

Helicopter Low Level Route Operations in Controlled and Uncontrolled Airspace

Generic Safety Case - Edition 2.1



Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

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Abstract		
<p>This document presents the results of the safety assessment for helicopter operations on IFR Low Level Route (LLR) in controlled and uncontrolled airspace.</p> <p>This generic safety case covers the different lifecycle stages of the change from definition to operation. It includes all the details/rationale for the safety assessment.</p> <p>A local safety assessment should be conducted based on this document to verify completeness and correctness of the generic safety case considering the local operational environment and any specific local regulation.</p> <p>The Project Owner shall verify that the Safety argument presented in this generic safety case is applicable and acceptable for the local deployment. This safety argument should be presented and accepted by the Competent Authority.</p> <p>The deployment of helicopter Low Level Route operations is a multi-actor change and therefore requires coordination between different stakeholders (service providers and helicopter operators). This coordination is essential to ensure a safe deployment.</p> <p>The Guidance Material for the local deployment based on this generic safety case will be provided through an Excel database or a Web Based Tool (still under finalisation). The main objective of this tool is to facilitate the identification of the applicable requirements for the local implementation and to provide specific guidance on some of the requirements.</p> <p>This document is the second release of the LLR Generic Safety Case which include the assessment of additional feature (optimal transition to existing approach) and the refinement of the existing analysis and requirements.</p>		
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EXECUTIVE SUMMARY

This document presents the results of the safety assessment for helicopter operations on IFR Low Level Route (LLR) in controlled and uncontrolled airspace and considering RNP 1 and RNP 0.3 route. This document covers the different lifecycles of the change from definition to operation.

A local safety assessment should be conducted based on this report to verify completeness and correctness of the generic safety case report considering the local operational environment and any local specific local regulation.

The Project Owner shall verify that the Safety argument presented in this generic safety case is applicable and acceptable for the local deployment. This safety argument should be presented and accepted by the Competent Authority.

The deployment of helicopter Low level Route operations is a multi-actor change and therefore requires coordination between different stakeholders (service providers and helicopter operators). This coordination is essential to ensure a safe deployment.

The Guidance Material for the local deployment based on this generic safety case will be provided through an Excel database or a Web Based Tool (still under finalisation). The main objective of this tool is to facilitate the identification of the applicable requirements for the local implementation and to provide specific guidance on some of the requirements.

This document is the second release of the LLR Generic Safety Case which include the assessment of additional feature (optimal transition to existing approach) and the refinement of the existing analysis and requirements.

This generic safety case provides a list of safety requirements for implementation and operations (listed in section 6) addressing normal operational conditions, abnormal operational conditions and failure conditions. Different sets of requirements have been identified to cover the different possible implementations (controlled and uncontrolled airspace, with or without optimal transition to existing approach). Furthermore the assumptions, recommendations and issues (listed in section 10) should be taken into account for the local implementation.

The Safety Requirements for implementation and operation created or amended compared to the previous version of the document are highlighted in bold in the tables of the present document.

This generic safety case presents the assurance that the Safety Requirements are complete, correct and realistic for this type of operations in controlled (Class C, D and E) and uncontrolled (Class G) airspace.

In uncontrolled airspace several aspects have been identified to mitigate the risk of mid-air collision like the establishment of Radio Mandatory Zones (RMZ), blind-call transmissions, depiction of the helicopter Low Level Route on VFR charts to inform all airspace users, AIC publication and use of on-board traffic advisory systems or equivalent systems to enhance the see and avoid between IFR helicopters and other aircraft in the vicinity (VFR or IFR). The implementation of these safety requirements should be decided locally by the Project Owner in charge of the local safety case considering the number of simultaneous flights planned on the Low Level Routes, the traffic density in the vicinity of the route considering all airspace users, the complexity of the airspace, the availability or not of Flight Information Service, etc... A new Mid Air Collision Risk Model in

uncontrolled airspace was developed within the frame of this generic safety case and could support the local assessment of the Mid Air Collision risk and the decision about the applicability of several Safety Requirements. For the time being only the simplified risk model is proposed in the Annex of this generic safety case and the detailed model will be available on demand.

In controlled and uncontrolled airspace several abnormal conditions (external events possibly affecting the safety of the operations) have been identified at generic level and have been mitigated by the definition of contingency procedures at the helicopter operator level. The completeness and correctness of these generic mitigations shall be verified by the operator and/or ANSPs\Competent Authorities considering the specificities of the local operational environment (e.g. obstacle-rich environment or flat areas, possible reliance on conventional nav aids, helicopter equipment, etc...).

Several requirements are dedicated to the optimal transition from the Low Level Route to an existing ILS or RNP approach in controlled airspace. These requirements mainly relate to procedure design (optimal 2D and vertical design in order to ensure a smooth transition) and integration of the helicopter into the approach sequence.

1 Generic safety case report

1.1 Purpose of the document

This document presents the results of the safety assessment for helicopter operations on IFR Low Level Routes (LLR) in controlled and uncontrolled airspace in the form of a generic safety case report.

This document supports a local safety case, addressing helicopter operations on the Low Level Route network, and the acceptance by the Competent Authority. In controlled airspace the safety assessment should be presented and coordinated by the Air Traffic service Provider whereas in uncontrolled airspace it is the Air Traffic service Provider and/or the helicopter operator who should present and coordinate the safety assessment.

This generic safety case was developed under the umbrella of the FLAG Helicopter Group which was created originally as an advisory group for the 5-Lives H2020 project co-funded by the European GNSS Agency.

The FLAG is supported by EUSPA (former GSA), EUROCONTROL and EASA and is now composed of a representative group of European helicopter operators, ANS providers, regulatory and national aviation authorities in order to harmonize the implementation of E-GNSS operations for rotorcraft in Europe.

Contributors involved in the development of this generic safety case:

- EUROCONTROL Safety Lead with the support of program, navigation and standardisation units
- Authorities: ANAC, DSAC, ENAC, FOCA and EASA
- Helicopter operators: REGA (Switzerland); Norskluftambulanse (Norway); BABCOCK France, Spain, Sweden, Portugal, Italy; NucleoElicotteri and Airgreen (Italy); BMI (Austria); Sécurité Civile (France); OEAMTC (Austria)
- Helicopter manufacturers: AIRBUS and LEONARDO
- ANSPs: AUSTROCONTROL, DSNA, ENAV, Skyguide and NAV Portugal
- Engineering and project coordination: PildoLabs

Six safety workshops in total have been organized to consolidate the development of this generic safety case. Coordination with EASA and ICAO operations AWO Helicopter panels has also been organised for joint reviews, contributions and dissemination.

It should be noted that content of this generic safety case has already been considered to develop some local safety cases.

1.2 Scope of the document

The scope of this document addresses the different lifecycles from definition to operation for helicopter operations on IFR Low Level Routes in controlled airspace (Class C, D and E) and uncontrolled airspace (Class G).

1.3 Intended readership

This generic safety case report is intended to be read and used by the following organizations:

- ANSPs
- Helicopter Operators
- Competent Authorities (EASA, National Supervisory Authorities,...)
- Other stakeholders interested in deploying LLR operations.

1.4 Safety assessment background

The following safety documents/presentations have been considered:

- SESAR Sol#113, DEL04.10-D11 “SESAR SOLUTION GUIDANCE (LLR)”
- Clean Sky (Garden/Care): Safety analysis of SNI Aircraft and Rotorcraft IFR operations at airport.
- NLR Study for implementation of IFR GA operation in airspace Class G in Switzerland (NLR-CR-2014-049)
- HELIOS Safety Assessment of IFR in Class G Airspace (P1756D4000)
- DGAC Démonstration de sécurité- Mise en œuvre de procédures de type « Point In Space » (PinS) dans le cadre du groupe de travail Hélicoptères Tout Temps (HTT)
- SESAR PROuD Local Safety Assessment (Norway and Switzerland)

1.5 Abbreviations

Term	Definition
A/C	Aircraft
ADS-B	Automatic Dependent Surveillance-Broadcast
AFARP	As Far As Reasonably Practicable
AFCS	Automatic Flight Control System
AFM	Aircraft Flight Manual
AGL	Above Ground Level
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
AIROPS	Aircraft Operations
AIS	Aeronautical Information Service
AISP	Aeronautical Information Service Provider
ALT	Altitude
AMC	Acceptable Means of Compliance
ANP	Actual Navigation Performance
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
AP	AutoPilot
ARG	Argument
ASD	Airspace Design
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSEP	Air Traffic Safety Electronics Personnel
ATSP	Air Traffic Service Provider
CAA	Civil Aviation Authority
Cb	Cumulonimbus
CNS	Communication Navigation Surveillance
CFIT	Controlled Flight Into Terrain
CR	Common Requirements
CTR	Control zone
DME	Distance measuring equipment
EASA	European Aviation Safety Agency
EFB	Electronic Flight Bag
EGNOS	European Geostationary Navigation Overlay Service
E-GNSS	Enhanced GNSS
EUSPA	EU Agency for the Space Programme

Term	Definition
ESSP	European SBAS Service Provider
FAA	Federal Aviation Administration
FATO	Final Approach & Take-Off area
FHA	Functional Hazard Assessment
FIS	Flight Information Service
FISO	Flight Information Service Officer
FL	Flight Level
FMP	Flow management Position
FMS	Flight Management System
FPD	Flight Procedure Design
FPLN	Flight Plan
FS	Functional System
GA	General Aviation
GNSS	Global Navigation Satellite System
GPS	Global Positioning system
GSN	Goal-Structuring Notation
HAZID	HAZard IDentification
HEMS	Helicopter Emergency Medical Service
HMI	Human Machine Interface
HTAWS	Helicopter Terrain Awareness and Warning System
HW	Hardware
ICAO	International Civil Aviation Organization
ID	Identification
IFP	Instrument Flight Procedure
IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IMP	IMPlmentation
IR	Implementing Rule
LA	Landing Accident
LLR	Low Level Route
LOC	Loss of Control
LOC-I	Loss of Control-Inflight
MAC	Mid Air Collision
MET	Meteorological
MOC	Means Of Compliance
MSAW	Minimum Safe Altitude Warning
ND	Navigation Display

Term	Definition
NMAC	Near Mid Air Collision
NM	Network Manager
NOTAM	Notice to Airmen
NSA	National Supervisory Authorities
OE	Operational Environment
OHA	Operational Hazard Assessment
OPE	OPERation
OPS	Operations
PANS	Procedures for Air Navigation Services
PBN	Performance Based Navigation
PinS	Point in Space
PSSA	Preliminary System Safety Assessment
QNH	Query: Nautical Height
RAIM	Receiver Autonomous Integrity Monitoring
RCS	Risk Classification Scheme
RE	Runway Excursion
RM	Risk Model
RMZ	Radio Mandatory Zone
RNAV	Area Navigation
RNP	Required Navigation Performance
RT	Radio Transmission
SAC	Safety Criteria
SAR	Search and Rescue
SARPS	Standards And Recommended Practices
SBAS	Satellite Based Augmentation System
SDD	Service Definition Document
SC	Severity Classification
SCGM	Safety Case Guidance Material
SCS	Severity Classification Scheme
SERA	Standardized European Rules of the Air
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departure
SIS	Signal in Space
SMS	Service Safety Management System
SoL	Safety Of Life
SR	Safety Requirement
SRS	Safety Requirement at Service Level
SRM	Safety Reference Material

Term	Definition
SSA	System Safety Assessment
STAR	Standard Arrival Route
STC	Supplement Type Certificate
SW	Software
TAS	Traffic Advisory System
TBD	To Be Determined
TC	Type Certificate
TCAS	Traffic Alert and Collision Avoidance System
TL	Transition Level
TMA	Terminal Manoeuvring Area
TMZ	Transponder Mandatory Zone
TRANS	TRANSition
TSE	Total System Error
TSO	Technical Standard Order
UIMC	Unintended Flight in IMC
VFR	Visual Flight Rules
VLA	Very Light Aircraft
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range
V&V	Validation and Verification
WPT	Waypoint

1.6 Definitions

Term	Definition
Competent Authority	Means one or more entities designated by a Member State and having the necessary powers and allocated responsibilities for performing the tasks related to certification, oversight and enforcement in accordance with the EASA Basic Regulation ((EU) No 2018/1139) and with the delegated and implementing acts adopted on the basis thereof, and with Regulation (EC) No 549/2004.
Electronic Conspicuity	Electronic Conspicuity (EC) is an umbrella term for a range of technologies that, in their most basic form, transmit the position of the host aircraft to other airspace users operating compatible equipment. More advanced devices can also transmit and receive, displaying and alerting pilots from other/conflicting traffic who have compatible EC devices. EC devices turn the traditional 'see and avoid' concept into 'see, BE SEEN, and avoid'. Definition from CAA UK (see CAP 1391)

Term	Definition
FLARM	FLARM is a traffic awareness and collision avoidance technology for General Aviation, light aircraft, and UAVs. FLARM is an electronic system used to selectively alert pilots from potential collisions between aircraft. It is not formally an implementation of ADS-B, as it is optimized for the specific needs of light aircraft, not for long-range communication or ATC interaction.
Hazard	Any condition, event, or circumstance which could induce harmful effects (e.g. an accident). This covers both pre-existing aviation hazards (not caused by ATM/ANS functional systems) and “system-generated hazards” i.e. new hazards introduced by the failure of the ATM/ANS functional systems
HEMS	<p>Helicopter Emergency Medical Service (HEMS) – A flight by a helicopter operating under a HEMS approval, the purpose of which is to facilitate emergency medical assistance, where immediate and rapid transportation is essential, by carrying:</p> <ul style="list-style-type: none"> • Medical personnel; or • Medical supplies (equipment, blood, organs, drugs); or • Ill or injured persons and other persons directly involved.
Level	‘level’ means a generic term relating to the vertical position of an aircraft in flight and meaning variously, height, altitude or flight level ([RD 4])
Operational hazard	A “system-generated” hazard (i.e. which results from failure of the ATM/ANS functional system) identified at the level of the Operational services delivered to the airspace user i.e. a level that is independent of the architecture of the system
RNP	There are several different levels of RNP. A performance value of RNP 0.3, for example, assures that the aircraft has the capability of remaining within 0.3 of a nautical mile to the right or left side of the centreline 95 percent of the time. In addition an on-board performance monitoring is required for RNP: the aircraft, or aircraft and pilot in combination, is required to monitor the Total System Error (TSE), and to provide an alert if the accuracy requirement is not met or if the probability that the TSE exceeds twice the accuracy value (0.6Nm for RNP 0.3) is larger than 10 ⁻⁵ .
SBAS	Satellite-based augmentation system (SBAS). A wide coverage augmentation system in which the user receives augmentation information from a satellite-based transmitter.

1.7 Reference material

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- [RD 3] Guidance to Apply the SESAR Safety Reference Material, Edition 00.03.01, 14th of December 2018
- [RD 4] (EU) No 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation (SERA)
- [RD 5] (EU) No 2020/587 laying down requirements for the performance and the interoperability of surveillance for the single European sky
- [RD 6] (EU) No 2017/373 common requirements for providers of ATM/ANS
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- [RD 27] EUROCONTROL European Airspace Concept Handbook for PBN Implementation Ed 4.0
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[RD 30] EASA CS-ACNS issue 3 October 2021

2 Background on current VFR helicopter operations

2.1 Description of current operations

Currently, most low level helicopter operations are conducted under Visual Flight Rules where the “see and avoid” principle prevails. For helicopters at and below 900 m (3 000 ft) above MSL or 300 m (1 000 ft) above terrain, whichever is the highest:

- By day (see [RD 4] SERA 5001):
 - in airspace classes F and G, flight visibility shall not be less than 800 m, provided that the pilot maintains continuous sight of the surface and if manoeuvred at a speed that will give adequate opportunity to observe other traffic or obstacles in time to avoid a collision;
 - in airspace classes B,C, D and E, flight visibility shall not be less than 5 km, the distance from cloud being not less than 1 500 m horizontally and 300 m (1 000 ft) vertically;
- At night: flight visibility shall not be less than 5km, provided that the pilot maintains continuous sight of the surface and the ceiling is not less than 450 m (1 500 ft) (see [RD 4]: SERA 5005 (c) 3));

Flight visibility minima lower than those specified above may be permitted for helicopters in special cases, such as medical flights, search and rescue operations and fire-fighting. (see [RD 4] SERA 5001 and 5005);

Different helicopter operators conduct different missions: HEMS, private transport, law enforcement, aerial work, oil platforms, etc;

This low level part of the airspace is shared with other type of aircraft such as Ultralight, Very Light Aircraft, gliders in particular in the vicinity of airports in airspace class G.

Usually, helicopter operators have to face significant weather and terrain-related challenges when performing specific flight operations (e.g. civil transport, medical emergencies, etc.). For those reasons and for decades, helicopter operations were suitably confined to flying only when they could meet strict visibility standards (VFR), limiting drastically their access in controlled airspace and accordingly the operations to and from airports. In addition, low cloud, fog, rain, snow, the presence of mountains and valleys could seriously affect safety and success of concerned operations.

Nowadays, the GNSS technology enhanced by SBAS systems (without the need of ground infrastructures) allows designing specific instrument (IFR) routes at low level. The GNSS technology provides the appropriate accuracy, integrity and availability for these new helicopter operations in controlled or uncontrolled airspace. Furthermore, the ICAO PBN concept [RD 17], thanks to the development of RNP1 and RNP0.3 navigation applications, makes a wide range of benefits available, facilitating the full integration of helicopter operations into the ATM system.

Dedicated helicopter narrow corridors (Low Level IFR routes) not only increase the TMAs’ sectors capacities, but should improve safety, flight efficiency, equity, accessibility and reduce the environmental impact (noise and pollution) in the airspace within the Terminal Manoeuvring Area (TMA).

Current IFR helicopter advanced on-board avionics are compliant with the technical system requirements needed to fly these routes with a very high accuracy (RNP1/RNP0.3) within 1.0/0.3 nautical miles on either side of the nominal flight path at least 95 percent of the time.

This translates into a greater ATCO confidence in the track-keeping performance of traffic movements, allowing placing routes closer together.

IFR Low Level Routes represent the best facilitation to allow helicopter operations in controlled

airspace and at the same time, they support connectivity between airports/heliports included in the TMA airspace, thanks to the implementation of PinS – Point in Space procedures concept providing a consistent path for navigation for the whole flight. Helicopter Routes can also be lower than the usual routes due to the smaller protected airspace (area) and shorter routings for helicopter operations limiting noise and environmental factors.

Helicopters reach their best operational performances when flying unconstrained in VFR, an operating mode heavily dependent upon weather conditions and visibility. However, this way of operating can be adversely affected by fog, cloudy weather or icing conditions, which can prevent helicopters from proceeding under VFR or make them subject to delays when operating to/from a controlled airspace (i.e: CTR) in a dense medium complexity ATM airspace.

Currently, all modern twin engine helicopters are IFR certified and characterized by advanced avionic standards. When flying in IFR mode, due to the lack of helicopter-specific routes and flight procedures, they will fly the same flight routes (airways) originally designed for fixed-wing aircraft.

These routes, being specifically designed for fixed-wing aircraft, are constraining for helicopters with important limitations on their operations, as they have flight profiles which are not optimised for this category of operations. In particular, helicopters have different needs, capabilities and performances in terms of descent rate and speed profile.

Forcing helicopters along the same routes designed for fixed wing can delay their operations to/from airports, and to/from airspace with a negative impact on the operations of both helicopters and commercial fixed-wing aircraft, increasing also Air Traffic Controllers' workload.

In current operations, arriving and departing helicopters are inserted in a managed airspace structure within published routes and procedures, whereby helicopters' specific needs are not taken into account. Rather than proceeding directly to a final destination, helicopters are routed in such a way that additional flight time is required, fuel management becomes a critical factor and delay can make the difference between life and death for rescue operations.

Further, and keeping in mind synchronisation of air and ground trajectories, helicopters' flight plans can be modified during the flight for a lot more reasons than a fixed-wing A/C, such as weather change, local routings that are unknown to aircrew, change messages being delayed or not treated...). Last but not least, those changes are not always known by all actors involved in the control of the flight.

In order to avoid such shortcomings for helicopters, future harmonisation and developments are essential.

2.2 Safety of current operations

Accident/incident data are insufficient when narrowed down to VFR operations due to a lack of accurate exposure data.

However, a literature survey shows that helicopter operations are becoming increasingly safer but still suffer from fatal accidents. Better equipment and better training have helped to reduce by half the mortality in Europe and the US over the last 6 years.¹

In 2016, the FAA provided the following figures over a period ranging from 2009 – 2013² (*analysis of 104 helicopter crashes*):

- 16 % of crashes were classified UIMC (Unintended Flight in IMC), highest just after the LOC (Loss of Control),
- second highest rate of crashes were rescue operations after private transport.

¹ Article "Helicopter Safety News", March 8th 2017, provided by IHST (International Helicopter Safety Team) - <http://www.ihst.org/> -

² 2016 Rotorcraft Safety Conference- FAA – "Accidents Investigations Lessons learned" – M. Hemann and S. Tyrell - https://www.faa.gov/news/conferences_events/2016_rotorcraft_safety/

According to pilots, deteriorating weather conditions are the main factor towards UIMCs. Weather reports are neither easily nor quickly obtained for an emergency take off; nor precise enough as they do not cover disturbances created by the terrain, or are simply outside from the MET coverage network. Rescue operations are especially concerned since they will operate in difficult or hostile surroundings with a high stress factor for the pilot due to the time constraint of the operation.

Further limitations/elements will impact the safety of operations:

- Helicopters not approved for IFR operations: flights in adverse weather conditions cannot be conducted. This seriously reduces the number of rotations. Operators hesitate to convert to IFR due to high and often long routing IFR routes, resulting in an increased risk for VFR operations in poor weather and/or inadvertent IMC. Inadvertent IMC has been one of the highest causes of accidents – with operators often not investing in training and certifying for this capability – An infrastructure for helicopter operations at low level could encourage commercial investment in more IFR capabilities, enhancing safety in the sector.
- The transition of daylight to night is recognised as being difficult to handle for the pilots as their vision and the sharpness of contrast rapidly diminishes,
- Changing weather conditions (in or near mountains, forests, sea) can rapidly lead to dangerous situations for the crew and passengers,
- Sharp increase in Ultralight, VLA, gliders traffic and the complexity of the mix with other traditional users is leading to a situation where the “see and avoid” principle becomes more and more difficult to apply,
- Obstacles (windmill fields, cranes, etc) are not always clearly identified,
- Technical issues such as de-icing and anti-icing equipment, etc.
- Missing helicopter dedicated IFR Infrastructure
- Missing local weather information for the low level part of the flight
- Missing dedicated CNS low level infrastructure (such as ADS-B)
- Missing accurate obstacle and terrain data

3 IFR Low Level Route Change overview

3.1 Concept of Operations

The introduction of RNP will optimise route structures and automation. The helicopter operational specificities and airspace management needs can be matched by developing PBN based Low Level IFR routes.

A RNP Low Level Route is an IFR route designed for helicopter operations which could be connected to PinS departures and approaches and/or other existing routes/SID/STAR/Approaches. The route can be designed according to different Navigation Specifications. RNP1 and RNP0.3 can be considered according to airspace constraints, which imply a tighter semi-width corridor for RNP 0.3.

The Fixed Radius Turn (FRT) applicable to en-route segment are not considered in this version of the generic safety case because its use on LLR was not considered to be sufficiently mature at that stage, only the use of Track to Fix (TF) is considered. RF (Radius to Fix) legs which are specific curve paths are an optional capability to use with RNP 1 and RNP 0.3 Navigation Specifications rather than a minimum requirement but are not applicable to en-route segment.

The route might be a bidirectional Low Level Route if procedures are in place to prevent its simultaneous use or if vertical separation is provided (i.e. 2000ft one way, 3000ft the opposite).

Design requirements are already defined: RNP 1 in general and RNP 0.3 where required or necessary (constraining environment). According to the ICAO PBN manual, chapter 7 “implementing RNP0.3”, a number of navigation systems using GNSS for positioning are capable of performing RNP0.3 operations if suitably integrated into the flight display system.

The RNP0.3 specifications take advantage of known functionality, on-board performance monitoring and alerting capability of many TSO-C145/C146 GPS systems, which are installed in a wide range of IFR helicopters.

The RNP0.3 Navigation specification would identify a single accuracy requirement for all phases of flight: lateral accuracy of ± 0.3 NM for at least 95% of the total flight time. Furthermore an on-board performance monitoring is required for RNP: the aircraft, or aircraft and pilot in combination, is required to monitor the Total System Error (TSE), and to provide an alert if the accuracy requirement is not met or if the probability that the TSE exceeds twice the accuracy value (0.6Nm for RNP 0.3) is larger than 10^{-5} . To the extent operational procedures are used to satisfy this requirement, the crew procedures, equipment characteristics, and installation are evaluated for their effectiveness and equivalence. This principle being applicable from departure to the final approach fix: en-route operations, arrival and departure procedures and initial and intermediate approaches. This enables the design of narrow routes with reduced protection which are width based on this accuracy requirement.

The RNP0.3 operations require on-board performance monitoring and alerting function based on 0.3NM for all phases of flight. The use of coupled AFCS (Automatic Flight Control System) for all RNP0.3 operations is strongly recommended in order to comply with the required performance (TSE).

The RNP0.3 specification is based on GNSS; its implementation with regard to LLR is not dependent on the availability of SBAS.

General requirements for PBN are provided in [RD 17], for designing RNP routes in [RD 7] and for airworthiness in [RD 15] and [RD 16].

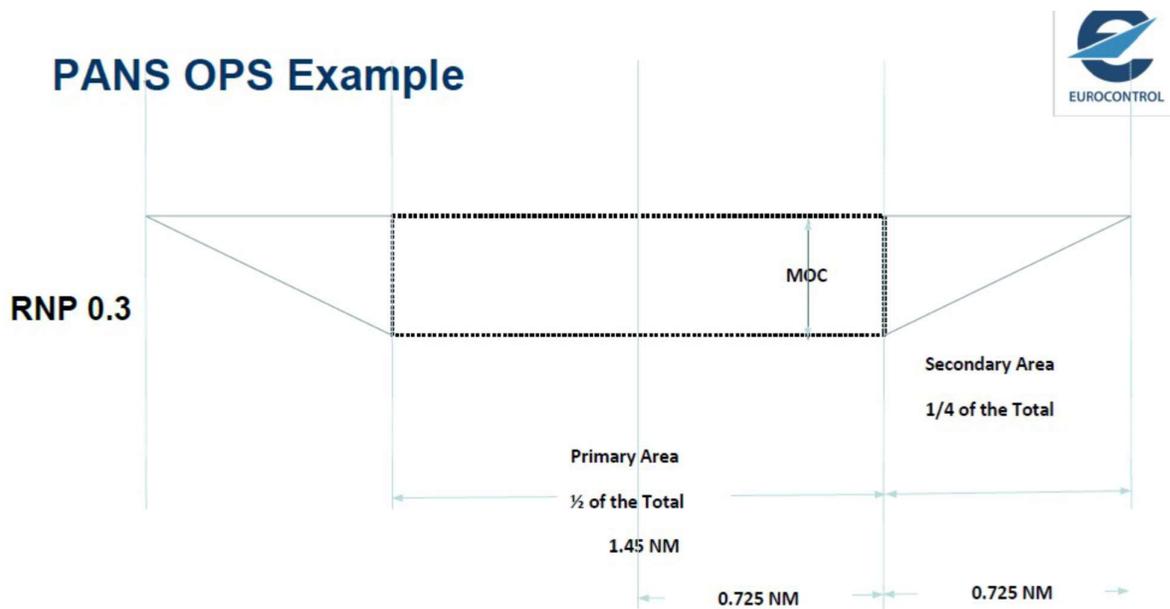
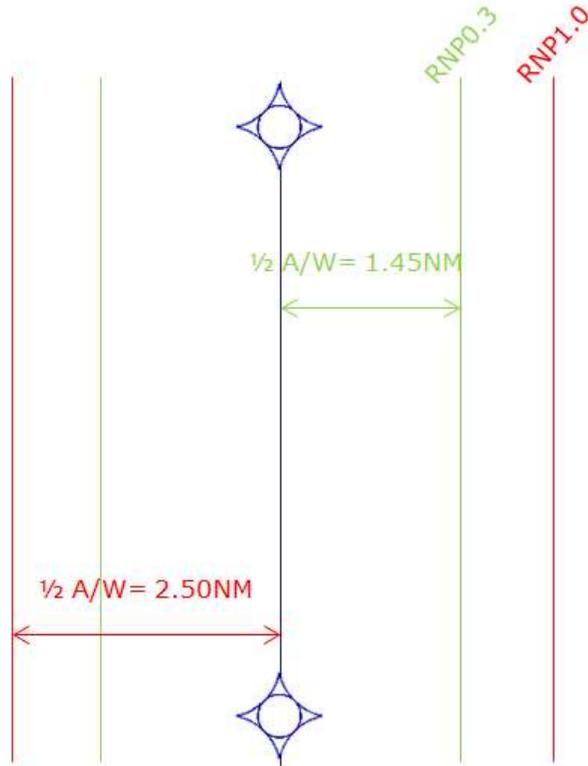


Figure 3-1 Low-Level route protection areas
 (> 30 Nm from aerodrome reference point)

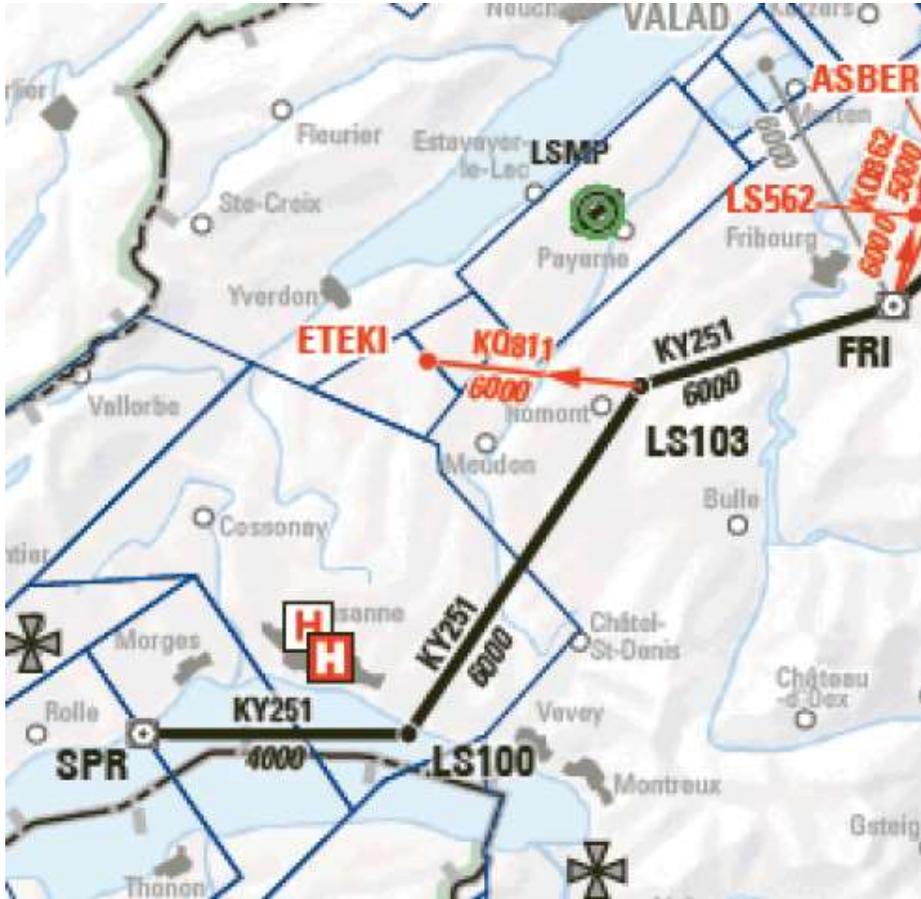


Figure 3-2 Example of RNP0.3 LLR (source: Skyguide)

3.1.1 Optimal transition to existing approach

As mentioned previously, for the landing phase, the LLR can be connected either to a PinS approach or to an existing approach. The PinS approach are assessed in a specific safety case. This section describes the concept of operation for the transition from LLR to an existing approach (PBN or conventional approach).

Such transition could be useful in order to provide more flexibility for planning an alternate. Such transition could also be useful as a contingency procedure.

One of the main challenge when implementing such concept it to enable an optimal transition between the LLR and the approach procedure, without for instance forcing the helicopter to climb to a higher level to capture the approach segment.

Such concept relies on Air Traffic Service in order to integrate the helicopter in the arrival sequence and to ensure appropriate separation between the helicopter and aircraft. For this reason, only the controlled airspace is assessed in current document.

Two possible solutions of transition to existing approach can be planned

- LLR network is directly connected to the existing approach at the IAF. This solution is illustrated on Figure 3-3 below. In order to ensure efficient operation, this solution would require that the altitude of the IAF is consistent with the altitude of the LLR (to avoid an important climb of the helicopter in order to join the approach)
- A new initial approach segment is published in order to efficiently connect the LLR to the existing approach. This solution is illustrated on Figure 3-4 below.

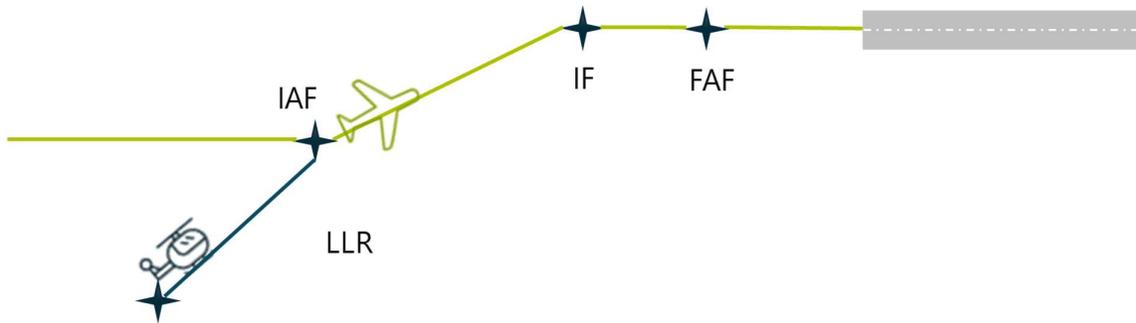


Figure 3-3: Illustration of the transition to existing approach – Option 1

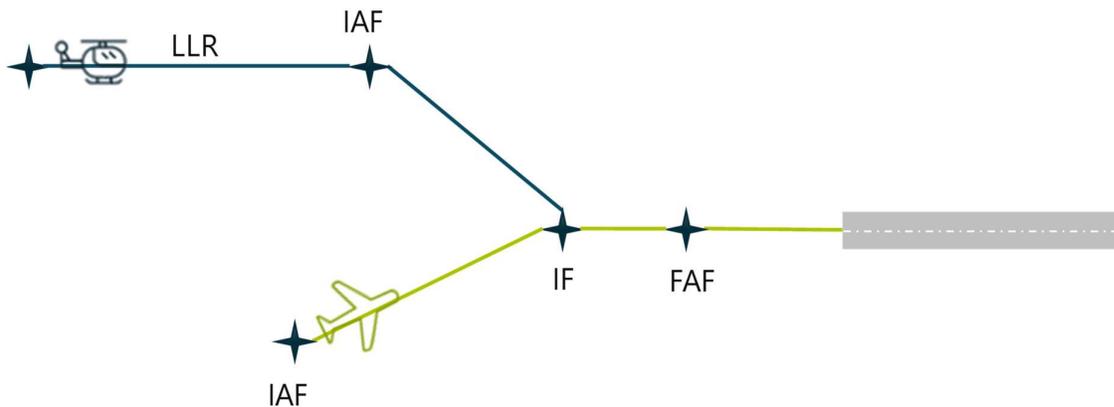


Figure 3-4: Illustration of the transition to existing approach – Option 2

The option 1 is the easiest one but might not be efficient in most situation, in particular in case of a IAF higher than the level of the Low Level Route. This option remains possible and will not require any additional requirement. Consequently, the present document focuses on the assessment of the option 2 with the design and publication of an initial approach segment to join the existing approach.

The main characteristics of the transition to existing approach are the followings

- Procedure design
 - New initial approach segment is designed connecting the LLR and the existing intermediate segment of the approach
 - The procedure design needs to take into account the level of the LLR in order to ensure a smooth transition with the approach on vertical aspects
 - The procedure design needs to take into account the performance of the helicopter in order to enable a smooth transition with the approach on lateral aspects (i.e. avoid overshoot of the approach axis)
- Operating method: The operating method are similar to the ones applicable for the management of aircraft approach. A specific focus for the integration of the helicopter in the aircraft sequence is needed from Air Traffic Control point of view.

The optimal transition to existing approach is considered as a possible additional feature to normal LLR. Dedicated safety requirements are defined in the present document and are clearly identified in the different tables of requirements in next sections of the document.

3.2 Operational Environment key characteristics

In this section, the following key relevant characteristics of the Low Level Route operational environment are reviewed, as these are expected to influence the helicopter operations safety risk assessment:

- Route structure
- Controlled airspace
- Uncontrolled airspace
- Density/complexity of traffic nearby the route structure
- Weather conditions
- ATM capabilities in terms of CNS

3.2.1 Route structure

An RNP route is designed to connect this route with aerodromes/landing sites or Helicopter PinS departures and approaches or existing routes/SID/STAR/Approaches. The RNP route could be designed according to RNP 1 or RNP 0.3 requirements.

This route might be a bidirectional Low Level Route if procedures are in place to prevent its simultaneous use or if vertical separation is provided (i.e. 2000ft one way, 3000ft the opposite)..

Route levels try to be the lowest possible (e.g. from 1000 ft AGL to 3000 ft AGL) in order to prevent icing conditions, interfering with fixed-wing aircraft or unnecessary climb/descent procedures. However the level really depends on the scenario for which the route is designed.

The Low Level Route segments lengths would normally be between 20 and 60 Nm but there is no limitation in the route total length.

The Fixed Radius Turn (FRT) are not considered in this version of the generic safety case because its use on LLR was not considered to be sufficiently mature at that stage, only the use of Track to Fix (TF) is considered. Furthermore RF leg cannot be used for en-route segment.

3.2.2 Controlled Airspace

Controlled airspace, when considering Low Level Route network operations, is generally limited to airspace classes C, D or E.

In such airspace ATS services are provided in accordance with Table 3-1 which is an extract of SERA regulation [RD 4]

Class	Type of flight	Separation provided	Service provided	Speed limitation (*)	Radio communication capability requirement	Continuous two-way air-ground voice communication required	Subject to an ATC clearance
C	IFR	IFR from IFR IFR from VFR	Air traffic control service	Not applicable	Yes	Yes	Yes
	VFR	VFR from IFR	(1) Air traffic control service for separation from IFR; (2) VFR/VFR traffic information (and traffic avoidance advice on request)	250 kts IAS below 3 050 m (10 000 ft) AMSL	Yes	Yes	Yes
D	IFR	IFR from IFR	Air traffic control service, traffic information about VFR flights (and traffic avoidance advice on request)	250 kts IAS below 3 050 m (10 000 ft) AMSL	Yes	Yes	Yes
	VFR	Nil	IFR/VFR and VFR/VFR traffic information (and traffic avoidance advice on request)	250 kts IAS below 3 050 m (10 000 ft) AMSL	Yes	Yes	Yes
E	IFR	IFR from IFR	Air traffic control service and, as far as practical, traffic information about VFR flights	250 kts IAS below 3 050 m (10 000 ft) AMSL	Yes	Yes	Yes
	VFR	Nil	Traffic information as far as practical	250 kts IAS below 3 050 m (10 000 ft) AMSL	No (**)	No (**)	No

(**) Pilots shall maintain continuous air-ground voice communication watch and establish two-way communication, as necessary, on the appropriate communication channel in RMZ.

Table 3-1: ATS Airspace classes C,D &E- Services provided

3.2.3 Uncontrolled Airspace

Uncontrolled airspace is relative to airspace class G.

In such airspace ATS services are provided in accordance with Figure 3-2 which is an extract of the SERA regulation [RD 4]

Class	Type of flight	Separation provided	Service provided	Speed limitation (*)	Radio communication capability requirement	Continuous two-way air-ground voice communication required	Subject to an ATC clearance
G	IFR	Nil	Flight information service if requested	250 kts IAS below 3 050 m (10 000 ft) AMSL	Yes (**)	No (**)	No
	VFR	Nil	Flight information service if requested	250 kts IAS below 3 050 m (10 000 ft) AMSL	No (**)	No (**)	No

(**) Pilots shall maintain continuous air-ground voice communication watch and establish two-way communication, as necessary, on the appropriate communication channel in RMZ.

Table 3-2: ATS Airspace classes G- Services provided

3.2.4 Density/complexity of traffic nearby the route structure

Density/complexity of traffic nearby the route structure in controlled airspace is managed by ATC. It is assumed that a strategic separation exists between the helicopter Low Level Route and other IFR routes/SIDs/STARs as far as practicable.

For the concept of transition to existing approach (3.1.1), only the environment with low to medium traffic are assessed. For higher level of traffic, it is considered that a concept like to Simultaneous Non Interfering (SNI) operation would be required in order to ensure safe and efficient operations.

In uncontrolled airspace, it is assumed that any helicopter Low Level Route is designed to avoid, as far as practicable, areas which are already congested with other aviation activities (gliding, parachuting,...)

3.2.5 Weather conditions

All kinds of weather conditions should be considered from IMC to VMC including marginal VMC

conditions. Marginal VMC conditions are certain conditions above VMC minima, which are fairly close to one or more of the VMC minima.

3.2.6 Aircraft eligibility and ATM capabilities in terms of CNS

Helicopters are equipped and certified in accordance with the relevant airworthiness criteria including the associated certification specifications (CS 27, 29) [RD 19] and are operated according to the EASA Air Operation regulation [RD 13].

3.2.6.1 Radiocommunication

In controlled airspace radio communication is mandatory except in airspace class E for VFR traffic and if no RMZ is implemented [RD 4].

IFR helicopters must be equipped with a radio communication system in uncontrolled airspace Class G. For IFR and VFR, continuous two-way air-ground communication is required only inside an RMZ.

3.2.6.2 Surveillance

IFR helicopters are equipped with secondary surveillance radar transponders [RD 5].

In airspace class G, all aircraft must be equipped with secondary surveillance radar transponders if flying within a TMZ [RD 4].

3.2.6.3 Navigation

IFR helicopters are equipped with the navigation system able to navigate on the Low Level Route (RNP 1 or RNP 0.3) and are normally equipped with “conventional” navigation system for the en-route phase composed of at least one VOR and one DME. It should be noted that VOR and DME raw data are generally not used to compute an RNAV/FMS position. Conventional en-route, departure and approach procedures are of course still possible by using onboard VOR and DME equipment.

3.3 Current operating methods & baseline

Most of the current helicopter onshore operations are conducted in VFR.

Helicopters are mostly operated for fast and direct transportation: they can fly a direct link with virtually no delay. However, if weather conditions do not allow VFR flight (VMC not fulfilled) the flight takes on a significantly different route structure in order to fly in IMC by considering the current IFR route structure which are not optimal for helicopter operations and are sometimes not available.

Fast and direct transportation is necessary to maintain a positive profit margin. The increase in mission time is one of the main concerns. If a pilot or operator has a choice with regard to operating under VFR or IFR, many do not choose to fly IFR due to these additional time constraints. Furthermore, the current fixed-wing IFR environment very often does not offer the direct routing that helicopter operators need.

Also other factors, such as the operational level are considered. There are different reasons that lead to select the correct levels considering icing, noise abatement and efficiency issues.

- Icing is the greatest concern; indeed when flying under IFR, helicopters must fly at levels and along routes originally designated for fixed-wing aircraft. It is at those levels that icing is more likely to occur;
- At the same time, they must be aware of the noise impact of flying at lower levels that may be costly due to the potential of negative community reaction;
- The “efficiency” is a reason for selecting a lower level because it takes longer to climb to and descend from higher levels and also requires more fuel. Another concern operating IFR is the lack of alternate airports or heliports along the designated IFR routes.
Pilots are required to carry enough fuel to land at an alternate heliport in case their original destination goes below minimums or is closed due to the unforeseen circumstances such as

heavy snow, severe icing, or ground incidents/accidents. This problem is exacerbated because there are not many IFR capable alternates available along the designated routes within range of their reserve fuel supply.

- Lack of routes for helicopters below FL 140-160 because the lower route network was designed for fixed-wing aircraft.
- Lack of approach procedures to the destination which mostly is not an airfield
- IFR flight plan requirements need a lead time of at least 60 minutes and is not practical in a time of critical mission like SAR or HEMS, explaining why special regulations for such operations, approved by the competent authority, could avoid this kind of delay.

Helicopter transportation is primarily intended to be short distance. Any additional routing other than direct point-to-point eliminates the primary advantages associated with helicopter operations. Development of specific IFR routes is considered as the key enabler for enhancing flight safety and service reliability of helicopter operations. Today, satellite navigation (GNSS) and the augmentation system open the way to the development and the implementation of helicopter -specific Low Level IFR routes.

Helicopter applications (corporate, offshore oil&gas support, search & rescue, Emergency Medical Services (HEMS)) require absolute flexibility supported by point-to-point IFR access to both congested airports and inaccessible locations.

This implies, for instance, not only the development of a IFR procedure for helicopters that will not interfere with traffic requiring a runway for take-off and landing, but also a net of dedicated routes which are helicopter tailored, aiming to facilitate increased helicopter operations and to maintain a high safety level in that airspace.

The standard IFR route network constrains helicopters to fly, in most cases, significantly higher than FL60, that are levels generally not used by helicopters due the high probability to encounter icing conditions.

Moreover, e.g., HEMS operations have a strong interest to go from one hospital to another one in IFR but high levels routes are not adapted for two main reasons:

- The distance between two hospitals is generally short and it would not be efficient to climb to fly at such IFR levels;
- With some pathologies onboard, HEMS helicopters cannot climb or descend too much or too quickly without any danger for the patients as the helicopter is not pressurised.

Helicopter capabilities, coupled with a large variety of operational tasks, require a flexible and rapid response from an ATM system. However, the current ATM and airspace system have been developed essentially around fixed-wing aircraft traffic without taking into account helicopter-specific needs.

In the near future, GNSS and the PBN navigation specification within Low Level IFR routes, will allow to avoid noise sensitive populated areas, interact with the conventional air traffic without interfering, merging the actual ATM architecture with future development and operate in optimal ways in obstacle-rich urban environments, increasing availability and safety even at night and in low visibility conditions.

The introduction of RNP will optimise route structures and automation. With the support of management tools, these will grant benefits in terms of safety and flight efficiency improvements. Helicopter characteristics/needs and Airspace management needs can be matched using dedicated Low Level IFR route PBN-based.

One other benefit for having dedicated RNP route for helicopters is the absence of impact on fixed wing aircraft operations (simultaneous non-interfering operations).

3.4 New operating methods on the LLR

New operating methods will allow conducting helicopter operations in IFR on a published

Performance Based Navigation (PBN) route designed as RNP 1 or RNP 0.3.

PBN represents a fundamental shift from sensor-based to performance-based navigation and offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria, i.e. it:

- reduces the need to maintain sensor-specific routes and procedures, and their associated costs;
- avoids the need for developing sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive;
- allows for more efficient use of airspace (route placement, fuel efficiency and noise abatement);

The rationale of the new operating method is the need to properly consider all the possible air platform requirements in the development of the new ATM system allowing the correct integration of the helicopter element in the Single European Sky.

Satellite-based instrument flight procedures is radically changing the way helicopters are operated, improving intermodal transport and both ATM and flight efficiency. The goal is a synchronised and predictable European ATM system, where partners and stakeholders are aware of the business and operational situations and collaborate to optimise the network.

The introduction of RNP will optimise routes structures and automation. Helicopter characteristics/needs and Airspace management needs can be matched by developing PBN based Low Level IFR routes in several airspace classes including Medium dense / Medium complexity airspace. The Low Level Routes can be directly linked to dedicate Point in Space (PinS) arrival and departure procedures or to existing Routes/SIDs/STARs/Approaches.

This helicopter operational improvement is expected to bring significant benefits:

- increase safety operational level
- improve efficiency
- reduce marginal VMC flights
- reduce costs
- increase airspace capacity
- improve access to busy and dense/complexity TMA architecture
- reduce the environmental impact of noise and pollution (i.e.: reduce fuel burn, reduce flight time)
- improve the level of life-critical service

The helicopter operator and the flight crew should respect the operational requirements associated to the Low Level Route (RNP 1 or RNP 0.3) as defined in [RD 13]

4 Overall Safety Assurance Strategy and Safety Argument

4.1 Safety assurance strategy and argument structure

The safety assurance for helicopter operations on the IFR Low Level Route shall cover the full lifecycle:

- Definition at service level,
- Operational specification and design of the “functional system” supporting LLR helicopter operations (procedures, human resources, equipment at ground and airborne levels and for all relevant domains),
- Implementation,
- Transition into service and
- Operations including safety monitoring.

The following operating modes/conditions are addressed in this safety assessment:

- Normal operating conditions
- Degraded modes (associated to abnormal or failure conditions).

The safety assurance strategy to demonstrate that helicopter operations on the IFR Low Level Route are acceptably safe has been defined based on the following inputs:

- Safety criteria have been defined for such operations,
- All actors (service providers and operators) from each domain have been identified,
- All lifecycle stages are addressed from the definition to the operations,
- Safety requirements for all responsible actors have been allocated to support compliance with safety criteria,
- Safety requirements for all responsible actors have been satisfied during the implementation phase,
- The transition from current operations to Low Level Route operations are addressed from a safety point of view,
- The safety performance of helicopter operations on the IFR Low Level Route is monitored during the service life.

This generic safety case is proposed to be organized as a reasoned and structured safety argument substantiated by the supporting safety evidence.

The safety assurance strategy is outlined through the safety argument, break down in sub-arguments driven by the system lifecycle phases.

The safety argument is presented in the next sub-sections of the current chapter using the GSN (Goal-Structuring Notation, which provides a graphical means of setting out hierarchical safety arguments, with textual annotations and references to supporting evidence).

The summary of the safety evidences is listed in the lower part of the argument figures (blue shaded text).

The details of the safety evidence (content, justification, how it has been produced, and traceability to references or data sources) are provided in the remaining chapters of this report.

4.2 Arg 0- Overall safety argument- top level

The top level (Arg 0) of the overall safety argument for why helicopter operations on LLR are considered safe is set out in Figure 4-1: Top level safety Argument. The arguments follow the main lifecycle phases of the project from the definition to the operation throughout service life. For each of those phases evidence needs to be generated demonstrating that the selected high-level safety criteria (Cr01) are met within the defined context (C01) and considering Justification (J0001).

It should be clarified at that stage that evidence are produced only for the Specification phase (Arg 1) and Design phase (Arg 2) in this generic safety case explaining why the present tense is used for these arguments. For the other arguments (Arg 3, 4 and 5), the evidence will be developed/produced by the relevant actors during the local implementation explaining why the future tense is used for these phases (implementation, transition into service and operations).

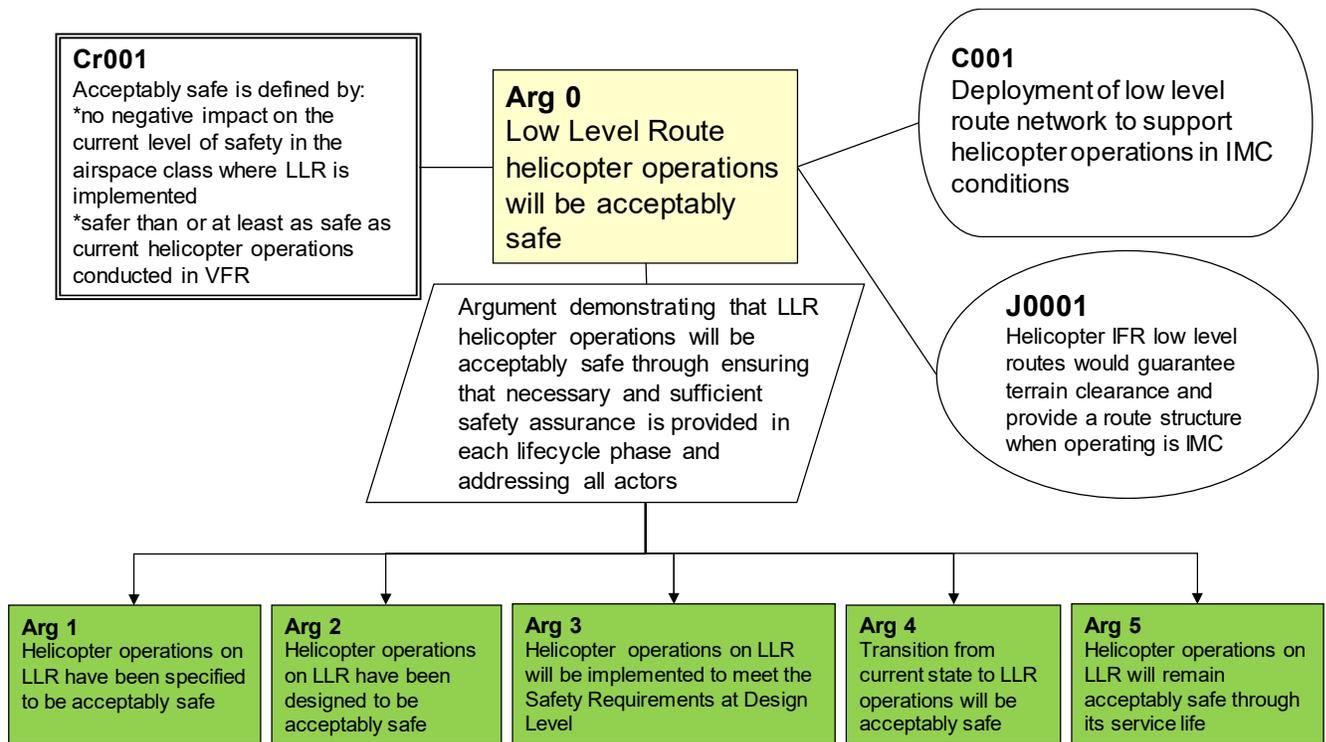
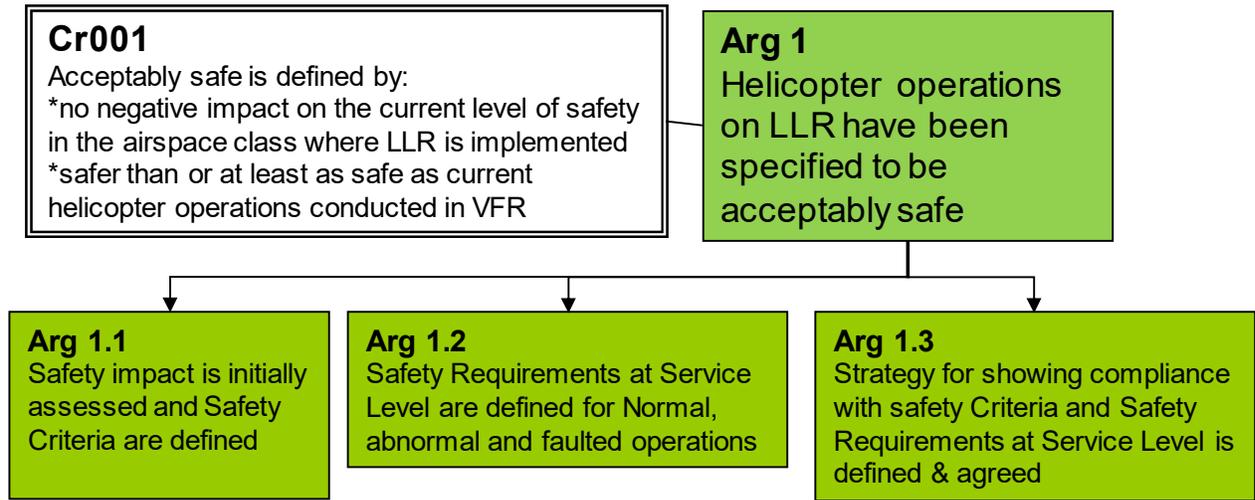


Figure 4-1: Top level safety Argument

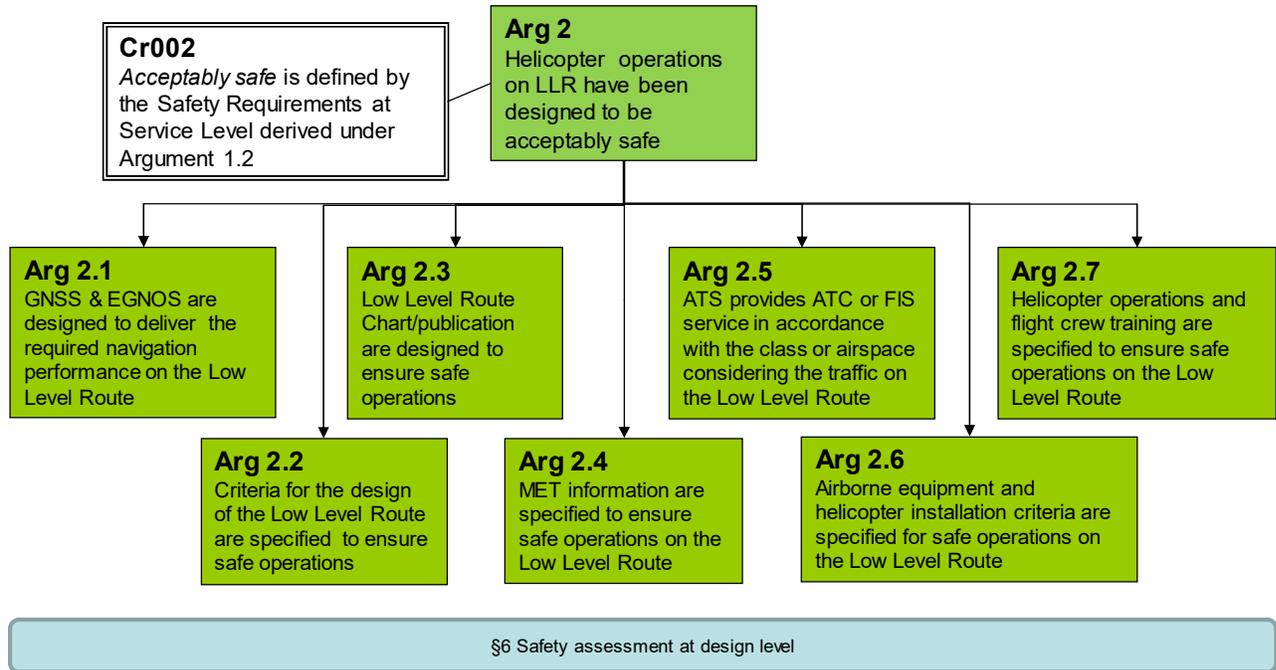
4.3 Arg 1- LLR helicopter operations have been specified to be acceptably safe



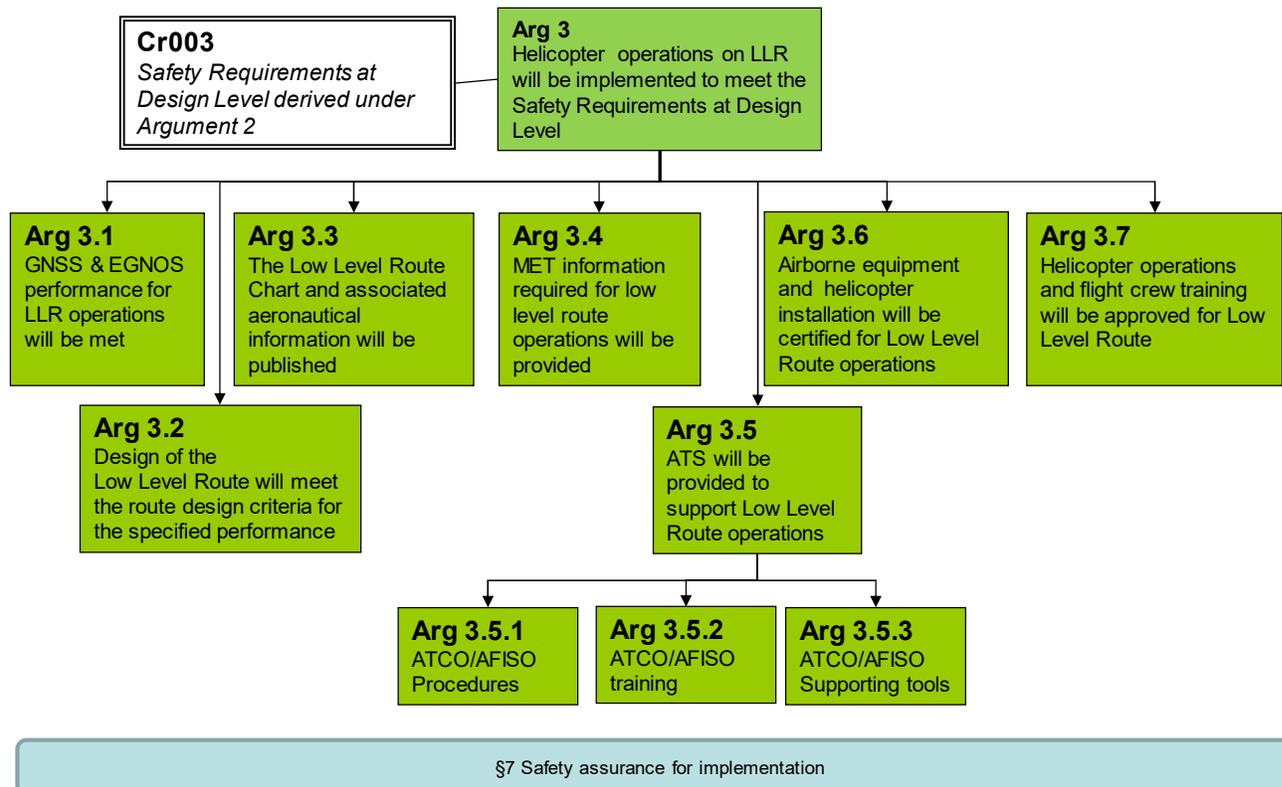
§5 Safety definition at operational service level



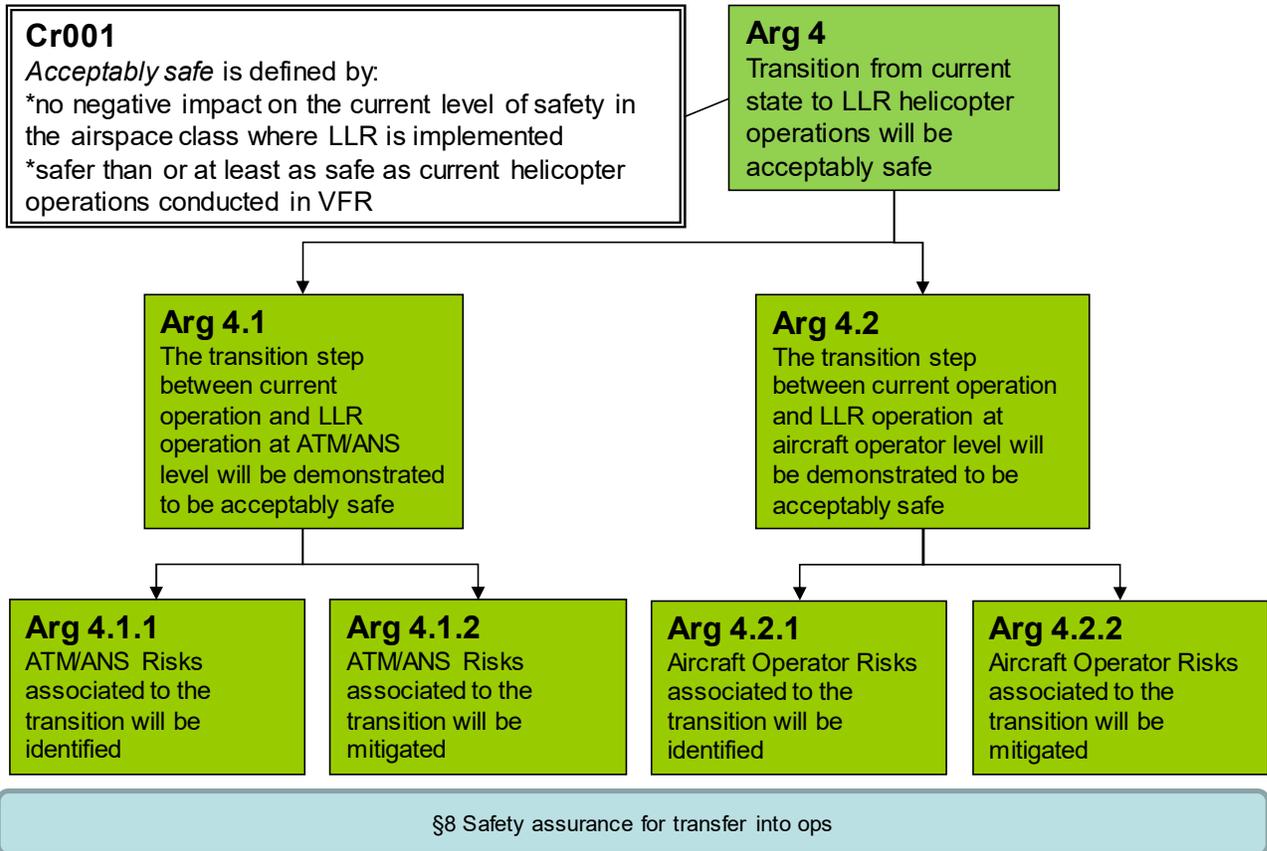
4.4 Arg 2- LLR Helicopter operations have been designed to be acceptably safe



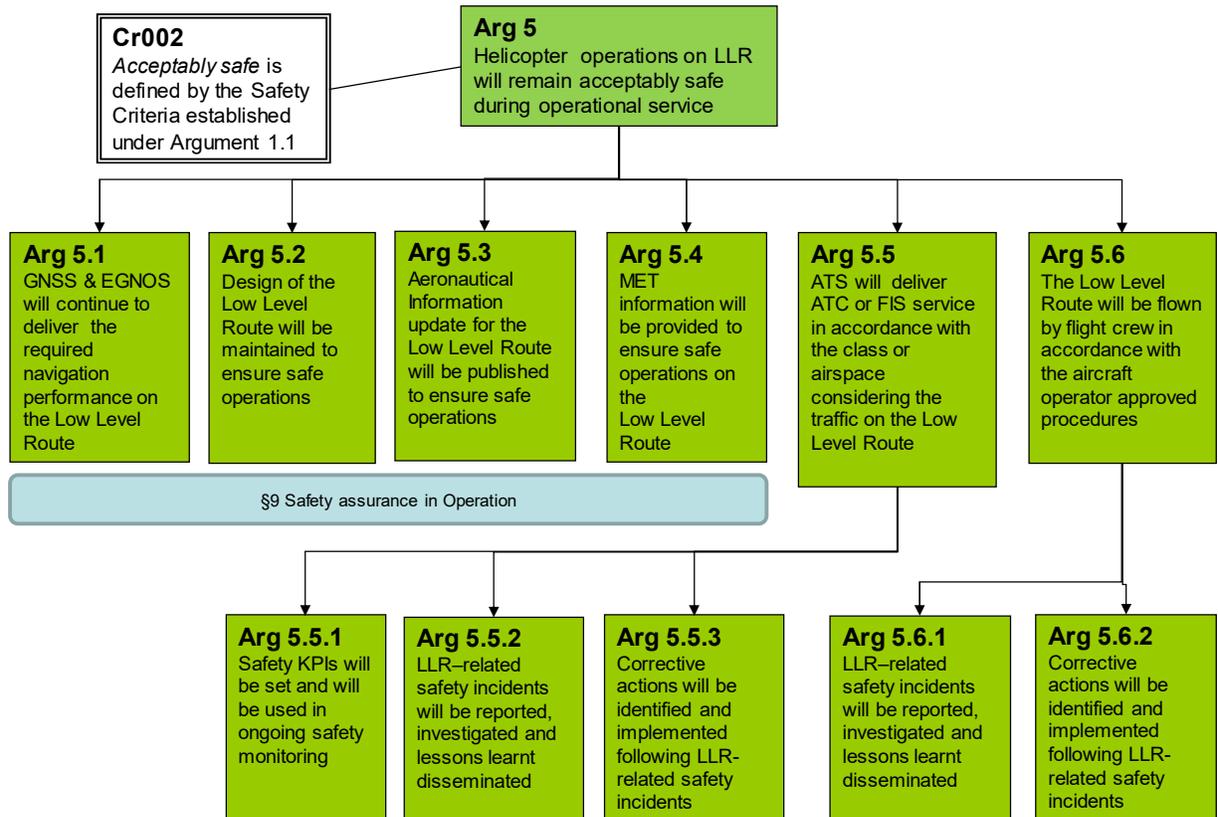
4.5 Arg 3- LLR Helicopter operations will be implemented to meet the Safety Requirements



4.6 Arg 4- Transition into service of LLR helicopter operations will be acceptably safe



4.7 Arg 5- LLR Helicopter operations will remain acceptably safe during operational service



5 Safety Assessment at operational service level

5.1 Safety Impact and Criteria

5.1.1 Relevant ATM/ANS “pre-existing” hazards

The following table identifies the list of pre-existing aviation hazards relevant for helicopter operations on the Low Level Route:

Pre-existing Aviation Hazards [Hp]	ATM-related accident type & Risk model
Hp#1 A situation in which the intended trajectories of two or more aircraft are in conflict	Mid-Air Collision (MAC) – See Annex A.2 for more details.
Hp#2 A situation where the intended trajectory of an aircraft is in conflict with terrain or an obstacle	Controlled Flight Into Terrain (CFIT) model – See Annex A.2 for more details.
Hp#3 Encounters with adverse weather	Loss of Control (LOC) or CFIT -No risk model available for LOC
Hp#4 Penetration of restricted airspace	No Risk model available

5.1.2 Safety impact analysis

This section presents an understanding of the safety impact of Low Level Route helicopter operations in view of the establishment of the Safety Criteria.

An analysis of the potential safety implications of those helicopter operations is undertaken for each of the accident risks identified as relevant at Section 5.1.1.

5.1.2.1 Impact on MAC risk

5.1.2.1.1 MAC risk in controlled airspace

The risk of Mid-Air Collision for IFR flights in airspace classes C, D or E shall remain the same when the Low Level Route is implemented since:

- The risk of Mid-Air Collision between helicopters operating on the Low Level Route is mitigated by the ATC.
- The risk of Mid-Air Collision between helicopters established on the Low Level Route and other IFR aircraft flying in the vicinity of the route is mitigated by ATC.
 - It is assumed that a strategic separation exists between the helicopter RNP route(s) and other IFR routes/SIDs/STARs. If a strategic separation cannot be provided, dedicated mitigation means relying on ATC shall be put in place to maintain separation between aircraft flying on these different procedures.
- The risk of Mid-Air Collision between helicopters established on the Low Level route and VFR aircraft flying in the vicinity of the route is mitigated by ATC as far as feasible (traffic information about VFR flights provided as far as possible) and by pilots (see and avoid principle).

It should be noted that for the helicopter operations conducted now in IFR there is a safety improvement compared to the operations conducted previously in VFR. Indeed separation with other IFR aircraft is provided by ATC and not by relying on the see and avoid principle.

5.1.2.1.2 MAC risk in uncontrolled airspace

The risk of Mid-Air Collision in airspace classes G shall remain the same when the Low Level Route is implemented however:

- The risk of Mid-Air Collision between helicopters operating on the Low Level Route should be mitigated by pilots/ helicopter operators.
- The risk of Mid-Air Collision between helicopters established on the Low Level Route and other IFR aircraft flying in the vicinity of the route should be mitigated by pilots.
 - It is assumed that a strategic separation exists between the helicopter RNP route(s) and other IFR routes/SIDs/STARs. If a strategic separation cannot be provided dedicated mitigation means relying on Flight Information Service (FIS) shall be put in place to maintain separation between aircraft flying on these different procedures.
- The risk of Mid-Air Collision between helicopters established on the Low Level Route and VFR aircraft flying in the vicinity of the route should be mitigated by pilots.

From [RD 14], an aircraft is around 400 times more likely to be involved in a MAC incident (NMAC) outside controlled airspace than inside it. Safety records for general aviation have not significantly improved in the last decade. MAC/NMAC is not in the top-5 causes of fatal GA accidents but Visual Flight Rules safety barriers are weak by design. A portion of the general aviation community has invested in voluntary equipment of low-cost electronic conspicuity devices to enhance the fragile “see and avoid” safety barrier.

5.1.2.2 Impact on CFIT risk

The risk of CFIT shall be reduced compared to current operations conducted in VFR thanks to a Low Level Route designed to prevent loss of separation with terrain/obstacle. Pilots will fly the route as published. Furthermore with this new operation there is no risk of an inadvertent entry into IMC which is an important cause of CFIT accidents for certain helicopter operations in VFR.

Note: Several accident precursors to CFIT exist and one is called “Controlled Flight Towards Terrain” as illustrated in Annex A.2. This accident precursor should not be confused with “Controlled Flight Into Terrain” which is the accident.

5.1.2.3 Impact on Loss of Control- Inflight Risk

With this new operation there is no risk of an inadvertent entry into IMC which was an important cause of inflight loss of control (LOC-I). However a new possible contributor is a severe weather encounter on the Low Level Route.

5.1.2.3.1 Impact on Landing Accident/Runway Excursion risk (for optimal transition to existing approach only)

This impact is only for the cases of implementation of optimal transition between LLR and existing approach (as defined in section 3.1.1).

The risk of a Landing Accident (LA)/ Runway Excursion (RE) shall be maintained, when optimal transition to existing approach operations are implemented, compared to standard/non optimal transition³ to existing IFR approach:

- With a transition to an existing IFR approach, pilots are always flying the same procedure, with the same descent gradient, always in the same direction with an assessment of the obstacles for the instrument flight phase. This contributes to reduce human error during the instrument flight phase. This benefit optimal to both optimal and non optimal transition to existing approach.

³ “non-optimal transition” in this context means a LLR transition to an existing approach which has not been modified for helicopter operations (e.g. direct transition from LLR to an existing IAF which has been considered appropriate for helicopter operations).

- The compatibility between the descent gradient and the helicopter speed/autopilot capabilities is considered during the design of the procedure for both optimal and non optimal transition to existing approach

5.1.3 Safety Criteria (SAC)

Considering the above assessed potential safety impact of helicopter Low Level Route operations, this sub-section defines the set of Safety Criteria (SAC).

Safety Criteria (SAC) define the acceptable level of safety (i.e. accident and incident risk level) to be achieved by the Concept of Operations under assessment.

The following table presents:

- The list of Safety Criteria applicable to LLR operations
- The type of airspace to which the SAC applies : controlled airspace or uncontrolled airspace or all
- The applicability depending on the types of operation: *Normal LLR* or *Transition to existing approach*
- The related risk : MAC, CFIT, LOC or LA/RE

SAC ID	Description	Type of airspace	Applicability (LLR or Transition)	Related risk
SAC-LLR_MAC_CTRL#1	The number of tactical conflicts between IFR flights shall not increase in controlled airspace following operations on the Low Level Route.	Controlled	LLR	MAC
SAC-LLR_MAC_CTRL#2	The number of imminent collisions between IFR and VFR flights shall not increase in controlled airspace following operations on the Low Level Route.	Controlled	LLR	MAC
SAC-LLR_CFIT_CTRL	The number of controlled flights towards terrain shall be reduced during Low Level Route operations compared to current VFR helicopter operations.	Controlled	LLR	CFIT
SAC-LLR_LOC-I_CTRL	The number of Loss of Control-Inflight events shall not increase during Low Level Route operations compared to current VFR helicopter operations.	Controlled	LLR	LOC
SAC-LLR_LA_CTRL	The number of Landing Accidents shall be maintained in controlled airspace with the introduction of optimal transition to existing approach compared to non optimal current IFR approach operations.	Controlled	Transition	LA/RE
SAC-LLR_MAC_UNCTRL#1	The number of imminent collisions between IFR flights shall not increase in uncontrolled airspace following operations on the Low Level Route.	Uncontrolled	LLR	MAC
SAC-LLR_MAC_UNCTRL#2	The number of imminent collisions between IFR and VFR flights shall not increase in uncontrolled airspace following operations on the Low Level Route.	Uncontrolled	LLR	MAC
SAC-LLR_CFIT_UNCTRL	The number of controlled flights towards terrain shall be reduced during Low Level Route operations compared to current VFR helicopter operations.	Uncontrolled	LLR	CFIT
SAC-LLR_LOC-I_UNCTRL	The number of Loss of Control-Inflight events shall not increase during Low Level Route operations compared to current VFR helicopter operations.	Uncontrolled	LLR	LOC

5.2 Safety Requirements at Service level in Normal operations

5.2.1 Controlled airspace

The ATM/ANS services relevant for helicopter operations on the Low Level Route are listed in the following table:

Relevant ATM/ANS Services
Establish and maintain separation between aircraft on the Low Level Route network
Separate aircraft from terrain/obstacles on the Low Level Route network
Establish adequate spacing between Low Level Route network and other routes
Inform A/C about other traffic
Prevent A/C from penetrating prohibited/restricted areas
Facilitate transition from the low level en-route network to the existing approach, if applicable (<i>for transition to existing approach only</i>)
Establish and maintain separation between aircraft during the transition to existing approach, if applicable (<i>for transition to existing approach only</i>)
Relevant Supporting services (AIS, MET, CNS,...)
Provide communication service to A/C and ATC
Provide navigation service to A/C
Provide surveillance service to ATC
Provide MET information to A/C and ATC

The following safety requirements at service level (Table 5-1) are formulated in order for LLR helicopter operations to meet the SAC in normal operating conditions (fault-free conditions). The safety requirements at service level focus on the change involved by operations on the LLR.

ANS service	Achieved by/ Success Case safety requirements at service level	Ref. SAC
Establish and maintain separation between aircraft on the Low Level Route network	<p>SRS_LLR_CTRL#1. Helicopter shall submit a flight plan</p> <p>SRS_LLR_CTRL#2. ATC shall separate traffic established on the Low Level Route network</p> <p>SRS_LLR_CTRL#3. ATC shall maintain separation between helicopters established on the Low Level Route network</p>	SAC-LLR_MAC_CTRL#1

ANS service	Achieved by/ Success Case safety requirements at service level	Ref. SAC
Separate aircraft from terrain/obstacles on the Low Level Route network	<p>SRS_LLR_CTRL#4. The Low Level Route shall be designed and promulgated to prevent loss of separation with terrain and obstacles</p> <p>SRS_LLR_CTRL#5. Helicopters shall respect the lateral path of the Low Level Route</p> <p>SRS_LLR_CTRL#6. Helicopters shall respect the vertical profile of the Low Level Route including compensation for low temperature and wind</p>	SAC-LLR_CFIT_CTRL
Establish adequate spacing between Low Level Route network and other routes	SRS_LLR_CTRL#7. Spacing between routes shall be determined considering navigation performance, separation minima, traffic density, sector size and controller procedures/ HMI	SAC-LLR_MAC_CTRL#1
Inform A/C about other traffic	SRS_LLR_CTRL#8. ATS shall inform helicopters about other known traffic	SAC-LLR_MAC_CTRL#2
Prevent aircraft to penetrate prohibited/restricted areas	SRS_LLR_CTRL#9. Helicopters shall be informed about prohibited/restricted areas in the vicinity of the Low Level Route network	SAC-LLR_MAC_CTRL#1 SAC-LLR_MAC_CTRL#2
Provide MET information	SRS_LLR_CTRL#10. Helicopters shall obtain information about the forecasted MET conditions on the Low Level Route	SAC-LLR_LOC-I_CTRL SAC-LLR_CFIT_CTRL
Facilitate transition from the low level en-route network to the existing approach <i>(for transition to existing approach only)</i>	<p>SRS_LLR_CTRL#11. The transition between LLR and existing approach shall be designed and promulgated to facilitate the safe transition between the LLR and the existing approach</p> <p>SRS_LLR_CTRL#12. Helicopters shall perform the transition between the low level route and the existing approach.</p>	SAC-LLR_LA_CTRL
Establish and maintain separation between aircraft during the transition to existing approach <i>(for transition to existing approach only)</i>	<p>SRS_LLR_CTRL#11. Helicopter shall submit a flight plan</p> <p>SRS_LLR_CTRL#13. ATC shall separate the traffic during the transition from LLR to existing approach</p>	SAC-LLR_MAC_CTRL#1

Table 5-1. Safety Requirements at Service level in controlled airspace-Normal operations

5.2.2 Uncontrolled airspace

The Services relevant for helicopter LLR operations are listed in the following table

Relevant ATM/ANS Services
Establish and maintain separation between aircraft on the Low Level Route network
Separate aircraft from terrain/obstacles on the Low Level Route network
Establish adequate spacing between Low Level Route network and other routes
Inform A/C about other traffic
Prevent A/C from penetrating prohibited/restricted areas
Relevant Supporting services (AIS, MET, CNS,...)
Provide communication service to A/C and ATC
Provide navigation service to A/C
Provide MET information to A/C and ATC

The following Safety Requirements at Service level (Table 5-2) are formulated in order for LLR helicopter operations to meet the SAC in normal operating conditions (fault-free conditions). The Safety Requirements at Service level focus on the change involved by operations on the LLR.

ANS service	Achieved by/ Success Case Safety Requirements at Service level	Ref. SAC
Establish and maintain separation between aircraft on the Low Level Route network	<p>SRS_LLR_UNCTRL#1. Helicopter Operator or third party shall manage the traffic on the Low Level Route network by establishing appropriate operational procedures commensurate to the foreseen traffic level</p> <p>SRS_LLR_UNCTRL#2. Each pilot shall maintain separation between helicopters established on the Low Level Route network based on information provided</p>	SAC-LLR_MAC_UNCTRL#1
Separate aircraft from terrain/obstacles on the Low Level Route network	<p>SRS_LLR_UNCTRL#3. The Low Level Route shall be designed and promulgated to prevent loss of separation with terrain and obstacles</p> <p>SRS_LLR_UNCTRL#4. Helicopters shall respect the lateral path of the Low Level Route</p> <p>SRS_LLR_UNCTRL#5. Helicopters shall respect the vertical profile of the Low Level Route including compensation for low temperature and wind</p>	SAC-LLR_CFIT_UNCTRL

ANS service	Achieved by/ Success Case Safety Requirements at Service level	Ref. SAC
Establish adequate spacing between Low Level Route network and other routes	SRS_LLR_UNCTRL#6. Spacing between routes shall be determined considering navigation performance, separation minima and traffic density	SAC-LLR_MAC_UNCTRL#1
Inform A/C about other traffic	SRS_LLR_UNCTRL#7. Helicopter pilots shall inform other A/C about their position, level and flight intent on a prescribed frequency for the specific route or by any other means approved by the competent authority	SAC-LLR_MAC_UNCTRL#2
Prevent aircraft to penetrate prohibited/restricted areas	SRS_LLR_UNCTRL#8. Helicopters shall be informed about prohibited/restricted areas in the vicinity of the Low Level Route network	SAC-LLR_MAC_UNCTRL#1 SAC-LLR_MAC_UNCTRL#2
Provide MET information	SRS_LLR_UNCTRL#9. Helicopters shall obtain information about the forecasted MET conditions on the Low Level Route	SAC-LLR_LOC-I_UNCTRL SAC-LLR_CFIT_UNCTRL

Table 5-2. Safety Requirements at Service level in uncontrolled airspace - Normal operations

5.3 Safety Requirements at Service level in Abnormal operations

The purpose of this section is to assess the ability of LLR helicopter operations to work through (robustness), or at least recover from (resilience) any abnormal conditions that might be encountered relatively infrequently (these might be conditions external to the scope of the Low Level Route implementation and therefore not under control).

5.3.1 Abnormal scenarios

The following abnormal conditions have been identified from a generic point of view:

ID	Abnormal Scenario
1	GNSS/SBAS interference – Ionospheric disturbances
2	Loss of communication
3	Strong wind gust or wind shear
4	Icing conditions
5	Thunderstorms

In the following paragraphs, each abnormal scenario is assessed for potential risk and mitigations are derived where necessary, in the form of Safety Requirements at Service level that are further consolidated under the following sub-sections:

1. GNSS/SBAS interference – Ionospheric disturbances

Different mitigations could be defined when such abnormal conditions are encountered such as conventional navigation, dead reckoning, use of airborne navigation procedure, emergency descent procedure at minimum IFR speed, VFR reversion when feasible, etc... therefore a precise and generic contingency procedure cannot be derived but shall be developed by the helicopter operator considering the local operational environment and the helicopter equipage.

SRS_LLRL_CTRL#14. In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform ATS as soon as possible when in controlled airspace.

SRS_LLRL_UNCTRL#10. In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform other aircraft and, if applicable, the Flight Information Service in uncontrolled airspace as soon as possible.

2. Loss of communication

SRS_LLRL_CTRL#15. In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure

SRS_LLRL_UNCTRL#11. In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure

3. Strong Wind gust or wind shear

Weather forecast during pre-flight information. Winds causing mechanic moderate to severe turbulence should be avoided, and if such a situation occurs pilot should as a first choice try to exit by turning around.

4. Icing Conditions

With ice, the helicopters face 2 problems: ice changes the shape of the airfoil and therefore there is a loss on the efficiency of the rotor system and it adds significant weight to the helicopter.

Even if Low Level Routes are designed at levels that limit icing conditions such an event cannot be excluded from the safety assessment. The first reaction, if the helicopter is not equipped with an icing protection system, will be to turn around and exit the icing environment. Careful attention to turn parameters must be adhered to when reverting course on a Low Level Route especially when RNP0.3 is used.

SRS_LLRL_CTRL#16. In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route

SRS_LLRL_UNCTRL#12. In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route

5. Thunderstorms

If the weather brief shows the presence of thunderstorms and CB activity, an airborne weather radar should be used to detect and avoid. Due to the fact that the possibilities for route deviations are limited, careful planning is vital to avoid such situations. Means of avoiding is time planning and rerouting by the use of weather radar services.

5.3.2 Derivation of Safety Requirements at Service level for Abnormal operations

The following Safety Requirements at Service level considering above abnormal conditions have been derived:

SRS ID	Description	Abnormal Scenario	Ref. SAC
Controlled airspace			
SRS_LLR_CTRL#14	In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform ATS as soon as possible when in controlled airspace.	#1	SAC-LLR_MAC_CTRL#1 SAC-LLR_MAC_CTRL#2 SAC-LLR_CFIT
SRS_LLR_CTRL#15	In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure	#2	SAC-LLR_MAC_CTRL#1 SAC-LLR_MAC_CTRL#2
SRS_LLR_CTRL#16	In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route	#4	SAC-LLR_LOC-I SAC-LLR_CFIT
Uncontrolled airspace			
SRS_LLR_UNCTRL#10	In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform other aircraft and, if applicable, the Flight Information Service in uncontrolled airspace as soon as possible.	#1	SAC-LLR_MAC_UNCTRL#1 SAC-LLR_MAC_UNCTRL#2 SAC-LLR_CFIT
SRS_LLR_UNCTRL#11	In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure	#2	SAC-LLR_MAC_UNCTRL#1 SAC-LLR_MAC_UNCTRL#2
SRS_LLR_UNCTRL#12	In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route	#4	SAC-LLR_LOC-I SAC-LLR_CFIT

Table 5-3. Safety Requirements at Service level in controlled and uncontrolled airspace - Abnormal operations

5.4 Safety Requirements at Service level in Faulted operations

This section concerns operations in the case of internal failures (OHA). It undertakes the assessment of possible adverse effects that failures internal to the end-to-end system supporting LLR helicopter operations might have upon the provision of the relevant operations and aims at deriving Safety Requirements at Service level (failure approach) to mitigate against these effects.

This section provides the list of the identified Operational Hazards and their operational effects with the indication of the distance to the accident.

5.4.1 Identification and analysis of Operational Hazards

The introduction of LLR helicopter operations might induce additional hazards or might involve modifications of the characteristics of the hazards already existing in current operations.

Two Hazard identification sessions has been held

- One in Strasbourg in June 2017 with representatives from France and Switzerland.
- One online hazard identification session in November 2020 in order to assess and mitigate the hazards created or impacted by the new operational features added in the second edition of the present generic safety case (i.e. transition to existing approach).

These two hazard identification sessions involved flight procedure designers, ATC, pilots, authorities and safety experts.

During the HAZID session the operational hazards relevant for LLR helicopter operations have been identified and their consequences have been assessed. The Operational Hazards are defined as closely as possible to the level of the ATM/ANS service delivered to airspace users. The identification of the operational hazards has been initiated from the list of (success) Safety Requirements at Service level in Normal operations of §5.2, complemented with the brainstorming involving the workshop representatives. The detailed process and intermediary results are presented in Annex A.1.

The Table 5-4 below provides the consolidated list of operational hazards:

ID	Hazard description	Operational effects	Mitigation of effects (ref. Risk model)	Distance to the accident ⁴ and associated precursor
In controlled airspace				
Hz_LL_R_01	Helicopter deviates from published Low Level Route towards terrain in controlled airspace	The helicopter might collide with terrain/obstacle following lateral or vertical deviation	<ul style="list-style-type: none"> - ATCO detection with or without MSAW - Pilot Visual avoidance - HTAWS if fitted 	CFIT distance d3a Controlled Flight toward terrain
Hz-LLR_05	Hz-LLR_05a: Helicopter deviates from published Low Level Route towards IFR or known VFR aircraft in controlled airspace	The helicopter might collide with other aircraft following lateral or vertical deviation	<ul style="list-style-type: none"> - ATCO detects and solves conflicts between IFR flights. - ATCO provides traffic information about VFR flights and traffic avoidance advice on request - TAS, FLARM or others (efficiency to be evaluated) 	MAC distance d4a Tactical Conflict
	Hz-LLR_05b: Helicopter deviates from published Low Level Route towards unknown VFR aircraft in controlled airspace		<ul style="list-style-type: none"> - Pilot see and avoid - TAS, FLARM or others (efficiency to be evaluated) 	MAC distance d2 Imminent Collision

⁴ The distance to the accident is detailed for each accident type in the tables of Annex A.3.

ID	Hazard description	Operational effects	Mitigation of effects (ref. Risk model)	Distance to the accident ⁴ and associated precursor
			Respect flight crew procedures in case of collision avoidance alert	
Hz_LL_R_10	Hz-LLR_10a: IFR or known VFR traffic flies towards helicopter established on the Low Level Route in controlled airspace	Aircraft might collide with IFR helicopter established on the Low Level Route	ATCO detects and solves conflicts between IFR flights.	MAC distance d4a Tactical Conflict (Airspace Class)
			ATCO provides traffic information about VFR flights and traffic avoidance advice on request TAS, FLARM or others (efficiency to be evaluated) Respect flight crew procedures in case of collision avoidance alert	
	Hz-LLR_10b: Unknown VFR traffic flies towards helicopter established on the Low Level Route in controlled airspace		Pilot see and avoid TAS, FLARM or others (efficiency to be evaluated)	MAC distance d2 Imminent Collision
Hz_LL_R_15	Helicopter encounters hazardous weather conditions on Low Level Route in controlled airspace	The helicopter enters in hazardous weather conditions which could lead to loss of control and/or CFIT	ATC assistance Weather avoidance if deviation on the route is possible (no terrain/obstacle) Airborne weather radar if installed EFB (Electronic Flight Bag) Weather Information update Flight turn back Landing	-CFIT distance d3b Flight toward terrain commanded -LOC-Inflight Loss of Control due to Environmental Factors: Adverse Weather
Hz_LL_R_20	Failure to manage properly the traffic on the Low Level Route in controlled airspace	Helicopter might collide with another helicopter on the Low Level Route	ATCO detects and solves conflicts between two or more helicopters established on the Low Level Route Use of speed management. Indeed ATCO should know the IFR speed range of the helicopters using the routes. (30-160 KIAS)	MAC distance d4a Tactical Conflict
Hz_LL_R_25	Helicopter fails to intercept smoothly the existing approach (ILS or RNP) from the Low Level Route in controlled airspace	The helicopter might conduct an unstable ILS or RNP approach with a risk of runway excursion	Pilot detection (too high, too low, overshoot,...) and flight crew correction of the path (vertical and/or lateral) or initiation of the missed approach	Landing RE distance d4a Unstable Approach

ID	Hazard description	Operational effects	Mitigation of effects (ref. Risk model)	Distance to the accident ⁴ and associated precursor
	<i>This hazard is specific to the optimal transition from low level route to existing approach.</i>		ATCO detection based on radar information	
In Uncontrolled airspace				
Hz_LL_R_50	Helicopter deviates from published Low Level Route towards terrain in uncontrolled airspace	The helicopter might collide with terrain/obstacle following lateral or vertical deviation	Pilot Visual avoidance HTAWS if fitted Digital Map system	CFIT distance d2 Imminent CFIT
Hz_LL_R_55	Helicopter deviates from published Low Level Route towards other traffic in uncontrolled airspace	The helicopter might collide with other aircraft following lateral or vertical deviation	Pilot Conflict detection Pilot visual avoidance TAS alert or equivalent	MAC distance d3 Conflict
Hz_LL_R_60	Other traffic flies towards helicopter established on the Low Level Route in uncontrolled airspace	Aircraft might collide with IFR helicopter established on the Low Level Route	Pilot Conflict detection Pilot visual avoidance TAS alert or equivalent	MAC distance d3 Conflict
Hz_LL_R_65	Helicopter encounters hazardous weather conditions on Low Level Route in uncontrolled airspace	The helicopter enters in hazardous weather conditions which could lead to loss of control and/or CFIT	Weather avoidance if deviation on the route is possible (no terrain/obstacle) Airborne weather radar if installed EFB (Electronic Flight Bag) Weather Information update Flight turn back Landing	-CFIT distance d3 Flight towards terrain commanded -LOC-Inflight Loss of Control due to Environmental Factors: Adverse Weather
Hz_LL_R_70	Failure to manage properly the traffic on Low Level Route in uncontrolled airspace	Helicopter might collide with another helicopter on the Low Level Route	Pilot visual avoidance Common frequency and mandatory position reporting over each waypoint or at least every 5-10 minutes TAS alert or equivalent	MAC distance d2 Imminent collision

Table 5-4. Consolidated list of LLR Operational Hazards

In the FHA tables of Annex A.1 the mitigation of effects (in terms of protection against their propagation) provides reference to the safety barriers of the relevant risk models provided in Annex A.2.

The distance to the accident relative to the hazard effects has been allocated according to the severity and risk classification scheme complemented by its associated accident distance-based classes provided in Annex A.3.

5.4.2 Safety Requirements at Service level associated to the Operational Hazards

According to the SRM [RD 2] and to a majority of ANSPs' safety assessment methodologies, Safety Requirements at Service level are formulated to limit the frequency at which the Operational Hazards could be allowed to occur (within SRM these SRSs are called "reliability/integrity" SRSs in order to distinguish them from the "functionality/performance" SRSs derived for normal operations at §5.2 and abnormal operations at §5.3).

The reliability/integrity SRSs allocation is performed using the severity and risk classification scheme complemented by accident distance-based classes tables defined in Annex A.3. It is well admitted that such severity and risk classification could be specific for the different operational environment. It is up to the helicopter operator to define the applicable severity & risk classification scheme or any alternate method in collaboration with the relevant ANSP/Competent Authority responsible for the safety level of the class of airspace where the Low Level Route will be implemented.

If the helicopter operator in collaboration with the relevant ANSP/Competent Authority defines a different severity and risk classification scheme or an alternate method then the quantitative figures of the following Safety Requirements at Service level must be modified accordingly.

Either quantitative SRSs could be derived (based on the agreed local scheme) or risk could be also assessed qualitatively.

Hazard ref	Safety Requirements at Service level (reliability/integrity)
Safety Requirements at Service level in Controlled Airspace	
Hz_LL_R_01	SRS_LL_R_CTRL#17. Frequency of occurrence of deviating laterally or vertically from published Low Level Route in controlled airspace leading to controlled flight towards terrain shall not be greater than 2×10^{-7} per flight
Hz_LL_R_05a	SRS_LL_R_CTRL#18. Frequency of occurrence of deviating laterally or vertically from published Low Level Route in controlled airspace leading to tactical conflict shall not be greater than 3.33×10^{-5} per flight hour
Hz_LL_R_05b	SRS_LL_R_CTRL#19. Frequency of occurrence of deviating laterally or vertically from published Low Level Route in controlled airspace leading to imminent collision shall not be greater than 1×10^{-6} per flight hour
Hz_LL_R_10a	SRS_LL_R_CTRL#20. Frequency of occurrence of IFR aircraft or known VFR aircraft flying towards helicopters established on the Low Level Route in controlled airspace leading to tactical conflict shall not be greater than 3.33×10^{-5} per flight hour
Hz_LL_R_10b	SRS_LL_R_CTRL#21. Frequency of occurrence of unknown VFR aircraft flying towards helicopters established on the Low Level Route in controlled airspace leading to imminent collision shall not be greater than 1×10^{-6} per flight hour
Hz_LL_R_15	SRS_LL_R_CTRL#22. Frequency of occurrence of helicopter encountering unplanned hazardous weather conditions on Low Level Route shall not be greater than 2×10^{-7} per flight
Hz_LL_R_20	SRS_LL_R_CTRL#23. Frequency of occurrence of tactical conflicts between helicopters established on the Low Level Route in controlled airspace shall not be greater than 3.33×10^{-5} per flight hour
Hz_LL_R_25	SRS_LL_R_CTRL#24. Frequency of occurrence of helicopter failing to intercept smoothly the existing approach (ILS or RNP) from the Low Level Route in controlled airspace shall be no greater than 1×10^{-4} per flight
Safety Requirements at Service level in Uncontrolled Airspace	
Hz_LL_R_50	SRS_LL_R_UNCTRL#13. Frequency of occurrence of deviating laterally or vertically towards terrain in uncontrolled airspace leading to controlled flight into terrain shall not be greater than 1×10^{-7} per flight hour
Hz_LL_R_55	SRS_LL_R_UNCTRL#14. Frequency of occurrence of deviating laterally or vertically from published Low Level Route in uncontrolled airspace leading to imminent infringement with other traffic shall not be greater than 4×10^{-5} per flight hour
Hz_LL_R_60	SRS_LL_R_UNCTRL#15. Frequency of occurrence of other aircraft flying towards helicopters established on the Low Level Route in uncontrolled airspace leading to imminent infringement shall not be greater than 4×10^{-5} per flight hour
Hz_LL_R_65	SRS_LL_R_UNCTRL#16. Frequency of occurrence of helicopter encountering unplanned hazardous weather conditions in uncontrolled airspace shall not be greater than 2×10^{-7} per flight hour
Hz_LL_R_70	SRS_LL_R_UNCTRL#17. Frequency of occurrence of imminent collision between helicopters established on the Low Level Route in uncontrolled airspace shall not be greater than 1.0×10^{-5} per flight hour

Table 5-5. Safety Requirements at Service level associated to the Operational Hazards

5.5 Synthesis of Safety Requirements at Service level

This section presents the synthesis of Safety Requirements at Service level identified through the different assessments in the previous sections (5.2, 5.3 and 5.4).

It is important to note that these Safety Requirements at Service Level are only high level requirements that are then further refined and detailed at Design Level in the next section of the document. The requirements to be considered within the frame of the implementation of Low Level Route are the Safety Requirements at Design Level listed in sections 6.1.5 and 6.2.5.

The Functional System design analysis is driven by the Safety Requirements at Service Level and supported by the use of a Logical Model. This analysis is conducted in section 6.1 for Normal operations, Abnormal operations and Faulted operations in controlled airspace and 6.2 for Normal operations, Abnormal operations and Faulted operations in uncontrolled airspace. The analysis under Faulted operations produces a causal analysis of each Operational Hazard, assess the risk and define mitigation such as to fulfil the Safety Requirement at Design Level associated to the Operational Hazard.

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The following table presents:

- The list of Safety Requirements at Service Level (SRS) applicable to LLR operations
- The type of airspace to which the SRS applies : controlled airspace or uncontrolled airspace
- The applicability depending on the types of operation: Normal LLR or Transition to existing approach
- The ID of the Safety Criteria (SAC) from which the Service Requirement at service Level is derived

SRS ID	Description	Type of Airspace (controlled, Uncontrolled)	Applicability (LLR or Transition)	Origin (SAC ID)
SRS_LLRL_CTRL#1	Helicopter shall submit a flight plan	Controlled	LLR	SAC-LLR_MAC_CTRL#1
SRS_LLRL_CTRL#2	ATC shall separate traffic established on the Low Level Route network	Controlled	LLR	SAC-LLR_MAC_CTRL#1
SRS_LLRL_CTRL#3	ATC shall maintain separation between helicopters established on the Low Level Route network	Controlled	LLR	SAC-LLR_MAC_CTRL#1
SRS_LLRL_CTRL#4	The Low Level Route shall be designed and promulgated to prevent loss of separation with terrain and obstacles	Controlled	LLR	SAC-LLR_CFIT_CTRL
SRS_LLRL_CTRL#5	Helicopters shall respect the lateral path of the Low Level Route	Controlled	LLR	SAC-LLR_CFIT_CTRL
SRS_LLRL_CTRL#6	Helicopters shall respect the vertical profile of the Low Level Route including compensation for low temperature and wind	Controlled	LLR	SAC-LLR_CFIT_CTRL
SRS_LLRL_CTRL#7	Spacing between routes shall be determined considering navigation performance, separation minima, traffic density, sector size and controller procedures/ HMI	Controlled	LLR	SAC-LLR_MAC_CTRL#1
SRS_LLRL_CTRL#8	ATS shall inform helicopters about other known traffic	Controlled	LLR	SAC-LLR_MAC_CTRL#2
SRS_LLRL_CTRL#9	Helicopters shall be informed about prohibited/restricted areas in the vicinity of the Low Level Route network	Controlled	LLR	SAC-LLR_MAC_CTRL#1, SAC-LLR_MAC_CTRL#2

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SRS ID	Description	Type of Airspace (controlled, Uncontrolled)	Applicability (LLR or Transition)	Origin (SAC ID)
SRS_LLRL_CTRL#10	Helicopters shall obtain information about the forecasted MET conditions on the Low Level Route	Controlled	LLR	SAC-LLR_LOC-I_CTRL, SAC-LLR_CFIT_CTRL
SRS_LLRL_CTRL#11	The transition between LLR and existing approach shall be designed and promulgated to facilitate the safe transition between the LLR and the existing approach	Controlled	Transition	SAC-LLR_LA_CTRL
SRS_LLRL_CTRL#12	Helicopters shall perform the transition between the low level route and the existing approach.	Controlled	Transition	SAC-LLR_LA_CTRL
SRS_LLRL_CTRL#13	ATC shall separate the traffic during the transition from LLR to existing approach	Controlled	Transition	SAC-LLR_MAC_CTRL#1
SRS_LLRL_CTRL#14	In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform ATS as soon as possible when in controlled airspace.	Controlled	LLR	SAC-LLR_MAC_CTRL#1, SAC-LLR_MAC_CTRL#2, SAC-LLR_CFIT_CTRL
SRS_LLRL_CTRL#15	In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure	Controlled	LLR	SAC-LLR_MAC_CTRL#1, SAC-LLR_MAC_CTRL#2
SRS_LLRL_CTRL#16	In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route	Controlled	LLR	SAC-LLR_LOC-I, SAC-LLR_CFIT_CTRL
SRS_LLRL_CTRL#17	Frequency of occurrence of deviating laterally or vertically from published Low Level Route in controlled airspace leading to controlled flight towards terrain shall not be greater than 2×10^{-7} per flight	Controlled	LLR	Hz_LLRL_01
SRS_LLRL_CTRL#18	Frequency of occurrence of deviating laterally or vertically from published Low Level Route in controlled airspace leading to tactical conflict shall not be greater than 3.33×10^{-5} per flight hour	Controlled	LLR	Hz_LLRL_05a

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SRS ID	Description	Type of Airspace (controlled, Uncontrolled)	Applicability (LLR or Transition)	Origin (SAC ID)
SRS_LLRL_CTRL#19	Frequency of occurrence of deviating laterally or vertically from published Low Level Route in controlled airspace leading to imminent collision shall not be greater than 1×10^{-6} per flight hour	Controlled	LLR	Hz_LLRL_05b
SRS_LLRL_CTRL#20	Frequency of occurrence of IFR aircraft or known VFR aircraft flying towards helicopters established on the Low Level Route in controlled airspace leading to tactical conflict shall not be greater than 3.33×10^{-5} per flight hour	Controlled	LLR	Hz_LLRL_10a
SRS_LLRL_CTRL#21	Frequency of occurrence of unknown VFR aircraft flying towards helicopters established on the Low Level Route in controlled airspace leading to imminent collision shall not be greater than 1×10^{-6} per flight hour	Controlled	LLR	Hz_LLRL_10b
SRS_LLRL_CTRL#22	Frequency of occurrence of helicopter encountering unplanned hazardous weather conditions on Low Level Route shall not be greater than 2×10^{-7} per flight	Controlled	LLR	Hz_LLRL_15
SRS_LLRL_CTRL#23	Frequency of occurrence of tactical conflicts between helicopters established on the Low Level Route in controlled airspace shall not be greater than 3.33×10^{-5} per flight hour	Controlled	LLR	Hz_LLRL_20
SRS_LLRL_CTRL#24	Frequency of occurrence of helicopter failing to intercept smoothly the existing approach (ILS or RNP) from the Low Level Route in controlled airspace shall be no greater than 1×10^{-4} per flight	Controlled	Transition	Hz_LLRL_25
SRS_LLRL_UNCTRL#1	Helicopter Operator or third party shall manage the traffic on the Low Level Route network by establishing appropriate operational procedures commensurate to the foreseen traffic level	Uncontrolled	LLR	SAC-LLRL_MAC_UNCTRL#1

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SRS ID	Description	Type of Airspace (controlled, Uncontrolled)	Applicability (LLR or Transition)	Origin (SAC ID)
SRS_LL_R_UNCTRL#2	Each pilot shall maintain separation between helicopters established on the Low Level Route network based on information provided	Uncontrolled	LLR	SAC-LLR_MAC_UNCTRL#1
SRS_LL_R_UNCTRL#3	The Low Level Route shall be designed and promulgated to prevent loss of separation with terrain and obstacles	Uncontrolled	LLR	SAC-LLR_CFIT_UNCTRL
SRS_LL_R_UNCTRL#4	Helicopters shall respect the lateral path of the Low Level Route	Uncontrolled	LLR	SAC-LLR_CFIT_UNCTRL
SRS_LL_R_UNCTRL#5	Helicopters shall respect the vertical profile of the Low Level Route including compensation for low temperature and wind	Uncontrolled	LLR	SAC-LLR_CFIT_UNCTRL
SRS_LL_R_UNCTRL#6	Spacing between routes shall be determined considering navigation performance, separation minima and traffic density	Uncontrolled	LLR	SAC-LLR_MAC_UNCTRL#1
SRS_LL_R_UNCTRL#7	Helicopter pilots shall inform other A/C about their position, level and flight intent on a prescribed frequency for the specific route or by any other means approved by the competent authority	Uncontrolled	LLR	SAC-LLR_MAC_UNCTRL#2
SRS_LL_R_UNCTRL#8	Helicopters shall be informed about prohibited/restricted areas in the vicinity of the Low Level Route network	Uncontrolled	LLR	SAC-LLR_MAC_UNCTRL#1, SAC-LLR_MAC_UNCTRL#2
SRS_LL_R_UNCTRL#9	Helicopters shall obtain information about the forecasted MET conditions on the Low Level Route	Uncontrolled	LLR	SAC-LLR_LOC-I_UNCTRL, SAC-LLR_CFIT_UNCTRL
SRS_LL_R_UNCTRL#10	In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform other aircraft and, if applicable, the Flight Information Service in uncontrolled airspace as soon as possible.	Uncontrolled	LLR	SAC-LLR_MAC_UNCTRL#1, SAC-LLR_MAC_UNCTRL#2, SAC-LLR_CFIT_UNCTRL
SRS_LL_R_UNCTRL#11	In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter	Uncontrolled	LLR	SAC-LLR_MAC_UNCTRL#1, SAC-LLR_MAC_UNCTRL#2

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SRS ID	Description	Type of Airspace (controlled, Uncontrolled)	Applicability (LLR or Transition)	Origin (SAC ID)
	to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure			
SRS_LLRL_UNCTRL#12	In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route	Uncontrolled	LLR	SAC-LLR_LOC-I_UNCTRL SAC-LLR_CFIT_UNCTRL
SRS_LLRL_UNCTRL#13	Frequency of occurrence of deviating laterally or vertically towards terrain in uncontrolled airspace leading to controlled flight into terrain shall not be greater than 1×10^{-7} per flight hour	Uncontrolled	LLR	Hz_LLRL_50
SRS_LLRL_UNCTRL#14	Frequency of occurrence of deviating laterally or vertically from published Low Level Route in uncontrolled airspace leading to imminent infringement with other traffic shall not be greater than 4×10^{-5} per flight hour	Uncontrolled	LLR	Hz_LLRL_55
SRS_LLRL_UNCTRL#15	Frequency of occurrence of other aircraft flying towards helicopters established on the Low Level Route in uncontrolled airspace leading to imminent infringement shall not be greater than 4×10^{-5} per flight hour	Uncontrolled	LLR	Hz_LLRL_60
SRS_LLRL_UNCTRL#16	Frequency of occurrence of helicopter encountering unplanned hazardous weather conditions in uncontrolled airspace shall not be greater than 2×10^{-7} per flight hour	Uncontrolled	LLR	Hz_LLRL_65
SRS_LLRL_UNCTRL#17	Frequency of occurrence of imminent collision between helicopters established on the Low Level Route in uncontrolled airspace shall not be greater than 1.0×10^{-5} per flight hour	Uncontrolled	LLR	Hz_LLRL_70

Table 5-6. Synthesis of Safety Requirements at Service level - LLR operations in controlled and uncontrolled airspace

6 Safety assessment- Design level

The design analysis of the Functional System enabling the LLR helicopter operations is a major tool for validating the design from a safety perspective i.e. ensuring that a correct and complete set of Safety Requirements has been derived such as all the Safety Requirements at Service level addressing the Functional System are fulfilled.

The design analysis is performed for Normal operations (section 6.1.2 for controlled airspace and 6.2.2 for uncontrolled airspace), Abnormal operations (section 6.1.3 for controlled airspace and 6.2.3 for uncontrolled airspace) and Faulted operations (section 6.1.4 for controlled airspace and 6.2.4 for uncontrolled airspace).

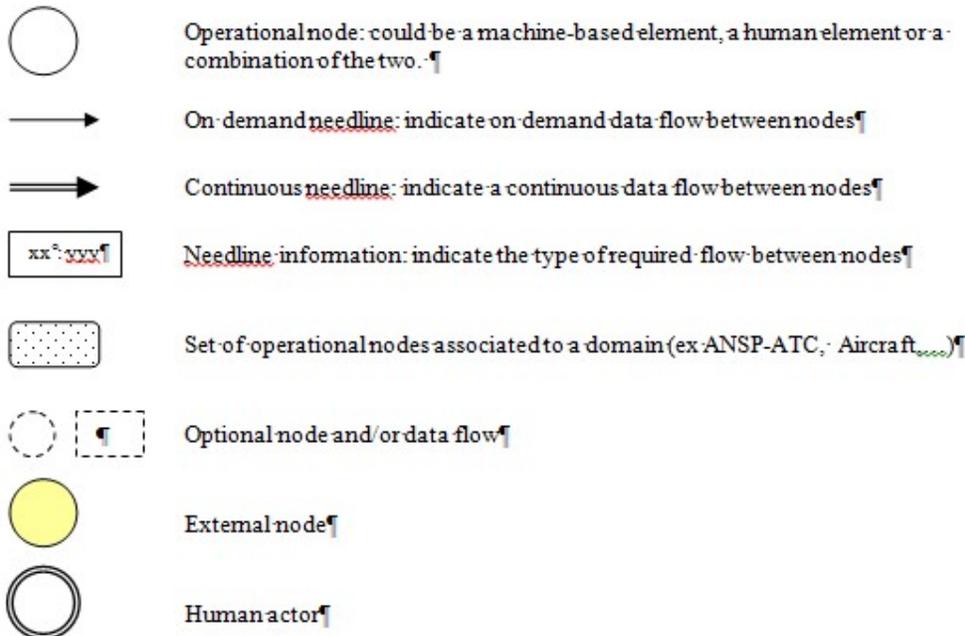
The design analysis is supported by a logical model of the LLR Functional System described in the next sub-section.

6.1 Functional System design analysis in Controlled airspace

6.1.1 LLR Functional System logical model

The LLR Functional System can be modelled via a high-level architectural representation of the main elements (people, equipment and procedures) performing the LLR helicopter operations as per Figure 6-1 and addressing all domains (all sub-arguments of Argument 2 – see section 4.4).

The symbols used in the Logical model are as follows:



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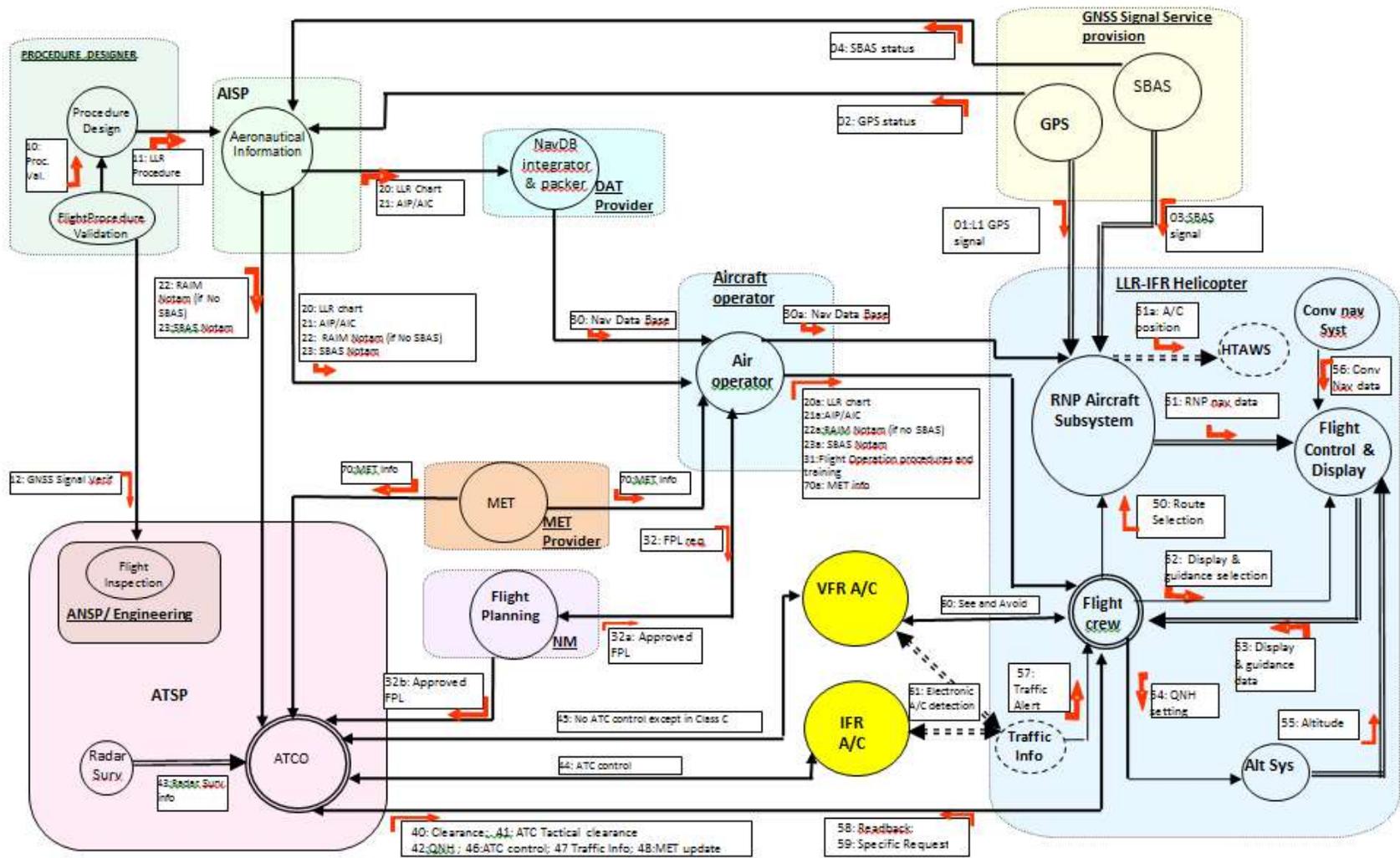


Figure 6-1: LLR Controlled Functional System logical model

The following table describes the Logical Model operational information.

item #	Information	Sending node	Receiving node	Usage(receiving node)
GNSS Signal Service Provision				
01	L1 GPS Signal	GPS	RNP aircraft Subsystem	To receive and decode GPS satellite signal
02	GPS Status	GPS	AIS Provider	<ul style="list-style-type: none"> - To be informed on the status of the GPS navigation infrastructure (GPS satellite) - To elaborate RAIM NOTAM when necessary
03	SBAS Signal (if SBAS required)	SBAS	RNP aircraft Subsystem	To receive and decode SBAS signal
04	SBAS Status (if SBAS required)	SBAS	AIS Provider	<ul style="list-style-type: none"> - To be informed on the status of the SBAS navigation infrastructure - To receive SBAS NOTAM proposal
ANSP/Engineering				
12	GNSS Signal verification	Procedure Design	Flight Inspection	To verify GPS and SBAS signal on the Low Level Route
Procedure Designer				
11	LLR Procedure	Procedure Design	AIS Provider	To obtain all data relevant for the aeronautical data origination including the procedure design (LLR chart)
			ATCO	To have all the necessary information on the LLR for proper operations (ops procedures, briefing,...)
10	Procedure validation	Flight Procedure Validation	Procedure Design	To validate that procedure has been designed in accordance with design criteria
AISP				
20	LLR Chart	AIS provider	Aircraft Operator	To be informed on the depiction/characteristics of the Low Level Route to be flown
			NavDB Integrator & packer	
21	AIP/AIC	AIS provider	Aircraft Operator	To be informed of specific LLR information (RNP value, limitation, etc...)
			NavDB Integrator & packer	
22	RAIM Notam	AIS provider	Aircraft Operator	<p>Required only if SBAS is not used</p> <p>To be informed about the GPS RAIM availability on the Low Level Route</p>

item #	Information	Sending node	Receiving node	Usage(receiving node)
23	SBAS Notam	AIS provider	Aircraft Operator	If SBAS required, to be informed about the SBAS availability on the Low Level Route. SBAS NOTAM could be regional.
			ATCO	
Aircraft Operator				
20a	LLR Chart	Aircraft Operator	Flight Crew	To obtain the Low Level Route chart (paper or electronic) for the flight in accordance with the operator's rule/format
21a	AIP/AIC	Aircraft Operator	Flight Crew	To be informed of specific LLR information (RNP value, limitation, etc...) in accordance with the operator's rule/format
22a	RAIM Notam	Aircraft Operator	Flight Crew	Required only if SBAS is not used To be informed about the GPS RAIM availability on the Low Level Route in accordance with the operator's rule/format
23a	SBAS Notam	Aircraft Operator	Flight Crew	If SBAS required, to be informed about the SBAS availability on the Low Level Route in accordance with the operator's rule/format
30a	Nav Data Base	Aircraft Operator	RNP aircraft Subsystem	To load the Navigation Data Base in the RNAV/FMS system in order to fly the Low Level Route appropriately
32	FPL request	Aircraft Operator	Flight Planning	To approve the helicopter operator flight plan including the Low Level Route. Exemption to flight plan submission for specific operations like HEMS, SAR could be provided.
31	Flight operation procedures and training	Aircraft Operator	Flight Crew	To be informed of appropriate procedures relevant for Low Level Route operations including contingency procedures and to be trained on these normal and abnormal procedures
70a	MET info	Aircraft Operator	Flight Crew	To be informed or self-brief about the weather forecast on the Low Level Route in accordance with the operator's rule/format
Network Manager (NM)				
32a	Approved FPL	Flight Planning	Aircraft Operator	To be informed on the status of the submitted flight plan
32b			ATCO	To be informed on the helicopter flight plan including the Low Level Route
ATSP				

item #	Information	Sending node	Receiving node	Usage(receiving node)
40	Clearance	ATCO	Flight Crew	To respect ATC clearances for the Low Level Route in controlled airspace
41	Tactical Clearances	ATCO	Flight Crew	To respect ATC instructions on the Low Level Route (e.g. level change, speed,...)
42	QNH	ATCO	Flight Crew	To obtain QNH for the Low Level Route
43	Radar Surveillance information	Radar Surv	ATCO	<ul style="list-style-type: none"> - To obtain surveillance information from IFR flight and VFR flight when required - To separate Aircraft under control
44	ATC Control	IFR A/C	ATCO	<ul style="list-style-type: none"> - To separate IFR from IFR in airspace class C, D and E - To separate IFR from VFR in airspace class C
45	No ATC Control except in Class C	VFR A/C	ATCO	<ul style="list-style-type: none"> - To separate VFR from IFR in airspace class C - To provide traffic information about VFR flight in class C and D - To provide traffic information about VFR flight as far as practicable in airspace class E
46	ATC control		ATCO	<ul style="list-style-type: none"> - To separate helicopter on the Low Level Route from other controlled aircraft
47	Traffic information	ATCO	Flight crew	<ul style="list-style-type: none"> - To obtain traffic information of other aircraft in the vicinity (only ATC known A/C)
48	MET update	ATCO	Flight crew	To obtain updated MET info on the Low Level Route
LLR-IFR Helicopter				
50	Route selection	Flight Crew	RNP Aircraft Subsystem	To select the Low Level Route
51	RNP nav Data	RNP Aircraft Subsystem	Flight Control and Display	<ul style="list-style-type: none"> - To display lateral deviation from the desired route and distance to next waypoint - To guide the helicopter respecting the lateral desired path - To display the Actual Navigation Performance (ANP)
51a	A/C position data	RNP Aircraft Subsystem	HTAWS	To obtain precise helicopter position for the Terrain Awareness Warning System if fitted
52	Display and guidance selection	Flight Crew	Flight Control and Display	<ul style="list-style-type: none"> - -To provide display and guidance mode in accordance with pilot's selection.
53	Display and guidance data	Flight Control and Display	Flight Crew	<ul style="list-style-type: none"> - To verify the Low Level Route to be flown - To verify the Actual Navigation Performance (ANP) - To monitor lateral deviation - To verify altitude - To be informed about failure (flag)

ite m #	Information	Sending node	Receiving node	Usage(receiving node)
54	QNH setting	Flight Crew	Alt Sys	- To receive QNH setting for altitude computation/correction
55	Altitude	Alt Sys	Flight Control and Display	- To display barometric altitude (pilot should apply any relevant correction for temperature)
56	Conv Nav data	Conv nav Syst	Flight Control and Display	- To display Conventional navigation information when required by regulation (e.g. VOR, DME..)
57	Traffic Alert	Traffic Info	Flight Crew	- To improve the situational awareness regarding other A/C in the vicinity - To take evasive manoeuvre
58	Readback	Flight Crew	ATCO	To confirm pilot acknowledgment of ATC clearances/instructions
59	Specific request	Flight Crew	ATCO	To be informed about pilot's request
60	See and Avoid	VFR A/C	Flight Crew	To avoid collision when weather conditions permit and requires that pilots should actively search for potentially conflicting traffic
61	Electronic A/C detection	VFR A/C	Traffic Info	To detect electronically other A/C in the vicinity of the helicopter
		IFR A/C		
DAT Provider				
30	Nav Data Base	NavDB integrator & packer	Aircraft Operator	To obtain the navigation base including all relevant data for the Low Level Route
MET Provider				
70	MET Info	MET	Aircraft Operator	To be informed about the weather forecast on the Low Level Route
			ATCO	To be informed about the weather forecast on the Low Level Route

6.1.2 Derivation of Safety Requirements at Design level – Normal operations

Each of the Safety Requirements at Service level for Normal operations (defined at section 5.2) is mapped onto the LLR Functional System model in view of identifying the human, procedural or equipment elements that need to concur to the satisfaction of the Safety Requirements at Service level and from there, to derive the appropriate Safety Requirements at design level addressing those elements.

The detailed safety requirement derivation process is provided in ANNEX B – section B.1.1.

6.1.3 Derivation of Safety Requirements at Design level – Abnormal operations

Taking advantage of the analysis of each Abnormal scenario, the Safety Requirements at service level for Abnormal operations (defined at section 5.3) are mapped onto the LLR Functional System model in view to derive the appropriate Safety Requirements addressing the Functional System elements that concur to the satisfaction of each Safety Requirement at service level.

The detailed safety requirement derivation process is provided in ANNEX B – section B.1.2.

6.1.4 Derivation of Safety Requirements at Design level – Faulted operations

The objective of the Functional System design analysis under Faulted operations (PSSA) consists in determining how the system architecture (encompassing people, procedures and equipment) designed for LLR can be made safe in the presence of internal system failures. For that purpose, the method consists in apportioning the Safety Requirements at Service level of each operational hazard into Safety Requirements at Design level to elements of the system driven by the analysis of the hazard causes.

Various methods are available to perform the causal analysis of the operational hazards.

One of them is the Fault tree analysis, used to identify the causes of hazards and combinations thereof, to assess the frequency of occurrence of the hazards (based on the knowledge on the frequency of occurrence of the hazard causes and the effectiveness of the mitigations) and ultimately to derive, if necessary, additional mitigations for preventing the hazard occurrence. Fault trees have been produced for a sub-set of LLR hazards and are presented in ANNEX C – section C.1.

For each operational hazard, the main causes have been submitted to the participants' discussion & validation together with the existing mitigations enabling to prevent the hazard occurrence or to protect against the propagation of the hazard effects. When necessary (with regard to the distance to the accident allocated to the operational hazard's effect within the workshop and the qualitative estimation of the hazard occurrence) additional mitigations have been derived as Safety Requirements for the Faulted operations.

These Safety Requirements have been consolidated, together with all the other safety requirements derived within this section 6 (addressing the safety assessment at the design level), in the next subsection 6.1.5

6.1.5 Derived Safety Requirements in controlled airspace – consolidated view

The next Table 6-1 is consolidating the Safety Requirements derived within the Functional System design analysis of the LLR operations for Normal, Abnormal and Faulted operations, in controlled airspace

This is these safety requirements (at design level) that must be considered for the local implementation and operations in controlled airspace.

For each safety requirement, this table indicates:

- The domain to which the requirement applies (FPD, ATS, AIS...)
- The applicability depending on the types of operation: *Normal LLR* or *Transition to existing approach*
- The ID of the Safety Requirement at Service Level at the origin from which the Service Requirement at Design Level is derived

The requirements highlighted in **bold** in this table are the ones impacted or created within the frame of this new edition of the Generic Safety Case.

SR ID	Description	Domain	Applicability	Ref. SRS ID
SR_LLRL_CTRL#1	If not exempted, the Helicopter Operator shall submit the flight plan to the Network Manager including the relevant part of the helicopter Low Level Route.	Helicopter operator	LLR	SRS_LLRL_CTRL#1
SR_LLRL_CTRL#2	The Helicopter pilot shall request to the Controller the clearance to enter on helicopter Low Level Route	Helicopter- Flight Crew	LLR	SRS_LLRL_CTRL#2, SRS_LLRL_CTRL#18
SR_LLRL_CTRL#3	The ATC Controller shall give a clearance to the helicopter pilot for entering on the helicopter Low Level Route	ATS	LLR	SRS_LLRL_CTRL#2, SRS_LLRL_CTRL#18
SR_LLRL_CTRL#4	The ATC Controller shall establish separation between helicopters operating on the Low Level Route in accordance with prescribed minima	ATS	LLR	SRS_LLRL_CTRL#2, SRS_LLRL_CTRL#18
SR_LLRL_CTRL#5	The ATC Controller shall separate helicopters established on the Low Level Route with other IFR aircraft in the vicinity of the route in airspace class C,D and E	ATS	LLR	SRS_LLRL_CTRL#2, SRS_LLRL_CTRL#18, SRS_LLRL_CTRL#20
SR_LLRL_CTRL#6	The ATC Controller shall separate helicopters established on the Low Level Route with VFR aircraft in the vicinity of the route in airspace class C	ATS	LLR	SRS_LLRL_CTRL#2, SRS_LLRL_CTRL#18, SRS_LLRL_CTRL#20
SR_LLRL_CTRL#7	The ATC Controller shall maintain separation between helicopters established on the Low Level Route in accordance with prescribed minima	ATS	LLR	SRS_LLRL_CTRL#3, SRS_LLRL_CTRL#18
SR_LLRL_CTRL#8	The terrain and obstacles used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.	FPD	LLR	SRS_LLRL_CTRL#4, SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#9	The helicopter Low Level Route shall be designed in accordance with criteria relative to En-Route criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.	FPD	LLR	SRS_LLRL_CTRL#4, SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#10	The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.	FPD	LLR	SRS_LLRL_CTRL#4, SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#11	The helicopter Low Level Route shall be published in the state AIP in accordance with ICAO Annex 4, ICAO Doc 8697, ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 part FPD and AIS and shall indicate the required aircraft navigation capability to fly the Low Level route (e.g. RNP 1, RNP 0.3).	AIS	LLR	SRS_LLRL_CTRL#4, SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#12	The promulgation of helicopter Low Level Routes shall comply with the appropriate data quality requirements of ICAO Annex 15 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.	AIS	LLR	SRS_LLRL_CTRL#4, SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24

SR ID	Description	Domain	Applicability	Ref. SRS ID
SR_LLRCtrl#13	The GNSS signal in space (GPS and SBAS if required) shall be compliant with ICAO Annex 10 SARPS and (EU) No 2017/373 Part CNS on the helicopter Low Level Route.	GNSS/SBAS service	LLR	SRS_LLRCtrl#5, SRS_LLRCtrl#17, SRS_LLRCtrl#24
SR_LLRCtrl#14	The Helicopter Operator shall use a navigation data base which satisfies the requirements of the AIR OPS regulation (EU) No 965/2012 in order to meet standards of integrity that are adequate for the intended use of the electronic navigation data.	Helicopter operator	LLR	SRS_LLRCtrl#5, SRS_LLRCtrl#17, SRS_LLRCtrl#24
SR_LLRCtrl#15	The Flight Crew shall insert the relevant part of the Low Level Route extracted from the navigation data base in the RNP system's flight plan	Helicopter- Flight Crew	LLR	SRS_LLRCtrl#5, SRS_LLRCtrl#17
SR_LLRCtrl#16	The Flight Crew shall respect the displayed RNP lateral navigation information if flight is conducted in manual mode or using Flight director	Helicopter- Flight Crew	LLR	SRS_LLRCtrl#5, SRS_LLRCtrl#17, SRS_LLRCtrl#24
SR_LLRCtrl#17	The ATC Controller shall provide the QNH information to the Flight Crew for the helicopter Low Level Route which could be a single value for the whole route or multiple values due to the route structure.	ATS	LLR	SRS_LLRCtrl#6, SRS_LLRCtrl#17
SR_LLRCtrl#18	The Flight Crew shall set the QNH appropriate for the Low Level Route or the part of the Low Level Route to be flown	Helicopter- Flight Crew	LLR	SRS_LLRCtrl#6, SRS_LLRCtrl#17
SR_LLRCtrl#19	The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind	Helicopter- Flight Crew	LLR	SRS_LLRCtrl#6, SRS_LLRCtrl#17, SRS_LLRCtrl#24
SR_LLRCtrl#20	The spacing between the helicopter Low Level Route and other routes/SIDs/STARs shall be defined by the air traffic service provider/ airspace designer to prevent loss of separation between aircraft operating on these routes considering navigation performance, separation minima, traffic density, sector size.	FPD	LLR	SRS_LLRCtrl#7, SRS_LLRCtrl#20
SR_LLRCtrl#21	The ATC Controller in airspace class D shall provide traffic information about VFR flights to helicopter established on the Low Level Route	ATS	LLR	SRS_LLRCtrl#8, SRS_LLRCtrl#18, SRS_LLRCtrl#20
SR_LLRCtrl#22	The ATC Controller in airspace class E shall provide, as far as practicable, traffic information about VFR flights to helicopter established on the Low Level Route	ATS	LLR	SRS_LLRCtrl#8, SRS_LLRCtrl#18, SRS_LLRCtrl#20
SR_LLRCtrl#23	The Flight Crew established on the Low Level Route shall actively search for potentially conflicting traffic when weather conditions permit, especially when operating in airspace where all traffic is not operating under the instructions of ATC like in class E airspace	Helicopter- Flight crew	LLR	SRS_LLRCtrl#8, SRS_LLRCtrl#19, SRS_LLRCtrl#21
SR_LLRCtrl#24	The helicopter Low Level Route chart shall clearly indicate the prohibited/restricted areas in the vicinity of the route	AIS	LLR	SRS_LLRCtrl#9

SR ID	Description	Domain	Applicability	Ref. SRS ID
SR_LLRL_CTRL#25	The MET service provider or an approved operator shall provide appropriate MET information to the Helicopter Operator for the flight planning which are at the minimum QNH, Cb cloud, lightning and in-flight icing.	MET	LLR	SRS_LLRL_CTRL#10, SRS_LLRL_CTRL#22
SR_LLRL_CTRL#26	The MET service provider or an approved operator shall provide current MET information to the ATC Controller for the helicopter Low Level Route which are at the minimum QNH, Cb cloud, lightning and in-flight icing.	MET	LLR	SRS_LLRL_CTRL#10, SRS_LLRL_CTRL#22
SR_LLRL_CTRL#27	The Flight Crew shall be informed by the Controller about any change of MET conditions on the helicopter Low Level Route.	Helicopter- Flight crew	LLR	SRS_LLRL_CTRL#10, SRS_LLRL_CTRL#22
SR_LLRL_CTRL#28	The design of the transition shall allow a smooth vertical transition from the LLR altitude to the altitude of capture of the existing approach	FPD	Transition	SRS_LLRL_CTRL#11, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#29	The 2D design of the transition shall minimize the risk of overshoot of the existing approach axis and shall intercept the approach axis at a sufficient distance from the runway for a safe and stable approach	FPD	Transition	SRS_LLRL_CTRL#11, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#30	The publication of the LLR transition to the existing approach (ILS or RNP) shall minimize the risk of flight crew misinterpretation of any data/elements of the charts.	AIS	Transition	SRS_LLRL_CTRL#11, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#31	The ATC controller shall give appropriate instructions when needed to facilitate the transition between the low level route and the existing approach (i.e. to facilitate the compliance with published altitude or speed constraints).	ATS	Transition	SRS_LLRL_CTRL#12
SR_LLRL_CTRL#32	The flight crew shall comply with constraints published on the flight procedure and with the ATC clearance/instruction relating to transition between the low level route and the existing approach.	Helicopter- Flight Crew	Transition	SRS_LLRL_CTRL#12
SR_LLRL_CTRL#33	The Flight Control and Display sub-system shall display an appropriate full scale deflection during transition between the low level route and the existing approach to avoid disturbance of the flight crew.	Helicopter- System	Transition	SRS_LLRL_CTRL#12
SR_LLRL_CTRL#34	The ATC controller shall integrate safely the helicopter traffic in the approach sequence considering the different operational scenarios which might happen during operation (e.g. through anticipate speed restriction, holdings,...)"	ATS	Transition	SRS_LLRL_CTRL#13
SR_LLRL_CTRL#35	In case of loss of RNP capability on the helicopter Low Level Route, flight crew shall respect helicopter operator's contingency procedures developed for such situations	Helicopter- Flight Crew	LLR	SRS_LLRL_CTRL#14
SR_LLRL_CTRL#36	The Flight Crew shall inform the Controller about the loss of RNP capability on the helicopter Low Level Route and about the contingency procedure	Helicopter- Flight Crew	LLR	SRS_LLRL_CTRL#14

SR ID	Description	Domain	Applicability	Ref. SRS ID
SR_LLRL_CTRL#37	The ATC Controller shall , as far as feasible, provide assistance to the Flight Crew following the loss of RNP capability on the helicopter Low Level Route	ATS	LLR	SRS_LLRL_CTRL#14
SR_LLRL_CTRL#38	In case of radio communication failure, the Flight Crew shall fly the procedure/route in accordance with the flight planning and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure	Helicopter- Flight Crew	LLR	SRS_LLRL_CTRL#15
SR_LLRL_CTRL#39	In case of icing conditions encountered on the helicopter Low Level Route, the Flight Crew shall respect helicopter operator's contingency procedures developed for such situations	Helicopter- Flight Crew	LLR	SRS_LLRL_CTRL#16
SR_LLRL_CTRL#40	The AIS provider shall verify that published Low Level Route data/elements are identical to those provided by the procedure designer	AIS	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#41	The Flight Crew shall verify the consistency of the Low Level Route with the published chart using the helicopter displayed data (FPLN, ND...)	Helicopter- Flight Crew	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#42	The RNP airborne systems based on GPS and/or SBAS shall be certified in accordance with EASA regulation and approved for the RNP requirement required by the published procedure	Helicopter- System	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#43	The Flight Crew shall be trained on RNP navigation, Low Level Route and associated contingency procedures	Helicopter- Flight Crew	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#44	ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route	ATS	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#18, SRS_LLRL_CTRL#20, SRS_LLRL_CTRL#23, SRS_LLRL_CTRL#24
SR_LLRL_CTRL#45	In radar environment, the Low Level Route shall be displayed, on demand, on the controller working position to facilitate the recognition of potential conflict	ATS	LLR	SRS_LLRL_CTRL#18, SRS_LLRL_CTRL#20
SR_LLRL_CTRL#46	The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.	AIS	LLR	SRS_LLRL_CTRL#20, SRS_LLRL_CTRL#21
SR_LLRL_CTRL#47	The design of the Low level route design shall minimize the risk of collision between helicopters by separating strategically when possible the different traffic flows operating on the Low Level Route network (e.g. vertical separation	FPD	LLR	SRS_LLRL_CTRL#23, SRS_LLRL_CTRL#18

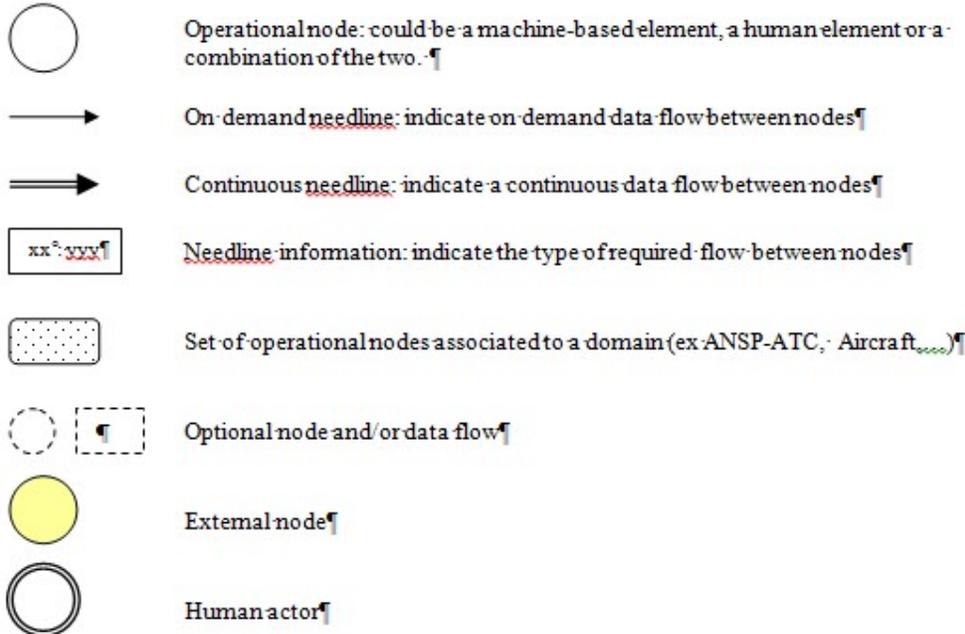
Table 6-1. Consolidated list of safety requirements for LLR operations in controlled airspace

6.2 Functional System design analysis in uncontrolled airspace

6.2.1 LLR Functional System logical model

The LLR Functional System can be modelled via a high-level architectural representation of the main elements (people, equipment and procedures) performing the LLR helicopter operations as per Figure 6-2 and addressing all domains (all sub-arguments of Argument 2 –see section 4.4).

The symbols used in the Logical model are as follows:



Helicopter Low Level Route operations in controlled and uncontrolled airspace
 Generic Safety Case

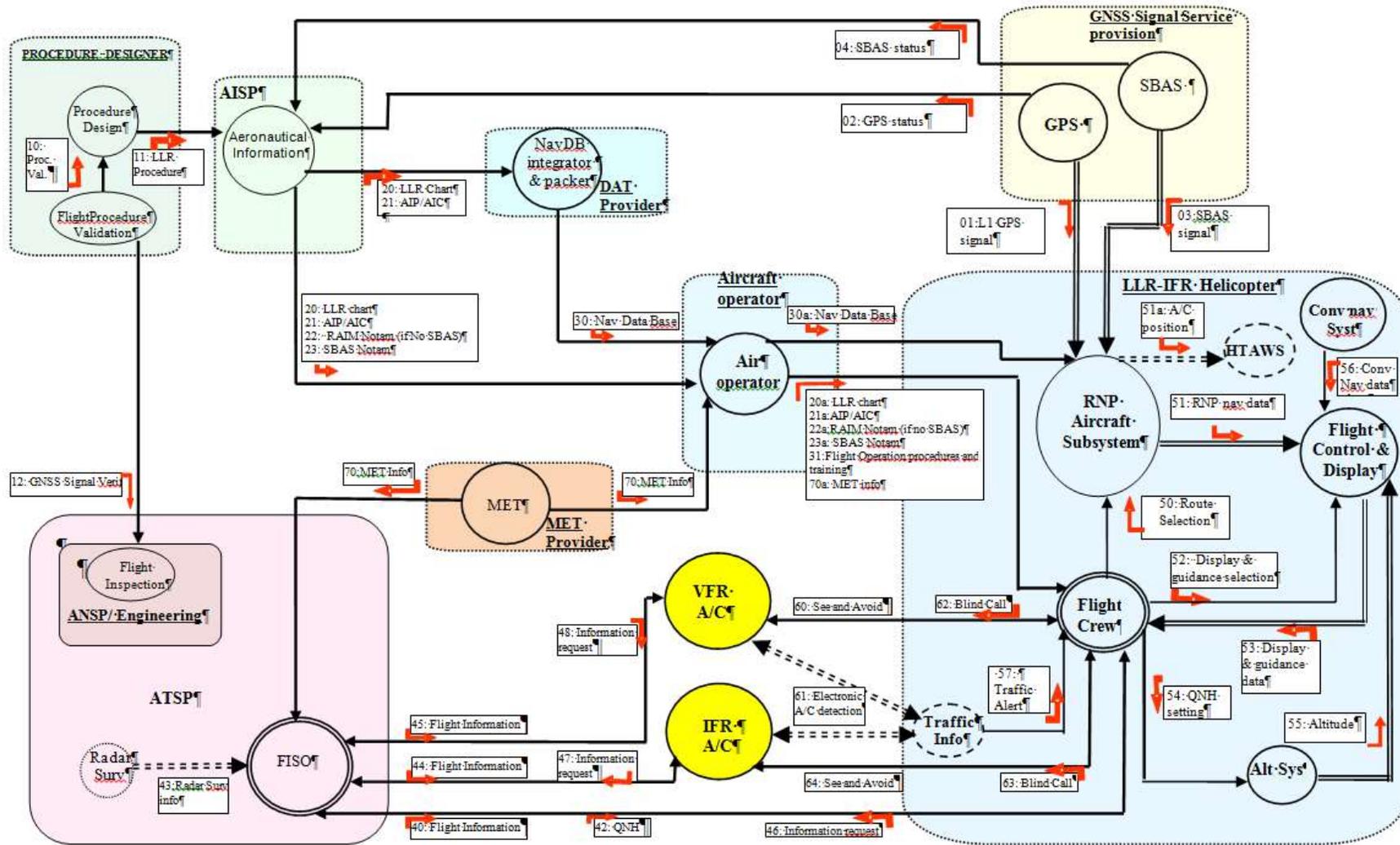


Figure 6-2: LLR Uncontrolled Functional System logical model

The following table describes the Logical Model operational information.

item #	Information	Sending node	Receiving node	Usage(receiving node)
GNSS Signal Service Provision				
01	L1 GPS Signal	GPS	RNP aircraft Subsystem	To receive and decode GPS satellite signal
02	GPS Status	GPS	AIS Provider	<ul style="list-style-type: none"> - To be informed on the status of the GPS navigation infrastructure (GPS satellite) - To elaborate RAIM NOTAM when necessary
03	SBAS Signal (if SBAS required)	SBAS	RNP aircraft Subsystem	To receive and decode SBAS signal
04	SBAS Status (if SBAS required)	SBAS	AIS Provider	<ul style="list-style-type: none"> - To be informed on the status of the SBAS navigation infrastructure - To receive SBAS NOTAM proposal
ANSP/Engineering				
12	GNSS Signal verification	Procedure Design	Flight Inspection	To verify GPS and SBAS signal on the Low Level Route
Procedure Designer				
11	LLR Procedure	Procedure Design	AIS Provider	To obtain all data relevant for the aeronautical data origination including the procedure design (LLR chart)
			FISO	To have all the necessary information on the LLR for proper operation (ops procedures, briefing,...)
10	Procedure validation	Flight Procedure Validation	Procedure Design	To validate that the procedure has been designed in accordance with design criteria
AISP				
20	LLR Chart	AIS provider	Aircraft Operator	To be informed on the depiction/characteristics of the Low Level Route to be flown
			NavDB Integrator & packer	
21	AIP/AIC	AIS provider	Aircraft Operator	To be informed of specific LLR information (RNP value, limitation, etc...)
			NavDB Integrator & packer	

item #	Information	Sending node	Receiving node	Usage(receiving node)
22	RAIM Notam	AIS provider	Aircraft Operator	Required only if SBAS is not used To be informed about the GPS RAIM availability on the Low Level Route
23	SBAS Notam	AIS provider	Aircraft Operator	If SBAS required, to be informed about the SBAS availability on the Low Level Route. SBAS NOTAM could be regional.
Aircraft Operator				
20a	LLR Chart	Aircraft Operator	Flight Crew	To obtain the Low Level Route chart (paper or electronic) for the flight in accordance with the operator's rule/format
21a	AIP/AIC	Aircraft Operator	Flight Crew	To be informed of specific LLR information (RNP value, limitation, etc...) in accordance with the operator's rule/format
22a	RAIM Notam	Aircraft Operator	Flight Crew	Required only if SBAS is not used To be informed about the GPS RAIM availability on the Low Level Route in accordance with the operator's rule/format
23a	SBAS Notam	Aircraft Operator	Flight Crew	If SBAS required, to be informed about the SBAS availability on the Low Level Route in accordance with the operator's rule/format
30a	Nav Data Base	Aircraft Operator	RNP aircraft Subsystem	To load the Navigation Data Base in the RNAV/FMS system in order to fly the Low Level Route appropriately
31	Flight operation procedures and training	Aircraft Operator	Flight Crew	To be informed of appropriate procedures relevant for Low Level Route operations including contingency procedures and to be trained on these normal and abnormal procedures
70a	MET info	Aircraft Operator	Flight Crew	To be informed about the weather forecast on the Low Level Route in accordance with the operator's rule/format
ATSP				
40	Flight Information	FISO	Flight Crew	To receive flight information if requested
42	QNH	FISO	Flight Crew	To obtain QNH for the Low Level Route
43	Radar Surveillance information	Radar Surv	FISO	To obtain radar information (if available) from IFR flight and VFR flight (if equipped)

item #	Information	Sending node	Receiving node	Usage(receiving node)
44	Flight Information	FISO	IFR A/C	To receive flight information if requested
45	Flight Information	FISO	VFR A/C	To receive flight information if requested
46	Information request	Flight Crew	FISO	To receive information request from helicopter flight crew (e.g. assistance)
47	Information request	IFR A/C	FISO	To receive information request from IFR A/C flight crew (e.g. assistance)
48	Information request	VFR A/C	FISO	To receive information request from VFR A/C flight crew (e.g. assistance)
LLR-IFR Helicopter				
50	Route selection	Flight Crew	RNP Aircraft Subsystem	To select the Low Level Route
51	RNP nav Data	RNP Aircraft Subsystem	Flight Control and Display	<ul style="list-style-type: none"> - To display lateral deviation from the desired route and distance to next waypoint - To guide the helicopter respecting the lateral desired path - To display the Actual Navigation Performance (ANP)
51a	A/C position data	RNP Aircraft Subsystem	HTAWS	To obtain precise helicopter position for the Terrain Awareness Warning System if fitted
52	Display and guidance selection	Flight Crew	Flight Control and Display	<ul style="list-style-type: none"> - To provide display and guidance mode in accordance with pilot's selection.
53	Display and guidance data	Flight Control and Display	Flight Crew	<ul style="list-style-type: none"> - To verify the Low Level Route to be flown - To verify the Actual Navigation Performance (ANP) - To monitor lateral deviation - To verify altitude - To be informed about failure (flag)
54	QNH setting	Flight Crew	Alt Sys	<ul style="list-style-type: none"> - To receive QNH setting for altitude computation/correction
55	Altitude	Alt Sys	Flight Control and Display	<ul style="list-style-type: none"> - To display altitude (pilot should apply any relevant correction for temperature)
56	Conv Nav data	Conv nav Syst	Flight Control and Display	<ul style="list-style-type: none"> - To display conventional navigation information when required by regulation (e.g. VOR, DME..)

item #	Information	Sending node	Receiving node	Usage(receiving node)
57	Traffic Alert	Traffic Info	Flight Crew	<ul style="list-style-type: none"> - To improve the situational awareness regarding other A/C in the vicinity - To take evasive manoeuvre
60	See and Avoid	VFR A/C	Flight Crew	To avoid collision when weather conditions permit and requires that pilots should actively search for potentially conflicting traffic
61	Electronic A/C detection	VFR A/C	Traffic Info	To detect electronically other A/C in the vicinity of the helicopter
		IFR A/C		
62	Blind Call	Flight Crew	VFR A/C	To be informed about the IFR helicopter flight on the Low Level Route
63	Blind Call	Flight Crew	IFR A/C	To be informed about the IFR helicopter flight on the Low Level Route
64	See and Avoid	IFR A/C	Flight Crew	To avoid collision when weather conditions permit and requires that pilots should actively search for potentially conflicting traffic
DAT Provider				
30	Nav Data Base	NavDB integrator & packer	Aircraft Operator	To obtain the navigation base including all relevant data for the Low Level Route
MET Provider				
70	MET Info	MET	Aircraft Operator	To be informed or self-brief about the weather forecast on the Low Level Route
			FISO	To be informed about the weather forecast on the Low Level Route

6.2.2 Derivation of Safety Requirements at Design level – Normal operations

Each of the Safety Requirements at Service level for Normal operations (defined at section 5.2.2) is mapped onto the LLR Functional System model in view of identifying the human, procedural or equipment elements that need to concur to the satisfaction of the Safety Requirements at Service level and from there, to derive the appropriate Safety Requirements at Design level addressing those elements.

The detailed safety requirement derivation process is provided in ANNEX B – section B.2.1.

6.2.3 Derivation of Safety Requirements at Design level – Abnormal operations

Taking advantage of the analysis of each abnormal scenario (performed at section 5.3.2), the Safety Requirements at Service level for Abnormal operations identified in that section are mapped onto the LLR Functional System model in view to derive the appropriate Safety Requirements at Design level addressing the Functional System elements that concur to the satisfaction of each Safety Requirement at Service level.

The detailed safety requirement derivation process is provided in ANNEX B – section B.2.2.

6.2.4 Derivation of Safety Requirements at Design level – Faulted operations

The objective of the Functional System design analysis under Faulted operations (PSSA) consists in determining how the system architecture (encompassing people, procedures and equipment) designed for LLR can be made safe in presence of internal system failures. For that purpose, the method consists in apportioning the Safety Requirements at Service level of each operational hazard into Safety Requirements at Design level to elements of the system driven by the analysis of the hazard causes.

Various methods are available to perform the causal analysis of the operational hazards.

One of them is the Fault tree analysis, used to identify the causes of hazards and combinations thereof, to assess the frequency of occurrence of the hazards (based on the knowledge on the frequency of occurrence of the hazard causes and the effectiveness of the mitigations) and ultimately to derive, if necessary, additional mitigations for preventing the hazard occurrence. Fault trees have been produced for LLR hazards and are presented in ANNEX C – section C.2.

For each operational hazard, the main causes have been submitted to the Participants' discussion & validation together with the existing mitigations enabling to prevent the hazard occurrence or to protect against the propagation of the hazard effects. When necessary (with regard to the distance to the accident allocated to the operational hazard's effect within the workshop and the qualitative estimation of the hazard occurrence) additional mitigations have been derived as Safety Requirements for the Faulted operations.

These Safety Requirements have been consolidated, together with all the other safety requirements derived within this section 6 (addressing the safety assessment at the design level), in the next sub-section 6.2.5

6.2.5 Derived Safety Requirements in uncontrolled airspace – Consolidated view

The next Table 6-2 is consolidating the Safety Requirements derived within the Functional System design analysis of the LLR operations for Normal, Abnormal and Faulted operations, in uncontrolled airspace

This is these safety requirements (at design level) that must be considered for the local implementation and operations in uncontrolled airspace.

For each safety requirement, this table indicates:

- The domain to which the requirement applies (FPD, ATS, AIS...)
- The ID of the Safety Requirement at Service Level at the origin from which the Service Requirement at Design Level is derived

Requirements in *italics* despite they are tagged as UNCTRL requirements are identical to requirements derived for the controlled airspace.

The requirements highlighted in **bold** in this table are the ones impacted or created within the frame of this new edition of the Generic Safety Case.

SR ID	Description	Domain	Ref. SRS ID
SR_LL_R_UCTRL#1	The Air Traffic Service Provider or Helicopter Operator or third party shall manage and monitor the planned traffic on the Low Level Route based on flight plan information to prevent simultaneous use of the route which might lead to conflicting situations.	ATS	SRS_LL_R_UNCTRL#1, SRS_LL_R_UNCTRL#17
SR_LL_R_UCTRL#2	The Flight Crew established on the Low Level Route shall actively search for conflicting traffic when weather conditions permit (see and avoid) based on traffic information provided by other aircraft and by flight information services when available	Helicopter- Flight Crew	SRS_LL_R_UNCTRL#2, SRS_LL_R_UNCTRL#14
SR_LL_R_UCTRL#3	VFR or IFR pilots flying in the vicinity of the Low Level Route shall actively search for conflicting traffic when weather conditions permit (see and avoid) based on traffic information provided by other aircraft and by flight information services when available	Other traffic- Pilot	SRS_LL_R_UNCTRL#2, SRS_LL_R_UNCTRL#15
SR_LL_R_UCTRL#4	<i>The terrain and obstacle used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.</i>	FPD	SRS_LL_R_UNCTRL#3, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#5	<i>The helicopter Low Level Route shall be designed in accordance with criteria relative to EnRoute criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.</i>	FPD	SRS_LL_R_UNCTRL#3, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#6	<i>The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.</i>	FPD	SRS_LL_R_UNCTRL#3, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#7	<i>The helicopter Low Level Route shall be published in the state AIP in accordance with ICAO Annex 4, ICAO Doc 8697, ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 part FPD and AIS and shall indicate the required aircraft navigation capability to fly the Low Level route (e.g. RNP 1, RNP 0.3).</i>	AIS	SRS_LL_R_UNCTRL#3, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#8	<i>The promulgation of helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 15 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.</i>	AIS	SRS_LL_R_UNCTRL#3
SR_LL_R_UCTRL#9	<i>The GNSS signal in space (GPS and SBAS if required) shall be compliant with ICAO Annex 10 SARPS and (EU) No 2017/373 Part CNS on the helicopter Low Level Route.</i>	GNSS/SBAS service	SRS_LL_R_UNCTRL#4, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#10	<i>The Helicopter Operator shall use a navigation data base which satisfies the requirements of the AIR OPS regulation (EU) No 965/2012 in order to meet standards or integrity that are adequate for the intended use of the electronic navigation data</i>	Helicopter operator	SRS_LL_R_UNCTRL#4, SRS_LL_R_UNCTRL#13

SR ID	Description	Domain	Ref. SRS ID
SR_LL_R_UCTRL#11	<i>The Flight Crew shall insert the relevant part of the Low Level Route extracted from the navigation database in the RNP system's flight plan</i>	Helicopter-Flight Crew	SRS_LL_R_UNCTRL#4, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#12	<i>The Flight Crew shall respect the displayed RNP lateral navigation information if the flight is conducted in manual mode or using a Flight director</i>	Helicopter-Flight Crew	SRS_LL_R_UNCTRL#4, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#13	The Flight Information Service Officer (FISO) shall provide the QNH information to the Flight Crew for the helicopter Low Level Route which could be a single value for the whole route or multiple values due to the route structure	ATS	SRS_LL_R_UNCTRL#5, SRS_LL_R_UNCTRL#13, SRS_LL_R_UNCTRL#16
SR_LL_R_UCTRL#14	<i>The Flight Crew shall set the QNH appropriate for the Low Level Route or the part of the Low Level Route to be flown</i>	Helicopter-Flight Crew	SRS_LL_R_UNCTRL#5, SRS_LL_R_UNCTRL#13, SRS_LL_R_UNCTRL#16
SR_LL_R_UCTRL#15	<i>The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind</i>	Helicopter-Flight Crew	SRS_LL_R_UNCTRL#5, SRS_LL_R_UNCTRL#13
SR_LL_R_UCTRL#16	<i>The spacing between the helicopter Low Level Route and other routes/SIDs/STARs shall be defined by the air traffic service provider/airspace designer to prevent loss of separation between aircraft operating on these routes considering navigation performance, separation minima, traffic density, sector size, etc.</i>	FPD	SRS_LL_R_UNCTRL#6
SR_LL_R_UCTRL#17	The Flight Crew established on the Low Level Route shall transmit regularly their position and flight intent to inform other aircraft operating on the Low Level Route and other aircraft flying in the vicinity of the Low Level Route on a prescribed frequency or by any other means approved by the competent authority	Helicopter-Flight Crew	SRS_LL_R_UNCTRL#7
SR_LL_R_UCTRL#18	VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational awareness of helicopters pilots established on the Low Level Route	Other traffic-Pilot	SRS_LL_R_UNCTRL#7, SRS_LL_R_UNCTRL#14, SRS_LL_R_UNCTRL#15
SR_LL_R_UCTRL#19	A Radio Mandatory Zone (RMZ) shall be defined around the Low Level Route in order to maintain continuous air-ground voice communication watch and establish two-way communication, as necessary, on the appropriate communication channel unless it is shown that mitigating the risk of conflict with VFR and IFR is not required considering the airspace structure, the traffic density and the traffic complexity.	ATS	SRS_LL_R_UNCTRL#7

SR ID	Description	Domain	Ref. SRS ID
SR_LLRL_UCTRL#20	When a Flight Information Service (FIS) is available and for known traffic, the Flight Information Service Officer shall provide information about helicopters established on the Low Level Route and A/C in the vicinities of the Low Level Route	ATS	SRS_LLRL_UNCTRL#7
SR_LLRL_UCTRL#21	<i>The helicopter Low Level Route chart shall clearly indicate the prohibited/restricted areas in the vicinity of the route</i>	AIS	SRS_LLRL_UNCTRL#8
SR_LLRL_UCTRL#22	<i>The MET service provider or an approved operator shall provide appropriate MET information to the Helicopter Operator for the planned flight which are at the minimum QNH, Cb cloud, lightning and in-flight icing</i>	MET	SRS_LLRL_UNCTRL#9
SR_LLRL_UCTRL#23	The Flight Crew shall be informed by the Flight Information Service or the Helicopter Operator about a change of MET conditions on the helicopter Low Level Route	Helicopter-Flight Crew	SRS_LLRL_UNCTRL#9, SRS_LLRL_UNCTRL#16
SR_LLRL_UCTRL#24	<i>In case of loss of RNP capability on the helicopter Low Level Route, the Flight Crew shall respect the Helicopter Operator's contingency procedures developed for such situations</i>	Helicopter-Flight Crew	SRS_LLRL_UNCTRL#10
SR_LLRL_UCTRL#25	<i>The Flight Information Service Officer (FISO) shall, as far as feasible, provide assistance to the Flight Crew following the loss of RNP capability on the helicopter Low Level Route</i>	ATS	SRS_LLRL_UNCTRL#10
SR_LLRL_UCTRL#26	<i>In case of radio communication failure, the Flight Crew shall fly the procedure/route in accordance with the flight plan and set the transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure</i>	Helicopter-Flight Crew	SRS_LLRL_UNCTRL#11
SR_LLRL_UCTRL#27	<i>In case of icing conditions encountered on the helicopter Low Level Route, the Flight Crew shall respect the Helicopter Operator's contingency procedures developed for such situations</i>	Helicopter-Flight Crew	SRS_LLRL_UNCTRL#12
SR_LLRL_UCTRL#28	<i>The AIS provider shall verify that published Low Level Route data/elements are identical to those provided by the procedure designer</i>	AIS	SRS_LLRL_UNCTRL#13
SR_LLRL_UCTRL#29	<i>The Flight Crew shall verify the consistency of the Low Level Route with the published chart using the helicopter displayed data (FPLN, ND, ...)</i>	Helicopter-Flight Crew	SRS_LLRL_UNCTRL#13
SR_LLRL_UCTRL#30	<i>The RNP airborne systems based on GPS and/or SBAS shall be certified in accordance with EASA regulation and approved for the RNP requirement required by the published procedure</i>	Helicopter-System	SRS_LLRL_UNCTRL#13
SR_LLRL_UCTRL#31	<i>The Flight Crew shall be trained on RNP navigation Low Level Route and associated contingency procedures</i>	Helicopter-Flight Crew	SRS_LLRL_UNCTRL#13

SR ID	Description	Domain	Ref. SRS ID
SR_LL_R_UCTRL#32	The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.	AIS	SRS_LL_R_UNCTRL#15
SR_LL_R_UCTRL#33	The design of the Low Level Route shall minimize the risk of collision between helicopters by separating strategically when possible the different traffic flows operating on the Low Level Route network (e.g. vertical separation).	FPD	SRS_LL_R_UNCTRL#17
SR_LL_R_UCTRL#34	The design of the Low Level Route shall, when possible, prevent crossing routes if traffic on these routes is not managed by an ATSP, operator or a third party	FPD	SRS_LL_R_UNCTRL#17
SR_LL_R_UCTRL#35	Helicopters operating Low Level Route in airspace class G shall be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic on this route unless it is shown that mitigating the risk of conflict with VFR and IFR is not required considering the airspace structure, the traffic density and the traffic complexity.	Helicopter-System	SRS_LL_R_UNCTRL#17

Table 6-2. Consolidated list of safety requirements for LLR operations in uncontrolled airspace

7 Safety assurance for Implementation

The safety assessment for the implementation will be developed by the ANSP or any appropriate project owner⁵ with the support of helicopter operator(s). The safety assessment will be conducted in compliance with the actors' SMS (Safety Management System) and documented in their local Safety Case/ local Safety Assessment.

The main goal of the safety assessment at this stage is to collect evidences and to provide assurance that each Functional System element (people, procedures, equipment) meets its Safety Requirements as defined during the design phase (section 6 -Safety assessment Design level). However, note that additional Safety Requirements might be derived during Implementation & Integration, in accordance with any need for further refinement and clarification of the design (as an example, HMI design will need to be detailed in view of the implementation; activities like life trials might contribute to the design refinement, for procedures, working method and HMI).

With regard to the Implementation phase, the outcome of the safety assessment is mainly documented in a table in which for every Safety Requirement derived and further consolidated at Section 6.1.5 (Controlled airspace) or 6.2.5 (Uncontrolled airspace), the evidence of its implementation is provided.

Depending on the element of the Functional System addressed by a Safety Requirement, that evidence might concern:

- For Navigation provision (GNSS and EGNOS): indicating reference to a navigation service provider (ESSP) document for SBAS coverage and performance and verification results of the signal on the Low Level Route
- For the Low Level Route design: providing a procedure design report and a procedure validation report
- For the publication: providing the Low Level Route chart as to be published in the AIP
- For MET information: indicating reference to MET information to be forecasted on the route
- For ATS Procedures and Training of ATCOs/FISOs: indicating the specific paragraph of the Training or Operating Manuals where the requirement is fulfilled, together with a short description;
- For ATS communication and surveillance: indicating that radio communication coverage and surveillance coverage (if required) have been verified all along the route through modelling verification or actual flights.
- For ATS Ground Equipment if impacted by the change: first providing justification for the required level of assurance and the associated selected techniques according to the integrity required. Then providing evidence from system Verification and Validation (V&V, based on, inter alia, analysis and/or testing) and/or from Service experience (data from previous operational use of the product) and/or from compliance with Standards.
- For helicopter certification: indicating that installation complies with relevant EASA regulation applicable to the required PBN operations associated to the Low Level Route.
- For helicopter operator: indicating that operator complies with relevant EASA regulation applicable to the required PBN operations associated to the Low Level Route and obtain a special approval for RNP 0.3 helicopter operations⁶ (PBN-SPA).
- For flight crew: indicating that they will comply with relevant EASA regulation applicable to the required PBN operations associated to the Low Level Route

⁵ An organisation approved by the Competent authority to conduct the safety assessment process

⁶ This special approval does not apply to RNP Approaches with LNAV or LPV minima.

8 Safety assurance for Transition into service

The safety assessment for the transition into service will be developed by the ANSP or any appropriate project owner⁷ with the support of helicopter operator(s). This safety assessment will be conducted in compliance with the actors' SMS (Safety Management System) and documented in their local Safety Case/ local Safety Assessment.

The transition into service phase addresses whether the fully proven system is ready to be brought into operational use, and without affecting the continuity and safety of the on-going ATM/ANS service and/or helicopter operations.

The safety assurance activities for the transition into service phase are driven by:

- Verification that the existing system has been brought up to the full standard of the safety assessment baseline
- Verification that the new system has been fully prepared for operational service
- Verification that the risk during the transition to the new system has been reduced as far as reasonably practicable (AFARP) and if needed the definition of additional safety requirements to maintain an acceptable level of safety when moving from the old systems to the new systems

With regard to the Transition into service phase (encompassing switch to operations processes...), the safety assessment should include:

- ATM/ANS risk identification and mitigation:
 - Ensure that transfer phase Safety Requirements for the installation of different ground equipment (if any), or change of ATM/ANS procedures are defined such that the risks induced by the transfer phase on on-going ATS operations are acceptable. Then ensure those requirements are met and document the evidence;
 - Verify that ATM/ANS Functional System elements continue to meet their Safety Requirements, with regard to those operational environment aspects that might slightly differ from the operational environment assumed in the safety assessment.
 - Validate the system as transferred into operation with respect to users' Safety expectations and collect evidence resulting from the system evaluation with respect to Safety, as performed by its end users – e.g. operational trials, transition analysis, Operational Readiness Review.
- Helicopter Operator risk identification and mitigation:
 - Ensure that change of flight crew procedures (in particular from VFR to IFR) are defined such that risks induced by the transfer phase on on-going helicopter operations are acceptable. Then ensure those requirements are met and document the evidence;
 - Verify that airborne/flight crew elements continue to meet their Safety Requirements, with regard to those operational environment aspects that might slightly differ from the operational environment assumed in the safety assessment.
 - Validate the system as transferred into operation with respect to users' Safety expectations and collect evidence resulting from the system evaluation with respect to Safety, as performed by its end users – e.g. operational trials, transition analysis, Operational Readiness Review.

All preparations for bringing the individual systems / subsystems into service, and for supporting them in service, have been completed. Those preparations should include such things as publication of operational procedures, airspace changes (if any), publication of engineering procedures, provision of resources (people, equipment spares, maintenance facilities, etc...) and training of operational and technical personnel.

⁷ An organisation approved by the Competent authority to conduct the safety assessment process

The process of switching over from the old systems (e.g. airspace without Low Level Route) to the new systems (airspace with Low Level Route structure) must be fully planned and resourced. This should include switchover procedures, allocation of responsibilities and the training / briefing of all personnel involved (e.g. Controllers, Flight Information Service Officers...).

All hazards associated with switchover from the old systems to the new systems must be assessed and mitigated sufficiently. This assessment should include a sort of FHA/PSSA/SSA of the switchover and should result in the additional procedures, allocation of responsibilities and training / briefing of personnel necessary to prevent (as far as possible) things going wrong, and to take the appropriate actions should something go wrong.

9 Safety assurance in Operation

The safety assessment process during operation should tackle the Continuous data collection and monitoring of safety performances and the safety of maintenance or planned interventions. This safety assessment process relies on the SMS (Safety Management System) of the different domains/actors involved in the operation (ANSP, Helicopter operators; ...)

The operation phase provides monitoring of the safety performance of the system during its operational lifetime, and provides evidence that the physical system in practice achieves an acceptable level of safety, as defined by the Safety criteria.

The safety assurance activities, at the operation level are driven by:

- Verification that Safety Criteria and/or Safety Requirements are met using continuous data collection and monitoring of safety performances;
- Verification that skills and knowledge of operational and technical personnel are maintained at ANSP and Helicopter Operator levels.
- Verification that all safety-related incidents are reported, investigated and the appropriate corrective actions taken.
- Verification that risks induced by any maintenance and/or planned intervention are known and are acceptable.

Safety risk monitoring of changes shall be conducted as part of the ANSP and Helicopter Operator safety management processes and applicable regulatory obligations. The Safety monitoring criteria shall be determined together with the means for measuring them.

10 Assumptions, Recommendations and Issues

10.1 Controlled airspace

10.1.1.1 Assumptions log

The following table lists the assumptions applicable to LLR operations in controlled airspace.

For each assumption, this table indicates:

- The domain to which the assumption applies (FPD, ATS, AIS...)
- The applicability depending on the types of operation: *Normal LLR* or *Transition to existing approach*
- The ID of the Safety Requirement at Service Level at the origin from which the assumption is derived
- The mean to validate the assumption

The assumptions highlighted in **bold** in this table are the ones impacted or created within the frame of this new edition of the Generic Safety Case.

ID	Assumption	Domain	Type of operation	Ref. SRS ID	Validation
ASS_LLRL_CTRL#1	The Network Manager is able to validate helicopter Low Level Route flight plans.	NM	LLR	SRS_LLRL_CTRL#1	Basic NM requirement
ASS_LLRL_CTRL#2	The Network Manager approves the helicopter Low Level Route flight plan and inform the Helicopter Operator following flight plan acceptance	NM	LLR	SRS_LLRL_CTRL#1	Basic NM requirement
ASS_LLRL_CTRL#3	The Network Manager distributes the helicopter Low Level Route flight plan to relevant Air Traffic Service units	NM	LLR	SRS_LLRL_CTRL#1	Basic NM requirement
ASS_LLRL_CTRL#4	The flight crew request to the controller the clearance to initiate the approach.	Helicopter-Flight Crew	Transition	SRS_LLRL_CTRL#13	Basic airmanship
ASS_LLRL_CTRL#5	The ATC controller gives the clearance to the flight crew to initiate the approach.	ATS	Transition	SRS_LLRL_CTRL#13	Basic ATC requirement
ASS_LLRL_CTRL#6	The helicopter control and guidance system providing lateral guidance on the Low Level Route is approved in accordance with EASA regulation	Helicopter-System	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24	Basic A/C certification
ASS_LLRL_CTRL#7	The altimetry system is approved in accordance with EASA regulation	Helicopter-System	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24	Basic A/C certification
ASS_LLRL_CTRL#8	The helicopter control and guidance system providing vertical guidance on the Low Level Route is approved in accordance with EASA regulation	Helicopter-System	LLR	SRS_LLRL_CTRL#17, SRS_LLRL_CTRL#24	Basic A/C certification

ID	Assumption	Domain	Type of operation	Ref. SRS ID	Validation
ASS_LLRL_CTRL#9	ATC procedures associated to QNH transmission are conducted in accordance with the local ATC rules and should not be different when considering helicopter Low Level Route	ATS	LLR	SRS_LLRL_CTRL#17	Basic ATC requirement
ASS_LLRL_CTRL#10	The Flight crew procedures associated to the QNH setting onboard the helicopter are conducted in accordance with the Helicopter Operator rules and are not different when considering Low Level Route operations	Helicopter-Flight Crew	LLR	SRS_LLRL_CTRL#17	Basic airmanship
ASS_LLRL_CTRL#11	TMA radar displays are adequate for providing an adequate traffic picture to depict IFR aircraft on the Low Level Route and in the vicinity of the Low Level Route	ATS	LLR	SRS_LLRL_CTRL#18, SRS_LLRL_CTRL#20, SRS_LLRL_CTRL#23	Basic ATC requirement
ASS_LLRL_CTRL#12	TMA radar displays are adequate for providing an adequate traffic picture to depict VFR aircraft equipped with transponder on the Low Level Route and in the vicinity of the Low Level Route	ATS	LLR	SRS_LLRL_CTRL#18, SRS_LLRL_CTRL#20	Basic ATC requirement
ASS_LLRL_CTRL#13	The ATC controller provides the QNH information to the flight crew for the existing approach (ILS or RNP)	ATS	Transition	SRS_LLRL_CTRL#24	Basic ATC requirement

Table 10-1: Assumptions log for LLR operations in controlled airspace

10.1.1.2 Recommendation log

The following table lists the recommendations applicable to LLR operations in controlled airspace.

For each recommendation, this table indicates:

- The domain to which the recommendation applies (FPD, ATS, AIS...)
- The applicability depending on the types of operation: *Normal LLR* or *Transition to existing approach*
- The ID of the Safety Requirement at Service Level at the origin from which the recommendation is derived

The recommendations highlighted in **bold** in this table are the ones impacted or created within the frame of this new edition of the Generic Safety Case.

Recommendation	Domain	Domain	Type of operation	Ref. SRS ID
REC_LLRL_CTRL#1	All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices	Other traffic-System	LLR	SRS_LLRL_CTRL#19, SRS_LLRL_CTRL#21

Recommendation	Domain	Domain	Type of operation	Ref. SRS ID
	authorized by the Competent Authority			
REC_LLRL_CTRL#2	Helicopters operating on Low Level Routes in airspace class E should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity	Helicopter-System	LLR	SRS_LLRL_CTRL#19, SRS_LLRL_CTRL#21
REC_LLRL_CTRL#3	Helicopters operating on Low Level Routes should be equipped with airborne weather radar or on-board Electronic Flight Bag (EFB) Ground Radar information.	Helicopter-System	LLR	SRS_LLRL_CTRL#22

Table 10-2: Recommendations log for LLR operations in controlled airspace

10.1.1.3 Issue log

The following sections synthesis the issues identified within this safety case :

- section 10.1.1.3.1 lists the open issues that should be resolved for LLR operations in controlled airspace.
- section 10.1.1.3.2 list the solved issues. These elements are not considered as issues anymore as they are solve, however, they are maintained in present document for recording purpose.

10.1.1.3.1 Open issues

No open issue is currently identified for LLR operations in controlled airspace

10.1.1.3.2 Solved issues

The following issues linked to LLR operations in controlled airspace have been solved:

Issue	Resolution
Issue_S_LLRL_CTRL#1. Verify with NM the flight plan validation process for helicopter Low Level Routes (KYxxx)	Helicopter Low Level Routes (KY xxx) are compatible with the NM flight plan system. The route should be declared by the ANSP as an ATS route. The route should be composed of waypoints named in accordance with the ICAO Annex 11 and EU N°2017/373 principles. The reference (xxx) of the route (KYxxx) should be allocated by EUROCONTROL on behalf of the ICAO European region liker any other ATS routes.
Issue_S_LLRL_CTRL#2. Confirm that current RT phraseology for pilot and controller is fully applicable to helicopter Low Level Route or if phraseology should be adapted	No specific RT phraseology was identified during the different workshop

Issue	Resolution
Issue_S_LLRL_CTRL#3. Safety issues related to bi-directional Low Level Route should be evaluated in order to prevent to use simultaneously the Low Level Route for traffic in opposite direction	See SR_LLRL_CTRL#47
Issue_S_LLRL_CTRL#4. Insertion by route name in the RNP aircraft system instead of inserting series of waypoints should be confirmed	Insertion by route name should be the only authorised procedure because waypoints inserted by the pilot in the RNP system to build the route could lead to errors except if robust operational procedures have been defined by the operator and approved by the Competent Authority.
Issue_S_LLRL_CTRL#5. Verify that a full scale lateral deviation for the RNP value is automatically provided (based on navigation data base) or if manual action from the Flight Crew is necessary to select the proper value, verify the feasibility of such actions considering all foreseeable operational conditions.	Full scale deflection shall be automatically “slaved” to the RNP value coming from the navigation data except if robust operational procedures have been defined by the operator and approved by the Competent Authority. The main reason is that pilots might easily forget the manual setting in case of heavy workload situation
Issue_S_LLRL_CTRL#6. Verify for RNP1 and RNP 0.3 Low Level Route if autopilot mode coupled to the navigation source is required to satisfy the navigation performance.	Refer to the Rotorcraft Flight Manual in order to determine if autopilot is required or not for RNP 0.3 or RNP 1.
Issue_S_LLRL_CTRL#7. Verify for Low Level Route if autopilot mode coupled to the ALT source is required to satisfy the navigation performance.	Refer to the helicopter operator manual

Table 10-3: Solved issue log for LLR operations in controlled airspace

10.2 Uncontrolled airspace

10.2.1.1 Assumptions log

The following table lists the assumptions applicable to LLR operations in uncontrolled airspace.

For each assumption, this table indicates:

- The domain to which the assumption applies (FPD, ATS, AIS...)
- The ID of the Safety Requirement at Service Level at the origin from which the assumption is derived
- The mean to validate the assumption

Assumptions in *italics* despite they are tagged as UNCTRL requirements are identical to assumptions derived for the controlled airspace.

The assumptions highlighted in **bold** in this table are the ones impacted or created within the frame of this new edition of the Generic Safety Case.

ID	Assumption	Domain	Ref. SRS ID	Validation
ASS_LLRL_UNCTRL#1.	The helicopter control and guidance system providing lateral guidance on the Low Level Route is approved in accordance with EASA regulation	Helicopter-System	SRS_LLRL_UNCTRL#13	Basic A/C certification
ASS_LLRL_UNCTRL#2.	The altimetry system is approved in accordance with EASA regulation	Helicopter-System	SRS_LLRL_UNCTRL#13	Basic A/C certification
ASS_LLRL_UNCTRL#3.	The helicopter control and guidance system providing vertical guidance on the Low Level Route is approved in accordance with EASA regulation	Helicopter-System	SRS_LLRL_UNCTRL#13	Basic A/C certification
ASS_LLRL_UNCTRL#4.	The Flight Information Service Officer (FISO) procedures associated to QNH transmission are conducted in accordance with the local FISO rules and should not be different when considering helicopter Low Level Route	ATS	SRS_LLRL_UNCTRL#13	Local FIS procedures
ASS_LLRL_UNCTRL#5.	<i>The Flight Crew procedures associated to the QNH setting onboard the helicopter are conducted in accordance with the Helicopter Operator rules and are not different when considering Low Level Route operations</i>	Helicopter-Flight Crew	SRS_LLRL_UNCTRL#13	Basic airmanship

Table 10-4: Assumptions log for LLR operations in uncontrolled airspace

10.2.1.2 Recommendation log

The following table lists the recommendation applicable to LLR operations in uncontrolled airspace.

For each recommendation, this table indicates:

- The domain to which the recommendation applies (FPD, ATS, AIS...)
- The ID of the Safety Requirement at Service Level at the origin from which the recommendation is derived

Recommendations in *italics* despite they are tagged as UNCTRL requirements are identical to recommendations derived for the controlled airspace.

The recommendations highlighted in **bold** in this table are the ones impacted or created within the frame of this new edition of the Generic Safety Case.

ID	Recommendation	Domain	Ref. SRS ID
REC_LLRL_UNCTRL #1	All aircraft operating in the vicinity of the Low Level Route in airspace class G should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the	Other traffic-System	SRS_LLRL_UNCTRL#14, SRS_LLRL_UNCTRL#15

ID	Recommendation	Domain	Ref. SRS ID
	Competent Authority		
REC_LL_R_UNCTRL#2	Helicopters operating on Low Level Routes in airspace class G should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity	Helicopter-System	SRS_LL_R_UNCTRL#14, SRS_LL_R_UNCTRL#15
REC_LL_R_UNCTRL#3	Helicopters operating on Low Level Routes should be equipped with airborne weather radar or on-board Electronic Flight Bag (EFB) Ground Radar information.	Helicopter-System	SRS_LL_R_UNCTRL#16

Table 10-5: Recommendation log for LLR operations in uncontrolled airspace

10.2.1.3 Issue log

The following sections synthesis the issues identified within this safety case :

- Section 10.2.1.3.1 lists the open issues that should be resolved for LLR operations in uncontrolled airspace.
- section 10.2.1.3.2 list the solved issues. These elements are not considered as issues anymore as they are solve, however, they are maintained in present document for recording purpose.

10.2.1.3.1 Open issues

The following issue should be resolved for LLR operations in uncontrolled airspace.

Issue	Resolution
Issue_O_LL_R_UNCTRL#1. It should be verified if the State/ANSP could delegate to Helicopter Operators or third parties the management and monitoring of the Low Level Route in the uncontrolled part of their airspace.	Open and to be addressed locally because several options are possible like the “one at a time” principle or a more capacity-oriented traffic management organised locally by an authorized actor

Table 10-6: Issue log for LLR operations in uncontrolled airspace

10.2.1.3.2 Solved issues

The following issues linked to LLR operations in uncontrolled airspace have been solved:

Issue	Resolution
Issue_S_LL_R_UNCTRL#1. Insertion by route name in the RNP aircraft system instead of inserting series of waypoints should be confirmed	<i>Insertion by route name should be the only authorised procedure because waypoints inserted by the pilot in the RNP system to build the route could lead to errors except if robust operational procedures have been defined by the operator and approved by the Competent Authority.</i>

Issue	Resolution
Issue_S_LLRL_UCTRL#2. <i>Verify that full scale lateral deviation for the RNP value is automatically provided (based on navigation data base) or if a manual action from the Flight Crew is necessary to select the proper value, verify the feasibility of such actions considering all foreseeable operational conditions.</i>	<i>Full scale deflection shall be automatically “slaved” to the RNP value coming from the navigation data except if robust operational procedures have been defined by the operator and approved by the Competent Authority. The main reason is that pilots might easily forget the manual setting in case of heavy workload situation.</i>
Issue_S_LLRL_UCTRL#3. <i>Verify for RNP1 and RNP0.3 Low Level Route if autopilot mode coupled to the navigation source is required to satisfy the navigation performance</i>	<i>Refer to the Rotorcraft Flight Manual in order to determine if autopilot is required or not for RNP 0.3 or RNP 1.</i>
Issue_S_LLRL_UCTRL#4. <i>Verify for Low Level Route if autopilot mode coupled to the ALT source is required to satisfy the navigation performance</i>	<i>Refer to the helicopter operator manual</i>
Issue_S_LLRL_UCTRL#5. <i>Safety issue related to bi-directional Low Level Route should be evaluated in order to prevent to use simultaneously the Low Level Route for traffic in opposite direction</i>	<i>See SR_LLRL_UCTRL#33 (The design of the Low Level Route shall minimize the risk of collision between helicopters by separating strategically when possible the different traffic flows operating on the Low Level Route network (e.g. vertical separation))</i>

Table 10-7: Solved log for LLR operations in uncontrolled airspace

11 Conclusions

This document contains the Specimen Safety Assessment for helicopter operations on IFR Low Level Route (LLR) in controlled and uncontrolled airspace in the form of a generic safety case report.

This operational safety assessment started by the identification of Safety Criteria describing what is acceptably safe for helicopter operations on IFR Low Level Route (LLR). Then Safety Requirements were derived at the Service level to satisfy the Safety criteria in Normal, Abnormal and Failure conditions. Finally when the high-level design architecture supporting the operational level was defined, Safety Requirements at Design level in Normal/Abnormal conditions and considering failure aspects were derived to satisfy the Safety Requirements at Service level. This is these safety requirements at design level (listed in Section 6) which should be considered for the local implementation. Furthermore the assumptions, recommendations and issues (see section 10) should also be taken into account for the local implementation.

Several safety workshops have been conducted to discuss and validate these Safety Criteria, Safety Requirements at Service level and Safety Requirements at Design level considering a generic operational scenario.

This generic safety case report presents the assurance that the Safety Requirements are complete, correct and realistic for this type of operations in controlled airspace (airspace class C, D and E) and in uncontrolled airspace (airspace class G).

The Project Owner shall verify that the Safety argument presented in this generic safety case is applicable and acceptable for the local deployment. This safety argument should be presented and accepted by the Competent Authority.

The deployment of helicopter Low level Route operations is a multi-actor change and therefore requires coordination between different stakeholders (service providers and helicopter operators). This coordination is essential to ensure a safe deployment.

The Guidance Material for the local deployment based on this generic safety case will be provided through an Excel database or a Web Based Tool (still under finalisation). The main objective of this tool is to facilitate the identification of the applicable requirements for the local implementation and to provide specific guidance on some of the requirements.

In uncontrolled airspace (class G) several aspects have been identified to mitigate the risk of mid-air collision like the establishment of Radio Mandatory Zones (RMZ), blind-call transmissions, depiction of the Low Level Route on VFR charts to inform all airspace users, AIC publication and use of on board traffic advisory systems or equivalent systems to enhance the see and avoid between IFR helicopters and other aircraft in the vicinity (VFR or IFR).. The implementation of those safety requirements should be decided locally considering the number of simultaneous flights planned on the Low Level Routes, the traffic density in the vicinity of the route considering all airspace users, the complexity of the airspace, the delivery or not of Flight Information Service, etc... A new Mid Air Collision Risk Model in uncontrolled airspace is proposed within the frame of this generic safety case and could support the local assessment of the Mid Air Collision risk and the decision about the applicability of several Safety Requirements. For the time being only the simplified risk model is proposed in the Annex of this generic safety case and the detailed model will be available on demand.

In controlled or uncontrolled airspace several abnormal conditions (external events affecting possibly the safety of the operations) have been identified at a generic level and have been mitigated by the definition of contingency procedures at the Helicopter Operator level. The completeness and correctness of these generic mitigations shall be verified by the operator and/or ANSP/Competent Authority considering the specificity of the local operational environment (e.g. obstacle-rich environment or flat areas, possible reliance on conventional nav aids, helicopter equipment, etc...).

Several requirements are dedicated to the optimal transition from the Low Level Route to an existing ILS or RNP approach. These requirements mainly relate to procedure design (optimal 2D and

vertical design in order to ensure a smooth transition) and integration of the helicopter into the approach sequence.

There is no main issue which remains open except the enhanced see and avoid aspect in uncontrolled airspace as just mentioned above which should be addressed locally.

ANNEX A – Operational Hazards identification & analysis & allocation of Safety Requirements at Service level

A.1 Operational Hazards identification and analysis

The first hazard identification session has been held in Strasbourg/France in June 2017.

During the HAZID session the operational hazards relevant for LLR helicopter operations have been identified and their consequences have been assessed.

The identification of the operational hazards has been driven by:

- the list of (success) Safety Requirements at Service level in Normal operations from § 5.2.
- the brainstorming involving the workshop participants including 6 pilots.

The operational effects and their mitigation in terms of protection against their propagation provides reference to the safety barriers of the MAC model (see Figure A-1 in controlled airspace and Figure A-2 in uncontrolled airspace), CFIT model (see Figure A-3 in controlled airspace and Figure A-4 in uncontrolled airspace) and Landing Accident/RE model (see Figure A-5).

The distance to the accident associated to the hazard effects indicated in the last column of the HAZID table (Table A-1. LLR Hazid table) has been allocated by the safety experts after the HAZID session using the severity classification scheme and the associated accident distance-based classes tables based on the MAC, CFIT and Landing Accident/RE risk models as provided in Annex A.2 and A.3.

A second workshop was organised in Trento/Italy in November 2017 where results of the previous workshop were validated. However after this workshop, it was decided to have a dedicated hazard for the failure of the management of the traffic on the Low Level Route in controlled and uncontrolled airspace. The following tables do not identify these two additional hazards but section 5.4 identifies them (Hz_LLRL_20 for controlled airspace and Hz_LLRL_20 for uncontrolled airspace).

A third safety workshop was organised in Lisbon in October 2018 where final open points and comments have been addressed.

For the uncontrolled airspace, the main outcome was the confirmation of the need to have:

- a traffic coordinator but focussing on strategic/planning aspect
- an RMZ and an onboard IFR helicopter system enhancing the see and avoid (e.g. TAS) except if it is shown that mitigating the risk of conflict between VFR and IFR is not required considering the airspace structure, the traffic density and the traffic complexity.

For the controlled airspace and more specifically for class E, the requirement requesting RMZ in class E was suppressed. Indeed if current IFR operations do not require RMZ it was estimated that few additional helicopter IFR flights will not require an implementation of a RMZ.

A fourth safety workshop (on line event) followed by two additional safety sessions were organised in 2020 and 2021 for the safety assessment of additional LLR operational features (RF/FRT, optimal transition to existing approach).

Minutes of these safety workshops have been issued.

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Hazard	Operational effects	Causes	Preventive mitigations	External Mitigations	Distance to the accident / associated precursor
<p>Helicopter deviates from published Low Level Route towards terrain or towards other aircraft in controlled airspace</p> <p>Scenario incl. different weather conditions and terrain environment (flat and rich obstacles)</p>	<p>The helicopter might collide with terrain/obstacles or other aircraft during Low Level Route operations following a lateral or vertical deviation from planned trajectory in controlled airspace</p>	<ul style="list-style-type: none"> - Emergency turn-back - GPS loss - Erroneous coding - Wrong pilot's entry (route, RNP value,...) - Wrong ATC clearance - Helicopter RNP non compliance - Pilot not qualified - RNAV system failure - Autopilot failure - Unclear QNH to be used below TL 	<ul style="list-style-type: none"> - Reduce speed Vy turn and inform ATC - ICAO Annex 10 compliance, RAIM prediction if SBAS not fitted - Procedure design, publication and coding assurance process - Clear RNP x Low Level Route publication - RNPx route Flight Crew training/ Air Ops special approval (RNP 0.3) - RNP x certification (CS -ACNS) considering demanding and non-demanding environment - Autopilot/FD required - Database validation at each AIRAC cycle (only for rich obstacle environment and very demanding operation- not relevant for basic operations) - ATCO training - Information of traffic in vicinity of the route (MAC risk) - Regional QNH or different QNH provided on the route by ATC (MAC risk) - Information of the published route to all airspace users 	<ul style="list-style-type: none"> - ATCO detection with or without radar - MSAW if fitted - Pilot Visual avoidance - HTAWS if fitted <ul style="list-style-type: none"> -ATCO detection with or without radar -See and avoid -TAS, FLARM or other traffic advisory system (efficiency to be evaluated) 	<p>CFIT distance d3a Controlled Flight Towards Terrain</p> <p>MAC distance d4a Tactical Conflict (IFR or known VFR traffic)</p> <p>MAC distance d2 Imminent Infringement (Unknown VFR traffic)</p>
<p>Helicopter deviates from published Low Level Route towards terrain</p>	<p>The helicopter might collide with terrain/obstacles or other aircraft during Low Level Route</p>	<p>Same as above except that ATC cause does not apply</p>	<p>Same as above except that ATC mitigation does not apply</p>	<ul style="list-style-type: none"> -Pilot visual avoidance -HTAWS if fitted 	<p>CFIT distance d2 Imminent CFIT</p>

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Hazard	Operational effects	Causes	Preventive mitigations	External Mitigations	Distance to the accident / associated precursor
or towards other aircraft in uncontrolled airspace	operation following a lateral or vertical deviation from planned trajectory in uncontrolled airspace			-See and avoid -TAS, FLARM or others (efficiency to be evaluated)	MAC distance d3 (Conflict)
Other traffic flies towards helicopter established on the Low Level Route in uncontrolled airspace	Aircraft might collide with IFR helicopter established on the Low Level Route in uncontrolled airspace	- Inadequate traffic information provided via RT - unclear VFR charting information - ...	Additional mitigations because ATC barrier is not present: - All aircraft are equipped with transponders - IFR helicopter equipped with TAS or equivalent - IFR helicopter informs regularly about its position on the route	Pilot see and avoid - TAS alert or equivalent	MAC distance d3 (Conflict)
Helicopter encounters hazardous weather conditions on Low Level Route	The helicopter enters in hazardous weather conditions on the Low Level Route which could lead to loss of control and/or CFIT	- Bad weather conditions	- MET information are available for the route	- Weather avoidance if deviation on the route is possible (no terrain/obstacle) - Flight turn back - Landing	-CFIT distance d3b Flight Toward Terrain Commanded --LOC-Inflight distance d3 Loss of Control due to environmental factors: adverse weather

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Hazard	Operational effects	Causes	Preventive mitigations	External Mitigations	Distance to the accident / associated precursor
Failure to manage properly the traffic on the Low Level Route in controlled airspace	Helicopter might collide with another helicopter using the Low Level Route	<ul style="list-style-type: none"> - Route design does not prevent conflict between helicopters - Inaccurate traffic picture 	<ul style="list-style-type: none"> - ATC detect the conflict with less safety margin 	<ul style="list-style-type: none"> - Pilot visual avoidance - TAS alert or equivalent 	-MAC distance d4a Tactical Conflict
Failure to manage properly the traffic on the Low Level Route in uncontrolled airspace	Helicopter might collide with another helicopter using the Low Level Route	<ul style="list-style-type: none"> - Route design does not prevent conflict between helicopters - Helicopter operator/s do not detect the conflict between helicopters 	<ul style="list-style-type: none"> - Coordination between operators flying the Low Level Route 	<ul style="list-style-type: none"> - Pilot visual avoidance - TAS alert or equivalent 	-MAC distance d2 Imminent collision
Helicopter fails to intercept smoothly the existing approach (ILS or RNP) from the Low Level Route in controlled airspace	The helicopter might conduct an unstable ILS or RNP approach with a risk of runway excursion	<ul style="list-style-type: none"> - Design of the transition (vertical, lateral) - Unclear aeronautical information/chart - Erroneous coding - Helicopter RNP non compliance - Pilot not qualified - RNAV system failure - Autopilot failure - Altimeter failure - Wrong QNH setting - Misleading ATC clearance/instruction 	<ul style="list-style-type: none"> - Procedure design, publication and coding assurance process - Clear transition publication - Pilot training - RNP x certification (CS -ACNS) - Autopilot/FD required - Valid navigation Database - ATCO training 	<ul style="list-style-type: none"> - Pilot detection (too high, too low, overshoot,...) and flight crew correction of the path (vertical and/or lateral) or initiation of the missed approach - ATCO detection based on radar information 	Landing/RE distance d4a Unstable Approach

Table A-1. LLR Hazid table

A.2 Applicable risk models with accident distance-based classes

This section provides the different simplified risk models applicable for this generic safety case. Each simplified model includes the relevant safety barriers and precursors with their accident distance-based classes (dx).

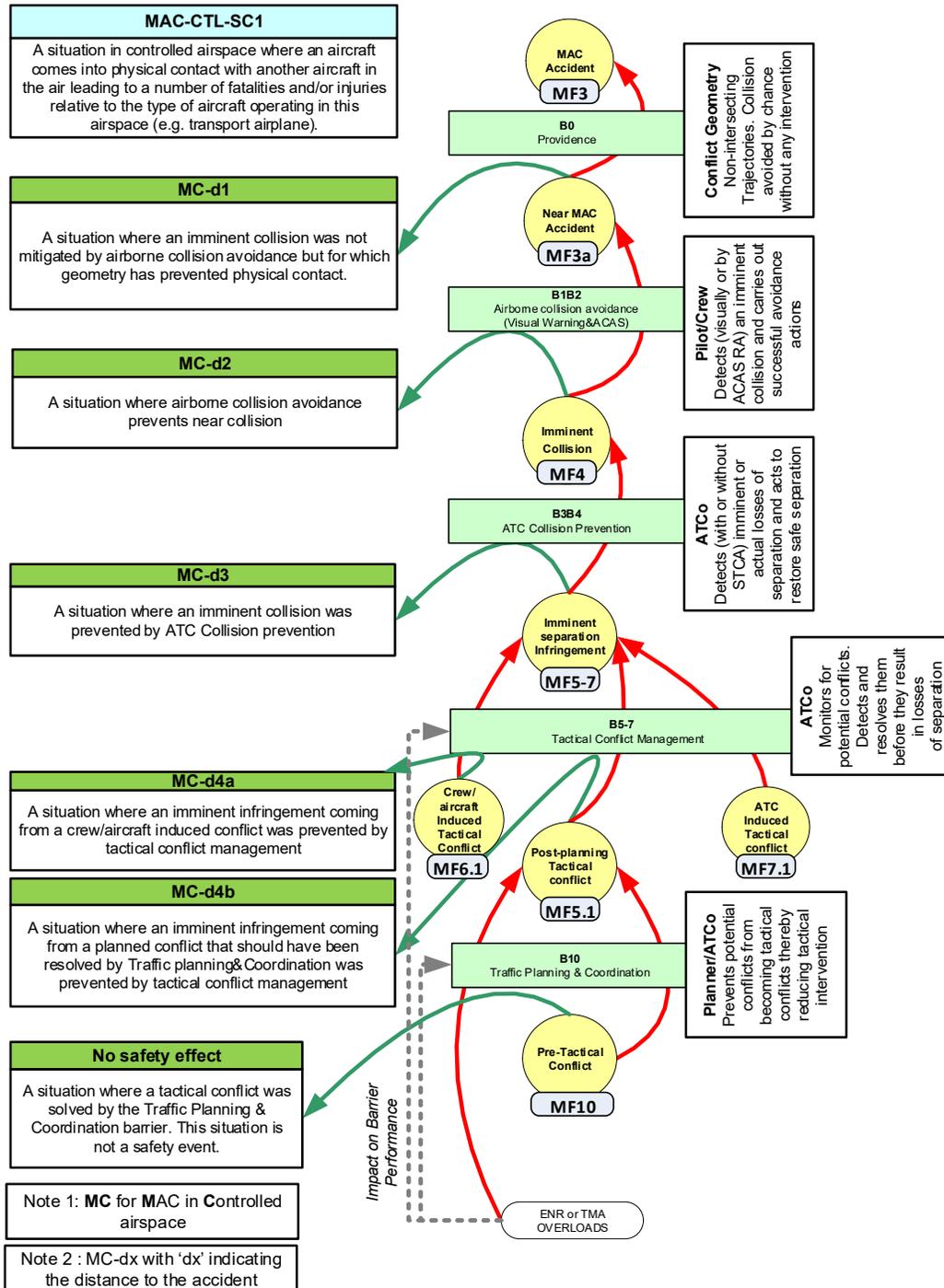


Figure A-1: Simplified MAC model for Controlled airspace with accident distance-based classes

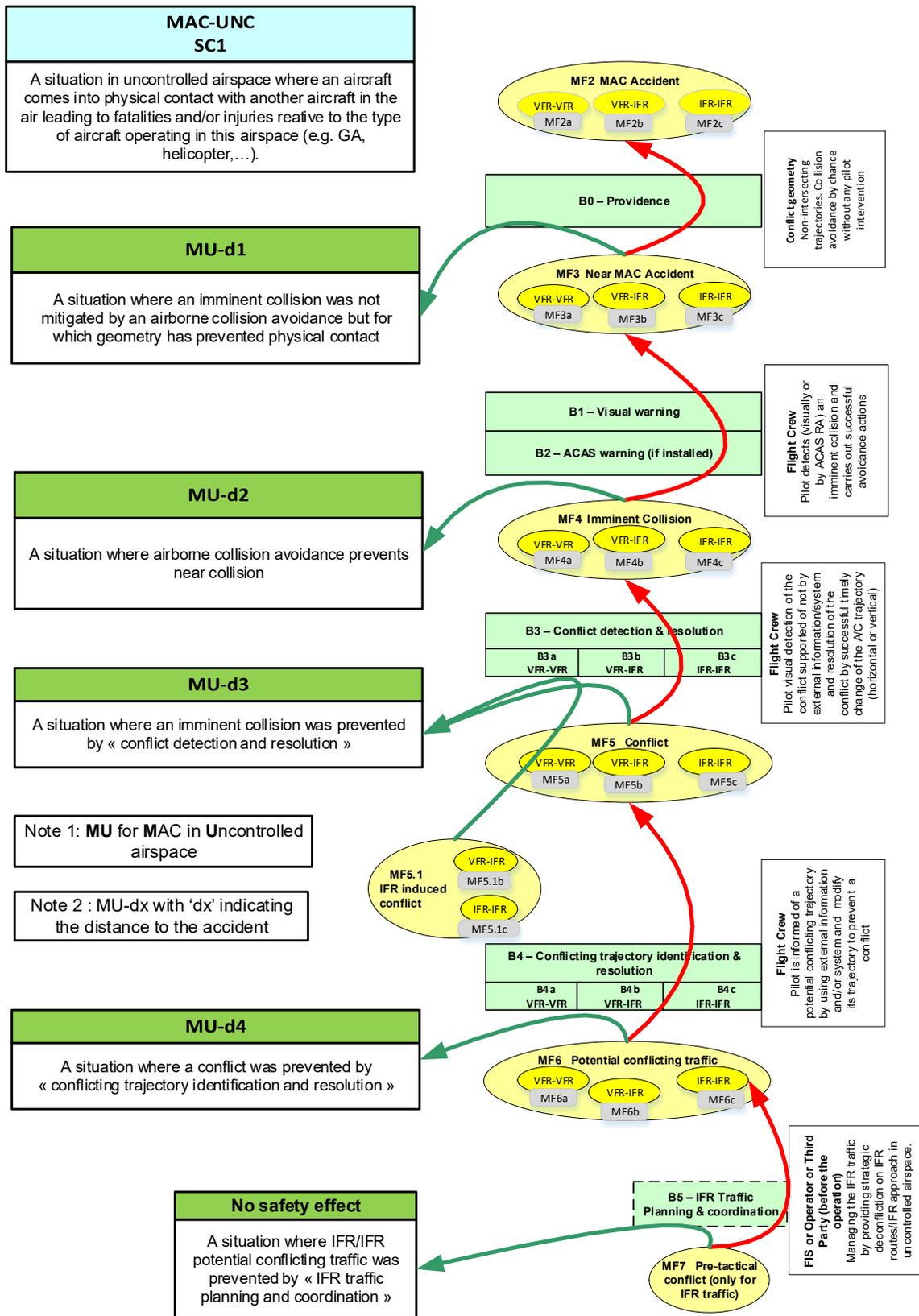


Figure A-2: Simplified MAC model for Uncontrolled airspace with accident distance-based classes

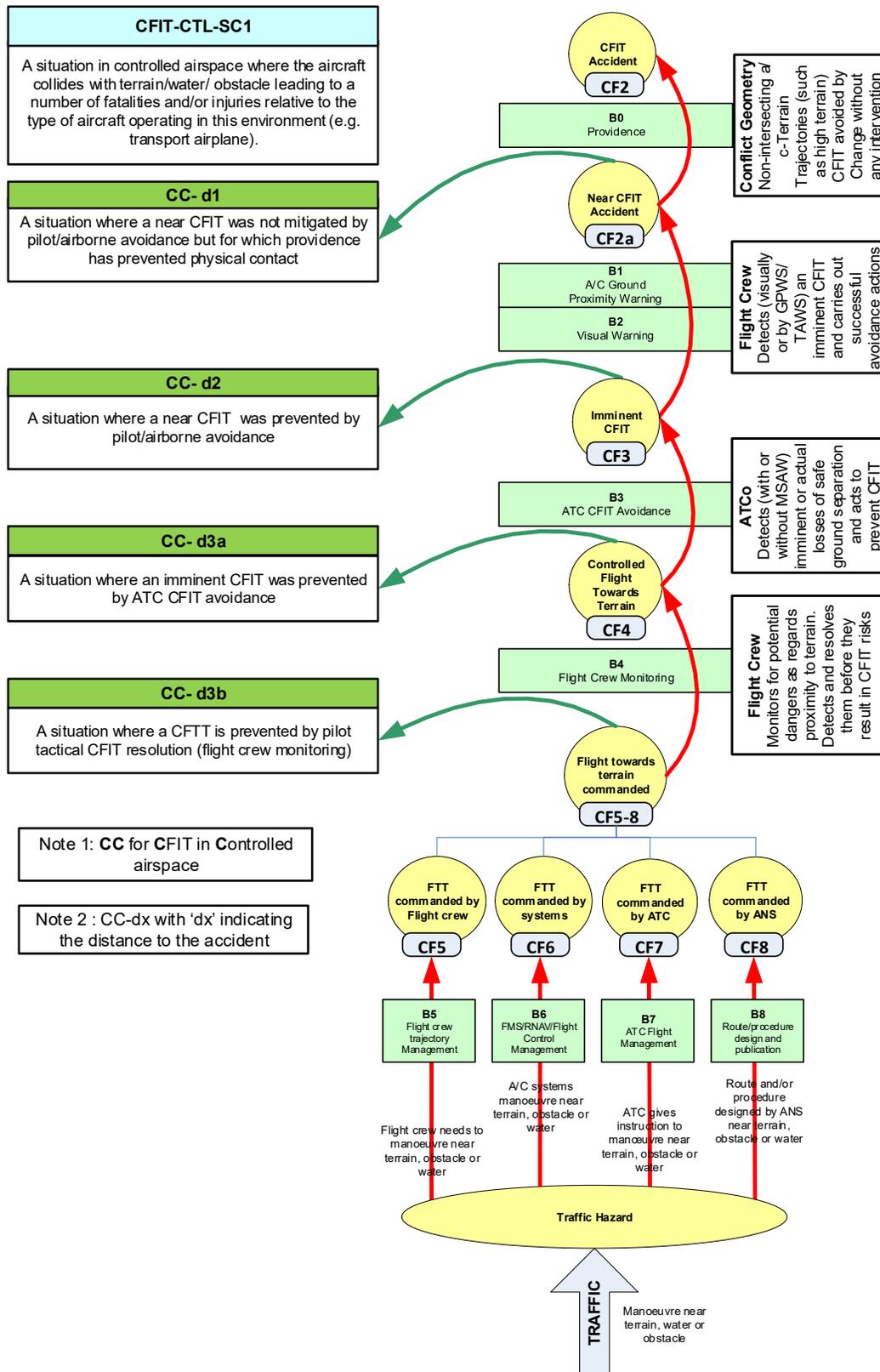


Figure A-3: Simplified CFIT model for Controlled airspace with accident distance-based classes

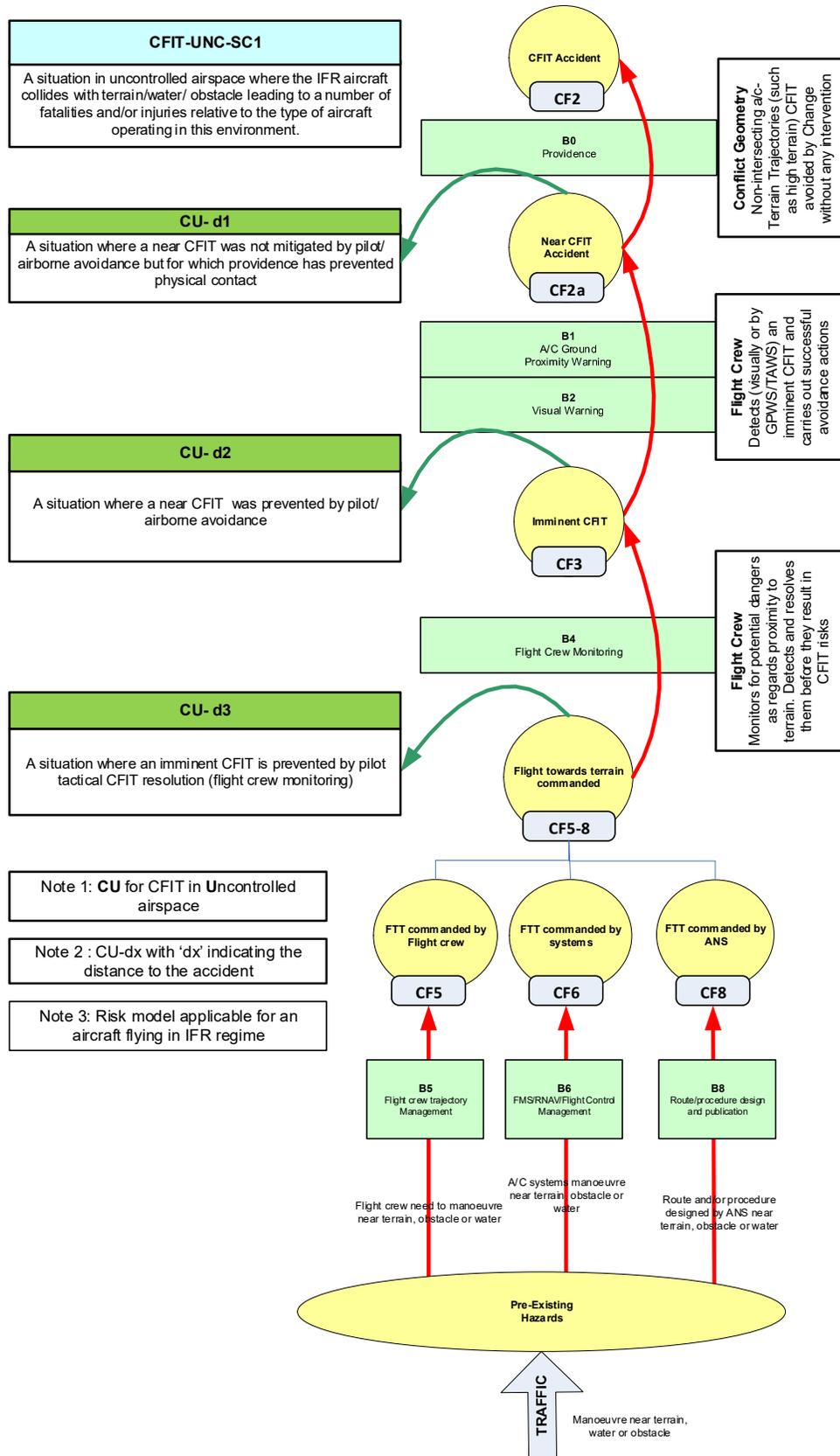


Figure A-4: Simplified CFIT model for Uncontrolled airspace with accident distance-based classes

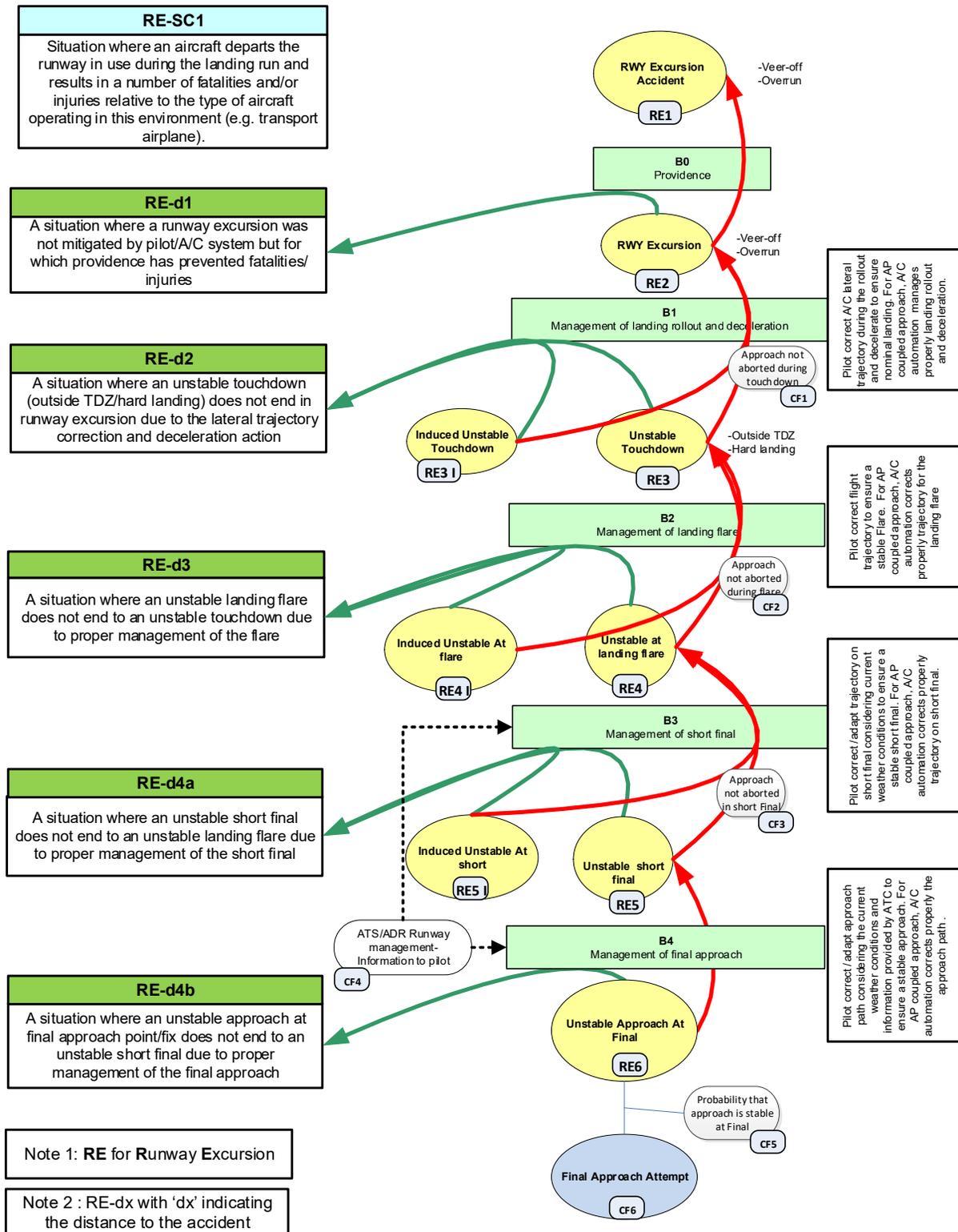


Figure A-5: Simplified Landing Runway Excursion model with accident distance-based classes

A.3 Allocation of Safety Requirements at Service level (reliability/integrity)

The current safety case guidance illustrates the allocation of quantitative Safety Requirements at Service level (reliability/integrity SRSs) using the generic severity and risk classification scheme and its associated accident distance-based classes tables proposed by the new E-SRM Guidance H (note that for each accident type a dedicated accident distance-based classes table is provided).

The severity and classification scheme relative to risks associated to this generic safety case is provided in Table A-2 below.

Severity Class	Accident/ Operational Effect	Harmful effect	Maximum tolerable frequency of accident
MAC-CTL-SC1	Mid air collision in controlled airspace	A situation in controlled airspace where an aircraft comes into physical contact with another aircraft in the air leading to a number of fatalities and/or injuries relative to the type of aircraft operating in this airspace (e.g. transport airplane).	1e-9 per flight hour
MAC-UNC-SC1	Mid-air collision in uncontrolled airspace	A situation in uncontrolled airspace where an aircraft comes into physical contact with another aircraft in the air leading to fatalities and/or injuries relative to the type of aircraft operating in this airspace (e.g. GA, helicopter,...).	1e-7 per flight hour
CFIT-CTL-SC1	CFIT in controlled airspace	A situation in controlled airspace where the aircraft collides with terrain/water/ obstacle leading to a number of fatalities and/or injuries relative to the type of aircraft operating in this environment (e.g. transport airplane).	1e-8 per flight
CFIT-UNC-SC1	CFIT in uncontrolled airspace	A situation in uncontrolled airspace where the IFR aircraft collides with terrain/water/ obstacle leading to a number of fatalities and/or injuries relative to the type of aircraft operating in this environment.	1e-8 per flight
RE- SC1	Fatal Runway Excursion	Situation when an aircraft departs the runway in use during the landing run and results in a number of fatalities and/or injuries relative to the type of aircraft operating in this environment (e.g. transport airplane).	1e-8 per movement

Table A-2: Severity and risk classification scheme

The following method to calculate SRS for a given hazard is:

$$SRS = \frac{MTFoO(dx)}{N \times IM}$$

where:

- MTFoO(dx) stands for the Maximum Tolerable Frequency of Occurrence being the maximum probability of the hazard's effect at such distance to the accident (dx) as defined in Table A-3 (MAC in controlled airspace), in Table A-4 (MAC in uncontrolled airspace), in Table A-5 (CFIT in controlled airspace), Table A-6 (CFIT in uncontrolled airspace) and in Table A-8 (Runway excursion)).
- N is the overall number of operational hazards with effect in a given accident distance-based class at a given barrier as obtained from Table A-8 below.

- IM is the Impact Modification factor to take account of additional information regarding the operational effect of the hazard, in particular related to the number of aircraft exposed to the operational hazard. In the current context IM is set to 1.

Severity Class	Distance-based Class⁸	Hazardous situation	Operational Effect	MTFoO [per fh]
MAC-CTL-SC1		A situation in controlled airspace where an aircraft comes into physical contact with another aircraft in the air leading to a number of fatalities and/or injuries relative to the type of aircraft operating in this airspace (e.g. transport airplane).	Accident - Mid air collision (MF3)	1e-9
	MC-d1	A situation where an imminent collision was not mitigated by an airborne collision avoidance but for which geometry has prevented physical contact.	Near Mid Air Collision (MF3a)	1e-6
	MC-d2	A situation where airborne collision avoidance prevents near collision	Imminent Collision (MF4)	1e-5
	MC-d3	A situation where an imminent collision was prevented by ATC Collision prevention	Imminent Infringement (MF5-7)	1e-4
	MC-d4a	A situation where an imminent infringement coming from a crew/aircraft induced conflict was prevented by tactical conflict management	Tactical Conflict (crew/aircraft induced) (MF6.1)	1e-3
	MC-d4b	A situation where an imminent infringement coming from a planned conflict was prevented by tactical conflict management	Tactical Conflict (planned) (MF5.1)	1e-2

Table A-3: Maximum tolerable frequency of occurrence at the different distance to the accident for MAC in controlled airspace

Severity Class	Distance-based Class⁹	Hazardous situation	Operational Effect	MTFoO [per fh]¹
MAC-UNC-SC1		A situation in uncontrolled airspace where an aircraft comes into physical contact with another aircraft in the air leading to fatalities and/or injuries relative to the type of aircraft operating in this airspace (e.g. GA, helicopter,...).	Accident - Mid-air collision (MF2)	1e-7 (Two orders of magnitude larger than controlled airspace)
	MU-d1	A situation where an imminent collision was not mitigated by an airborne collision avoidance but for which geometry has	Near Mid-Air Collision (MF3)	1e-5 (One order of magnitude larger than

⁸ MC for Mid-air collision in Controlled airspace

⁹ MU for Mid-air collision in Uncontrolled airspace

Severity Class	Distance-based Class⁹	Hazardous situation	Operational Effect	MTFoO [per fh]¹
		prevented physical contact.		controlled airspace)
	MU-d2	A situation where airborne collision avoidance prevents near collision	Imminent Collision (MF4)	1e-4 (One order of magnitude larger than controlled airspace)
	MU-d3	A situation where an imminent collision was prevented by « conflict detection and resolution »	Conflict (MF5)	1e-3 (no comparison with controlled airspace possible)
	MU-d4	A situation where a conflict was prevented by « conflicting trajectory identification and resolution »	Potential conflicting traffic (MF6)	To be defined locally

Table A-4. Maximum tolerable frequency of occurrence at the different distance to the accident for MAC in uncontrolled airspace

MTFoO which are defined for the MAC risk in uncontrolled airspace might vary strongly from one environment to the other depending on local traffic systems and procedures. These values need to be refined or defined locally based on the local environment.

Severity Class	Distance-based Class¹⁰	Hazardous situation	Operational Effect	MTFoO [per movt.]
CFIT-CTL-SC1		A situation in controlled airspace where the aircraft collides with terrain/water/obstacle leading to a number of fatalities and/or injuries relative to the type of aircraft operating in this environment (e.g. transport airplane).	CFIT Accident (CF2)	1e-8
	CC-d1	A situation where a near CFIT was not mitigated by pilot/airborne avoidance but for which providence has prevented physical contact	Near CFIT (CF2a)	1e-8 ¹¹
	CC-d2	A situation where a near CFIT is prevented by pilot/airborne avoidance	Imminent CFIT (CF3)	1e-6
	CC-d3a	A situation where an imminent CFIT is prevented by ATC CFIT avoidance	Controlled flight towards terrain (CF4)	1e-5
	CC-d3b	A situation where a controlled flight towards terrain is prevented by pilot tactical CFIT resolution (flight crew monitoring)	Flight towards terrain commanded (CF5-8)	1e-5

¹⁰ CC for Controlled flight into terrain in Controlled airspace

¹¹ A favourable aircraft trajectory geometry (providence) is not considered to be credible to prevent the collision with terrain/water/ obstacle following a near CFIT. Thus Near CFIT (CF2a) and CFIT accident (CF2) have the same MTFoO

Table A-5. Maximum tolerable frequency of occurrence at the different distance to the accident for CFIT in controlled airspace

Note that the MTFoO values for CC-d3a and CC-d3b are the same. This is due to the relatively weak performance of the barrier between these two precursors, and the fact that figures from the Integrated Risk Model have been rounded.

Severity class	Distance-based Class¹²	Hazardous situation	Operational Effect	MTFoO [per flight]
CFIT-UNC-SC1		A situation in uncontrolled airspace where the IFR aircraft collides with terrain/water/ obstacle leading to a number of fatalities and/or injuries relative to the type of aircraft operating in this environment.	CFIT Accident (CF2)	1e-8
	CU-d1	A situation where a near CFIT was not mitigated by pilot/airborne avoidance but for which providence has prevented physical contact	Near CFIT (CF2a)	1e-8 ¹³
	CU-d2	A situation where a near CFIT is prevented by pilot/airborne avoidance	Imminent CFIT (CF3)	1e-6
	CU-d3	A situation where a controlled flight towards terrain is prevented by pilot tactical CFIT resolution (flight crew monitoring)	Flight towards terrain commanded (CF5-8)	1e-5

Table A-6. Maximum tolerable frequency of occurrence at the different distance to the accident for CFIT in uncontrolled airspace

Severity class	Distance-based Class¹⁴	Hazardous situation	Operational Effect	MTFoO [per flight]
RE-SC1		Situation when an aircraft departs the runway in use during the landing run and results in a number of fatalities and/or injuries relative to the type of aircraft operating in this environment (e.g. transport airplane).	RE1 Fatal Runway excursion	1e-8
	RE-d1	A situation where a runway excursion was not mitigated by pilot/A/C but for which providence has prevented fatalities/injuries	RE2 Runway excursion	1e-6

¹² CU for **C**ontrolled flight into terrain in **U**ncontrolled airspace

¹³ A favourable aircraft trajectory geometry (providence) is not considered to be credible to prevent the collision with terrain/water/ obstacle following a near CFIT. Thus Near CFIT (CF2a) and CFIT accident (CF2) have the same MTFoO.

¹⁴ RE for **R**unway **E**xursion

Severity class	Distance-based Class ¹⁴	Hazardous situation	Operational Effect	MTFoO [per flight]
	RE-d2	A situation where an unstable touchdown (outside TDZ/hard landing) does not end in runway excursion due to the lateral trajectory correction and deceleration action	RE3 Unstable touchdown	1e-5
	RE-d3	A situation where an unstable landing flare does not end to an unstable touchdown due to proper management of the flare	RE4 Unstable landing flare	1e-4
	RE-d4a	A situation where an unstable short final does not end to an unstable landing flare due to proper management of the short final	RE5 Unstable short final	1e-3
	RE-d4b	A situation where an unstable approach at final approach point/fix does not end to an unstable short final due to proper management of the final approach	RE6 Unstable final approach	1e-2

Table A-7. Maximum tolerable frequency of occurrence at the different distance to the accident for Landing Runway Excursion

Distance-based Class (dx) ¹⁵	Number of operational hazards with effect in a given distance-based class per Accident Type				
	MAC-CTL	CFIT- CTL	MAC-UNC	CFIT- UNC	RE
d2	10	10	10	10	10
d3	25	n/a	25	50	10
d3a	n/a	50	n/a	n/a	n/a
d3b	n/a	50	n/a	n/a	n/a
d4	n/a	n/a	TBD locally	n/a	n/a
d4a	30	n/a	n/a	n/a	10
d4b	30	n/a	n/a	n/a	10

Table A-8. Maximum hazard number per accident distance-based class

A.4 Allocating Criticality

The process is described in SRM [RD 2] Guidance K.3

¹⁵ Number of hazards for distance d1 are not provided in this table because Safety Requirement at Service level (reliability/integrity) cannot be set for such distance which is linked to the providence barrier.

The Level of Criticality is allocated based on the quantitative SRS derived from the standard SRS setting process in the SRM.

Level of Criticality		Frequency for CFIT in controlled/uncontrolled airspace, MAC in controlled airspace and for Runway Excursion	Frequency for MAC in uncontrolled airspace
Extreme Criticality	E1	< 10 ⁻⁹ per movement or per flight/hour	< 10 ⁻⁷ per flight/hour
	E2	< 10 ⁻⁸ per movement or per flight/hour	< 10 ⁻⁶ per flight/hour
High Criticality	H1	< 10 ⁻⁷ per movement or per flight/hour	< 10 ⁻⁵ per flight/hour
	H2	< 10 ⁻⁶ per movement or per flight/hour	< 10 ⁻⁴ per flight/hour
Medium Criticality	M1	< 10 ⁻⁵ per movement or per flight/hour	< 10 ⁻³ per flight/hour
	M2	< 10 ⁻⁴ per movement or per flight/hour	< 10 ⁻² per flight/hour
Low Criticality	L1	< 10 ⁻³ per movement or per flight/hour	< 10 ⁻¹ per flight/hour

Table A-9. Frequency & level of criticality

Conversion of the frequency of occurrences to different units is to be done as necessary depending on the different risk model metrics used to define the Safety Requirements at Service level (per approach, per flight, per flight hour) and the needs of the project safety assessment.

A set of 3 Principles are also proposed in the method:

- P1 – Preventing unsafe design
 - (P1a) No single human error should lead directly to an event defined as extremely critical
 - (P1b). No flight crew / ATCO error combining with a maintenance staff error should lead directly to an event defined as extremely critical
- P2 – Evidence exists of the human contribution to safety
 - P2: The human contributes positively to the Safety Requirements at Service level; evidence is available and is of a high or medium quality.
- P3 – No evidence for the human contribution to safety
 - P3: The human may contribute positively to the Safety Requirements at Service level, but no evidence is available or is of low quality.

ANNEX B – Detailed derivation of Safety Requirements for Normal and Abnormal operations

B.1 Controlled airspace

B.1.1 Normal operations

The table below derives assumptions and Safety Requirements at Design Level for Normal LLR operations by mapping the Safety Requirements at Service level for Normal operations onto the related elements of the LLR Functional system logical model from Section 6.1.1.

Safety Requirements at Service level (Normal operation)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
SRS_LLRL_CTRL#1: Helicopter shall submit a flight plan	SR_LLRL_CTRL#1. If not exempted, the Helicopter Operator shall submit the flight plan to the Network Manager including the relevant part of the helicopter Low Level Route.	Air Operator → Flight Planning (32 FPL req)
	ASS_LLRL_CTRL#1. The Network Manager is able to validate helicopter Low Level Route flight plans. See Issue_S_LLRL_CTRL#1	Flight Planning
	ASS_LLRL_CTRL#2. The Network Manager approves the helicopter Low Level Route flight plan and inform the Helicopter Operator following flight plan acceptance	Flight Planning → Air Operator (32a Approved FPL)
	ASS_LLRL_CTRL#3. The Network Manager distributes the helicopter Low Level Route flight plan to relevant Air Traffic Service units	Flight Planning → ATCO (32b Approved FPL)
SRS_LLRL_CTRL#2: ATC shall separate traffic established on the Low Level Route network	SR_LLRL_CTRL#2. The Helicopter pilot shall request to the Controller the clearance to enter on helicopter Low Level Route See Issue_S_LLRL_CTRL#2	Pilot → ATCO (59 Specific Request)
	SR_LLRL_CTRL#3. The ATC Controller shall give a clearance to the helicopter pilot for entering on the helicopter Low Level Route See Issue_S_LLRL_CTRL#2	ATCO → Pilot (40 Clearance)
	SR_LLRL_CTRL#4. The ATC Controller shall establish separation between helicopters operating on the Low Level Route in accordance with prescribed minima See Issue_S_LLRL_CTRL#3	ATCO → Pilot (46 ATC control)
	SR_LLRL_CTRL#5. The ATC Controller shall separate helicopters established on the Low Level Route with other IFR aircraft in the vicinity of the route in airspace class C,D and E	ATCO → Pilot (41 ATC tactical clearance)
		ATCO → IFR A/C (44 ATC control)
	SR_LLRL_CTRL#6. The ATC Controller shall separate helicopters established on the Low Level Route with VFR aircraft in the vicinity of the route in airspace class C	ATCO → Pilot (41 ATC tactical clearance) ATCO → VFR A/C (45 No ATC control except in

Safety Requirements at Service level (Normal operation)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
		class C)
<p>SRS_LLRL_CTRL#3: ATC shall maintain separation between helicopters established on the Low Level Route network</p>	<p>SR_LLRL_CTRL#7. The ATC Controller shall maintain separation between helicopters established on the Low Level Route in accordance with prescribed minima</p>	<p>ATCO → Pilot (46 ATC control)</p>
<p>SRS_LLRL_CTRL#4: The Low Level Route shall be designed and promulgated to prevent loss of separation with terrain and obstacles</p>	<p>SR_LLRL_CTRL#8. The terrain and obstacles used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.</p>	<p>Procedure design</p>
	<p>SR_LLRL_CTRL#9. The helicopter Low Level Route shall be designed in accordance with criteria relative to En-Route criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.</p>	<p>Procedure design → Aeronautical Information (11 LLR procedure)</p>
	<p>SR_LLRL_CTRL#10. The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.</p>	<p>Flight Procedure validation → Procedure Design (10 Proc Val)</p>
	<p>SR_LLRL_CTRL#11. The helicopter Low Level Route shall be published in the state AIP in accordance with ICAO Annex 4, ICAO Doc 8697, ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 part FPD and AIS and shall indicate the required aircraft navigation capability to fly the Low Level route (e.g. RNP 1, RNP 0.3).</p>	<p>Aeronautical Information → Air operator (20 LLR Chart) Aeronautical Information → NavDB integrator & packer (20 LLR Chart)</p>
<p>SRS_LLRL_CTRL#5: Helicopters shall respect the lateral path of the Low Level Route</p>	<p>SR_LLRL_CTRL#13. The GNSS signal in space (GPS and SBAS if required) shall be compliant with ICAO Annex 10 SARPS and (EU) No 2017/373 Part CNS on the helicopter Low Level Route.</p>	<p>GPS → RNP aircraft subsystem (01 L1 GPS signal) SBAS → RNP aircraft subsystem (03 SBAS signal)</p>
	<p>SR_LLRL_CTRL#14. The Helicopter Operator shall use a navigation data base which satisfies the requirements of the AIR OPS regulation (EU) No 965/2012 in order to meet standards of integrity that are adequate for the intended use of the electronic navigation data.</p>	<p>NavDB integrator & packer → Air Operator (30 Nav Data Base) Air Operator → RNP aircraft subsystem (30a)</p>

Safety Requirements at Service level (Normal operation)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
	<p>SR_LLRL_CTRL#15. The Flight Crew shall insert the relevant part of the Low Level Route extracted from the navigation data base in the RNP system's fight plan</p> <p>See Issue_S_LLRL_CTRL#4</p> <p>SR_LLRL_CTRL#16. The Flight Crew shall respect the displayed RNP lateral navigation information if flight is conducted in manual mode or using Flight director</p> <p>See Issue_S_LLRL_CTRL#5</p> <p>See Issue_S_LLRL_CTRL#6</p>	<p>Nav Data Base)</p> <p>Flight Crew → RNP aircraft subsystem (50 Route Selection)</p> <p>Flight crew → Flight control & display (52 display & guidance selection)</p> <p>Flight control & display → Flight Crew (53 Display and guidance data)</p>
<p>SRS_LLRL_CTRL#6: Helicopters shall respect the vertical profile of the Low Level Route including compensation for low temperature and wind</p>	<p>SR_LLRL_CTRL#17. The ATC Controller shall provide the QNH information to the Flight Crew for the helicopter Low Level Route which could be a single value for the whole route or multiple values due to the route structure.</p> <p>SR_LLRL_CTRL#18. The Flight Crew shall set the QNH appropriate for the Low Level Route or the part of the Low Level Route to be flown</p> <p>SR_LLRL_CTRL#19. The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind</p> <p>See Issue_S_LLRL_CTRL#7</p>	<p>ATCO → Flight Crew (42 QNH)</p> <p>Flight Crew → Alt Sys (54 QNH setting)</p> <p>Alt Sys → Flight control & display (55 altitude)</p> <p>Flight control & display → Flight crew (53 Display and guidance data)</p>
<p>SRS_LLRL_CTRL#7: Spacing between routes shall be determined considering navigation performance, separation minima, traffic density, sector size and controller procedures/ HMI</p>	<p>SR_LLRL_CTRL#20. The spacing between the helicopter Low Level Route and other routes/SIDs/STARs shall be defined by the air traffic service provider/ airspace designer to prevent loss of separation between aircraft operating on these routes considering navigation performance, separation minima, traffic density, sector size.</p>	<p>ATSP</p>
<p>SRS_LLRL_CTRL#8: ATS shall inform helicopters about other known traffic</p>	<p>SR_LLRL_CTRL#21. The ATC Controller in airspace class D shall provide traffic information about VFR flights to helicopter established on the Low Level Route</p> <p>SR_LLRL_CTRL#22. The ATC Controller in airspace class E shall provide, as far as practicable, traffic information about VFR flights to helicopter established on the Low Level Route</p>	<p>ATCO → Flight crew (47 Traffic information)</p> <p>ATCO → Flight crew (47 Traffic information)</p>

Safety Requirements at Service level (Normal operation)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
	SR_LLRL_CTRL#23. The Flight Crew established on the Low Level Route shall actively search for potentially conflicting traffic when weather conditions permit, especially when operating in airspace where all traffic is not operating under the instructions of ATC like in class E airspace	Flight crew → VFR A/C (60 See and Avoid)
SRS_LLRL_CTRL#9: Helicopters shall be informed about prohibited/restricted areas in the vicinity of the Low Level Route network	SR_LLRL_CTRL#24. The helicopter Low Level Route chart shall clearly indicate the prohibited/restricted areas in the vicinity of the route	Aeronautical Information → Air operator (20 LLR Chart) Air operator → Flight crew (20a LLR Chart)
SRS_LLRL_CTRL#10: Helicopters shall obtain information about the forecasted MET conditions on the Low Level Route	SR_LLRL_CTRL#25. The MET service provider or an approved operator shall provide appropriate MET information to the Helicopter Operator for the flight planning which are at the minimum QNH, Cb cloud, lightning and in-flight icing. <i>Some MET data (e.g. in-flight icing) might not be provided directly by the MET service provider but might be computed by the helicopter operator based on others MET data.</i>	MET → Air operator (70 MET info) Air operator → Flight crew (70a MET info)
	SR_LLRL_CTRL#26. The MET service provider or an approved operator shall provide current MET information to the ATC Controller for the helicopter Low Level Route which are at the minimum QNH, Cb cloud, lightning and in-flight icing. <i>Some MET data (e.g. in-flight icing) might not be provided directly by the MET service provider but might be computed by the helicopter operator based on others MET data.</i>	MET → ATCO (70 MET info)
	SR_LLRL_CTRL#27. The Flight Crew shall be informed by the Controller about any change of MET conditions on the helicopter Low Level Route.	ATCO → Flight crew (48 MET update)
SRS_LLRL_CTRL#11. The transition between LLR and existing approach shall be designed and promulgated to facilitate the safe transition between the LLR and the existing approach	SR_LLRL_CTRL#28. The design of the transition shall allow a smooth vertical transition from the LLR altitude to the altitude of capture of the existing approach	Procedure design
	SR_LLRL_CTRL#29. The 2D design of the transition shall minimize the risk of overshoot of the existing approach axis and shall intercept the approach axis at a sufficient distance from the runway for a safe and stable approach	Procedure design
	SR_LLRL_CTRL#30. The publication of the LLR transition to the existing approach (ILS or RNP) shall minimize the risk of flight crew misinterpretation of any data/elements of the charts.	Aeronautical Information
SRS_LLRL_CTRL#12. Helicopters shall perform the transition between the low level route and the existing	SR_LLRL_CTRL#31. The ATC controller shall give appropriate instructions when needed to facilitate the transition between the low level route and the existing approach (i.e. to facilitate the compliance with published altitude or speed constraints).	ATCO → Pilot (41 ATC tactical clearance)

Safety Requirements at Service level (Normal operation)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
approach.	SR_LLRL_CTRL#32. The flight crew shall comply with constraints published on the flight procedure and with the ATC clearance/instruction relating to transition between the low level route and the existing approach.	Flight control & display → Flight Crew (53 Display and guidance data)
	SR_LLRL_CTRL#33. The Flight Control and Display sub-system shall display an appropriate full scale deflection during transition between the low level route and the existing approach to avoid disturbance of the flight crew.	Flight control & display → Flight Crew (53 Display and guidance data)
SRS_LLRL_CTRL#13. ATC shall separate the traffic during the transition from LLR to existing approach	ASS_LLRL_CTRL#4. The flight crew request to the controller the clearance to initiate the approach.	Pilot → ATCO (59 Specific Request)
	ASS_LLRL_CTRL#5. The ATC controller gives the clearance to the flight crew to initiate the approach.	ATCO → Pilot (41 ATC tactical clearance)
	SR_LLRL_CTRL#34. The ATC controller shall integrate safely the helicopter traffic in the approach sequence considering the different operational scenarios which might happen during operation (e.g. through anticipate speed restriction, holdings,...)"	ATCO → Pilot (46 ATC control)

B.1.2 Abnormal operations

The table below derives assumptions and Safety Requirements at Design Level for Abnormal LLR operations by mapping the Safety Requirements at Service level (Functionality and Performance) for abnormal operations onto the related elements of the LLR Functional system logical model from Section 6.1.1.

Safety Requirements at Service level (Abnormal operation)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
SRS_LLRL_CTRL#14: In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform ATS as soon as possible when in controlled airspace.	SR_LLRL_CTRL#27. The Flight Crew shall be informed by the Controller about any change of MET conditions on the helicopter Low Level Route.	Helicopter operator → Flight Crew (70a MET info)
	SR_LLRL_CTRL#35. In case of loss of RNP capability on the helicopter Low Level Route, flight crew shall respect helicopter operator's contingency procedures developed for such situations	Conv nav Syst → Flight control & display (56 Conv Nav data) Air operator → Flight Crew (31 flight operation procedures and training)
	SR_LLRL_CTRL#36. The Flight Crew shall inform the Controller about the loss of RNP capability on the helicopter Low Level Route and about the contingency procedure	Flight crew → ATCO (59 Specific Request)

Safety Requirements at Service level (Abnormal operation)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
	SR_LLRL_CTRL#37. The ATC Controller shall , as far as feasible, provide assistance to the Flight Crew following the loss of RNP capability on the helicopter Low Level Route	ATCO → Flight Crew (46 ATC control Request)
SRS_LLRL_CTRL#15: In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure	SR_LLRL_CTRL#38. In case of radio communication failure, the Flight Crew shall fly the procedure/route in accordance with the flight planning and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure	Flight Crew
SRS_LLRL_CTRL#16: In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route	SR_LLRL_CTRL#39. In case of icing conditions encountered on the helicopter Low Level Route, the Flight Crew shall respect helicopter operator's contingency procedures developed for such situations	Air operator → Flight Crew (31 flight operation procedures and training)

B.2 Uncontrolled airspace

B.2.1 Normal operations

The table below derives assumptions and Safety Requirements for Normal LLR operations by mapping the Safety Requirements at Service level for Normal operations onto the related elements of the LLR Functional system logical model from Section 6.2.1.

Note: Requirements in italics despite they are tagged as UNCTRL requirements are identical to requirements derived for the controlled airspace.

Safety Requirements at Service level (Normal operations)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
<p>SRS_LL_R_UNCTRL#1: Helicopter Operator or third party shall manage the traffic on the Low Level Route network by establishing appropriate operational procedures commensurate to the foreseen traffic level</p>	<p>SR_LL_R_UNCTRL#1. The Air Traffic Service Provider or Helicopter Operator or third party shall manage and monitor the planned traffic on the Low Level Route based on flight plan information to prevent simultaneous use of the route which might lead to conflicting situations.</p> <p>Issue_O_LL_R_UNCTRL#1. It should be verified if the State/ANSP could delegate to Helicopter Operators or third parties the management and monitoring of the Low Level Route in the uncontrolled part of their airspace.</p>	Air Operator
<p>SRS_LL_R_UNCTRL#2: Each pilot shall maintain separation between helicopters established on the Low Level Route network based on information provided</p>	<p>SR_LL_R_UNCTRL#2. The Flight Crew established on the Low Level Route shall actively search for conflicting traffic when weather conditions permit (see and avoid) based on traffic information provided by other aircraft and by flight information services when available</p> <p>SR_LL_R_UNCTRL#3. VFR or IFR pilots flying in the vicinity of the Low Level Route shall actively search for conflicting traffic when weather conditions permit (see and avoid) based on traffic information provided by other aircraft and by flight information services when available</p>	<p>Flight Crew → IFR A/C Flight Crew → VFR A/C FISO → Flight Crew</p> <p>VFR A/C → Flight Crew IFR A/C → Flight Crew</p>
<p>SRS_LL_R_UNCTRL#3: The Low Level Route shall be designed and promulgated to prevent loss of separation with terrain and obstacles</p>	<p>SR_LL_R_UNCTRL#4. <i>The terrain and obstacle used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.</i></p> <p>SR_LL_R_UNCTRL#5. <i>The helicopter Low Level Route shall be designed in accordance with criteria relative to EnRoute criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.</i></p> <p>SR_LL_R_UNCTRL#6. <i>The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.</i></p> <p>SR_LL_R_UNCTRL#7. <i>The helicopter Low Level Route shall be published in the state AIP in accordance with ICAO Annex 4, ICAO Doc 8697, ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 part FPD and AIS and shall indicate the required aircraft navigation capability to fly the Low Level route (e.g. RNP 1, RNP 0.3).</i></p>	<p>Procedure design</p> <p>Procedure design → Aeronautical Information</p> <p>Flight Procedure validation → Procedure Design</p> <p>Aeronautical Information → Air Operator (20 LLR chart)</p> <p>Aeronautical Information → NavDB integrator & packer (20 LLR Chart)</p>

Safety Requirements at Service level (Normal operations)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
	SR_LL_R_UCTRL#8. <i>The promulgation of helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 15 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.</i>	Aeronautical Information
SRS_LL_R_UNCTRL#4: Helicopters shall respect the lateral path of the Low Level Route	SR_LL_R_UCTRL#9. <i>The GNSS signal in space (GPS and SBAS if required) shall be compliant with ICAO Annex 10 SARPS and (EU) No 2017/373 Part CNS on the helicopter Low Level Route.</i>	GPS → RNP aircraft subsystem (01 L1 GPS signal) SBAS → RNP aircraft subsystem (03 SBAS signal)
	SR_LL_R_UCTRL#10. <i>The Helicopter Operator shall use a navigation data base which satisfies the requirements of the AIR OPS regulation (EU) No 965/2012 in order to meet standards or integrity that are adequate for the intended use of the electronic navigation data</i>	NavDB integrator → Air Operator (30 Nav Data Base) Air Operator → RNP aircraft subsystem (30a Nav Data Base)
	SR_LL_R_UCTRL#11. <i>The Flight Crew shall insert the relevant part of the Low Level Route extracted from the navigation database in the RNP system's flight plan</i> <i>See Issue_S_LL_R_UCTRL#1</i>	Flight Crew → RNP aircraft subsystem (50 Route selection)
	SR_LL_R_UCTRL#12. <i>The Flight Crew shall respect the displayed RNP lateral navigation information if the flight is conducted in manual mode or using a Flight director</i> <i>See Issue_S_LL_R_UCTRL#2 and Issue_S_LL_R_UCTRL#3</i>	Flight Crew → Flight control & display (52 display & guidance selection) Flight control & display → Flight Crew (53 Display and guidance data)
SRS_LL_R_UNCTRL#5: Helicopters shall respect the vertical profile of the Low Level Route including compensation for low temperature and wind	SR_LL_R_UCTRL#13. <i>The Flight Information Service Officer (FISO) shall provide the QNH information to the Flight Crew for the helicopter Low Level Route which could be a single value for the whole route or multiple values due to the route structure</i>	FISO → Flight Crew (42 QNH)
	SR_LL_R_UCTRL#14. <i>The Flight Crew shall set the QNH appropriate for the Low Level Route or the part of the Low Level Route to be flown</i>	Flight Crew → Alt Sys (54 QNH setting)
	SR_LL_R_UCTRL#15. <i>The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind</i> <i>See Issue_S_LL_R_UCTRL#4</i>	Alt Sys → Flight control & display (55 altitude) Flight control & display → Flight crew (53 Display and guidance data)

Safety Requirements at Service level (Normal operations)	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
<p>SRS_LL_R_UNCTRL#6: Spacing between routes shall be determined considering navigation performance, separation minima and traffic density</p>	<p>SR_LL_R_UNCTRL#16. <i>The spacing between the helicopter Low Level Route and other routes/SIDs/STARs shall be defined by the air traffic service provider/airspace designer to prevent loss of separation between aircraft operating on these routes considering navigation performance, separation minima, traffic density, sector size, etc.</i></p>	ATSP
<p>SRS_LL_R_UNCTRL#7: Helicopter pilots shall inform other A/C about their position, level and flight intent on a prescribed frequency for the specific route or by any other means approved by the competent authority</p>	<p>SR_LL_R_UNCTRL#17. The Flight Crew established on the Low Level Route shall transmit regularly their position and flight intent to inform other aircraft operating on the Low Level Route and other aircraft flying in the vicinity of the Low Level Route on a prescribed frequency or by any other means approved by the competent authority</p>	<p>Flight Crew → IFR A/C Flight Crew → VFR A/C</p>
	<p>SR_LL_R_UNCTRL#18. VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational awareness of helicopters pilots established on the Low Level Route</p>	<p>VFR A/C → Flight Crew IFR A/C → Flight Crew</p>
	<p>SR_LL_R_UNCTRL#19. A Radio Mandatory Zone (RMZ) shall be defined around the Low Level Route in order to maintain continuous air-ground voice communication watch and establish two-way communication, as necessary, on the appropriate communication channel unless it is shown that mitigating the risk of conflict with VFR and IFR is not required considering the airspace structure, the traffic density and the traffic complexity.</p>	<p>VFR A/C → Flight Crew IFR A/C → Flight Crew</p>
	<p>SR_LL_R_UNCTRL#20. When a Flight Information Service (FIS) is available and for known traffic, the Flight Information Service Officer shall provide information about helicopters established on the Low Level Route and A/C in the vicinities of the Low Level Route</p>	FISO → Flight Crew
<p>SRS_LL_R_UNCTRL#8: Helicopters shall be informed about prohibited/restricted areas in the vicinity of the Low Level Route network</p>	<p>SR_LL_R_UNCTRL#21. <i>The helicopter Low Level Route chart shall clearly indicate the prohibited/restricted areas in the vicinity of the route</i></p>	<p>Aeronautical Information → Air Operator (20 LLR Chart) Air operator → Flight crew (20a LLR Chart)</p>
<p>SRS_LL_R_UNCTRL#9: Helicopters shall obtain information about the forecasted MET</p>	<p>SR_LL_R_UNCTRL#22. The MET service provider or an approved operator shall provide appropriate MET information to the Helicopter Operator for the planned flight which are at the minimum QNH, Cb cloud, lightning and in-flight icing</p>	<p>MET → Air operator (70 MET info) Air Operator → Flight crew (70a MET info)</p>

Safety Requirements at Service level <i>(Normal operations)</i>	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
conditions on the Low Level Route	<i>Some MET data (e.g. in-flight icing) might not be provided directly by the MET service provider but might be computed by the helicopter operator based on others MET data.</i>	
	SR_LLRL_UCTRL#23. The Flight Crew shall be informed by the Flight Information Service or the Helicopter Operator about a change of MET conditions on the helicopter Low Level Route	Air Operator → Flight crew (48 MET update)

B.2.2 Abnormal operations

The table below derives assumptions and Safety Requirements for Abnormal LLR operations by mapping the Safety Requirements at Service level (Functionality and Performance) for abnormal operations onto the related elements of the LLR Functional system logical model from Section 6.2.1..

Note: Requirements in italics despite they are tagged as UNCTRL requirements are identical to requirements derived for the controlled airspace.

Safety Requirements at Service level <i>(Abnormal operations)</i>	Safety Requirements at Design Level	Maps on to / Data flow (Logical Model)
<p>SRS_LLR_UNCTRL#10: In case of loss of RNP navigation, the pilot shall revert to contingency procedures and inform other aircraft and, if applicable, the Flight Information Service in uncontrolled airspace as soon as possible.</p>	<p>SR_LLR_UCTRL#23. <i>The Flight Crew shall be informed by the Flight Information Service or the Helicopter Operator about a change of MET conditions on the helicopter Low Level Route</i></p>	<p>Helicopter operator → Flight Crew (70a MET info)</p>
	<p>SR_LLR_UCTRL#24. <i>In case of loss of RNP capability on the helicopter Low Level Route, the Flight Crew shall respect the Helicopter Operator's contingency procedures developed for such situations</i></p>	<p>Conv nav Syst → Flight control & display (56 Conv Nav data) Air Operator → Flight Crew (31 flight operation procedures and training)</p>
	<p>SR_LLR_UCTRL#25. <i>The Flight Information Service Officer (FISO) shall, as far as feasible, provide assistance to the Flight Crew following the loss of RNP capability on the helicopter Low Level Route</i></p>	<p>FISO → Flight crew</p>
<p>SRS_LLR_UNCTRL#11: In case of loss of communication, the pilot shall fly the procedure/route in accordance with the flight plan and set transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure</p>	<p>SR_LLR_UCTRL#26. <i>In case of radio communication failure, the Flight Crew shall fly the procedure/route in accordance with the flight plan and set the transponder to Code 7600 or the ADS-B transmitter to indicate the loss of air-ground communications and respect any instruction published in the AIP for radio communication failure</i></p>	<p>Flight Crew</p>
<p>SRS_LLR_UNCTRL#12: In case of icing conditions, a flight crew contingency procedure should be defined considering the operational environment of the Low Level Route</p>	<p>SR_LLR_UCTRL#27. <i>In case of icing conditions encountered on the helicopter Low Level Route, the Flight Crew shall respect the Helicopter Operator's contingency procedures developed for such situations</i></p>	<p>Air Operator → Flight Crew (31 flight operation procedures and training)</p>

ANNEX C – Detailed derivation of Safety Requirements for Faulted operations

This section identifies the causes of the hazards identified in section 5.4 and derives Safety Requirements at logical level for faulted operations, based on the Safety Requirements at service level associated to the Operational Hazards.

C.1 Controlled Airspace

C.1.1 Hazard Hz_LLR_01: Helicopter deviates from published Low Level Route towards terrain in controlled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations, where the failure could be:

- A lateral deviation.
- A vertical deviation

This hazard could lead to a controlled flight towards terrain with a distance to the accident defined at CC-d3a (see **Table A-5**).

Basic causes for such failures have been captured in the Hz_LLR_01 Fault Tree (See Figure C-1). Two main branches are described in this fault tree: the lateral deviation on the left side and the vertical deviation of the right side. It is shown in the fault tree by the undeveloped event (Deviation is towards terrain) that the allocated probability to the functional system is directly related to the operational environment (rich obstacle or non-rich obstacle).

The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

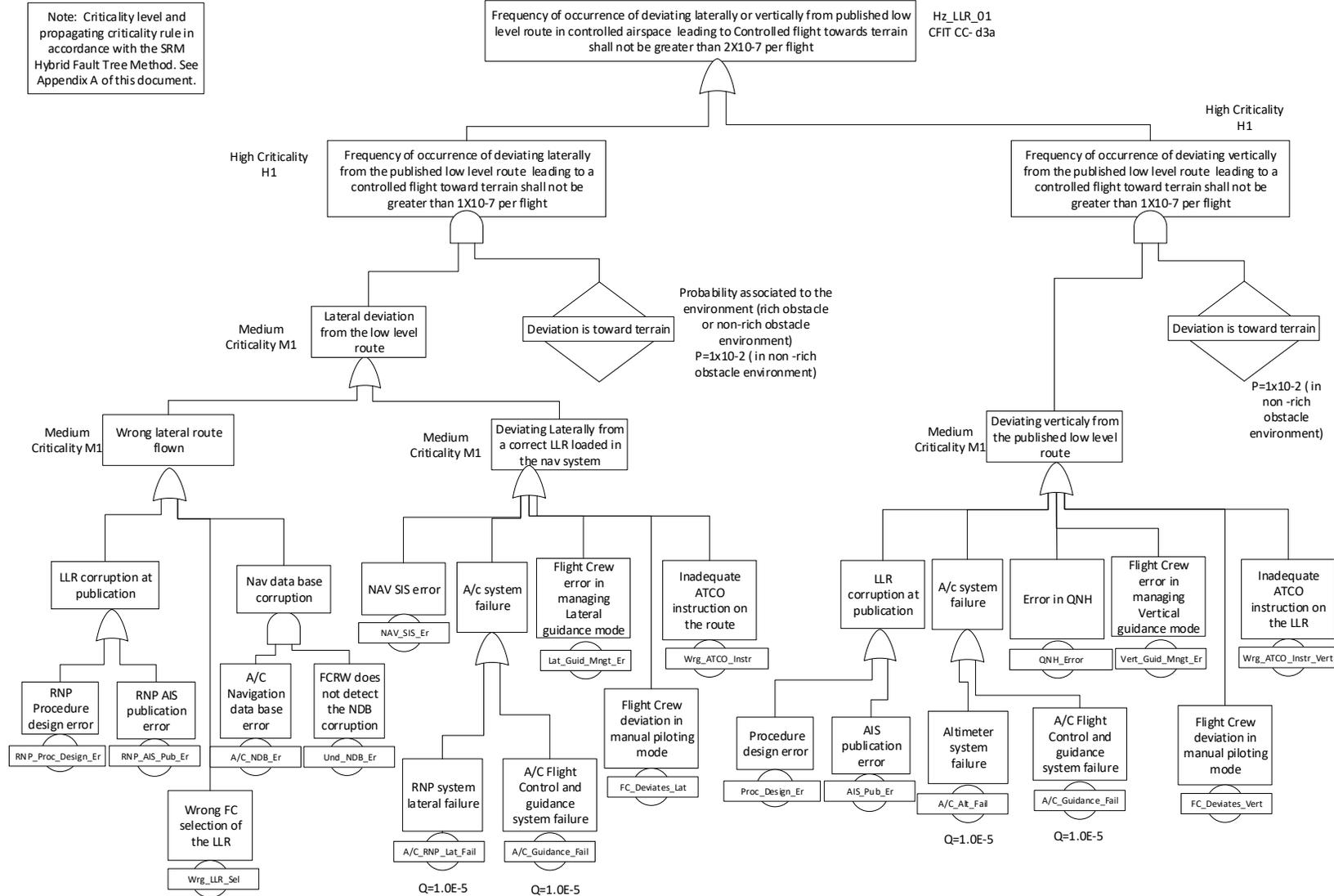


Figure C-1: Hz_LL_R_01 Fault tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-1 below describes the basic causes of the Hazard Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Lateral Deviation from the Low Level Route			
RNP Procedure design error	RNP_Proc_Design_Er	The RNP route design is not designed in accordance with the rules	SR_LLRL_CTRL#9. The helicopter Low Level Route shall be designed in accordance with criteria relative to En-Route criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.
		The RNP design error is not detected during the procedure validation process (ground and/or flight)	SR_LLRL_CTRL#10. The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.
		There is an error in the survey for the route design	SR_LLRL_CTRL#8. The terrain and obstacles used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.
RNP AIS publication Error	AIS_Pub_Er	The AIP (including procedure charts) includes errors on the RNP route (e.g. WPT location, course...) despite a correct procedure design.	SR_LLRL_CTRL#40. The AIS provider shall verify that published Low Level Route data/elements are identical to those provided by the procedure designer

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Aircraft Navigation data base error	A/C_NDB_Er	The Aircraft Navigation data base used by the onboard navigation system includes an incorrect Low Level Route despite the procedure publication was correct	See SR_LLRL_CTRL#12 and SR_LLRL_CTRL#14
Flight Crew does not detect the NDB corruption	Und_NDB_Er	The Flight Crew does not detect an inconsistency between the AIS publication and the procedure loaded in the RNP system	<p>SR_LLRL_CTRL#11. The helicopter Low Level Route shall be published in the state AIP in accordance with ICAO Annex 4, ICAO Doc 8697, ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 part FPD and AIS and shall indicate the required aircraft navigation capability to fly the Low Level route (e.g. RNP 1, RNP 0.3).</p> <p>SR_LLRL_CTRL#41. The Flight Crew shall verify the consistency of the Low Level Route with the published chart using the helicopter displayed data (FPLN, ND...)</p>
Flight Crew does not select the correct Low Level Route	Wrg_LLRL_Sel	The Flight Crew does not insert the correct Low Level Route in the RNAV flight plan	<p>SR_LLRL_CTRL#15. The Flight Crew shall insert the relevant part of the Low Level Route extracted from the navigation data base in the RNP system's flight plan</p> <p>See Issue_S_LLRL_CTRL#1</p> <p>SR_LLRL_CTRL#41: The Flight Crew shall verify the consistency of the Low Level Route with the published chart using the helicopter displayed data (FPLN, ND...)</p>

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Aircraft RNP System Failure in lateral	A/C_RNP_Fail_Lat	The Aircraft RNP system provides incorrect lateral deviation despite a correct defined path to be flown	SR_LLRL_CTRL#42. The RNP airborne systems based on GPS and/or SBAS shall be certified in accordance with EASA regulation and approved for the RNP requirement required by the published procedure
		Loss of the lateral deviation due to aircraft RNP system failure	SR_LLRL_CTRL#42. The RNP airborne systems based on GPS and/or SBAS shall be certified in accordance with EASA regulation and approved for the RNP requirement required by the published procedure
Aircraft Flight Control and Guidance System Failure	A/C_Guidance_Fail	The Aircraft Control and Guidance system provides incorrect lateral guidance on the Low Level Route despite correct lateral information from the aircraft RNP system	ASS_LLRL_CTRL#6. The helicopter control and guidance system providing lateral guidance on the Low Level Route is approved in accordance with EASA regulation
Flight Crew error in managing the lateral guidance modes	Lat_Guidance_Mngt_Er	The Flight Crew does not manage properly the selection of the lateral guidance mode and RNP navigation source is not coupled to the guidance system	SR_LLRL_CTRL#43. The Flight Crew shall be trained on RNP navigation, Low Level Route and associated contingency procedures
Flight Crew deviates from lateral displayed guidance in manual piloting mode	FC_Deviates_Lat	In manual or FD mode, the Flight Crew deviates laterally from a correct displayed guidance	SR_LLRL_CTRL#16. The Flight Crew shall respect the displayed RNP lateral navigation information if flight is conducted in manual mode or using Flight director See Issue_S_LLRL_CTRL#5 and Issue_S_LLRL_CTRL#6
			SR_LLRL_CTRL#43. The Flight Crew shall be trained on RNP navigation, Low Level Route and associated contingency procedures

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Inadequate ATCO instructions on the Low Level Route	Wrg_ATCO_Instr	The Controller provides inadequate instructions/clearance just before joining the Low Level Route or on the Low Level Route	SR_LLRL_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route
Erroneous Nav Signal In Space (SIS)	NAV_SIS_Er	An undetected erroneous NAV Signal In Space (GNSS, SBAS) is transmitted to airspace users	SR_LLRL_CTRL#13. The GNSS signal in space (GPS and SBAS if required) shall be compliant with ICAO Annex 10 SARPS and (EU) No 2017/373 Part CNS on the helicopter Low Level Route.
Vertical Deviation from the Low Level Route			
Procedure design error	Proc_Design_Er	The vertical path of the Low Level Route is not designed in accordance with the rules	SR_LLRL_CTRL#9. The helicopter Low Level Route shall be designed in accordance with criteria relative to En-Route criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.
		The design error is not detected during the procedure validation process (ground and/or flight)	SR_LLRL_CTRL#10. The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.
AIS publication Error	AIS_Pub_Er	The AIP (including procedure charts) includes error on the vertical path (e.g., Route level, altitude constraints (AT, AT or above, etc...)) despite a correct procedure design.	SR_LLRL_CTRL#8. The terrain and obstacles used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
			<p>SR_LLRL_CTRL#40. The AIS provider shall verify that published Low Level Route data/elements are identical to those provided by the procedure designer</p>
Altimeter system Failure	A/C_Alt_Fail	The Aircraft altimeter system provides incorrect altitude despite correct QNH setting	<p>ASS_LLRL_CTRL#7. The altimetry system is approved in accordance with EASA regulation</p>
Aircraft Flight Control and Guidance System Failure	A/C_Guidance_Fail	The Aircraft Control and Guidance system provides incorrect Vertical guidance on the Low Level Route	<p>ASS_LLRL_CTRL#8. The helicopter control and guidance system providing vertical guidance on the Low Level Route is approved in accordance with EASA regulation</p>
Flight Crew error in managing the Vertical guidance modes	Vert_Guidance_Mngt_Er	The Flight Crew does not manage properly the selection of the vertical guidance mode	<p>SR_LLRL_CTRL#19. The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind</p>
			<p>SR_LLRL_CTRL#43. The Flight Crew shall be trained on RNP navigation, Low Level Route and associated contingency procedures</p>
Flight Crew deviates from vertical path in manual piloting mode	FC_Deviates_Vert	In manual or FD mode, the Flight Crew deviates vertically from the level depicted on the chart	<p>SR_LLRL_CTRL#19. The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind</p> <p>See Issue_S_LLRL_CTRL#7</p>

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
			SR_LLRL_CTRL#43. The Flight Crew shall be trained on RNP navigation, Low Level Route and associated contingency procedures
Inadequate ATCO instructions on the Low Level Route	Wrg_ATCO_Instr	The Controller provides inadequate instructions/clearance just before joining the Low Level Route or on the Low Level Route	SR_LLRL_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route
Error in QNH	QNH_Error	The Controller provides a wrong QNH with an error exceeding the vertical safety margin and Flight Crew does not detect the error	SR_LLRL_CTRL#17. The ATC Controller shall provide the QNH information to the Flight Crew for the helicopter Low Level Route which could be a single value for the whole route or multiple values due to the route structure.
		Flight Crew selects the wrong QNH despite the Controller providing the correct one	ASS_LLRL_CTRL#9. ATC procedures associated to QNH transmission are conducted in accordance with the local ATC rules and should not be different when considering helicopter Low Level Route
			SR_LLRL_CTRL#18. The Flight Crew shall set the QNH appropriate for the Low Level Route or the part of the Low Level Route to be flown
			ASS_LLRL_CTRL#10. The Flight crew procedures associated to the QNH setting onboard the helicopter are conducted in accordance with the Helicopter Operator rules and are not different when considering Low Level Route operations

Table C-1: Derivation of Mitigation/Safety Requirements for Hazard Hz_LLRL_01

C.1.2 Hazard Hz_LL_R_05a: Helicopter deviates from published Low Level Route towards IFR or known VFR aircraft in controlled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations, when the helicopter deviates from the route towards an aircraft flying in the vicinity of the route and this traffic could be a known VFR or IFR flight.

This hazard could lead to a tactical conflict in airspace class C, D or E with a distance to the accident defined at MC-d4a (see **Table A-3**).

Basic causes for such failures have been captured in the Hz-LLR 05a Fault Tree (See Figure C-2). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Note: Criticality level and propagating criticality rule in accordance with the SRM Hybrid Fault Tree Method. See Appendix A of this document

Frequency of occurrence of deviating laterally or vertically from published low level route in controlled airspace leading to tactical conflict shall not be greater than 3.33×10^{-5} per flight hour or 3.33×10^{-5} per flight (*)

Hz_LL_R_05a - MAC MC-d4a
(*) For simplification it is assumed that the duration of the flight is 1 hour

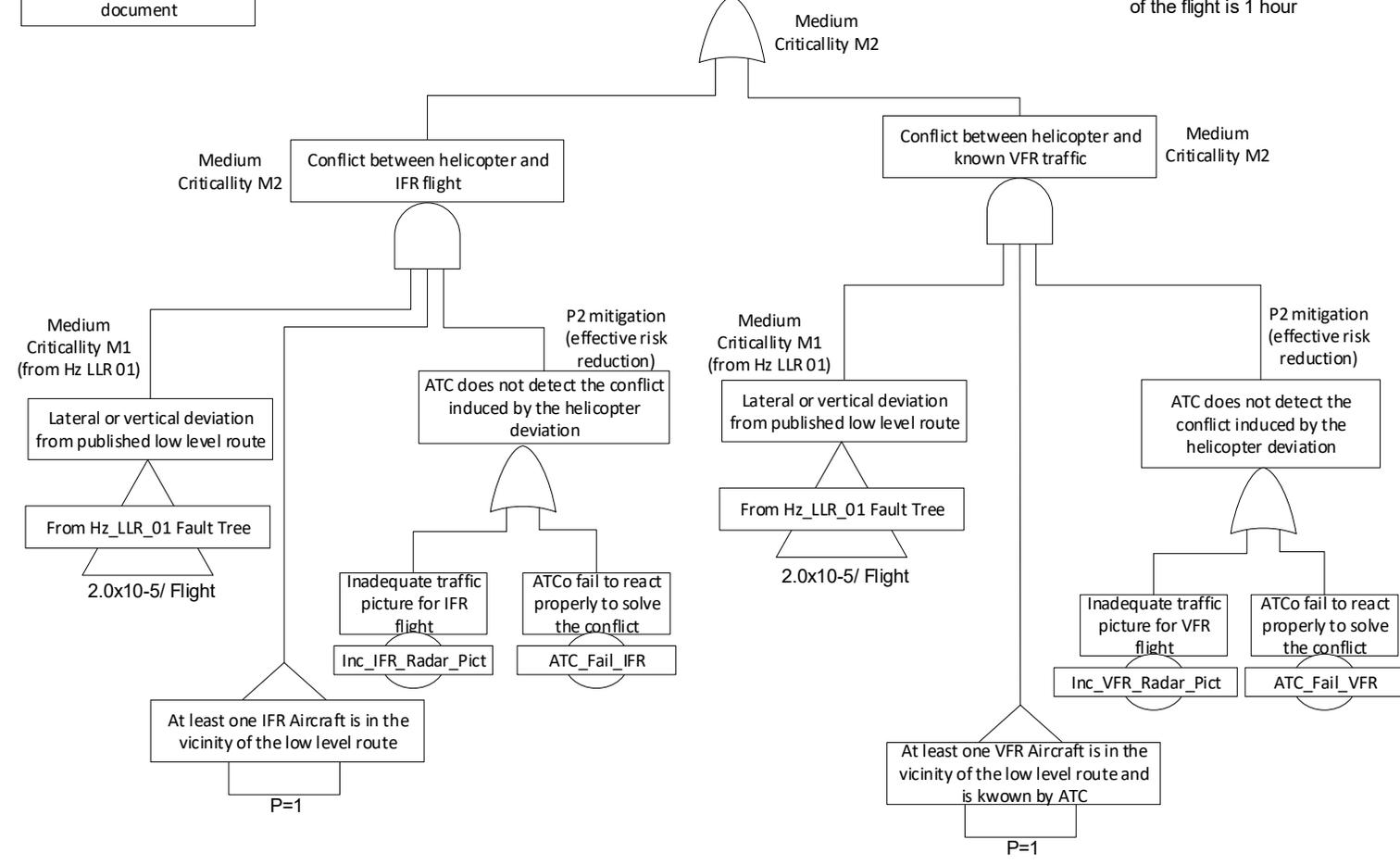


Figure C-2: Hz_LL_R_05a Fault tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-2 below describes the basic causes of the Hz LLR 05a Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Conflict between helicopter and IFR flight			
Lateral or vertical deviation from published Low Level Route	The helicopter deviates from the Low Level Route See Hz#LLR_01 Fault Tree (Figure C-1)		
One IFR aircraft is in the vicinity of the Low Level Route	To be conservative it is assumed that there is at least one IFR aircraft in the vicinity of the helicopter which deviates from the Low Level Route (Probability = 1)		
Inadequate traffic picture for IFR flight	Inc_IFR_Radar_Pict	The traffic picture is inadequate for IFR aircraft	ASS_LLRL_CTRL#11. TMA radar displays are adequate for providing an adequate traffic picture to depict IFR aircraft on the Low Level Route and in the vicinity of the Low Level Route
The Controller fails to react properly to solve conflict	ATC_Fail_IFR	Despite an adequate traffic picture, the Approach controller fails to take the appropriate decision to solve the conflict between the helicopter and another IFR flight	SR_LLRL_CTRL#5. The ATC Controller shall separate helicopters established on the Low Level Route with other IFR aircraft in the vicinity of the route in airspace class C,D and E
			SR_LLRL_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route
			SR_LLRL_CTRL#45. In radar environment, the Low Level Route shall be displayed, on demand, on the controller working position to facilitate the recognition of potential conflict

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

			SR_LLRL_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route
Conflict between helicopter and known VFR traffic			
Lateral or vertical deviation from the published Low Level Route	The helicopter deviates from the Low Level Route See Hz#LLR_01 Fault Tree (Figure C-1)		
One VFR aircraft is in the vicinity of the Low Level Route and is known by ATC	To be conservative it is assumed that there is at least one VFR aircraft in the vicinity of the helicopter which deviates from the Low Level Route (Probability = 1)		
Inadequate traffic picture for VFR flight	Inc_VFR_Radar_Pict	The traffic picture is inadequate for VFR aircraft Note: because the traffic is known it is assumed that the VFR aircraft is equipped with a transponder switched on	ASS_LLRL_CTRL#12. TMA radar displays are adequate for providing an adequate traffic picture to depict VFR aircraft equipped with transponder on the Low Level Route and in the vicinity of the Low Level Route
The Controller fails to react properly to solve conflict	ATC_Fail_VFR	despite an adequate traffic picture or a reported position from the VFR pilot, the Approach Controller fails to take the appropriate decision to solve the conflict between the helicopter and the known VFR	See SR_LLRL_CTRL#6, SR_LLRL_CTRL#21 and SR_LLRL_CTRL#22
			SR_LLRL_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route
			SR_LLRL_CTRL#45. In radar environment, the Low Level Route shall be displayed, on demand, on the controller working position to facilitate the recognition of potential conflict

Table C-2: Derivation of Mitigation/Safety Requirements for Hazard Hz_LLRL_05a

C.1.3 Hazards Hz_LL_R_05b: Helicopter deviates from published Low Level Route towards unknown VFR aircraft in controlled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations. The helicopter deviates from the route towards an aircraft flying in the vicinity of the route and this traffic is an unknown VFR traffic e.g. in airspace class E airspace.

This hazard could lead to an imminent collision with a distance to the accident defined at MC-d2 (See **Table A-3**).

Basic causes for such failures have been captured in the Hz-LLR 05b Fault Tree (See Figure C-3). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

Note: Criticality level and propagating criticality rule in accordance with the SRM Hybrid Fault Tree Method. See Appendix A of this document

Frequency of occurrence of deviating laterally or vertically from published low level route in controlled airspace leading to imminent infringement shall not be greater than 1×10^{-6} per flight hour or 1×10^{-6} per flight (*)

Hz_LL_R_05b – MAC MC-d2

(*) For simplification it is assumed that the duration of the flight is 1 hour

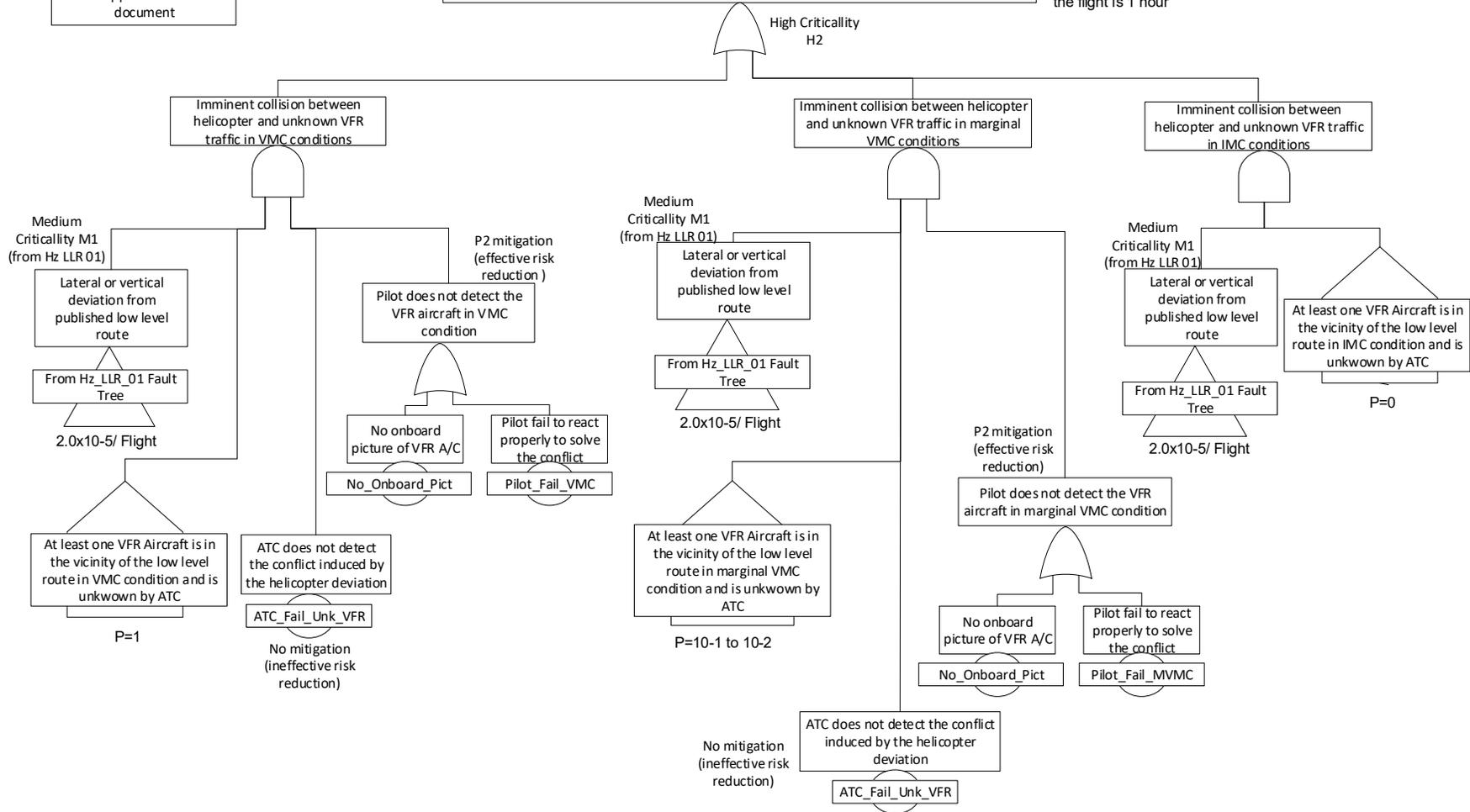


Figure C-3: Hz_LL_R_05b Fault tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-3 below describes the basic causes of the Hz LLR 05b Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Imminent collision between helicopter and unknown VFR traffic in VMC conditions			
Lateral or vertical deviation from published Low Level Route	The helicopter deviates from the Low Level Route See Hz#LLR_01 Fault Tree (Figure C-1)		
One VFR aircraft is in the vicinity of the Low Level Route and is unknown by ATC	To be conservative it is assumed in VMC conditions that there is at least one VFR aircraft unknown to ATC in the vicinity of the helicopter which deviates from the Low Level Route (Probability = 1)		
ATC does not detect the conflict induced by the helicopter deviation	ATC_Fail_Unk_VFR	ATC in airspace class E does not detect the conflict because VFR traffic is unknown	REC_LLRL_CTRL#1. All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority
No onboard picture of the VFR A/C	No_Onboard_Pict	The helicopter operating on Low Level Route in airspace class E is not equipped with a system detecting electronically the other aircraft in the vicinity or the VFR aircraft is not equipped with a transponder or equivalent	REC_LLRL_CTRL#1. All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority
			REC_LLRL_CTRL#2. Helicopters operating on Low Level Routes in airspace class E should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Pilots fail to react properly to solve the conflict	Pilot_Fail_VMC	<p>Pilots operating an aircraft shall maintain vigilance so as to see and avoid other aircraft.</p> <p>Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout considering that most midair collision accidents and reported near-MAC incidents occur during good VFR weather conditions and during daylight hours.</p>	SR_LLRL_CTRL#23. The Flight Crew established on the Low Level Route shall actively search for potentially conflicting traffic when weather conditions permit, especially when operating in airspace where all traffic is not operating under the instructions of ATC like in class E airspace
Imminent collision between helicopter and unknown VFR traffic in marginal VMC conditions			
Lateral or vertical deviation from published Low Level Route	<p>The helicopter deviates from the Low Level Route</p> <p>See Hz#LLR_01 Fault Tree (Figure C-1)</p>		
One VFR aircraft is in the vicinity of the Low Level Route and is unknown by ATC	<p>It is assumed in such marginal VMC conditions that the probability of having VFR aircraft unknown to ATC in the vicinity of the helicopter which deviates from the Low Level Route is rather low (Probability = 10⁻¹ to 10⁻²)</p>		
ATC does not detect the conflict induced by the helicopter deviation	ATC_Fail_Unk_VFR	ATC in airspace class E does not detect the conflict because VFR traffic is unknown	REC_LLRL_CTRL#1. All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority
No onboard picture of the VFR A/C	No_Onboard_Pict	The helicopter operating on Low Level Route in airspace class E is not equipped with a system detecting electronically the other aircraft in the vicinity or the VFR aircraft is not equipped with a transponder or equivalent	REC_LLRL_CTRL#1. All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

			REC_LLRL_CTRL#2. Helicopters operating on Low Level Routes in airspace class E should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity
The pilot fails to react properly to solve the conflict	Pilot_Fail_MVMC	See and Avoid in marginal weather conditions is ineffective for the pilot in most cases	SR_LLRL_CTRL#23. The Flight Crew established on the Low Level Route shall actively search for potentially conflicting traffic when weather conditions permit, especially when operating in airspace where all traffic is not operating under the instructions of ATC like in class E airspace but see and avoid ineffective in marginal VMC conditions therefore REC_LLRL_CTRL#1. And REC_LLRL_CTRL#2. Could become Safety requirements
Imminent collision between helicopter and unknown VFR traffic in IMC conditions			
Lateral or vertical deviation from published Low Level Route	The helicopter deviates from the Low Level Route See Hz#LLR_01 Fault Tree (Figure C-1)		
One VFR aircraft is in the vicinity of the Low Level Route and is unknown by ATC	It is assumed in IMC conditions that the probability of having VFR aircraft unknown to ATC in the vicinity of the helicopter is null in accordance with the Rules of the Air (Probability = 0)		

Table C-3: Derivation of Mitigation/Safety Requirements for Hazard Hz_05b

C.1.4 Hazards Hz_LL_R_10a : IFR or known VFR traffic flies towards helicopter established on the Low Level Route in controlled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations, an IFR aircraft or a known VFR aircraft flies towards helicopter established on the Low Level Route.

This hazard could lead to a tactical conflict in airspace class C, D or E with a distance to the accident defined at MC-d4a (see **Table A-3**).

Basic causes for such failures have been captured in the Hz-LLR 10a Fault Tree (See Figure C-3). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

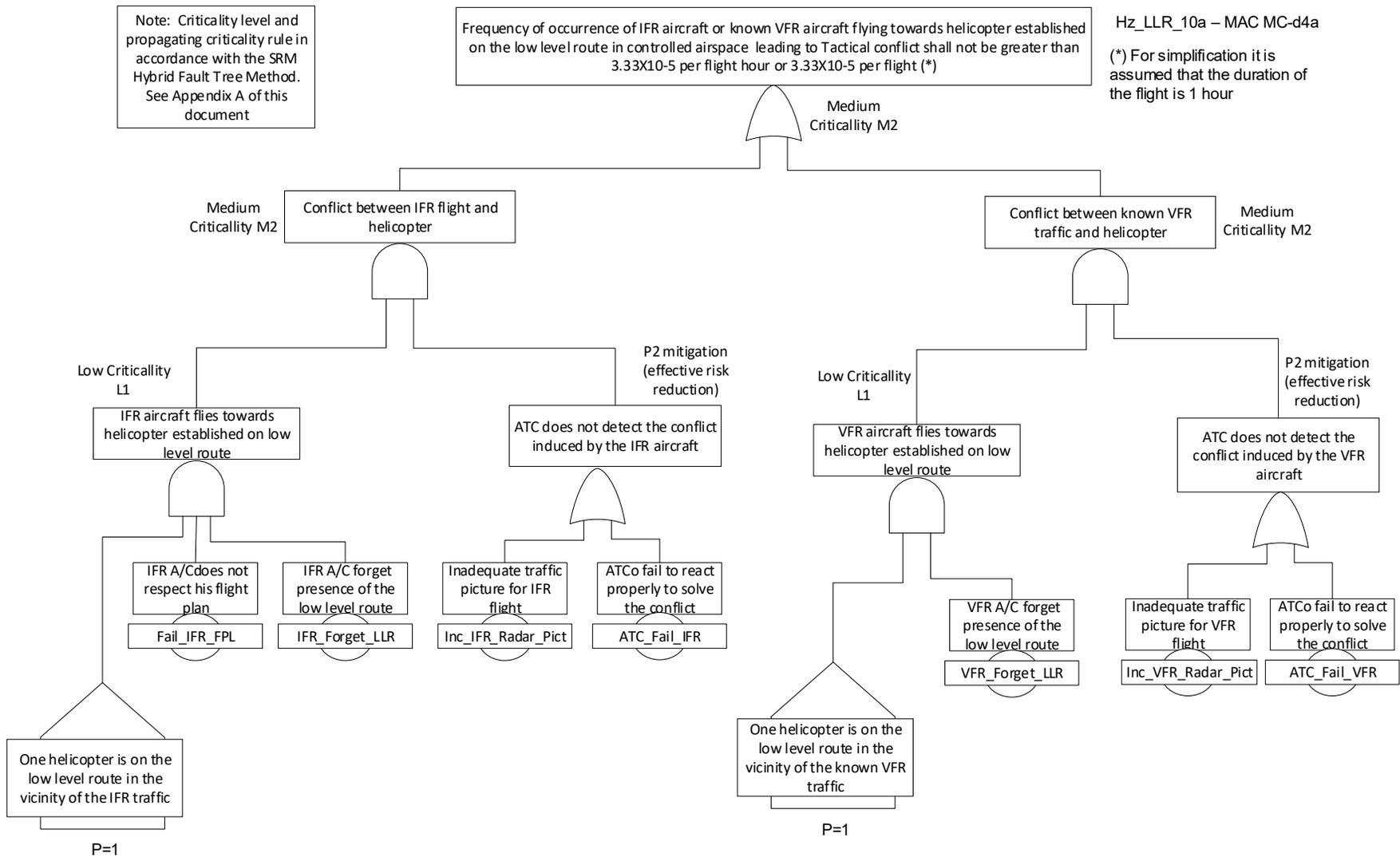


Figure C-4: Hz_LLRR_010a Fault tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-4 below describes the basic causes of the Hz LLR 10a Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Conflict between IFR flight and helicopter			
One helicopter is on the Low Level Route in the vicinity of the IFR traffic	To be conservative it is assumed that there is at least one helicopter on the Low Level Route in the vicinity of the IFR traffic (Probability = 1)		
IFR aircraft does not respect its flight plan	Fail_IFR_FPL	The IFR aircraft does not respect its flight plan or the deviation to the flight plan is not coordinated with the controller	No specific requirement because this is a basic airmanship principle (IFR aircraft will respect their flight plan)
			SR_LL_R_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route
IFR A/C forgets the presence of the Low Level Route	IFR_forget_LL_R	The pilot of the IFR aircraft is not properly informed about the helicopter Low Level Route	SR_LL_R_CTRL#46. The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.
Inadequate traffic picture for IFR flight	Inc_IFR_Radar_Pict	The traffic picture is inadequate for IFR aircraft	ASS_LL_R_CTRL#11. TMA radar displays are adequate for providing an adequate traffic picture to depict IFR aircraft on the Low Level Route and in the vicinity of the Low Level Route
	ATC_Fail_IFR	The Approach Controller despite an adequate traffic picture fails to take the	SR_LL_R_CTRL#5. The ATC Controller shall separate helicopters established on the Low Level

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

The Controller fails to react properly to solve conflict		appropriate decision to solve the conflict between the helicopter and another IFR flight	Route with other IFR aircraft in the vicinity of the route in airspace class C,D and E
			SR_LLRL_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route
			SR_LLRL_CTRL#45. In radar environment, the Low Level Route shall be displayed, on demand, on the controller working position to facilitate the recognition of potential conflict
Conflict between known VFR traffic and helicopter			
One helicopter is on the Low Level Route in the vicinity of the known VFR traffic	To be conservative it is assumed that there is at least one helicopter on the Low Level Route in the vicinity of the known VFR traffic (Probability = 1)		
VFR A/C forget presence of the Low Level Route	VFR_forget_LLRL	The pilot of the VFR aircraft is not properly informed about the helicopter Low Level Route	SR_LLRL_CTRL#46. The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.
Inadequate Traffic picture for VFR flight	Inc_VFR_Radar_Pict	The traffic picture is inadequate for VFR aircraft Note: Because the traffic is known it is assumed that the VFR aircraft is equipped with a transponder switched to on	ASS_LLRL_CTRL#12. TMA radar displays are adequate for providing an adequate traffic picture to depict VFR aircraft equipped with transponder on the Low Level Route and in the vicinity of the Low Level Route
The Controller fails to react properly to solve a conflict	ATC_Fail_VFR	The Approach Controller despite an adequate traffic picture or a reported	See SR_LLRL_CTRL#6, SR_LLRL_CTRL#21 and SR_LLRL_CTRL#22

		<p>position from the VFR pilot fails to take the appropriate decision to solve the conflict between the helicopter and the known VFR</p>	<p>SR_LLRL_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route</p> <p>SR_LLRL_CTRL#45. In radar environment, the Low Level Route shall be displayed, on demand, on the controller working position to facilitate the recognition of potential conflict</p>
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Table C-4: Derivation of Mitigation/Safety Requirements for Hazards Hz_LLRL_10a

C.1.5 Hazard Hz_LLRL_10b: Unknown VFR traffic flies towards helicopter established on the Low Level Route in controlled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations, an unknown VFR aircraft (e.g. in class E airspace) flies towards helicopter established on the Low Level Route.

This hazard could lead to an imminent collision with a distance to the accident defined at MC-d2 (see **Table A-3**).

Basic causes for such failures have been captured in the Hz-LLRL 10b Fault Tree (See Figure C-5). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-5 below describes the basic causes of the Hz LLR 10b Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Imminent collision between unknown VFR traffic and helicopter in VMC conditions			
One helicopter is on the Low Level Route in the vicinity of the unknown VFR traffic	To be conservative it is assumed that there is at least one helicopter on the Low Level Route in the vicinity of the unknown VFR traffic (Probability = 1)		
VFR A/C forgets the presence of the Low Level Route	VFR_forget_LL	The pilot of the VFR aircraft is not properly informed about the helicopter Low Level Route	SR_LL <u>CTRL#46</u> . The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.
ATC does not detect the conflict induced by the unknown VFR traffic	ATC_Fail_Unk_VFR	ATC in airspace class E does not detect the conflict because VFR traffic is unknown	REC_LL <u>CTRL#1</u> . All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority
No onboard picture of the VFR A/C	No_Onboard_Pict	The helicopter operating on a Low Level Route in airspace class E is not equipped with a system detecting electronically the other aircraft in the vicinity or the VFR aircraft is not equipped with a transponder or equivalent	REC_LL <u>CTRL#1</u> . All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

			REC_LLRL_CTRL#2. Helicopters operating on Low Level Routes in airspace class E should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity
Pilots fail to react properly to solve the conflict	Pilot_Fail_VMC	The pilot operating an aircraft shall maintain vigilance so as to see and avoid other aircraft. Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout considering that most midair collision accidents and reported near-MAC incidents occur during good VFR weather conditions and during daylight hours.	See SR_CTRL 140
Imminent collision between unknown VFR traffic and helicopter in marginal VMC conditions			
One helicopter is on the Low Level Route in the vicinity of the unknown VFR traffic	To be conservative it is assumed that there is at least one helicopter on the Low Level Route in the vicinity of the unknown VFR traffic (Probability = 1)		
One VFR aircraft is in the vicinity of the Low Level Route and is unknown by ATC	It is assumed in such marginal VMC conditions that the probability of having VFR aircraft unknown to ATC in the vicinity of the helicopter is rather low (Probability = 10 ⁻¹ to 10 ⁻²)		
VFR A/C forgets the presence of the Low Level Route	VFR_forget_LLRL	The pilot of the VFR aircraft is not properly informed about the helicopter Low Level Route	SR_LLRL_CTRL#46. The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

<p>ATC does not detect the conflict induced by the helicopter deviation</p>	<p>ATC_Fail_Unk_VFR</p>	<p>ATC in airspace class E does not detect the conflict because VFR traffic is unknown</p>	<p>REC_LLRL_CTRL#1. All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority</p>
<p>No onboard picture of the VFR A/C</p>	<p>No_Onboard_Pict</p>	<p>The helicopter operating on Low Level Route in airspace class E is not equipped with a system detecting electronically the other aircraft in the vicinity or the VFR aircraft is not equipped with a transponder or equivalent</p>	<p>REC_LLRL_CTRL#1. All VFR aircraft operating in the vicinity of the Low Level Route in airspace class E should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority</p> <p>REC_LLRL_CTRL#2. Helicopters operating on Low Level Routes in airspace class E should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity</p>
<p>The pilot fails to react properly to solve the conflict</p>	<p>Pilot_Fail_MVMC</p>	<p>See and Avoid in marginal weather conditions is ineffective for the pilot in most of the cases</p>	<p>SR_LLRL_CTRL#23. The Flight Crew established on the Low Level Route shall actively search for potentially conflicting traffic when weather conditions permit, especially when operating in airspace where all traffic is not operating under the instructions of ATC like in class E airspace but see and avoid ineffective in marginal VMC conditions therefore REC_LLRL_CTRL#1. and REC_LLRL_CTRL#2. could become Safety requirements</p>

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Imminent collision between unknown VFR traffic and helicopter in IMC conditions	
One helicopter is on the low level route	To be conservative it is assumed that there is at least one helicopter on the Low Level Route (Probability = 1)
One VFR aircraft is in the vicinity of the Low Level Route and is unknown by ATC	It is assumed in IMC conditions that the probability of having VFR aircraft unknown to ATC in the vicinity of the helicopter is null in accordance with the Rules of the Air (Probability = 0)

Table C-5: Derivation of Mitigation/Safety Requirements for Hazard Hz_LLRR_10b

C.1.6 Hazard Hz-LLR_15: Helicopter encounters hazardous weather conditions on Low Level Route

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations where a hazardous weather condition is encountered.

This hazard could lead to a flight towards terrain commanded with a distance to the accident defined at CC-d3b (see **Table A-5**) or to a precursor of inflight loss of control due to environmental factors (adverse weather).

Basic causes for such failures have been captured in the Hz-LLR 15 Fault Tree (See Figure C-6). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related

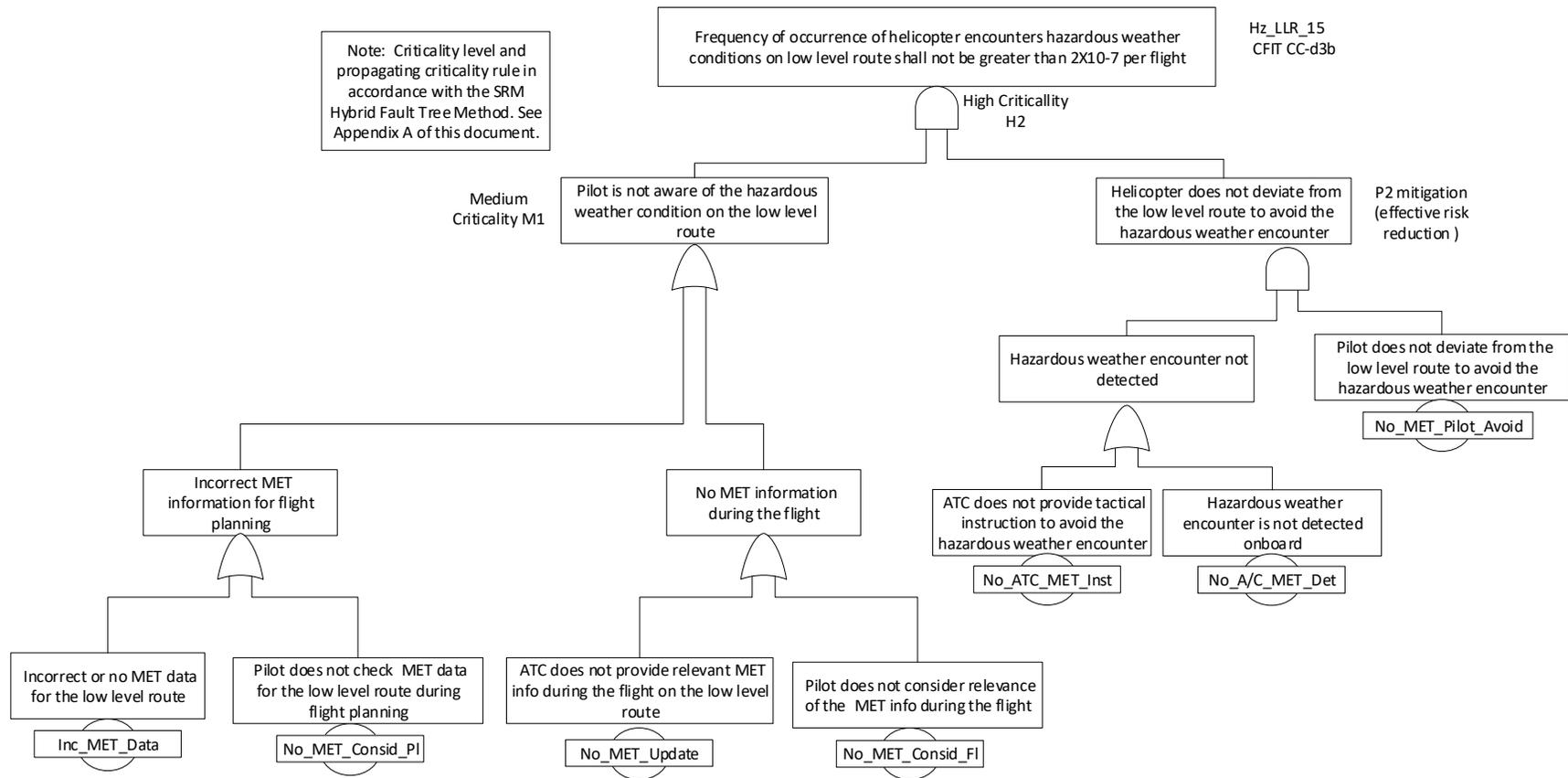


Figure C-6: Hz_LL_R_15 Fault tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-6 below describes the basic causes of the Hz LLR 15 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Incorrect or no MET data for the Low Level Route	Inc_MET_Data	There is no MET data forecasted for the Low Level Route or MET information are not correct/complete	SR_LLRL_CTRL#25 above. The MET service provider or an approved operator shall provide appropriate MET information to the Helicopter Operator for the flight planning which are at the minimum QNH, Cb cloud, lightning and in-flight icing.
The pilot does not check MET data for the Low Level Route during flight planning	No_MET_Consid_PI	The pilot does not consider the forecasted MET information on the Low Level Route during the flight planning	No requirement because basic airmanship
ATC does not provide relevant MET info during the flight on the Low Level Route	No_MET_Update	The Controller does not provide relevant MET information to helicopter operating on the Low Level Route	See SR_LLRL_CTRL#26 and SR_LLRL_CTRL#27
ATC does not provide tactical instruction to avoid hazardous weather encounter	No_ATC_MET_Inst	The Controller does not support the pilot in order to avoid the hazardous weather encounter by providing e.g. vectoring or levelchange.	No requirement because basic ATC procedure
There is no onboard detection of the hazardous weather encounter	No_A/C_MET_Inst	Systems detecting dangerous weather conditions are not installed or not efficient	REC_LLRL_CTRL#3. Helicopters operating on Low Level Routes should be equipped with airborne weather radar or on-board Electronic Flight Bag (EFB) Ground Radar information.
The pilot does not deviate from the low level route to avoid the hazardous weather encounter	No_MET_Pilot_Avoid	The pilot does not deviate from the Low Level Route laterally vertically by e.g. conducting a flight turn back or when feasible a landing	No requirement because basic airmanship

Table C-6: Derivation of Mitigation/Safety Requirements for Hazards Hz_LLRL_15

C.1.7 Hazard Hz-LLR_20: Failure to manage properly the traffic on the Low Level Route in controlled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations where at least two helicopters are established on the Low Level Route.

This hazard could lead to a tactical conflict in airspace class C, D or E with a distance to the accident defined at MC-d4a (see **Table A-3**).

Basic causes for such failures have been captured in the Hz-LLR 20 Fault Tree (See Figure C-7). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

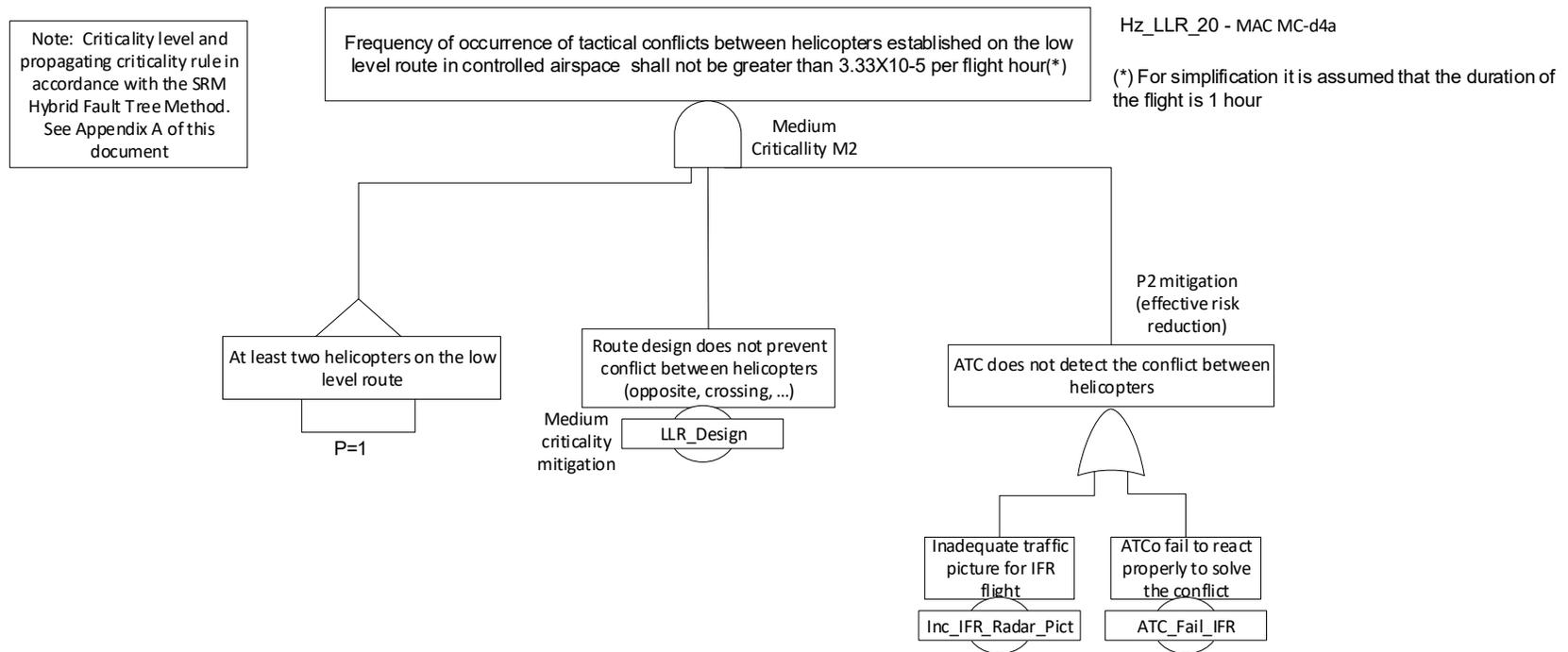


Figure C-7: Hz_LLR_20 Fault tree

Table C-9 below describes the basic causes of the Hz LLR 20 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Two helicopters on the Low Level Route	To be conservative it is assumed that there is at least two helicopters on the Low Level Route (Probability = 1)		
Low level route design does not prevent conflict between helicopters (opposite, crossing...)	LLR_Design	The route design permits to have bi-directional route or crossing route at same level	SR_LLR_CTRL#47. The design of the Low level route design shall minimize the risk of collision between helicopters by separating strategically when possible the different traffic flows operating on the Low Level Route network (e.g. vertical separation).
Inadequate traffic picture for IFR flight	Inc_IFR_Radar_Pict	The traffic picture is inadequate for IFR aircraft	ASS_LLR_CTRL#11. TMA radar displays are adequate for providing an adequate traffic picture to depict IFR aircraft on the Low Level Route and in the vicinity of the Low Level Route
The Controller fails to react properly to solve conflict	ATC_Fail_IFR	Despite an adequate traffic picture, the Approach Controller fails to take the appropriate decision to solve the conflict between two helicopters flying on the Low Level Route	See SR_LLR_CTRL#2, SR_LLR_CTRL#3, SR_LLR_CTRL#4 and SR_LLR_CTRL#7
			SR_LLR_CTRL#44. ATC Controllers shall be briefed on the RNP navigation and on helicopter Low Level Route

Table C-7: Derivation of Mitigation/Safety Requirements for Hazards Hz_LLR_20

C.1.8 Hazard Hz-LLR_25: Failure to intercept smoothly the existing approach from the Low Level Route in controlled airspace

Section 5.4.1 describes in more details this Hazard which occurs during the transition to existing approach (ILS or RNP) from the Low Level Route operations. This hazard could lead to an unstable approach at low altitude (due to the optimised interception) with a distance to the accident defined at RE-d4a (see **Table A-7**).

Basic causes for such failures have been captured in the Hz-LLR 25 Fault Tree (See Figure C-8). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

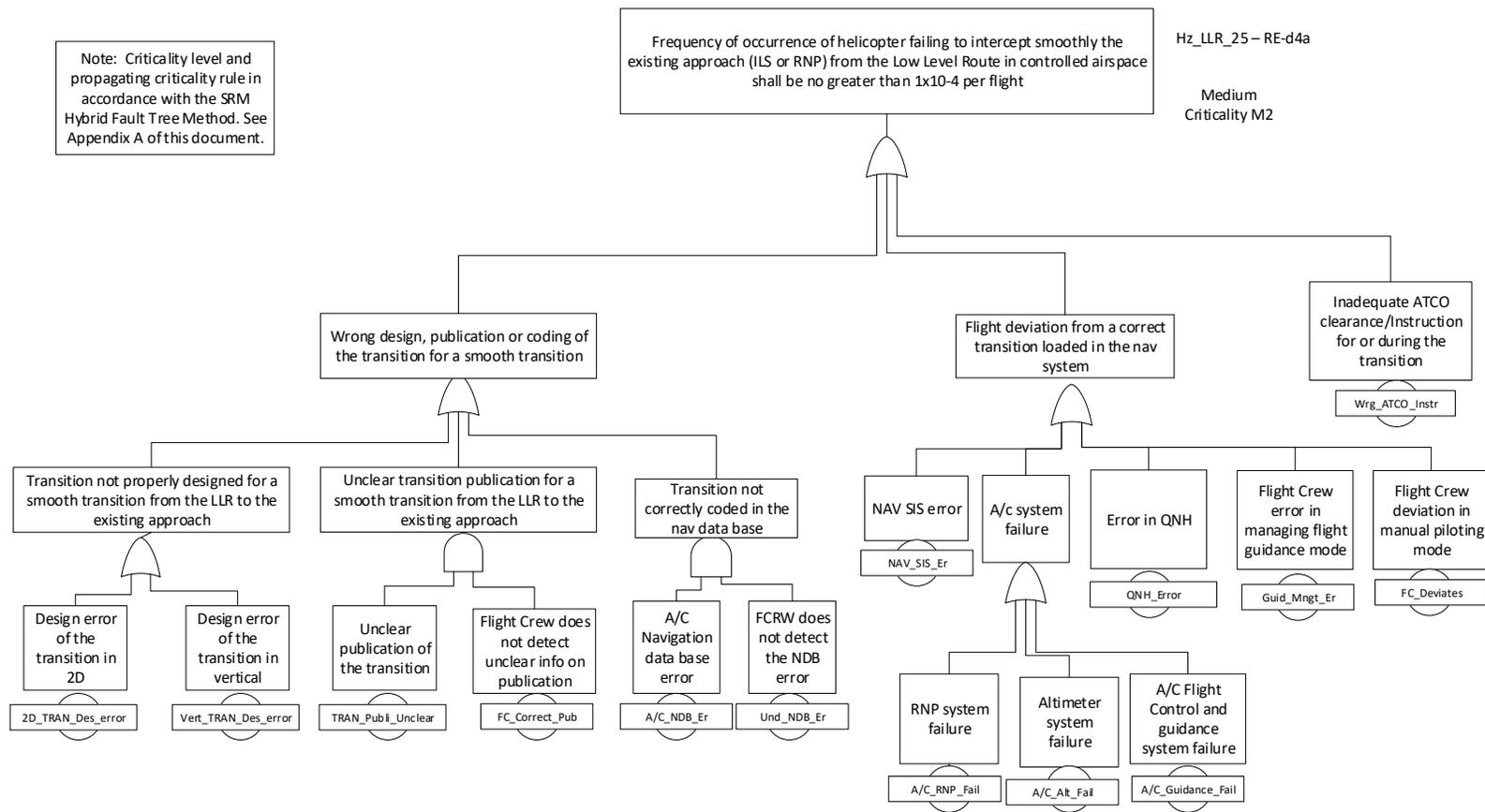


Figure C-8: Hz_LLR_25 Fault tree

Table C-9 below describes the basic causes of the Hz LLR 25 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Wrong design, publication or coding of the transition for a smooth transition			
Design error of the transition in 2D	2D_TRAN_Des_error	The 2D design of the transition does not allow to intercept smoothly the existing ILS/RNP approach axis	<p>SR_LLR_CTRL#29. The 2D design of the transition shall minimize the risk of overshoot of the existing approach axis and shall intercept the approach axis at a sufficient distance from the runway for a safe and stable approach</p> <p>See SR_LLR_CTRL#8, SR_LLR_CTRL#9 and SR_LLR_CTRL#10, which are also applicable to the transition.</p>
Design error of the transition in vertical	Vert_TRAN_Des_error	The design of the transition in vertical does not allow to intercept smoothly the existing ILS or RNP approach	<p>SR_LLR_CTRL#28. The design of the transition shall allow a smooth vertical transition from the LLR altitude to the altitude of capture of the existing approach</p> <p>See SR_LLR_CTRL#8, SR_LLR_CTRL#9 and SR_LLR_CTRL#10, which are also applicable to the transition.</p>
Unclear publication of the transition	TRAN_Publi_Unclear	The publication of the transition (charting) in lateral and/or in vertical is unclear for the flight crew	<p>SR_LLR_CTRL#30. The publication of the LLR transition to the existing approach (ILS or RNP) shall minimize the risk of flight crew misinterpretation of any data/elements of the charts.</p> <p>See SR_LLR_CTRL#11, SR_LLR_CTRL#12 and SR_LLR_CTRL#40, which are also applicable to</p>

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Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
			the transition.
Flight Crew does not detect unclear info on publication	FC_Correct_Pub	The flight crew does not detect unclear data/elements on the chart and misinterpret them	See SR_LLRL_CTRL#41 which is also applicable to the transition.
A/C Navigation data base error	A/C_NDB_Er	The Aircraft Navigation data base used by the onboard navigation system includes an incorrect transition despite the procedure publication was correct	See SR_LLRL_CTRL#12 and SR_LLRL_CTRL#14, which are also applicable to the transition.
FCRW does not detect the NDB error	Und_NDB_Er	The Flight Crew does not detect an inconsistency between the AIS publication and the procedure loaded in the RNP system	SeeSR_LLRL_CTRL#11 and SR_LLRL_CTRL#41, which are also applicable to the transition.
Flight deviation from a correct transition loaded in the nav system			
NAV SIS error	NAV_SIS_Er	An undetected erroneous NAV Signal In Space (GNSS, SBAS) is transmitted to airspace users	See SR_LLRL_CTRL#13 which is also applicable to the transition.
RNP system lateral failure	A/C_RNP_Fail	The Aircraft RNP system provides incorrect lateral deviation despite a correct defined path to be flown	See SR_LLRL_CTRL#42 which is also applicable to the transition.
Altimeter system failure	A/C_Alt_Fail	The Aircraft altimeter system provides incorrect altitude despite correct QNH setting	See ASS_LLRL_CTRL#7 which is also applicable to the transition.
A/C Flight Control and guidance system failure	A/C_Guidance_Fail	The Aircraft Control and Guidance system provides incorrect lateral or vertical guidance on the transition	See ASS_LLRL_CTRL#6 and ASS_LLRL_CTRL#8, which are also applicable to the transition.
Error in QNH	QNH_Error	The Controller provides a wrong QNH	ASS_LLRL_CTRL#13. The ATC controller provides the QNH information to the flight crew for the existing approach (ILS or RNP)
Flight Crew error in managing flight guidance mode	Guid_Mngt_Er	The Flight Crew does not manage properly the selection of the lateral and/or vertical guidance mode	See SR_LLRL_CTRL#19 and SR_LLRL_CTRL#43, which are also applicable to the transition
Flight Crew deviation	FC_Deviates	In manual or FD mode, the Flight Crew deviates laterally	See SR_LLRL_CTRL#16 and SR_LLRL_CTRL#43,

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Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
in manual piloting mode		or vertically from a correct displayed guidance	which are also applicable to the transition
Inadequate ATCO clearance/instruction			
Inadequate ATCO clearance/instruction for or during the transition	Wrg_ATCO_Instr	The Controller provides inadequate instructions/clearance just before the transition or on the transition	See SR_LLRL_CTRL#44, which is also applicable to the transition.

Table C-8: Derivation of Mitigation/Safety Requirements for Hazards Hz_LLRL_25

C.2 Uncontrolled Airspace

C.2.1 Hazard Hz_LL_R_50 Helicopter deviates from published Low Level Route towards terrain in uncontrolled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations, where the failure could be:

- A lateral deviation
- A vertical deviation

This hazard could lead to a controlled flight towards terrain with a distance to the accident defined at CU-d2 (see **Table A-6**).

Basic causes for such failures have been captured in the Hz_LL_R_50 Fault Tree (see Figure C-9). Two main branches are described in this fault tree: the lateral deviation on the left side and the vertical deviation on the right side. It is shown in the fault tree by the undeveloped event (Deviation is towards terrain) that the allocated probability to the functional system is directly related to the operational environment (rich obstacle or non-rich obstacle).

The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

Note: Criticality level and propagating criticality rule in accordance with the SRM Hybrid Fault Tree Method. See Appendix A of this document.

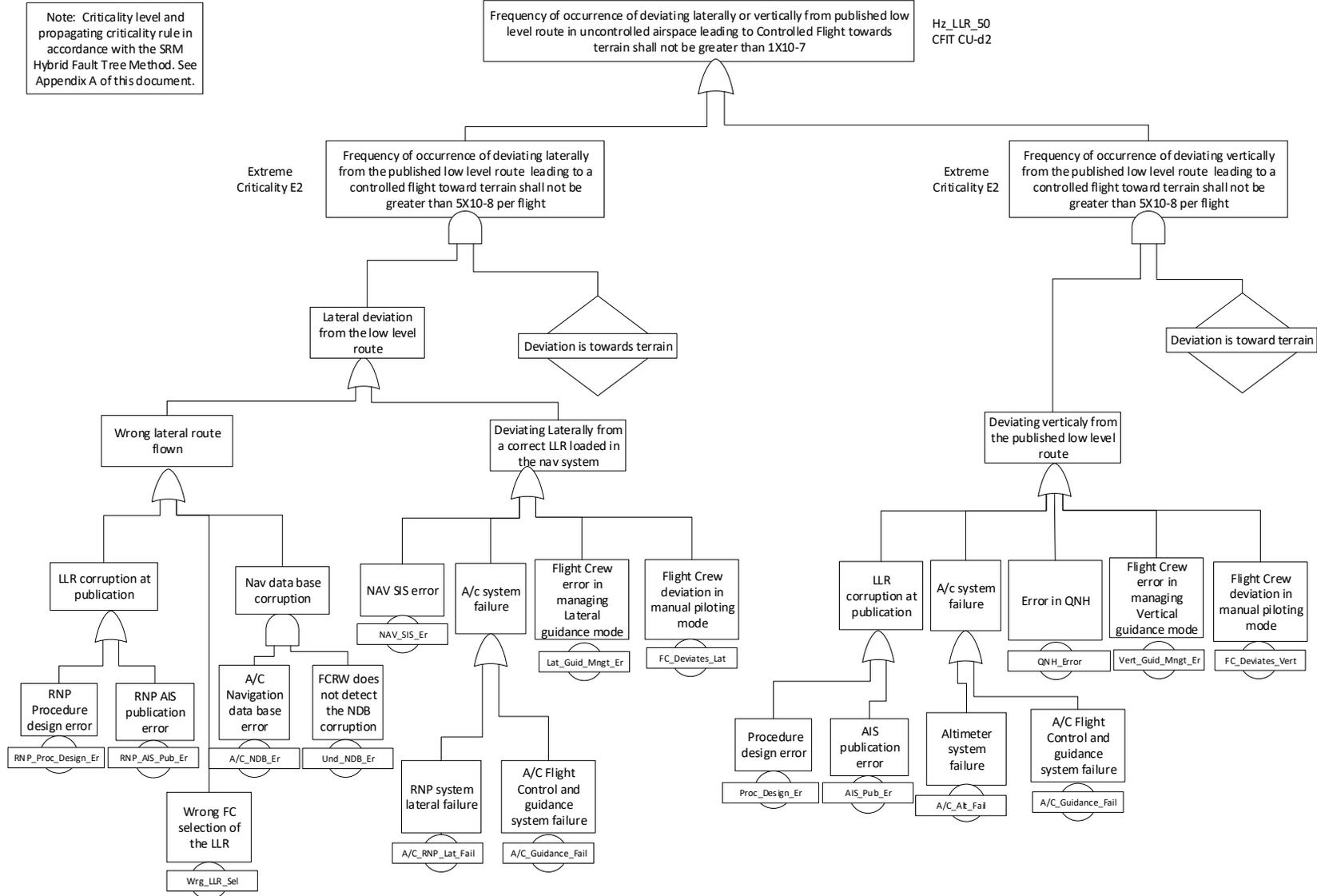


Figure C-9: Hz_LL_R_50 Fault Tree

Table C-9 below describes the basic causes of the Hz LLR50 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Lateral Deviation from the Low Level Route			
RNP Procedure design error	RNP_Proc_Design_Er	The RNP route designed is not designed in accordance with the rules	SR_LL_R_UCTRL#5. <i>The helicopter Low Level Route shall be designed in accordance with criteria relative to EnRoute criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.</i>
		The RNP design error is not detected during the procedure validation process (ground and/or flight)	SR_LL_R_UCTRL#6. <i>The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.</i>
		There is an error in the survey for the route design	SR_LL_R_UCTRL#4. <i>The terrain and obstacle used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.</i>
RNP AIS publication Error	AIS_Pub_Er	The AIP (including procedure charts) includes error on the RNP route (e.g. WPT location, course, ...) despite a correct procedure design	SR_LL_R_UCTRL#28. <i>The AIS provider shall verify that published Low Level Route data/elements are identical to those provided by the procedure designer</i>

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Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Aircraft Navigation data base error	A/C_NDB_Er	The Aircraft Navigation data base used by the onboard navigation system includes an incorrect Low Level Route despite the procedure publication was correct	SR_LL_R_UCTRL#10. <i>The Helicopter Operator shall use a navigation data base which satisfies the requirements of the AIR OPS regulation (EU) No 965/2012 in order to meet standards or integrity that are adequate for the intended use of the electronic navigation data</i>
Flight Crew does not detect the NDB corruption	Und_NDB_Er	The Flight Crew does not detect an inconsistency between the AIS publication and the procedure loaded in the RNP system	SR_LL_R_UCTRL#7. <i>The helicopter Low Level Route shall be published in the state AIP in accordance with ICAO Annex 4, ICAO Doc 8697, ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 part FPD and AIS and shall indicate the required aircraft navigation capability to fly the Low Level route (e.g. RNP 1, RNP 0.3).</i>
			SR_LL_R_UCTRL#29. <i>The Flight Crew shall verify the consistency of the Low Level Route with the published chart using the helicopter displayed data (FPLN, ND, ...)</i>
Flight Crew does not select the correct Low Level route	Wrg_LL_R_Sel	The Flight Crew does not insert the correct Low Level Route in the RNAV flight plan	SR_LL_R_UCTRL#11. <i>The Flight Crew shall insert the relevant part of the Low Level Route extracted from the navigation database in the RNP system's flight plan</i> See Issue_S_LL_R_UCTRL#1
			SR_LL_R_UCTRL#29. <i>The Flight Crew shall verify the consistency of the Low Level Route with the published chart using the helicopter displayed data (FPLN, ND, ...)</i>

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Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Aircraft RNP System failure in lateral	A/C_RNP_Fail_Lat	The aircraft RNP system provides incorrect lateral deviation despite a correct defined path to be flown	SR_LLRL_UCTRL#30. <i>The RNP airborne systems based on GPS and/or SBAS shall be certified in accordance with EASA regulation and approved for the RNP requirement required by the published procedure</i>
		Loss of the lateral deviation due to aircraft RNP system failure	SR_LLRL_UCTRL#30. <i>The RNP airborne systems based on GPS and/or SBAS shall be certified in accordance with EASA regulation and approved for the RNP requirement required by the published procedure</i>
Aircraft Flight Control and Guidance System failure	A/C_Guidance_Fail	The Aircraft Control and Guidance system provides incorrect lateral guidance on the Low Level Route despite correct lateral information from the aircraft RNP system	ASS_LLRL_UNCTRL#1. <i>The helicopter control and guidance system providing lateral guidance on the Low Level Route is approved in accordance with EASA regulation</i>
Flight Crew error in managing the lateral guidance modes	Lat_Guidance_Mngt_Er	The Flight Crew does not manage properly the selection of the lateral guidance mode and RNP navigation source is not coupled to the guidance system	SR_LLRL_UCTRL#31. <i>The Flight Crew shall be trained on RNP navigation Low Level Route and associated contingency procedures</i>
Flight Crew deviates from lateral displayed guidance in manual piloting mode	FC_Deviates_Lat	In manual or FD mode, the Flight Crew deviates laterally from a correct displayed guidance	SR_LLRL_UCTRL#12. <i>The Flight Crew shall respect the displayed RNP lateral navigation information if the flight is conducted in manual mode or using a Flight director</i> See Issue_S_LLRL_UCTRL#2Issue_S_LLRL_UCTRL#3
			SR_LLRL_UCTRL#31. <i>The Flight Crew shall be trained on RNP navigation Low Level Route and associated contingency procedures</i>

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Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Erroneous Nav Signal In Space (SIS)	NAV_SIS_Er	An undetected erroneous NAV Signal In Space (GNSS, SBAS) is transmitted to airspace users	SR_LL_R_UCTRL#9. <i>The GNSS signal in space (GPS and SBAS if required) shall be compliant with ICAO Annex 10 SARPS and (EU) No 2017/373 Part CNS on the helicopter Low Level Route.</i>
Vertical Deviation from the Low Level Route			
Procedure design error	Proc_Design_Er	The vertical path of the Low Level Route is not designed in accordance with the rules	SR_LL_R_UCTRL#5. <i>The helicopter Low Level Route shall be designed in accordance with criteria relative to EnRoute criteria as defined in ICAO Doc 8168 Part II (PANS OPS) and (EU) No 2017/373 Part FPD.</i>
		The design error is not detected during the procedure validation process (ground and/or flight)	SR_LL_R_UCTRL#6. <i>The validation of the helicopter Low Level Route shall be made in accordance with the process specified in ICAO Doc 9906 and (EU) No 2017/373 Part FPD.</i>
AIS publication error	AIS_Pub_Er	The AIP (including procedure charts) includes errors on the vertical path (e.g., route level, altitude constraints (AT, AT or above, etc, ...)) despite a correct procedure design	SR_LL_R_UCTRL#4. <i>The terrain and obstacle used in the design of the helicopter Low Level Route shall comply with the appropriate data quality requirements of ICAO Annex 14, Annex 15, Doc 10066 and respect the European Regulation (EU) No 2017/373 Part AIS on the quality of aeronautical data/information.</i>
			SR_LL_R_UCTRL#28. <i>The AIS provider shall verify that published Low Level Route</i>

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Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
			<i>data/elements are identical to those provided by the procedure designer</i>
Altimeter system failure	A/C_Alt_Fail	The aircraft altimeter system provides an incorrect altitude despite correct QNH setting	ASS_LLRL_UNCTRL#2. <i>The altimetry system is approved in accordance with EASA regulation</i>
Aircraft Flight Control and Guidance System failure	A/C_Guidance_Fail	The Aircraft Control and Guidance system provides an incorrect vertical guidance on the Low Level Route	ASS_LLRL_UNCTRL#3. <i>The helicopter control and guidance system providing vertical guidance on the Low Level Route is approved in accordance with EASA regulation</i>
Flight Crew error in managing the vertical guidance modes	Vert_Guidance_Mngt_Er	The Flight Crew does not manage properly the selection of the vertical guidance mode	SR_LLRL_UCTRL#15. <i>The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind</i>
			SR_LLRL_UCTRL#31. <i>The Flight Crew shall be trained on RNP navigation Low Level Route and associated contingency procedures</i>
Flight Crew deviates from vertical path in manual piloting mode	FC_Deviates_Vert	In manual or FD mode, the Flight Crew deviates vertically from the level depicted on the chart	SR_LLRL_UCTRL#15. <i>The Flight Crew shall select and respect the level depicted on the helicopter Low Level Route chart including compensation for low temperature and wind</i> and Issue UCTRL 030
			SR_LLRL_UCTRL#31. <i>The Flight Crew shall be trained on RNP navigation Low Level Route and associated contingency procedures</i>

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Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Error in QNH	QNH_Error	The FISO provides a wrong QNH with an error exceeding the vertical safety margin and the Flight Crew does not detect the error	<p>SR_LLRL_UCTRL#13. The Flight Information Service Officer (FISO) shall provide the QNH information to the Flight Crew for the helicopter Low Level Route which could be a single value for the whole route or multiple values due to the route structure</p>
		<p>ASS_LLRL_UNCTRL#4. The Flight Information Service Officer (FISO) procedures associated to QNH transmission are conducted in accordance with the local FISO rules and should not be different when considering helicopter Low Level Route</p>	
		The Flight Crew selects the wrong QNH despite the FISO providing the correct one	<p>SR_LLRL_UCTRL#14. <i>The Flight Crew shall set the QNH appropriate for the Low Level Route or the part of the Low Level Route to be flown</i></p>
		<p>ASS_LLRL_UNCTRL#5. <i>The Flight Crew procedures associated to the QNH setting onboard the helicopter are conducted in accordance with the Helicopter Operator rules and are not different when considering Low Level Route operations</i></p>	

Table C-9: Derivation of Mitigation/Safety Requirements for Hz_LLRL_50

C.2.2 Hazard Hz_LL_R_55 Helicopter deviates from published Low Level Route towards other traffic in uncontrolled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations, the helicopter deviates from the route towards an aircraft flying in the vicinity of the route and this traffic could be VFR or IFR flight. Weather conditions could be VMC, marginal VMC or IMC conditions.

This hazard could lead to an imminent infringement in airspace class G with a distance to the accident defined at MU-d3 (see **Table A-4**).

Basic causes for such failures have been captured in the Hz_LL_R_55 Fault Tree (see Figure C-10). The basic causes are related to air, ground, or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

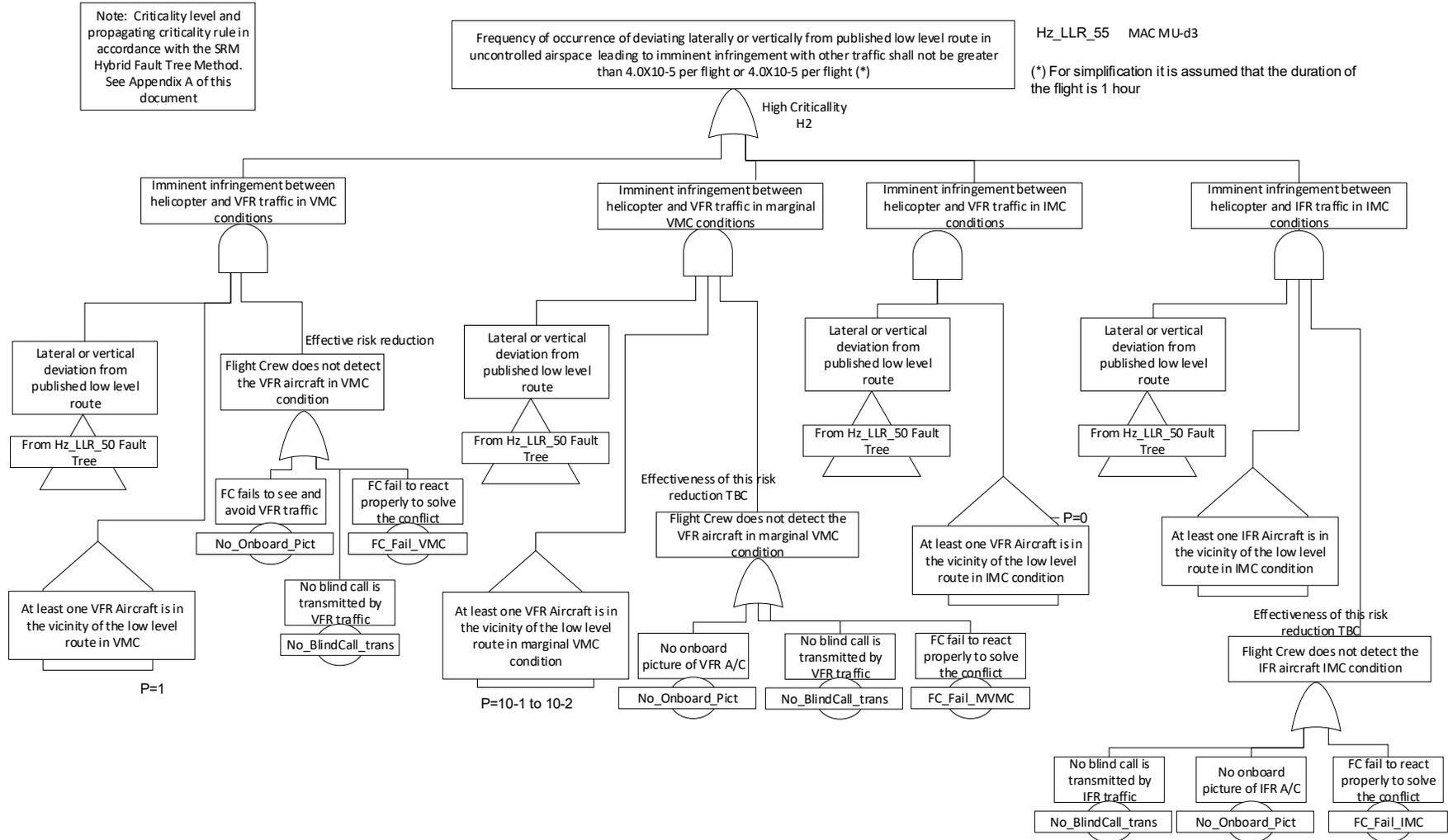


Figure C-10: Hz_LL_R_55 Fault Tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-10 below describes the basic causes of the Hz_LL_R_55 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Imminent infringement between helicopter and VFR traffic in VMC conditions			
Lateral or vertical deviation from the published Low Level Route	The helicopter deviates from the Low Level Route See Hz#LLR_50 Fault Tree		
One VFR aircraft is in the vicinity of the Low Level Route	To be conservative it is assumed in VMC conditions that there is at least one VFR aircraft in the vicinity of the helicopter which deviates from the Low Level Route (Probability = 1)		
No onboard picture of the VFR A/C	No_Onboard_Pict	The helicopter operating on a Low Level Route in airspace class G is not equipped with a system detecting electronically the other aircraft in the vicinity or the VFR aircraft is not equipped with a transponder or equivalent system	<p>REC_LL_R_UNCTRL#1. All aircraft operating in the vicinity of the Low Level Route in airspace class G should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority</p> <p>REC_LL_R_UNCTRL#2. Helicopters operating on Low Level Routes in airspace class G should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity</p>
The pilot fails to react properly to solve the conflict	Pilot_Fail_VMC	<p>Pilot operating an aircraft shall maintain vigilance so as to see and avoid other aircraft.</p> <p>Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout considering that most midair collision accidents and reported near-MAC</p>	SR_LL_R_UCTRL#2. The Flight Crew established on the Low Level Route shall actively search for conflicting traffic when weather conditions permit (see and avoid) based on traffic information provided by other aircraft and by flight information services when available

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

		incidents occur during good VFR weather conditions and during daylight hours .	
No blind call is transmitted by VFR traffic	No_BlindCall_trans	VFR pilots flying in the vicinity of the Low Level Route do not transmit regularly their position and flight intent	SR_LL_R_UCTRL#18. VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational awareness of helicopters pilots established on the Low Level Route
Imminent infringement between helicopter and VFR traffic in marginal VMC conditions			
Lateral or vertical deviation from the published Low Level Route	The helicopter deviates from the Low Level Route See Hz#LLR_50 Fault Tree		
One VFR aircraft is in the vicinity of the Low Level Route	It is assumed in such marginal VMC conditions that the probability of having VFR aircraft in the vicinity of the helicopter which deviates from the Low Level Route is rather low (Probability = 10 ⁻¹ to 10 ⁻²)		
No onboard picture of the VFR A/C	No_Onboard_Pict	The helicopter operating on a Low Level Route in airspace class G is not equipped with a system detecting electronically the other aircraft in the vicinity or the VFR aircraft is not equipped with a transponder or equivalent	<p>REC_LL_R_UNCTRL#1. All aircraft operating in the vicinity of the Low Level Route in airspace class G should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority</p> <p>REC_LL_R_UNCTRL#2. Helicopters operating on Low Level Routes in airspace class G should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity</p>

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

The pilot fails to react properly to solve the conflict	Pilot_Fail_MVMC	See and Avoid in marginal weather conditions is ineffective for the pilot in most of the cases	<p>SR_LL_R_UNCTRL#2. The Flight Crew established on the Low Level Route shall actively search for conflicting traffic when weather conditions permit (see and avoid) based on traffic information provided by other aircraft and by flight information services when available</p> <p>but see and avoid ineffective in marginal VMC conditions therefore REC_LL_R_UNCTRL#1. and REC_LL_R_UNCTRL#2. could become Safety requirements</p>
No blind call is transmitted by VFR traffic	No_BlindCall_trans	VFR pilots flying in the vicinity of the Low Level Route do not transmit regularly their position and flight intent	<p>SR_LL_R_UNCTRL#18. VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational awareness of helicopters pilots established on the Low Level Route</p>
Imminent infringement between helicopter and unknown VFR traffic in IMC conditions			
Lateral or vertical deviation from the published Low Level Route	<p>The helicopter deviates from the Low Level Route</p> <p>See Hz#LLR_50 Fault Tree</p>		
One VFR aircraft is in the vicinity of the Low Level Route	<p>It is assumed in IMC conditions that the probability of having VFR aircraft in the vicinity of the helicopter is null in accordance with the Rules of the Air (Probability = 0)</p>		
Imminent infringement between helicopter and IFR traffic in IMC conditions			

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Lateral or vertical deviation from published Low Level Route	The helicopter deviates from the Low Level Route See Hz#LLR_50 Fault Tree		
One IFR aircraft is in the vicinity of the Low Level Route	It is assumed in IMC conditions that the probability of having VFR aircraft in the vicinity of the helicopter is null		
No onboard picture of the IFR A/C	No_Onboard_Pict	The helicopter operating on a Low Level Route in airspace class G is not equipped with a system detecting electronically the other aircraft in the vicinity or the IFR aircraft is not equipped with a transponder or equivalent	REC_LL_R_UNCTRL#1. All aircraft operating in the vicinity of the Low Level Route in airspace class G should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority
			REC_LL_R_UNCTRL#2. Helicopters operating on Low Level Routes in airspace class G should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity
The pilot fails to react properly to solve the conflict	Pilot_Fail_IFR	See and Avoid in IMC conditions is ineffective	REC_LL_R_UNCTRL#1. and REC_LL_R_UNCTRL#2. could become Safety requirements
No blind call is transmitted by IFR traffic	No_BlindCall_trans	IFR pilots flying in the vicinity of the Low Level Route do not transmit regularly their position and flight intent	SR_LL_R_UCTRL#18. VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational awareness of helicopters pilots established on the Low Level Route

Table C-10: Derivation of Mitigation/Safety Requirements for Hazard Hz_LL_R_55

C.2.3 Hazard Hz_LL_R_60 Other traffic deviates towards helicopter established on the Low Level Route in uncontrolled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations, an IFR aircraft or VFR aircraft flies towards helicopter established on the Low Level Route.

This hazard could lead to an imminent collision in airspace class G with a distance to the accident defined at MU-d3 (see **Table A-4**).

Basic causes for such failures have been captured in the Hz_LL_R_60 Fault Tree (See Figure C-11). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

Helicopter Low Level Route operations in controlled and uncontrolled airspace

Generic Safety Case

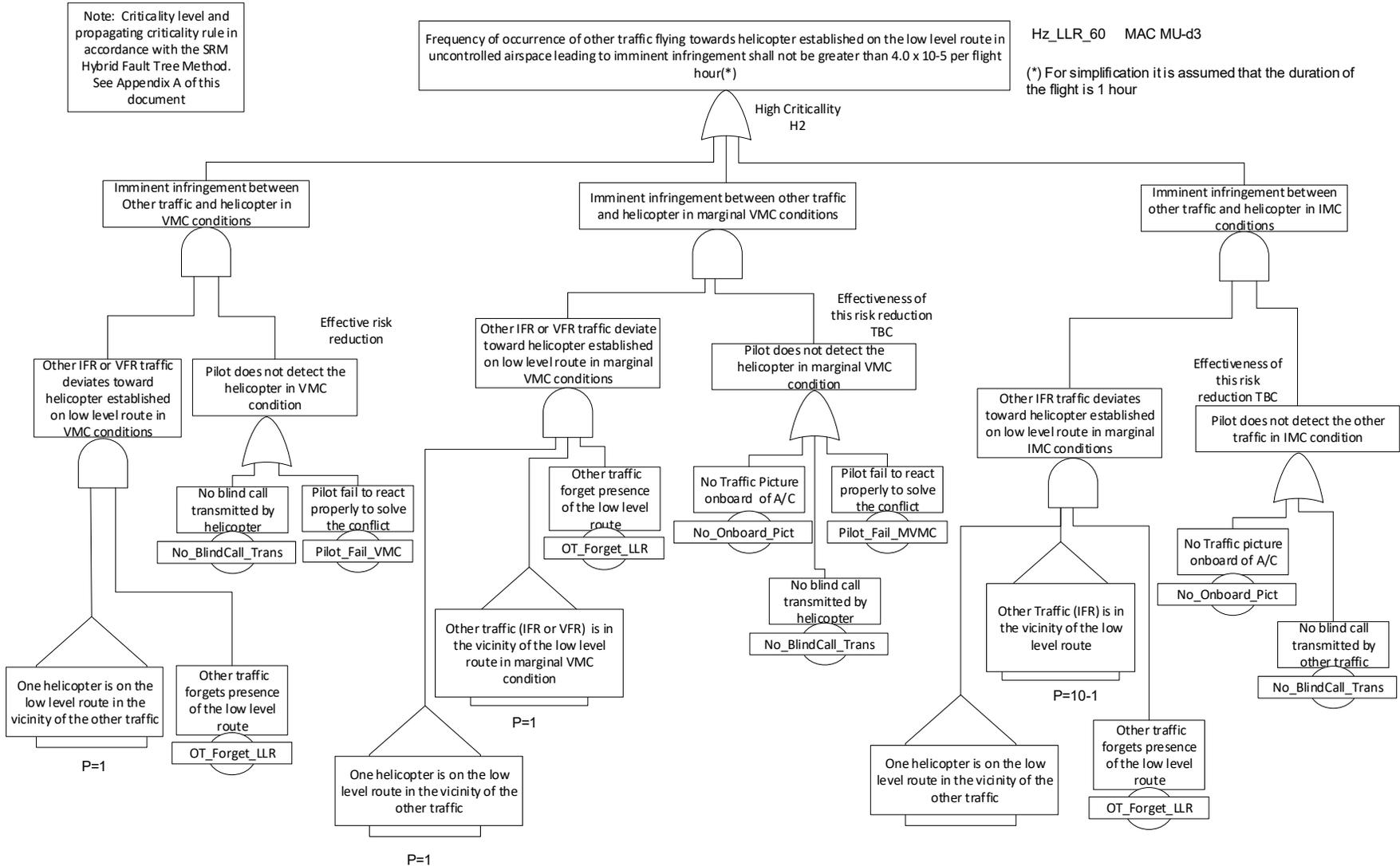


Figure C-11: Hz_LL_R_60 Fault Tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-11 below describes the basic causes of the Hz_LL_R_60 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Imminent infringement between other traffic and helicopter in VMC conditions			
One helicopter is on the Low Level Route in the vicinity of other traffic	To be conservative it is assumed that there is at least one helicopter on the Low Level Route in the vicinity of other traffic (Probability = 1)		
Other traffic forgets presence of the Low Level Route	OT_forget_LL_R	The pilot of the other aircraft is not properly informed about the helicopter Low Level Route	SR_LL_R_UCTRL#32. The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.
The pilot fails to react properly to solve the conflict	Pilot_Fail_VMC	The pilot of the other traffic shall maintain vigilance so as to see and avoid other aircraft. Pilots should also keep in mind their responsibility for continuously maintaining a vigilant lookout considering that most midair collision accidents and reported near-MAC incidents occur during good VFR weather conditions and during daylight hours .	SR_LL_R_UCTRL#3. VFR or IFR pilots flying in the vicinity of the Low Level Route shall actively search for conflicting traffic when weather conditions permit (see and avoid) based on traffic information provided by other aircraft and by flight information services when available
No blind call is transmitted by helicopter	No_BlindCall_trans	Helicopter pilots established on the Low Level Route do not transmit regularly their position and flight intent	SR_LL_R_UCTRL#18. VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational

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			awareness of helicopters pilots established on the Low Level Route
Imminent infringement between other traffic and helicopter in marginal VMC conditions			
One helicopter is on the Low Level Route in the vicinity of other traffic	To be conservative it is assumed that there is at least one helicopter on the Low Level Route in the vicinity of the other traffic (Probability = 1)		
Other traffic (IFR or VFR) is in the vicinity of the Low Level Route	It is assumed in such marginal VMC conditions that the probability of having other traffic (VFR and IFR) in the vicinity of the helicopter is medium (Probability = 1 to 10-1)		
Other traffic forgets presence of the Low Level Route	OT_forget_LL	The pilot of the other aircraft is not properly informed about the helicopter Low Level Route	SR_LL_UCTRL#32. The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.
No onboard traffic picture	No_Onboard_Pict	The helicopter operating on a Low Level Route in airspace class G is not equipped with a system detecting electronically the other aircraft in the vicinity or the other traffic is not equipped with a transponder or equivalent	<p>REC_LL_UNCTRL#1. All aircraft operating in the vicinity of the Low Level Route in airspace class G should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC) devices authorized by the Competent Authority</p> <p>REC_LL_UNCTRL#2. Helicopters operating on Low Level Routes in airspace class G should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity</p>

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Generic Safety Case

The pilot fails to react properly to solve the conflict	Pilot_Fail_MVMC	See and Avoid in marginal weather conditions is ineffective for the pilot in most of the cases	REC_LLRL_UNCTRL#1. and REC_LLRL_UNCTRL#2. could become Safety requirements
No blind call is transmitted by helicopter	No_BlindCall_trans	Helicopter pilots established on the Low Level Route do not transmit regularly their position and flight intent	SR_LLRL_UNCTRL#18. VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational awareness of helicopters pilots established on the Low Level Route
Imminent infringement between other traffic and helicopter in IMC conditions			
One helicopter is on the Low Level Route	To be conservative it is assumed that there is at least one helicopter on the Low Level Route (Probability = 1)		
Other aircraft is in the vicinity of the Low Level Route	It is assumed in IMC conditions, at low level and in class G that the probability of having IFR aircraft in the vicinity of the helicopter is low (10-1)		
Other traffic forgets presence of the Low Level Route	OT_forget_LLRL	The pilot of the other aircraft is not properly informed about the helicopter Low Level Route	SR_LLRL_UNCTRL#32. The helicopter Low Level Route shall be clearly depicted on IFR and VFR charts to inform pilots of low level traffic on these routes. In order to avoid misusing the Low Level Route by VFR traffic, the VFR chart should not give the information for navigation allowing manual coding.
No onboard traffic picture	No_Onboard_Pict	The helicopter operating on a Low Level Route in airspace class G is not equipped with a system detecting electronically the other	REC_LLRL_UNCTRL#1. All aircraft operating in the vicinity of the Low Level Route in airspace class G should be equipped with secondary surveillance radar transponders or interoperable Electronic Conspicuity (EC)

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		aircraft in the vicinity or the other traffic is not equipped with a transponder or equivalent	<p>devices authorized by the Competent Authority</p> <p>REC_LLRL_UNCTRL#2. Helicopters operating on Low Level Routes in airspace class G should be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic in the vicinity</p>
The pilot fails to react properly to solve the conflict	Pilot_fail_IMC	Pilots shall maintain vigilance so as to see and avoid other aircraft but in such weather conditions (IMC) and without a system enhancing the see and avoid (e.g. TAS or equivalent system) the visual avoidance is very inefficient	See REC_LLRL_UNCTRL#1. and REC_LLRL_UNCTRL#2.
No blind call is transmitted by helicopter	No_BlindCall_trans	Helicopter pilots established on the Low Level Route do not transmit regularly their position and flight intent	SR_LLRL_UNCTRL#18. VFR or IFR pilots flying in the vicinity of the Low Level Route shall transmit regularly their position and flight intent on a prescribed frequency or by any other means approved by the competent authority to improve the situational awareness of helicopters pilots established on the Low Level Route

Table C-11: Derivation of Mitigation/Safety Requirements for Hazard Hz_LLRL_60

C.2.4 Hazard Hz_LL_R_65 Helicopter encounters hazardous weather conditions on Low Level Route in uncontrolled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations where hazardous weather conditions are encountered.

This hazard could lead to a flight towards terrain commanded with a distance to the accident defined at CU-d3 (see **Table A-6**) or to a precursor of inflight loss of control due to environmental factors (adverse weather).

Basic causes for such failures have been captured in the Hz_LL_R_65 Fault Tree (See Figure C-12). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

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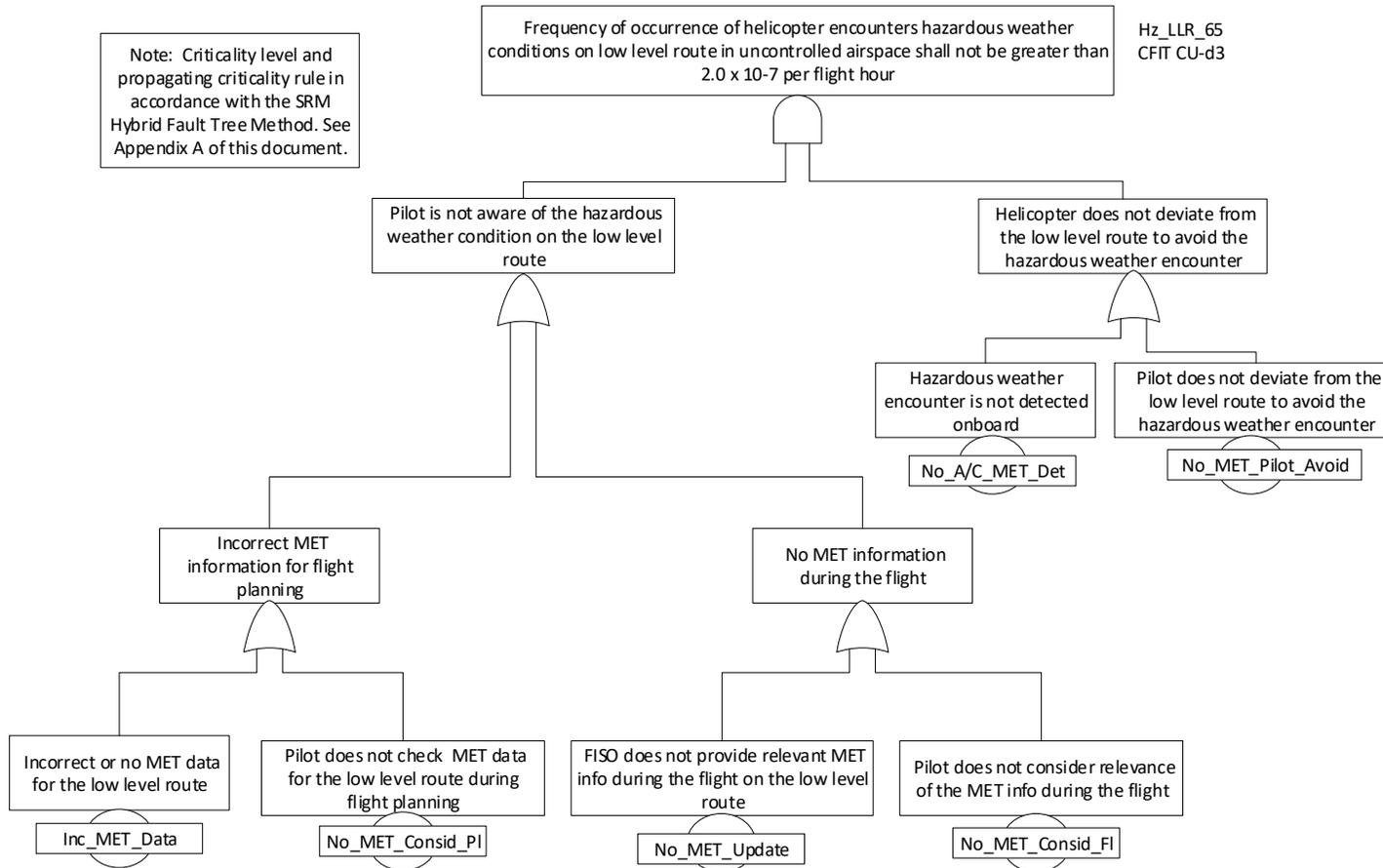


Figure C-12: Hz_LLR_65 Fault Tree

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Generic Safety Case

Table C-12 below describes the basic causes of the Hz LLR 065 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Incorrect or no MET data for the Low Level Route	Inc_MET_Data	There is no MET data forecasted for the Low Level Route or MET information are not correct/complete	See SR_LL_R_UCTRL#13 and SR_LL_R_UCTRL#14
The pilot does not check MET data for the Low Level Route during flight planning	No_MET_Consid_PI	The pilot does not consider the forecasted MET information on the Low Level Route during the flight planning	No requirement because basic airmanship
The FISO does not provide any relevant MET info during the flight on the Low Level Route	No_MET_Update	The FISO does not provide any relevant MET information to helicopter operating on the Low Level Route	See SR_LL_R_UCTRL#13 and SR_LL_R_UCTRL#23
The pilot does not consider the relevance of the MET info during the flight	No_MET_Consid_Fl	The pilot does not consider relevant the MET information provided by FISO during the flight	See SR_LL_R_UCTRL#14
There is no onboard detection of the hazardous weather encounter	No_A/C_MET_Inst	Systems detecting dangerous weather conditions are not installed or not efficient	REC_LL_R_UNCTRL#3. Helicopters operating on Low Level Routes should be equipped with airborne weather radar or on-board Electronic Flight Bag (EFB) Ground Radar information.
The pilot does not deviate from the Low Level Route to avoid the hazardous weather encounter	No_MET_Pilot_Avoid	The pilot does not deviate from the Low Level Route laterally vertically by e.g. conducting a flight turn back or when feasible a landing	No requirement because basic airmanship

Table C-12: Derivation of Mitigation/Safety Requirements for Hazard Hz_LL_R_65

C.2.5 Hazard Hz_LL_R_70 Failure to manage properly the traffic on the Low Level Route in uncontrolled airspace

Section 5.4.1 describes in more details this Hazard which occurs during helicopter Low Level Route operations where at least two helicopters are established on the Low Level Route.

This hazard could lead to an imminent collision in airspace class G with a distance to the accident defined at MU-d2 (see **Table A-4**).

Basic causes for such failures have been captured in the Hz_LL_R_70 Fault Tree (see Figure C-13). The basic causes are related to air, ground or spatial elements failures and could be human or equipment related.

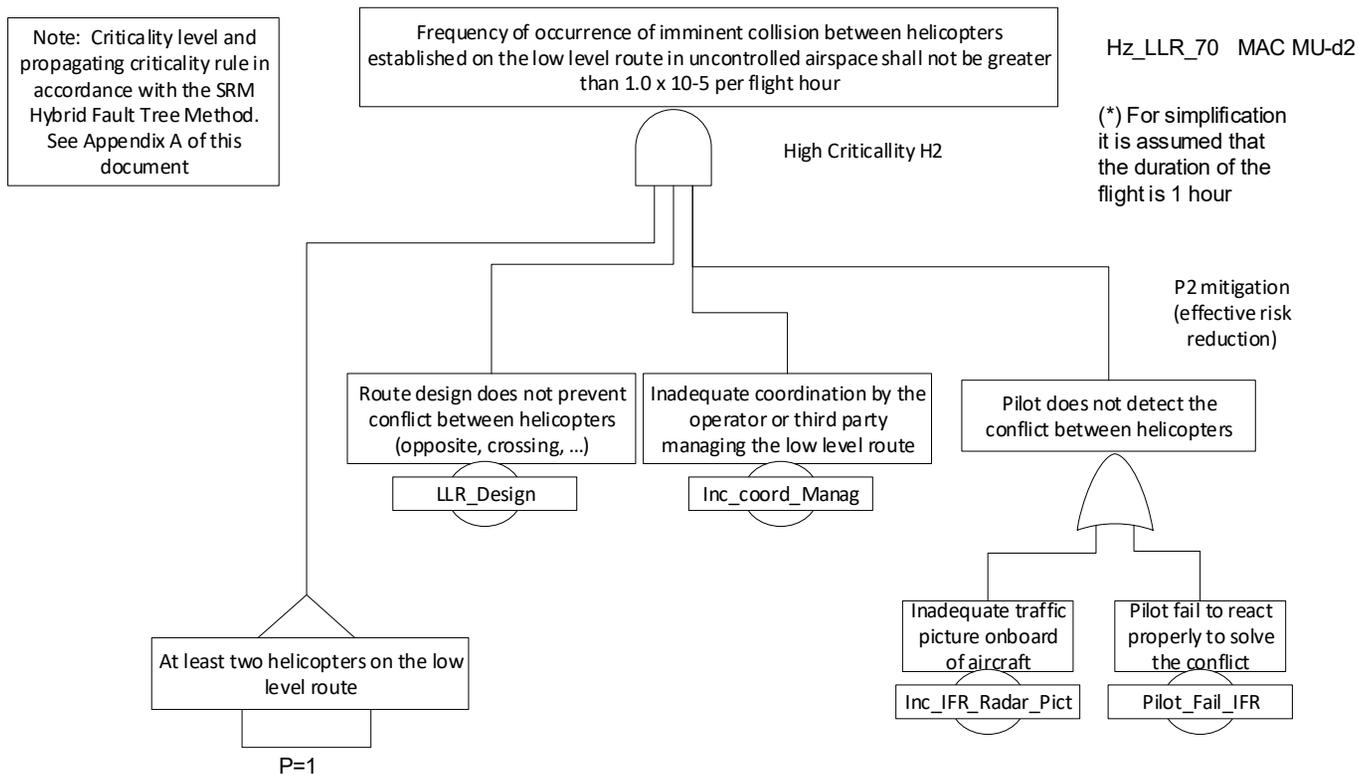


Figure C-13: Hz_LL_R_70 Fault Tree

Helicopter Low Level Route operations in controlled and uncontrolled airspace
Generic Safety Case

Table C-13 below describes the basic causes of the Hz LLR 70 Fault Tree and identifies the mitigations/safety requirements necessary to satisfy the associated Safety Requirement at Service level.

Type of failure	Cause Id	Cause description	Mitigation/Safety Requirement
Two helicopters on the Low Level Route	To be conservative it is assumed that there is at least two helicopters on the Low Level Route (Probability = 1)		
Low level route design does not prevent conflict between helicopters (opposite, crossing,...)	LLR_Design	The route design permits to have bi-directional route or crossing route at the same level	<p>SR_LLRL_UCTRL#33. The design of the Low Level Route shall minimize the risk of collision between helicopters by separating strategically when possible the different traffic flows operating on the Low Level Route network (e.g. vertical separation).</p> <p>See Issue_S_LLRL_UCTRL#5</p>
			<p>SR_LLRL_UCTRL#34. The design of the Low Level Route shall, when possible, prevent crossing routes if traffic on these routes is not managed by an ATSP, operator or a third party</p>
Inadequate coordination established between Aircraft Operator/s	Inc_Coord_Manag	The Aircraft Operators or a third party managing the Low Level Route network do not establish the appropriate coordination and two or more helicopters use the same route at the same time	<p>SR_LLRL_UCTRL#1. The Air Traffic Service Provider or Helicopter Operator or third party shall manage and monitor the planned traffic on the Low Level Route based on flight plan information to prevent simultaneous use of the route which might lead to conflicting situations.</p>

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No onboard traffic picture	No_Onboard_Pict	The helicopter operating on a Low Level Route in airspace class G is not equipped with a system detecting electronically the other helicopter established also on the Low Level Route	SR_LLRL_UCTRL#35. Helicopters operating Low Level Route in airspace class G shall be equipped with a system enhancing the see and avoid by providing situational awareness of the traffic on this route unless it is shown that mitigating the risk of conflict with VFR and IFR is not required considering the airspace structure, the traffic density and the traffic complexity.
Pilot fails to react properly to solve the conflict	Pilot_fail_IFR	Pilots shall maintain vigilance so as to see and avoid other aircraft but in certain weather conditions (IMC) and without a system enhancing the see and avoid (e.gf. TAS or equivalent system) the visual avoidance is very inefficient	See SR_LLRL_UCTRL#35

Table C-13: Derivation of Mitigation/Safety Requirements for Hazard Hz_LLRL_70

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