GBAS CAT II-III Functional Descriptions Update Report-update for V3

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EUROCONTROL, AIRBUS, ENAV, SEAC, THALES	

Abstract

This OSED describes the optimised operations in low visibility conditions by using GBAS. The concept applies to approach and landing with GBAS. The OSED describes flight crew and ATC procedures to be used with the introduction of GBAS. The use of landing clearance line concept by ATC will allow benefiting from the expected capacity increase when using GBAS in LVP. GBAS is expected to co-habit with ILS in the first implementation phase thus ATC procedures for mixed landing environments are also described.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] EUROCONTROL	[redacted]	02/02/2015

Reviewed By - *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] Airbus	[redacted]	02/04/2015
[redacted] ENAV		02/04/2015
[redacted] SEAC		02/04/2015
[redacted] EUROCONTROL		03/04/2015
[redacted] EUROCONTROL		07/04/2015
[redacted] EUROCONTROL		10/04/2015
[redacted] THALES		15/04/2015
[redacted] SEAC		15/04/2015

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	Position & Title	Date
[redacted] INECO	[redacted]	15/04/2015
[redacted] / INECO		15/04/2015
[redacted] ENAIRE		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] THALES		15/04/2015
[redacted] AIRBUS		15/04/2015
[redacted] INDRA		15/04/2015
[redacted] THALES		15/04/2015
[redacted] THALES		15/04/2015
[redacted] ENAIRE		15/04/2015
[redacted] NATS		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] Thales		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] EUROCONTROL		15/04/2015
[redacted] SICTA - ENAV		15/04/2015
[redacted] - ENAV		15/04/2015
[redacted]		15/04/2015
[redacted]		15/04/2015
[redacted] Tuifly		15/04/2015

[redacted] Novair	[redacted]	15/04/2015
[redacted] Air France		15/04/2015

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] AIRBUS	[redacted]	17/04/2015
[redacted] EUROCONTROL		17/04/2015
[redacted] ENAV		17/04/2015
[redacted] THALES		17/04/2015
[redacted] SEAC		17/04/2015
[redacted] ENAIRE		17/04/2015

Rejected By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date

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This deliverable consists of SJU foreground.

Table of Contents

List of tables

List of figures

Executive summary

This OSED details the operational concept for [AO-0505-A] Improved Low Visibility Runway Operations using GBAS CAT II/III for precision approaches based on GPS L1. [AO-0505-A] addressed in Operational Focus Area (OFA) 01.01.01 "LVP using GBAS" written by Ops 06.02 Airport Detailed Operational Description (DOD) for the Concept Storyboard Step 1.

Today busy European airports operate near their maximum capacity in good weather conditions but the landing rate is decreased during low visibility conditions experienced in bad weather. When visibility drops below the required minimum in order to ensure safe operations the air traffic control establishes low visibility procedures (LVP) which regulate the ground movements and protect the Instrument Landing System (ILS) signal used by approach and landing aircraft.

The ILS system is installed in the runway area and is subject to multi-path effects which place restrictions on building development and also on aircraft movements in the airport. In low visibility conditions the flight crew is required to use on-board automation (i.e. autoland) for approach and landing that are highly dependable on the ILS signal. These aircraft operations are called Category II and III (CAT II/ III). Due to the technical nature of the ILS signal the ILS protection areas become larger in low visibility and aircraft entering the runway areas are required to hold on the CAT III holding points as opposed to CAT I holding points, which are closer to the runway and used in good visibility. This results in restricted ground movements and greater final approach spacing margins between aircraft in order to accommodate the subsequently longer runway occupancy times (ROT).

This OSED develops the optimised low visibility operations using GBAS operational concept aiming to describe how to increase runway throughput in LVP or how to be resilient to adverse weather conditions. In the meantime is important to maintain safety and not increase pilot and ATC workload. The operational concept described is based on the determination of a landing clearance line instead of holding points for aircraft/vehicle vacating runway and also in the provision of a late landing clearance to pilots when the arrival aircraft is using GBAS for the approach. These elements shall enable to decrease final approach spacing in LVP by the use of GBAS.thus increasing runway throughput.

The OSED also investigates the the ATC procedures for managing and possibly optimising mixed ILS/GBAS equipage operations. In both mixed mode runway operation and segregated runway operations.

Other operational elements such as phraseology, ATC interface HMI, flight plan and failure scenarios are also described.

This concept of operation is destined to busy airports with an important capacity demand in LVP which have an A-SMGCS level 1 system. The expected benefit is to decrease the final approach spacing in front of a GBAS arrival aircraft of at least 1 NM (in comparison to ILS) thus increasing runway throughput. Additional spacing margin reduction might be possible provided local airport ILS CSA and their effect in airport movement restrictions. With gaining confidence in the new operational method the final approach spacing can be further decreased.

The OSED also describes the case when no optimisation is aimed destined to airports with no capacity constrained. In this case operational procedures related to managing GBAS or a mixed ILS/GBAS landing environment can be used.

The scope of the OSED is limited to the use of GBAS for straight-in ILS look alike approach procedures. But GBAS is a technology enabling also advanced procedures such as curved approaches. Within the 6.8.5 project, the GBAS advanced procedure are defined in a dedicated OSED and have been operationally assessed and separate validation activities. In the upcoming SESAR 2020 research additional advanced arrival operations enabled by GBAS such as increased and adaptive glide slopes as well as adaptive runway aiming points will be developed and assessed.

1 Introduction

1.1 Purpose of the document

The Operational Service and Environment Definition (OSED) describe the operational concept defined in the Detailed Operational Description (DOD) in the scope of its Operational Focus Area (OFA).

It defines the operational services, their environment, use cases and requirements.

The OSED is used as the basis for assessing and establishing operational, safety, performance and interoperability requirements for the related systems further detailed in the Safety and Performance Requirements (SPR) document. The OSED identifies the operational services supported by several entities within the ATM community and includes the operational expectations of the related systems.

This OSED is a top-down refinement of the **WP06.02** DOD produced by the federating OPS 06.02 project. It also contains additional information which should be consolidated back into the higher level SESAR concepts using a "bottom up" approach.

The figure below presents the location of the OSED within the hierarchy of SESAR concept documents, together with the SESAR Work Package or Project responsible for their maintenance.

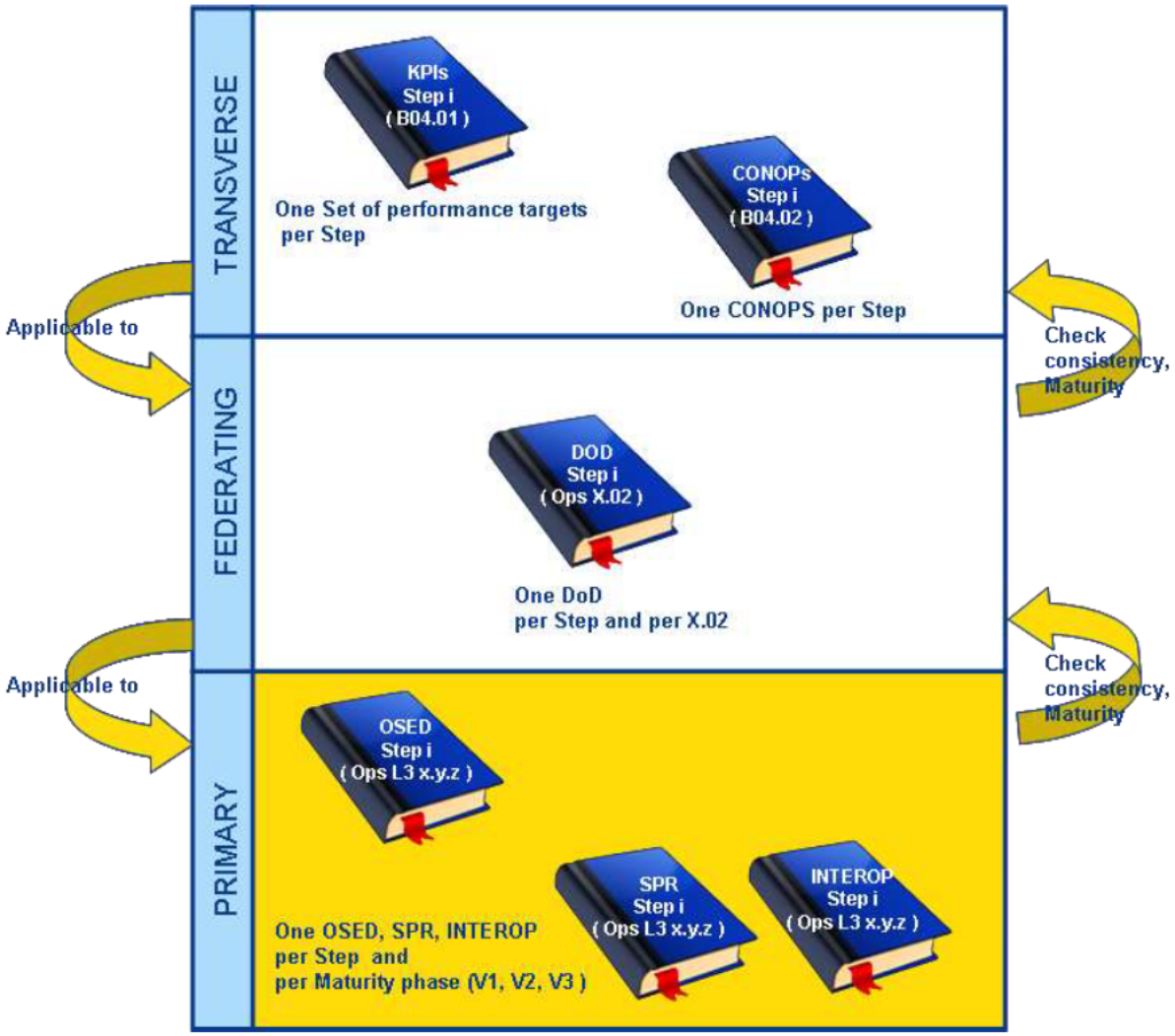


Figure 1: OSED document with regards to other SESAR deliverables

In Figure 1, the Steps are driven by the OI Steps addressed by the project in the Integrated Roadmap document.

This OSED is the final update of GBAS CAT II/III functional description [22] reaching V3 maturity. The update includes the assessments from the the V2 and V3 operational validation activities; the safety assessment and the airspace user consultations through collected during 2 workshops.

1.2 Scope

This OSED details the operational concept for [AO-0505-A] Improved Low Visibility Runway Operations using GBAS CAT II/III for precision approaches based on GPS L1. [AO-0505-A] addressed in Operational Focus Area (OFA) 01.01.01 "LVP using GBAS" written by Ops 06.02 Airport Detailed Operational Description (DOD) for the Concept Storyboard Step 1.

Other operational concepts in the OFA such as the use of GBAS for CAT I operations or GBAS advanced operations are out of the scope of this document.

Operational Package (PAC)	Operational Sub Package (SPC)	Operational Focus Area (OFA)	Projects
PAC01 Increased Runway and Airport Throughput	SPC01.01 Weather Resilience	OFA01.01.01 LVPs using GBAS	6.8.5 GBAS Operational Implementation
			9.12 GBAS CAT II/III (airborne)
			15.3.6 GAST-D (ground)
			15.3.7 Multi-GNSS GBAS CAT II/IIII

Table 1-1 OFA 01.01.01 Scope and sitting

The OSED refines the Arrival scenario described by OPS 06.02 Airport DOD. It is assumed that the DOD Arrival scenario provide an intermediate level of detail, while this OSED describes the actions/systems interactions at a detailed level for low visibility operations using GBAS. For the purpose of this OSED, the 'LVP using GBAS' refer to GBAS CAT II and GBAS CAT III approach operations as well as low visibility take off operations.

The OSED refines the following process from Ops. 06.02 Airport DOD

- Prepare and Execute Landing

Currently no operational service is described in the Ops.06.02 Airport DOD

This OSED captures expected performance in accordance with the performance framework (B.04.01).

The OSED develops use cases including non-nominal situations.

The OSED defines the Operational Requirements, based on the expected performance, scenarios and use cases.

1.3 Intended readership

This document is to support any ATC, Airspace Users, ANSPs, Airport Operations and Safety Regulators willing to develop optimised low visibility operations using GBAS.

The following Primary Projects could get benefit from this OSED:

- P06.08.08: Enhanced Arrival Procedures Enabled By GBAS
- P09.12: GBAS CAT II/III (airborne)
- P15.03.06: GBAS CAT II/III GAST-D (ground)
- P15.03.07: Multi-GNSS GBAS CAT II/IIII

More information about the different links between the projects at OFA level is provided in section 1.5

The OSED can also support the consolidation activities within SWP6.8 and in particular with P6.8.3 concepts which focus on reducing the separation and spacing constraints impacting final approach operations (removal of ILS critical and sensitive areas)

At a higher project level Ops P06.02, WPB and WP for Transversal Areas are expected to use this document as an input into their consolidation activities and the architecture and performance modelling. In particular Ops P06.02 is invited to consider the inclusion of final approach in DOD.

1.4 Structure of the document

Chapter 1 This section introduces the document.

Chapter 2 This section specifies the operational concept and where it sits with the relevant DOD with a series of mapping tables.

Chapter 3 This section details the current operating method and the new optimised operating method with the proposed changes of the SESAR solution.

Chapter 4 This section describes the environment for the described operational services and the different actors affected by the new concept of operation.

Chapter 5 This section includes different use cases for both nominal and failure conditions,

Chapter 6 This section defines the operational requirements.

Appendix A: Guided take-off using GBAS

Appendix B: Milan Malpensa – LVO Spacing

Appendix C: London Heathrow MLS procedures

1.5 Background

1.5.1 GBAS CAT II/III Standards review

The CAT II/III development for GBAS builds on the original CAT I GBAS developments. This is accomplished by introducing the concept of service types. Service Types are matched sets of airborne and ground performance and functional requirements. GBAS approach services are further differentiated into multiple types referred to as GBAS Approach Service Types (GAST).

A GAST is defined as the matched set of airborne and ground performance and functional requirements that are intended to be used in concert in order to provide approach guidance with quantifiable performance. Four types of approach service; GAST A, GAST B, GAST C and GAST D are currently proposed.

The GBAS GAST-D concept was developed by ICAO NSP (Navigation System Panel) to allow GBAS to support CAT II/III approach and landing operations using GPS L1. The only GBAS CAT II/III ICAO standard is the GAST-D Baseline Document Standard [5] and its companion document, the GBAS GAST-D Technical Concept Paper [6].

This standard is addressing the case of a GBAS System based on GPS L1 constellation only and intends to support CAT III operations, however it focuses mainly on the technical requirements and moreover on the ground station and constellation ones.

The GAST-D airborne requirements have to be addressed during the operational approval. This is due to the fact that CAT II/III operations are unique in that the aircraft and operational approval includes comprehensive total-system error evaluations. So where a common level of performance was sufficient in standardizing CAT I operations, for CAT II/III it may not be feasible given the complexity and range of aircraft implementations. Different aircraft designs have a different dependence upon and sensitivity to GBAS errors. This will be addressed in SESAR P9.12.

EUROCONTROL has developed several documents to support GBAS Cat I and initial GBAS CAT II/III ATM requirements based on ICAO standardisation work. These are summarized in the EUROCONTROL GBAS CON OPS [7,8].

A concept of "Optimised Low visibility Operations" is described in ICAO EUR Doc.13 [9] and is based on the EUROCONTROL Landing Clearance Line study [10] and EUROCONTROL Safety Assessment on Optimised Operations (Draft) [11].

Last but not least, the project will benefit from the input coming from previous activities carried by EUROCONTROL and other Stakeholders (e.g. national initiatives). These activities were actively coordinated through the LATO task force at European level as well as through the EUROCONTROL/FAA International GBAS Working Group at a global level. This collaboration is continuing in the SESAR framework as well.

No regulatory material has been defined yet for GBAS CAT II/III operations. Existing ICAO Annexes and other regulation applicable to ILS CAT II/III operations such as EU OPS are assumed to apply.

Previous deliverables in P6.8.5 addressing CAT II/III operations are used as inputs.

Past research, but also on-going SESAR activities addressing GBAS, are basing their developments on the ICAO GAST-D Baseline document.

1.5.2 Relations of GBAS projects within the OFA

The GBAS activities within SESAR can be found in two thematic threads:

- The operational thread where GBAS is part of the Airport operations activities (WP6);
- The system thread where the ground and system level activities are found in the CNS area (WP15), and the aircraft level activities in Aircraft Aspects (WP9).

These activities, regarding mono-constellation GBAS, are covered by the following three main projects which have strong interactions (see Figure 2 : Relation between the three GBAS (using GPS L1) projects below):

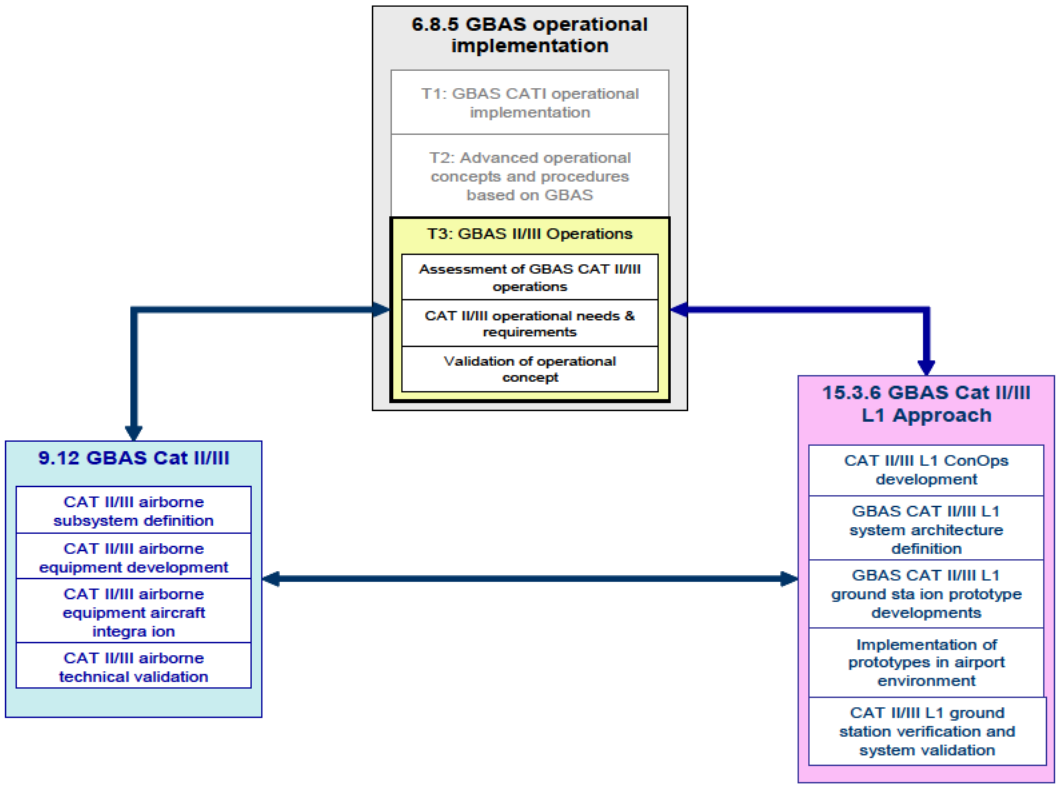


Figure 2 : Relation between the three GBAS (using GPS L1) projects

- P 6.8.5 “GBAS Operational Implementation” identifies operational needs and requirements for GBAS-based CAT II/III operations, receive inputs from technical projects and validates the concept of operation.
- P 9.12 “GBAS CAT II/III Airborne aspects” assesses the airborne technical feasibility of the GBAS Cat II/III concept, for both mainline aircraft and business aircraft, identifying high level airborne requirements and providing the first level of technical validation (performance, functional, safety). It also develops airborne prototypes and simulation models for both aircraft categories (mainline and business) and starts integration for the validation of the concept.
- P 15.3.6 “GBAS L1 CAT II/III Approach” addresses ground aspects & systems aspects through coordination with WP9.12.

Coordination between P6.8.5, P9.12 and P15.3.6 was initially established during the PIR phase and continued during the T020 development thanks to the contributions of both the 9.12 PM and the 6.8.5 T11 leader. And now it is formally put in practice with the OFA mechanism establishment and continues its way.

1.5.3 ‘LVP using GBAS’ validation at OFA level

P6.8.5 will focus on the operational requirements of GBAS using GPS L1 (GAST-D) for CAT II/III operations, whereas P9.12 and P15.3.6 will be mainly in charge of the technical verification of the GAST-D standard for the airborne and ground equipment. P15.3.7 will address the multi-constellation GBAS (this includes the assessment of the eventual operational changes related to multi-GNSS GBAS).

The use of GBAS for CAT III is similar to current precision approach operations using ILS. However the optimised LVP operations using GBAS described in this OSED bring some new operational changes notably through the proposed use of the landing clearance line and the mixed ILS/GBAS landings which need to be addressed. Based on the above and also the ICAO and EUROCONTROL inputs described in Section 1.5.1, the initial maturity of the operational concept was considered as V2 as defined by the E-OCVM methodology.

The final maturity of the optimised LVP using GBAS as described in this OSED has reached V3 maturity as the assessments of V2 and V3 validation activities, the safety considerations and the airspace user inputs are included in this OSED.

CAT II/III operations are unique in that the aircraft and operational approval includes comprehensive total-system error evaluations. As such the ICAO GAST-D standard has some operational requirements and preliminary EUROCONTROL studies identified some operational requirements.
This need to be handled by the technical projects (P15.3.6 and P9.12) and will feed P6.8.5 accordingly.

Therefore, although the validation exercises identified as contributors to the OFA all come from P6.8.5, the few system validation activities from the technical projects will complement these exercises and will contribute to the high-level requirements identified at the DOD level. In particular, the only requirement found in the 06.02 DOD related to GBAS (REQ-06.02-DOD-6200.0025) addresses the flight crew, whereas the operational needs in P6.8.5 for CAT III might impact other ATM actors such as Airports and ATC.

The interaction of projects regarding validation is described in the picture below:

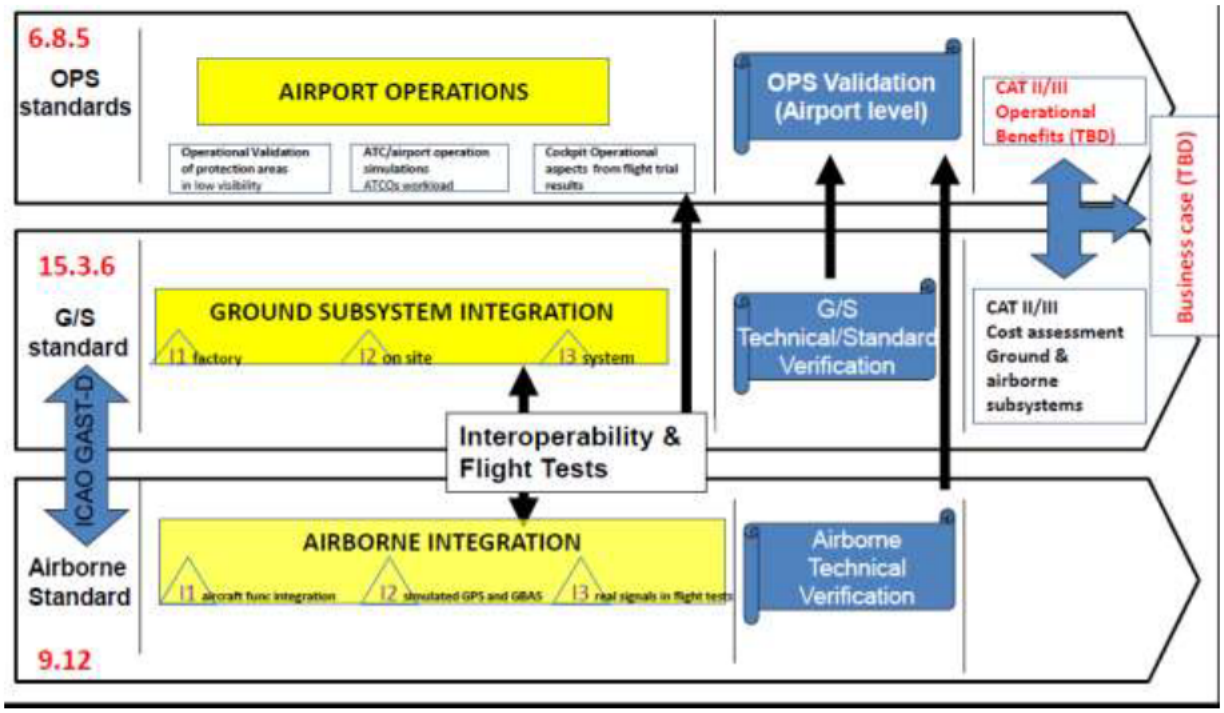


Figure 3 : Contribution of the three GBAS (using GPS L1) projects to the GBAS concept validation

1.5.3.1 Inputs from WP 15.3.6

Appendix A The project 15.3.6 developed the GBAS CATII/III L1 (GAST-D) CONOPS. This study was based in ICAO standards [5], [6] and EUROCONTROL GBAS CONOPS [7,8] which include some operational requirements. The GAST-D CONOPS is limited to the evaluation of differences between ILS and GAST-D for a single approach operation and was reviewed by WP6.8.5.

Appendix B This OSED completes the operational evaluation by taking a top down approach from Airport 6.2 DOD. This means the OSED will address the operational benefit of using GBAS in airport through the development of the optimised operations in LVP using the GBAS concept. In addition the OSED will develop the operational evaluation of mixed ILS/GBAS equipage management and guided take-off operations with GBAS currently not addressed in P15.3.6 GBAS GAST-D CONOPS.

1.5.3.2 Inputs from WP 9.12

The project 9.12 has performed a Cat III Operational evaluations results in simulator with pilots using GAST D. The disappearance of G/S deviations below 100 ft and reversion/toggling of Cat III vs Cat I capacity (GAST D vs GAST C) and associated alert messages was tested and evaluated. These results are feeding this OSED.

1.6 Glossary of terms

Category I (CAT I) Operation. A precision instrument approach and landing with:

a) a decision height not lower than 60 m (200 ft); and
b) with either a visibility not less than 800 m or a runway visual range not less than 550 m.

Category II (CAT II) Operation. A precision instrument approach and landing with:

a) a decision height lower than 60m (200 ft), but not lower than 30 m (100ft); and
b) a runway visual range not less than 300 m

Category IIIA (CAT IIIA) Operation. A precision instrument approach and landing with:

a) a decision height lower than 30 m (100 ft), or no decision height; and

b) a runway visual range not less than 175 m

Category IIIB (CAT IIIB) Operation. A precision instrument approach and landing with:
a) a decision height lower than 15 m (50 ft), or no decision height; and
b) a runway visual range less than 175 m but not less than 50 m

Category IIIC (CAT IIIC) Operation. A precision instrument approach and landing with no decision height and no runway visual range limitations.

Note: The above classification does not yet comprise the changed operational designations currently being implemented within ICAO. These notably have no impact for CAT II/III operations and their designation.

Guided Take-Off A take-off in which the take-off run is not solely controlled with the aid of the external visual references, but also with the aid of instrument references (e.g ILS localizer guidance)

ILS Critical Area (Annex 10) An area of defined dimensions around the localizer and glide path antennas where vehicles, including aircraft, are excluded during all ILS operations. The critical area is protected because the presence of vehicles and/or aircraft inside its boundaries will cause unacceptable disturbance to the ILS signal-in-space.

ILS Sensitive Area (Annex 10) An area extending beyond the critical area where parking and/or movement of vehicles, including aircraft, is controlled to prevent the possibility of unacceptable interference to the ILS signal during ILS operations. The sensitive area is protected to provide protection against interference caused by large moving objects outside the critical area but still normally within the airfield boundary.

Low Visibility Operation: An operation involving:
(a) an approach with minima less than Category I (CAT II/III, LTS CAT I or OTS CAT II) ;or
(b) a take-off runway visual range (RVR) less than 550 m

Low Visibility Procedures (ICAO EUR Doc.13): Specific procedures applied at an aerodrome for the purpose of ensuring safe operations during Lower than Standard Category I, Other than Standard Category II, Category II and III approaches and/or departure operations in RVR conditions less than a value 550 m.

Lower than Standard Cat I Operations - LTS CAT I (EC N.859/2008 OPS 1.435) A Category I Instrument Approach and Landing Operations using CAT I DH, with an RVR lower than would normally be associated with the applicable DH.

Other than Standard Cat II Operation – OTS CAT II (EC N.859/2008 OPS 1.435) A Category II Instrument Approach and Landing Operations to a runway where some or all of the elements of the ICAO Annex 14 Precision Approach Category II lighting system are not available.

Obstacle Free Zone (OFZ) (Annex 14) The airspace above the inner approach surface, inner transitional surfaces, and balked landing surface and that portion of the strip bounded by these surfaces, which is not penetrated by any fixed obstacle other than a low-mass and frangibly mounted one required for navigation purposes.

Runway Visual Range (RVR) (Annex 3) The range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying its centreline.

Runway holding position (Annex 14) A designated position intended to protect a runway, an obstacle limitation surface, or an ILS/MLS critical/sensitive area at which taxiing aircraft and vehicles should stop and hold, unless otherwise authorised by an aerodrome control tower.

1.7 Acronyms and Terminology

Term	Definition
A/C	Aircraft
ADD	Architecture Definition Document
AGL	Above Ground Level
AP	Automatic Pilot
APP	Approach
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
A/THR	Automatic Thrust
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
CAT	Category
CONF	Configuration
CONOPS	Concept of Operations
CRZ	Cruise
CSA	Critical and Sensitive Area
DA	Decision Altitude
DES	Descent
DH	Decision Height
DOD	Detailed Operational Description
EASA	European Aviation Safety Agency
E-ATMS	European Air Traffic Management System
ECAM	Electronic Centralized Aircraft Monitoring
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FD	Flight Director
FLX	Flexible

Term	Definition
FMA	Flight Mode Annunciator
FMS	Flight Management System
FPLN	Flight Plan
GAST	GBAS Approach Service Type
GBAS	Ground Based Augmentation System
GLS	GBAS Landing System
GPS	Global Positioning Service
G/S	Glide Slope
HMI	Human Machine Interface
HUD	Head Up Display
IAS	Indicated Airspeed
IDENT	Identifier
ILS	Instrument Landing System
IRS	Interface Requirements Specification
INTEROP	Interoperability Requirements
LOC	Localizer
LS	Landing System
LTS	Lower than Standard
LVC	Low Visibility Conditions
LVP	Low Visibility Procedures
NAV	Navigation
NCD	No Computed Data
ND	Navigation Display
NLA	New Large Aircraft
NM	Nautical Miles
NO	Normal Operations
NOTAM	Notice To Airman

Term	Definition
OCD	Operational Concept Description
OFA	Operational Focus Areas
OSED	Operational Service and Environment Definition
OTS	Other than Standard
P/B	Push Button
PFD	Primary Flight Display
PNF	Pilot Non Flying
PVI	Para Visual Indicator
QFU	Runway Heading
RVR	Runway Visual Range
RWY	Runway
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Safety and Performance Requirements
STAR	Standard Terminal Arrival Route
TAD	Technical Architecture Description
TOGA	Take-off/Go-Around
TRANS	Transition
TS	Technical Specification
VAPP	Approach Speed
VIA	Via
V/S	Vertical Speed

2 Summary of Operational Concept from DOD

This section contains the link with the relevant DOD scenarios and use cases, environment, processes and services relevant to this OSED.
The following tables are coherent with the related DOD Ops 06.02: Airport Detailed Operational Description.

2.1 Mapping tables

Table 1 lists the Operational Improvement steps (OIs from the definition phase), within the associated Operational Focus Area addressed by the OSED.

Relevant OI Steps ref. (coming from the Integrated Roadmap)	Operational Focus Area name / identifier	Story Board Step	Master or Contributing (M or C)	Contribution to the OIs short description
AO-0505-A	Improve Low Visibility Operation using GBAS CATII/III based on GPS L1	1	M	Use GBAS CAT II/III based on GPS L1 for precision approaches

Table 2-1: List of relevant OIs within the OFA

Table 2 describes the ATM phases of flight as described in the 6.2 DOD

ATM PHASES										
Planning Phases		Execution Phase								Post-Operations Analysis Phase
Long Term Planning	Medium/ Short Term Planning	Pre-Departure	Taxi-Out Take-Off	Climb	Cruise	Descent	Approach	Final Approach	Landing and Taxi-In	
		Flight Phases								

Table 2-2 SESAR CONOPS ATM Phases and Flight Phases

Table 3 identifies the link with the applicable scenarios and use cases in the 6.2 DOD

Operational Scenario	Use Case Identification	Reference to DOD section where it is described	OFA 01.01.01
Medium/Short-Term Planning	UC 6 12 UC 6 14	Section 4.2.5.2.2 Section 4.2.4.2.3	LVPs using GBAS
Execution Phase	UC 6 14	Section 4.2.4.2.3	LVPs using GBAS
Arrival	UC 6 99	Section 4.2.5.2.1	LVPs using GBAS

Table 2-3 DOD 6.2 List of Use Cases and Operational Scenarios allocated to OFA 01.01.01

Table 4 identifies the applicable environments from the Airport DOD.

Operational Environment	Description of environment	Reference to DOD section where it is described	OFA 01.01.01
Layout & Basic Operational Criteria (Category 2)	- Multiple Independent Runways, complex surface layout - Multiple Dependent Runways, complex surface layout[1] - Single Runway, complex surface layout - Multiple Independent Runways, non-complex surface layout - Multiple Dependent Runways, non-complex surface layout - Single Runway, non-complex surface layout	Section 3.1.1.2	LVPs using GBAS
External Influences Airport Class (Category 4)	- Highly Constrained (Geographical / Weather issues) - Highly Constrained (Political / Community issues) - Moderately Constrained (both Geographical / Weather and Political / Community) - Lightly or Unconstrained	Section 3.1.1.4	LVPs using GBAS

Table 2-4 DOD6.2 List of airport categories allocated to OFA

Table 5 identifies the link with the applicable Operational Processes and Services defined in the Airport DOD

DOD Element Category / Title	Elements identification	Elements *short* description	Reference to DOD section where it is described	OFA 01.01.01
Process	Prepare and Execute Landing	Execute Approach	5.2.2	LVP using GBAS
	Prepare and Execute Take-Off			

Table 2-5 DOD 6.2 List of Processes allocated to OFA

The Primary project recommends that DOD 6.2 allocates the Prepare and Execute Take-Off process also to OFA 01.01.01 as regarding GBAS guided take-offs.

Table 6 identifies the Airport DOD operational requirements allocated to this OFA

DOD Requirement Identification	DOD requirement title	Reference to DOD section where it is described
REQ-06.02-DOD-6200.0025	The Flight Crew shall be able to perform precision approaches in Low Visibility Conditions using GBAS CAT II/III (based on GPS L1)	6.2

Table 2-6 DOD 6.2 Operational Requirement to OFA 01.01.01

The Ops 06.02 DOD defines the following performance requirements as applicable to all OFA's: Security, Environment, Flexibility, Access and Equity.
The new SESAR performance framework [25] defines Resilience as new performance requirements, which is defined as below:
Resilience is the ability to withstand and recover from planned and unplanned events and conditions which cause a loss of nominal capacity. Planned and unplanned events and conditions include among other low visibility conditions.
Simply stated the increase of runway throughput during LVP is resilience to maintain nominal (good weather) runway throughput.
Provided the new definition, resilience seem the most appropriate key performance indicator to be addressed by the OSED. Nevertheless this comes somehow late in the project, as most deliverables such as initial OSED, validation reports and safety assessment identifies increasing runway throughput in LVP as a main KPI. Therefore it is suggested that increase of runway throughput or capacity and resilience is are used interchangeably in the context of the 6.8.5 project deliverables.

2.2 Operational Concept Description

This OSED details the operational concept for [AO-0505-A] Improved Low Visibility Runway Operations using GBAS CAT II/III for precision approaches based on GPS L1. [AO-0505-A] addressed in Operational Focus Area (OFA) 01.01.01 "LVP using GBAS" written by Ops 06.02 Airport Detailed Operational Description (DOD) for the Concept Storyboard Step 1.

The OSED is based on the Arrival scenario described by OPS 06.02 Airport DOD. The Arrival scenario describes the processes and interactions that a flight encounters from the preparation of the landing phase (some 10-15 minutes before Top of Descent) until the aircraft arrives in-block at the parking stand.

It is assumed that the DOD Arrival scenario provide an intermediate level of detail, while this OSED describes the actions/systems interactions at a detailed level for low visibility operations using GBAS.

2.2.1 Airport capacity needs

Today busy European airports operate near their maximum capacity in good weather conditions but the landing rate is decreased during low visibility conditions experienced in bad weather. When visibility drops below the required minimum in order to ensure safe operations the air traffic control establishes low visibility procedures (LVP) which regulate the ground movements and protect the Instrument Landing System (ILS) signal used by approach and landing aircraft.

The ILS system is installed in the runway area and is subject to multi-path effects which place restrictions on building development and also on aircraft movements in the airport. In low visibility conditions the flight crew is required to use on-board automation (i.e. autoland) for approach and landing that are highly dependable on the ILS signal. These aircraft operations are called Category II and III (CAT II/ III). Due to the technical nature of the ILS signal the ILS protection areas become larger in low visibility and aircraft entering the runway areas are required to hold on the CAT III holding points as opposed to CAT I holding points, which are closer to the runway and used in good visibility. This results in restricted ground movements and greater final approach spacing margins between aircraft in order to accommodate the subsequently longer runway occupancy times (ROT).

The consequence is a significant decrease of runway throughput during low visibility conditions.

2.2.2 Optimised low visibility operations using GBAS

The Ground Based Augmentation System (GBAS) augments the satellite signal and will provide for approach and landing in low visibility conditions. The GBAS system has limited or no sensitive area and is usually located outside aircraft movement areas. This allows for reducing the aircraft runway occupancy times in LVP and thus reduced final approach spacing.

In Chapter 3 of the OSED are described more in detail the changes to ATC procedures that enable increasing runway throughput in the low visibility conditions by using GBAS. The concept is further referred to as **optimised low visibility operations using GBAS**. The low visibility operations as referred in this OSED include CAT III and CAT II approach operations, but often only CAT III is mentioned for simplicity reasons.

The introduction of new technology approach and landing aids such as GBAS will, in many cases, be on runways already equipped with ILS, so ATC procedures for managing and optimising **mixed ILS/GBAS low visibility operations** are also developed in the OSED.

The use of GBAS for guided take-off in low visibility is separately described in Appendix A.

The concept described in the OSED applies from where the aircraft intercepts the final approach course until when the aircraft has vacated the runway. The basis is the approach and landing phases of flight, as described by Arrival scenario in the Airport DOD (6.2). But TMA/APP control as related to approach clearance and Tower control as related to runway vacating are detailed in the later chapters.

The operational actors impacted by this concept are Airport, TMA/APP/TWR ATC and Flight Crew.

This impact is further addressed in the differences between ILS and GBAS in Chapter 3.

2.2.3 GBAS as an enabler

Some other GBAS benefits include:

- One GBAS ground station can serve multiple runways, and provide for multiple approaches per runway end (different glides slopes and several runway thresholds)
- Flight Inspection: GBAS is expected to have significantly reduced inspection costs compared to ILS system with fewer required inspections mostly made on the ground. Details are provided in ICAO Doc.8071. In addition, due to the redundancy incorporated into a GBAS ground station some maintenance can be carried out even while CAT III operations are being conducted.
- System resilience: GBAS offers flexibility near the airfield as the station can be located further away from the runway. Certain siting and signal protection area must still be met; the GBAS protection area being named Local Object Consideration Area (LOCA). However this is likely to be less onerous than ILS as the station can be located further away.
- False capture: ILS localizer false captures are situations where the aircraft prematurely initiates a turn onto the localizer centreline. This false capture cannot happen with GBAS
- GBAS on board HMI is ILS lookalike and transparent to flight crew.

3 Detailed Operating Method

The Ground Based Augmentation System (GBAS) augments the satellite signal and will provide for approach and landing in low visibility conditions. The GBAS system has limited or no sensitive area and is usually located outside aircraft movement areas. This allows for reducing the aircraft runway occupancy times in LVP and thus reduced final approach spacing.

This chapter describes in detail the changes to ATC procedures that enable increasing runway throughput in the low visibility conditions by using GBAS; called **optimised low visibility operations using GBAS**. The low visibility operations as referred in this OSED include CAT III and CAT II approach operations, but often only CAT III is mentioned for simplicity reasons.

The optimised low visibility approach operations using GBAS, is based on the following changes to current procedures in order to achieve the expected capacity benefits.

- ATC to use a **landing clearance line** for aircraft vacating the runway, instead of today's ILS CAT III holding
- ATC to provide the pilots with **late landing clearance**, up to 1NM before threshold
- ATC to **reduce the final approach spacing** in LVP in front of GBAS equipped aircraft

This leads to an immediate improvement in runway throughput in adverse weather conditions. The amount of runway throughput gained will depend also on surveillance and wake turbulence separation and spacing rules.

The introduction of new technology approach and landing aids such as GBAS will, in many cases, be on runways already equipped with ILS, so ATC procedures for managing and optimising **mixed ILS/GBAS low visibility operations** are also described as part of the new operating method.

The OSED assess the implementation of the proposed changes in ATC procedures for operations in both runway configurations:

- Arrival only runway configuration (segregated runway), usually used in multiple runway airports environments
- Arrival and departure runway configuration (mixed mode), usually in single runway airport or multiple runway airport environments

The affected actors are TMA/Final Approach Controller, Tower/Runway Controller and Aircraft Operators (Pilots). Their roles, functions and responsibilities as related to LVP using GBAS are further refined in the following chapters.

It is assumed that the aircraft operators are certified and approved to conduct low visibility operations with GBAS.

It is also assumed that the airport is certified to provide low visibility operations and is equipped with A-SMGCS.

ILS can also provide guided take-off operations in low visibility departures. In this case, ATC must protect ILS critical and sensitive areas as well. GBAS will offer this capability without the need to protect particular critical and sensitive areas.

This OSED describes the guided take-off using GBAS In Appendix A

.

3.1 Previous Operating Method (ILS)

This section describes how the procedures employed by controllers and pilots today to operate the ILS landing system and to perform CAT II and CAT III operations in in low visibility conditions.

The procedures are described as related to the main operators of the system; ATC/Aerodromes and Aircraft operators.

3.1.1 Low visibility operations using ILS

In most European airports, the ILS is used today for low visibility operations. The ILS system is installed in the runway area and is subject to multi-path effects which place restrictions on building development and on aircraft movements in the airport. During low visibility conditions the flight crew is required to use on-board automation (i.e. autoland) for approach and landing that is highly dependable on the ILS signal. These aircraft operations are called Category II and III operations. As such for the safety of operations it is **highly important to protect the ILS signal during aircraft CAT II and CAT III operations (low visibility operations**). These results in large protection areas for ILS in the airport surface which are also known as ILS critical and sensitive areas (ILS CSA). The ILS CSA should not be penetrated by vehicles or aircraft in the airports during low visibility operations to ensure accuracy and integrity of the ILS. The following is required:

- All vehicles and aircraft on ground must remain outside the ILS Critical Area when the aircraft on final approach has passed the outer marker [Annex 10, Vol. 1, Attachment C)] ;
- ILS Sensitive area must be cleared before the controller can issue landing clearance to the following aircraft when the approaching aircraft reaches a defined distance to threshold (typically 2 NM). Exceptionally the landing clearance can be delayed until 1NM providing that the position of the approaching aircraft can be monitored and the pilot has been warned to expect a late landing clearance [ICAO EUR Doc.13].
- When departing aircraft are using the same runway as arriving aircraft, it is essential that the aircraft taking off has passed over the ILS localizer antenna before the arriving aircraft reaches a point on the approach where the interference caused by the overflight will have a critical effect. The aim should be for the departing aircraft to pass over the ILS localizer antenna before the arriving aircraft reaches a point 2 NM from touchdown or before landing clearance can be given to arriving aircraft.

Therefore during low visibility operations the aircraft runway occupancy times are increased, which is accommodated by ATC adding extra spacing margins between aircraft on final approach and thus reducing runway throughput.

During low visibility operations the protection of the Obstacle Free Zone (OFZ) is also to prevent runway incursions. The CAT II/III holding point not only protects the ILS CSA but also the Obstacle Free Zone (OFZ) which is usually smaller.

3.1.1.1 MLS operations at Heathrow

London Heathrow is equipped with another navigation aid (MLS) besides ILS and can be taken as an example of having two (or more) navigation aids for precision approaches. At London Heathrow, MLS has a smaller Localiser Sensitive Area (LSA), so reducing the size of the protected area around the runway when aircraft are conducting an MLS approach. This reduces runway occupancy time (including clearing LSA). MLS Landing Clearance is given at 1NM (rather than 2NM, exceptionally 1NM with ILS). Deductive reduced spacing results in increased capacity in LVP. Unless the required wake turbulence separation is greater, Heathrow will provide 5 NM spacing ahead of the aircraft conducting an MLS approach during LVPs. The MLS Heathrow procedures are included in Appendix C.
If a GBAS would be installed in Heathrow the same operational concept and reduced spacing in LVP would be deployed as with MLS. The resulting increase in runway throughput in LVP would depend on the amount of GBAS equipped aircraft operating in this airport.

3.1.1.2 Rules applicable to low visibility operations (LVO)

According to ICAO PANS ATM (Section 7.12.2.1) the appropriate ATS authority shall establish provisions at the aerodrome to support departure operations in RVR conditions with less than 550m RVR as well as precision approach CAT II/III operations. Such provisions are called Low Visibility Procedures (LVP) and relate mainly to control of traffic on the manoeuvring area for protecting the ILS and the runway area as well as adjusting the final approach spacing between successive aircrafts.

According to EASA regulation, LVP procedures should be established also prior to allowing Lower than Standard Category I operations and Other than Standard Category II operations

The activation of LVP depends on the current weather and visibility conditions at the airport. The visual limits are specific to each airport. The limits are published in the aeronautical information publication (AIP). Requirements for LVP and activation LVO are published in the internal ATC guidelines. These guidelines are based on ICAO EUR Doc.13 'European Guidance Material on All Weather Operations at Aerodromes' [9].

The provision of MET forecasts to ATC during LVP is also very important. Such provisions are specified in ICAO Annex 3. The provision of secondary power supply for radio navigation aids in LVP is specified in Annex 10, Volume I, Chapter 2.

3.1.2 ATC procedures with ILS

3.1.2.1 Transition to TMA

When arriving in the TMA, on the first call with ATC, the pilot is provided the approach clearance by the TMA/Approach controller. The approach clearance includes the expected landing procedure, which today is usually the ILS. The landing procedure is also published via ATIS broadcasting available to pilots before entry to the TMA. The TMA/Approach controller will assume that this is the preferred landing procedure by the flight crew.
In addition to the landing procedure, ATIS will also publish that LVP are in place.

3.1.2.2 Final approach

ATC controls the sequence of arrival aircraft to establish aircraft onto the final approach sequence. According to PANS ATM [12] Section 8.9.4 'the approach controller shall be responsible for maintaining separation specified in 8.7.3 between succeeding aircraft on the same final approach, except when that the responsibility is transferred to the aerodrome controller'.
Usually the final approach controller provides vectors to pilots such as to capture the ILS signal and start descending. Alternatively, when no vectoring is done, the pilots use a predefined approach charts to all the way to the final approach fix. When flight crew reports 'established on the ILS' the final approach controllers says ''Cleared ILS approach".

In case the ILS landing system unpredictably becomes unserviceable the ATC unit in contact with the flight shall report this to the flight crew. In low visibility conditions the flight crew will have to abort the approach and landing and either proceed to the opposite runway (if traffic and winds permits and ILS is operational and working) or wait in a holding, as assigned by ATC.

As described 3.1.1.2 the increased runway occupancy times in LVP results in final approach controller providing extra longitudinal spacing margins to be applied between successive approaching aircrafts or between departing and approaching aircraft.
ATC is responsible for ensuring that spacing between aircrafts conform LVP constraints.

The extra spacing margins applied in different European airports varies according to airport layout, the size of the ILS CSA and the availability of surveillance technologies (A-SMGCS).

The most conservative values for spacing aircraft on final approach during LVP are 10 to 15 NM between arriving aircrafts.
The least conservative values spacing aircraft on final approach during LVP, applied today at capacity demanding airports, are 7 to 8 NM between arriving aircrafts.
These values have been the main assumption for different validations exercises.

When using a runway in mixed departure/arrival mode it is often common to interlace one departure between two arrivals. In LVO this makes even more sense since the extra time (spacing distance) needed between two arrivals can be used by one departure. The time it takes to line up from a CAT II/III holding point, take-off and overfly the ILS antenna is more or less the same as the time needed between two consecutive landings. The experience in some States is that to achieve this, the departing aircraft must commence its take-off run before the arriving aircraft reaches a point 6 NM from touchdown. If the airport is not capacity constrained it would be normal for ATC to add some extra buffers to the minimum spacing requirements and for instance apply a 10 NM standard spacing between any two arrivals during LVO so that the runway controller always will have a good opportunity to launch one departure in between two arrivals without having to coordinate in every single case with final approach control the distance gap that is required for the departure.

3.1.2.3 Landing

The tower runway controller will normally take over the frequency of an arriving aircraft around outer marker but the control responsibility in LVO is reduced to the runway only. The tower runway controller gives landing clearance at latest 2 NM before threshold to arriving aircraft.

3.1.2.4 Runway operations

The tower runway controller controls traffic in the manoeuvring areas by applying special rules such as longitudinal separation in taxiways, maximum taxi speeds, taxiways for use, holding points and stop-bars procedures. The taxiways might have on one or both sides a stop bar of red lights.

For aircraft vacating the runway during Category III operations, exit taxiway centre line lights may be colour-coded to facilitate notification of runway vacated; the colour coding ends at the boundary of the ILS critical/sensitive area. Such holding positions will be appropriately marked and will display signs conforming to the specifications in ICAO Annex 14, Volume I.

For departing aircraft tower controller verifies that the CAT III holding points are respected in LVP.

The runway controller uses A-SMGCS surveillance HMI, when available, in order to verify positions and identities of all involved movements on or close to the runway.

Pilots are required to make a “Runway Vacated” call when the runway is vacated or when the aircraft has reached the colour code of part of the exit taxiway centre line lights (if applicable). Due allowance is made for aircraft size to ensure that the entire aircraft is clear of the ILS critical/sensitive area.

3.1.2.5 Tower Supervisor, landing aid status and ATIS input

Tower supervisor or any assigned role in the tower will be responsible for inputting to the ATIS broadcast the use and status of landing aids. If the equipment is unserviceable it shall immediately be inputted to the ATIS. Any change in landing aid status shall be relayed to all controller positions that are concerned such as runway controller, TMA and approach controllers as well as TMA supervisor. This is particularly critical during LVO. ATC shall inform the flight crew without delay on any degradation of service. Depending on the failure time this information shall be transmitted by RTF, or/and by ATIS and/or by NOTAM.
The ATC HMI may display information on the availability of ILS used for CAT III landings.

3.1.2.6 Conclusion

As a result, during good weather (CAT I) the spacing between two successive aircraft on final approach can be as close as the minimum radar separation requirement, typically 3 NM, when wake

vortex turbulence separation is not required. Under special conditions and requirements this spacing can be reduced to 2.5NM on final approach.
In LVO, extra spacing margins resulting in 7NM, 10NM or even 15 NM between consecutive landings are applied on final approach, so that the runway extended occupancy times described above can be respected and the ILS areas are protected..
The most constraining separation or spacing criteria is always the one that will be applied by ATC. I.e if wake turbulence separation of 10 NM is required between a pair of aircraft but runway occupancy protection in LVO only requires 6 NM, ATC will still apply 10 NM.

An example from Milan Malpensa spacing applied for Low Visibility Operations is included in Appendix B.

An example from London Heathrow MLS procedures is included in Appendix C

3.1.3 Aircraft Operation

This part describes the Operating Method to perform an ILS CAT III approach on mainline aircraft.

In order to perform CAT II and CAT III operations and take off with RVR less than 150 m (for categories A, B and C aircraft) or less than 200 m (for categories D and E aircraft), the operator must hold the relevant approval issued by the State to which it belongs.

To perform low visibility operations the operator shall follow the implemented low visibility aerodrome operation procedures (Low Visibility Procedures - LVP). For each flight in the Flight Plan, field 18, the applicable RVR minima for approach, landing and take-off operations shall always be reported as in the following example. E.g.: RVR/150 RMK/LVTO RVR 125.

3.1.3.1 Flight preparation

In addition to the normal flight preparation, the following preparation must be performed when ILS CAT III precision approach is planned:

- Ensure that destination airport meets CAT III requirements,
- Check that aircraft meets required equipment for ILS CAT III,
- Check that crew qualification is up-to-date,
- Consider extra fuel for possible approach delay,
- Consider weather at alternate.

3.1.3.2 Cruise

During the cruise flight phase, the crew can prepare the descent and approach. The crew needs to:

- Define the lateral and vertical flight plan via the selection of a final approach, STAR, TRANS and VIA. Once entered, the crew checks the information via the Navigation Display for trajectory and altitude / speed constraint verification.
    - The crew can select the ILS final approach in different ways:
        - By selecting an ILS approach stored in database. This approach is then inserted in the FMS FPLN and automatically tuned,
        - Or by tuning manually the ILS frequency and course.
- Enter the wind and performance data for descent and approach.
- Check the tuning of the appropriate ILS ground station with information provided on PFD or ND. The crew can check that the precision approach is selected when the distance to destination along the flight plan is below 300NM. Note that at this distance, the precision approach means is unlikely to be received. The crew can also check that the identifier of the approach is displayed on the ND if FMS CRZ/DES/APPR phase is active and the distance to destination along the flight plan is below 250NM.

3.1.3.3 Descent and approach

APPROACH TECHNIQUE

There are two approach techniques:

- The decelerated approach,
- The stabilized approach.

The decelerated approach refers to an approach where the aircraft reaches 1000ft in the landing configuration at VAPP (final approach speed). This is the preferred technique for an ILS approach.

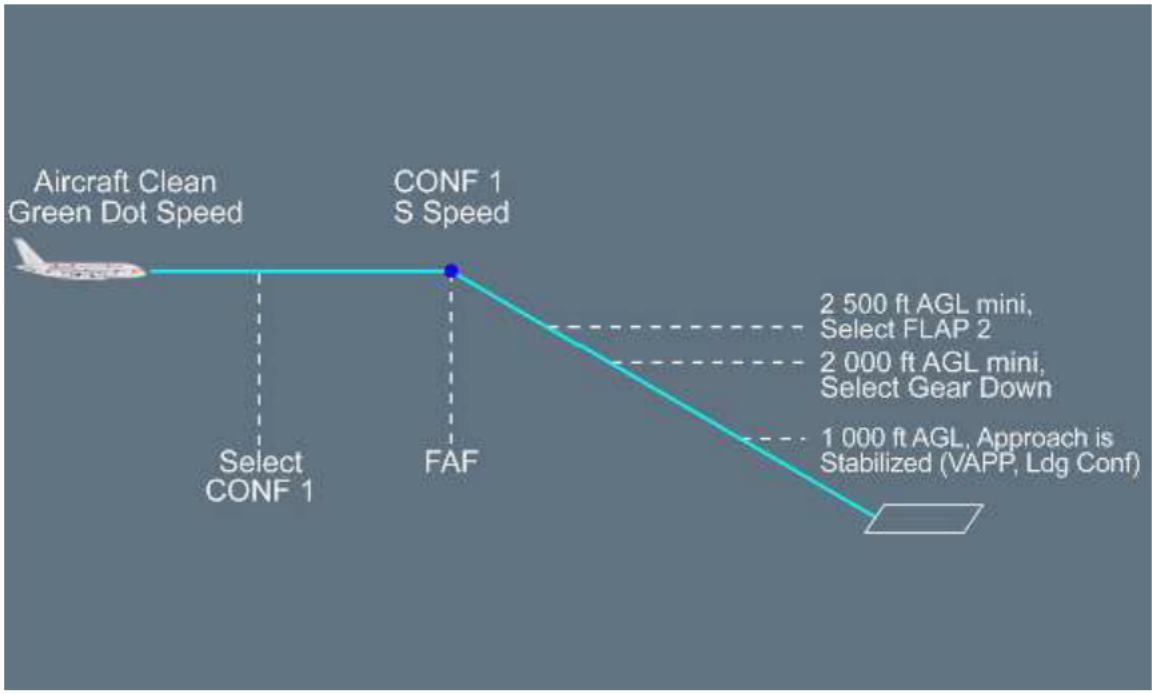


Figure 4: Decelerated approach

Note: The stabilized approach refers to an approach where the aircraft reaches the FAF in the landing configuration at VAPP. This technique is recommended for non-precision approaches. To get a valuable deceleration pseudo waypoint and to ensure a timely deceleration, the pilot should enter VAPP as a speed constraint at the FAF.

SPEED MANAGEMENT

Managed speed with A/THR use is recommended for the approach. Once the approach phase has been activated, the A/THR will guide aircraft speed towards the manoeuvring speed of the current configuration, whenever higher than VAPP, e.g. green dot for Conf 0, S speed for Conf 1 etc.

APPROACH PREPARATION

Before commencing a precision approach a number of factors must be considered by the crew. In addition to the standard approach briefing, the following points should be emphasized during an approach briefing for a low visibility approach:

- Aircraft capability
- Airport facilities
- Crew qualification
- Weather minima
- Task sharing
- Call-outs
- Go-around strategy

Irrespective of the actual weather conditions, the crew should plan the approach strategy using the best approach capability. This would normally be LAND3 DUAL, depending upon aircraft status.

The crew should then assess the weather with respect to possible downgrade capability.

Conditions	APPR1	LAND1	LAND2	LAND3	
				With DH	No DH
Flying technique	Hand flying or AP/FD, A/THR	AP/FD down to DH		AP/FD/ATHR and Autoland	
Minima & weather	DA (DH) baro ref visibility	DH with RA RVR			
Autoland	Not Allowed	Recommended		Mandatory	

Table 3-1 Aircraft landing modes

When the aircraft reaches the arrival airport terminal area, the crew can prepare the approach and landing. The crew needs to:

- Check that the FMS approach phase has been activated. If not, the crew needs to force the activation of the approach phase.
- Check that the ILS associated to the runway forecast for landing is correctly tuned and correctly received. The crew displays ILS information and checks:
    - Identification of the selected ILS approach is properly displayed on the PFD.
    - The approach category displayed on FMA that confirms the crew strategy for approach,
    - Localizer and Glideslope scales and deviations are displayed on PFD, if inside coverage,

.

INTERCEPTION OF FINAL APPROACH COURSE

To ensure a smooth interception of final approach course, the aircraft ground speed will be appropriate, depending upon interception angle and distance to runway threshold.

If ATC provides radar vectors, the crew will use the DIR TO RADIAL IN facility. This ensures:

- A proper F-PLN sequencing
- A comprehensive ND display
- Assistance for lateral interception.

The final approach course interception in NAV mode is possible if GPS is PRIMARY or if the navigation accuracy check is positive.

Once cleared for the approach by the ATC, the crew:

- Presses the APPR P/B to arm the approach modes when applicable,
- Monitors the capture of the LOC and of the G/S to announce it when displayed on the FMA,
- Monitors the FMA display for the aircraft capability.

Figure 5: Monitoring ILS final approach on PFD

During ILS approach, approach capability downgrading may occur upon aircraft systems failures. Crew is informed via approach capability displayed on FMA and approach capability status displayed on ECAM.

According to the height at which the approach capability downgrading occurs, the aircrew shall apply following procedure:

- Above 1000 ft, if the pilot estimates he has time to reconfigure the A/C (minima update according to the approach capability and compared to actual weather conditions), he can continue the approach,
- Below 1000 ft, pilot should not modify the minima:
  - In case visual references are acquired, pilot can continue approach,
  - In case visual references are not acquired, pilot has to perform a go-around.
- Category changes are inhibited below Alert Height when system is fail-operative (LAND 3 DUAL).

TRAJECTORY STABILIZATION

The first prerequisite for safe final approach and landing is to stabilize the aircraft on the final approach flight path laterally and longitudinally, in landing configuration, at VAPP speed, i.e.:

- Only small corrections are necessary to rectify minor deviations from stabilized conditions
- The thrust is stabilized, usually above idle, to maintain the target approach speed along the desired final approach path.

For automatic landing performance purposes, stabilized conditions need to be reached at 1000 feet above airfield elevation. If, for any reason, one flight parameter deviates from stabilized conditions, the PNF will make a callout as stated below:

Exceedance and associated PNF callout

Parameter		Exceedance		Callout
IAS		VAPP + 10kts / -5kts		"SPEED"
V/S		<-1000ft/mn		"SINK RATE"
Pitch		attitude + 10° / 0°		"PITCH"
Bank angle		7°		"BANK"
ILS or GLS	Localizer	Excess deviation	1/2 dot PFD	"LOCALIZER"
	Glide slope		1/2 dot PFD	"GLIDE SLOPE"

Table 3-2 Pilot Non Flying callouts

Following a PNF flight parameter exceedance call out, the suitable PF response will be:

- Acknowledge the PNF call out, for proper crew coordination purposes,
- To take immediate corrective action to control the exceeded parameter back into the defined stabilized conditions,
- To assess whether stabilized conditions will be recovered early enough prior to landing, otherwise initiate a go-around.

AUTOMATIC LANDING

During automatic landing, the following AP/FD modes succeed on FMA as described on the figure hereafter.

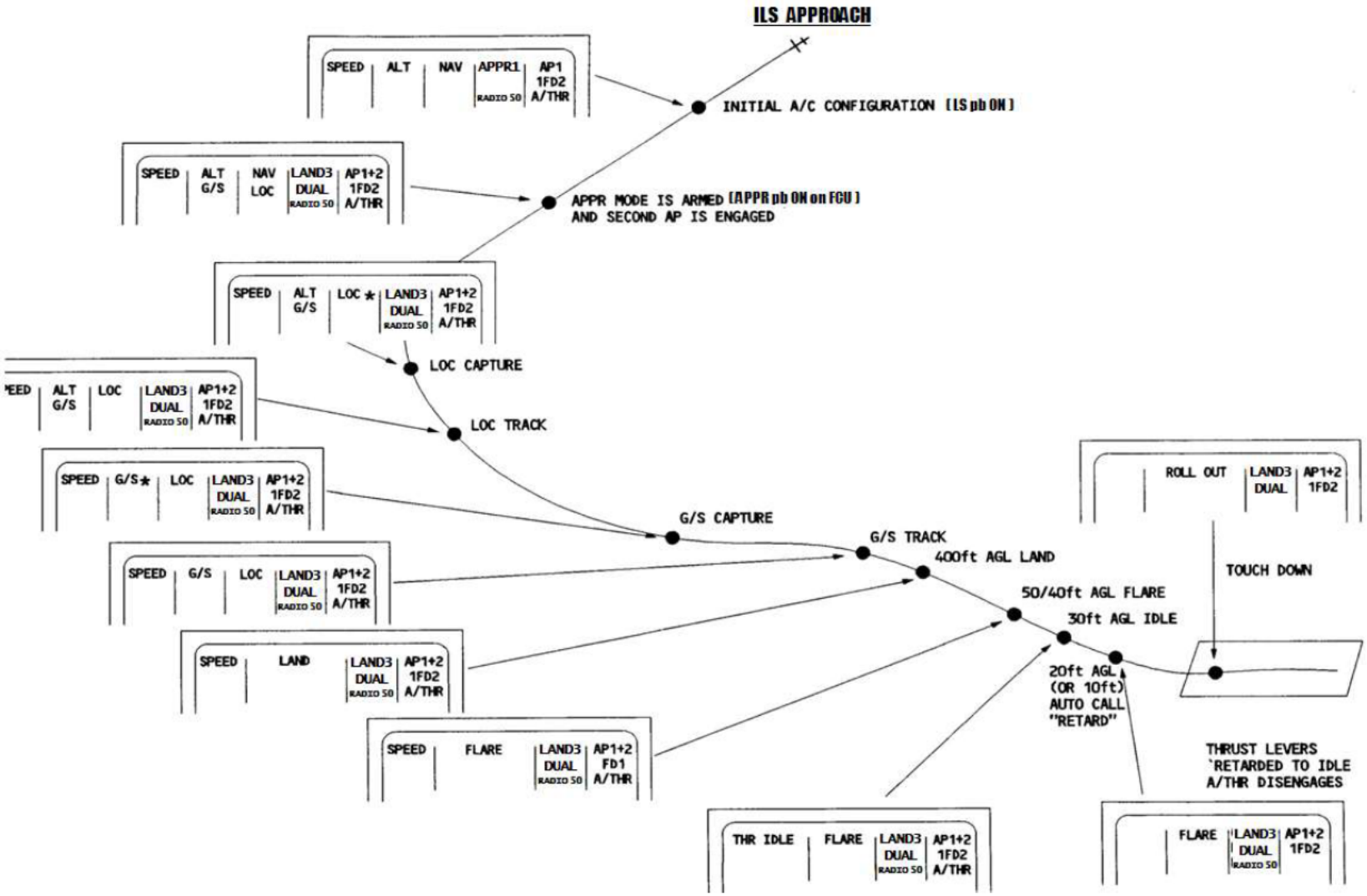


Figure 6: AP/FD modes succession with LAND3 DUAL capability

AUTOLAND WARNING

A monitoring of AUTOLAND conditions is performed in order to warn the crew on failure conditions that requires performing an immediate go-around.

The AUTOLAND light flashes, when the aircraft is below 200ft RA with at least one AP engaged and one of the following conditions is detected:

- Excessive deviation for Glide or LOC,
- Or loss of LOC (above 15ft) or G/S (above 100ft) on both MMRs,
- Or loss of two AP,
- Or difference between RAs greater than 15ft with LAND TRACK mode activated,
- Or long Flare detection.

Figure 7: AUTOLAND warning light

REACHING THE MINIMA

Decision to land or go-around must be made at DA/DH at the latest. Reaching the DA/DH, at MINIMUM call out:

- If suitable visual reference can be maintained and the aircraft is properly established, continue and land.
- If not, go-around.

3.1.3.4 Go-around

The crew must be mentally ready for a go-around at any stage of the approach. If a failure occurs above 1000ft RA, all ECAM actions (and DH amendment if required) should be completed before reaching 1000ft RA, otherwise a go-around should be initiated.

This ensures proper task sharing for the remainder of the approach. Any alert generated below 1000ft should lead to a go-around.

Go-around based on ILS guidance, is not considered

3.2 New SESAR Operating Method (GBAS)

This section describes the ATC procedures related to the introduction of GBAS. It is expected that GBAS implementation will be in many cases on the runways already equipped will ILS and for a considerable period of time both technologies will co-exist. So the ATC procedures for managing and possibly optimising the **mixed ILS/GBAS low visibility operations** are also developed as a second part of this section.

The aircraft operator procedures for using GBAS are also described.

3.2.1 Optimised low visibility operations using GBAS (only)

In the new operating method GBAS is used instead of the ILS system to perform for CAT III operations. The Ground Based Augmentation System (GBAS) augments the satellite signal and will provide for approach and landing in low visibility conditions. The GBAS system has limited or no protection area. The GBAS Local Object Consideration Areas (LOCA) is usually located outside aircraft movement areas.

The optimised operation using GBAS concept is developed to reduce impact of LVP on runway capacity. This concept is based in EUROCONTROL Landing Clearance Line study [10] and ICAO EUR Doc.13, Chapter 8 [9]. The optimised operations using GBAS can be used at any airport equipped with GBAS. But in practise the additional requirements described here means that this concept will most likely be implemented in high capacity airports where additional runway capacity is required in LVP.

The optimised operations using GBAS concept addresses two limiting factors in LVP. The first is the location of the aircraft holding positions on ground and the second is the position at which ATC gives landing clearance to arriving aircraft. Other capacity limiting factors in LVP such as slower taxi speeds leading to an increase of runway occupancy time are outside the scope of this concept.

The optimised LVP using GBAS is based on the following changes to current ATC procedures in order to achieve the expected capacity benefits.

- ATC (Tower) to use a **landing clearance line** for aircraft vacating the runway, instead of today's ILS CAT III holding
- ATC (Tower) to provide the pilots with **late landing clearance**, up to 1NM before threshold
- ATC (Approach) to **reduce the final approach spacing** in LVP in front of GBAS equipped aircraft

The impact of such changes in reducing final approach spacing is assessed for both segregated runway (arrival only) and mixed mode runway (departures/arrivals) operations.

A benefit of using GBAS in the mixed mode runway is the fact that the aircraft will not be expected to overfly the GBAS before the next arrival aircraft is cleared for approach (as is the case today with ILS)

3.2.1.1 The landing clearance line

The CAT II/III holding point protects the Obstacle Free Zone (OFZ) and the ILS Sensitive Area (SA), which is usually larger than OFZ. With GBAS there is no need to protect the ILS SA, but the OFZ still need to be protected during CAT II/III operations. Therefore it is proposed to determine **a landing clearance line** instead of a holding point **for aircraft/vehicles vacating the runway**.

The landing clearance line will not be marked on the actual airfield but will only be displayed on the A-SMGCS HMI in the tower.

The determination of the landing clearance position [10] is defined by two criteria:

- The wingtip clearance from touchdown to end of roll out along the runway.
  Once the following aircraft has landed, it may in some cases travel behind the aircraft on the taxiway and the landing clearance line must ensure wingtip clearance between the aircraft on the runway and the aircraft on the taxiway. For an A380 the formula in [17] equates to 77,5m for a Code F aircraft using the runway and 60m for a code E aircraft using the runway.
- The collision risk during the landing and balked landing.

The preceding aircraft is still within the OFZ at the time that landing clearance is issued to the following aircraft. This creates a potential risk of collision if the following aircraft performs a missed approach or balked landing. Assessment of this risk [11] results in the landing clearance line being further from the runway for the first 900m from the threshold. This in particular protects aircraft and vehicles crossing the runway close to the threshold

In segregated runway case: The aircraft is considered runway vacated as soon as it has passed the landing clearance line and a landing clearance can be given at the following arrival aircraft even as late as 1 NM before touchdown.

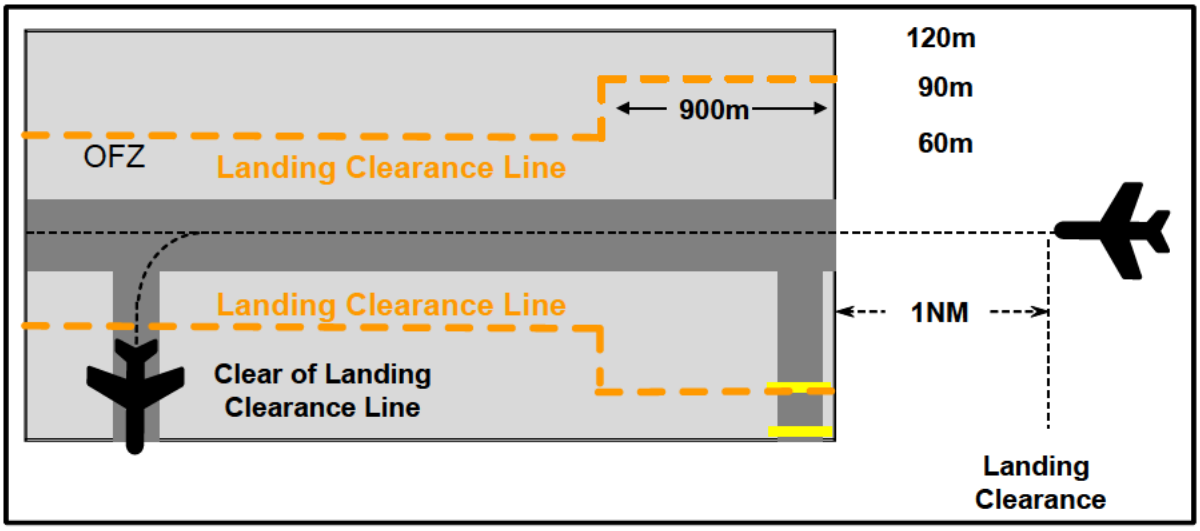


Figure 8 Landing Clearance Line (arrival only runway)

In mixed mode runway case: The departing aircraft will hold at CAT III holding.

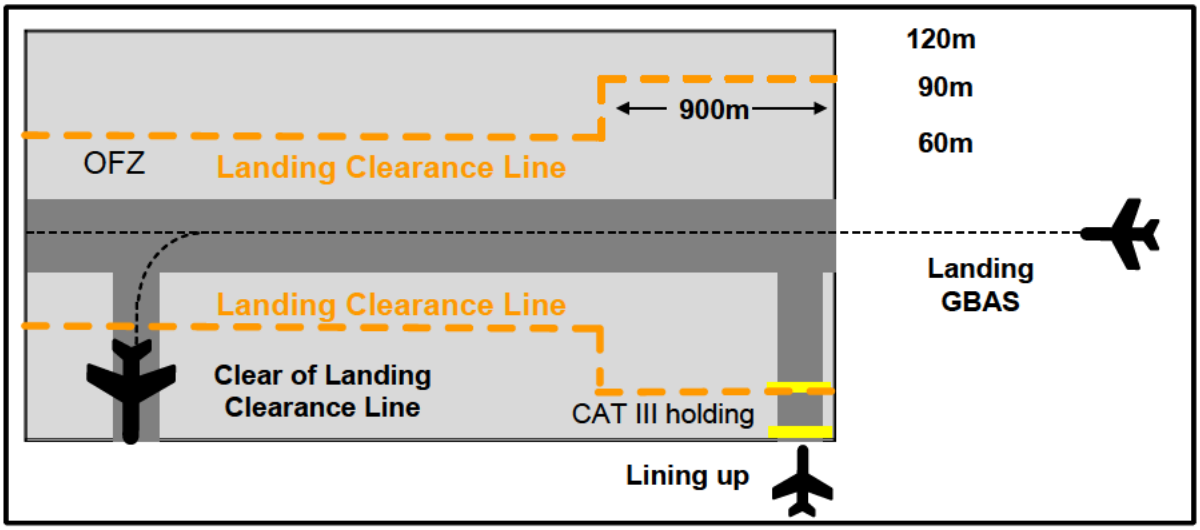


Figure 9 Landing clearance line (departure/arrival runway)

Note: Initially in the OSED it was proposed that the departing aircraft lining up behind GBAS arrival could use the CAT I holding point (as no effect on GBAS landing). The condition was that this CAT I holding point could only be in a runway entry position at least 900m after touchdown zone, in order to avoid collision risk in case of a balked landing. After consultation with airspace users the alternate use of CAT III and CAT I holding points was considered very complex to manage by ATCO and AU, as it may introduce confusion to pilots on which holding point to use. From a pilot perspective it is more important to have addition 900m in the runway in LVP then holding at a CAT I holding points, instead of CAT III. Finally, this concept of operation may introduce safety risks when an aircraft aborts a GBAS approach and performs an ILS approach or when an aircraft performs a GBAS go-around and next arrival is an ILS approach. Therefore it was decided that also for GBAS the CAT III holding point is to be used in case of departing aircraft

3.2.1.2 The provision of late landing clearance to pilots

With GBAS there is no need to protect the ILS sensitive area, so the landing clearance can be given later than 2NM (refer to 3.1.1). According to ICAO Doc.13 the latest position where the landing clearance can be given is 200 ft or 0.6 NM from touchdown when using required surveillance means. But it was considered acceptable by pilots to receive the landing clearance at latest 1 NM before threshold for GBAS approaching aircraft.

Note: Initially in the OSED, the late GBAS landing clearance was suggested to be given at 0.6 NM from the runway threshold (as stated in ICAO doc.13). After consultation with airspace users it was considered that 0.6 NM is not operationally feasible. The pilots reported that the landing clearance should be received before the missed approach point, which is usually selected at 1 NM before threshold. Otherwise after the missed approach, with no clearance to land, the pilots have to go around. A clearance received at 0.6 NM would also interfere with aural radio altimeter announcements. The 200ft Radio Altitude is reached at 0.5 NM (.47 exactly) before the Landing Threshold. So if the approaching Aircraft should be cleared latest at that point and pilot should have managed a read back, the controller has to start to speak latest at 0.8 NM (.79 exactly), if he takes 4 sec for the clearance. Then the pilot takes 1 sec until he starts his clearance read back with another 4 sec. (with 130kts, which is a rather low Approach speed for Airliners, the Aircraft will be at 304ft Radio Altitude -assumed that the approach sector is at flat level) With higher approach speeds - up to 160kts are normal – so the controller has to start earlier with the clearance. The 1 NM value was considered feasible by the airspace users and was used in the validation exercises.

3.2.1.3 Reduced final approach spacing

The use of the landing clearance line instead of ILS CAT III holding points for aircraft vacating the runway reduces the runway occupancy time in LVP. Based on this ATC controllers can reduce final approach spacing thus increasing runway throughput in adverse weather conditions. The amount of runway throughput gained will depend also on surveillance and wake turbulence separation and spacing rules.

The segregated runway case: The benefit from reducing the runway occupancy times by using the landing clearance line and by providing late landing clearance to pilots will be executed by the final approach controller in that the spacing between arrivals can be shorter than in the case of ILS CATII/III landings. This is expected not to add work load since the capacity will still be lower than in good visibility conditions.

The mixed runway case: The spacing between departure and arrival can be reduced as there is no need to overfly the GBAS ground station before clearance is given to the arriving aircraft and also from the possibility to provide a late landing clearance to pilots.

At the moment of writing this document there are no binding regulations regarding spacing criteria of GBAS. Reported practices from different airports are as varied as 7NM, 10NM or even 15 NM between consecutive arrivals in LVP. In busy and high capacity demanding airports, which are the target of this concept, 7NM and 6 NM final approach spacing is reported achievable in LVP.. The OSED proposes reduction of spacing criteria for GBAS through the use of the landing clearance line and the provision of late landing clearance of at least 1 NM. This means that if for example 6 NM is applied in front of an ILS, than 5NM can be applied in front of a GBAS arrival. In cases when additional spacing buffers are used with ILS (it might be related to the location and characteristics of ILS CSA) then even more than 1NM reduction can be achieved with GBAS.

3.2.2 ATC procedures with GBAS

3.2.2.1 Transition to TMA

Similarly to ILS, on first call when arriving to the TMA, the pilot is provided the approach clearance by the TMA/Approach radar controller. In the new operating method the expected landing procedure is

GBAS. On the ATIS there will be published that GBAS landing procedure is available. The TMA controller will read the approach clearance accordingly.

3.2.2.2 Final approach

The final approach controller is able to reduce the final approach spacing as described in 3.2.1.3 for both runway configurations.

Similarly to ILS, the final approach controller will provide vectors to pilots to capture the GBAS Final Approach Segement (FAS). The same vectoring rules apply for GBAS, i.e to ATC to provide a maximum 45 degrees interception heading to the FAP or further, intercept the GBAS glide slope from below. Alternatively, when no vectoring is done, the pilots use a predefined GBAS approach charts all the way to the final approach fix. . Once established final approach the pilots will report 'Established on GBAS approach course'' and the final approach controller will clear the aircraft for GBAS approach.

If GBAS unpredictably becomes unserviceable the ATC unit in contact with the flight shall report this to the flight crew. In low visibility conditions the flight crew will have to abort the approach and landing and either proceed to the opposite runway (if traffic and winds permits and GBAS is operational and working) or wait in a holding, as assigned by ATC.

3.2.2.3 Landing

The tower runway controller provides to GBAS arriving aircraft the landing clearance at latest 1 NM before the runway threshold.

3.2.2.4 Runway Operations

The tower runway controller will use the landing clearance line for aircraft vacating the runway. The other traffic is controlled as with ILS. The tower runway controller will consider the arriving aircraft has vacated the runway as soon as the landing clearance line (displayed in the A-SMGCS HMI), instead of CAT III holding point.

In case of departures the runway controller makes sure that no vehicle or aircraft enters the runway if not authorised to do so. The CAT III holding point is used for departure aircraft also in the case of GBAS.

3.2.2.5 Tower Supervisor, landing aid status and ATIS input

Similarly to ILS, the tower supervisor or any assigned role in the tower will be responsible for inputting to the ATIS broadcast the use and status of landing aids such as GBAS. Any change shall be immediately relayed to the concerned controller positions.

The ATC HMI may display information on the availability of GBAS station as well as the GBAS approach capability per runway end.

3.2.2.6 Conclusions

The changes proposed to ATC procedures as related to GBAS are expected to allow for reducing the final approach spacing in LVP of at least 1NM before GBAS arriving aircraft.

The runway controller and approach control both might need collaborative access to support tools that can assist determining each individual spacing between arrivals, in order to accommodate the departures, well in advance (in the order of 20 minutes before landing and before final approach vectoring has begun), in order to maximise the runway throughput. Such tools are coupled AMAN/DMAN planning/sequencing tools and an approach spacing tool.

When implementing new optimised LVP procedures with GBAS it is assumed that this will be done step wise. By gaining trust in the system and the procedures and by collecting supporting data the local implementation will reduce the spacing gradually before reaching full optimisation

3.2.3 Mixed ILS/GBAS low visibility operations

3.2.3.1 Non optimised low visibility operations using mixed GBAS/ILS

The introduction of new technology approach and landing aids such as GBAS will be done, in many cases, in runways already equipped with ILS. ATC procedures for managing mixed ILS/GBAS equipage operations have to be developed.

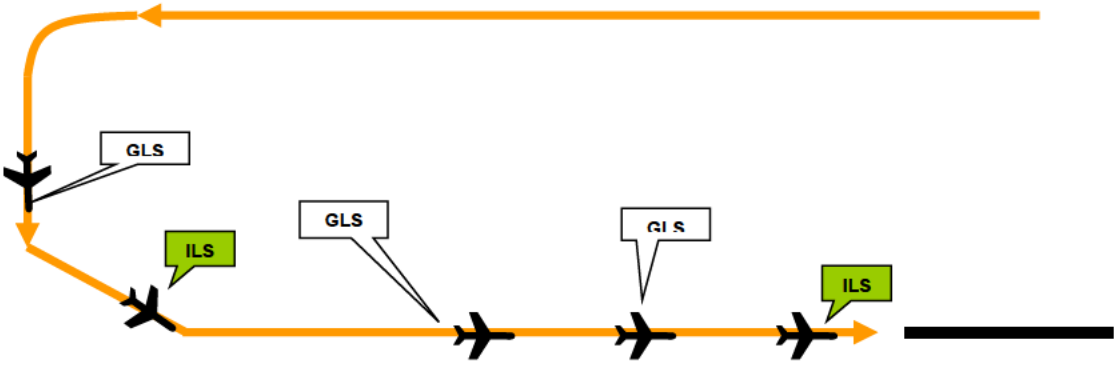
Some airport installing GBAS might have a medium demand (no capacity constraints) such that there is no need to benefit from the reduced critical and sensitive area. We assume in this OSED that both systems use the same threshold and glideslope so that each approach profile looks the same to ATC. In this case the same operating method as ILS is used and there is no need to implement A-SMGCS.

The only difference is that ATC will need to know which aircraft will perform a GBAS and which aircraft will perform an ILS approach. This can be solved through R/F communication or ATC HMI implementation based on the information available from the flight plan.

3.2.3.2 Optimised low visibility operations using mixed GBAS / ILS

When installing GBAS with the objective to increase capacity, the optimised low visibility operations using GBAS can be implemented. This can be achieved through the use of the landing clearance line and the provision of the late landing clearance can be developed as described in Section 3.1.2. However this operation is a bit more challenging when both ILS and GBAS landing systems continue to provide for CAT III operations. The ATC will need to know if the aircraft is equipped with ILS or GBAS to properly manage the aircraft

The segregated runway case: The main capacity benefit on segregated runways will be the opportunity to space GBAS landings closer to preceding landing than what is possible for ILS landings.



GLS approaches can be spaced closer behind preceding ILS and GLS since landing clearance can be given later and the preceding also will occupy the runway shorter as the ILS sensitive areas do not have to be respected for GLS approaches. Total capacity becomes higher in Low Visibility Conditions.

The mixed mode runway case: The spacing between departure and arrival can be reduced when the arrival is a GBAS aircraft as no protection is required and also from the possibility to provide a late landing clearanceto pilots. This is a more difficult and complex operation that might require good assisting tools in order to work safely and efficiently on the runway.

3.2.4 ATC procedures for using ILS/GBAS

3.2.4.1 Transition to TMA

On first call when arriving to the TMA, the pilot is provided the approach clearance by the TMA/Approach radar controller. In the mixed ILS/GBAS operations the expected landing procedure can be ILS or GBAS. On the ATIS, if available, GBAS and ILS landing procedures will be published as available. Or it can be stated that one of the procedures is the expected landing procedures (e.g. GBAS procedures) and the ILS procedure is available upon request. The TMA controller will read the approach clearance following what landing capability information the airline operations has provided in the flight plan (item 10a). If the pilot for some reason prefers another landing procedure that the one cleared for than he/she should ask for it to the TMA/Approach controller. The TMA controller will acknowledge this and transfer to adjacent downstream controller. This information will thereby also be relayed to the tower runway controller. The approach controller will grant the requested landing procedure if possible.

3.2.4.2 Final approach

The controller who is responsible for executing the vectoring for final approach or, in case no other traffic is concerned and no vectoring is needed, and because of existing predefined approach charts all the way to the final approach fix, will normally give the “Cleared ILS approach” clearance when flight crew is reporting established on ILS. In case of GBAS landing the report from flight crew that they are established will still be needed and the controller in charge will then respond “Cleared for GBAS/GLS approach”.

In case the ILS landing system unpredictably becomes unserviceable the Final approach controller will report this to the pilot. The pilot will, depending on the weather situation continue to a visual landing or if possible shift to GBAS depending on the capabilities and equipment on board, as well as time available to rebrief the approach and reconfigure. It is considered feasible that the re-configuration for another approach can happen at latest 10 NM before threshold. In case is not possible to change to another approach then a go-around is required.

In case GBAS landing system becomes unserviceable the same procedure will be applied by ATC. Flight crew will have the opportunity to reset to an ILS landing procedure and either continue the approach and landing or ask for a new approach, if necessary for the reset procedure to be done in a safe manner.

When optimisation is required the final approach controller, when possible, will reduce the spacing before a GBAS approach aircraft with 1NM.

3.2.4.3 Landing

In the case of mixed ILS/ GBAS operations and mixed landings and take-offs the tower runway controller needs to assure a safe operation of all the movements on the runway.

The tower runway controller needs to know if the equipment on ground becomes unserviceable so that he anticipates what action the flight crew might take depending on what equipment is not anymore useable. It is also proposed that the flight plan indicates the GBAS capability for each aircraft/flight crew that would be able to perform a GBAS landing, even when an ILS landing is requested.

The tower runway controller provides to GBAS arriving aircraft the landing clearance at latest 1 NM before the runway threshold and to ILS arriving aircraft at latest 2 NM before the threshold.

3.2.4.4 Runway Operations

The tower runway controller will use the landing clearance line (displayed in the A-SMGCS HMI) to consider that the previous aircraft vacated the runway when the next arrival is GBAS. If the following arrival is ILS than the CAT III holding point is used for considering the previous aircraft has vacated the runway.

In case of departures the runway controller makes sure that no vehicle or aircraft enters the runway if not authorised to do so. The CAT III holding point is used for departure aircraft for both ILS and GBAS operations.

3.2.4.5 Tower Supervisor, landing aid status and ATIS input

Tower supervisor or any assigned role in the tower will be responsible for inputting to the ATIS broadcast the use and status of landing aids. In the case of multiple landing aids being applied for the runway in use, this has to be considered so that the ATIS is clear and easy to understand for flight crews. If the equipment is unserviceable it shall immediately be input to the ATIS be it ILS or GBAS. Any change in landing aid status shall be relayed to all controller positions that are concerned, the runway controller, TMA and approach controllers as well as TMA supervisor. All flight crews concerned will then also be informed by ATC.

The ATC HMI may display information on the availability of GBAS station as well as the GBAS approach capability per runway end

3.2.4.6 Conclusion

When no optimisation is required, to change from ILS landing system to managing mixed ILS and GBAS landings is considered not very complicated for air traffic control as the spacing applied and runway holding points are the same. There is a need for ATC to know which landing aid the aircraft is using for CAT III operations when both systems are available so that any degradation of service is informed immediately to flight crew. This concept is beneficial for airport where increasing capacity is not the main objective. Instead the Airport has identified other benefits from the use of GBAS such as system resilience to multipath for restricting environments or snow; flexibility of movement close to runway as the station can be located further away; the use of one system for multiple runways etc. Please refer to Section 2.3.3.

When optimisation is desired during the use of both ILS and GBAS landing systems ATC has more complicated tasks. In this case ATC can reduce the final approach spacing before a GBAS arriving aircraft. Also ATC will need to manage two different runway vacation positions for ILS and GBAS. And ATC will use two different distances for providing the latest landing clearance to arriving aircraft, 1NM for GBAS arrival and 2NM for ILS arrival.

3.2.5 Aircrew Operation using GBAS

This part describes the Operating Method to perform a GBAS CAT III approach within GAST D standard, i.e. with a GBAS system based on GPS L1 constellation only, on mainline aircraft.

The Aircrew operation perspective to conduct a GBAS approach is independent of the different airport and ATC operational configuration (mixed ILS/GBAS, optimised operation or not).

3.2.5.1 Flight preparation

In addition to the normal flight preparation, the same preparation as for ILS must be performed when GBAS CAT III precision approach is planned:

- Ensure that destination airport meets CAT III requirements,
- Check that aircraft meets required equipment for GBAS CAT III,
- Check that crew qualification is up-to-date,
- Consider extra fuel for possible approach delay,
- Consider weather at alternate.

Assuming that GBAS CAT III availability is changing according to GPS satellites constellation status and geometry, it has been envisaged to provide the aircrew with a tool having the capability to predict the availability of CAT III operations at destination, taking into account the local specificities (e.g. mountainous characteristics). The question of the need for such a tool for the aircrew, either on ground or on-board the aircraft, has been addressed to a panel of Airspace Users pilots and Airbus test and training pilots.

Given the results of GBAS CAT III availability first simulations (99.9% CAT III availability considering satellites outages - 99.997% CAT III availability with no satellites outages; both based on a 24 satellite GPS constellation as opposed to the current 31 satellite one), pilots state that such a tool would be useless on-board the aircraft, because the availability check would always be positive, except maybe once upon a time: by habit, the pilot may not perform the check if the result is generally positive. However the fuel on-board constraints are more and more important and signal unavailability information needs to be provided to pilots, if a risk is perceived. The GBAS ground station status will be provided by ATC as it is the case today for ILS unavailability.

3.2.5.2 Cruise

During the cruise flight phase, the crew can prepare the descent and approach in the same way as for an ILS approach.

3.2.5.3 Descent and approach

APPROACH TECHNIQUE

As for ILS, the decelerated approach is the preferred technique for a GBAS approach using the AP/FDs, the LOC and G/S modes, A/THR in the SPEED mode, and a managed speed target.

SPEED MANAGEMENT

Speed management in GLS is the same as in ILS.

APPROACH PREPARATION

Before commencing a precision approach a number of factors must be considered by the crew. In addition to the standard approach briefing, the following points should be emphasized during an approach briefing for a low visibility approach:

- Aircraft capability
- Airport facilities
- Crew qualification
- Weather minima
- Task sharing
- Call-outs
- Go-around strategy

Irrespective of the actual weather conditions, the crew should plan the approach strategy using the best approach capability. This would normally be LAND3 DUAL, depending upon aircraft status **and GBAS signal performance availability**.

Indeed, GBAS CAT II/III using GAST D introduces the LAND3 (i.e. CAT III) capability to be dependent on GBAS signal in space performance, which is new compared to ILS where only the airborne systems failures will affect the airborne LAND 3 capability. This could lead to aircraft approach capability downgrading from LAND3 to LAND1, LAND1 (i.e. CAT1 with Autoland capability) being the approach capability corresponding to the current GBAS CAT I using GAST C.

It is to be noted that, following an aircraft approach capability downgrading from LAND3 to LAND1, the LAND3 capability may be recovered because signal performance is back. Indeed, operational evaluations with Airspace Users, Airbus test and training pilots, led to the conclusion that we must not prevent, at system level, the LAND3 capability return, in order to always benefit from the highest available capability.

The crew should then assess the weather with respect to possible downgrade capability the same way as for ILS.

Conditions	APPR1	LAND1	LAND2	LAND3	
				With DH	No DH

Flying technique	Hand flying or AP/FD, A/THR	AP/FD down to DH	AP/FD/ATHR and Autoland
Minima & weather	DA (DH) baro ref visibility	DH with RA RVR	
Autoland	Not Allowed	Recommended	Mandatory

Table 3-3 Aircraft landing modes

When the aircraft reaches the arrival airport terminal area, the crew can prepare the approach and landing the same way as for ILS.

INTERCEPTION OF FINAL APPROACH COURSE

Interception of final approach course in GLS is the same as in ILS.

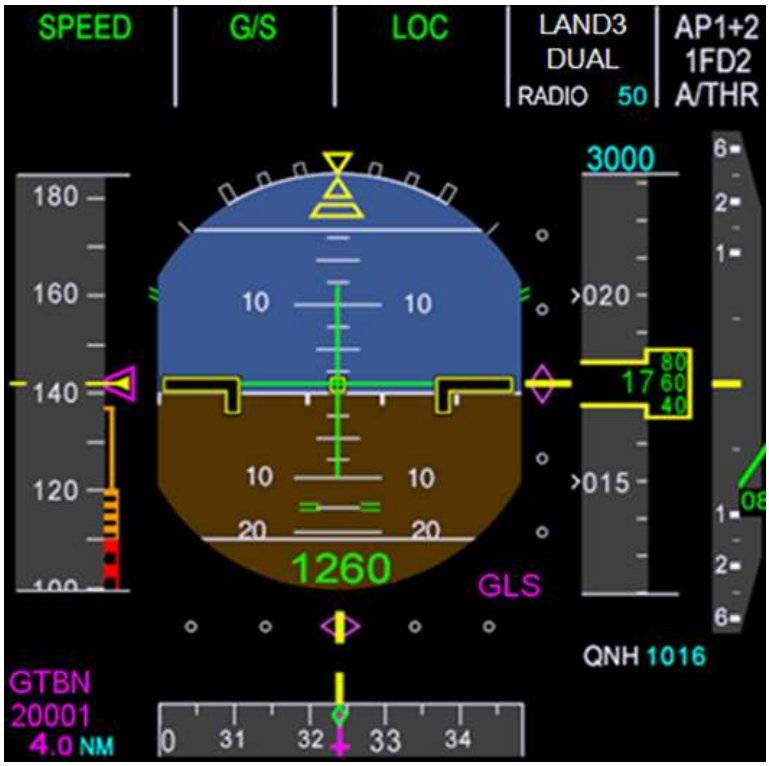


Figure 10: Monitoring GLS final approach on PFD

During GLS CAT II/III approach, approach capability downgrading/upgrading may occur upon aircraft systems failures and/or GBAS signal performance downgrade/upgrade. Crew will be informed via approach capability displayed on FMA and approach capability status displayed on ECAM.

According to the height at which the approach capability downgrading occurs, the aircrew shall apply current procedures, as for any approach capability downgrading (being due to GBAS signal performance or aircraft systems failures):

- Above 1000 ft, if the pilot estimates he has time to reconfigure the A/C (minima update according to the approach capability and compared to actual weather conditions), he can continue the approach,
- Below 1000 ft, the pilot should not modify the minima:
  - In case visual references are acquired, the pilot can continue approach,
  - In case visual references are not acquired, crew has to perform a go-around.

- Category changes are inhibited below Alert Height in fail-operative system (LAND 3 DUAL).

TRAJECTORY STABILIZATION

Trajectory stabilization criteria, flight parameter monitoring and callout in GLS are the same as in ILS.

AUTOMATIC LANDING

During GLS automatic landing, the AP/FD modes succeed on FMA as for an ILS automatic landing.

AUTOLAND WARNING

As for ILS, a monitoring of AUTOLAND conditions is performed in GLS, according to same criteria, in order to warn the crew on failure conditions that requires performing an immediate go around.

GLS VERTICAL DEVIATION BEHAVIOUR BELOW 100FT

In GBAS CAT II/III, it is envisaged the possibility to decorrelate alerting between lateral and vertical deviations in order to gain continuity assuming vertical is more sensitive to continuity loss and vertical deviations are not anymore used approximately below 100 ft (altitude aircraft dependant) by the guidance laws.

As a consequence, below 100ft, GBAS G/S deviation may be lost being Not Computed Data (NCD), within the GBAS receiver, while LOC deviation would still be Normal Operations (NO). It means that LOC deviation could still be displayed whereas G/S deviations would be lost. Aircraft capability would then remain in LAND3 condition as shown in the following figure.

Figure 11: PFD without G/S deviation at 70ft RA

Two reasons have been provided to suggest such behaviour:

- G/S deviations are not used anymore by the autopilot below 100 ft so there is no consequence on guidance
- ILS G/S deviation is very noisy below 50 ft and even if displayed is not used by the crew, so the removal of G/S deviations will not constitute an operational difference. In addition, G/S deviations are removed by design when the aircraft crosses the runway threshold, so this provision only concerns the phase between 100ft and about 50ft height.

During GBAS CAT II/III operational evaluations with Airspace Users and Airbus test and training pilots, it turned out that no pilot detected the G/S deviation disappearance below 100ft RA. Reason is that pilots either look outside searching for visual references or monitor the automatic flare on PFD (essentially FMA indication and AP/FD behaviour).

During debriefing of these evaluations, most pilots agreed that G/S deviation disappearance is acceptable. Moreover, it has been noticed that same situation could occur in ILS, in case of loss of the ILS Glide ground station.

REACHING THE MINIMA

Decision to land or go-around in GLS is the same as in ILS.

3.2.5.4 Go around

Go-around procedure in GLS is the same as in ILS

3.3 Differences between new and previous Operating Methods

3.3.1 Aerodrome and ATC perspective

3.3.1.1 Flight Plan

When ILS and GBAS procedures will be available for CAT II/III, the Approach and Tower ATC need to know which landing procedure each arrival is capable of making and what landing procedure is the preferred one. This is more complex than today's situation, where only one landing system is available.

The capability to fly ILS is put in flight plan item 10a but is normally not displayed on the controller interface since ILS is assumed to be commonly used by most IFR flights. The GBAS capability is also put in item 10a in the flight plan. But since only some aircraft will be GBAS capable there is a need to make this information available to air traffic controllers. ILS is included in the flight plan as a minimum equipment list (MEL). To date the GBAS capability is optional.

It will therefore be assumed by ATC that if GBAS capability is provided in the flight plan than this is the desired approach, if available to the destination airport.

Another way of doing is for ATC to provide the expected approach landing. If this is not the desired approach by the pilot, than he should indicate this at first TMA contact. When possible his desires will be accommodated by TMA/Approach controller..

3.3.1.2 Phraseology

The phraseology to be used for clearing approaches with GBAS needs to be harmonized at a global level. According to ICAO PANS OPS Volume II Part III Section 3 Chapter 6 §6.8, the instrument approach chart for GBAS approach procedure shall be identified by the title GLS Rwy XX. Several States (USA, Australia, Germany and Switzerland) that have implemented GBAS Cat I operations have adapted GLS in the phraseology to clear for the approach in order to be consistent with the chart name.

From a safety perspective "GLS" could easily be mixed up with "ILS" in particular at the beginning of a radio transmission when there is a risk of cut-off or when controller or flight crew is in stress. This possibility of mix-up was confirmed by several ATCOs and pilots during the workshops and validation exercises. When optimised low visibility operations using GBAS and ILS, the potential phraseology misunderstandings might lead to an involuntary infringement of the separation if the controller expects a GLS landing and optimise the spacing while the flight crew is actually performing an ILS approach and the ILS sensitive area should be protected.

One State, Spain, has implemented GBAS CAT I with "GBAS" instead of "GLS" in both phraseology and on AIP charts

At London Heathrow where MLS is used the charts indicate MLS but on radio the controllers and flight crew uses "Micro wave'.

Note that both controllers and flight crew are always free to revert to spelling by using the radio telephony alphabet in order to further clarify a message. In this case " Golf Lima Sierra" could be recommended for use when meaning GLS.

It shall also be mentioned that when several landing procedures are published for the same runway the STAR that is published in the AIP uses different names for each of them. This type of naming convention will also help distinguishing between the two landing aids ILS and GLS.

A global consistent naming and phraseology recommendation should be published by ICAO for GBAS approach covering phraseology, charting and flight deck selection aspects. This aspect is considered as ongoing for the OSED and should be addressed and resolved at ICAO level.

Recommendation:. The GBAS phraseology shall be determined in such a way that it prevents being confused with ILS

3.3.1.3 Use of landing clearance line

The use of the landing clearance line for optimised operations using GBAS is new. Therefore, ATC procedures need to be developed for these operations and controller training needs to be performed on how to use the landing clearance line.

3.3.1.4 ATC support tools (optional)

When optimised operations are implemented the approach and runway controllers will need to apply varying and tailored distances between arrivals, depending on whether the incoming aircraft intends to perform an ILS or GBAS CAT III approach. This is associated with the requirements to consider also wake vortex and radar separation minima. In such operational environment there might be a need for ATC tools supporting the air traffic controller by taking into account several separation standards. There is a need to ensure that GBAS is considered in case this tool is being developed by operational concepts addressing final approach spacing criteria.

When GBAS/ILS operations apply current ILS criteria for spacing there may be no need to require additional support tools for ATC.

3.3.1.5 ATC Interface

The GBAS ground station status of operation need to be displayed to ATC in a similar fashion as ILS. As with ILS today, depending on local requirements some States will only display the GBAS ground station status as green/red (operational/non-operational) and some States will display the GBAS operational status at each runway end in use. This is a local implementation issue.

In ILS environment there is a requirement for some ANSP's to enable/disable the approach depending on whether the runway is in use or not. This is due to opposite runway end ILS interference. Some ANSP's also use this procedure to avoid the use of the wrong runway end due to incorrect ATC clearance or misunderstanding (there is no requirement coming from ICAO). With GBAS all approaches can be enabled no interference. This is a local decision, however. Please refer to [19] for more information.

3.3.1.6 Missed approach

3.3.1.6.1 Procedure design missed approach

For each runway at an airport there will be one or several missed approach procedures. The aim of having such procedures is to make sure that a missed approach will remain safe in relation to other traffic and terrain. Many aspects need to be considered when designing the missed approach procedures and therefore each case can be seen as very locally specific. There is a need to further explore how the missed approach procedure at candidate airports will be affected when implementing optimised GBAS operations in LVP. This is in particular true for the mixed arrival departure runway mode of operation

3.3.1.6.2 Multiple missed approaches

GBAS can serve to multiple runways which is not the case with ILS today where each runway end capable of ILS landing has a separate ILS installed. So if GBAS is out of service or GBAS is degraded several approaches are affected. There is a need to develop contingency and back up procedures for air traffic controllers to cope with multiple missed approaches on one or more runways. There is a need to assess how many go-arounds can be handled by ATC in the same time.

3.3.1.7 GBAS failure and degraded modes

Due to the technical differences of the two systems, GBAS and ILS do not have exactly the same degraded modes. The Chapter 5 addresses use cases for these situations.

In all failure or degraded mode cases, the pilot must advise ATC and receive a revised ATC clearance before changing the instrument approach being used, as this might be relevant to final approach spacing. The change should be acknowledged and steps taken to establish the required spacing. In some cases, this may require ATC to discontinue the approach. There might also be aircraft which are unable to continue with the approach and have to be re-sequenced, or diverted.

When the aircraft is established in GBAS (or ILS) it is unlikely that the pilot will be able to change the type of approach (not minima) and ground or airborne system failure will result in the instrument approach being discontinued. It is assumed that the latest point at which the pilot can change the approach is prior to 10 NM [19].

Information on failures and downgraded systems must be published by NOTAM and on the ATIS.

In terms of continuity of service, it has to be noted, that the required value is based on safety considerations and is related to an individual aircraft. There is a need to assess that multiple go-arounds are not a safety issue. The operational impact of a degradation of a GAST-D station to GAST-C operation could lead to a reduction of the availability of the station during LVP. Availability assessments need to demonstrate that the risk of degradation to GAST-C while low visibility conditions are prevailing is acceptable.

3.3.1.8 NOTAM, ATIS

The terminology to be used in the NOTAM format and ATIS message needs to include provisions for GBAS landing system. Several options were developed in P15.3.6 GAST-D CONOPS [19].

During the introduction period of GBAS CAT II/III operations, NOTAM's based on the predictable unavailability may be issued. ATC will than not provide GBAS/GLS approach clearances during these periods.

3.3.2 Aircrew Operations

3.3.2.1 GLS approach capability depending on GBAS signal performance

From an aircrew operation viewpoint, the main difference between new and previous Operating Methods is that GBAS CAT II/III using GAST D introduces the aircraft approach capability to be dependent on GBAS signal in space performance, which is new compared to ILS where only the airborne systems failures will affect the approach capability. This could lead to aircraft approach capability downgrading from LAND3 to LAND1, or upgrading from LAND1 to LAND3, depending on GBAS signal in space performance.

However, operational impact is limited, because the same operational procedures apply for changes in approach capability; despite the reason beyond the change which may be GBAS signal performance or aircraft systems failures.

3.3.2.2 Vertical deviation behaviour below 100ft

From aircrew operation viewpoint, the other slight difference between new and previous Operating Methods is the vertical deviation behaviour below 100ft:

- ILS G/S deviation is noisy, especially below 50 ft and even if displayed is not used by the crew,
- GLS G/S deviation will generally remain valid and smooth, but may be lost in some rare cases, while the LOC deviation would still be displayed, due to alerting decorrelation between lateral and vertical deviations in order to gain continuity, as vertical performance is more sensitive to continuity loss than lateral.

However, operational impact is very limited because:

- G/S deviations are not used anymore by the autopilot below 100 ft so there is no consequence on guidance,
- Pilots do not monitor G/S deviation below 100ft, because they either look outside searching for visual references or monitor the automatic flare on PFD,

Same situation could occur in ILS, in case of loss of the ILS Glide ground station

4 Detailed Operational Environment

The Operational Processes related to this OSED, as described in 6.2 Airport DOD is:

- Prepare and Execute Approach and Landing.

This operational service is part of the Arrival scenario, described in the DOD as ‘’the processes and interactions that a flight encounters from the preparation of the landing phase (some 10-15 minutes before Top of Descent) until the aircraft arrives in-block at the parking stand (CDM milestone: AIBT), for SESAR Concept Story Board Step 1.

The operational concept developed in the OSED is applicable to Category 2 (Layout & Basic Operational Criteria) and Category 4 (External Influences) airports, as defined by the 6.2 Airport Ops DOD.

4.1 Operational Characteristics

A number of airports will be modelled to assess the potential benefit of GBAS. The airports can have different runway layouts, external influencing factors and capacity needs.

4.1.1 Airspace Structure and Boundaries

The airports considered in this OSED are all surrounded by a Terminal Control Area (TMA) and approach equipped with surveillance systems. The approach includes Initial, Intermediate, Final and Missed Approach segments.
The OSED applies from the preparation of the approach phase (some 10-15 minutes before Top of Descent) when aircraft intercepts the final approach course until when the aircraft has vacated the runway.

Types of Airspace – ICAO Classification
The airspace is classified so that all traffic (IFR and VFR) is controlled.

4.1.2 Type of Approaches

The OSED applies to CAT II/III Precision Approaches and Departure Operations in visibility less than 550 m. For simplification reasons only CAT III approaches will be modelled.
For the purpose of this OSED it is assumed a straight in final approach (from FAP to DH) is an ILS-look alike straight-in segment, with a maximum 5^0 offset from the runway centreline. The GBAS technical standards currently allow offsets only for CAT I, not for CAT II or III procedures. PANS-OPS also recommend using only straight-in procedures.
The typical glide path angle $3^{0,}$ for CAT III operations conducted in low visibility conditions. The steeper glide path angles such 5^0 are out of the scope.

The capture of the final approach segment by an Radius to Fix leg (curved approach) is considered in [18].
The threshold crossing height is assumed to be variable, similarly between ILS and GBAS (about 40-60ft), although there is a recommendation in PANS-OPS (ICAO DOC 8168) to standardise on 50ft (40ft for short runways).
The missed approach could be conventional, RNAV or RNP.

4.1.3 Airspace Users

The OSED applies to all airspace users conducting CAT II/ III approach operations and departures on visibility less than 550m (mainline and business aircraft). It is assumed that aircrew is capable of performing GBAS CAT III approaches.

4.1.4 Runway Layout and Usage

The OSED applies to airports having single or multiple runways. The runways can be parallel; dependent with regard to wake vortex separation if they are separated by 1035 metres or less or independent parallel runways if separated by more than 1035 metres. The runways can also be crossing, or the final approach and/or departure tracks can converge.
The runways can be configured in segregated mode; landings and runway(s) take-off on separate runway(s), or in mixed mode (interlaced landings and take-offs on the same runway).
The concept assesses both runway configurations which makes it applicable to a variety of airport layouts.

4.1.5 Separation Minima

The following separations/spacing criteria apply for final approach:
- radar separation minima
- wake turbulence minima
- runway operations spacing constraints

Considering the removal of ILS CSA, this OSED provides a theoretical reduction of separation in the final approach. The amount of such reduction is validated in V2 and V3, by taking into account any other separation or spacing constraints such as radar minimum separation, wake turbulence minimum separation and runway occupancy constraints. Please refer to 3.2.2.6.

4.1.6 Airport airside service

The aerodrome shall provide for runway and runway visual aids (marking, lighting) suitable for CAT II and CAT III operations for both ILS and GBAS operations

4.1.7 Meteorological Services

Runway Visual Range (RVR) is measured according to the requirements of low visibility operations.

4.1.8 ATM/CNS Capabilities

Communication:
- VHF voice between ATC and aircraft.
- VHF Data Link between GBAS ground system and aircraft through a single VHF Antenna.

Surveillance:
- The surveillance systems are based on primary and secondary radars currently, a mix of radar and possibly other surveillance means in the future.
- For optimised operations, the airport uses surface surveillance coverage (A-SMGCS Level 1, SMR) in LVP.

Navigation
Ground Navaid coverage needs to support CAT II/III operations and low visibility departures. Final approach capture is made inside the GBAS station coverage. (23 NM before threshold)
Aircraft navigation equipage as required to support navigation on the initial, intermediate and missed approach segments.

4.1.9 ATC Tools

In high capacity airports, the planning of traffic entering into the TMA is supported by an AMAN. The AMAN information is updated automatically by the system as well as manually by the Executive Controller TMA to assure that the landing sequence and expected Landing Time at any time is up to date.

The Executive Controller TMA will manage speed and provide heading instructions to arriving aircraft in order to get the aircraft aligned on the final approach path at the correct distance or time behind the preceding aircraft. This will be supported by a separation tool if traffic density and complexity require. This could be the use of time based spacing or other dynamic separation methods. With such tool the Executive Controller Approach will respect the Radar and Wake Vortex separation standards. For GBAS, the tool will need to be fed with flight plan data on GBAS equipage, thus allowing runway operations separations be adapted. By default all CAT II/III capable aircraft are equipped with ILS.

In the case of mixed mode operation, it is expected that AMAN will be integrated with DMAN. The ATC Tower Runway Controller will assure that departing flights are correctly inserted into the runway sequence.

4.1.10 Ground Station Service

The GBAS ground station can provide the redundancy to enable scheduled maintenance even during CAT III operations. Maintenance personnel would be able to change some modular components of the GS individually while still providing CAT III functionality.

With respect to the operation of the GBAS ground station, it is assumed that there are basically two options for the accessibility for in-service maintenance:

a) All equipment is located in a shelter at the airport. If the equipment is in the aircraft movement area, this would imply that no maintenance could be conducted during LVP

b) Core components (e.g., processing boards) are located in a designated Maintenance Control Room. This would imply that some maintenance actions could be carried out while the ground station provides GAST-D approach service. This would enhance the availability of the ground station and may be beneficial for ANSP or airports.

4.1.11 Traffic Density

The concept applies to high capacity demanding airports. As such the recorded traffic samples of all IFR flights for 24 hours selected are representative of busy days. The ILS CAT III movements will be the baseline.

Currently for GBAS equipage the data comes from Airbus and Boeing and by expert judgement. The GBAS CAT III movements will be higher the ILS.

4.2 Roles and Responsibilities

Role	Responsibility
Tower supervisor (or other tower roles)	Tower ATC can be represented by Supervisor, Flight data assistant, Ground or Runway controller depending on local delegation of tasks. Tower ATC will manage the enabling/disabling of GBAS approaches in the cases where this equipment is operated from the tower. In some towers it is technical staff who does the actual operation of the interface equipage and the remote data terminal console is then located outside the tower premises. The tower supervisor will in most cases be the role that initiates the low visibility operations at an airport and shall inform the airport operator and the approach control unit concerned, similarly information shall be transferred when low visibility operations are no longer in use. Tower ATC is responsible for the coordination with Approach for the spacing that is needed between arrivals in order to obtain an optimised runway throughput. Tower ATC is also responsible for the input of operational data to the ATIS (Automatic Terminal Information

	Service) broadcast. If GBAS landing aid is provided for the active arrival runway this shall be put on the ATIS.
Tower runway controller	The Runway controller is assisted by an advanced surface movement guidance and control system (A-SMGCS), when available. Specific tasks for this OSED are: On a mixed arrival-departure runway • Determine the departure sequence based on the arriving traffic • Determine if the coordinated runway throughput spacing need is provided by approach control. • Be aware of what landings are making GBAS landings
Tower ground controller	The ground controller is responsible for providing clearance to the holding points before the runway for departing aircraft, or vehicles and aircraft crossing a runway. The ground controller needs to be aware of the planned sequence for departure and assign holding points accordingly when operating optimised mixed ILS/GBAS movements.
TMA/Approach controller	In this OSED we focus on arriving traffic and the related approach controller tasks are: • Provide approach clearance. • Receive/request preferred landing procedure (i.e. ILS or GBAS) from flight crew. • Sequence arriving traffic according to an AMAN proposed sequence. • Vector arriving traffic. • Space and separate arriving traffic according to the current situation and requirements per flight in an optimised manner by applying varying distance spacing depending on the landing procedure the flight crew will be using. • Get the confirmation from flight crew that ILS/GBAS approach is established.
Flight crew	Specific tasks regarding this OSED are: • The flight crew will receive the approach clearance based on what Landing aid has been input in the flight plan. • The flight crew shall report to ATC if the landing procedure proposed by approach control is not the preferred one and shall suggest another procedure in that case. GBAS instead of ILS or vice versa. • Flight crew shall be aware of the mixed use of CAT II/III and CAT I holding points when optimised GBAS/ILS operations are applied.
NOTAM officer	Responsible for updating and sending current status of the GBAS system in the NOTAM format. The information is received from Tower Supervisor.
Airline operations	Responsible for inputting GBAS capability in the flight plan.
ANSP procedure designer	Responsible for developing the GBAS landing procedures.
Airport operator	Responsible for installing and maintaining the markings, lighting and other guidance functions that are critical in LVO. Responsible for publishing LVP's for vehicle drivers at airside. Responsible for the adherence of these procedures. Often installation, operation and maintenance of precision approach navaids (ILS, GBAS) delegated from ANSP.

4.3 Human Factors

A human performance assessment has been conducted [21] to assess human performance issues triggered by the concept. The identified human performance issues led to some requirements detailed in Chapter 6.

4.3.1 Flight Crew

The main changes related to the Flight Crew operational procedures are resumed in section 3.3.2 regarding the differences between previous and new operating method.

The flight crew should also become familiar with the new GBAS phraseology to be used for approach and landing as explained in section 3.3.1.2.

When ILS and GBAS landing systems are both operational, the flight crew shall communicate to ATC the preferred approach type.

4.3.2 TMA/Approach and Tower ATC

The main changes related to ATC Approach and Tower operations are summarized in section 3.3.1. Air traffic controllers need to know which landing procedure each arrival is capable of making and what landing procedure is the preferred one..

The capability to fly ILS is today put in flight plan item 10a with designation 'S' to indicate VOR/ILS and VHF capable, but is normally not displayed on the controller interface since ILS is assumed to be commonly used by most IFR flights. The GBAS capability will also be put in item 10a with designation 'A' in the flight plan and there is a need to make this information available to air traffic controllers.

It is recommended that when optimised operations using GBAs are implemented in a mixed ILS/GBAS environment the GBAS capability is displayed in the ATC systems. Alternatively this information is communicated by the pilot on first contact with ATC and then relayed accordingly to other relevant ATC sectors. .It is important that pilots communicate to ATC the preferred approach type. ATC will try to accommodate this request.

The approach and runway controllers will manage in a new way the optimisation in terms of varying and tailored distances between arrivals. The workload from the new procedures should be acceptable by ATC.

For the runway controller working with arrivals and departures on one runway (mixed runway mode) in ILS/GBAS optimised operations good planning tools for allocating departures to the correct holding points might be needed or approach spacing tables can be used.

Regarding contingency and back up procedures in case of GBAS equipment failure it is important that controllers do not encounter workload or separation infringement issues (i.e. multiple simultaneous go-arounds on two or more runways)

The GBAS phraseology aspects for ATC are resumed in 3.3.1.2

4.4 Constraints

The main technical constraint is the ground system performance and aircraft approach capability to be dependent on GBAS signal in space performance.

The procedure design criteria for GBAS CAT II/III operations should be included in the ICAO PANS OPS. A study on procedure design criteria has been conducted in SESAR P15.3.6 and will be forwarded to ICAO panels responsible for developing new criteria and updating the ICAO PANS OPS.

Operational constraints may arise from the difference between official phraseology and safety assessments in several countries. ICAO requires using the system designation in the chart name when clearing an aircraft for approach and landing. The GBAS procedure chart is called GLS to be in line with the three letter limitation in current avionics. But the use of GLS in phraseology to clear aircraft for approach is considered as a source for oral/listening confusion, with ILS, since both landing procedures will end with the letters –LS and in (push-to-talk) aviation radiotelephony, the first letter is sometimes transmitted incomplete, if Pilot or ATC do not pay special attention. One country is already using non-ICAO phraseology for MLS for this reason.

5 Use Cases

The OSED refines the Arrival scenario described by OPS 06.02 Airport DOD. It is assumed that the DOD Arrival scenario provide an intermediate level of detail, while in this chapter, the use cases provide details on the actors/actions/systems interactions for optimised low visibility operations using GBAS

5.1 Use Case - GBAS Arrival Flight (segregated mode runway)

5.1.1 General Conditions

The use case details landing of arrival aircraft when using GBAS. The GBAS initial approach is under TMA control; and final approach under APP control and landing under tower runway control. . For aircraft vacating the runway the landing clearance line displayed in the A-SMGCS is used. The GBAS landing clearance can be provided to pilots at latest 1 NM before touchdown.

The Airport operates in arrival only runway (segregated runway mode).

The airport is assumed to be equipped with an A-SMGCS (level 1).

The GBAS Ground System is considered as the only instrument landing system available to all runways.

The GBAS/GLS procedures are developed as an overlay of ILS procedures.

The phraseology used for approach clearance is a proposal and should be decided at ICAO level.

The use case applies to low visibility conditions and low visibility procedures are in place.

The GBAS capability is indicated in the flight plan Item 10a with designation ‘A’.

ATC provides approach data for the destination airport via ATIS, if available.

ATC uses a final approach spacing tool or final approach spacing tables based on distance in order to provide optimised distances between arriving aircraft

5.1.2 Pre-Conditions

The use case starts when the aircraft is entering the terminal area.

The flight crew prepare descent and approach using GBAS.

5.1.3 Post Conditions

The use case ends when aircraft has vacated the runway.

5.1.4 Actors

- TMA/Approach Controller
- Tower Runway controller
- Tower Supervisor
- Flight Crew

5.1.5 Trigger

Flight Crew checks ATIS information regarding GBAS/GLS landing or contact TMA/APP.

5.1.6 Nominal Flow

1. ATIS provides landing runway direction; GBAS/GLS landing procedure and that LVP are in place. If ATIS is not available this information is provided by TMA/APP controller to flight crew via R/T.

2. The Flight Crew selects or manually tunes the GBAS/GLS final approach.

3. The Flight Crew checks that the GBAS station in use for the landing runway direction is correctly tuned and received with pilot verification of Reference Path ID (RPI).

Note: RPI is required by ICAO to be verified. The Airport ID and the channel number are optional as they may not be displayed on some aircraft types.

4. The TMA/APP controller initiates the approach clearance including the expected GBAS/GLS landing procedure.

5. The Flight Crew reads back the GBAS/GLS approach clearance to TMA/APP controller with Reference Path ID

6. The Flight Crew checks GBAS/GLS approach capability available on FMA on-board.

7. The TMA/APP controller organises the sequence of arriving aircraft to be established on the final approach.

8. The TMA/APP controller provides radar vectors to flight crew to intercept final approach or clears for a conventional / RNP or RNAV procedure leading to a GBAS/GLS final approach. ATC reduces final approach spacing between GBAS arrival aircraft by at least 1NM (as compared to ILS)

9. The Flight Crew intercepts the final approach either through vectoring or transitioning from RNAV mode to GLS navigation mode.

10. The flight crew confirms established on GBAS/GLS approach course.

11. TMA/APP controller provides cleared for GBAS/GLS approach message.

12. The Flight Crew (PNF) monitors continuously the GBAS/GLS CAT III approach parameters (G/S and LOC deviations) on PFD and approach capability on FMA (the FMA displays ‘LAND 3 DUAL’ or ‘LAND3 SINGLE’ to present the aircraft CAT III approach capability. Refer to 3.1.2.2.3). Approach capability status is also displayed on ECAM in case of approach capability downgrade.

13. The Flight Crew (PNF) monitors continuously GBAS/GLS autoland status.

14. The TMA/APP controller transfers the aircraft to the Tower Controller by ‘Contact tower’. The TMA/APP controller remains responsible for the control until landing, but TWR Runway controller has the radio contact.

15. The Flight Crew contacts the TWR Runway controller.

16. The Flight Crew performs an onboard distance/altitude check at 3 to 5 NM before threshold.

17. The TWR Runway controller monitors and verifies continuously using an HMI of the terminal radar, that the spacing between all arrivals is sufficient for providing the anticipated landing clearances no later than at the stipulated distances. The TWR Runway controller checks that the runway is free.

18. The Tower Runway Controller provides clearance to land at latest 1 NM before threshold.

19. The Flight Crew decides to land at decision height/ altitude (DH/A).

20. The Flight Crew reports runway vacated.

21. The Tower Runway Controller verifies that the aircraft has passed the Landing Clearance Line in the A-SMGCS HMI.

22. The Tower Controller then clears the following aircraft to land.

5.1.7 Alternate Flow

(19) **The Flight Crew does not have the required visual references at DH/DA**.

23. The Flight Crew performs a go-around.

24. The Flight Crew informs TWR Runway controller about the go around.

25. TWR Runway controller reads the missed approach procedure to the Flight Crew.

26. The Flight Crew performs the missed approach.

27. The Flight Crew repositions for another approach procedures (the same or different procedure) or divert to alternate airport.

28. Return to step 2.

5.1.8 Non-Nominal Flow

The non-nominal flow describes different failures that may occur during nominal operation steps. In brackets () is indicated the step when the failure occurs.

Step (3) T**he GBAS approach capability is downgraded onboard**

29. The flight crew is alerted by the onboard systems that GBAS capability is downgraded.

30. The flight crew checks the FMA and ECAM to verify GBAS approach capability downgrade and remaining available approach capability (e.g. LAND 1, or LAND 2 refer to 3.1.2.2.3).

31. The Flight Crew informs TMA/APP controller about the GBAS/GLS capability downgrade.

32. The Flight Crew verifies that actual weather permits CAT I or CAT II operations, according to remaining available approach capability. When weather permits only CAT III operations, go to step 23.

33. The flight crew checks the aircraft is above 1000 ft AGL. If the aircraft is below 1000ft, go to step 23.

34. The Flight Crew adjusts decision height and informs TMA/APP controller that CAT I or CAT II approach will be conducted.

35. The step returns to 13.

Step (11) T**he GBAS approach capability is downgraded onboard**

36. The Flight Crew checks the aircraft distance from threshold is 10NM or more and the approach clearance was not given.

37. The Flight Crew contact TMA/APP controller for another GBAS/GLS landing procedure.

38. The TMA/APP controller clears for another GBAS/GLS landing procedure in another runway end.

39. The Flight Crew reconfigures for the new GBAS/GLS procedure.

40. The step returns to 5

Step (31) **Two consecutive landing aircraft report that GBAS/GLS approach is unavailable.**

41. TMA/APP controller considers GBAS/GLS procedure unavailable for landing until further notice.

42. The Tower Supervisor updates the ATIS with another GBAS/GLS landing procedure. If no other GBAS/GLS landing procedure available, ATC informs flight crew to go to alternate airport.

43. The Step return to 1.

Step (36) **The aircraft distance from the threshold is less than 10 NM and approach clearance was given.**

44. The step returns to 32.

Step (37) **Only one GBAS/GLS landing procures available**.

45. The step returns to 23.

Step (13) **Any alert generated below 1000 ft and above DH/A**

46. The step returns to 23.

Step (19) **Any alert generated below DH/A**

47. The GBAS/GLS landing is completed.

Step (3) **The GBAS approach capability is lost on board**

48. The flight crew is alerted by the onboard system that the GBAS capability is lost (GNSS signal loss at aircraft level and/or loss of GBAS VDB signal)

49. The Flight Crew inform the TMA/APP controller about the GBAS capability loss.

50. The Flight Crew checks the aircraft distance from threshold is 10NM or more.

51. The step returns to 36

Step (47) **The aircraft distance from the threshold is less than 10 NM**

52. The step returns to 32

Step (5) The GBAS ground station downgrades

53. All concerned controllers are informed without delay on any downgrade of the GBAS ground station through ATC Interface or by Tower Supervisor. (The GBAS station can downgrade from GAST-D to GAST-C. GAST-C station offers CAT I operations)

54. The TMA/APP controller and or TWR Runway controller informs without delay the Flight Crew that the GBAS station is downgraded and that only CAT I operations are possible. The Flight Crew should be able to detect the ground station downgrade also through onboard GBAS monitoring equipment.

55. The Tower Supervisor updates ATIS information accordingly.

56. The step returns to 32.

Step (5) The GBAS ground station becomes unavailable

57. All concerned controllers are informed without delay on any unavailability of the GBAS ground station for approach through ATC Interface or by Tower Supervisor. (The unavailability referred here includes all GBAS ground station failures as well as VDB signal loss or VDB antenna failure)

58. The TMA/APP controller and or TWR Runway controller informs without delay the Flight Crew that the GBAS station is unavailable. The Flight Crew should be able to detect the unavailability also through onboard GBAS monitoring equipment.

59. The step returns to 23.

5.2 Use Case - GBAS Arrival Departure Flight Management (mixed mode runway)

5.2.1 General Conditions

The use case details optimised low visibility procedures when GBAS is used. The GBAS initial approach is under TMA control; final approach under APP control and landing under tower runway control. For departing aircraft the CAT III holoding point is used. For aircraft vacating the runway the landing clearance line displayed in the A-SMGCS is used. The GBAS landing clearance can be provided ato the pilots at latest 1 NM before touchdown. The airport operates in arrival and departure in the same runway (mixed runway mode).

The airport is assumed to be equipped with an A-SMGCS (level 1).

The GBAS Ground System is considered as the only instrument landing system available to all runways.

The GBAS/GLS procedures are developed as an overlay of ILS procedures.

The phraseology used for approach clearance is a proposal and should be decided at ICAO level

The use case starts when low visibility procedures are planned.

The GBAS capability is indicated in FPL Item 10a with designation 'A'.

ATC uses a final approach spacing tool or final approach spacing tables based on distance in order to provide optimised distances between arriving aircraft such as to allow when needed a departure aircraft.

The flight crew prepare descent and approach using GBAS

5.2.2 Pre-Conditions

The use case starts when the aircraft is entering the terminal area.

5.2.3 Post

The use case ends when aircraft has vacated the runway or the aircraft has departed.

5.2.4 Actors

- TMA/Approach Controller
- Tower Runway Controller
- Tower Supervisor
- Flight Crew

5.2.5 Trigger

Flight Crew checks ATIS information regarding GBAS/GLS landing or contact TMA/APP

Several aircrafts are expected for departure.

5.2.6 Nominal Flow

The nominal flow for arrival aircraft in this use case is the same as in use case 5.1
The only difference in the used case is that ATC needs to ensure that appropriate spacing is allocated between GBAS arrival aircraft is such that a departure aircraft is possible.

Therefore in this use case only the ATC actions related to arrival and departure management are included.

Planning Phase

1. Tower supervisor determines according to final approach spacing tool or final approach spacing tables what time intervals shall be provided by approach between arrivals in order to accommodate different runway occupancy times to be used in GBAS CAT III LVP conditions.

2. Tower supervisor coordinates with TMA supervisor the runway occupancy times that shall be input into the spacing tool and arrival sequence management tool settings, if used.

3. Tower supervisor and TMA supervisor check and confirm that the correct final approach spacing values have been provided to the ATC .

Execution Phase

4. TMA/APP controller uses the ATC arrival management tool or spacing tables in order to sequence arriving traffic.

5. TMA/APP controller uses and follows the minimum spacing advisory tool or spacing tables in order to provide gaps between arrivals that can accommodate the anticipated runway departures.

6. Tower Runway controller holds each departing aircraft at CAT III holding points.

7. Simultaneously the TMA/APP controllers will provide individual spacing times according to the values that have been forwarded by the tower runway controller. .

8. Tower Runway controller provides landing clearance to first arriving aircraft.

9. Flight crew read back landing clearance and land.

11. Tower Runway controller verifies on A-SMGCS HMI that the runway is free from other traffic and that the landing aircraft has passed the holding point of next departure.

12. Tower Runway controller will provide line up clearance to departing aircraft according to the planned sequence whenever possible.

13. Tower Runway controller gives line up clearance to next departing aircraft.

14. Flight crew read back line up clearance and move into take-off position.

15. Tower Runway controller monitors the line up while also monitoring the progress of next landing aircraft.

16. Preceding landing aircraft reports ‘Runway vacated’.

17. Tower Runway controller verifies that preceding arriving aircraft has vacated the runway, on A-SMGCS HMI (aircraft must have passed the landing clearance line), and verifies again that runway is free from other vehicles and obstacles.

18. Tower Runway controller gives ‘cleared for take-off’ to departing aircraft.

19. Flight crew read back departure clearance and commence take-off.

20. Tower Runway controller verifies on A-SMGCS HMI that departure is airborne.

21. Tower Runway controller simultaneously has monitored the next arriving aircraft and will provide landing clearance at latest 1 NM before touchdown. Resume step 1.

22. Tower Runway controller hand over departing aircraft to TMA/APP controller and changes the frequency of the departing aircraft.

5.2.7 Alternate Flow

The alternative flow of this use case is the same as in the first use case when GBAS only aircraft are used.

Please refer to Section 5.1.7

5.2.8 Non-Nominal Flow

The non-nominal flow of this use case is similar to the first use case when GBAS only aircraft are used.

Please refer to Section 5.1.7

5.3 Use Case – GBAS/ILS Optimised Mixed Arrival Management (segregated runway)

5.3.1 General Conditions

The use case details landing of arrival aircraft when ILS and GBAS are used for approach and landing in LVP. The GBAS or ILS initial approach is under TMA control; the final approach under APP control and the landing under tower runway control. In front of a GBAS arriving aircraft, the runway is considered vacated as soon as the preceding aircraft passes the landing clearance line. In front of an ILS arriving aircraft, the runways is considered vacated as soon as the preceding aircraft passess the CAT III holding point (the ILS CSA needs to be protected for the next arrival) For GBAS arrival the landing clearance can be provided to pilots at latest 1 NM before touchdown. For ILS arrival aircraft the landing clearance shall be provided at latest 2NM before touchdown..

The airport is assumed to be equipped with an A-SMGCS (level 1).

The ILS and GBAS landing systems are considered available to several runways ends.

The GBAS/GLS procedures are developed as an overlay of ILS procedures (for GBAS-only scenarios please refer to Use Case 1).

The airport operates in segregated runway mode.

The phraseology used for GBAS/GLS approach clearance is a proposal and should be decided at ICAO level.

The use case applies to low visibility conditions and low visibility procedures are in place.

The GBAS capability is indicated in the flight plan Item 10a with designation ‘A’.

ATC provides approach data for the destination airport via ATIS, if available.

ATC uses a final approach spacing tool or final approach spacing tables based on distance in order to provide optimised distances between arriving aircraft. In front of a GBAS arriving aircraft the spacing can be reduced at least 1NM (as compared to ILS)

5.3.2 Pre-Conditions

The use case starts when aircraft is entering the terminal area.

In this use case the Flight Crew prefers GBAS/GLS Cat III approach.

The execution is taking place in a peak hour when minimum and fully optimised spacing is desired.

The flight crew prepare descent and approach.

5.3.3 Post Conditions

The use case ends when aircraft has vacated the runway.

5.3.4 Actors

- TMA/Approach Controller
- Tower Runway controller
- Tower Supervisor
- Flight Crew

5.3.5 Trigger

Flight Crew checks ATIS information regarding ILS and/or GBAS/GLS landing or contact TMA/APP.

5.3.6 Nominal Flow

1. ATIS provides landing runway direction; ILS and GBAS/GLS landing procedures and that LVP are in place

2. The Flight Crew checks that the preferred approach GBAS/GLS is available onboard, otherwise will use ILS.

3. The Flight Crew selects or manually tunes the GBAS/GLS final approach or alternatively the ILS frequency.

4. The Flight Crew checks that the GBAS station in use for the landing runway direction is correctly tuned and verifies Reference Path ID or verifies ILS Ident.

5. The TMA/APP controller initiates the approach clearance including the expected ILS and GBAS/GLS landing procedures depending on the flight plan information.

6. The Flight Crew informs the TMA/APP controller that GBAS/GLS procedure is preferred (if not GBAS/GLS capable the flight crew will report that ILS is the preferred approach).

7. The Flight Crew reads back the GBAS/GLS/ILS approach clearance to TMA/APP controller and verifies cohesion between approach name and RPID or ILS Ident.

8. The TMA/APP controller notes the information and relays it to the adjacent downstream controller (if it is not provided automatically by the flight plan system).

9. The TMA/APP controller organises the sequence of arriving aircraft to be established on the final approach using an arrival sequencing tool that is capable of optimizing the sequence depending on GBAS/GLS capability.

10. The TMA/APP controller provides radar vectors to flight crew to intercept final approach or clears for a conventional/RNP or RNAV procedure leading to a GBAS/GLS (or ILS) final approach.

11. The Flight Crew intercepts the final approach either through vectoring or transitioning from RNAV mode to GLS (or ILS) navigation mode.

12. The flight crew confirms established on GBAS/GLS approach course (or ILS).

13. TMA/APP controller provides cleared for GBAS/GLS (or ILS) approach.

14. TMA/APP controller will use a spacing tool or final approach spacing tables in order to space GBAS/GLS approaches with less spacing than the aircraft using ILS approach whenever there are no other, more penalising spacing criteria to be respected.

15. The Flight Crew (PNF) monitors continuously the GBAS/GLS CAT III approach parameters (G/S and LOC deviations) on PFD and approach capability on FMA (the FMA displays ‘LAND 3 DUAL’ or ‘LAND3 SINGLE’ to present the aircraft CAT III approach capability. Refer to 3.1.2.2.3). Approach capability status is also displayed on ECAM in case of approach capability downgrade (or similar for ILS).

16. The Flight Crew (PNF) monitors continuously GBAS/GLS autoland status (or similar for ILS).

17. The TMA/APP controller transfers the aircraft to the Tower Controller by ‘Contact tower’. The TMA/APP controller remains responsible for the control until landing, but TWR Runway controller has the radio contact.

18. The Flight Crew contact the TWR Runway controller.

19. The Flight Crew performs an onboard distance/altitude check at 3 to 5 NM before threshold.

20. The TWR Runway controller monitors and verifies continuously using an HMI of the terminal radar, that the spacing between all arrivals is sufficient for providing the anticipated landing clearances no later than at the stipulated distances.

21. The TWR Runway controller verifies that the runway is free.

22. The Tower Runway Controller provides clearance to land at latest 0.6 NM before threshold for GBAS/GLS landings and at latest 2 NM for ILS landings.

23. The Flight Crew decides to land at decision height/ altitude (DH/A).

24. The Flight Crew reports runway vacated.

25. For GBAS/GLS landings the Tower Runway Controller verifies that the aircraft has passed the Landing Clearance Line using A-SMGCS HMI. For ILS landings the Tower Runway controller verifies that the landing has vacated the ILS sensitive area.

26. The Tower Controller then clears the following aircraft to land.

5.3.7 Alternate Flow

Step (23) **The Flight Crew does not have the required visual references at DH/DA**

27. The Flight Crew performs a go-around.

28. The Flight Crew informs TWR Runway controller about the go around.

29. TWR Runway controller reads the missed approach procedure to the Flight Crew.

30. The Flight Crew performs the missed approach.

31. The Flight Crew repositions for another approach procedures (the same or different procedure) or divert to alternate airport

32. The step returns to 2.

5.3.8 Non-Nominal Flow

The non-nominal flow describes different failures on GBAS that may occur during nominal operation steps. In number in brackets () indicates the step when the failure occurs.

Step (3) The GBAS approach capability is downgraded onboard

33. The Flight Crew is alerted by the onboard system that GBAS/capability is downgraded.

34. The Flight Crew checks the FMA and ECAM to verify GBAS approach capability downgrade and remaining available approach capability (e.g. LAND 1, or LAND 2 refer to 3.1.2.2.3)

35. The Flight Crew informs TMA/APP controller about the GBAS/GLS capability downgrade.

36. The Flight Crew verifies that actual weather permits CAT I or CAT II operations, according to remaining available approach capability. When weather permits only CAT III operations, go to step (27).

37. The flight crew checks the aircraft is above 1000 ft AGL. If the aircraft is below 1000ft, go to step 27.

38. The Flight Crew adjusts decision height and informs APP controller that CAT I or CAT II approach will be conducted.

39. The step returns to 16.

Step (10) The GBAS approach capability is downgraded onboard

40. The flight crew checks the aircraft distance from threshold is 10NM or more and the approach clearance was not given.

41. The flight crew contact TMA/APP controller to request another landing procedure.

42. The TMA APP clears the flight crew for another GBAS/ILS procedure permitting CAT III operations. The TMA/APP relays this information to the Tower Runway Controller.

43. The flight crew reconfigure the aircraft for the new GBAS/ILS landing procedure.

44. The flight crew reads back the GBAS/ILS landing procedure.

45. The flight crew reports established on GBAS/ILS Localizer course.

46. The step returns to 13.

Step (40) **The aircraft distance from the threshold is less than 10 NM and approach clearance was given**.

47. The step returns to 36.

Step (33) **Two consecutive landing aircraft report that GBAS/GLS approach is unavailable**

48. TMA/APP controller considers GBAS/GLS procedure unavailable for landing until further notice.

49. The Tower Supervisor updates the ATIS removing the GBAS/GLS landing procedure.

50. The Step returns to 1.

Step (13) **Any alert generated below 1000 ft and above DH/A**

51. The step returns to 27.

Step (21) **Any alert generated below DH**

52. The Flight Crew continues the landing.

53. The step returns to 24.

Step (3) The GBAS approach capability is lost on board

54. The Flight Crew is alerted by the onboard system that the GBAS capability is lost (GNSS signal loss at aircraft level and/or loss of GBAS VDB signal)

55. The Flight Crew informs the TMA/APP controller about the GBAS capability loss

56. The step returns to 36.

Step (5) The GBAS ground station downgrades

57. All concerned controllers are informed without delay on any downgrade of the GBAS ground station through ATC Interface or by Tower Supervisor. (The GBAS station can downgrade from GAST-D to GAST-C. GAST-C station ofers CAT I operations)

58. The TMA/APP controller and/or TWR Runway controller informs without delay the Flight Crew that the GBAS station is downgraded and that only CAT I operations are possible. Aircraft already cleared for and established on final approach may complete the CAT III operation. .

59. The Tower Supervisor updates ATIS information accordingly.

60. The step returns to 36.

Step (5) The GBAS ground station becomes unavailable

61. All concerned controllers are informed without delay on any unavailability of the GBAS ground station for approach through ATC Interface or by Tower Supervisor. (The unavailability referred here includes all GBAS ground station failures as well as VDB signal loss or VDB antenna failure)

62. The TMA/APP controller and or TWR Runway controller informs without delay the Flight Crew that the GBAS station is unavailable. The Flight Crew should be able to detect the unavailability also through onboard GBAS monitoring equipment.

63. The step returns to 36.

5.4 Use Case – GBAS/ILS Arrival/Departure Flight Management (mixed mode runway)

5.4.1 General Conditions

The use case details landing of arrival aircraft when ILS and GBAS are used for approach and landing in LVP. The GBAS or ILS initial approach is under TMA control; the final approach under APP control and the landing under tower runway control. In front of a GBAS arriving aircraft, the runway is considered vacated as soon as the preceding aircraft passes the landing clearance line. In front of an ILS arriving aircraft, the runways is considered vacated as soon as the preceding aircraft passes the CAT III holding point (the ILS CSA needs to be protected for the next arrival) For GBAS arrival the landing clearance can be provided to pilots at latest 1 NM before touchdown. For ILS arrival aircraft the landing clearance shall be provided at latest 2NM before touchdown.

.

For both ILS and GBAS departing aircraft the CAT III holding point is used

The airport operates in mixed runway mode.

The airport is assumed to be equipped with an A-SMGCS (level 1).

The GBAS/GLS procedures are developed as an overlay of ILS procedures (for GBAS-only scenarios please refer to Use Case 1).

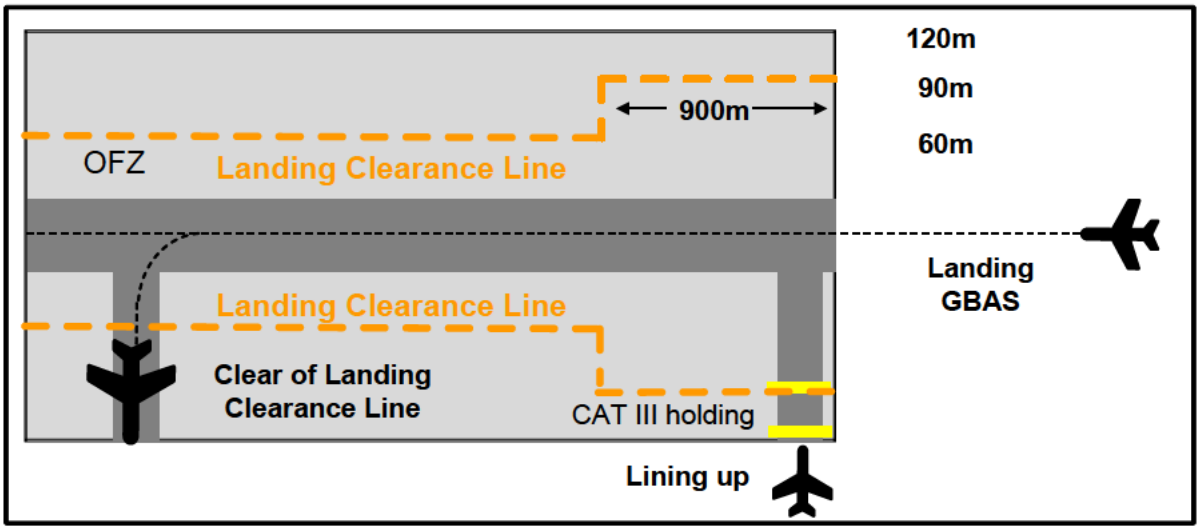
The phraseology used for GBAS approach clearance is a proposal and should be decided at ICAO

The use case applies to low visibility conditions and low visibility procedures are in place.

The GBAS capability is indicated in the flight plan Item 10a with designation 'A'.

ATC provides approach data for the destination airport via ATIS, if available.

ATC uses a final approach spacing tool or final approach spacing tables based on distance in order to provide optimised distances between arriving aircraft and allow for a departure in between two arrivals when needed. In front of a GBAS arriving aircraft the spacing can be reduced at least 1NM (as compared to ILS)



5.4.2 Pre-Conditions

The use case starts when aircraft is entering the terminal area.

The execution is taking place in a peak hour when minimum and fully optimised spacing is desired.

The flight crew prepare descent and approach.

5.4.3 Post Conditions

The use case end when aircraft vacates the runway or departs

5.4.4 Actors

- TMA/Approach Controller
- Tower Runway controller
- Tower Supervisor
- Flight Crew

5.4.5 Trigger

Several arriving GBAS equipped aircraft are expected to enter the TMA.

Several aircrafts are expected to depart.

Flight Crew checks ATIS information regarding ILS and/or GBAS/GLS landing or contact TMA/APP.

5.4.6 Nominal Flow

The nominal flow for arrival aircraft in this use case is the same as in use case 5.3.

The only difference in the used case is that ATC needs to ensure that appropriate spacing is allocated between GBAS arrival aircraft or GBAS and ILS arrival aircraft such that a departure aircraft is possible.

Therefore in this use case only the ATC actions related to arrival and departure management are included.

Planning Phase

1. Tower supervisor determines according to final approach spacing tool or final approach spacing tables values what time intervals shall be provided by approach between arrivals in order to accommodate different runway occupancy times to be used in ILS and GBAS CAT III LVP conditions

2. Tower supervisor coordinates with TMA supervisor the runway occupancy times that shall be input into the spacing tool and arrival sequence management tool settings, if such tool is used.

3. Tower supervisor and TMA supervisor check and confirm that the correct final approach spacing values have been provided to the ATC.

Execution Phase

4. TMA/APP controller uses the ATC arrival management tool or spacing tables in order to sequence arriving traffic.

5. TMA/APP controller uses and follows the minimum spacing advisory tool or spacing tables in order to provide gaps between arrivals that can accommodate the anticipated runway departures.

6. Tower Ground controller checks before push-back with each departure the capability to depart at position CAT III holding point. The tower ground controller also checks if the arriving aircraft is at required distance from threshold

7. Tower Runway controller holds each departing aircraft at CAT III holding points.

8. Simultaneously the TMA/APP controllers will provide individual spacing times according to the values that have been forwarded by the tower runway controller.

9. Tower Runway controller provides landing clearance to first arriving aircraft, if GBAS at altest 1 NM , if ILS at latest 2NM.

10. Flight Crew reads back landing clearance and lands.

11. Tower Runway controller verifies on A-SMGCS HMI that the runway is free from other traffic and that the landing aircraft has passed the holding point of next departure.

12. Tower Runway controller will provide line up clearance to departing aircraft according to the planned sequence whenever possible.

13. Tower Runway controller gives line up clearance to next departing aircraft.

14. Flight Crew reads back line up clearance and moves into take-off position.

15. Tower Runway controller monitors the line up while also monitoring the progress of next landing aircraft.

16. Preceding landing aircraft reports ‘Runway vacated’.

17. Tower Runway controller verifies that preceding arriving aircraft has left the runway,. Tower runway controller uses the landing clearance line when the next arrival is GBAS or the CAT III holding when the next arrival is ILS on A-SMGCS HMI, and verifies again that runway is free from other vehicles and obstacles.

18. Tower Runway controller gives ‘cleared for take-off’ to departing aircraft.

19. Flight Crew reads back departure clearance and commences take-off.

20. Tower Runway controller verifies on A-SMGCS HMI that departure is airborne.

21. Tower Runway controller simultaneously has monitored the next arriving aircraft and will provide landing clearance. Resume step 1.

22. Tower Runway controller hand over departing aircraft to TMA/APP controller and changes the frequency of the departing aircraft Operational Scenario 1 (to be repeated for each scenario)

5.4.7 Alternate Flow

The alternative flow of this use case is the same as in the third use case (5.3) when GBAS and ILS are both used.

Please refer to Section 5.3.7

5.4.8 Non-Nominal Flow

The non-nominal flow of this use case is similar to the third use case (5.3) when GBAS and ILS aircraft are used.

Please refer to Section 5.3.7

6 Requirements

6.1 GBAS System Requirements

6.1.1 Aircraft

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0010
Requirement	The aircraft's on-board GLS function to land shall be able to operate with any Cat II/III GLS ground station compliant with ICAO Annex 10 GAST D
Title	Aircraft compliance to ground station
Status	<Validated>
Rationale	The application of this requirement will allow the aircraft with the on-board GLS function to land on any runway equipped with any type of Cat II/III GLS ground station compliant with ICAO standards.
Category	<Interoperability>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Aircraft	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0020
Requirement	The ILS on-board design shall be the reference for the on-board GLS CAT II/III approach selection, display, guidance, warning, considering the ILS look-alike concept
Title	ILS look-alike concept
Status	<Validated>
Rationale	This requirement allows the following benefits: • Reduced systems impact. • Limited training for crews: crews already know how to operate ILS approaches down to the runway. By using almost the same definition for selection, display and warning, crews would be able to use the already developed skills for the new GLS system. • Improved operational efficiency: crews have already developed skills on a very close system. The behaviour of the new one, being as close as possible to the existing one, should not surprise the crews.
Category	<Design>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Aircraft	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0030
Requirement	The GLS Cat II/III aircraft precision approach capability shall provide the flight air crew with accurate and timely information on GLS service degradation and failures.
Title	Aircraft status monitoring and GAST-D
Status	<Validated>
Rationale	With the introduction of GAST D concept for Cat II/III performance requirement, the aircraft approach capability shall take into account availability of GAST D or GAST C active service type. GLS service information shall be displayed to air crew to allow them to perform predefined operational procedures in case of service degradation or failure.
Category	<Interoperability>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Aircraft	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0040
Requirement	The aircraft shall be capable to perform guided take-off based on GLS lateral guidance, similar to the existing ILS based take-off.
Title	GLS guided take-off
Status	<Validated>
Rationale	Provide similar capability to ILS based guided take-off
Category	<Design>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Aircraft	N/A

6.1.2 Ground System

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0050
Requirement	The GBAS ground system shall be able to provide for GBAS CAT II/III precision approach capability to any GLS CAT III capable aircraft, as defined in ICAO Annex 10 GAST D SARPS
Title	Ground station conformity
Status	<Validated>
Rationale	The application of this requirement will allow the ground station to provide for GBAS CAT II/III precision approach to GLS arrival aircraft.
Category	<Interoperability>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Ground station	N/A

Identifier	REQ-06.08.05-OSED-GBAS.0060
Requirement	The GBAS GAST-D ground station shall provide accurate and timely information on GBAS service degradation and failures to the relevant maintenance of ATC units

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Ground station	N/A

Identifier	REQ-06.08.05-OSED-GBAS.0070
Requirement	The GBAS GAST-D ground station shall provide timely information on the GBAS service availability for each runway end for which an approach is provided

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Ground station	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0080
Requirement	The GBAS ground stations shall provide for guided take-off service similar to the existing ILS based take-off.
Title	GLS guided take-off
Status	<Validated>
Rationale	Provide similar capability to ILS based guided take-off
Category	<Design>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Ground station	N/A

6.2 GBAS Operational Requirements

6.2.1 Flight crew

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0090
Requirement	The Flight Crew shall be able to perform precision approaches in Low Visibility Conditions using GBAS CAT II/III (based on GPS L1)
Title	Aircraft capability
Status	<Validated>
Rationale	The Flight Crew shall be able to perform precision approaches in Low Visibility Conditions using GBAS CAT II/III (based on GPS L1)
Category	<Design>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Air crew	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0100
Requirement	At any time during the flight, the crew shall be aware of aircraft GLS Cat II/III approach capabilities if equipment availability and/or navigation performance is downgraded
Title	Aircraft status monitoring
Status	<Validated>
Rationale	The crew needs to know approach capability whatever the flight phase, in order to prepare the approach in advance
Category	<Operational>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Flight Crew	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0110
Requirement	The flight crew shall be able to perform a safe operation in case of provision of GBAS CAT II landing clearance by ATC as late as 1 NM before touchdown.
Title	Aircraft status monitoring
Status	<Validated>
Rationale	The provision of late landing clearance by ATC to pilots as late as 1NM allows for optimised LVP using GBAS. This should be acceptable by pilots and not impair their ability to land safely
Category	<Operational>
Validation Method	<Real Time Simulation>

Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Flight Crew	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0120
Requirement	When both ILS and GBAS procedures are available, the flight crew shall communicate to ATC the preferred approach type
Title	Mixed ILS/GBAS operations
Status	<Validated>
Rationale	When ATIS or ATC provides more than one approach available in LVP, both ILS and GBAS), the flight crew shall indicate to ATC which approach type is preferred.
Category	<Operational>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Flight Crew	N/A

6.2.2 Air traffic control

Identifier	REQ-06.08.05-OSED-GBAS.0130
Requirement	The Tower Runway Controller shall be able to use the landing clearance line (displayed in the A-SMGCS) for aircraft vacating the runway in front of a GBAS arrival aircraft.

[Req Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

Identifier	REQ-06.08.05-OSED-GBAS.0140
Requirement	The Tower Runway Controller shall be able to provide a late landing clearance as late as 1NM before touchdown to air crew performing a GBAS approach in LVP.

[Req Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A

<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

[Req]

Identifier	REQ-06.08.05-OSED-GBAS.0150
Requirement	The final approach controller and Tower Runway Controller shall be able to reduce final approach spacing before GBAS equipped arrival aircraft (as compared with today ILS) under low visibility operations

[Req Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0160
Requirement	ATC shall be provided the GBAS station status indication (red/green)
Title	GBAS station status on ATC Interface
Status	<Validated>
Rationale	The implementation of ATC interface is a local decision. Some States may display the status of GBAS/GLS approach for each runway in use. At least the status of the GBAS ground station status is required to be provided. For more information refer to [Ref, Sec 6.4]
Category	<HMI>
Validation Method	<Fast Time Simulation><Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC HMI	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0170
Requirement	The air traffic controller shall be displayed information on GBAS aircraft capabilities
Title	GBAS aircraft capabilities on ATC HMI
Status	<Validated>
Rationale	With ILS, the information in flight plan item 10a is not displayed to air traffic controller as it is assumed that all aircraft are equipped with ILS by default. With GBAS, particularly in LVP the air traffic controller needs to be displayed in relevant ATS systems if the aircraft is GBAS capable for approach clearance. In case an ATC tool is used for sequencing of aircraft in final approach aircraft GBAS capability should be an input to such tool.
Category	<HMI>
Validation Method	<Fast Time Simulation><Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC HMI	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0180
Requirement	ATC shall be able to differentiate between ILS and GBAS capable aircraft when both landing aids are used for approach and landing.
Title	Mixed ILS/GBAS operations
Status	<Validated>
Rationale	ATC shall be able to know which aircraft is equipped with GBAS. This can be achieved through HMI extracting this information from the flight plan. Or this communication is passed by air crew radio contact and noted by ATC in electronic or paper strips and relayed to the other relevant control units.
Category	<Operational>
Validation Method	<Fast Time Simulation><Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute approach and landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC HMI	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0190
Requirement	ATC shall be able to manage the landings of aircraft when both ILS and GBAS are used in LVP
Title	Mixed ILS/GBAS operations
Status	<Validated>
Rationale	ILS and GBAS are expected to co-habit for some years to come. ATC should be aware which aircraft is using ILS and which is using GBAS for approach through flight plan information and radio communications with air crew.
Category	<Operational>
Validation Method	<Fast Time Simulation><Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0200
Requirement	ATC shall be able to provide service degradation/failure information in a timely and safe manner to aircrafts when both ILS and GBAS are used in LVP
Title	Mixed ILS/GBAS operations
Status	<Validated>
Rationale	ILS and GBAS are expected to co-habit for some years to come. ATC should be aware which aircraft is using ILS and which is using GBAS for approach. and landings in order to provide timely information to air crew in case of any service degradation or failure.
Category	<Safety>
Validation Method	<Fast Time Simulation><Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance

<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0210
Requirement	ATC shall ensure no infringement of ILS CSA and OFZ during mixed ILS/GBAS landings through correct application of the landing clearance line and CAT III holding points for aircraft vacating the runway
Title	ATC procedures for landing clearance – specific constraint
Status	<Validated>
Rationale	In mixed ILS/GBAS landing, the tower runway controller uses the landing clearance line for aircraft vacating the runway before a GBAS arrival, and the CAT III holding point for aircraft vacating the runway before an ILS arrival.
Category	<Safety>
Validation Method	<Fast Time Simulation><Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0220
Requirement	ATC shall be able to manage GBAS station failures that affect multiple runway ends when only GBAS is used.
Title	ATC Procedures on GBAS station failures
Status	<Validated>
Rationale	The GBAS station failure may affect several runway ends (not the case with ILS). ATC procedures shall be aware of this nd able to manage the situation.
Category	<Safety>
Validation Method	<Fast Time Simulation><Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute approach and landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0230
Requirement	ATC shall be able to manage GBAS service degradation when only GBAS is used and when both ILS and GBAS are used for approach and landings
Title	ATC Procedures on GBAS service degradation
Status	<Validated>
Rationale	The GBAS service degradation may affect one or several runway ends. ATC procedures shall be developed to address this situation
Category	<Safety>

Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute approach and landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0240
Requirement	The phraseology used for GBAS approaches shall be determined in such a way that it prevents being confused with ILS
Title	Phraseology for degraded conditions
Status	<Validated>
Rationale	The phraseology used for clearing GBAS aircraft should be such as to prevent confusions with ILS. It is desired that chart naming and phraseology also are consistent.
Category	<Operational>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC, Flight Crew	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0250
Requirement	The air traffic controllers shall receive a training on optimised low visibility operations using GBAS
Title	Phraseology for degraded conditions
Status	<Validated>
Rationale	The use of landing clearance line and the provision of late landing clearance are new procedures not part of standard ATC training syllabus.
Category	<Operational>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ATC, Flight Crew	N/A

6.3 Implementation Requirements

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0260
Requirement	The phraseology to be associated with GBAS operations shall be coordinated at global level, through ICAO
Title	Phraseology to clear the approach
Status	<In Progress>
Rationale	It is very important to use the same phraseology for GBAS/GLS approach clearance for global interoperability reasons. The ICAO PANS OPS has names the chart title GLS chart, The name of the chart is usually used for approach clearance. The ICAO PANS ATM suggests GBAS to be used. A solution need to be identified and proposed.
Category	<Interoperability>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ICAO	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0270
Requirement	The GBAS ground station information shall be promulgated in AIP.
Title	AIP requirements
Status	<Validated>
Rationale	When States implement GBAS/GLS CAT II/III operations, relevant information regarding GBAS station as a landing aid is to be included in AIP AD 2.19
Category	<Interoperability>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<APPLIES_TO>	<Operational Process>	Execute approach and landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ANSP	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0280
Requirement	ANSP shall distribute NOTAM in case of unavailability of the GBAS/GLS service
Title	NOTAM
Status	<Validated>
Rationale	NOTAM are usually used by pilots and flight dispatchers before the flight. Regarding GBAS the NOTAM will include any known service unavailability, downgrade of service, time and expected duration of degradation
Category	<Interoperability>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<APPLIES_TO>	<Operational Process>	Execute approach and landing	N/A
<APPLIES_TO>	<Operational Focus	OFA01.01.01	N/A

	Area>		
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ANSP	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0290
Requirement	ATC shall broadcast ATIS information regarding available GBAS/GLS approaches in LVP
Title	ATIS information on available approaches
Status	<Validated>
Rationale	ATIS information is very useful to provide the pilots information regarding the status of available GBAS/GLS approaches well before first contact with ATC in the TMA. This reduces pilot workload and relieves frequency congestion. ATIS should not include information already in AIP
Category	<Interoperability>
Validation Method	<Expert Group (Judgement Analysis)>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<APPLIES_TO>	<Operational Process>	Execute approach and landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	ANSP	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0300
Requirement	The aircraft operator shall provide information on GBAS aircraft capabilities in the flight plan item 10.a
Title	Flight plan information
Status	<Validated>
Rationale	The flight plan item 10a with a designator ‘A’ means the aircraft is GBAS equipped. This only means aircraft is GBAS capable (not which category of operation Cat I or Cat II/III). The air traffic controller needs to know if the aircraft is GBAS capable for approach clearance. The GBAS capability is confirmed by flight crew via RTF upon initial contact.
Category	<Operational>
Validation Method	<Flight Trial>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute Approach and Landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Airline operations	N/A

[REQ]

Identifier	REQ-06.08.05-OSED-GBAS.0310
Requirement	A-SMGCS shall be implemented for optimised low visibility operations using GBAS
Title	A-SMGCS Level 1
Status	<Validated>
Rationale	The air traffic controller will use A-SMGCS Level 1 HMI to determine whether the aircraft has cleared the runway.
Category	<Interoperability>

Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-06.02-DOD-6200.0025	<Partial>
<APPLIES_TO>	<Operational Process>	Execute approach and landing	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA01.01.01	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	ALL	N/A
<ALLOCATED_TO>	<Operator>	Airport, ANSP	N/A

6.4 Information Exchange Requirements

This section has to be filled in for V2 and refined in V3.

This section shall describe the subset of the operational requirements associated with an information exchange. The information exchange requirements develop the DOD information exchange needs which are applicable to the Operational Focus Area addressed by this OSED (i.e. there is at least an intended addressee of the exchange who is an actor in the OFA).

The OSED defines the requirements, which will be completed with quantitative characterisation in the Safety and Performance document (SPR).

The Information Exchange Requirements address the information to exchange between actors. They are deduced from the interactions between processes or from the services.

The requirements shall be traced with respect to the high level operational requirements identified in the DOD, when available:

- *For Step 1, if the DOD is not available, a provisional description of Information Exchange Requirements shall be provided, based on the description of the Process in the OSED;*
- *For step 2 & 3 where a top down approach is applied, the requirements shall be derived from the DOD and based on the description of the Process in the OSED.*

A coordination shall be done with WP08 to fill out the IER table properly.

In order to enable the import of SE Data in the SESAR SE Repository, the description shall use the layout described in ***Error! Reference source not found.****. The layout is illustrated below.*

[IER]

Identifier	Name	Issuer	Intended Addressees	Information Element	Involved Operational Activities	Interaction Rules and Policy	Status	Rationale	Satisfied DOD Requirement Identifier	Service Identifier
									DOD Requirement Identifier<Partial>	Service Identifier

Table 6-1: IER layout

The Identifier field contains the Operational project number, owner of the requirement.

If the information element already exists in the AIRM then provide its name in the AIRM. Else either put the name of the information element and provide the description of the information element using the information element template in Appendix B, or provide the name of the information element and the reference to an external / standard source.

In the fields "Issuer" and "Intended addressees", the use of roles defined by B.04.02 in ***Error! Reference source not found.*** *should be preferred. The syntax of the roles shall be respected, either using B.04.02 roles or using roles defined in the OSED.*

If the service portfolio already contains a service which fulfils the Information Exchange Requirement, this last should trace to this service in the field "Service Identifier".

7 References

7.1 Applicable Documents

This OSED complies with the requirements set out in the following documents:

[1] Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[2] Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[3] Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Toolbox%20User%20Manual.doc

[4] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

7.2 Reference Documents

The following documents were used to provide input/guidance/further information/other:

[5] ICAO–NSP, GBAS CAT II_III Development Baseline SARPs Proposal, 28/05/10

[6] ICAO–NSP, Conceptual Framework for the Proposal for GBAS to Support CAT III Operations, version 6.5

[7] EUROCONTROL GBAS Operational Use Description (CONOPS), Appendix 2 Initial GBAS CAT II/III functional description

[8] EUROCONTROL GBAS Operational Use Description (CONOPS), Appendix 3 Final GBAS CAT II/III functional description

[9] ICAO EUR Doc.013 'European Guidance Material on All Weather Operations at Aerodromes', 4th Ed. Sept.2012

[10] EUROCONTROL Landing Clearance Line Determination, version1.4, 21 Dec 2010

[11] EUROCONTROL Safety Assessment of Optimised Operations in Low Visibility Conditions utilising landing clearance delivery position and/or landing clearance line concept,version1.5, 15 Dec 2010

[12] ICAO Doc.4444 Procedures for Air Navigation Services Air Traffic Management (PANS-ATM)

[13] ICAO Annex 10, Volume I, Radio Navigation Aids

[14] ICAO Annex 14 Volume I, Aerodrome Design and Operations

[15] ICAO Annex 3 Meteorological Service for International Air Navigation

[16] ICAO Circular 301, New Larger Aeroplanes, Infringement of the Obstacle Free Zone: operational measures and aeronautical study – 2006 section 1.3.1

[17] EU OPS, Subpart E, All Weather Operations, Ops 1.430, Appendix 1 (new)

[18] SESAR P6.8.5 RNP to GLS OSED

[19] SESAR P15.3.6 Deliverable 20 'GBAS GAST-D CONOPS', Final version, July 2012

[20] SESAR P06.08.05-D48-Concept Validation Plan for GBAS CAT II-III for V3

[21] SESAR P06.08.05-D49-GBAS CAT II-III Concept Validation Execution for V3

[22]SESAR OFA 01 01 01 GBAS CAT III L1 Safety Assessment Report (SAR) Ed 00 01 00 Final, January 2015

[23]SESAR P06.08.05 D11 GBAS CATII/III Functional Description Update Report V2, May 2013

[24]SESAR 06.02 Step 1 Airport DOD 2014 Update, December 2014

7.3 Transversal Areas References

[25]SESAR B4.1 Performance Framework, Edition 2, November 2014

[26]SESAR Safety Reference Material, https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[27]SESAR Human Performance Reference Material , https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

Appendix A Low visibility take-offs using GBAS

Previous Operating Method

Some aircraft are equipped with a take-off guidance system that provides directional guidance information to the pilot during the take-off. This operation is referred to as a guided take-off. Whenever an aircraft is conducting a guided take-off, the guidance signal (normally the ILS or MLS localizer) must be protected. Guided take-offs may not operate in some countries.

In some States it is mandatory for the pilot to conduct a guided take-off below 125 m RVR (150 m for Cat D aircraft), but a pilot may request to conduct a guided take-off at any time. ATC must then inform the pilot if the guidance signal is or is not protected. The conditions under which guided take-offs are available should be published in the AIP.

In today's operational environment, the establishment of LVP is also required where runways are used for departure operations in RVR conditions less than a value of 550 m, even if the runway is not equipped for CAT II/III approach and landing. If notified by a pilot of an intention to conduct guided take-off, *ATC must not allow aircraft or vehicles within the applicable ILS localiser critical and sensitive areas during the conduct of the take-off as described in Annex 10, vol.1, attachment C, 2.1.9.1*

The guided take-off concept described here applies to Lower than Standard Category I Operations as defined by EASA [17].

In particular, paragraph (a) Take-off minima, sub-paragraph (4) (ii), states that:
"Subject to the approval of the Authority, an operator of an aeroplane using either:

a. an approved lateral guidance system; or,
b. an approved HUD/HUDLS for take-off may reduce the take-off minima to an RVR less than 125 m (Category A, B and C aeroplanes) or 150 m (Category D aeroplanes) but not lower than 75 m provided runway protection and facilities equivalent to Category III landing operations are available."

HUD allows reducing the take-off RVR from 125m to 75m (EASA world) or 500ft to 300ft (FAA world) thanks to specific HMIs (yaw bar, LOC deviation...) when departing on Cat III approved runways.

PFD (Primary Flight Display) displays the same kind of HMIs but since the PFD is not superimposed with the real external view, it cannot be used for RVR reduction at take-off.

Note: PVI (Para Visual Indicator) also allows reducing take-off RVR from 125m to 75m (EASA world) or 500ft to 300ft (FAA world) thanks to lateral guidance information.

Guided Take-Off based on ILS - Aircrew Operation

When the LOC signal is available, the RWY guidance mode gives lateral guidance orders during takeoff, and initial climb.

The RWY guidance law aims at maintaining the aircraft on the runway centreline during the take-off run, and on the LOC beam when the aircraft is airborne. To do so, RWY mode provides the FD yaw bar order. The yaw bar is only available if the runway has a LOC aligned with the runway centreline.

RWY mode arms when the aircraft approaches the runway threshold.

When the flight crew sets the thrust levers to FLX or TOGA for take-off, RWY mode engages, and the yaw bar appears on PFD and HUD.

The yaw bar indicates the correction that the flight crew must apply to the rudder pedal, in order to move the aircraft to the runway centreline.

The LOC deviation symbol indicates the position of the aircraft in relation to the runway centreline.

The combination of both helps the flight crew perform an accurate take-off roll.

In the illustration below, the aircraft is on the left side of the runway centreline, and the yaw bar provides an order to go the right side.

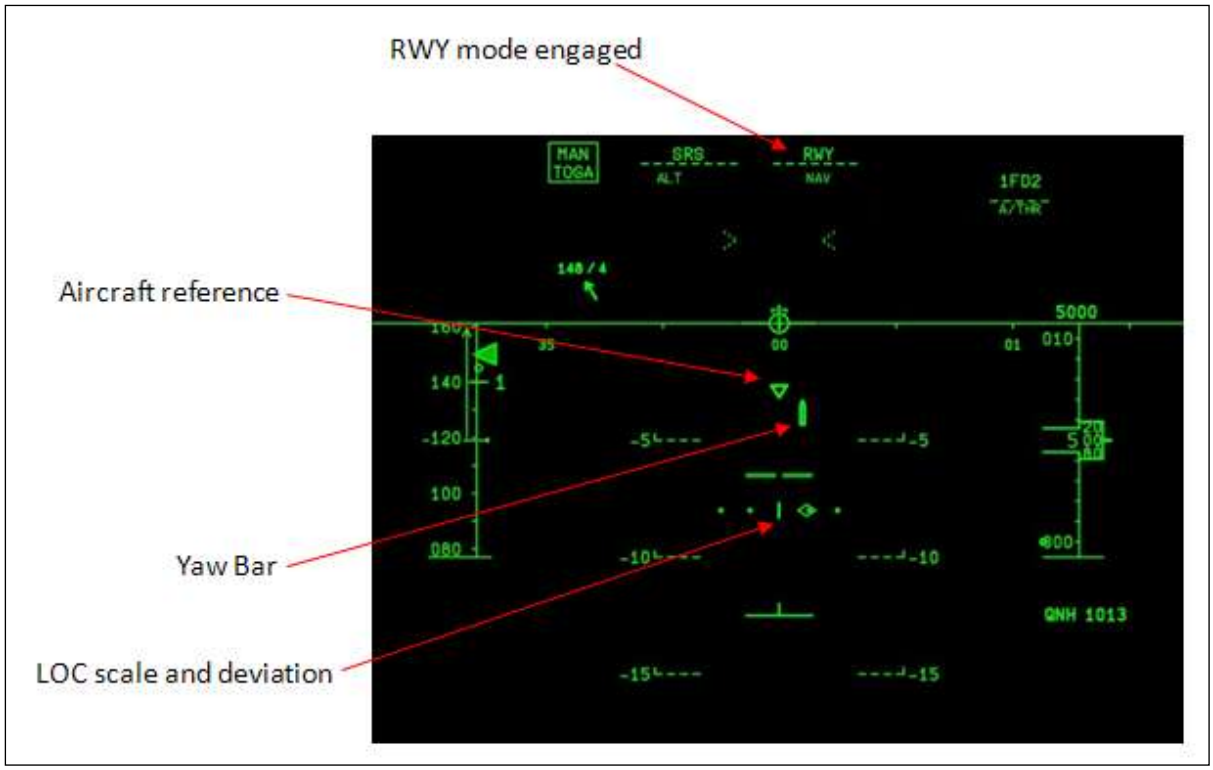


Figure 12: GBAS guided take-off information on HUD

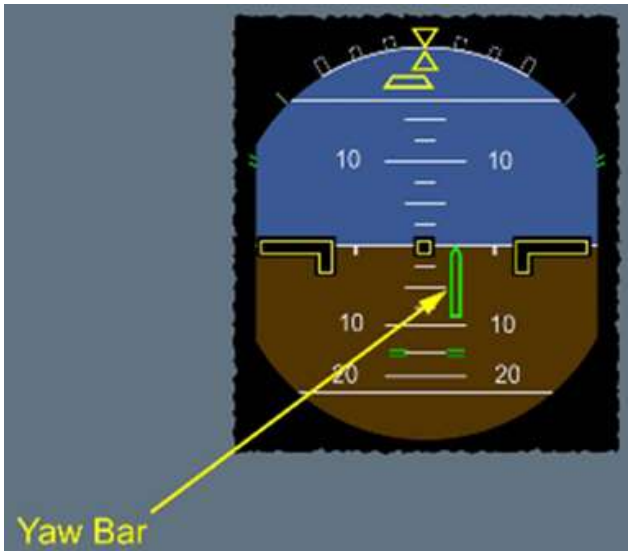


Figure 13: Yaw bar on PFD

The flight crew must use both the LOC deviation and the yaw bar to smoothly direct the aircraft to the runway centreline, in addition to the external parameters.

RWY mode disengages and yaw bar disappears soon after take-off (at 30 or 50 ft RA, depending whether NAV guidance mode is armed).

Guided take-off based on GBAS – ATC Perspective

When GBAS is used for guided take-off, ATC do not need to protect the ILS CSA.

All other requirements remain the same as for ILS.

Guided take-off based on GBAS - Aircrew operation

Low visibility take off from aerodromes not open to CAT II and CAT III operations is allowed only if special procedures have been implemented. Pilots must hold a valid instrument license for low visibility operations and ratings concerning low visibility operations they intend to perform.

With ILS or localizer approaches, at certain airports where only one runway end is equipped with ILS or LOC, the back course of the localizer is utilized to serve the opposite non-equipped runway end.

From aircrew operation viewpoint, the new GLS guided take-off operating method will be identical to previous ILS guided take-off operating method, except that:

- With ILS, when only one QFU of a runway was ILS-equipped, a take-off on the opposite QFU necessitated to perform a back course take-off.
- While with GLS, ground station providing approach capacity to all runway ends, there will be no need to perform back course take-off.

Differences between new and previous Operating Methods

Guided take-off - Aircrew operation

From aircrew operation viewpoint, the only difference between new and previous guided take-off operating methods is that no back course take-off needs to be performed with new operating method.

Appendix B Milan Malpensa LVO Procedures

An example of LVO spacing applied to Milan Malpensa airport (LIMC) is provided below.

- In Standard scenario (DEP 35R – ARR 35L) following spacing are applied:

(SMR in use)

Conditions	Spacing (NM)
• 1500 > RVR TDZ > 550 m or ceiling= 200 ft	**6**
• RVR TDZ ≤ 550 m or ceiling < 200 ft • Usage of TWY H	**8**
• RVR TDZ ≤ 550 or ceiling< 200 ft • Usage of TWY GW and H	**10**

(SMR not available)

Conditions	Spacing (NM)
• 1500 > RVR TDZ > 550 m or ceiling= 200 ft	**10**

In a Scenario with a single RWY in operations, following spacing are applied:

(SMR in use)

Conditions	Spacing (NM)
• 1500 > RVR > 550 m or ceiling= 200 ft	**10**
• RVR TDZ ≤ 550 m or ceiling < 200 ft	**15***
• RVR TDZ < 150 m	**20**

* If needed this value can be reduced to 10NM on ATC discretion and with no departures

(SMR not available)

Conditions	Spacing (NM)	Rate (n/hour)
• 1500 > RVR > 800 m	**10**	**15**
• 800 > RVR > 550 m or ceiling = 200 ft	**15**	**10**
• RVR < 550 m or ceiling < 200 ft	**-**	**6 (Total)**

In case of 6 total movements, the rate of movements will be agreed between the Milan ACC and Milan Malpensa airport ANSP in order to balance the possible incoming traffic with departures.

The distances have to be considered between the TDZ and the following approach.
Minimum separations are based on expected aircrafts speed.

Appendix C NATS London Heathrow Procedures

TOI 040/13

MLS Phase 3

User Group(s): VCR, VCF Effective: 10 June 2013

Introduction

Following further research and development work, MLS Phase 3 procedures are to be introduced. This will result in reduced spacing **ahead** of any aircraft which has been confirmed as carrying out an MLS approach during LVPs. The MLS approach is confirmed by the pilot reporting “Microwave established” and the controller selecting the “M” indication green on EFPS.

Procedure

MLS Phase 3 Concept

Due to the greater accuracy of MLS, it can remain within CAT III tolerance with aircraft positioned closer to the runway than with ILS. Therefore, for an aircraft carrying out an MLS approach, the previous aircraft must be clear of the MLS Landing Clearance Line.

MLS Landing Clearance Line

The MLS Landing Clearance Line defines an area contained within lines 107.5m from the centreline on each side of the runway for the first 900m, then 82m from the centreline on each side for the remainder of the runway. This map is available on A-SMGCS Line Maps (MLS). An example of Runway 09R and Runway 09L MLS Trigger Line is shown below.

Whenever LVPs are in force, the appropriate map must be selected by the Air controller(s).

Protection of the MLS Sensitive Areas

The MLS Localiser Sensitive Area refers to any area inside the MLS Landing Clearance Line. The MLS Glidepath Sensitive Area is the same as the ILS Glidepath Sensitive Area.

Arriving Aircraft

The fact that the aircraft is conducting an MLS approach must be confirmed by the pilot reporting "Microwave established" and the controller selecting the "M" indication green on EFPS.
If the spacing is 5 NM but the aircraft does not inform the arrivals controller, the type of approach must be confirmed.
No aircraft or vehicle is permitted to infringe the MLS Landing Clearance Line ahead of an arriving aircraft that is confirmed as conducting an MLS approach from the time the aircraft is 1 NM from touchdown until it has completed its landing run. Landing clearance must not be issued if the MLS Landing Clearance Line is known to be infringed.

A380

An A380 has the same effect on the MLS as any other aircraft. The A380 DLSA only applies to the ILS.

Departing Aircraft

MLS is not used by departing aircraft.

Arrival Spacing

Unless the required wake turbulence separation is greater, TC Heathrow will provide 5 NM spacing **ahead** of the aircraft conducting an MLS approach during LVPs.

RIMCAS

Due to the limitations of the current RIMCAS system, a **stage 2 (red)** RIMCAS alert may be triggered during LVPs, even though a legitimate landing clearance was given to the aircraft conducting an MLS approach. This will occur in the following circumstance:

- The arriving MLS aircraft is 30 seconds or less from touchdown, and;
- The aircraft ahead of the MLS aircraft is less than 137m from the runway centreline (the monitored area for RIMCAS while set to LVP mode).

To ensure consistent application of RIMCAS procedures, it has been agreed that the controller reaction to a **stage 2 (red)** RIMCAS alert during LVPs ahead of an aircraft conducting an MLS approach will be as follows:

If a **stage 2 (red)** alert is generated, a 'go around' **shall** be issued to the arriving MLS aircraft.

The following TOIs are current on date of publication:
2012: 038/12, 084/12 2013: 008/13, 011/13, 012/13, 013/13, 014/13, 016/13, 017/13, 018/13, 019/13, 021/13, 022/13, 023/13, 024/13, 025/13, 027/13, 028/13, 029/13, 030c/13, 031/13, 032/13, 034/13, 035/13, 036/13, 037/13, 038/13, 039/13, 040/13.
Originator: Heathrow ATC Operations

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