; Problems monitoring resolution progress?; May take inappropriate action; Potential problem during future handover	1, 2, 3. Check on strip markings; PC	1. M 2. M-H 3. M	
1.5 Check resolution progress						
Do in order.						
1.5.1 Observe that a/c has manoeuvred	1. Fail to observe (entire) a/c manoeuvre 2. Misperceive/Mis-project a/c manoeuvre 3. Observe wrong a/c	1. Forget action; Poor decision, No decision 2. Mis-see; Misprojection 3. Mis-see	1. A/c may not have manoeuvred; Possible loss of separation 2. A/c have manoeuvred incorrectly; Possible loss of separation 3. Controller does not 'see' a/c manoeuvre; 'a/c' manoeuvres unexpectedly	1, 2, 3. Recalculation; Reminder; STCA	1. L-M 2. L-M 3. M-H	
1.5.2 Observe that conflict is resolved	1. Fail to observe that conflict is resolved	1. Forget action; Poor decision, No decision	1. Conflict may still exist; Possible loss of separation	1. Recalculation; Reminder; STCA	1. L-M	
1.5.3 Detect reminder to issue instructions for resumption of requested FPR and closure of resolution	1. Fail to detect reminder	1. No detection - visual	1. Controller does not issue instructions for resumption of requested FPR; A/c does not resume requested FPR	1. Radar monitoring; PC; CORA 2 if conflict occurs	1. M	

1.5.4 Issue instructions for resumption of requested FPR and closure of resolution	1. Fail to issue instructions 2. Issue instructions incorrectly 3. Issue wrong instructions	1. Forget action 2. Incorrect Information, Unclear information 3. Incorrect Information	1, 2, 3. A/c does not resume requested FPR; Potential conflict	1, 2, 3. Radar monitoring; PC; CORA 2 if conflict occurs; Pilot query	1. M 2. M-H 3. M-H	
1.6 Monitor situation						
Do throughout as appropriate.						
1.6.1 Ensure that trajectory modified following resolution is not modified again (protected trajectory)	1. Fail to ensure that trajectory modified is not modified again	1. Forget action; Poor decision, No decision	1. Trajectory may be modified again in error	1. Not known	1. ?	How is a protected trajectory indicated?
1.6.2 Check that indicated conflicts are valid, and that resolutions are valid solutions (Task will diminish with increasing trust)	1. Fail to check that indicated conflicts are valid 2. Fail to check that all valid conflicts are indicated (Is this part of the task?) 3. Fail to check that indicated resolutions are valid solutions 4. Fail to check that resolutions are provided for all conflicts	1, 2, 3, 4. Forget action; Poor decision, No decision	1. Controller may be reacting to false alarms 2. CORA 2 may be missing valid conflicts; Possible loss of separation 3. Resolution maybe invalid; Possible loss of separation 4. Controller may fail to react to conflicts	1, 2, 3, 4. None	1. M 2. L 3. L 4. L	
1.6.3 Check that different data sources are coherent	1. Fail to check that different data sources are coherent	1. Forget action; Poor decision, No decision	1. CORA 2 data may be inconsistent; Controller may have faulty picture; Workload increase; Controller may implement invalid solutions; Possible loss of separation	1. None	1. L	

Table A.8.2: Recovery Success Likelihood Scale

RSL	Detection	Diagnosis	Correction
High	> Easily detected > Immediate, clear, direct feedback of actions/effects > Active involvement and constant monitoring > Independent/third party checks, automatic checks or cues to check	> No diagnosis required or very reliable diagnosis expected > No 'expectation bias'/'confirmation bias'	> Easily corrected, requiring no changes to plan, and causing little or no additional workload > Plenty of time available for recovery
Moderate -High			
Moderate	> Detectable > Feedback available > Regular but intermittent monitoring > Some cues to check or occasional independent checking by third party or automation	> May require some interpretation or diagnosis > Incorrect diagnosis possible > May be some 'expectation bias'/'confirmation bias'	> May necessitate changes to plan or corrective action using practised procedure causing some additional workload > Controller prepared and able to intervene > Some time pressure to recover error
Low-Moderate			
Low	> Difficult to detect > No feedback, or poor, indirect or delayed feedback > No monitoring or passive monitoring > High reliance on memory to check or suspect error	> Hard to diagnose, diagnosis very likely to be incorrect > Strong 'expectation bias'/'confirmation bias'	> Plan modification or difficult or complex correction process required, causing considerable workload > Controller unprepared or not familiar with procedures, with limited ability to intervene > Strong time pressure, or insufficient time available for recovery

9. APPENDIX A.9: CO-SPACE HAZOP WORKSHEETS

Table A.9.1: Co-Space HAZOP Worksheets for 'Identify and Select Target'

Project: Co-space, Delegation of "Merge Behind"			Subsystem 1: Identify and Select Target				Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
1. Less action	1.1. Pilot doesn't confirm he has heard the target	1.1. The controller will have to repeat message					
	1.2. Pilot doesn't read back the target reference	1.1. The controller will have to repeat message					
2. Wrong action	2.1. Controller identifies wrong target	2.1. Potential for a/c collision	3	4	U	2.1. Target positioning by pilot but this is not compulsory at present (note that this aspect had already been identified by the Project team).	1. Anti Overlap (display decluttering) as it currently exists needs some improvement. Review how this software tool can be used to support the controller during delegation and what improvements are required for it to be effective.
						2.2. Confirmation of target	2. Consider making target positioning by pilot a compulsory subtask in target selection.
						2.3. Read back of target from pilot to controller	3. Explore how data link technology could be used to support both controller and pilot when selecting a target during delegation.
						2.4. The pilot may question the target selection if he has enough supporting information	
						2.5. Controller monitoring of the a/c may identify that the pilot has the wrong target later in the task.	
						2.6. The pilot's TCAS (visual and audible alarm)	

Project: Co-space, Delegation of "Merge Behind"			Subsystem 1: Identify and Select Target				Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
						2.7. The controller's STCA (short term conflict alert) will sound a couple of minutes before separation infringement	
						2.8. The use of Anti-Overlap software tool on the controller's interface	
3. Wrong action	3.1. Pilot selects wrong target	3.1. Potential for a/c collision				3.1. Target positioning by pilot but this is not compulsory at present	1. Anti Overlap (display decluttering) as it currently exists needs some improvement. Review how this software tool can be used to support the controller during delegation and what improvements are required for it to be effective.
						3.2. Confirmation of target	2. Consider making target positioning by pilot a compulsory subtask in target selection.
						3.3. Controller monitoring of the a/c may identify that the pilot has the wrong target later in the task.	3. Explore how data link technology could be used to support both controller and pilot when selecting a target during delegation.
						3.4. The pilot's TCAS (visual and audible alarm)	
						3.5. The controller's STCA (short term conflict alert) will sound a couple of minutes before separation infringement	
						3.6. The use of Anti-Overlap software tool on the controller's interface	
4. Out of sequence	4.1. Pilot identifies correct target and goes straight to next action because he feels threatened	4.1. Potential for a/c collision	5	2	N	4.1. Pilot's TCAS (visual and audible)	4. Review safeguards for preventing the pilot from acting own initiative to ensure that they are adequate.
						4.2. Clear to controller from interface if pilot has taken action	
						4.3. Procedural controls	

Project: Co-space, Delegation of "Merge Behind"			Subsystem 1: Identify and Select Target				Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
5. Out of sequence	5.1. Pilot identifies correct target and goes straight to next action (anticipates controllers instruction)	5.1. Infringement of desired separation	2	4	N	5.1. Pilot's TCAS (visual and audible)	4. Review safeguards for preventing the pilot from acting own initiative to ensure that they are adequate.
		5.2. If action given is different to that anticipated by the pilot, there may be a delay in undertaking controller's instruction				5.2. Clear to controller from interface if pilot has taken action	
						5.3. Procedural controls	
6. Out of sequence	6.1. Controller goes straight to delegation without confirmation from pilot	6.1. Pilot doesn't select target/undertake action.					
7. Out of sequence	7.1. Controller goes straight to instruction of delegation omitting to identify target	7.1. Pilot can't implement instruction					
8. Extra action	8.1. Pilot carries out an action before delegation occurs e.g. slows down	8.1. HAZOP Team were unsure if this situation would ever arise and of its consequences.					4. Review safeguards for preventing the pilot from acting own initiative to ensure that they are adequate.
9. Extra action	9.1. Pilot requests more information	9.1. The controller will have to repeat message					
10. No action/more time	10.1. No action taken by pilot or pilot takes too much time to identify target.	10.1. Delegation action may have to be changed or cancelled.					5. Assess performance limits of delegation in terms of maximum number of delegations that can be managed by the controller and impact of abnormal conditions such as response to errors or delay.

Project: Co-space, Delegation of "Merge Behind"			Subsystem 1: Identify and Select Target				Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
		10.2. Increase in workload on controller.					
		10.3. Controller may pay too much attention to one particular a/c. (Similar to Cause 4.2 in Subsystem 2.)					
11. wrong information	11.1. Controller gives right target to wrong pilot	11.1. Same as "wrong target selected" above.				11.1. Same as "wrong target selected" above.	1. Anti Overlap (display decluttering) as it currently exists needs some improvement. Review how this software tool can be used to support the controller during delegation and what improvements are required for it to be effective.
							2. Consider making target positioning by pilot a compulsory subtask in target selection.
							3. Explore how data link technology could be used to support both controller and pilot when selecting a target during delegation.
12. wrong information	12.1. Controller gives wrong target to correct a/c	12.1. Same as "wrong target selected" above.				12.1. Same as "wrong target selected" above.	1. Anti Overlap (display decluttering) as it currently exists needs some improvement. Review how this software tool can be used to support the controller during delegation and what improvements are required for it to be effective.
							2. Consider making target positioning by pilot a compulsory subtask in target selection.
							3. Explore how data link technology could be used to support both controller and pilot when selecting a target during delegation.
13. Wrong information	13.1. Controller gives wrong information to wrong a/c	13.1. Same as "wrong target selected" above.				13.1. Same as "wrong target selected" above.	1. Anti Overlap (display decluttering) as it currently exists needs some improvement. Review how this software tool can be used to support the controller during delegation and

Project: Co-space, Delegation of "Merge Behind"			Subsystem 1: Identify and Select Target				Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
							what improvements are required for it to be effective.
							2. Consider making target positioning by pilot a compulsory subtask in target selection.
							3. Explore how data link technology could be used to support both controller and pilot when selecting a target during delegation.
14. More information	14.1. Controller may give other instruction along with delegation instruction	14.1. Pilot could omit to do any of the instructions.				14.1. The controller should not give more than 3 instructions to the pilot in any circumstances.	6. This issue was considered to be outwith scope of the Cospace project. This issue should be documented for consideration if the system is implemented.
15. Other task interference	15.1. Pilot undertaking other task while undertaking delegation	15.1. See no action/wrong action				15.1. Normal flying tasks take precedence over target selection	7. The Project Team findings on the Task Interference Effects on pilot and controller should be used to review the potential consequences and available safeguards. Recommendations should be made where necessary.
		15.2. Delegation task may take precedence over normal flying action (endanger flight)	3	4	U	15.2. Task Interference is currently being considered as part of the Cospace project	
16. Other task interference	16.1. Controller undertaking another task while giving delegation instruction to a pilot	16.1. This is more of a concern during the target selection and delegation instruction steps of the task. Once these steps are completed by the controller s/he just monitors the a/c activity				16.1. Task Interference is currently being considered as part of the Cospace project	7. The Project Team findings on the Task Interference Effects on pilot and controller should be used to review the potential consequences and available safeguards. Recommendations should be made where necessary.

Project: Co-space, Delegation of "Merge Behind"			Subsystem 1: Identify and Select Target				Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
17. Clarity	17.1. It is not clear to pilot what he is supposed to do (clarity - what is being said by controller)	17.1. Wrong action (see above)				17.1. Instructions are repeated by the controller	
18. Clarity	18.1. Clarity of instructions (equipment)	18.1. Wrong action (see above)					
19. Clarity	19.1. Pilot and controller receiving different (visual) information	19.1. Increase in workload on controller and pilot					5. Assess performance limits of delegation in terms of maximum number of delegations that can be managed by the controller and impact of abnormal conditions such as response to errors or delay.
		19.2. Controller may pay too much attention to particular a/c					
20. Abnormal conditions	20.1. Pilot experiencing difficulties in cockpit	20.1. No delegation will take place					
21. Abnormal conditions	21.1. Emergency (pilot or controller)	21.1. No delegation will take place					
22. Abnormal conditions	22.1. Severe weather (could be cause of rejection)	22.1. No delegation will take place					
23. Abnormal conditions	23.1. Shift change	23.1. No delegation will take place				23.1. Controller will finish targeting before hand over	
24. Training	24.1. Additional training in use of delegation required for pilots						8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.

Project: Co-space, Delegation of "Merge Behind"			Subsystem 1: Identify and Select Target				Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
	24.2. Additional training in use of delegation required for controllers						

Table A.9.2: Co-Space HAZOP Worksheets for 'Instruct to Merge Behind'

Project: Co-space, Delegation of "Merge Behind" Subsystem 2: Instruct to Merge Behind							Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking S	L	R	Safeguards	
1. Purpose	1.1. Aircraft not flying straight to merging point	1.1. Pilot can't achieve what's being asked - delegation is refused				1.1. Pilot would refuse delegation	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
		1.2. Additional work for controller if problem is detected early.				1.2. Controller would see on his/her interface that the a/c is behaving abnormally	9. Ensure controller and pilot procedures are easily understood and adequately support delegation requirements.
		1.3. Late detection would result in loss of separation/ spacing				1.3. Controller training	10. Review and identify available controller monitoring assistance tools to support early detection or prevent occurrence of separation infringement.
2. Purpose	2.1. After merging point a/c not flying on same trajectory	2.1. Pilot can't achieve what's being asked - delegation is refused				2.1. Controller training	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
		2.2. Additional work for controller if problem is detected early.				2.2. Controller would see on his/her interface that the a/c is behaving abnormally	9. Ensure controller and pilot procedures are easily understood and adequately support delegation requirements.
		2.3. Late detection would result in loss of separation/ spacing				2.3. Pilot would refuse delegation	10. Review and identify available controller monitoring assistance tools to support early detection or prevent occurrence of separation infringement.
3. Purpose	3.1. The two a/c do not have compatible performances	3.1. Pilot can't achieve what's being asked - delegation is refused				3.1. Controller training	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
		3.2. Additional work for controller if				3.2. Controller would see on his/her interface that the a/c is behaving	9. Ensure controller and pilot procedures are easily understood and adequately support

Project: Co-space, Delegation of "Merge Behind" Subsystem 2: Instruct to Merge Behind							Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
		problem is detected early.				abnormally	delegation requirements.
		3.3. Higher workload if early detection of problem.				3.3. Pilot would refuse delegation	10. Review and identify available controller monitoring assistance tools to support early detection or prevent occurrence of separation infringement.
		3.4. Late detection would result in loss of separation/ spacing					
		3.5. Trailing traffic sequence may be impacted					
4. Purpose	4.1. Predicted separation at merging point lower than desired separation	4.1. Pilot can't achieve what's being asked - delegation is refused				4.1. Controller training	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
		4.2. Additional work for controller if problem is detected early.				4.2. Controller would see on his/her interface that the a/c is behaving abnormally	9. Ensure controller and pilot procedures are easily understood and adequately support delegation requirements.
		4.3. Late detection would result in loss of separation/ spacing				4.3. Pilot would refuse delegation	10. Review and identify available controller monitoring assistance tools to support early detection or prevent occurrence of separation infringement.
		4.4. Trailing traffic sequence may be impacted					
5. No action	5.1. Pilot does not adjust speed	5.1. Spacing infringement	3	3	N	5.1. Current pilot support tools in cockpit, e.g. alert or autopilot	10. Review and identify available controller monitoring assistance tools to support early detection or prevent occurrence of separation infringement.
		5.2. Higher workload					

Project: Co-space, Delegation of "Merge Behind" Subsystem 2: Instruct to Merge Behind							Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
		for controller					
6. No action	6.1. Controller omits to give delegation but thinks they have given delegation	6.1. Spacing infringement				6.1. Marking functions on controller interface allows delegation to be marked for each a/c	11. Provide more information and guidance on how display marking for the data link and delegation instruction is to be used.
		6.2. Pilot can't achieve what's being asked - delegation is refused					12. Review how the existing marking functions on the controller interface can be used to support the controller during delegation and what improvements are required for it to be effective.
		6.3. Additional work for controller if problem is detected early.					13. Review how data link technology can be used to automatically confirm pilot action (mode activation) prior to changes being seen on controller's radar.
		6.4. Late detection would result in loss of separation/spacing					
7. Less action	7.1. Pilot reduces speed too much	7.1. Impacts spacing and increases workload for trailing a/c and resulting knock on effect	2	4	N	7.1. Current pilot support tools in cockpit, e.g. TCAS	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
						7.2. Controller monitoring and intervention	
8. More Action	8.1. Pilot increases speed too much	8.1. Loss of spacing with target a/c				8.1. Current pilot support tools in cockpit, e.g. TCAS	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
						8.2. Controller monitoring and intervention	
9. More Action	9.1. Controller gives superfluous instructions	9.1. No real consequences					

Project: Co-space, Delegation of "Merge Behind" Subsystem 2: Instruct to Merge Behind							Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
10. More Action	10.1. Delegations given to too many a/c	10.1. Modified controller situational awareness				10.1. Marking functions on controller interface allows delegation to be marked for each a/c	5. Assess performance limits of delegation in terms of maximum number of delegations that can be managed by the controller and impact of abnormal conditions such as response to errors or delay.
		10.2. Knock on problems during sector transfer					11. Provide more information and guidance on how display marking for the data link and delegation instruction is to be used.
							12. Review how the existing marking functions on the controller interface can be used to support the controller during delegation and what improvements are required for it to be effective.
							13. Review how data link technology can be used to automatically confirm pilot action (mode activation) prior to changes being seen on controller's radar.
11. Wrong action	11.1. Controller gives incompatible instructions	11.1. Pilot may execute given incompatible instruction					8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
		11.2. Pilot may question incompatible instruction					14. Review how existing and potential safeguards and supporting tools for pilot and controller can be used to prevent errors rather than respond to them.
							15. Controller training should include guidance on what information needs to be given at specific times during delegation.
12. Wrong action	12.1. Controller gives remain instruction instead of merge instruction	12.1. If applicability conditions for remain are not met then pilot can refuse delegation or question controller					8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.

Project: Co-space, Delegation of "Merge Behind" Subsystem 2: Instruct to Merge Behind							Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
		12.2. If applicability conditions are met for remain then no consequence other than higher workload for controller					14. Review how existing and potential safeguards and supporting tools for pilot and controller can be used to prevent errors rather than respond to them.
							15. Controller training should include guidance on what information needs to be given at specific times during delegation.
13. Wrong action	13.1. Controller gives correct instruction but pilot takes wrong action (other than delegated instruction)	13.1. Loss of spacing				13.1. Controller monitoring and intervention	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
		13.2. Higher workload for controller					14. Review how existing and potential safeguards and supporting tools for pilot and controller can be used to prevent errors rather than respond to them.
14. Extra action	14.1. Pilot takes additional action not requested by controller	14.1. Separation infringement with a/c other than target	3	2	N	14.1. Controller monitoring and intervention	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
						14.2. Current pilot support tools in cockpit, e.g. TCAS	
15. Less information	15.1. Controller only gives part of instruction (doesn't give distance or way point)	15.1. Pilot questions controller				15.1. Controller monitoring and intervention	8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.
		15.2. Pilot interprets instruction himself resulting in separation infringement with a/c				15.2. Current pilot support tools in cockpit, e.g. TCAS	14. Review how existing and potential safeguards and supporting tools for pilot and controller can be used to prevent errors rather than respond to them.

Project: Co-space, Delegation of "Merge Behind" Subsystem 2: Instruct to Merge Behind							Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
		other than target. See 14.1 Extra Action above.					
		15.3. If 'at least' is not specified then pilot will act on 'exactly' which will mean multiple speed adjustments by pilot and for trailing arrival stream. See 7.1 and 8.1 above.					15. Controller training should include guidance on what information needs to be given at specific times during delegation.
16. Less information	16.1. Controller loses track of what delegation has been given to which a/c					16.1. Marking functions on controller interface allows delegation to be marked for each a/c	1. Anti Overlap (display decluttering) as it currently exists needs some improvement. Review how this software tool can be used to support the controller during delegation and what improvements are required for it to be effective.
						16.2. The use of Anti-Overlap software tool on the controller's interface	12. Review how the existing marking functions on the controller interface can be used to support the controller during delegation and what improvements are required for it to be effective.
17. More time	17.1. Controller takes too long to give delegation instruction after giving target	17.1. Pilot unable to do anything with instruction as to late					
		17.2. More work for controller					
18. More time	18.1. Pilot takes too long to take action (time constraints given by way point -	18.1. Similar to 7.1 and 8.1 above					

Project: Co-space, Delegation of "Merge Behind" Subsystem 2: Instruct to Merge Behind							Recommendations
Guideword deviation	Error / Causes	Consequences	Risk Ranking			Safeguards	
			S	L	R		
	spacing)						
19. More information	19.1. Pilot receives more information on cockpit display	19.1. Increased difficulty in obtaining relevant information					16. Review how data link technology could be used to support pilot during delegation and what improvements are required for it to be effective.
20. More information	20.1. Pilot gives more information to controller than required.	20.1. No real consequences					
21. Clarity	21.1. As for sub system 1 Target Selection						
22. Task interference	22.1. As for sub system 1 Target Selection						
23. Training	23.1. As for sub system 1 Target Selection						
24. Abnormal conditions	24.1. Controller needs to cancel delegation	24.1. Delegation is cancelled					
25. Abnormal conditions	25.1. Pilot may need to cancel delegation	25.1. Delegation is cancelled					

Table A.9.3: Co-Space HAZOP Recommendations

Recommendations	Place(s) Used
1. Anti Overlap (display decluttering) as it currently exists needs some improvement. Review how this software tool can be used to support the controller during delegation and what improvements are required for it to be effective.	1.1.2, 1.1.3, 1.1.11, 1.1.12, 1.1.13, 1.2.16
2. Consider making target positioning by pilot a compulsory subtask in target selection.	1.1.2, 1.1.3, 1.1.11, 1.1.12, 1.1.13
3. Explore how data link technology could be used to support both controller and pilot when selecting a target during delegation.	1.1.2, 1.1.3, 1.1.11, 1.1.12, 1.1.13
4. Review safeguards for preventing the pilot from acting own initiative to ensure that they are adequate.	1.1.4, 1.1.5, 1.1.8
5. Assess performance limits of delegation in terms of maximum number of delegations that can be managed by the controller and impact of abnormal conditions such as response to errors or delay.	1.1.10, 1.1.19, 1.2.10
6. This issue was considered to be outwith scope of the Cospace project. This issue should be documented for consideration if the system is implemented.	1.1.14
7. The Project Team findings on the Task Interference Effects on pilot and controller should be used to review the potential consequences and available safeguards. Recommendations should be made where necessary.	1.1.15, 1.1.16
8. Implement a suitable training programme for both pilots and controllers in the application and use of delegation.	1.1.24, 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.7, 1.2.8, 1.2.11, 1.2.12, 1.2.13, 1.2.14, 1.2.15
9. Ensure controller and pilot procedures are easily understood and adequately support delegation requirements.	1.2.1, 1.2.2, 1.2.3, 1.2.4
10. Review and identify available controller monitoring assistance tools to support early detection or prevent occurrence of separation infringement.	1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5
11. Provide more information and guidance on how display marking for the data link and delegation instruction is to be used.	1.2.6, 1.2.10
12. Review how the existing marking functions on the controller interface can be used to support the controller during delegation and what improvements are required for it to be effective.	1.2.6, 1.2.10, 1.2.16
13. Review how data link technology can be used to automatically confirm pilot action (mode activation) prior to changes being seen on controller's radar.	1.2.6, 1.2.10
14. Review how existing and potential safeguards and supporting tools for pilot and controller can be used to prevent errors rather than respond to them.	1.2.11, 1.2.12, 1.2.13, 1.2.15
15. Controller training should include guidance on what information needs to be given at specific times during delegation.	1.2.11, 1.2.12, 1.2.15
16. Review how data link technology could be used to support pilot during delegation and what improvements are required for it to be effective.	1.2.19

Table A.9.4: Co-Space HAZOP Risk Ranking Matrix

Likelihood \ Severity	5	4	3	2	1
4	A	A	C	N	N
3	A	C	N	N	N
2	C	N	N	U	U
1	C	N	U	U	U

Severity Ratings

1 Loss of aircraft
2 Near miss
3 Infringement of desired separation
4 Infringement of desired spacing
5 No Safety Implications

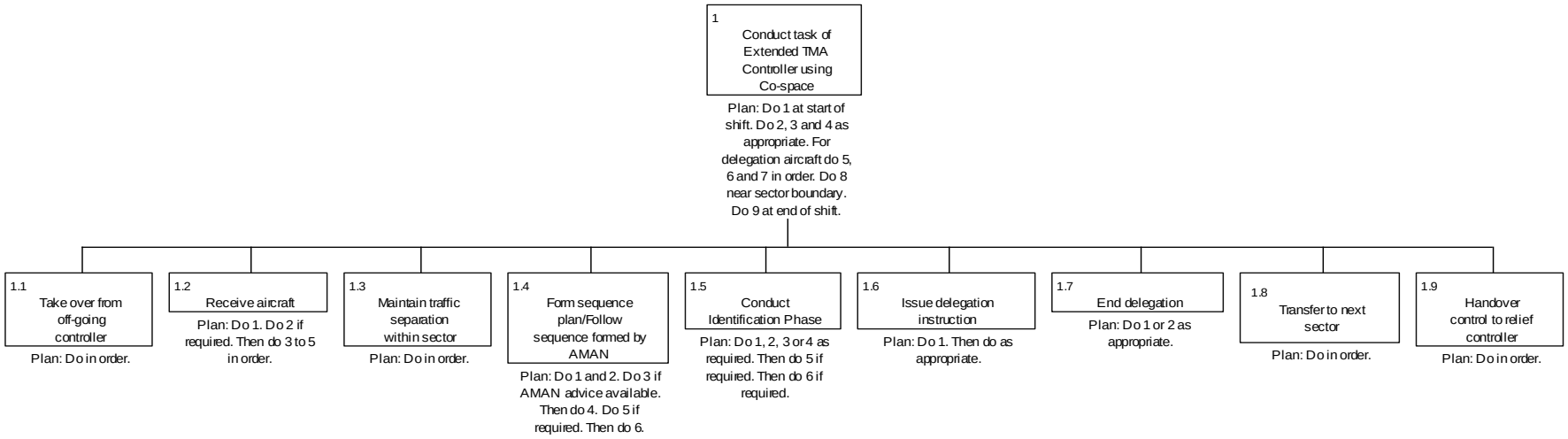
Likelihood Ratings

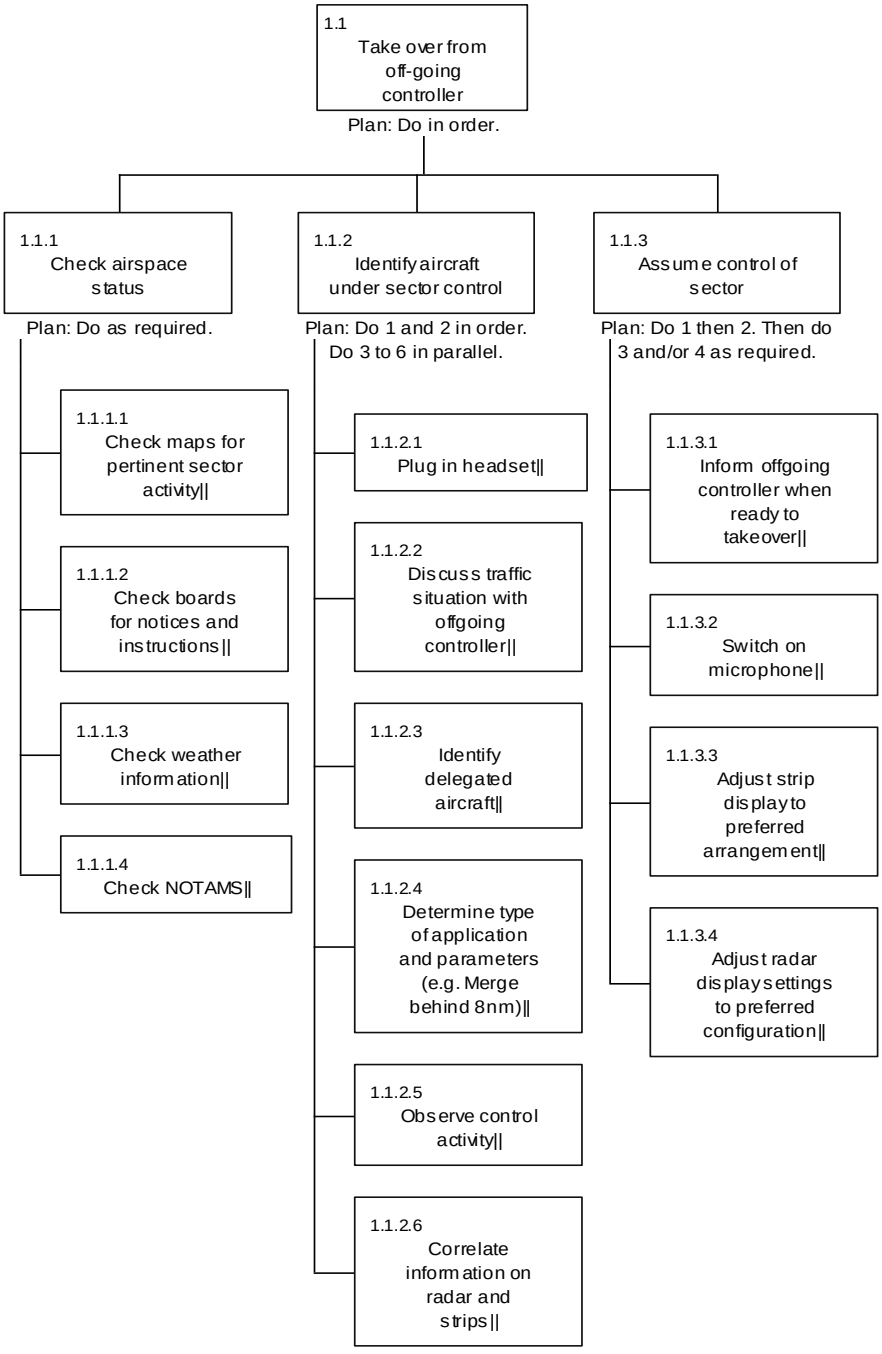
1 Could occur on an annual basis (or more often) for each controller
2 Could occur on an annual basis (or more often) for each airspace
3 Could occur once across all airspace
4 Not expected to occur

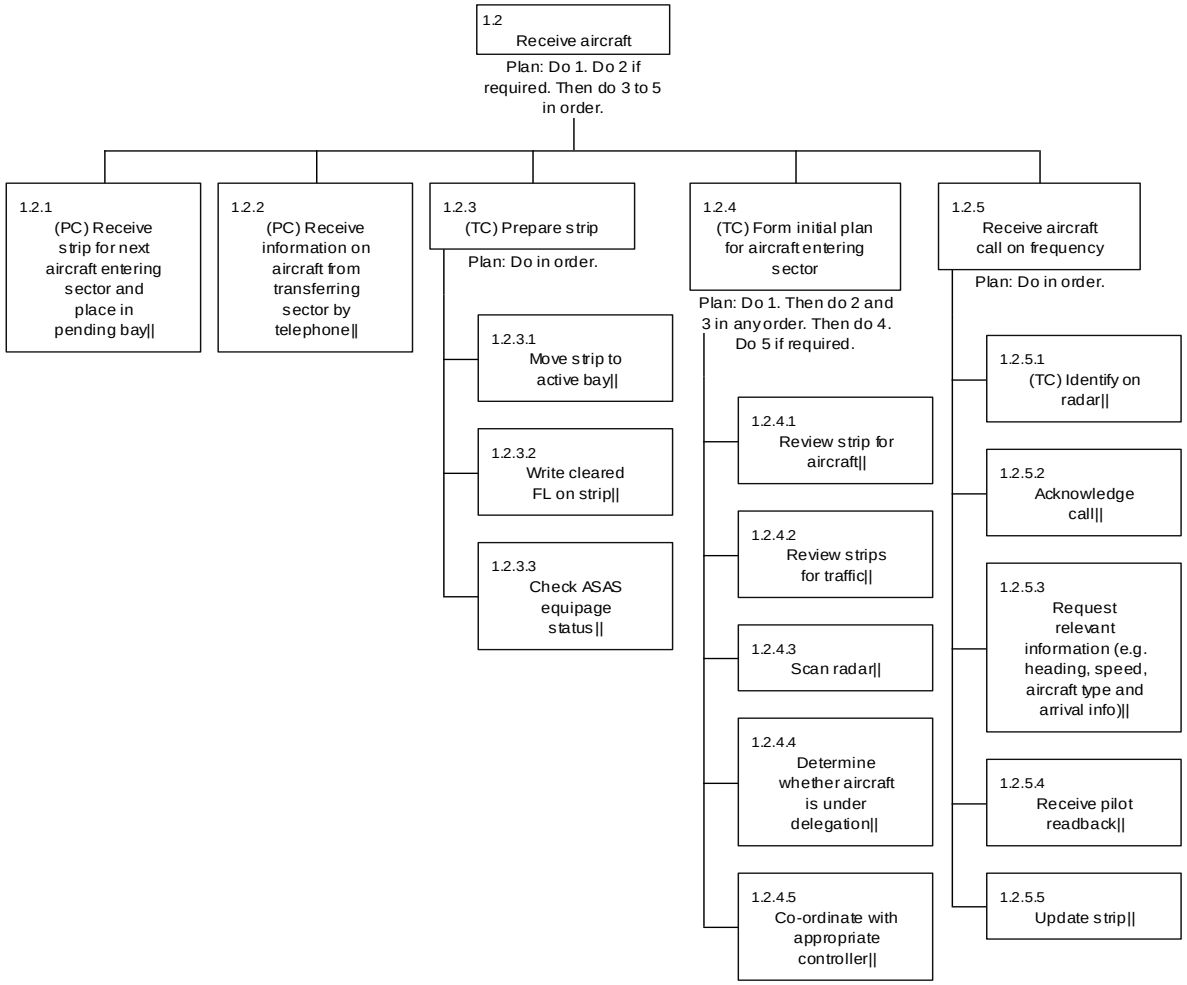
Risk Ranking

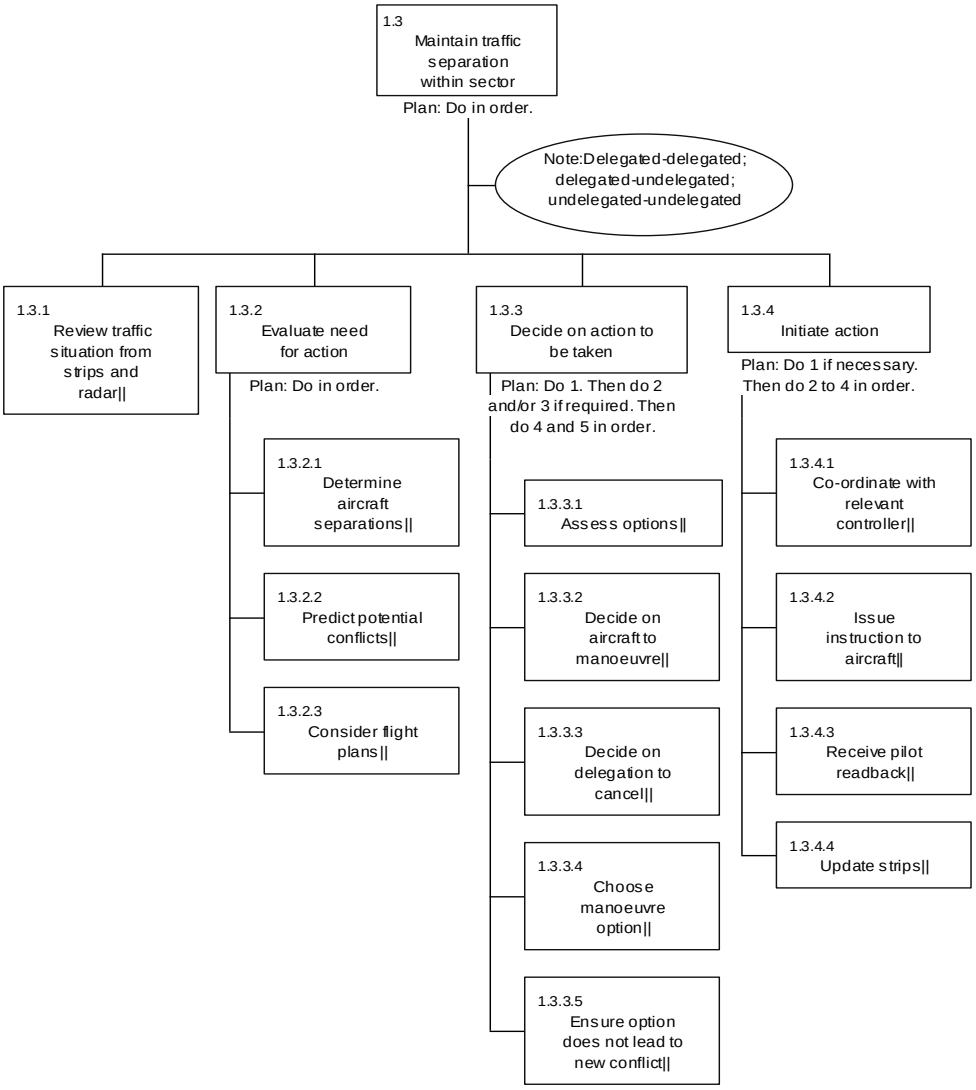
A Acceptable - no risk control measures needed
C Acceptable with Control - risk control measures are in place
N Not Desirable - risk control measures to be introduced within a specified time limit
U Unacceptable

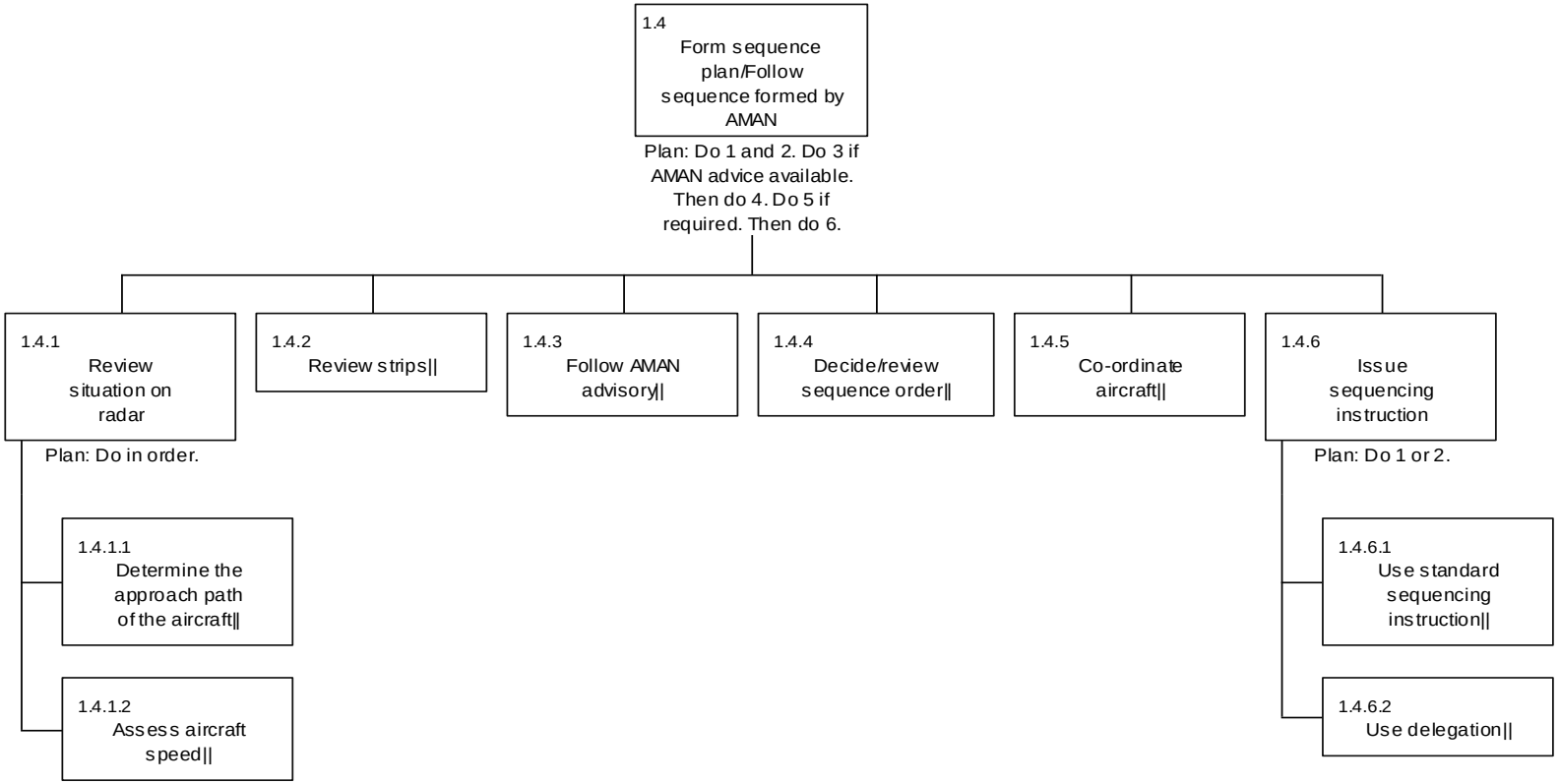
10. APPENDIX A.10: CO-SPACE HIERARCHICAL TASK ANALYSIS

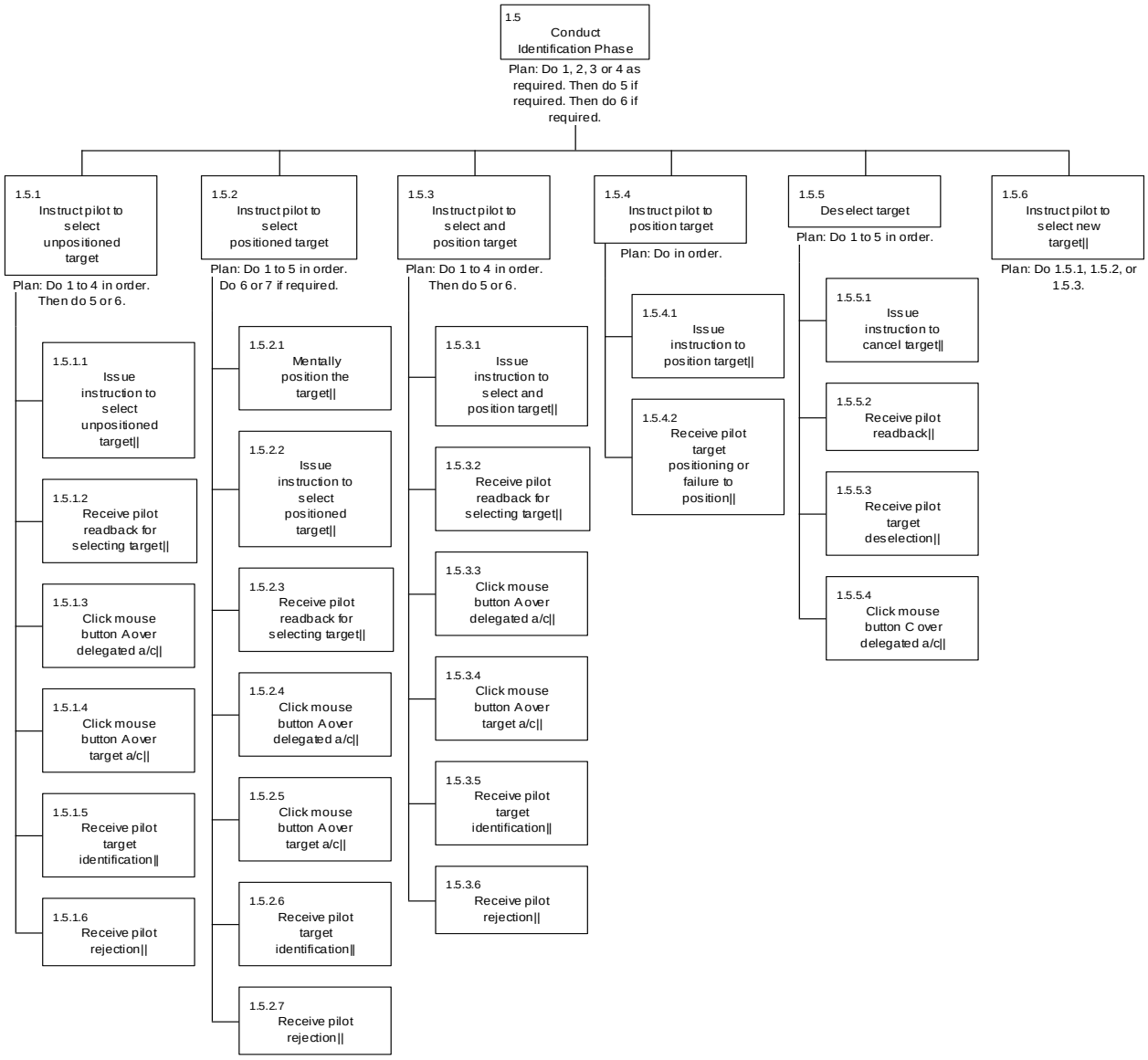


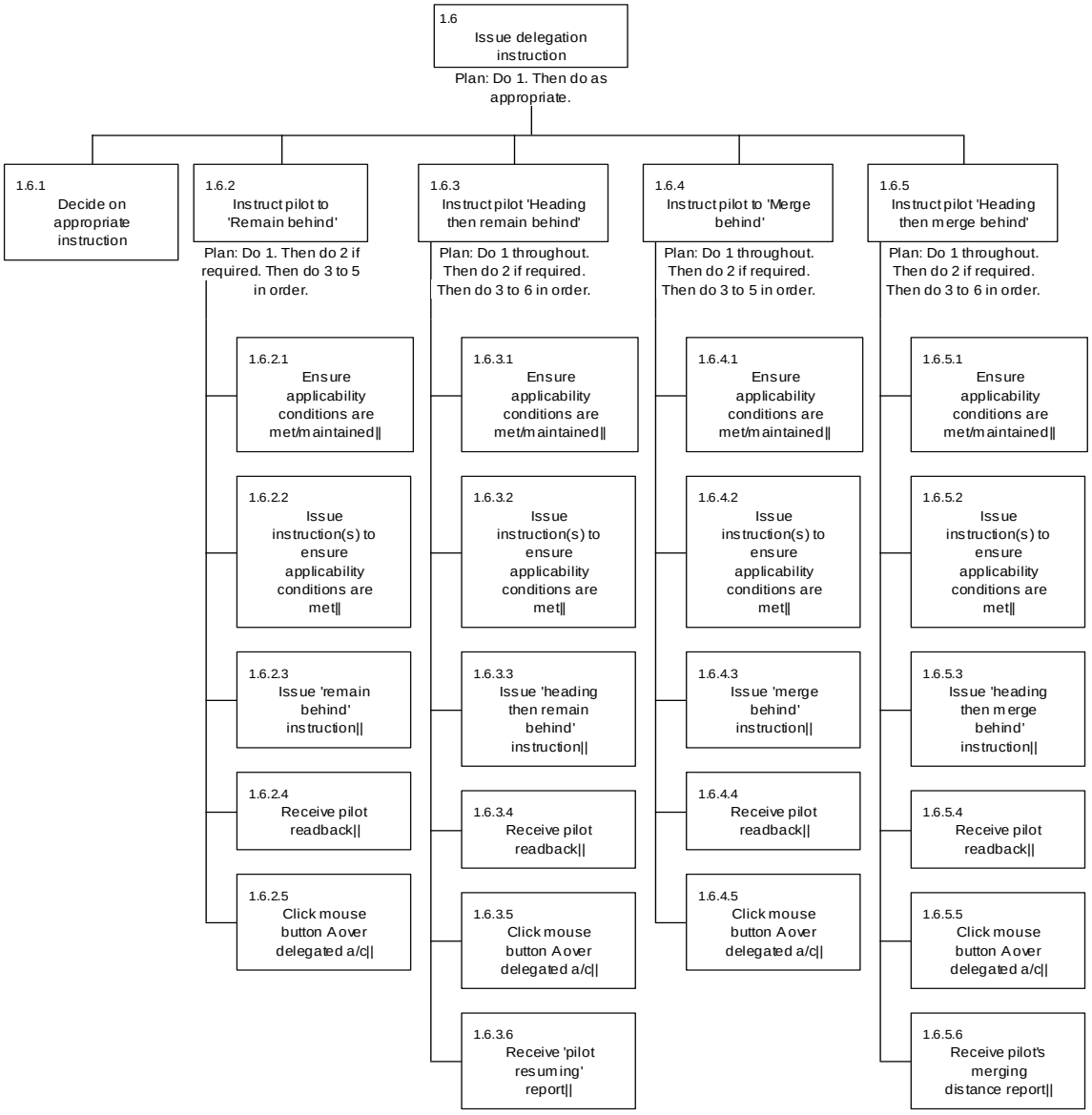

1.1
Take over from off-going controller
Plan: Do in order.
1.1.1
Check airspace status
Plan: Do as required.
1.1.1.1
Check maps for pertinent sector activity||
1.1.1.2
Check boards for notices and instructions||
1.1.1.3
Check weather information||
1.1.1.4
Check NOTAMS||
1.1.2
Identify aircraft under sector control
Plan: Do 1 and 2 in order. Do 3 to 6 in parallel.
1.1.2.1
Plug in headset||
1.1.2.2
Discuss traffic situation with offgoing controller||
1.1.2.3
Identify delegated aircraft||
1.1.2.4
Determine type of application and parameters (e.g. Merge behind 8nm)||
1.1.2.5
Observe control activity||
1.1.2.6
Correlate information on radar and strips||
1.1.3
Assume control of sector
Plan: Do 1 then 2. Then do 3 and/or 4 as required.
1.1.3.1
Inform offgoing controller when ready to takeover||
1.1.3.2
Switch on microphone||
1.1.3.3
Adjust strip display to preferred arrangement||
1.1.3.4
Adjust radar display settings to preferred configuration||

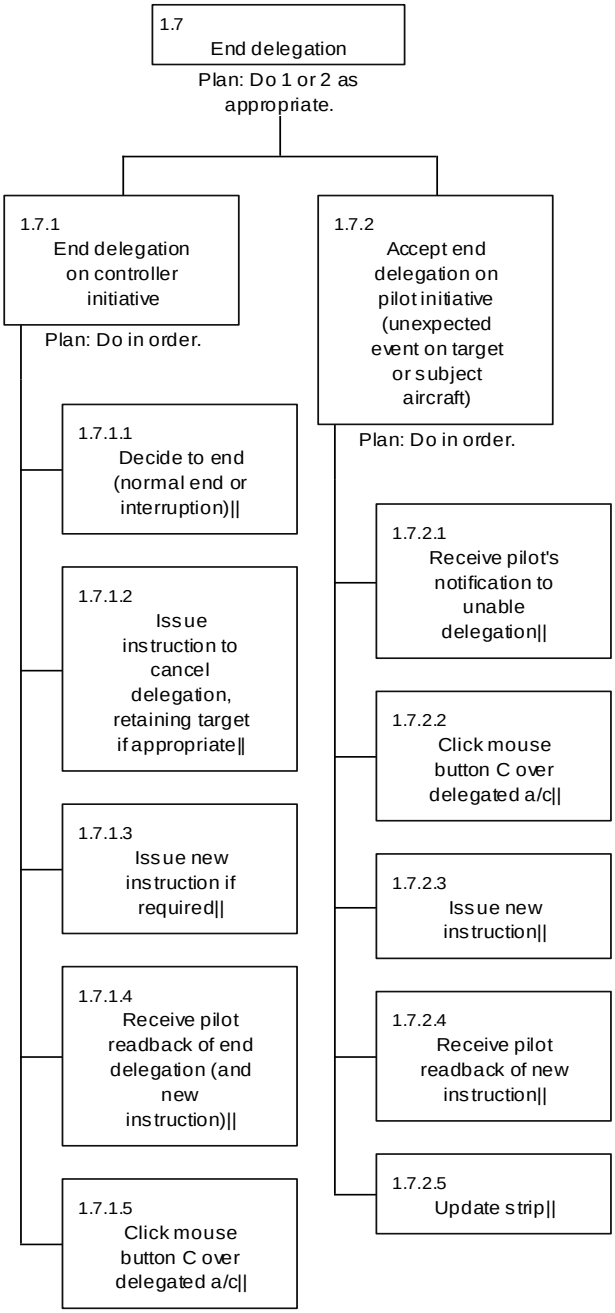

1.2
Receive aircraft
Plan: Do 1. Do 2 if required. Then do 3 to 5 in order.
1.2.1
(PC) Receive strip for next aircraft entering sector and place in pending bay||
1.2.2
(PC) Receive information on aircraft from transferring sector by telephone||
1.2.3
(TC) Prepare strip
Plan: Do in order.
1.2.3.1
Move strip to active bay||
1.2.3.2
Write cleared FL on strip||
1.2.3.3
Check ASAS equipage status||
1.2.4
(TC) Form initial plan for aircraft entering sector
Plan: Do 1. Then do 2 and 3 in any order. Then do 4. Do 5 if required.
1.2.4.1
Review strip for aircraft||
1.2.4.2
Review strips for traffic||
1.2.4.3
Scan radar||
1.2.4.4
Determine whether aircraft is under delegation||
1.2.4.5
Co-ordinate with appropriate controller||
1.2.5
Receive aircraft call on frequency
Plan: Do in order.
1.2.5.1
(TC) Identify on radar||
1.2.5.2
Acknowledge call||
1.2.5.3
Request relevant information (e.g. heading, speed, aircraft type and arrival info)||
1.2.5.4
Receive pilot readback||
1.2.5.5
Update strip||

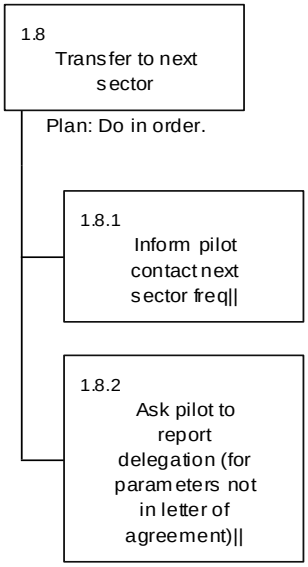

1.3
Maintain traffic separation within sector
Plan: Do in order.
Note:Delegated-delegated; delegated-undelegated; undelegated-undelegated
1.3.1
Review traffic situation from strips and radar||
1.3.2
Evaluate need for action
Plan: Do in order.
1.3.2.1
Determine aircraft separations||
1.3.2.2
Predict potential conflicts||
1.3.2.3
Consider flight plans||
1.3.3
Decide on action to be taken
Plan: Do 1. Then do 2 and/or 3 if required. Then do 4 and 5 in order.
1.3.3.1
Assess options||
1.3.3.2
Decide on aircraft to manoeuvre||
1.3.3.3
Decide on delegation to cancel||
1.3.3.4
Choose manoeuvre option||
1.3.3.5
Ensure option does not lead to new conflict||
1.3.4
Initiate action
Plan: Do 1 if necessary. Then do 2 to 4 in order.
1.3.4.1
Co-ordinate with relevant controller||
1.3.4.2
Issue instruction to aircraft||
1.3.4.3
Receive pilot readback||
1.3.4.4
Update strips||

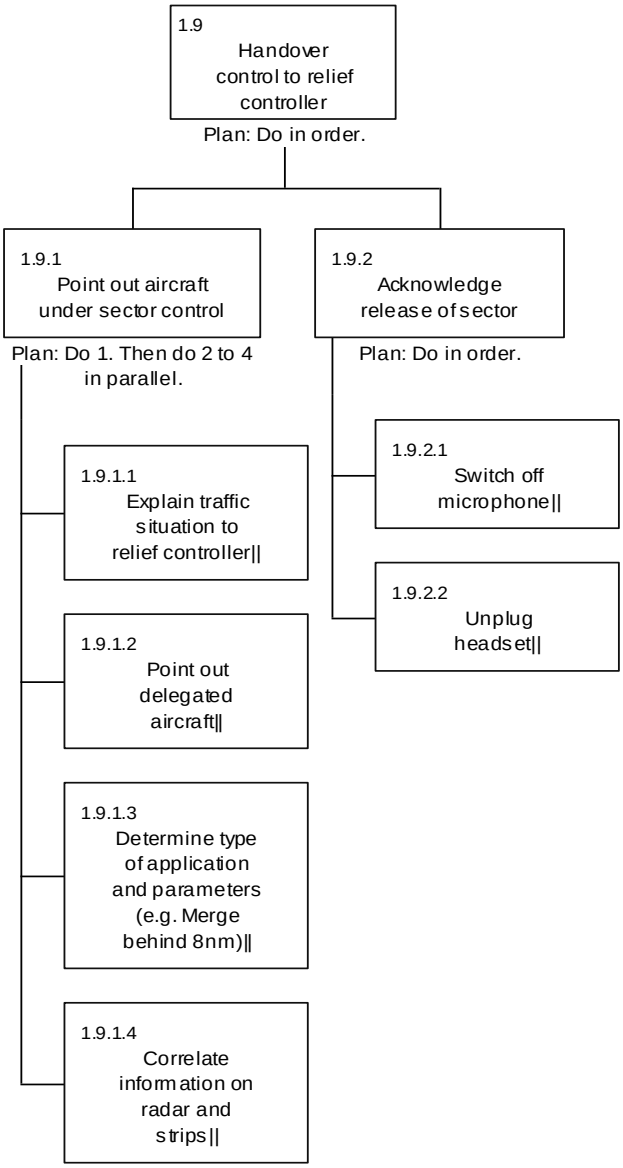

1.4
Form sequence plan/Follow sequence formed by AMAN
Plan: Do 1 and 2. Do 3 if AMAN advice available. Then do 4. Do 5 if required. Then do 6.
1.4.1
Review situation on radar
Plan: Do in order.
1.4.1.1
Determine the approach path of the aircraft‖
1.4.1.2
Assess aircraft speed||
1.4.2
Review strips||
1.4.3
Follow AMAN advisory||
1.4.4
Decide/review sequence order‖
1.4.5
Co-ordinate aircraft||
1.4.6
Issue sequencing instruction
Plan: Do 1 or 2.
1.4.6.1
Use standard sequencing instruction||
1.4.6.2
Use delegation||


1.5
Conduct Identification Phase
Plan: Do 1, 2, 3 or 4 as required. Then do 5 if required. Then do 6 if required.
1.5.1
Instruct pilot to select unpositioned target
Plan: Do 1 to 4 in order. Then do 5 or 6.
1.5.1.1
Issue instruction to select unpositioned target||
1.5.1.2
Receive pilot readback for selecting target||
1.5.1.3
Click mouse button A over delegated a/c||
1.5.1.4
Click mouse button A over target a/c||
1.5.1.5
Receive pilot target identification‖
1.5.1.6
Receive pilot rejection||
1.5.2
Instruct pilot to select positioned target
Plan: Do 1 to 5 in order. Do 6 or 7 if required.
1.5.2.1
Mentally position the target||
1.5.2.2
Issue instruction to select positioned target||
1.5.2.3
Receive pilot readback for selecting target||
1.5.2.4
Click mouse button A over delegated a/c||
1.5.2.5
Click mouse button A over target a/c||
1.5.2.6
Receive pilot target identification‖
1.5.2.7
Receive pilot rejection||
1.5.3
Instruct pilot to select and position target
Plan: Do 1 to 4 in order. Then do 5 or 6.
1.5.3.1
Issue instruction to select and position target||
1.5.3.2
Receive pilot readback for selecting target||
1.5.3.3
Click mouse button A over delegated a/c||
1.5.3.4
Click mouse button A over target a/c||
1.5.3.5
Receive pilot target identification‖
1.5.3.6
Receive pilot rejection||
1.5.4
Instruct pilot to position target
Plan: Do in order.
1.5.4.1
Issue instruction to position target||
1.5.4.2
Receive pilot target positioning or failure to position||
1.5.5
Deselect target
Plan: Do 1 to 5 in order.
1.5.5.1
Issue instruction to cancel target‖
1.5.5.2
Receive pilot readback||
1.5.5.3
Receive pilot target deselection||
1.5.5.4
Click mouse button C over delegated a/c||
1.5.6
Instruct pilot to select new target||
Plan: Do 1.5.1, 1.5.2, or 1.5.3.


1.6
Issue delegation instruction
Plan: Do 1. Then do as appropriate.
1.6.1
Decide on appropriate instruction
1.6.2
Instruct pilot to 'Remain behind'
Plan: Do 1. Then do 2 if required. Then do 3 to 5 in order.
1.6.2.1
Ensure applicability conditions are met/maintained||
1.6.2.2
Issue instruction(s) to ensure applicability conditions are met||
1.6.2.3
Issue 'remain behind' instruction||
1.6.2.4
Receive pilot readback||
1.6.2.5
Click mouse button A over delegated a/c||
1.6.3
Instruct pilot 'Heading then remain behind'
Plan: Do 1 throughout. Then do 2 if required. Then do 3 to 6 in order.
1.6.3.1
Ensure applicability conditions are met/maintained||
1.6.3.2
Issue instruction(s) to ensure applicability conditions are met||
1.6.3.3
Issue 'heading then remain behind' instruction||
1.6.3.4
Receive pilot readback||
1.6.3.5
Click mouse button A over delegated a/c||
1.6.3.6
Receive 'pilot resuming' report||
1.6.4
Instruct pilot to 'Merge behind'
Plan: Do 1 throughout. Then do 2 if required. Then do 3 to 5 in order.
1.6.4.1
Ensure applicability conditions are met/maintained||
1.6.4.2
Issue instruction(s) to ensure applicability conditions are met||
1.6.4.3
Issue 'merge behind' instruction||
1.6.4.4
Receive pilot readback||
1.6.4.5
Click mouse button A over delegated a/c||
1.6.5
Instruct pilot 'Heading then merge behind'
Plan: Do 1 throughout. Then do 2 if required. Then do 3 to 6 in order.
1.6.5.1
Ensure applicability conditions are met/maintained||
1.6.5.2
Issue instruction(s) to ensure applicability conditions are met||
1.6.5.3
Issue 'heading then merge behind' instruction||
1.6.5.4
Receive pilot readback||
1.6.5.5
Click mouse button A over delegated a/c||
1.6.5.6
Receive pilot's merging distance report||


1.7
End delegation
Plan: Do 1 or 2 as appropriate.
1.7.1
End delegation on controller initiative
Plan: Do in order.
1.7.1.1
Decide to end (normal end or interruption)||
1.7.1.2
Issue instruction to cancel delegation, retaining target if appropriate‖
1.7.1.3
Issue new instruction if required||
1.7.1.4
Receive pilot readback of end delegation (and new instruction)||
1.7.1.5
Click mouse button C over delegated a/c||
1.7.2
Accept end delegation on pilot initiative (unexpected event on target or subject aircraft)
Plan: Do in order.
1.7.2.1
Receive pilot's notification to unable delegation||
1.7.2.2
Click mouse button C over delegated a/c||
1.7.2.3
Issue new instruction||
1.7.2.4
Receive pilot readback of new instruction||
1.7.2.5
Update strip||


1.8
Transfer to next sector
Plan: Do in order.
1.8.1
Inform pilot contact next sector freq||
1.8.2
Ask pilot to report delegation (for parameters not in letter of agreement)||


1.9
Handover control to relief controller
Plan: Do in order.
1.9.1
Point out aircraft under sector control
Plan: Do 1. Then do 2 to 4 in parallel.
1.9.1.1
Explain traffic situation to relief controller||
1.9.1.2
Point out delegated aircraft||
1.9.1.3
Determine type of application and parameters (e.g. Merge behind 8nm)||
1.9.1.4
Correlate information on radar and strips||
1.9.2
Acknowledge release of sector
Plan: Do in order.
1.9.2.1
Switch off microphone||
1.9.2.2
Unplug headset||

11. APPENDIX A.11: CO-SPACE TRACER-LITE ANALYSIS WORKSHEET

KEY:
☒ = External Error is same as current.
🡻 = External Error(s) described in hierarchy below.
RSL = Recovery Success Likelihood (see Table A.11.2 for RSL Scale)

Table A.11.1: TRACEr-lite Analysis Worksheet

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
1 CONDUCT TASK OF EXTENDED TMA CONTROLLER USING CO-SPACE						
Do 1 at start of shift. Do 2, 3 and 4 as appropriate. For delegation a/c do 5, 6 and 7 in order. Do 8 near sector boundary. Do 9 at end of shift.						
1.1 Take over from off-going controller	🡻					
Do in order.						
1.1.1 Check airspace status	☒					
Do as required.						
1.1.1.1 Check maps for pertinent sector activity ‖	☒					
1.1.1.2 Check boards for notices and instructions ‖	☒					
1.1.1.3 Check weather information ‖	☒					
1.1.1.4 Check NOTAMS ‖	☒					
1.1.2 Identify a/c under sector control	🡻					

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
Do 1 and 2 in order. Do 3 to 6 in parallel.						
1.1.2.1 Plug in headset ‖	☒					
1.1.2.2 Discuss traffic situation with offgoing controller ‖	☒					
1.1.2.3 Identify delegated a/c ‖	1. Fail to identify delegated a/c 2. Identify a/c as delegated when not delegated 3. Confuse delegated a/c 4. Forget delegated a/c	1, 2. Mishear, Mis-see, Forget information, Misrecall information 3. Misrecall information 4. Forget information	1. Relief controller unaware of delegated a/c, May fail to monitor / end delegation. 2. Relief controller falsely believes a/c are delegated, May fail to provide positive control 3. Relief controller confuses delegated and non-delegated a/c 4. Relief controller forgets a/c are delegated	1, 2, 3, 4. Check on delegation symbols on radar display, Radar monitoring, RT communication with a/c, ATCO in situ	1. M-H 2. M-H 3. M-H 4. M-H	Important that a/c are marked as delegated on radar display to achieve this RSL.
1.1.2.4 Determine type of application and parameters (e.g. Merge behind 8nm) ‖	1. Fail to identify type of application 2. Misidentify type of application 3. Confuse type of application between different a/c 4. Misidentify parameters(s)/value(s) 5. Forget type of application	1, 2, 3, 4. Mishear, Mis-see, Forget information, Misrecall information 5. Forget information	1. Relief controller unaware of type of application 2, 3. Relief controller's perception of type of application is incorrect 4. Relief controller has false understanding of parameter(s), May fail to provide appropriate spacing 5. Relief controller forgets type of application	1, 2, 3, 4, 5. Memory, Radar monitoring, RT communication with a/c, ATCO in situ	1. M-H 2. M 3. M 4. M 5. M-H	Recall of type of application depends on controller memory.
1.1.2.5 Observe control activity ‖	☒					
1.1.2.6 Correlate information on radar and strips ‖	☒					
1.1.3 Assume control of sector	☒					

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
Do 1 then 2. Then do 3 and / or 4 as required.						
1.1.3.1 Inform offgoing controller when ready to takeover ‖	☒					
1.1.3.2 Switch on microphone ‖	☒					
1.1.3.3 Adjust strip display to preferred arrangement ‖	☒					
1.1.3.4 Adjust radar display settings to preferred configuration ‖	☒					
1.2 Receive a/c	🡻					
Do 1. Do 2 if required. Then do 3 to 5 in order.						
1.2.1 (PC) Receive strip for next a/c entering sector and place in pending bay ‖	☒					
1.2.2 (PC) Receive information on a/c from transferring sector by telephone ‖	1. Fail to identify delegated a/c 2. Wrongly identify a/c as delegated 3. Fail to identify type of application 4. Misidentify type of application 5. Confuse type of application between different a/c 6. Misidentify parameters(s)/value(s)	1, 3. No detection - auditory, Mishear, Forget information, Misrecall information 2, 4. Mishear 5, 6. Mishear, Forget information, Misrecall information	1. Controller unaware of delegated a/c, May fail to monitor / end delegation 2. Controller falsely believes a/c are delegated, May fails to provide positive control 3. Controller unaware of type of application 4, 5. Controller's perception of type of application is incorrect 6. Relief controller has false understanding of parameter(s), May fail to provide appropriate spacing	1, 2. Check on delegation symbols on radar display?, Check on strip markings?, Radar monitoring, RT communication with a/c 3, 4, 5, 6. Check on strip markings?, Radar monitoring, RT communication with a/c	1. M 2. M 3. L 4. L-M 5. L-M 6. M	Unsure whether this task involves communicating information regarding delegation status. Receiving controller has a visual indication of delegation status.
1.2.3 (TC) Prepare strip	☒					Delegation is not

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
						marked on the strip.
Do in order.						
1.2.3.1 Move strip to active bay ‖	☒					
1.2.3.2 Write cleared FL on strip ‖	☒					
1.2.3.3 Check ASAS equipage status ‖	1. Fail to check ASAS equipage status 2. Check ASAS equipage status on wrong strip 3. Misread ASAS status	1. Forget action, No decision 2, 3. Mis-see	1. Controller unaware of ASAS equipage 2, 3. Controller falsely believes a/c is ASAS equipped, Controller attempts delegation	1, 2, 3. RT communication with a/c (Task 1.5)	1. M-H 2. M-H 3. M-H	Controller will have, in future, many such items to check.
1.2.4 (TC) Form initial plan for a/c entering sector	🡻					
Do 1. Then do 2 and 3 in any order. Then do 4. Do 5 if required.						
1.2.4.1 Review strip for a/c ‖	☒					
1.2.4.2 Review strips for traffic ‖	☒					
1.2.4.3 Scan radar ‖	☒					
1.2.4.4 Determine whether a/c is under delegation ‖	1. Fail to identify delegated a/c 2. Identify a/c as delegated when not delegated 3. Fail to identify type of application 4. Misidentify type of application 5. Confuse type of application between different a/c 6. Misidentify parameters(s)/value(s)	1, 3. No detection - visual, Mis-see 2, 4. Mis-see 5, 6. Mis-see	1. Controller unaware of delegated a/c, May fail to monitor / end delegation 2. Controller falsely believes a/c are delegated, May fails to provide positive control 3. Controller unaware of type of application 4, 5. Controller's perception of type of application is incorrect 6. Relief controller has false understanding of	1, 2. Check on delegation symbols on radar display?, Check on strip markings, Radar monitoring, RT communication with a/c 3, 4, 5, 6. Check on strip markings, Radar monitoring, RT communication with a/c	1. M 2. M 3. M-H 4. M 5. M 6. M	How is this task achieved? Does receiving controller have visual indication of delegation status.

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
			parameter(s), May fail to provide appropriate spacing?			
1.2.4.5 Co-ordinate with appropriate controller ‖	☒?					Is this necessary?
1.2.5 Receive a/c call on frequency	☒					
Do in order.						
1.2.5.1 (TC) Identify on radar ‖	☒					
1.2.5.2 Acknowledge call ‖	☒					
1.2.5.3 Request relevant information (e.g. heading, speed, a/c type and arrival info) ‖	☒					Any other info req. relating to ASAS?
1.2.5.4 Receive pilot readback ‖	☒					
1.2.5.5 Update strip ‖	☒					
1.3 Maintain traffic separation within sector Delegated-delegated; delegated-undelegated; undelegated-undelegated	🡻					
Do in order.						
1.3.1 Review traffic situation from strips and radar ‖	1. Fail to monitor progress of delegation instruction on radar 2. Mis-see radar	1. Forget action, No detection - visual 2. Mis-see	1. Controller unaware of the progress of delegated a/c, Possible build up effect of problems in long chains, Applicability conditions not maintained, Potential for loss of spacing 2. Controller has incorrect knowledge of a/c details	1. Delegation symbols help to attract attention, Controller in situ, RT communications?, STCA 2. Check on strip markings, RT communication	1. M 2. M	Progress of delegation should be supported by automatic compliance monitoring if possible. Controllers should have a permanent indication of delegation status, type of application

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
						and associated parameters.
1.3.2 Evaluate need for action	↓					
Do in order.						
1.3.2.1 Determine a/c separations ‖	1. Fail to notice a/c separations 2. Misinterpret a/c separations 3. Confuse separations of delegated and non-delegated a/c	1, 3. Mis-see 2. Misprojection	1, 3. Controller unaware of a/c separations, Potential loss of separation 2. Controller has incorrect knowledge of a/c separations, Potential loss of separation	1, 2. STCA 3. Delegation symbols, STCA	1. M 2. M 3. M	Progress of delegation should be supported by automatic compliance monitoring if possible.
1.3.2.2 Predict potential conflicts ‖	1. Fail to predict potential conflict 2. Falsely identify potential conflict	1, 2. Misprojection	1. Conflict, Potential loss of separation 2. Workload increase	1. RT communication, STCA 2. No recovery necessary	1. M	
1.3.2.3 Consider flight plans ‖	1. Fail to check flight plan 2. Misread flight plan 3. Check wrong flight plan	1. Forget action 2, 3. Mis-see	1. Controller unaware of a/c route / destination / weight, etc., Applicability conditions not met 2, 3. Controller has incorrect knowledge of a/c route / destination / weight etc, Applicability conditions not met	1, 2, 3. RT communication, Radar monitoring (destination code)	1. M 2. M-H 3. M-H	
1.3.3 Decide on action to be taken	1. Fail to decide on action 2. Decide on action with inappropriate parameter 3. Decide to take action on wrong a/c	1. Forget action, Late or no decision, Poor decision 2, 3. Poor decision	1, 2, 3. Potential loss of separation	1, 2, 3. STCA	1. L-M 2. L-M 3. L-M	Same as current, but different implications in chains of a/c or in case one delegation has to be cancelled.
Do 1. Then do 2 and / or 3 if required. Then do 4 and 5 in order.						
1.3.3.1 Assess options ‖	☒					
1.3.3.2 Decide on a/c to	1. Fail to decide on a/c to	1. Forget action	1. Potential loss of	1, 2. Radar	1. L-M	Same as current,

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
manoeuvre ‖	manoeuvre 2. Decide to manoeuvre wrong a/c	2. Poor decision	separation 2. Potential secondary conflict, Knock-on effects in chain, Potential loss of separation	monitoring, STCA	2. M	but different implications in chains of a/c or in case one delegation has to be cancelled.
1.3.3.3 Decide on delegation to cancel ‖	1. Fail to cancel delegation when required 2. Decide on wrong delegation to cancel	1, 2. Poor decision Fail to consider effects	1. Delegation still active, A/c may not maintain applicability conditions, Workload not optimised 2. Delegation still active Workload not optimised,	1, 2. Radar monitoring	1. M-H 2. M-H	Unsure about consequences.
1.3.3.4 Choose manoeuvre option ‖	1. Choose wrong manoeuvre option	1. Poor decision	1. Potential secondary conflict, Knock-on effects in chain, Potential loss of separation	1. Radar monitoring, STCA	1. M	
1.3.3.5 Ensure option does not lead to new conflict ‖	1. Fail to ensure manoeuvre does not lead to new conflict	1. Poor decision	1. Potential secondary conflict, Knock-on effects in chain, Potential loss of separation	1. Radar monitoring, STCA	1. M	
1.3.4 Initiate action	↓					
Do 1 if necessary. Then do 2 to 4 in order.						
1.3.4.1 Co-ordinate with relevant controller ‖	☒					
1.3.4.2 Issue instruction to a/c ‖	1. Fail to cancel delegation 2. Cancel wrong delegation	1. Forget action 2. Incorrect information, Unclear information	1. Controller not working to plan, Delegation still active May have false picture, 2. Controller has false picture regarding delegation status, Potential loss of assumed spacing	1. Check on strip markings, Radar monitoring, RT communication with a/c 2. RT readback, Radar monitoring, RT communication with a/c, RT query	1. M 2. M	Controllers should have a permanent indication of delegation status, type of application and associated parameters.
1.3.4.3 Receive pilot readback ‖	☒					

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
(PNF readback instruction)	☒					
(PF execute)	☒					
1.3.4.4 Update strips ‖	☒					
1.4 Form sequence plan / Follow sequence formed by AMAN	🡻					
Do 1 and 2. Do 3 if AMAN advice available. Then do 4. Do 5 if required. Then do 6.						
1.4.1 Review situation on radar	1. Fail to notice applicability conditions are not met during check 2. Fail to check applicability conditions are not met	1. No detection - visual, Mis-see 2. Forget action, Poor decision, Late decision	1, 2. A/c have incompatible performances or speeds, inappropriate trajectories or separations, A/c unable to maintain spacing, Potential for loss of spacing	1, 2. Subsequent radar monitoring, RT communication with a/c	1. M 1. M	Important that controller checks all applicability conditions. An aide memoire and training may be necessary initially.
Do in order.						
1.4.1.1 Determine the approach path of the a/c ‖	1. Misjudge approach path 2. Fail to determine approach path (Unlikely)	1. Misprojection 2. Mis-see, Forget action	1. A/c inappropriately spaced, Resequencing, Applicability conditions may not be met? 2. Not analysed further.	1. Subsequent radar monitoring, RT comunication	1. M-H	
1.4.1.2 Assess a/c speed ‖	1. Fail to assess a/c speed 2. Misidentify a/c 3. Misjudge a/c speed	1. Forget action 2. Mis-see 3. Misprojection	1, 2, 3. A/c have incompatible speeds, A/c unable to maintain spacing, Potential for loss of spacing	1, 2, 3. Subsequent radar monitoring, RT communication	1. M 2. M 3. M	
1.4.2 Review strips ‖	1. Fail to review strip 2. Misread strip 3. Read wrong strip 4. Forget or mis-recall information on strip	1. Forget action 2. Mis-see 3. Mis-see 4. Forget information, Misrecall information	1, 2, 3, 4. Applicability conditions may not be met	1, 2, 3, 4. RT communication, Radar monitoring	1. M-H 2. M 3. M 4. M	
1.4.3 Follow AMAN advisory ‖	1. Fail to check AMAN / check late	1. Forget action, No decision, Poor decision,	1. ATCO unaware of AMAN, AMAN may have	1, 2,, 4. Radar monitoring	1. M 2. M	Same as current, but less time

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
	2. Fail to check suitability /integrity of AMAN advisory 3. Mis-interpret AMAN advisory 4. Ignore AMAN Advisory	Late Decision 2. Forget action, No decision, Poor decision 3. Mis-see, Poor decision, No decision 4. Poor decision, No decision	changed 2. AMAN advisory may not be appropriate, Potential mis-sequencing, Applicability conditions may not be met 3, 4. Potential mis-sequencing, Applicability conditions may not be met		3. M 4. M	available for recovery.
1.4.4 Decide / review sequence order ‖	1. Mis-calculate sequence order / Decide on inappropriate sequence order 2. Fail to integrate a/c into sequence 3. Fail to resequence in timely manner	1. Misprojection, Poor decision, Late decision, 2. Forget action 3. Late decision	1, 2, 3. Potential mis-sequencing	1, 2, 3. Radar monitoring	1. L-M 2. L-M 3. L-M	Same as current?
1.4.5 Co-ordinate a/c ‖	1. Fail to co-ordinate	1. Forget action	Same as current			
1.4.6 Issue sequencing instruction	1. Fail to issue instruction 2. Issue sequencing instruction late	1, 2. Forget action, Late decision	Same as current			
Do 1 or 2.						
1.4.6.1 Use standard sequencing instruction ‖	☒					
1.4.6.2 Use delegation ‖	1. Use delegation when not appropriate	1. Poor decision	1. A/c have incompatible performances or speeds, inappropriate trajectories or separations, A/c unable to maintain Potential for loss of spacing	1. Subsequent radar monitoring, RT communication with a/c	1. L	Important that controller checks all applicability conditions. An aide memoire may be necessary initially.
1.4.7 Receive pilot readback ‖	☒					
1.4.8 Update strip ‖	☒					
1.4.9 Monitor and maintain sequencing and spacing [see 1.3] ‖	1. Fail to monitor and maintain sequencing and spacing	1. Forget action, Poor decision	1. Potential mis-sequencing, Potential loss of separation	1. RT communication, STCA	1. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
1.5 Conduct Identification Phase	🡻					
Do 1, 2, 3 or 4 as required. Then do 5 if required. Then do 6 if required.						
1.5.1 Instruct pilot to select unpositioned target	🡻					
Do 1 to 4 in order. Then do 5 or 6. Do 7 throughout as appropriate.						
1.5.1.1 Issue instruction to select unpositioned target ‖	1. Fail to issue instruction to select target 2. Instruct pilot to select wrong target 3. Issue wrong / inappropriate instruction 4. Issue instruction to wrong a/c 5. Issue unclear instruction	1. Forget action, Late decision 2, 4. Incorrect information, Unclear information 3. Misprojection, Poor decision, Incorrect information 5. Unclear information	1. Pilot does not select target, No delegation, Pilot selects target late, Applicability conditions may change 2. Pilot tries to select wrong target 3. (Depends on instruction) Pilot responds to instruction (select / position) 4. Wrong a/c selects target 5. Pilot tries to select wrong target, Pilot does not select target, Pilot selects target late	1. Memory 2, 5. RT readback 3. Radar monitoring, RT readback 4. RT readback, Radar monitoring	1. M 2. M-H 3. H 4. M-H 5. M	
1.5.1.2 Receive pilot readback for selecting target ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot may have selected wrong target a/c	1. Radar monitoring	1. L-M 2. M	
1.5.1.3 Click mouse button A over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c	1. Forget action, Poor decision 2, 3, 4. Selection error 5. Poor decision	1. Controller may forget about delegation 2. Miscellaneous information appears 3. Selection unfinished?	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring	1. M 2. H 3. M-H 4. M-H 5. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
	5. Select inappropriate a/c		4. Unintended a/c selected 5. Inappropriate a/c selected	5. Radar monitoring, RT communication		
1.5.1.4 Click mouse button A over target a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select delegated a/c 4. Select unintended a/c 5. Select inappropriate a/c	1. Forget action, Poor decision 2, 3, 4. Selection error 5. Poor decision	1. Controller may forget about delegation 2. Miscellaneous information appears 3. Selection unfinished? 4. Unintended a/c selected 5. Inappropriate a/c selected	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring 5. Radar monitoring, RT communication	1. M 2. H 3. M-H 4. M-H 5. M	
1.5.1.5 Receive pilot target identification ‖	1. Fail to detect / query failed or non-identification 2. Fail to detect / query non-response 3. Fail to detect / query mis-identification	1, 3. Mishear 2. No detection - auditory, Poor decision, No decision	1, 2. Pilot failed to select target, Controller unaware of failed or non-identification 3. Pilot identified wrong target, Controller unaware of mis-identification	1, 2, 3. Future RT communication	1. M 2. M 3. L-M	
1.5.1.6 Receive pilot rejection ‖	1. Fail to detect / query pilot rejection	1. Mishear, No detection - auditory	1. Controller unaware of pilot rejection, Controller may assume pilot has identified target, Controller has faulty picture	1. Future RT communication	1. M	
1.5.2 Instruct pilot to select positioned target	↓					
Do 1 to 5 in order. Do 6 or 7 if required.						
1.5.2.1 Mentally position the target ‖	1. Position target incorrectly	1. Misprojection	1. Controllers positioning of target is incorrect, Pilot given incorrect positioning, Risk of selecting wrong target	1. Future RT communication - information redundancy (Unique identifier)	1. M-H	
1.5.2.2 Issue instruction to select positioned target ‖	1. Fail to issue instruction 2. Instruct pilot to select wrong target	1. Forget action 2, 3, 5. Incorrect information, Unclear	1. Pilot does not select target, No delegation, Pilot selects target late,	1. Memory 2, 6. RT readback 3. RT readback, Pilot	1. M 2. M-H 3. M-H	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
	3. Instruct pilot to select wrong position 4. Issue wrong / inappropriate instruction 5. Issue instruction to wrong a/c 6. Issue unclear instruction	information 4. Misprojection, Poor decision, Incorrect information 6. Unclear information	Applicability conditions may change 2. Pilot tries to select wrong target 3. Pilot confusion, RT clarification, Pilot tries to select wrong target 4. (Depends on instruction) Pilot responds to instruction (select / position) 5. Wrong a/c selects target 6. Pilot tries to select wrong target, Pilot does not select target, Pilot selects target late,	query 4. Radar monitoring, RT readback 5. RT readback, Radar monitoring	4. H 5. M-H 6. M	
1.5.2.3 Receive pilot readback for selecting target ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot may have selected wrong target a/c	1. Radar monitoring	1. L-M 2. M	
1.5.2.4 Click mouse button A over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c 5. Select inappropriate a/c	1. Forget action, Poor decision 2, 3, 4. Selection error 5. Poor decision	1. Controller may forget about delegation 2. Miscellaneous information appears 3. Selection unfinished? 4. Unintended a/c selected 5. Inappropriate a/c selected	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring 5. Radar monitoring, RT communication	1. M 2. H 3. M-H 4. M-H 5. M	
1.5.2.5 Click mouse button A over target a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c 5. Select inappropriate a/c	1. Forget action, Poor decision 2, 3, 4. Selection error 5. Poor decision	1. Controller may forget about delegation 2. Miscellaneous information appears 3. Selection unfinished? 4. Unintended a/c selected 5. Inappropriate a/c	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring 5. Radar monitoring, RT communication	1. M 2. H 3. M-H 4. M-H 5. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
			selected			
1.5.2.6 Receive pilot target identification ‖	1. Fail to detect / query failed or non-identification 2. Fail to detect / query non-response 3. Fail to detect / query mis-identification	1. Mishear 2. No detection - auditory, Poor decision, No decision 3. Mishear	1, 2. Pilot failed to select target, Controller unaware of failed or non-identification 3. Pilot identified wrong target, Controller unaware of mis-identification	1, 2, 3. Future RT communication	1. M 2. M 3. L-M	
1.5.2.7 Receive pilot rejection ‖	1. Fail to detect / query pilot rejection	1. Mishear, No detection - auditory	1. Controller unaware of pilot rejection, Controller may assume pilot has identified target, Controller has faulty picture	1. Future RT communication	1. M	
1.5.3 Instruct pilot to select and position target	↓					
Do 1 to 4 in order. Then do 5 or 6.						
1.5.3.1 Issue instruction to select and position target ‖	1. Fail to issue instruction 2. Fail to instruct pilot to select target 3. Fail to instruct pilot to position target 4. Instruct pilot to select wrong target 5. Issue wrong / inappropriate instruction 6. Issue instruction to wrong a/c 7. Issue unclear instruction	1 2, 3. Forget action 4, 6. Incorrect information, Unclear information 5. Misprojection, Poor decision, Incorrect information 7. Unclear information	1, 2, 3. Pilot does not select / position target, No delegation, Pilot selects / positions target late, Applicability conditions may change 4. Pilot tries to selects / position wrong target 5. (Depends on instruction) Pilot responds to instruction (select / position) 6. Wrong a/c selects target 7. Pilot tries to select wrong target, Pilot does not select target, Pilot selects target late	1. Memory 2, 3. Memory, Pilot query 4, 7. RT readback 5. Radar monitoring, RT readback 6. RT readback, Radar monitoring	1. M 2. M 3. M 4. M-H 5. H 6. M-H 7. M	
1.5.3.2 Receive pilot readback for selecting	1. Fail to detect / query erroneous readback	1. Mishear 2. No detection -	1, 2. Pilot may have selected wrong target a/c	1, 2. Radar monitoring	1. L-M 2. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
target ‖	2. Fail to detect / query missing readback	auditory, Forget action, Poor decision, No decision				
1.5.3.3 Click mouse button A over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c 5. Select inappropriate a/c	1. Forget action, Poor decision 2, 3, 4. Selection error 5. Poor decision	1. Controller may forget about delegation 2. Miscellaneous information appears 3. Selection unfinished? 4. Unintended a/c selected 5. Inappropriate a/c selected	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring 5. Radar monitoring, RT communication	1. M 2. H 3. M-H 4. M 5. M	
1.5.3.4 Click mouse button A over target a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c 5. Select inappropriate a/c	1. Forget action, Poor decision 2, 3, 4. Selection error 5. Poor decision	1. Controller may forget about delegation 2. Miscellaneous information appears 3. Selection unfinished? 4. Unintended a/c selected 5. Inappropriate a/c selected	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring 5. Radar monitoring, RT communication	1. M 2. H 3. M-H 4. M 5. M	
1.5.3.5 Receive pilot target identification ‖	1. Fail to detect / query failed or non-identification 2. Fail to detect / query non-response 3. Fail to detect / query mis-identification	1. Mishear 2. No detection - auditory, Poor decision, No decision 3. Mishear	1, 2. Pilot failed to select target, Controller unaware of failed or non-identification 3. Pilot identified wrong target, Controller unaware of mis-identification	1, 2, 3. Future RT communication	1. M 2. M 3. L-M	
1.5.3.6 Receive pilot rejection ‖	1. Fail to detect / query pilot rejection	1. Mishear, No detection - auditory	1. Controller unaware of pilot rejection, Controller may assume pilot has identified target, Controller has faulty picture	1. Future RT communication	1. M	
1.5.4 Instruct pilot to position target	↓					
Do in order.						
1.5.4.1 Issue instruction to	1. Fail to issue instruction	1. Forget action	1. Pilot does not position	1. Memory	1. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
position target ‖	2. Issue wrong / inappropriate instruction 3. Issue instruction to wrong a/c 4. Issue unclear instruction	2. Misprojection, Poor decision, Incorrect information 3. Incorrect information, Unclear information 4. Unclear information	target, No delegation, Pilot position target late, Applicability conditions may change 2. (Depends on instruction) Pilot responds to instruction (select / position) 3. Wrong a/c position target 4. Pilot does not position select target, Pilot positions target late	2. Radar monitoring, RT readback 3. RT readback, Radar monitoring 4. RT Readback	2. H 3. M-H 4. M	
1.5.4.2 Receive pilot target positioning or failure to position ‖	1. Fail to detect / query failure to position 2. Fail to detect / query non-response 3. Fail to query spurious position	1. Mishear 2. No detection - auditory, Poor decision, No decision 3. Mishear, Poor decision	1, 2, 3. Pilot may have selected wrong target a/c	1, 2, 3. Future RT communication, Radar monitoring	1. M 2. M 3. L-M	
1.5.5 Deselect target	↓					
Do 1 to 5 in order.						
1.5.5.1 Issue instruction to cancel target ‖	1. Fail to issue instruction to cancel target 2. Issue cancellation instruction to wrong a/c 3. Issue unclear cancellation instruction	1. Forget action, 2. Incorrect information, Unclear information 3. Unclear information	1. Pilot does not deselect target, Target still selected, Pilot may still believe a/c is delegated 2. Wrong a/c deselects target 3. Pilot tries to select wrong target, Pilot does not select target, Pilot selects target late	1. Memory 2 RT readback, Radar monitoring 3. RT readback	1. L-M 2. M 3. M	
1.5.5.2 Receive pilot readback ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1. Pilot may have selected wrong target a/c, Pilot may not have deselected target 2. Pilot may not have deselected target	1. Radar monitoring	1. L-M 2. M	
1.5.5.3 Receive pilot target	1. Fail to detect / query	1. Mishear	1, 2, 3. Target may still be	1, 2, 3. Future RT	1. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
deselection ||	failure to deselect 2. Fail to detect / query non-response 3. Fail to query spurious response	2. No detection - auditory, Poor decision, No decision 3. Mishear, Poor decision	selected	communication, Radar monitoring	2. M 3. M	
1.5.5.4 Click mouse button C over delegated a/c ||	1. Fail to deselect a/c 2. Click w rong mouse button (A or B) 3. Deselect target a/c 4. Deselect unintended a/c	1. Forget action, Poor decision 2, 3, 4. Selection error	1. A/c still show n as delegated, Controller may forget a/c is no longer delegated 2. A - Displays a/c as delegated OR no effect?, B - Miscellaneous information appears 3. Miscellaneous information appears 4. Miscellaneous information appears	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring	1. M 2. H 3. H 4. H	
1.5.6 Instruct pilot to select new target ||	See 1.5.1, 1.5.2, or 1.5.3.	See 1.5.1, 1.5.2, or 1.5.3.	See 1.5.1, 1.5.2, or 1.5.3.	See 1.5.1, 1.5.2, or 1.5.3.		
Do 1.5.1, 1.5.2, or 1.5.3.						
1.6 Issue delegation instruction	🡻					
Do 1. Then do as appropriate.						
1.6.1 Decide on appropriate instruction	1. Choose inappropriate or unsuitable instruction	1. Poor decision, Late decision	1. Unsuitable delegation instruction, Potential for loss of spacing, Unable to sequence as planned, Potential re-sequencing may be required	1. Radar monitoring	1. M-H	
1.6.2 Instruct pilot to 'Remain behind'	🡻					
Do 1. Then do 2 if required. Then do 3 to 5 in order. Then do 6 or 7.						

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
1.6.2.1 Ensure applicability conditions are met / maintained ‖	1. Fail to notice applicability conditions are met/maintained during check 2. Fail to check applicability conditions are met/maintained 3. Misjudge applicability condition(s)	1. No detection - visual, Mis-see 2. Forget action, Poor decision, Late decision 3. Misprojection, Poor decision	1, 2, 3. A/c have incompatible performances or speeds, inappropriate trajectories or separations, A/c unable to maintain Potential for loss of spacing	1, 2, 3. Subsequent radar monitoring, RT communication with a/c	1. M 2. M 3. M	Important that controller checks all applicability conditions. Simple aide memoire?
1.6.2.2 Issue instruction(s) to ensure applicability conditions are met ‖	1. Fail to issue instruction to ensure applicability conditions are met 2. Issue wrong or unsuitable instruction to ensure applicability conditions are met 3. Issue instruction to ensure applicability conditions are met to wrong a/c	1. Forget action, Late decision 2. Misprojection, Poor decision, Incorrect information, Unclear information 3. Incorrect information, Unclear information	1. Pilot does not execute instruction, Applicability conditions not met 2. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 3. Wrong a/c responds to instruction, Possible loss of spacing or separation	1. Memory 2. Radar monitoring, RT readback, STCA 3. RT readback, Radar monitoring, STCA	1. L-M 2. M-H 3. M-H	
1.6.2.3 Issue 'remain behind' instruction ‖	1. Fail to instruct pilot to remain behind 2. Issue instruction incorrectly 3. Issue wrong instruction 4. Issue instruction to wrong a/c 5. Issue instruction with inappropriate parameter	1. Forget action, Late decision 2, 3, 4. Incorrect information, Unclear information 5. Misprojection, Poor decision	1. Pilot takes no action, Controller may falsely believe pilot is now under delegation, Faulty picture 2, 3, 5. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 4. Wrong a/c responds to instruction, Possible loss of spacing or separation	1. Memory 2, 3, 4. RT readback, RT query, Radar monitoring, STCA 5. Radar monitoring, STCA	1. M 2. M-H 3. M 4. M-H 5. M	
1.6.2.4 Receive pilot readback ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot and controller may have different knowledge states, Pilot responds incorrectly to instruction, Possible loss of spacing or separation	1, 2. Radar monitoring	1. L-M 2. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
1.6.2.5 Click mouse button A over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c	1. Forget action, Poor decision 2, 3, 4. Selection error	1. Controller may forget about delegation 2. Miscellaneous information appears 3. If target a/c is in selected stage, controller may think s/he has given the delegation instruction 4. If unintended a/c is in selected stage, controller may think s/he has given the delegation instruction	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring, other controller	1. M 2. H 3. M-H 4. M-H	
1.6.3 Instruct pilot 'Heading then remain behind'	↓					
Do 1 throughout. Then do 2 if required. Then do 3 to 6 in order. Do 7 and 8 if required.						
1.6.3.1 Ensure applicability conditions are met / maintained ‖	1. Fail to notice applicability conditions are met/maintained during check 2. Fail to check applicability condition(s) are met/maintained 3. Misjudge applicability condition(s)	1. No detection - visual, Mis-see 2. Forget action, Poor decision, Late decision 3. Misprojection, Poor decision	1, 2, 3. A/c have incompatible performances or speeds, inappropriate trajectories or separations, A/c unable to maintain Potential for loss of spacing	1, 2, 3. Subsequent radar monitoring, RT communication with a/c	1. M 2. M 3. M	Important that controller checks all applicability conditions. Simple aide memoire?
1.6.3.2 Issue instruction(s) to ensure applicability conditions are met ‖	1. Fail to issue instruction 2. Issue wrong or unsuitable instruction 3. Issue instruction to wrong a/c	1. Forget action, Late decision 2. Misprojection, Poor decision, Incorrect information, Unclear information 3. Incorrect information, Unclear information	1. Pilot does not execute instruction, Applicability conditions not met 2. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 3. Wrong a/c responds to instruction, Possible loss of	1. Memory 2. Radar monitoring, RT readback, STCA 3. RT readback, Radar monitoring, STCA	1. L-M 2. M-H 3. M-H	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
			spacing or separation			
1.6.3.3 Issue 'heading then remain behind' instruction ‖	1. Fail to issue 'heading then remain behind' instruction 2. Issue wrong or unsuitable heading 3. Issue instruction incorrectly 4. Issue wrong instruction 5. Issue instruction to wrong a/c	1. Forget action, Late decision 2. Incorrect information, Unclear information, Misprojection 3, 4, 5. Incorrect information, Unclear information	1. Pilot takes no action, Controller may falsely believe pilot is now under delegation, Faulty picture 2, 3, 4. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 5. Wrong a/c responds to instruction, Possible loss of spacing or separation	1. Memory 2, 3, 4. RT readback, RT query, Radar monitoring, STCA 5. Radar monitoring, STCA	1. M 2. M 3. M-H 4. M 5. M-H	
1.6.3.4 Receive pilot readback ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot and controller may have different knowledge states, Pilot responds incorrectly to instruction, Possible loss of spacing or separation	1, 2. Radar monitoring	1. L-M 2. M	
1.6.3.5 Click mouse button A over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c	1. Forget action, Poor decision 2, 3, 4. Selection error	1. Controller may forget about delegation 2. Miscellaneous information appears 3. If target a/c is in selected stage, controller may think s/he has given the delegation instruction 4. If unintended a/c is in selected stage, controller may think s/he has given the delegation instruction	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring, other controller	1. M 2. H 3. M-H 4. M-H	
1.6.3.6 Receive 'pilot resuming' report ‖	1. Fail to detect / query erroneous / spurious 'pilot resuming' report 2. Fail to detect / query missing 'pilot resuming' report	1. Mishear 2. No detection - auditory, Forget information, Poor decision	1, 2. Pilot and controller may have different knowledge states, Controller believes pilot is resuming, Possible loss of spacing or separation	1. Radar monitoring, 2. Future RT communication	1. M 2. L-M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
1.6.4 Instruct pilot to 'Merge behind'	↓					
Do 1 throughout. . Then do 2 if required. Then do 3 to 5 in order. Do 6 and 7 if required.						
1.6.4.1 Ensure applicability conditions are met / maintained ‖	1. Fail to notice applicability conditions are met/maintained during check 2. Fail to check applicability condition(s) are met/maintained 3. Misjudge applicability condition(s)	1. No detection - visual, Mis-see 2. Forget action, Poor decision, Late decision 3. Misprojection, Poor decision	1, 2, 3. A/c have incompatible performances or speeds, inappropriate trajectories or separations, A/c unable to maintain Potential for loss of spacing	1, 2, 3. Subsequent radar monitoring, RT communication with a/c	1. M 2. M 3. M	Important that controller check all applicability conditions. Simple aide memoire?
1.6.4.2 Issue instruction(s) to ensure applicability conditions are met ‖	1. Fail to issue instruction 2. Issue wrong or unsuitable instruction 3. Issue instruction to wrong a/c	1. Forget action, Late decision 2. Misprojection, Poor decision, Incorrect information, Unclear information 3. Incorrect information, Unclear information	1. Pilot does not execute instruction, Applicability conditions not met 2. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 3. Wrong a/c responds to instruction, Possible loss of spacing or separation	1. Memory 2. Radar monitoring, RT readback, STCA 3. RT readback, Radar monitoring, STCA	1. L-M 2. M-H 3. M-H	
1.6.4.3 Issue 'merge behind' instruction ‖	1. Fail to instruct pilot to merge behind 2. Issue instruction incorrectly 3. Issue wrong instruction 4. Issue instruction to wrong a/c 5. Issue instruction with inappropriate parameter	1. Forget action, Late decision 2, 3, 4. Incorrect information, Unclear information 5. Misprojection, Poor decision	1. Pilot takes no action, Controller may falsely believe pilot is now under delegation, Faulty picture 2, 3, 5. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 4. Wrong a/c responds to instruction, Possible loss of spacing or separation	1. Memory 2, 3, 4. RT readback, RT query, Radar monitoring, STCA 5. Radar monitoring, STCA	1. M 2. M-H 3. M 4. M-H 5. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
1.6.4.4 Receive pilot readback ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot and controller may have different knowledge states, Pilot responds incorrectly to instruction, Possible loss of spacing or separation	1, 2. Radar monitoring	1. L-M 2. M	
1.6.4.5 Click mouse button A over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c	1. Forget action, Poor decision 2, 3, 4. Selection error	1. Controller may forget about delegation 2. Miscellaneous information appears 3. If target a/c is in selected stage, controller may think s/he has given the delegation instruction 4. If unintended a/c is in selected stage, controller may think s/he has given the delegation instruction	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring, other controller	1. M 2. H 3. M-H 4. M-H	
1.6.5 Instruct pilot 'Heading then merge behind'	↓					
Do 1 throughout. Then do 2 if required. Then do 3 to 6 in order. Do 7 and 8 if required.						
1.6.5.1 Ensure applicability conditions are met / maintained ‖	1. Fail to notice applicability conditions are met/maintained during check 2. Fail to check applicability condition(s) are met/maintained 3. Misjudge applicability condition(s)	1. No detection - visual, Mis-see 2. Forget action, Poor decision, Late decision 3. Misprojection, Poor decision	1, 2, 3. A/c have incompatible performances or speeds, inappropriate trajectories or separations, A/c unable to maintain Potential for loss of spacing	1, 2, 3. Subsequent radar monitoring, RT communication with a/c	1. M 2. M 3. M	Important that controller check all applicability conditions. Simple aide memoire?
1.6.5.2 Issue instruction(s) to ensure applicability conditions are met ‖	1. Fail to issue instruction to ensure applicability conditions are met	1. Forget action, Late decision 2. Misprojection, Poor	1. Pilot does not execute instruction, Applicability conditions not met	1. Memory 2. Radar monitoring, RT readback, STCA	1. L-M 2. M-H 3. M-H	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
	2. Issue wrong or unsuitable instruction to ensure applicability conditions are met 3. Issue instruction to ensure applicability conditions are met to wrong a/c	decision, Incorrect information, Unclear information 3. Incorrect information, Unclear information,	2. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 3. Wrong a/c responds to instruction, Possible loss of spacing or separation	3. RT readback, Radar monitoring, STCA		
1.6.5.3 Issue 'heading then merge behind' instruction ||	1. Fail to issue 'heading then merge behind' instruction 2. Issue wrong or unsuitable heading 3. Issue instruction incorrectly 4. Issue wrong instruction 5. Issue instruction to wrong a/c 6. Issue instruction with inappropriate parameter	1. Forget action, Late decision 2. Incorrect information, Unclear information, Misprojection 3, 4, 5. Incorrect information, Unclear information 6. Misprojection, Poor decision	1. Pilot takes no action, Controller may falsely believe pilot is now under delegation, Fault picture 2, 3, 4, 6. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 5. Wrong a/c responds to instruction, Possible loss of spacing or separation	1. Memory 2, 3, 4, 5. RT readback, RT query, Radar monitoring, STCA 6. Radar monitoring, STCA	1. M 2. M 3. M-H 4. M 5. M-H 6. M	
1.6.5.4 Receive pilot readback ||	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot and controller may have different knowledge states, Pilot responds incorrectly to instruction, Possible loss of spacing or separation	1. Radar monitoring	1. L-M 2. M	
1.6.5.5 Click mouse button A over delegated a/c ||	1. Fail to select a/c 2. Click wrong mouse button (B or C) 3. Select target a/c 4. Select unintended a/c	1. Forget action, Poor decision 2, 3, 4. Selection error	1. Controller may forget about delegation 2. Miscellaneous information appears 3. If target a/c is in selected stage, controller may think s/he has given the delegation instruction 4. If unintended a/c is in selected stage, controller	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring, other controller	1. M 2. H 3. M-H 4. M-H	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
			may think s/he has given the delegation instruction			
1.6.5.6 Receive pilot's merging distance report ‖	1. Fail to detect / query failure to report merging distance 2. Fail to query spurious or erroneous report of merging distance	1. No detection - auditory, Forget action, Poor decision, No decision 2. Mishear, Poor decision, No decision	1. Controller unaware when a/c merging 2. Controller has false knowledge of merging distance	1, 2. Radar monitoring, Controller query	1. M 2. M	
1.7 End delegation	↓					
Do 1 or 2 as appropriate.						
1.7.1 End delegation on controller initiative	↓					
Do in order.						
1.7.1.1 Decide to end (normal end or interruption) ‖	1. Fail to decide to end when appropriate 2. Decide to end when not necessary 3. Decide to end 'wrong' delegation	1. Forget action, No decision, Late decision, Poor decision 2, 3. Poor decision	1. A/c still delegated, Potential loss of spacing, Workload increase, Pilot reports – RT occupancy 2, 3. No negative impact?	1. Radar monitoring, RT communications	1. M 2. N/A 3. N/A	
1.7.1.2 Issue instruction to cancel delegation, retaining target if appropriate ‖	1. Fail to instruct pilot to cancel delegation 2. Fail to instruct pilot to retain target 3. Issue wrong instruction 4. Issue instruction to wrong a/c	1. Forget action 2. Forget action, Poor decision, No decision 3, 4. Incorrect information, Unclear information	1. Pilot does not deselect target, Target still selected, Pilot may still believe a/c is delegated 2. Workload increase (controller and pilot), RT occupancy, changes in applicability conditions 3. (Depends on instruction) Pilot responds to instruction (select / position), Pilot selects / positions new target 4. Wrong a/c responds to instruction	1. Memory 2. Future RT communication 3. RT readback, Radar monitoring 4. Radar monitoring, RT readback	1. L-M 2. M-H 3. M-H 4. M-H	
1.7.1.3 Issue new instruction if required ‖	1. Fail to issue new instruction 2. Issue instruction	1. Forget action 2, 3. Incorrect information, Unclear	1. Pilot maintains situation 2, 4. (Depends on instruction) Pilot responds	1. Memory, RT query 2. RT readback, RT query, Radar	1. M 2. M-H 3. M-H	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
	incorrectly 3. Issue instruction to wrong a/c 4. Issue wrong or unsuitable instruction	information 4. Misprojection, Poor decision, Incorrect information	to instruction, Possible loss of spacing or separation 3. Wrong a/c responds to instruction, Possible loss of spacing or separation	monitoring 3. RT readback, Radar monitoring 4. Radar monitoring	4. M	
1.7.1.4 Receive pilot readback of end delegation (and new instruction) ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query missing readback	1. Mishear 2. No detection - auditory, Forget action, Poor decision, No decision	1, 2. Pilot and controller may have different knowledge states, Pilot still believes a/c is under delegation, Possible loss of spacing or separation	1. Radar monitoring	1. L-M 2. M	
1.7.1.5 Click mouse button C over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (A or B) 3. Select target a/c 4. Select unintended a/c	1. Forget action, Poor decision 2. Selection error 3, 4. Selection error	1. A/c still shown as delegated, Controller may forget a/c is no longer delegated 2. A - Displays a/c as delegated OR no effect?, B - Miscellaneous information appears 3, 4. If a/c is in delegated state, controller may forget when deselected	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring, other controller	1. M 2. H 3. M-H 3. M-H	
1.7.1.6 Update strip for new instruction‖	1. Fail to update strip 2. Update wrong strip 3. Update strip incorrectly	1. Forget action 2. Selection error 3. Incorrect Information, Unclear information, Misrecall information	1. Controller forgets delegation instruction, Failure to transfer information at handover 2, 3. Controller has incorrect knowledge of delegation instruction, Failure to transfer information at handover	1, 2, 3. Check on strip markings, Handover, Other controller	1. M 2. M-H 3. M	
1.7.2 Accept end delegation on pilot initiative (unexpected event on target or subject a/c)	↓					
Do in order.						

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
1.7.2.1 Receive pilot's notification to unable delegation ‖	1. Fail to detect pilot's notification to unable delegation 2. Mishear pilot's notification 3. Confuse a/c notifying	1. No detection - auditory 2, 3. Mishear	1. Controller may re-request notification. No impact 2. Controller unaware of pilot's notification to unable delegation, Controller may assume a/c is still under delegation 3. Controller believes different a/c is unabling delegation, Controller unaware that a/c calling is unabling delegation	1, 2, 3. Future RT communication	1. H 2. H 3. M-H	
1.7.2.2 Click mouse button C over delegated a/c ‖	1. Fail to select a/c 2. Click wrong mouse button (A or B) 3. Select target a/c 4. Select unintended a/c	1. Forget action, Poor decision 2. Selection error 3, 4. Selection error	1. A/c still shown as delegated, Controller may forget a/c is no longer delegated 2. A - Displays a/c as delegated OR no effect?, B - Miscellaneous information appears 3. Miscellaneous information appears 4. Miscellaneous information appears	1. Radar monitoring, Check on strip markings 2, 3, 4. Radar monitoring	1. M-H 2. H 3. H 3. H	
1.7.2.3 Issue new instruction ‖	1. Fail to issue new instruction 2. Issue instruction incorrectly 3. Issue instruction to wrong a/c 4. Issue wrong or unsuitable instruction	1. Forget action 2, 3. Incorrect information, Unclear information 4. Misprojection, Poor decision, Incorrect information,	1. Pilot does not execute instruction 2, 4. (Depends on instruction) Pilot responds to instruction, Possible loss of spacing or separation 3. Wrong a/c responds to instruction, Possible loss of spacing or separation	1. Memory 2. RT readback, RT query, Radar monitoring 3. RT readback, Radar monitoring 4. Radar monitoring	1. L-M 2. M-H 3. M-H 4. M	
1.7.2.4 Receive pilot readback of new instruction ‖	1. Fail to detect / query erroneous readback 2. Fail to detect / query	1. Mishear 2. No detection - auditory, Forget action,	1, 2. Pilot and controller may have different knowledge states, Pilot	1, 2. Radar monitoring, STCA	1. L-M 2. M	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
	missing readback	Poor decision, No decision	responds incorrectly to instruction, Possible loss of spacing or separation			
1.7.2.5 Update strip ‖	1. Fail to update strip 2. Update w rong strip 3. Update strip incorrectly	1. Forget action 2. Selection error 3. Incorrect Information, Unclear information, Misrecall information	1. Controller forgets delegation instruction, Failure to transfer information at handover 2, 3. Controller has incorrect know ledge of delegation instruction, Failure to transfer information at handover	1, 2, 3. Check on strip markings, Handover, Other controller	1. M 2. M-H 3. M	
1.8 Transfer to next sector	🡻					
Do in order.						
1.8.1 Inform pilot contact next sector freq. ‖	☒					
1.8.2 Ask pilot to report delegation (for parameters not in letter of agreement) ‖	1. Fail to ask pilot to report delegation	1. Forget action, Poor decision	1. Next sector controller unaw are of delegation	None?	M	Is delegation visually indicated to next sector controller?
1.9 Handover control to relief controller	🡻					
Do in order.						
1.9.1 Point out a/c under sector control	☒					
Do 1. Then do 2 to 4 in parallel.						
1.9.1.1 Explain traffic situation to relief controller ‖	☒					
1.9.1.2 Point out delegated a/c ‖	1. Fail to point out delegated a/c 2. Point out a/c as	1. Forget action 2. Misrecall information	1. Relief controller unaw are of type of application 2. Relief controller falsely	1, 2. Radar monitoring, RT communication w ith	1. M-H 2. M-H	

Task Step	External Error	Internal Error	Initial Consequences	Detection Means	RSL	Comments
	delegated when not delegated		believes a/c is delegated	a/c, Relief controller prompt		
1.9.1.3 State type of application and parameters (e.g. Merge behind 8nm) ‖	1. Fail to state type of application 2. State incorrect type of application 3. Confuse type of application between different a/c 4. Misidentify parameters(s)/value(s)	1. Forget action 2, 3, 4. Misrecall information, Incorrect information	1. Relief controller unaware of type of application, 2, 3. Relief controller's perception of type of application is incorrect 4. Relief controller has false understanding of parameter(s), May fail to provide appropriate spacing	1, 2, 3, 4. Radar monitoring, RT communication with a/c, Relief controller requests prompt	1. M-H 2. M 3. M 4. M	
1.9.1.4 Correlate information on radar and strips ‖	☒					
1.9.2 Acknowledge release of sector	☒					
Do in order.						
1.9.2.1 Switch off microphone ‖	☒					
1.9.2.2 Unplug headset ‖	☒					

Table A.11.2: Recovery Success Likelihood Scale

RSL	Detection	Diagnosis	Correction
High	> Easily detected > Immediate, clear, direct feedback of actions/effects > Active involvement and constant monitoring > Independent/third party checks, automatic checks or cues to check	> No diagnosis required or very reliable diagnosis expected > No 'expectation bias'/'confirmation bias'	> Easily corrected, requiring no changes to plan, and causing little or no additional workload > Plenty of time available for recovery
Moderate -High			
Moderate	> Detectable > Feedback available > Regular but intermittent monitoring > Some cues to check or occasional independent checking by third party or automation	> May require some interpretation or diagnosis > Incorrect diagnosis possible > May be some 'expectation bias'/'confirmation bias'	> May necessitate changes to plan or corrective action using practised procedure causing some additional workload > Controller prepared and able to intervene > Some time pressure to recover error
Low-Moderate			
Low	> Difficult to detect > No feedback, or poor, indirect or delayed feedback > No monitoring or passive monitoring > High reliance on memory to check or suspect error	> Hard to diagnose, diagnosis very likely to be incorrect > Strong 'expectation bias'/'confirmation bias'	> Plan modification or difficult or complex correction process required, causing considerable workload > Controller unprepared or not familiar with procedures, with limited ability to intervene > Strong time pressure, or insufficient time available for recovery