

Implementation and Use of new Jeppesen Chart Design [SIDs and STARs]



Operational Risk Assessment (ORA)



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2 Glossary of Terms

Barrier

A function planned to prevent, control, or mitigate undesired events or accidents. Preventive barriers aim at preventing the Top Event from occurring; recovery barriers aim at minimizing the consequences after the Top Event has occurred. (ICAO)

BowTie

Bowtie is one of many barrier risk models available to assist the identification and management of risk. (Bowtie is recommended by ICAO)

Hazard

A condition or an object with the potential to cause injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform. (ICAO)

ICAO

The *International Civil Aviation Organization* is a specialized agency of the United Nations.

OEM

Original Equipment Manufacturer

ORA

Operational Risk Assessment

Risk Mitigation

The process of incorporating defences or preventive controls to lower the severity/or likelihood of a hazard's projected consequence.

Safety Issue

A manifestation of a hazard or combination of several hazards in a specific context. The Safety Issue (SI) has been identified through the systematic Hazard Identification process of the organisation. A SI could be a local implication of one hazard or a combination of hazards in one part of the operation.

SID

Standard Instrument Departure

STAR

Standard Terminal Arrival Route

Threat

A factor that may cause the Top Event to happen, if unmitigated by preventive barriers. (ICAO)

Top Event

The central element of a BowTie; a point in time which describes the release or loss of control over a Hazard. This is the undesired system state.



3 Introduction

Jeppesen, a well-known flight support provider and Boeing subsidiary, serves the aviation community with aeronautical charts for more than 80 years.

Following market feedback, a pilot research phase as well as following human factor principles, Jeppesen developed a new chart design to enhance the interaction of pilots with the Standard Terminal Arrival Route (STAR) and Standard Instrument Departure (SID) charts on the flight deck. This new chart design aims to

accommodate pilot requests for increased situational awareness and to enhance information flow during the respective phases of flight.

The result of Jeppesen's research and design phase are shown in the Appendix.

Before releasing the new chart design to the aviation industry, Jeppesen wanted to gain a thorough understanding of the implication this change would bring to pilots and flight operations and, consequently,

what kind of training (if any) would be required.

Therefore, TRS Aviation Consulting GmbH (TRS), as a provider of consulting services in the aviation business, has been appointed to perform a Hazard Identification and Operational Risk Assessment to evaluate the impact of the implementation of the changed chart design on flight operations.

3.1 Scope of the Operational Risk Assessment

The new chart layout will be assessed using the Operational Risk Analysis (ORA) method. (Information on the topic can be found on the [EASA website](#))

The goal of this assessment is to analyse the changes resulting from the new chart design, in order to evaluate the need and effectivity of mitigation factors during the implementation phase.

The ORA identifies potential hazards of function or malfunction (detected erroneous output or behaviour, or undetected erroneous output) and associated failure scenarios and analyses the operational impact of these failure scenarios. The ORA then proposes mitigation means, operational procedures, training, administration and methods to ensure appropriate accuracy.

Because only safety hazards will be addressed, this ORA encompasses use

of the charts in standard Jeppesen output-formats only. This includes the depiction of pre-composed Jeppesen SID and STAR charts in paper as well as Jeppesen's digital delivery channels, devices using Apple iOS, Windows and online applications. Use of devices with possible other/different depiction (provided e.g. by OEMs) will not be part of this assessment.

The hazard identification has been performed from the perspective of the end-user.

Jeppesen estimates that about 30% of the charts affected by this change will see an increased in size due to the fact that the layout is now to-scale. Effects based on this circumstance are not part of the assessment.

The implementation phase for the new chart design is estimated to take 2 years. However, the scope of this assessment only involves the first 6-months of the implementation

phase. Only few "new" charts will be available at the beginning of this phase, but it is expected that enough "new" charts will be available after this 6-months period.

As all SID and STAR charts for an individual airport will be revised at the same time, there will never be a mixture of old and new charts at one airport.

For the evaluation of risks, the ICAO Doc 9859 "Safety Management Manual" has been used. The manual is available for download [here](#)

EASA

European Aviation Safety Agency



ICAO

International Civil Aviation Organization



3.2 Method

TRS has chosen the Operational Risk Assessment (ORA) method which is a standard method for risk assessments in the aviation industry.

As a tool to help visualising this assessment, a software created by the leading provider of barrier based risk management solutions, called BowTie, has been used. Information on this software can be found [here](#)

3.2.1 Operational Risk Assessment

The Operational Risk Management consists of three major elements.

- Hazard identification
- Risk assessment
- Risk mitigation

Hazard identification is about collecting and analysing operational safety data, thereby identifying safety issues. Such safety data typically includes safety reports, occurrence reports, flight data events, and the results of safety surveys and audits. Hazard identification provides the basis for a risk assessment.

The risk assessment itself identifies and classifies the safety issues and threats. Safety risk is the projected likelihood and severity of the consequence or outcome from an existing hazard or threat.

The risk mitigation process alleviates the safety issues to an acceptable level.



3.2.2 BowTie Method

BowTie diagrams are a simple and effective tool for communicating risk assessment results. The diagrams clearly display the links between the potential causes, preventive and mitigative controls and consequences of a major incident. BowTie diagrams may be used to display the results of various types of risk assessments.

The general structure of a BowTie diagram is represented in the diagram below:

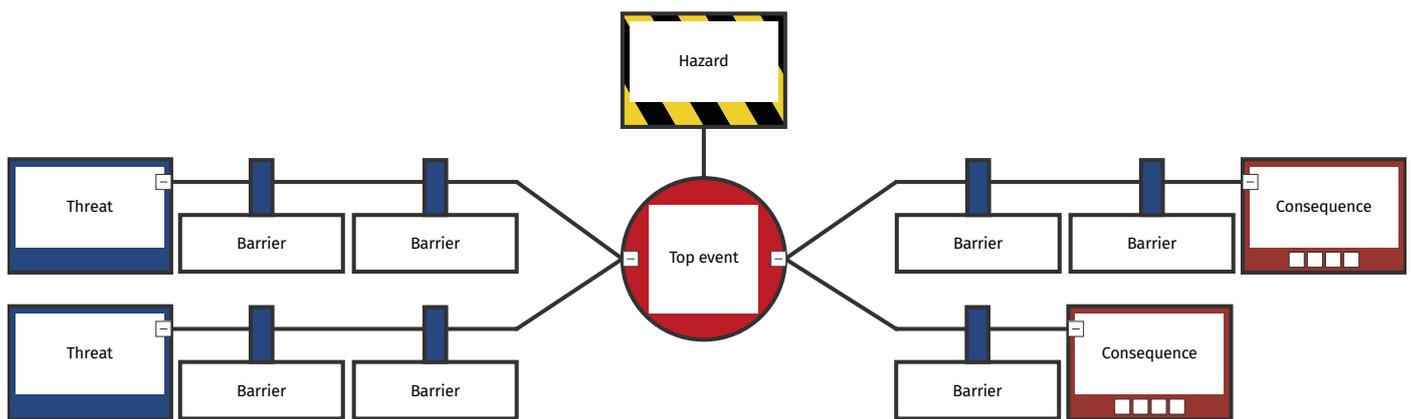


Figure 1 Example of complete BowTie

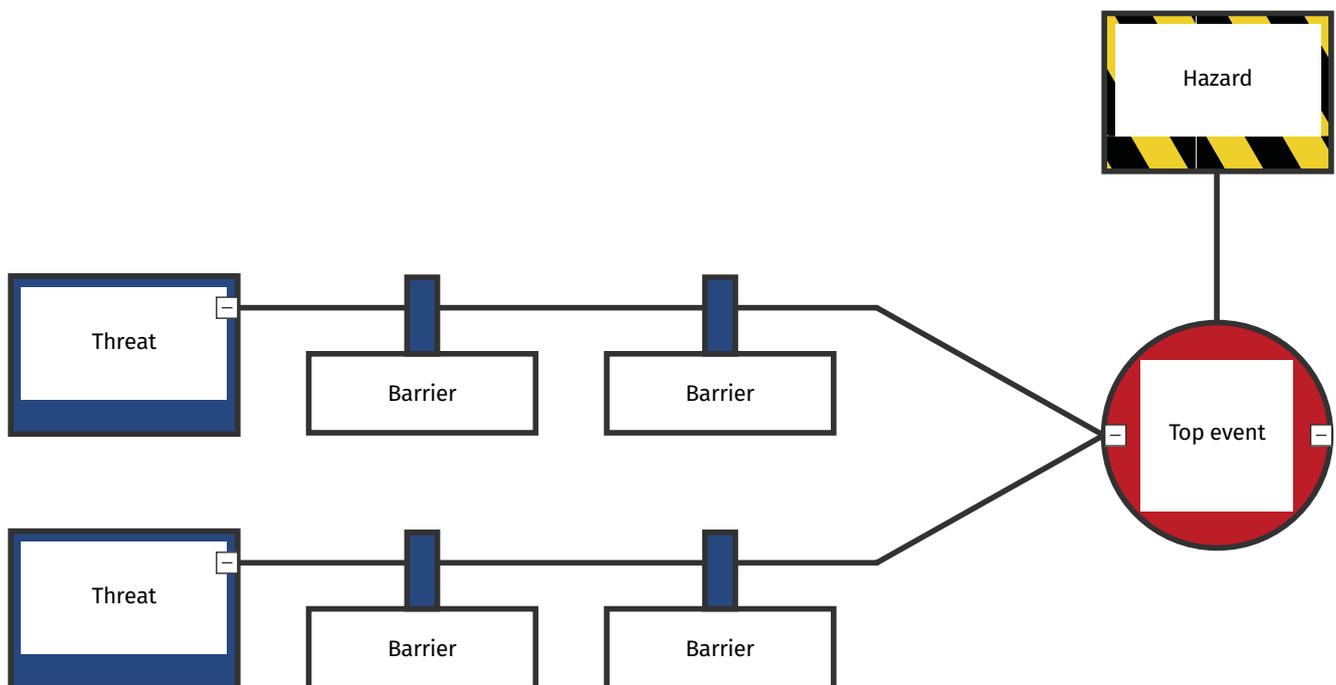


Figure 2 Example of a BowTie structure used in this assessment

4 The TRS Approach

TRS developed a concept for an independent analysis and evaluation of the assessment, let's call it TRS approach.

The TRS approach is subdivided in 4 different steps:

- Analysing
- Determining
- Identifying
- Classifying

4.1 Step 1 Analysing Differences Between Old and New SID/STAR Charts

As initial step, current Jeppesen SID and STAR charts have been compared to the charts in new chart design which will be introduced starting late 2016. Therefore, sample charts have been provided by Jeppesen.

Differences found while analysing those charts are listed below and can be identified at the following sample of KONIL 5C and KONIL 3D Standard Instrument Departures at the airport LSGG (Geneva) and HAWKZ 4 Standard Terminal Arrival Route at the airport KSEA (Seattle).

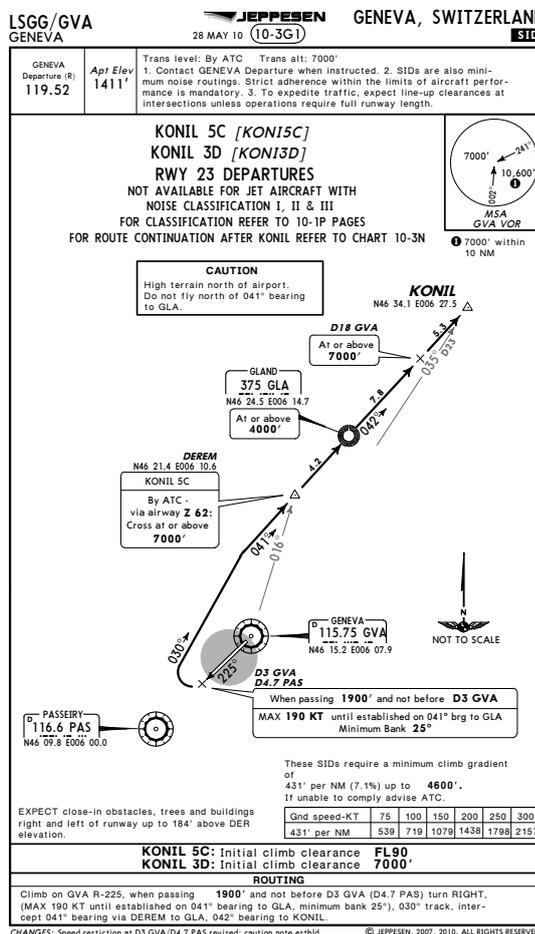


Figure 3 Current SID Chart Design – LSGG KONIL 5C/3D

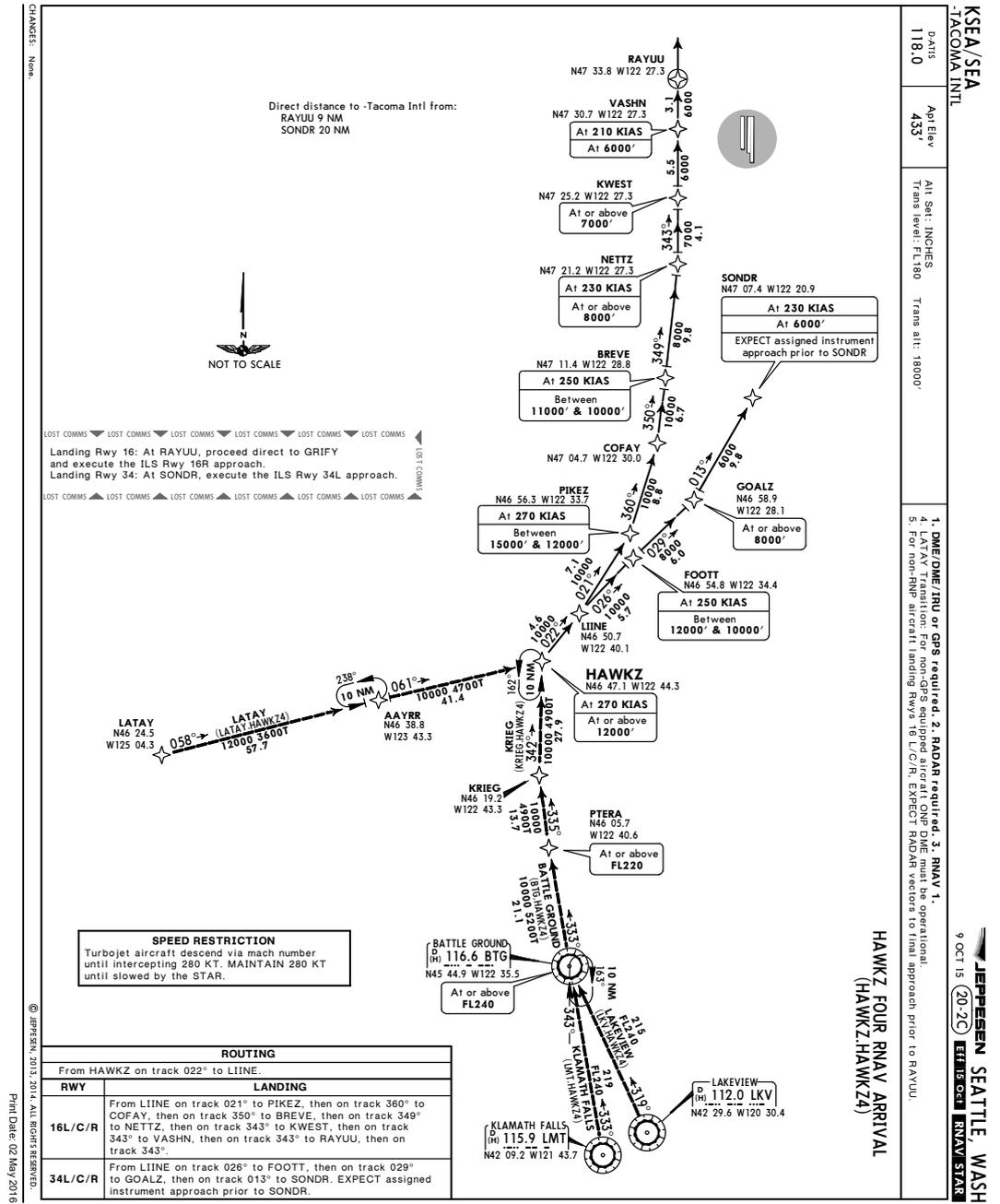
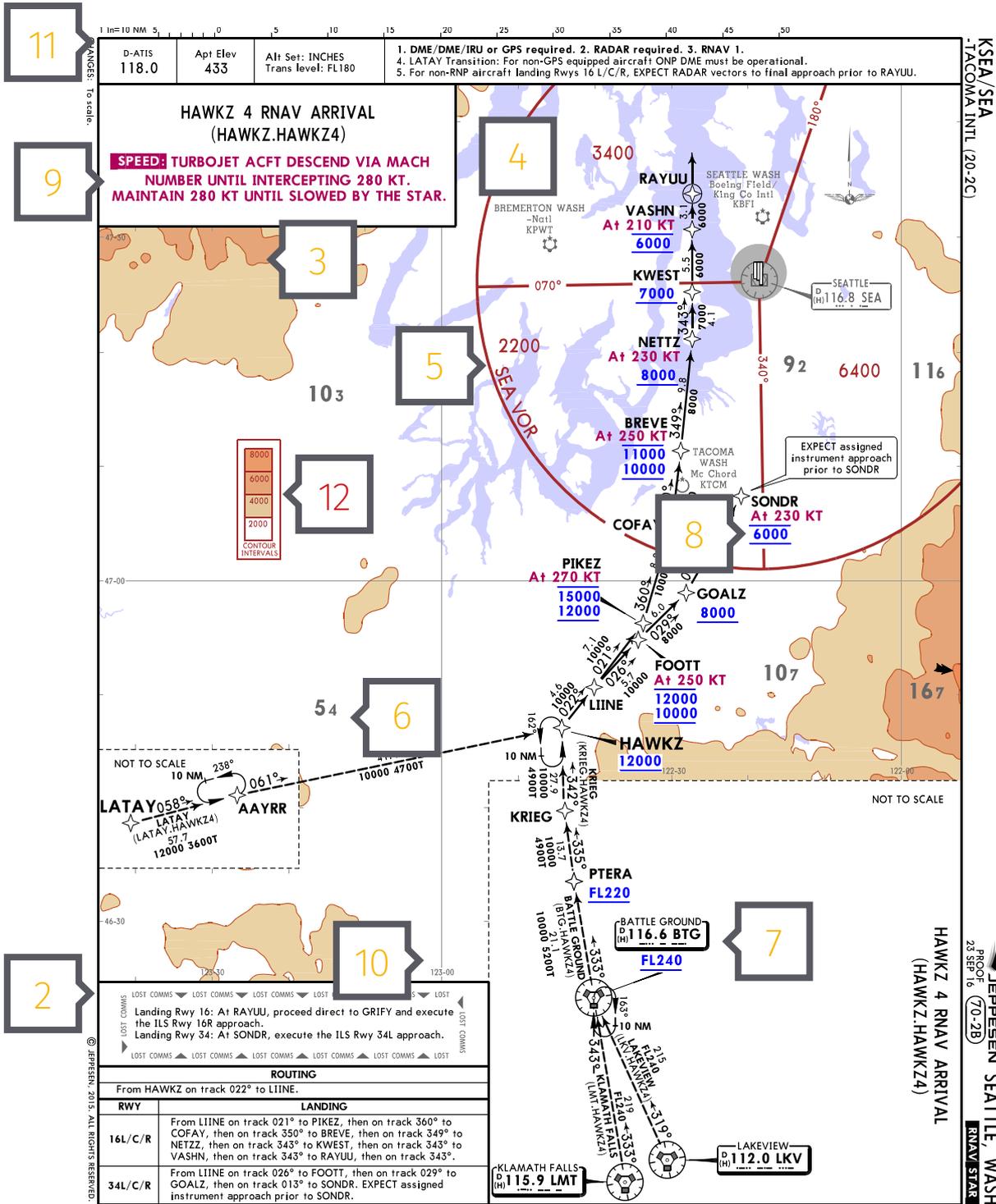


Figure 4 Current STAR Chart Design – KSEA HAWKZ 4

More sample charts are to be found in the Appendix.



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Figure 6 New STAR Chart Design – KSEA HAWKZ 4



The size of the charts has been increased (where necessary) for a better presentability and to outline the flight procedures to scale.



Content and text boxes have been placed on the same location of every chart. Content has been decluttered. Text boxes are always aligned with the orientation of the procedure.



Terrain and water bodies are now visible on the chart as well as national borders and neighbouring aerodromes within the plan view.



Different colours and shades have been introduced to depict terrain, landscape, limiting altitudes and speeds, grid altitudes, MSA and other relevant information for execution of the flight procedure.



MSA (Minimum Safe Altitude) is now shown in the plan view on SID/STAR charts with MSA outlines, altitude and referencing its appropriate navaid.



Grid Minimum Off Route Altitudes (MORAs) are now available on the new charts with colour coding for values above or below 10.000 feet.



Coordinates below waypoints or other nav aids have been removed.



Altitude restrictions are depicted prominently in blue and with an under-/over-bar – as required by the procedure.



Speed restrictions depicted prominently in magenta in the new layout.



Latitude/longitude grid available on new charts.



Scale available on charts.



After reviewing the new chart design, we found the listed changes to be an improvement in presentation of information. From our point of view, conduct of flight and especially decision making in flight will be facilitated by the improved situational awareness resulting from the new chart design.

In addition to the differences/improvements listed above, we have noticed to following which should be improved before introduction to the new charts:

Readability of map symbology aggravated due to selected colours.

Note: This has been taken care of with the latest version of the new chart design.

4.2 Step 2 Determining the Top Event and the Associated Threats

The top event and the associated threats have been identified during workshop sessions with pilots and other specialists as well as results from interviews and meetings with subject matter experts. As a matter of fact, the top event is a combination of different factors.

The top event that has been found as being applicable for this assessment was identified as the “Deviation of the Aircraft from a Safe Flight Path”.

The associated threats in regards to this top event have been defined as follows:

-
- Lack of ready working knowledge caused by new chart design
-
- Misinterpretation of information contained on new charts
-
- Mixture of charts (old vs. new)

4.3 Step 3 Identifying the Relevant Safety Issues Leading to a Threat

As for the Top Event, safety issues have been identified following a systematic process, involving groups of aviation experts and pilots.

The process resulted in the following safety issues:

-
- Distraction by new chart design
-
- Increased head down time
-
- Different knowledge levels of flight crew
-
- Increased workload

4.4 Step 4 Classifying the Safety Issues

The safety issues have been classified, using an evaluation process, which is described in the ICAO Safety Management Manual (Doc 9859). To receive an independent classification, TRS had initiated a survey, in accordance to the evaluation tables below. The result of this survey has been taken as a basis for the risk assessment.

Likelihood	Meaning	Value
Frequent	Likely to occur many times (has occurred frequently)	5
Occasional	Likely to occur sometimes (has occurred infrequently)	4
Remote	Unlikely to occur, but possible (has occurred rarely)	3
Improbable	Very unlikely to occur (not known to have occurred)	2
Extremely improbable	Almost inconceivable that the event will occur	1

Table 1 Safety Risk Probability Table ICAO 9859

Severity	Meaning	Value
Catastrophic	<ul style="list-style-type: none"> Equipment destroyed Multiple deaths 	A
Hazardous	<ul style="list-style-type: none"> A large reduction in safety margins, physical distress or a workload such that the operators cannot be relied upon to perform their tasks accurately or completely Serious injury Major equipment damage 	B
Major	<ul style="list-style-type: none"> A significant reduction in safety margins, a reduction in the ability of the operators to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency Serious incident Injury to persons 	C
Minor	<ul style="list-style-type: none"> Nuisance Operating limitations Use of emergency procedures Minor incident 	D
Negligible	<ul style="list-style-type: none"> Few consequences 	E

Table 2 Safety Risk Severity Table ICAO 9859

Risk Probability		Risk Severity				
		Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent	5	5A	5B	5C	5D	5E
Occasional	4	4A	4B	4C	4D	4E
Remote	3	3A	3B	3C	3D	3E
Improbable	2	2A	2B	2C	2D	2E
Extremely Improbable	1	1A	1B	1C	1D	1E

Table 3 ICAO Safety Risk Assessment Matrix

The safety issues have been classified, using an evaluation process, which is described in the ICAO Safety Management Manual (Doc 9859). To receive an independent classification, TRS had initiated a survey, this survey has been responded to by several flight operations and the outcome can be found in the table below. The result of this survey has been taken as a basis for the risk assessment.

Code	Safety Issue	Classification
si-01	Distraction by new chart design	3D
si-02	Increased head down time	3D
si-03	Different knowledge levels of flight crew	3D
si-04	Increased workload	2D

In general, the classification, as an outcome from the survey, shows that there are slight safety concerns that may be relevant during the implementation phase.

However, this risk evaluation does not include any preparation or training of the flight crew. For a smooth transition TRS suggests some mitigations which are described in Chapter 5. This will lead to a safe implementation of the new chart design in the flight operations affected by this change.

5 Threat Analysis

5.1 BowTie Overview Diagram

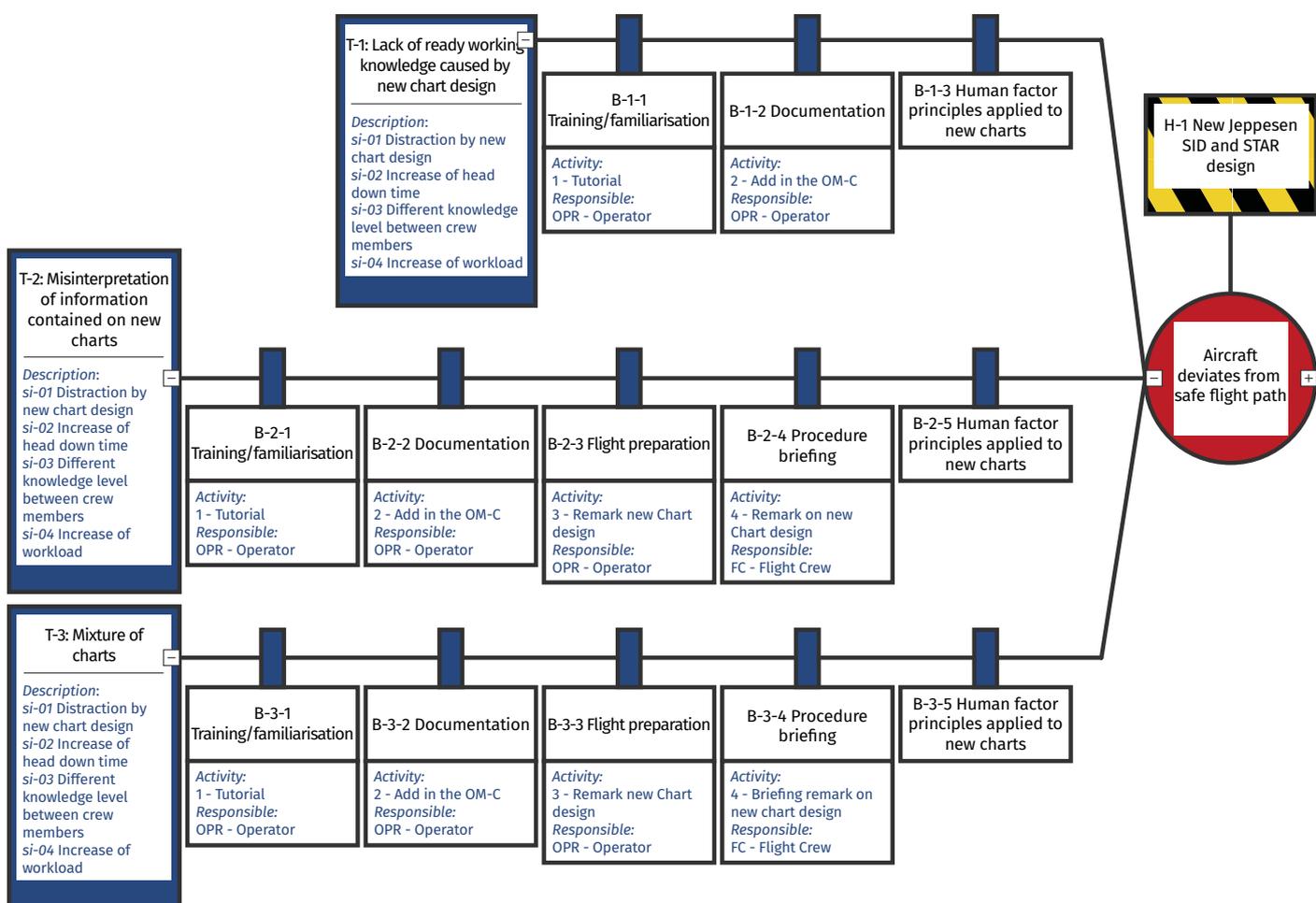


Figure 7 BowTie Overview

5.1.1 Description of the BowTie Overview Diagram

The overview above shows the complete assessment. It emphasises all scenarios that may lead to the top event. For a better understanding each threat string will be discussed in detail on the following pages.

5.2 Threat String 1: T-1 of H-1

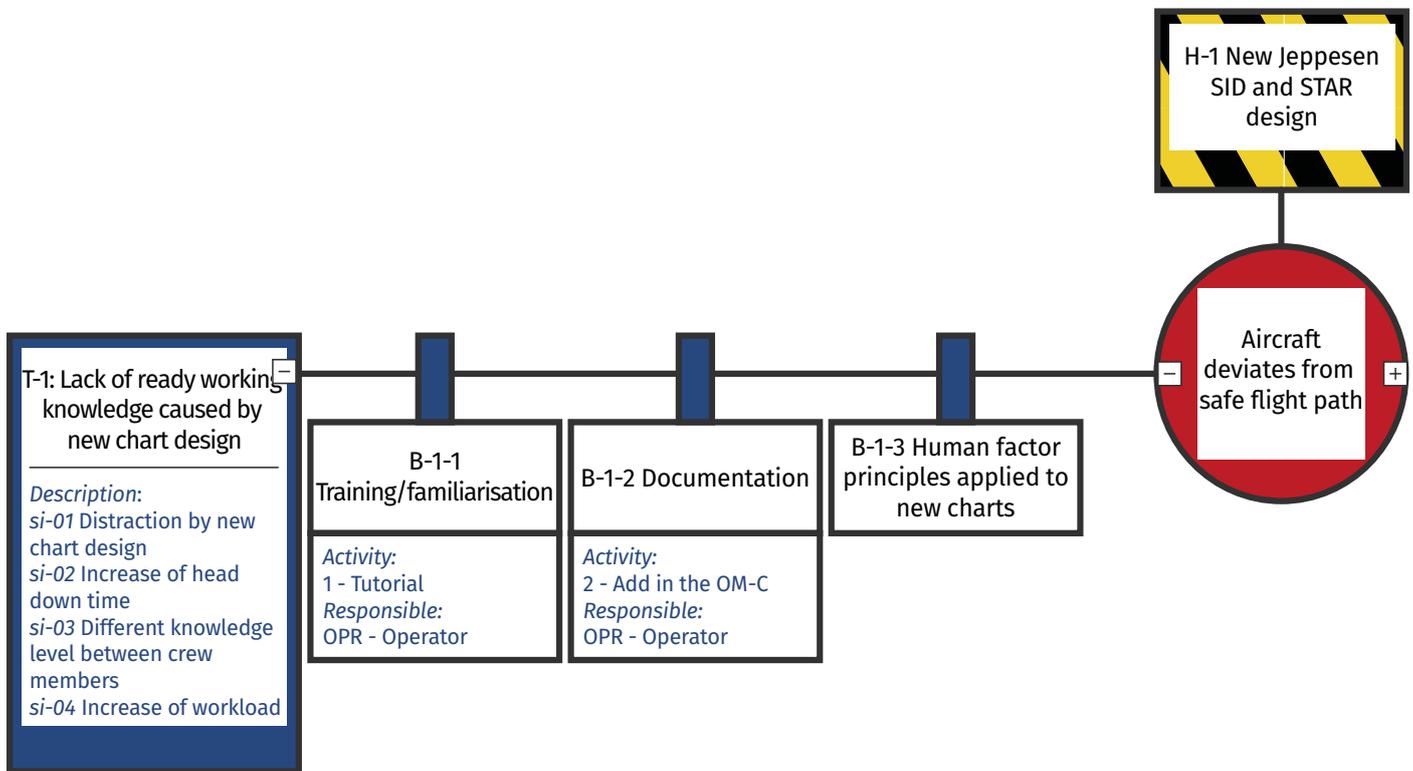


Figure 8 BowTie String 1

5.2.1 Description

This threat string describes the risk associated with the implementation of the new chart design in regards to habits of flight crew who are used to the old design and have been working with these charts for many years. They now face a new design and have to adopt these accordingly.

The following safety issues have been assigned to this threat string:

si-01, si-02, si-03 and si-04. These safety issues are further described in chapter 5.2.3.

5.2.2 Proposed Mitigation

B-1-1 Training/familiarisation

Jeppesen will provide a tutorial for flight crew training, which shows the differences between the old and new chart design and includes a detailed description of changes. This tutorial enables flight crew to familiarise themselves with the new design and be prepared for implementation.

A timely training (we recommend 4 weeks) before the release of the new charts is highly recommended.

B-1-2 Documentation

The documentation barrier shall be made available at the same time as the familiarisation barrier. It is necessary to update the information contained in the OM Part C (Jeppesen Route Manual General), so that all information in regards to the new chart design is available in time.

Timely updated documentation is crucial for the safe implementation of the new chart design.

B-1-3 Human factor principles applied to new charts

The new chart design is based on human factor principles. It therefore represents a preventive barrier by itself.

5.2.3 Post Mitigation

Code	Safety Issue	Classification	Effect of Barrier	Risk Rating with Preventive Barrier
si-01	Distraction by new chart design	3D	decrease	2E
si-02	Increased head down time	3D	decrease	2E
si-03	Different knowledge levels of flight crew	3D	decrease	2E
si-04	Increased workload	2E	constant	2E

The post mitigation activities B-1-1 Training/Familiarisation, B-1-2 Documentation and B-1-3 Human Factor Principles which are suggested in the BowTie diagram are necessary for decreasing the safety issue risk rating. The implementation of the procedures of the BowTie leads to a decrease in the risk ranking of the safety issues si-01, si-02 and si-03. There is no change in the risk ranking for si-04.

All resulting safety issues are in the green area.

5.3 Threat String 2: T-2 of H-1

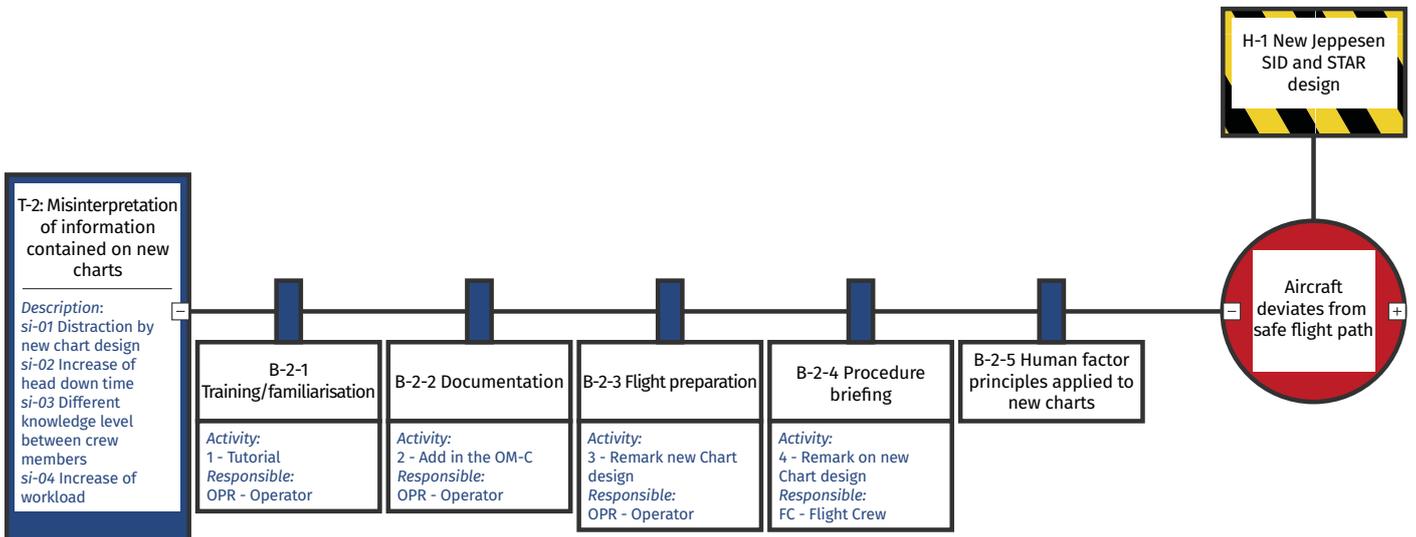


Figure 9 BowTie String 2

5.3.1 Description

This threat string describes the risk associated with possible misinterpretation information contained on new charts due to lack of knowledge.

The following safety issues have been assigned to this threat string:

si-01, si-02, si-03 and si-04. These safety issues are further described in chapter 5.3.3.

5.3.2 Proposed Mitigation

B-2-1 Training/familiarisation

Jeppesen will provide a tutorial for flight crew training, which shows the differences between the old and new chart design and includes a detailed description of changes. This tutorial enables flight crew to familiarise themselves with the new design and be prepared for implementation.

A timely training (we recommend 4 weeks) before the release of the new charts is highly recommended.

B-2-2 Documentation

The documentation barrier shall be made available at the same time as the familiarisation barrier. It is necessary to update the information contained in the OM Part C (Jeppesen Route Manual General), so that all information in regards to the new chart design is available in time.

Timely updated documentation is crucial for the safe implementation of the new chart design.

B-2-3 Flight preparation

Before commencing flight, special emphasis shall be placed on the new chart design during pre-flight briefing. Flight crew shall be aware of the charts to be used for the next flight (old, new or a combination – e.g. departure airport old chart design, arrival airport new chart design).

B-2-4 Procedure briefing

Special emphasis shall be placed on the changed layout when briefing a procedure, e.g. SID or STAR. Flight crew shall be aware of the specific layout used for the procedure and briefed accordingly.

B-2-5 Human factor principles applied to new charts

The new chart design is based on human factor principles. It therefore represents a preventive barrier by itself.

5.3.3 Post Mitigation

Code	Safety Issue	Classification	Effect of Barrier	Risk Rating with Preventive Barrier
si-01	Distraction by new chart design	3D	decrease	2E
si-02	Increased head down time	3D	decrease	2E
si-03	Different knowledge levels of flight crew	3D	decrease	2E
si-04	Increased workload	2E	constant	2E

The post mitigation activities B-2-1 Training/Familiarisation, B-2-2 Documentation, B-2-3 Human Factor Principles, B-2-4 Procedure Briefing and B-2-5 Human Factor Principles which are suggested in the BowTie diagram are necessary for decreasing the safety issue risk rating. The implementation of the procedures of the BowTie leads to a decrease in the risk ranking of the safety issues si-01, si-02 and si-03. There is no change in the risk ranking for si-04.

All resulting safety issues are in the green area.

5.4 Threat Sting 3: T-3 of H-1

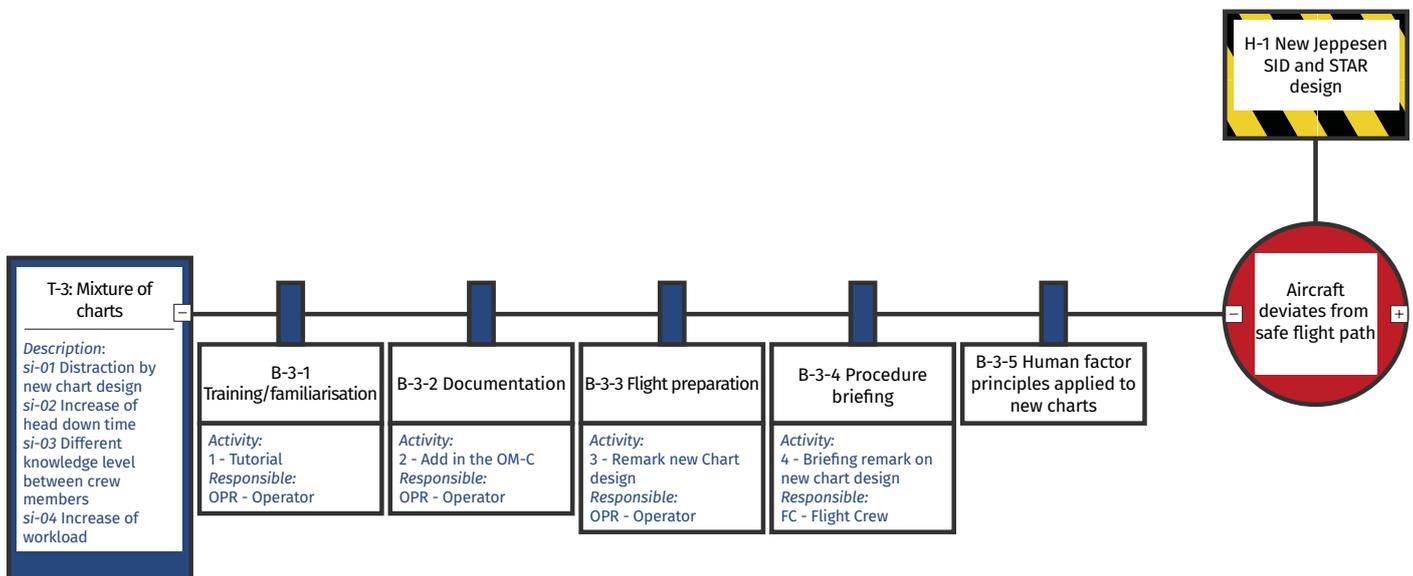


Figure 10 BowTie String 3

5.4.1 Description

This threat string considers the risk resulting from a mixture of old and new chart design. As the complete transition from old to new chart design takes approximately two years, a mixture of charts may occur in this period. This implies that on one flight old and new chart layout may have to be used.

The following safety issues have been assigned to this threat string:

si-01, si-02, si-03 and si-04. These safety issues are further described in chapter 5.4.3.

5.4.2 Proposed Mitigation

B-3-1 Training/familiarisation

Jeppesen will provide a tutorial for flight crew training, which shows the differences between the old and new chart design and includes a detailed description of changes. This tutorial enables flight crew to familiarise themselves with the new design and be prepared for implementation.

A timely training (we recommend 4 weeks) before the release of the new charts is highly recommended.

B-3-2 Documentation

The documentation barrier shall be made available at the same time as the familiarisation barrier. It is necessary to update the information contained in the OM Part C (Jeppesen Route Manual General), so that all information in regards to the new chart design is available in time.

Timely updated documentation is crucial for the safe implementation of the new chart design.

B-3-3 Flight preparation

Before commencing flight, special emphasis shall be placed on the new chart design during pre-flight briefing. Flight crew shall be aware of the charts to be used for the next flight (old, new or a combination – e.g. departure airport old chart design, arrival airport new chart design).

B-3-4 Procedure briefing

Special emphasis shall be placed on the changed layout when briefing a procedure, e.g. SID or STAR. Flight crew shall be aware of the specific layout used for the procedure and briefed accordingly.

B-3-5 Human factor principles applied to new charts

The new chart design is based on human factor principles. It therefore represents a preventive barrier by itself.

5.4.3 Post Mitigation

Code	Safety Issue	Classification	Effect of Barrier	Risk Rating with Preventive Barrier
si-01	Distraction by new chart design	3D	decrease	2E
si-02	Increased head down time	3D	decrease	2E
si-03	Different knowledge levels of flight crew	3D	decrease	2E
si-04	Increased workload	2E	constant	2E

The post mitigation activities B-3-1 Training/Familiarisation, B-3-2 Documentation, B-3-3 Human Factor Principles, B-3-4 Procedure Briefing and B-3-5 Human Factor Principles which are suggested in the BowTie diagram are necessary for decreasing the safety issue risk rating. The implementation of the procedures of the BowTie leads to a decrease in the risk ranking of the safety issues si-01, si-02 and si-03. There is no change in the risk ranking for si-04.

All resulting safety issues are in the green area.

6 Conclusion/Recommendation

Although the new chart design is a huge improvement (e.g. situational awareness during approach) this change represents a risk, which needs to be mitigated appropriately.

Safety risk management is an essential part of nowadays management systems and therefore risk matrices (combined with the BowTie's) are one tool for organisations seeking fast, effective and practical risk assessment. These tools should not be used in isolation, but rather in conjunction with the rest of the organisations safety management processes.

After an in-depth evaluation of the mitigation possibilities TRS recommended to Jeppesen to create a training tutorial. Jeppesen has taken this very serious and provided TRS with a tutorial containing all the information needed to raise awareness for flight crew using Jeppesen charts in the new design. From our perspective, this tutorial is sufficient for a successful and risk free transition to the new chart design. This tutorial is available from Jeppesen.

In addition, we would like to point out that classroom training has been part of the discussion on possible mitigation ways, but this has been ruled out as it is not necessary as shown by this assessment.

The implementation phase of the new charts is estimated to take two years (starting in late 2016). We recommend to implement procedures on the use of the different chart designs and to amend related briefing procedures for flight crews.

In Chapter 4.1 "Analysing Differences Between Old and New SID/STAR Charts" we recommended (on page 11, flag number 12) to revise the selected colours for better readability. This has been taken very serious by Jeppesen and the updated charts now show improvement in this respect as a result of this ORA.

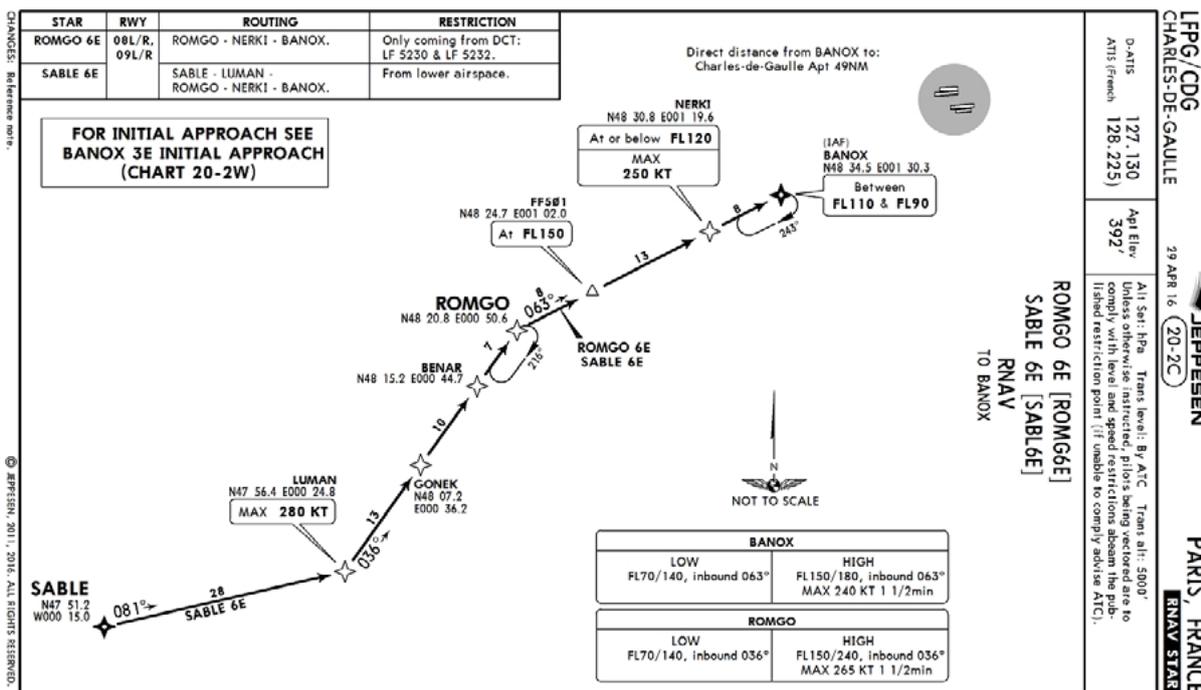
In addition, Jeppesen will provide the updated information in the OM Part C (Route Manual General).

The topic related to the implementation of the new charts should also be an item to be discussed during simulator sessions (or line checks, if applicable). However, we do not see the need for a specific simulator sessions covering the new chart design.

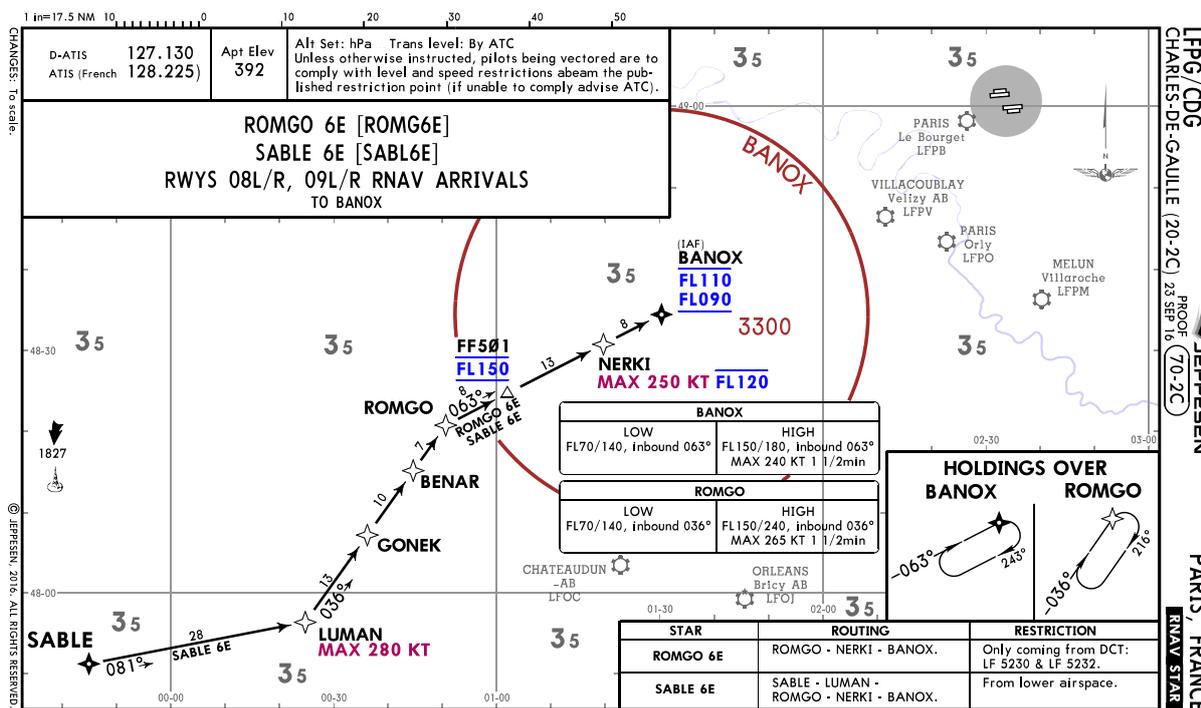
As mentioned before, the right side of the BowTie has not been part of this assessment. However, the consequences contained in this part (e.g. SOPs, Crew Coordination) will reduce the impact of the implementation of the new chart design even further. Therefore a level, acceptable for all operations, will always be reached.

7 Appendix

7.1 Chart Samples

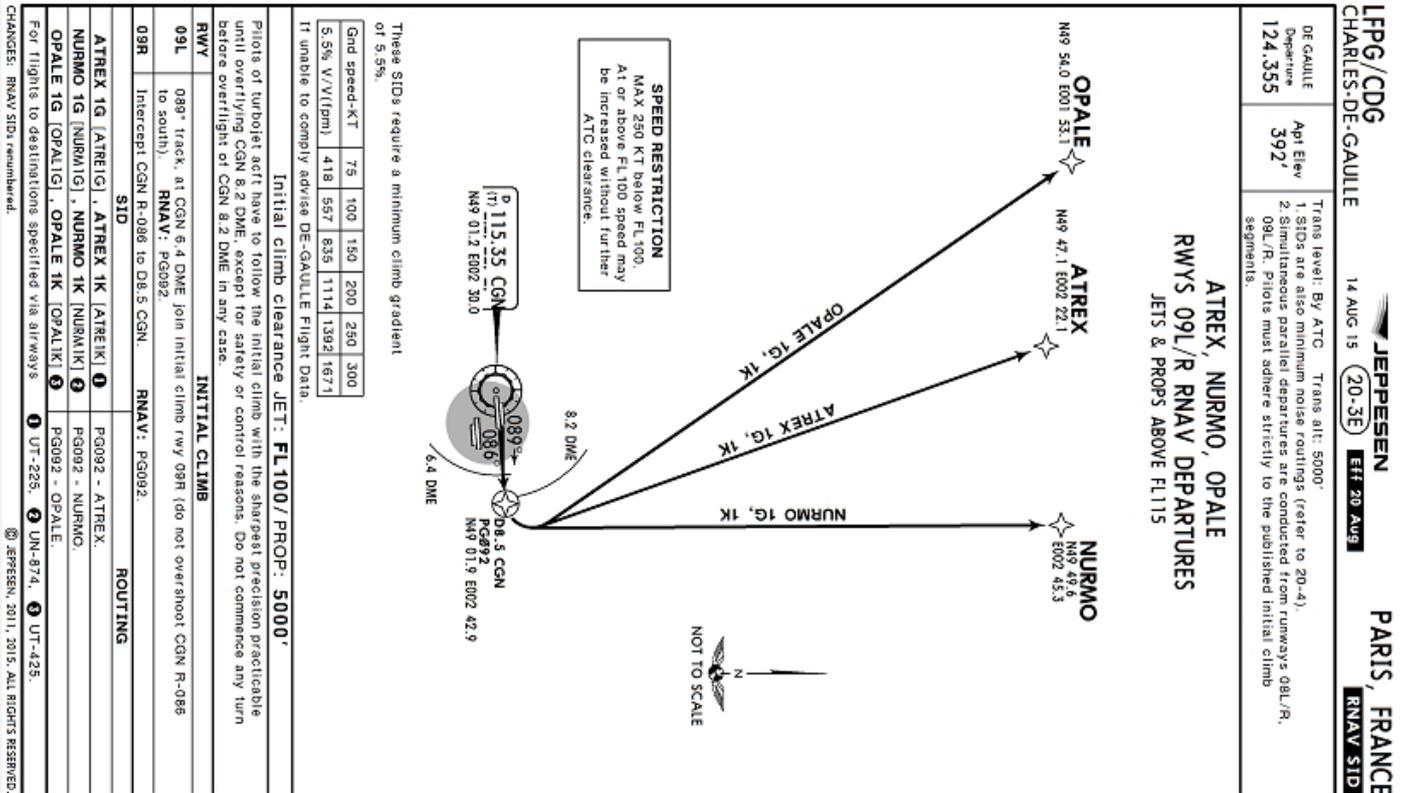


LFPG/CDG STAR (Old Design)

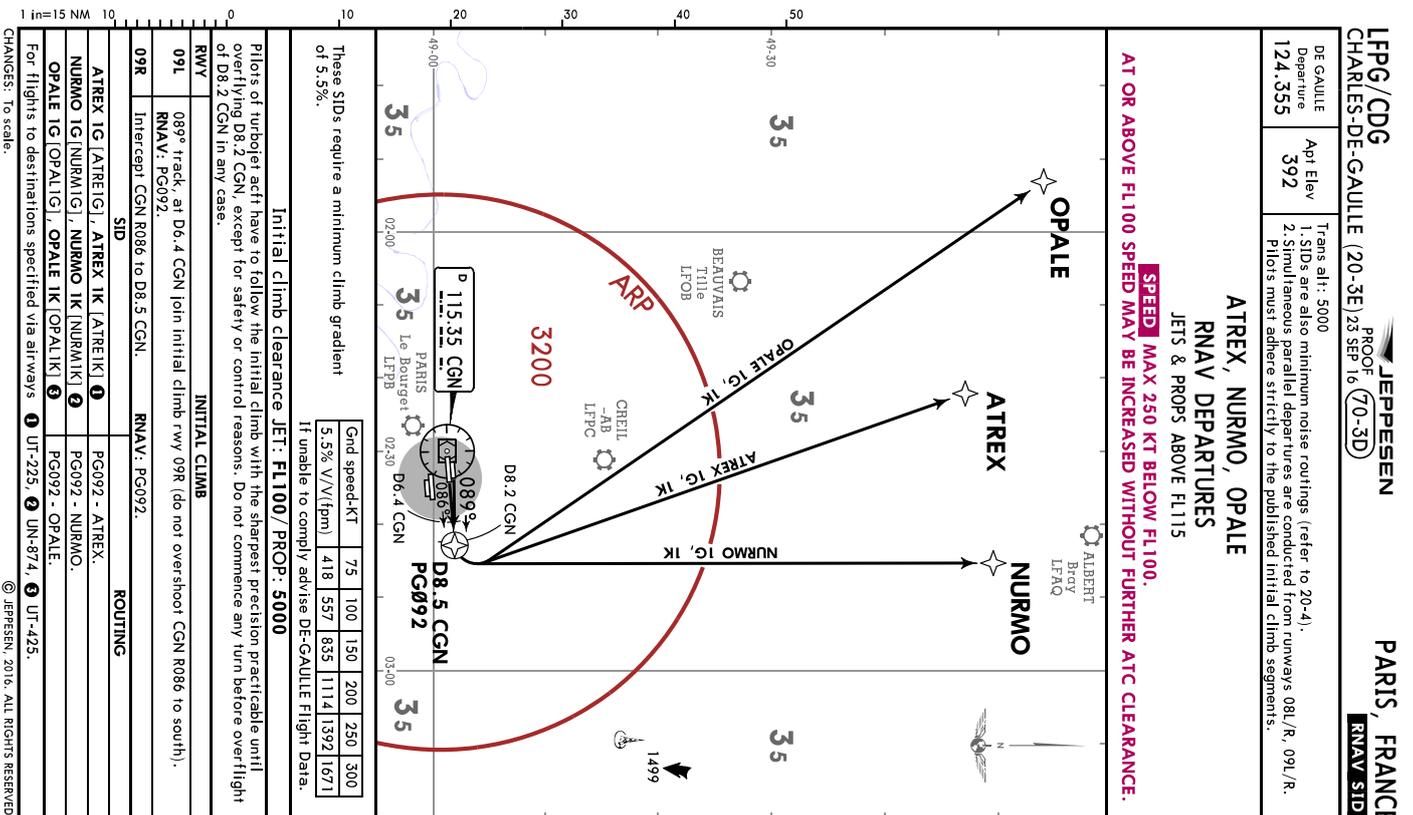


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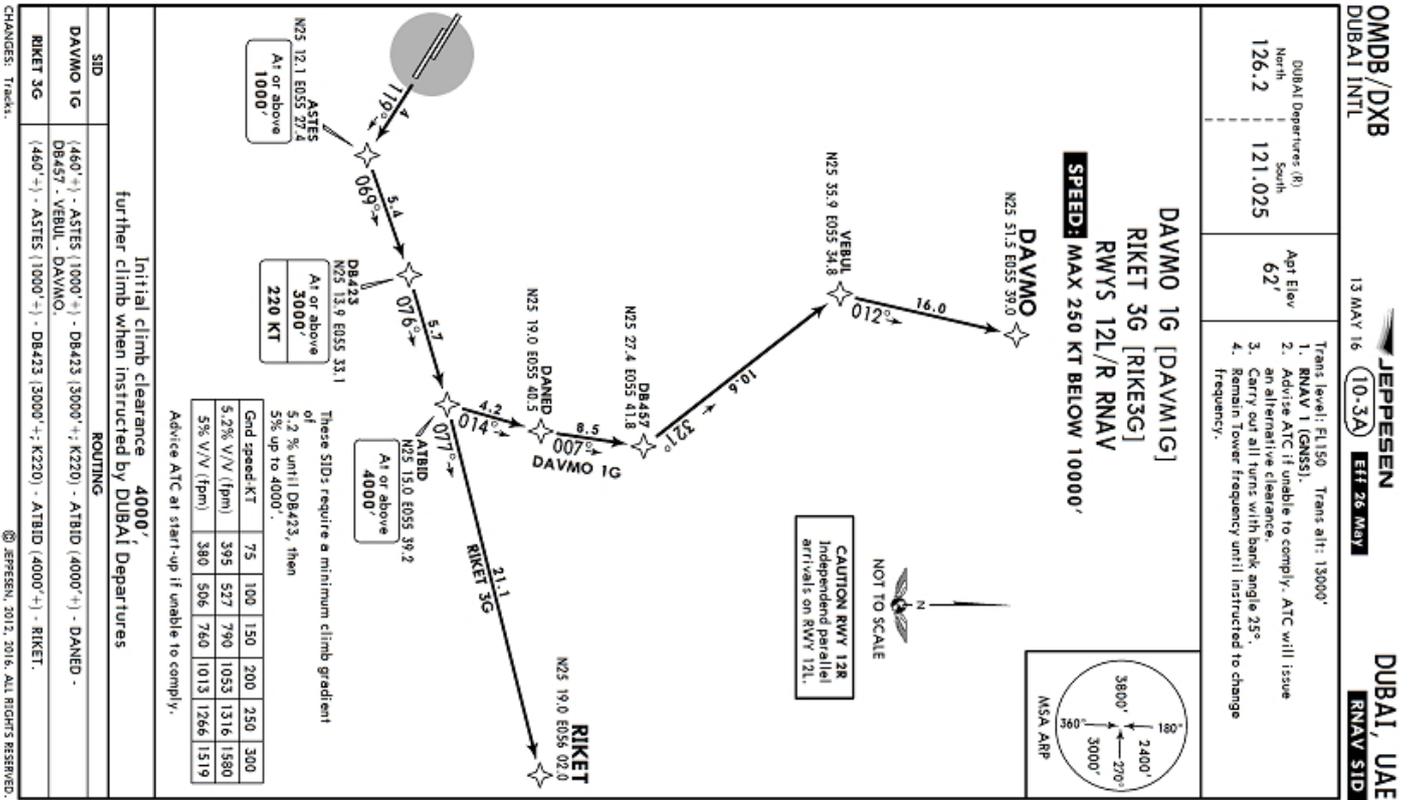
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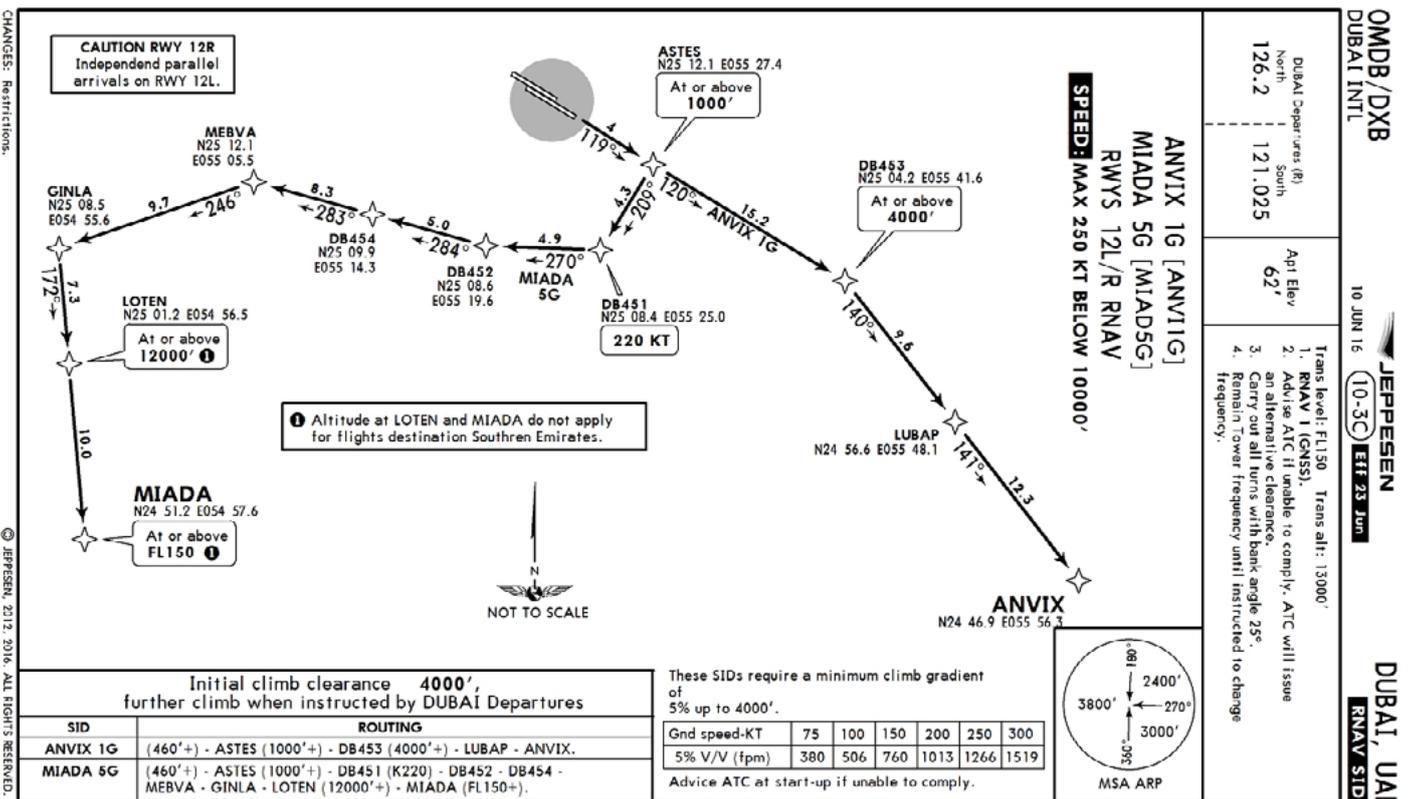
LFPG/CDG SID (Old Design)



LFPG/CDG SID (New Design)



OMDB/DMB SID (Old Design)

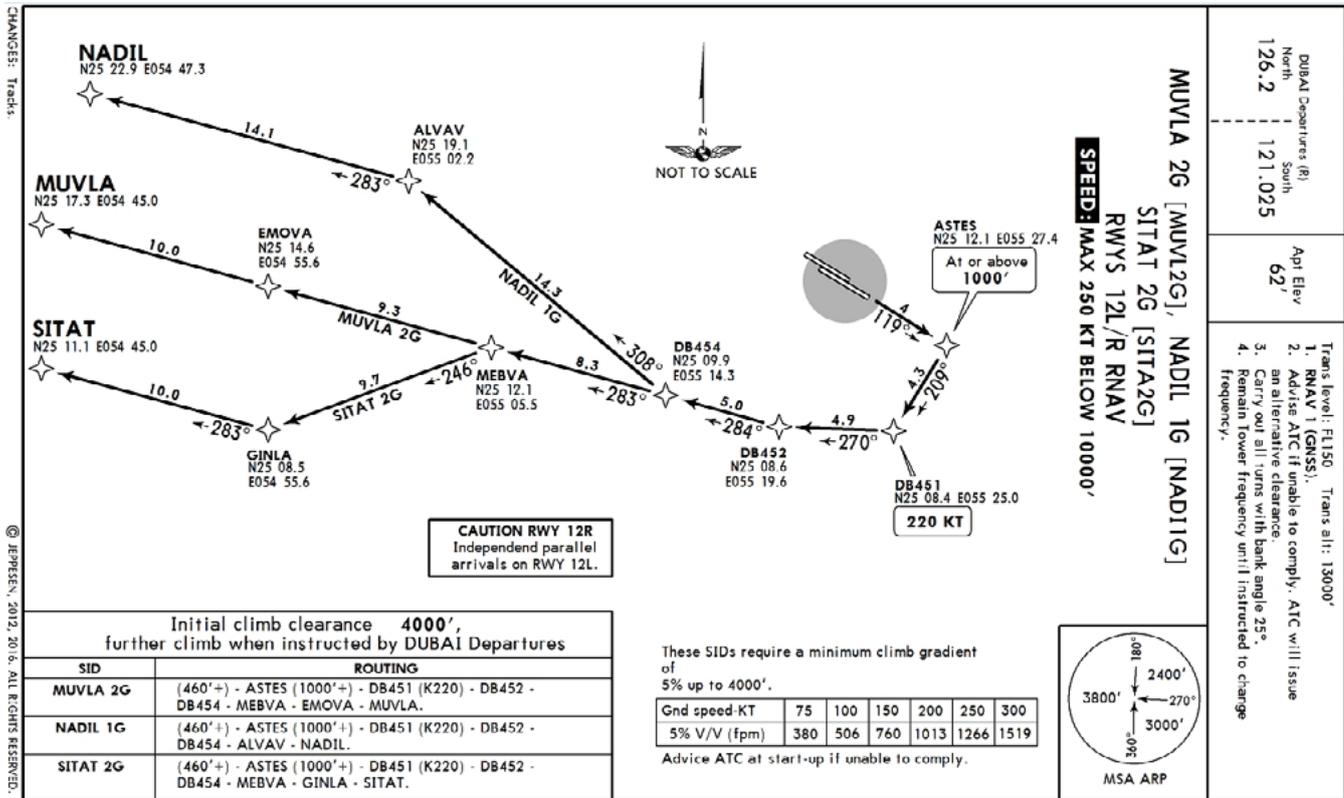


OMDB/DMB SID (Old Design)

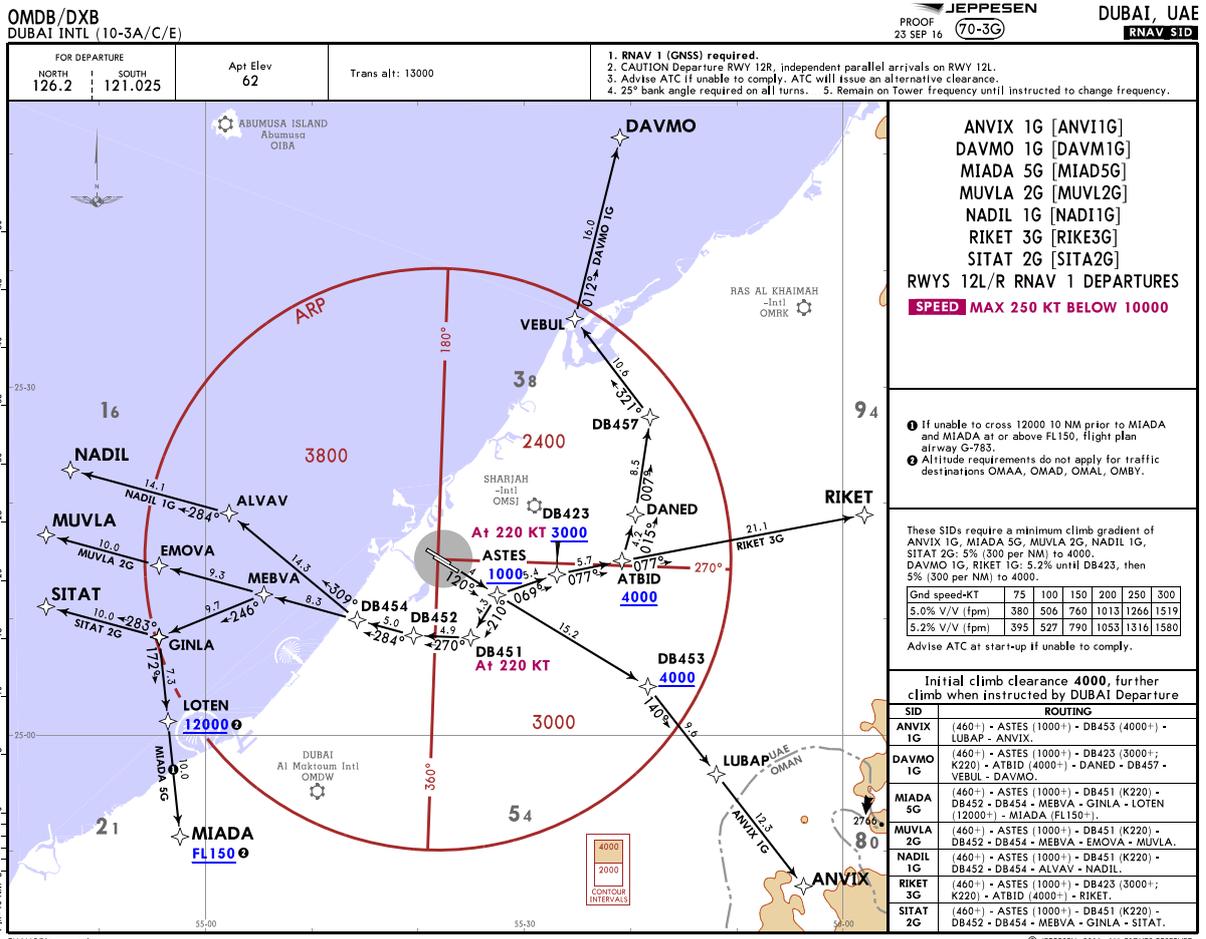
CHANGES: TRACKS.

CHANGES: RESTRICTIONS.

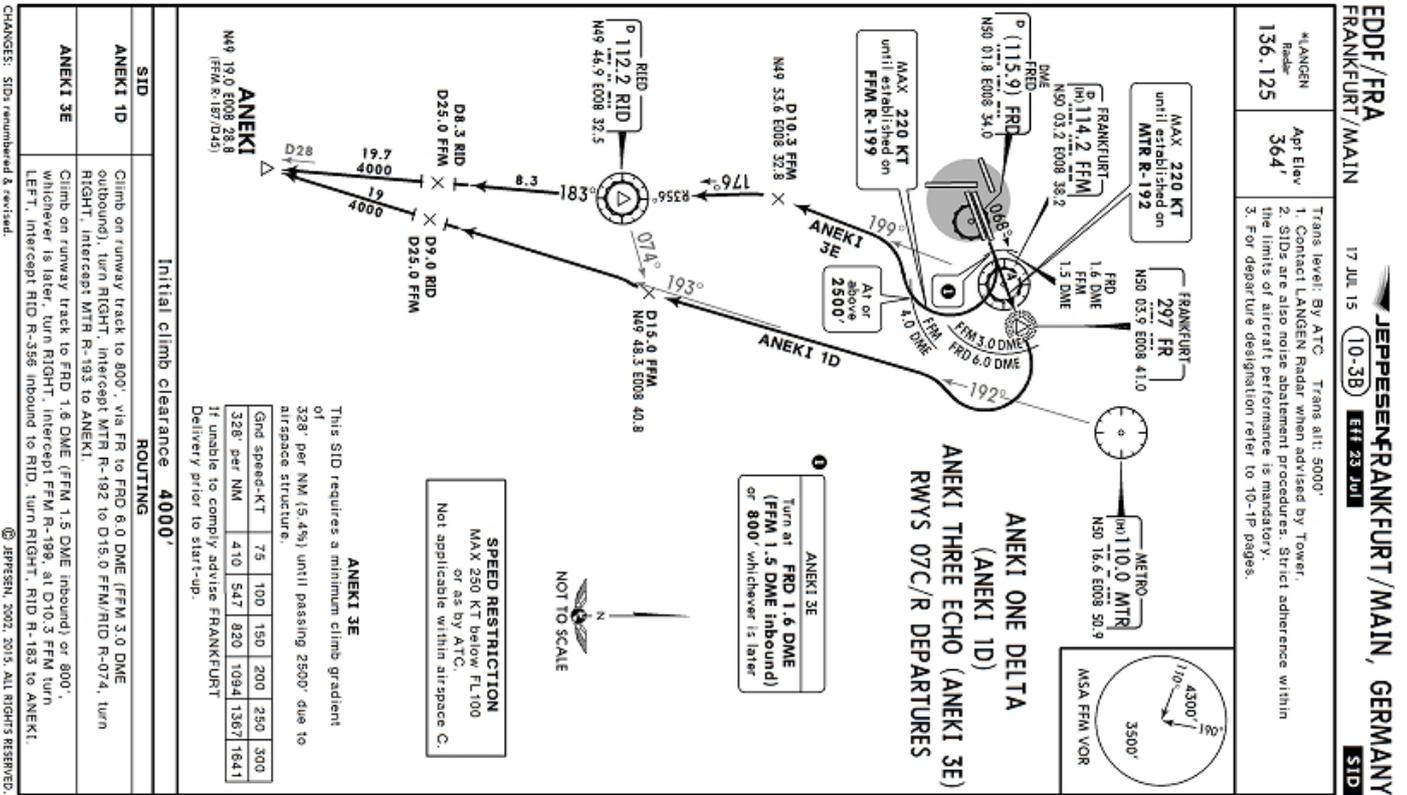
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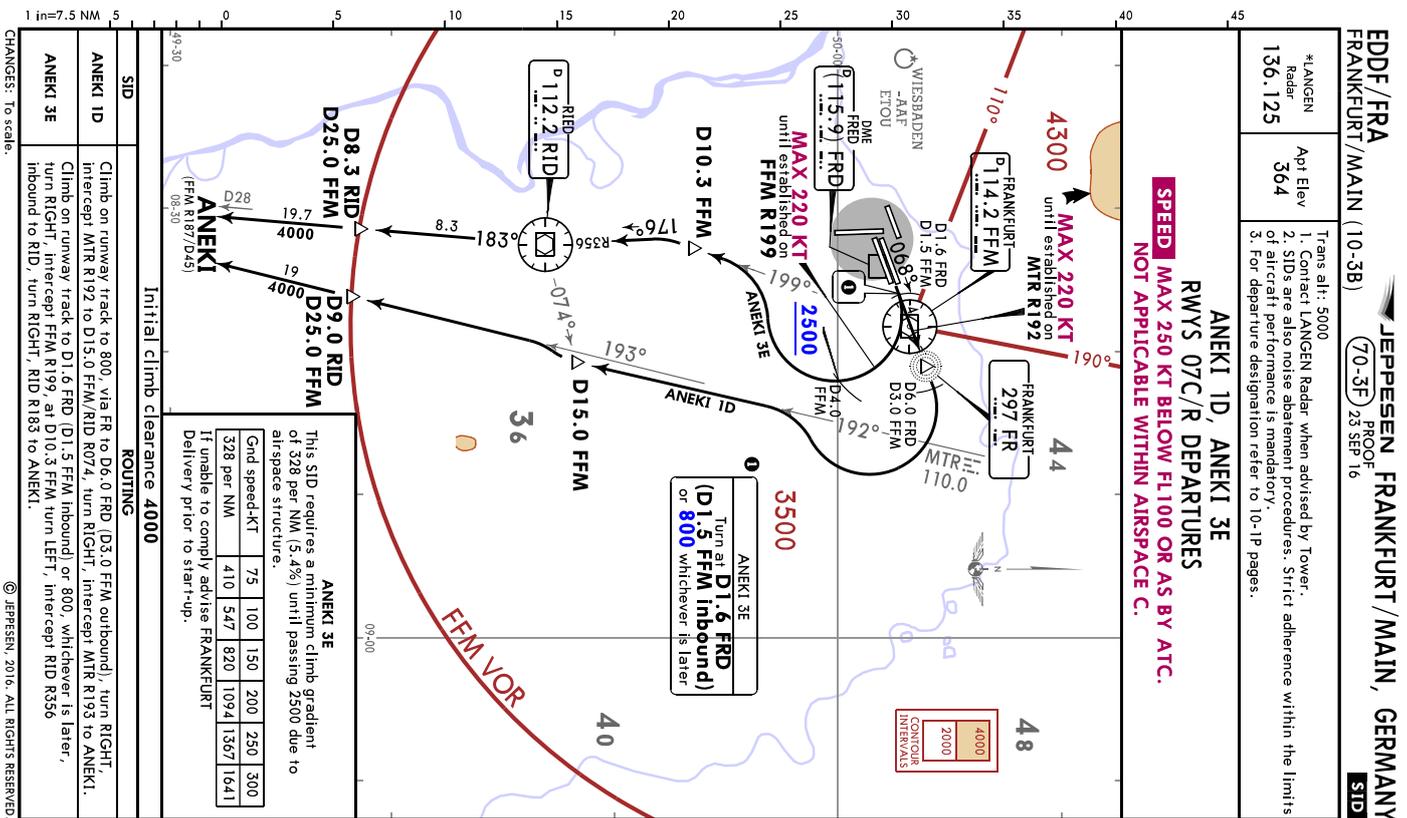
OMDB/DXB SID (Old Design)



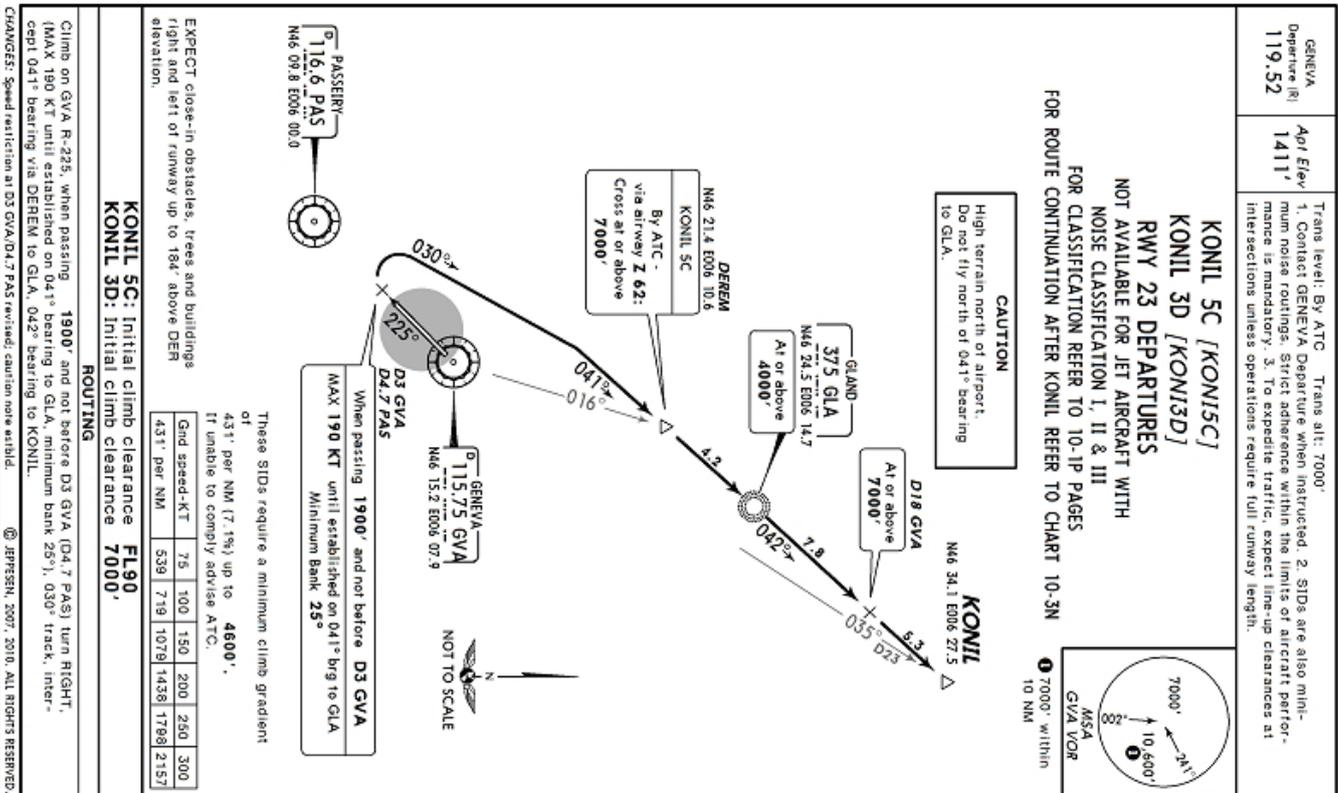
OMDB/DXB SID (New Design)



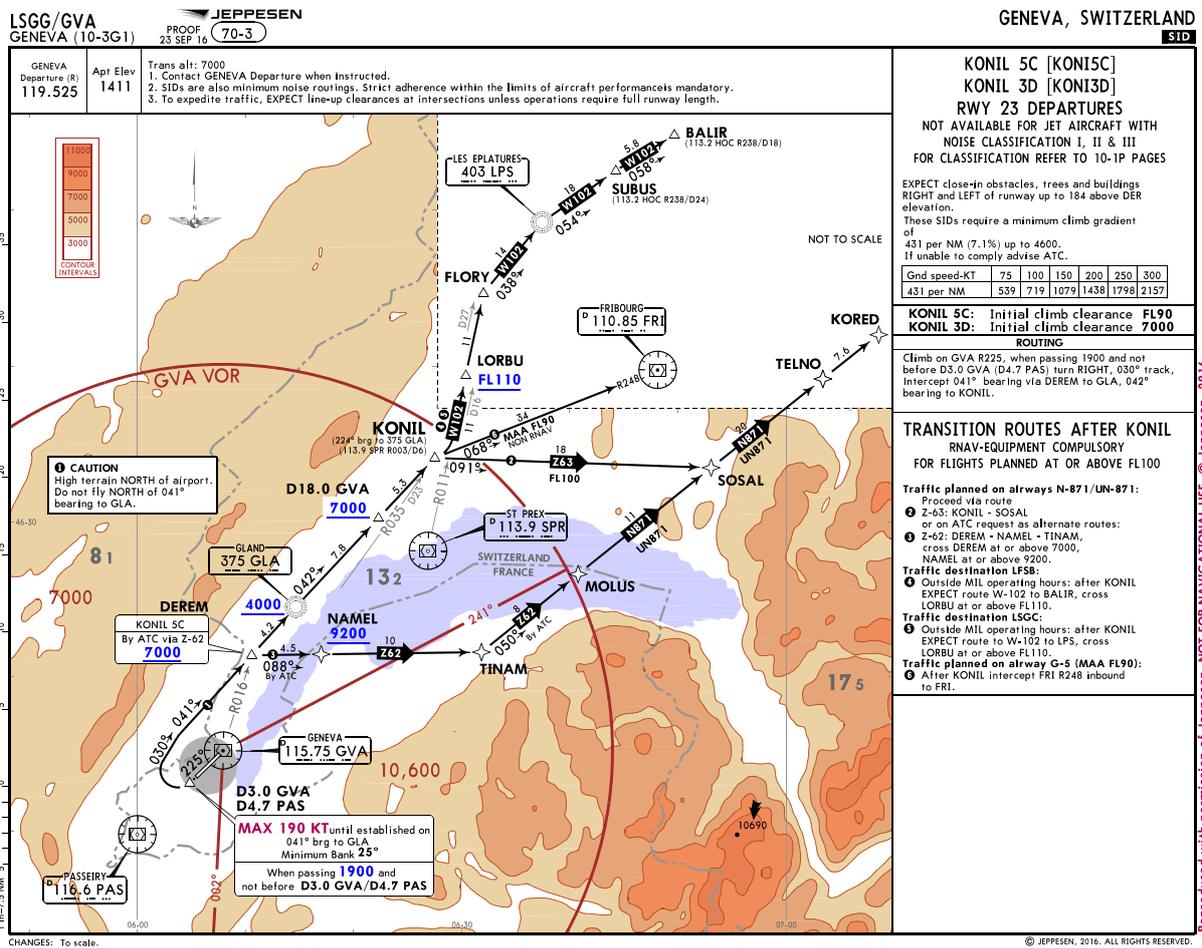
EDDF/FRA SID (Old Design)



EDDF/FRA SID (New Design)



LSGG/GVA SID (Old Design)



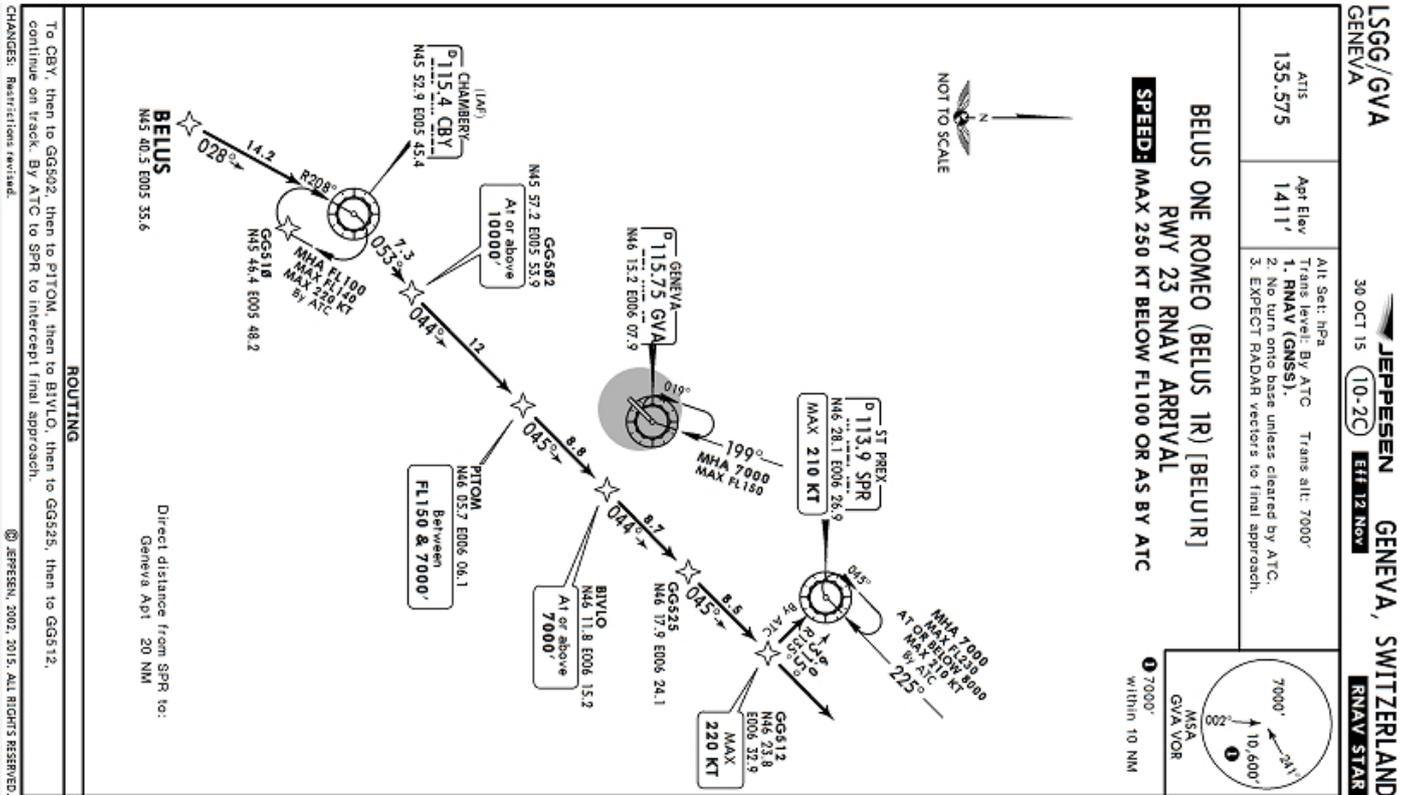
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LSGG/GVA GENEVA (10-3G1)

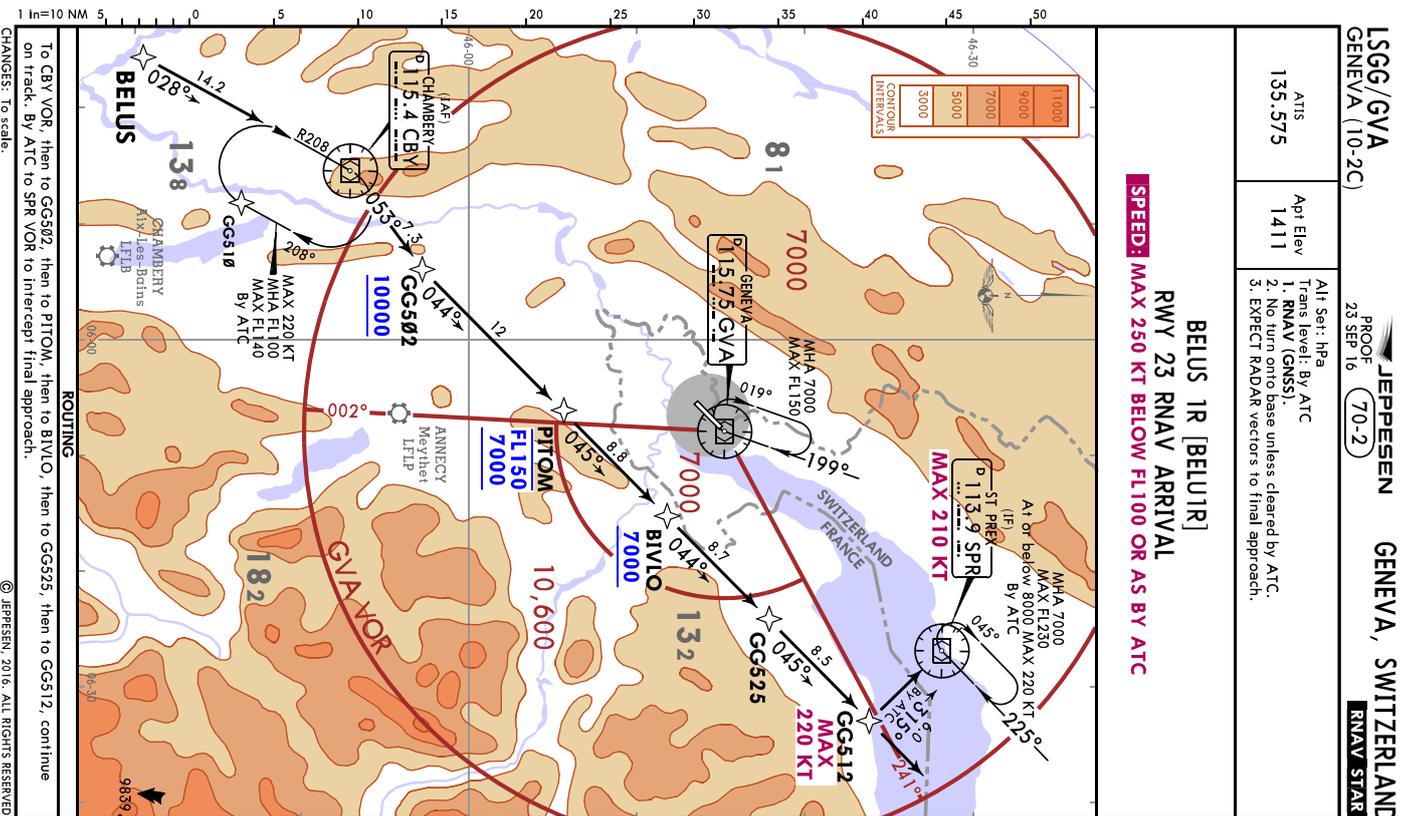
JEPPESSEN GENEVA, SWITZERLAND SID

28 MAY 10 (10-3G1)

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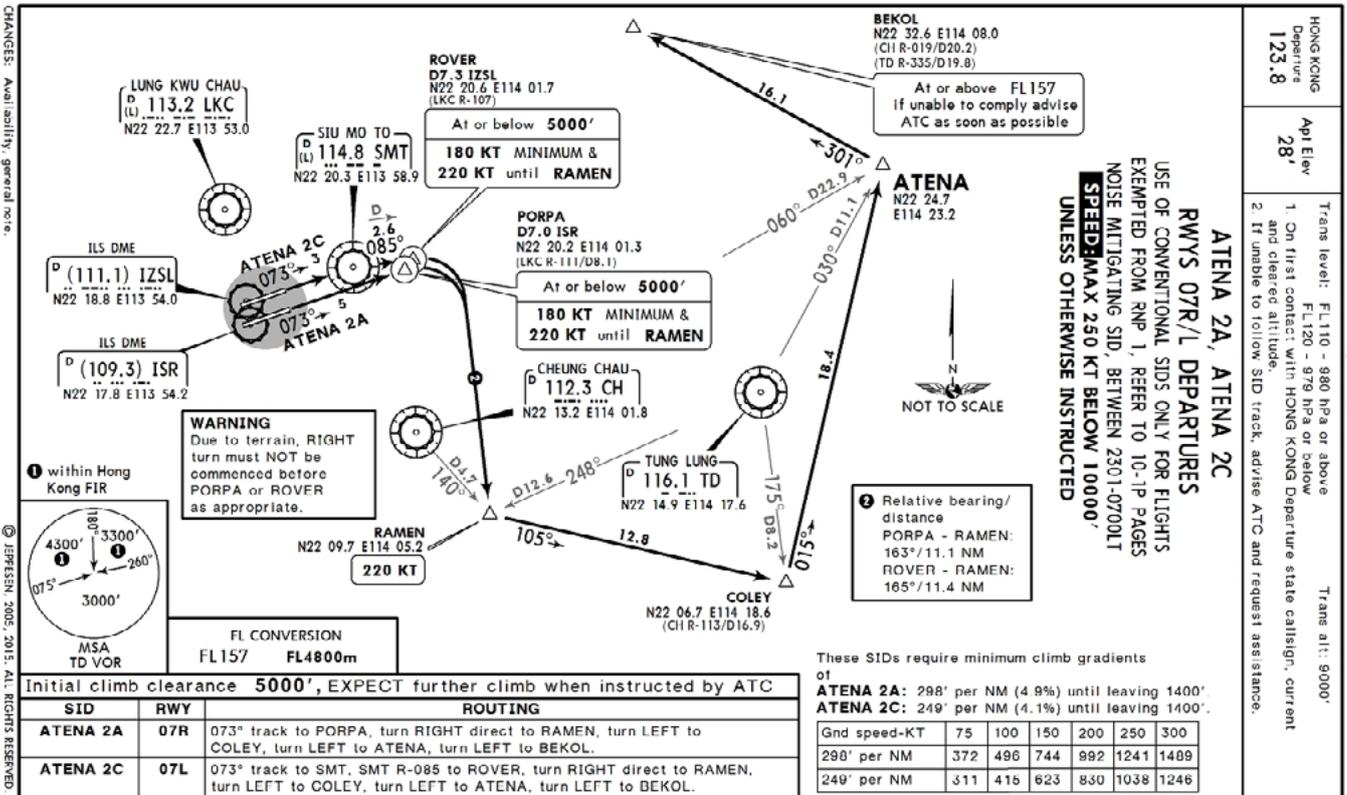


LSGG/GVA STAR (Old Design)

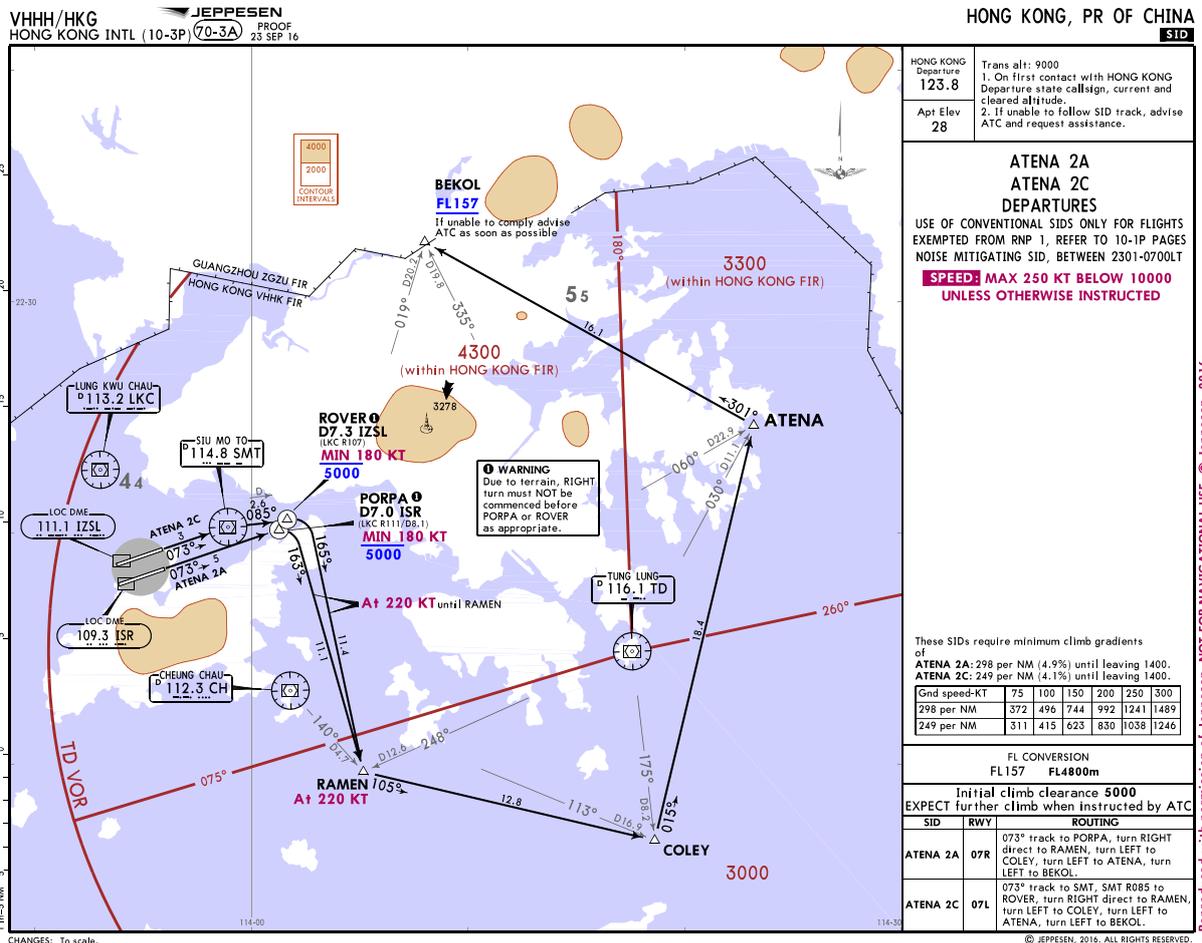


LSGG/GVA STAR (New Design)

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VHHH/HKG SID (Old Design)

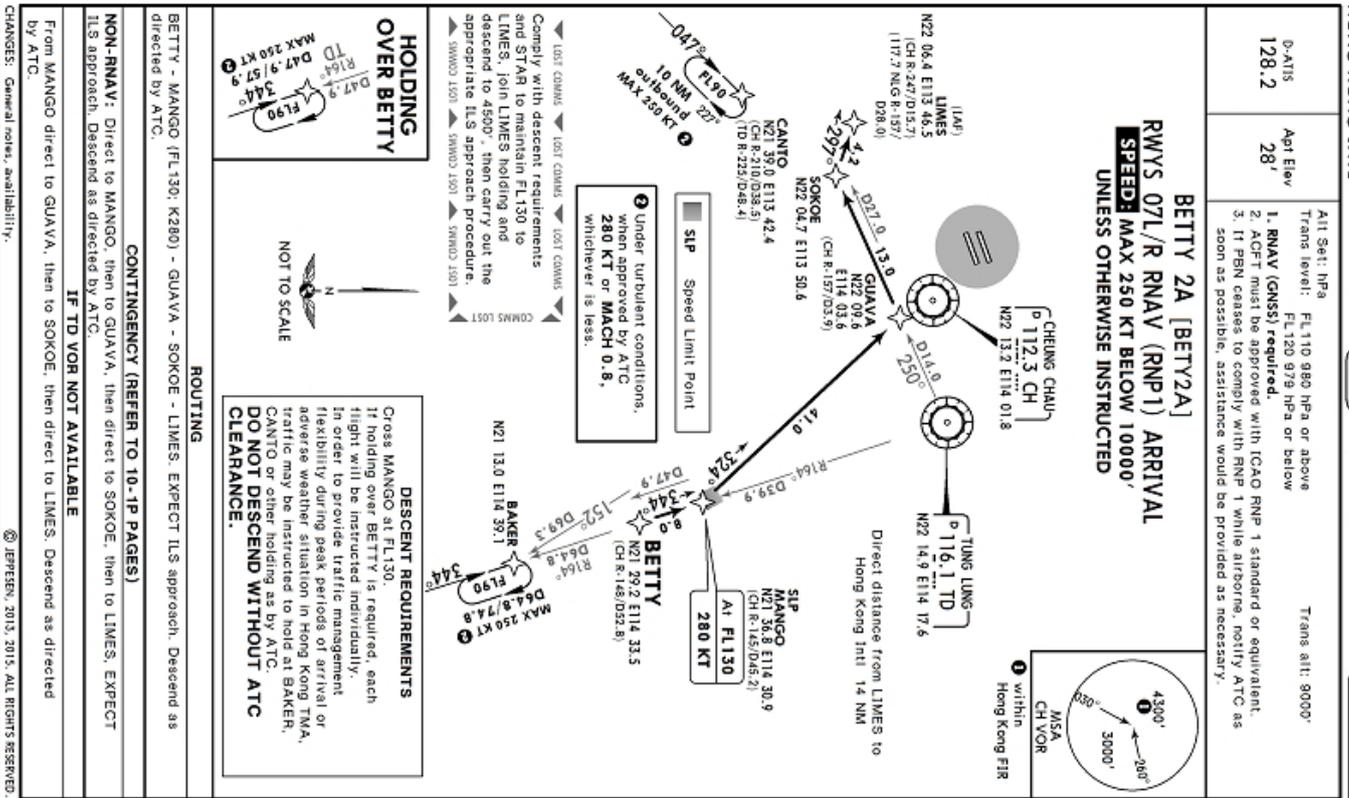


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CHANGES: Availability, general note.

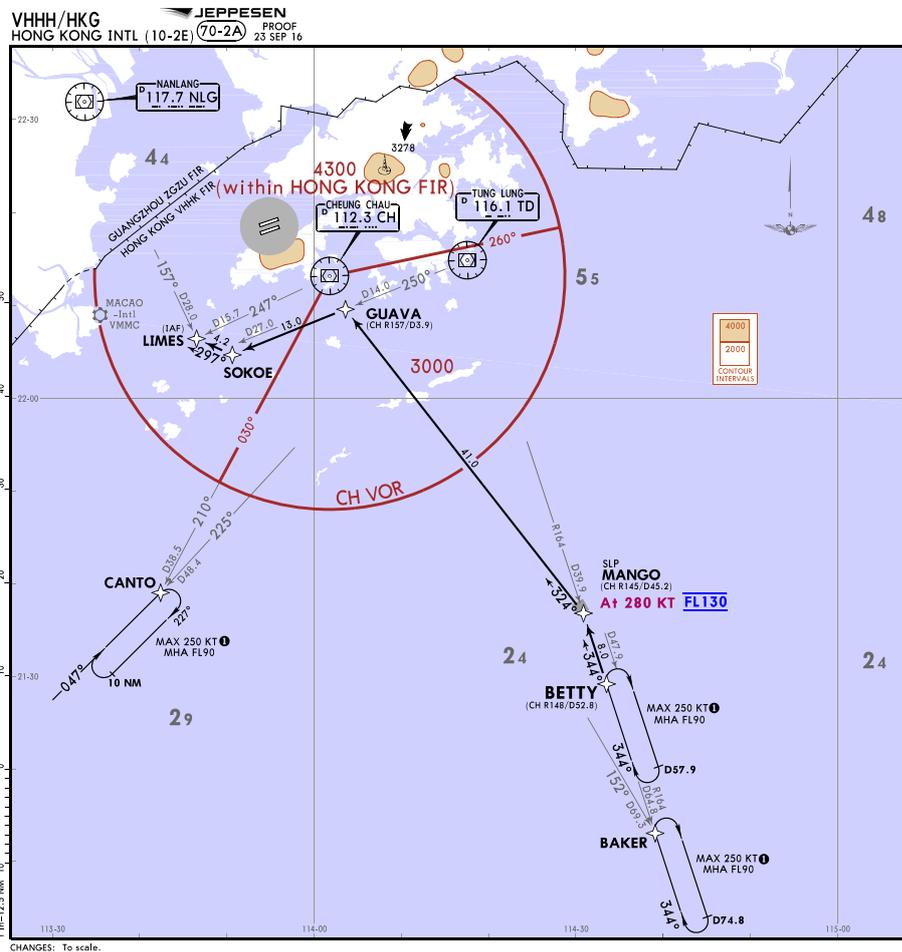
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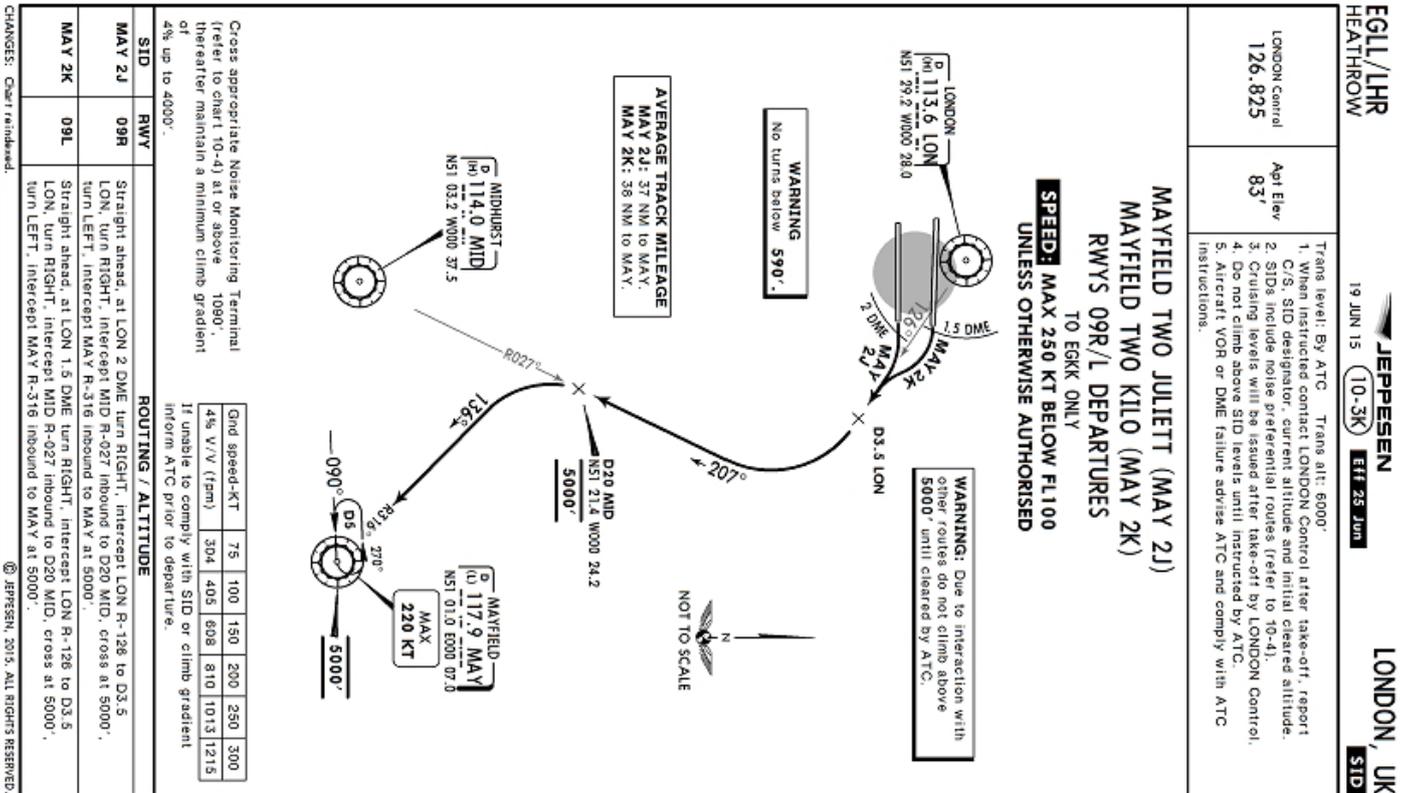
VHHH/HKG
 HONG KONG INTL
 6 NOV 15
10-2E EFF 12 NOV
RNAV STAR
JEPPESSEN HONG KONG, PR OF CHINA

VHHH/HKG STAR (Old Design)

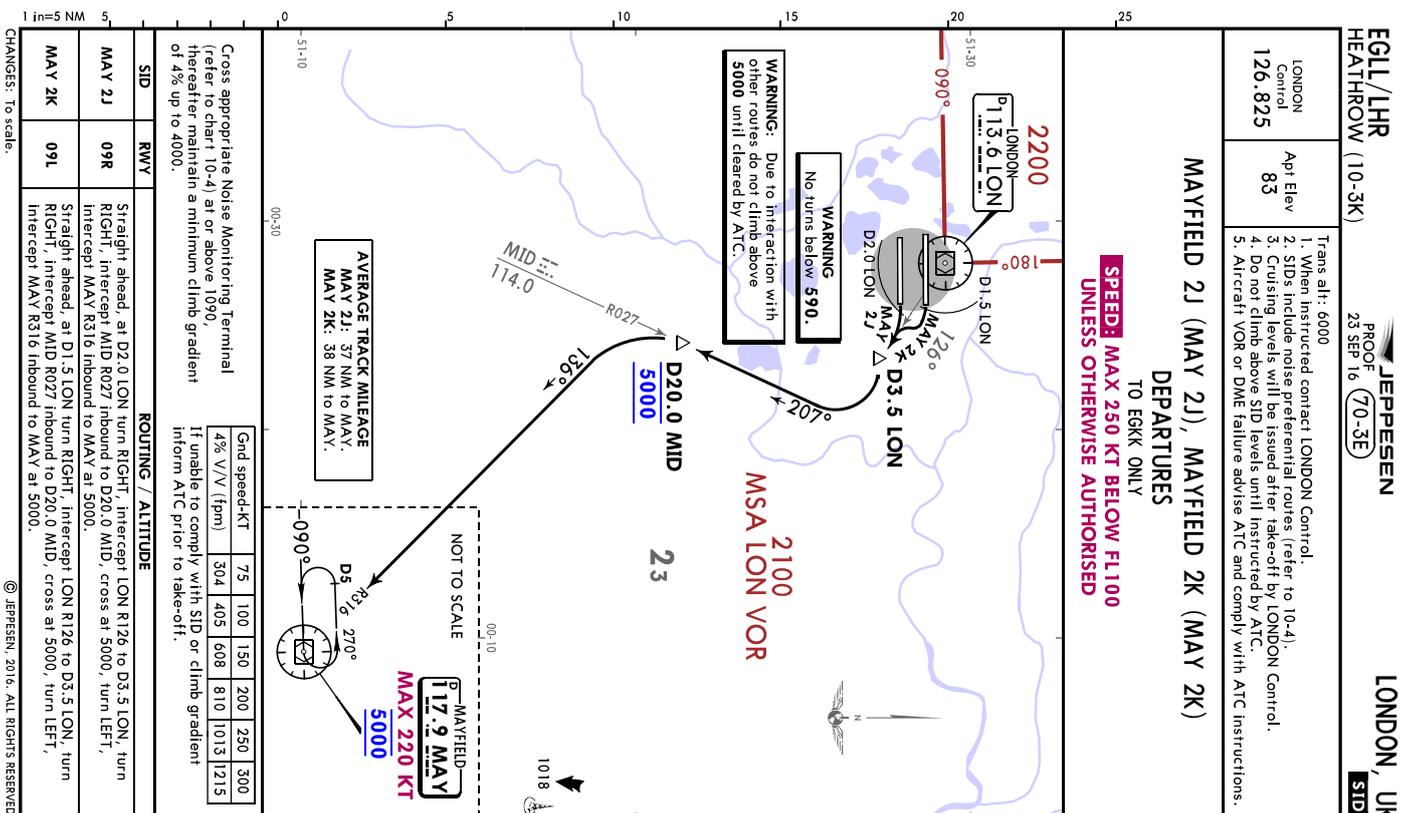


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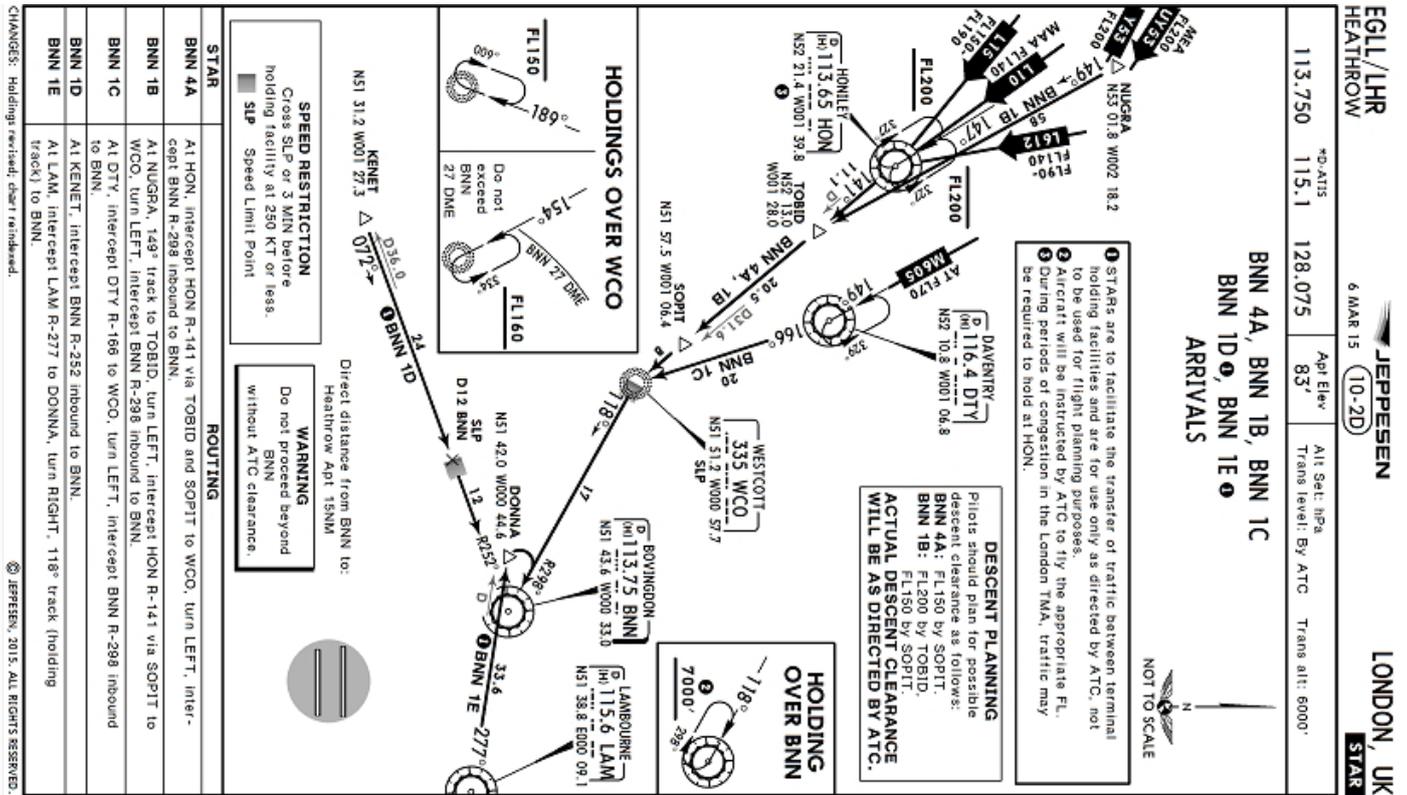
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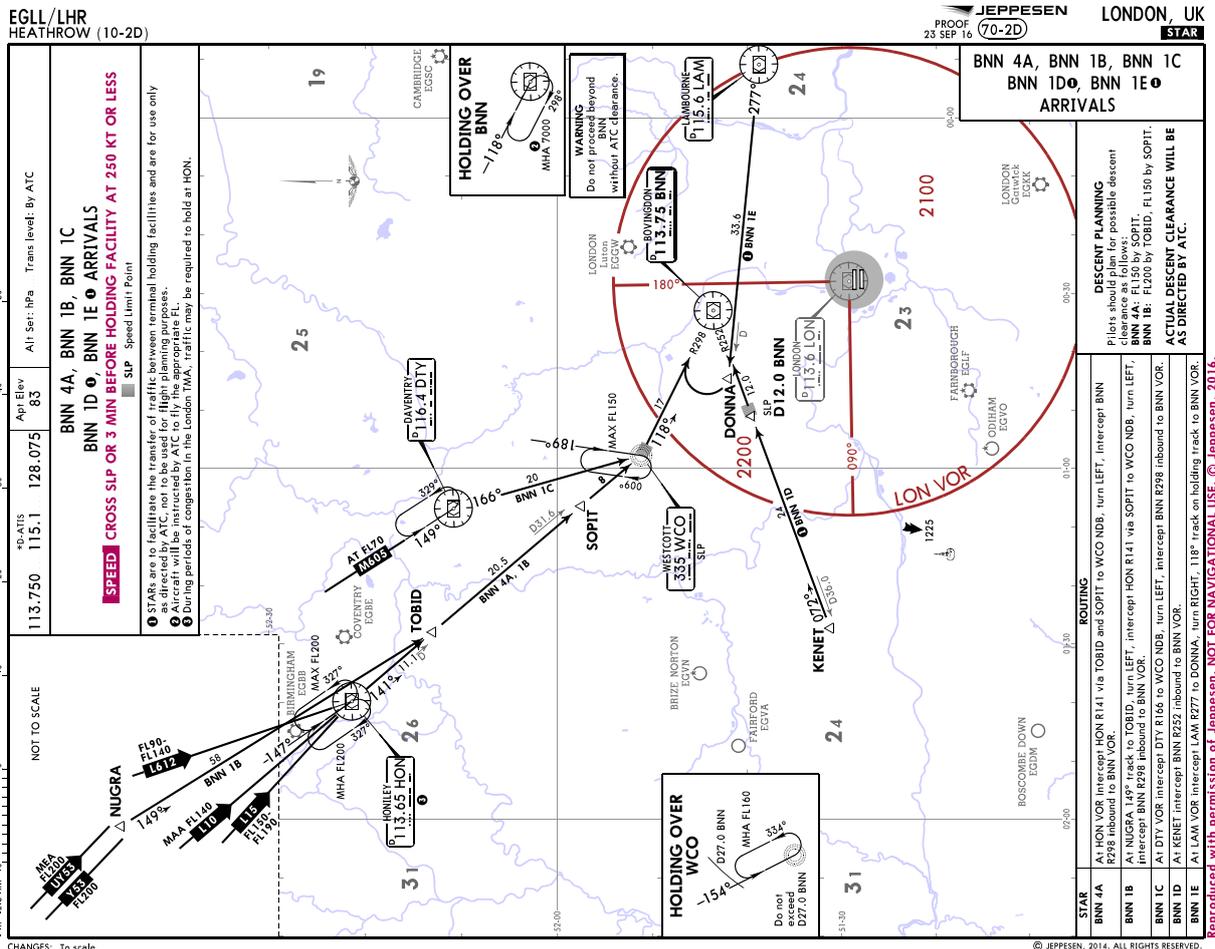
EGL/LHR SID (Old Design)



EGL/LHR SID (New Design)

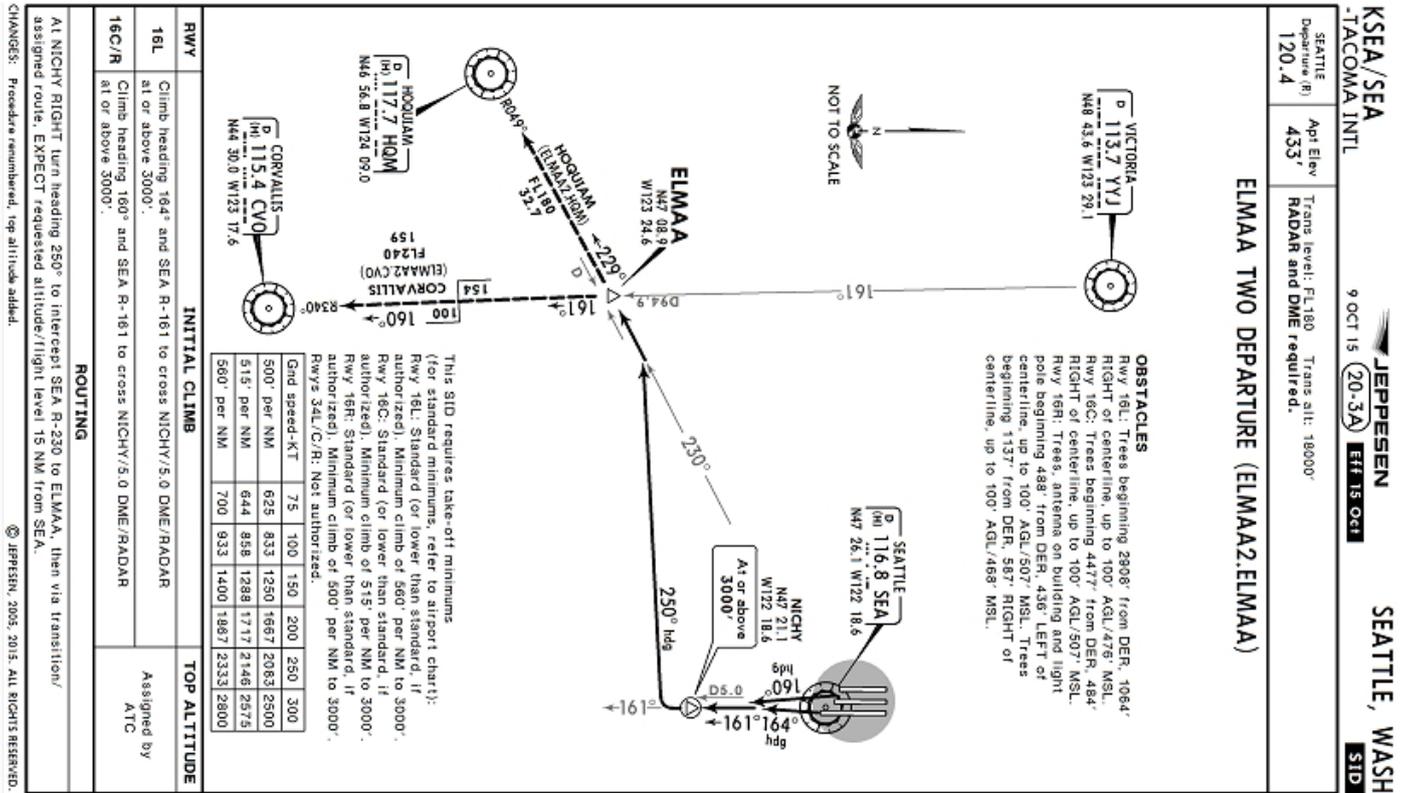


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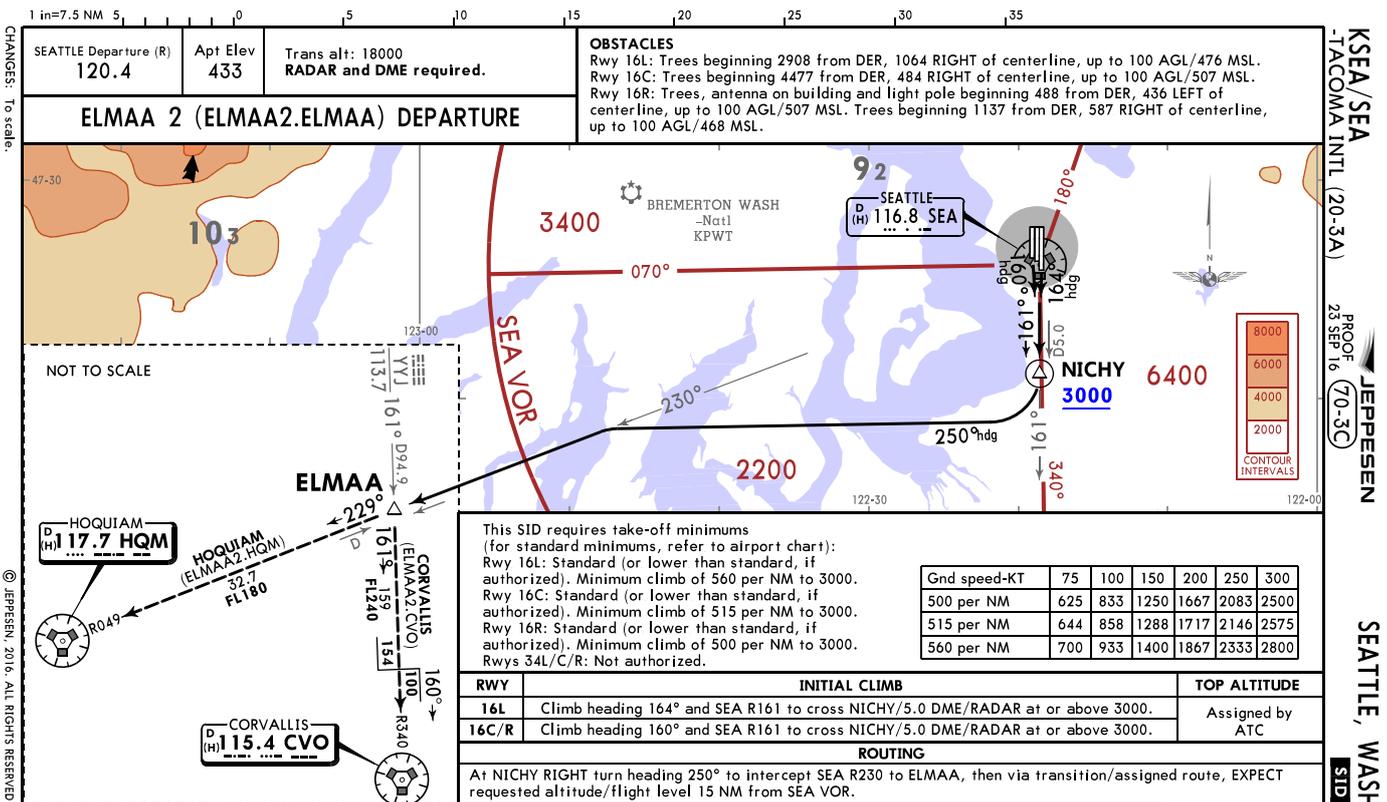


EGLL/LHR STAR (New Design)

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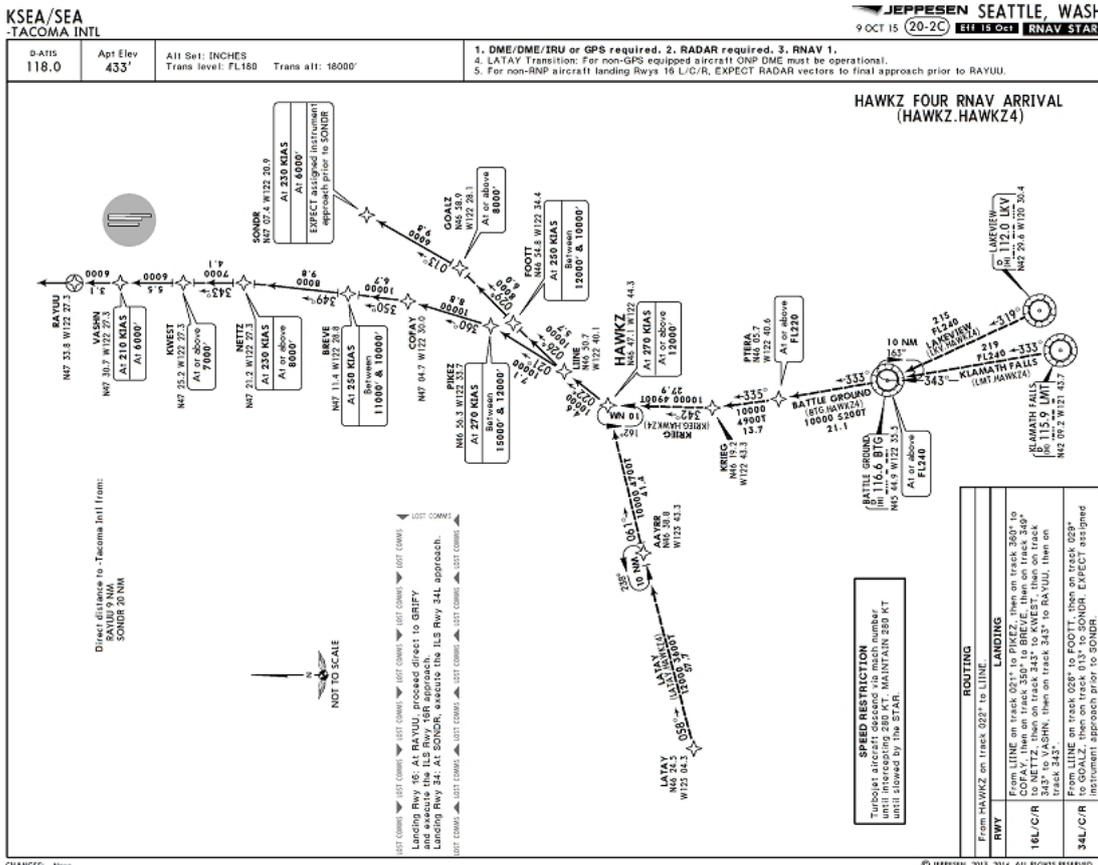


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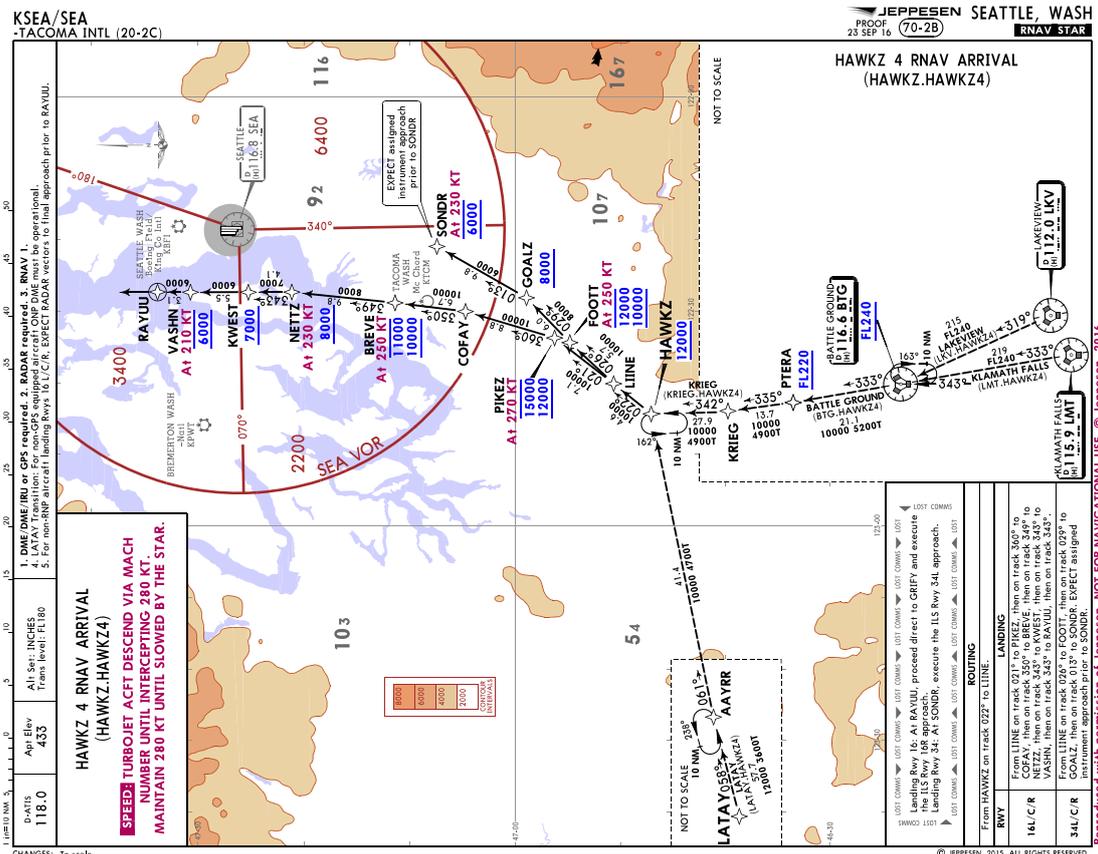


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KSEA/SEA SID (Old Design)



KSEA/SEA STAR (Old Design)



KSEA/SEA STAR (New Design)

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