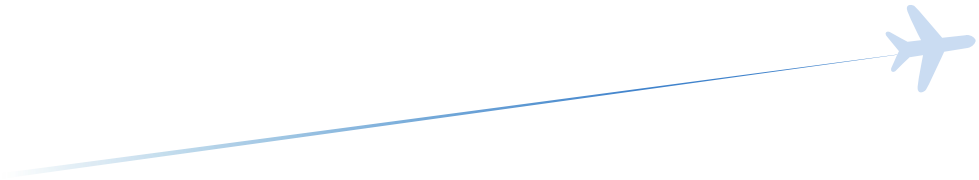

System Requirements Specification Document

D1.2

MALORCA

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MALORCA

MACHINE LEARNING OF SPEECH RECOGNITION MODELS FOR CONTROLLER ASSISTANCE

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 698824.

Abstract / Executive Summary

This System Requirements Specification document collects and describes the technical requirements which shall guide the development and implementation of a controller support tool, henceforth referred to as **THE SYSTEM**, based on speech recognition in ATM environment. The version 3.00 of this document results from updating previous version with respect to results from Proof-of-Concept Trials in January 2018.

Requirements which are specifically related to MALORCA and differ from the generic requirements can be found in a SRS Annex [3] to this document. The Annex will be maintained during the whole project with high frequency. This document will, however, be only updated at the end of the project (or on request of SJU).

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1 Introduction

1.1 Purpose

The purpose of this System Requirements Specification document [1] for the MALORCA project is to provide a structured list of **generic**[2] requirements for the controller support tool based on speech recognition (THE SYSTEM) as formalised in Grant Agreement number [13] between The Single European Sky ATM (Air Traffic Management) Research Joint Undertaking and MALORCA partners. The project objectives and scope as well as how the project is executed and monitored can be found in [8]. The requirements then shall serve as a basis for THE SYSTEM development. These here specified requirements take into account the outputs from the OCD [1].

This document describes generic requirements of THE SYSTEM as a whole; the specific requirements for the concrete modules of THE SYSTEM are elaborated in SRS Annex [3]. This particularly applies for the learning component of THE SYSTEM, one of the concrete objectives of the MALORCA project.

The requirements specified in this document form a roadmap for building an operational system in the generic sense. Therefore, some of the requirements described in this document may not be fulfilled during the MALORCA project due to different constraints such as data availability and access to operational room, but are stated as a theoretical guideline that can be achieved if the described conditions are satisfied.

The version 3.00 of this document results from updating previous version with respect to results from Proof-of-Concept Trials in January 2018.

1.2 Intended readership

This document is intended for all MALORCA project members and other stakeholders interested in voice recognition subject-matter, mainly within, but not limited to the SESAR Programme.

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[1] The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

[2] "generic" in this context means that the requirements have to be detailed within the MALORCA project and also afterwards so that the requirements are usable for contract negation between ANSPs on the one hand and system supplier on the other hand.

The contributors of the next MALORCA work packages are the main audience so that the different views of the different MALORCA team members converge to common challenges being addressed during the remaining 20 months of the project.

Furthermore, it might be an input for PJ16 in SESAR2020 IR project which is tasked with a transversal role related to HMI and human performance aspects, and will investigate new HMI needs (response time, appearance and other characteristics) and interaction modes (touch, gesture, voice etc...).

1.3 Structure

This System Requirements Specification document is structured in the following way:

Section 1 is the introduction. It describes the purpose and structure of the document and the methodology used to document the requirements.

Section 2 gives an overall system description, including the context and data flows.

Section 3 describes the functional requirements, conditions and constraints of the system.

Section 4 describes the functional requirements with respect to machine learning

Section 5 describes the non-functional requirements.

Section 6 contains the glossary of terms, which are used in the requirements of section 3 and 4. Some terms in the generic requirements might not be defined yet. The definition of these terms will be caught up later.

The appendix contains a definition of recognition and error rates, the list of commands, which should be recognized, the list of used abbreviations and the references.

1.4 Requirement Definitions

This section is to cover requirements definitions. According to ISO/IEC/IEEE standard 29148:2011, each requirement should fulfil the specific quality criteria. Pohl et al. [11] present the following ones which will serve as a guideline to the requirements presented in this document:

- Agreed: A requirement is agreed upon if it is correct and necessary in the opinion of all stakeholders.
- Unambiguous: A requirement that is unambiguously documented can be understood in in only one way [ISO/IEC/IEEE 29148:2011].
- Necessary: A documented requirement must represent the facts and conditions of the system context in a way that is valid with regard to the actualities of the system context [ISO/IEC/IEEE 29148:2011].

- Consistent: Requirements must be consistent with regard to all other requirements [ISO/IEC/IEEE 29148:2011].
- Verifiable: A requirement must be described in a way that allows for verification [ISO/IEC/IEEE 29148:2011].
- Feasible: It must be possible to implement each requirement given the organizational, legal, technical, or financial constraints [ISO/IEC/IEEE 29148:2011].
- Traceable: A Requirement is traceable if its origin as well as its realization and its relation to other documents can be retraced [ISO/IEC/IEEE 29148:2011].
- Complete: Each individual requirement must completely describe the functionality it specifies [ISO/IEC/IEEE 29148:2011].
- Understandable: Requirements must be comprehensible to each stakeholder.

According to [11] generic requirement shall be written in the following way:

<Object> shall OR should OR will <verb> <Statement>

1.4.1 Template for Text of Requirement

Rupp et al. [11] propose the complete requirements template with conditions in **Figure 1** for structuring the text of the requirement.

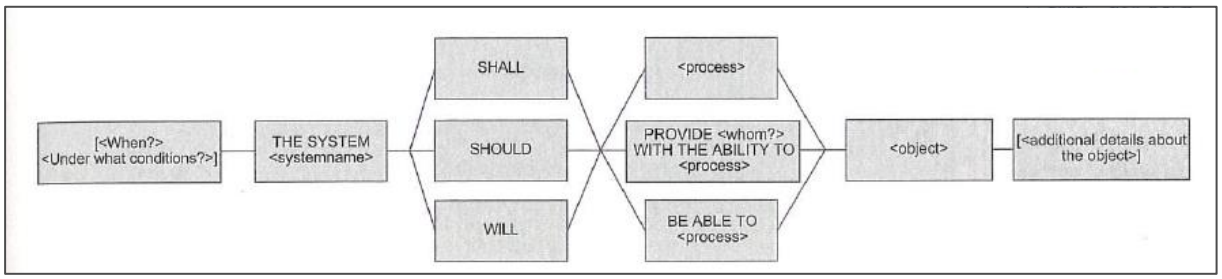

Figure 1 Requirements-Template (taken from [11], p. 177)

SHALL/SHOULD/WILL define, how important the requirement is.

- SHALL: this is a must/mandatory-requirement. . Outside a research project acceptance of the product may be rejected if such a requirement is not fulfilled. These requirements will be tested.
- SHOULD: This requirement is nice to have if it is implemented, but it is not mandatory.
- WILL: defines requirements, which help to make preparations for the future. In the future these requirements are mandatory. These requirements are not tested now.[3]

[3] The project partners try to implement all SHALL and SHOULD requirements in the MALORCA project. Due to budget constraints and time limitation not everything will be possible in the context of MALORCA. Priority, however, is then on SHALL requirements. It is not intended to implement already WILL requirements in the

The system activity can be classified as one of three types:

- <process verb> is used if the SYSTEM itself starts the process. It independently starts from other (external) triggers. The user is not necessary. <process> is a template for the performed activity.
- PROVIDE <whom?> WITH THE ABILITY TO <process>: Here the user starts an activity or interacts with the SYSTEM.
- BE ABLE to <process>: This is an interface requirement: Here the SYSTEM performs an action if a third party (not the user) initiate the action

The list of people specified in <whom?> must be defined in more detail either directly in the subsection of the requirement or in the glossary section.

The OBJECT makes the <process> activity more concrete. It may specify the WHAT, WHERE and HOW.

The CONDITION starts with an IF or WHEN typically. The conditions maybe concatenated by AND and/or OR.

Examples:

THE SYSTEM SHALL provide the ANSP's maintenance staff with the ability to define a list of waypoints for which DIRECT-TO advisories maybe recognized.

This is a mandatory requirement. The user of the system has to define the list of waypoints, for which DIRECT_TO advisories may be recognized. Waypoints, which are not specified in the list, are not recognized.

The requirement is on the other hand also a requirement from the system to the ANSP. The maintenance staff of the ANSP has to specify a list of waypoints, which should be recognized. The <process > activity is here "define".

A <list of waypoints, for which DIRECT-TO advisories maybe recognized.> is the OBJECT.

The level of detail is very high. <list of waypoints> could be more precise, e.g. <list of waypoints in an OSM waypoint file> and OSM waypoint file has to be defined in a glossary.

The above requirement could also be formulated as:

MALORCA project. For a real product, however, the implementation of SHALL and WILL requirements is also mandatory. The WILL requirements are, therefore, more an input for system suppliers and SESAR partners after the MALORCA project.

THE SYSTEM SHALL provide the ANSP's maintenance staff with the ability to define a list of waypoints. Only for waypoints defined in this list DIRECT-TO advisories are created.

1.4.2 Template for Process of Requirement Definition and Negotiation

For the purpose of MALORCA requirements management, proposed set of predefined attributes in a structured way will be used for each documented requirement, see **Table 1** .

Identifier	<TYPE> -<SubType>-001
Title	Short describing requirement
Requirement	Describing text according to template in section 1.4 Most nouns and verbs should be specified in the glossary. Some requirements contain a "condition" section. The condition(s) describe mandatory pre-conditions which must be fulfilled in order to fulfil also the requirement within MALORCA project.
Rationale / Why this requirement	Description for the others (not the author) why this requirement
RQ from (Who benefits)?	Partner 1 acronym — Status: unknown 2016-xx-yy Partner i acronym — Status: unknown 2016-xx-yy
RQ for (Who has to implement RQ)?	Partner i acronym — Status: checking 2016-xx-yy Partner k acronym — Status: accepted 2016-xx-yy
Priority	Shall / Should / will see template in section 1.4
Category	FR for functional requirement of NFR for non-functional requirement
Test Method / Acceptance Criteria	e.g. demonstration, Inspection, Analysis, Unit-Test, see below
Conflicts	If this requirement contradicts to another requirement
Additional Information	
History	Date of change (yy-mm-dd) | ID of the editor | Comments

Table 1: Requirement Template

The rows "RQ from (Who benefits)?" and "RQ for (Who has to implement RQ))?" specify who should check this requirement. Often the partner in "RQ from (Who benefits)?" has to provide information

and the partner in “RQ from (Who has to implement RQ)?” has to implement the requirement. After the partner name we specify the status:

- Unknown: The partner has not read this requirement or the new version of this requirement
- Checking: Somebody of partner has read the requirement, but it is now discussed by that partner internally
- Accepted: The partner has accepted the requirement
- Rejected: The partner has rejected the requirement. In this case the row “Additional Information” SHALL contain further text information.
- Changed: Another partner has made significant modifications to the requirement, after the partner has changed to a value different from unknown. In this case the partner who modified SHALL add a line to the history row.

The date in this row specifies when the last status change has occurred.

“Test Method / Acceptance Criteria” can be as following:

- Inspection
- Demonstration
- Test O1, Test O2, Test T1, Test T2
- Unit Test
- Analysis
- None: System boundary

“None: System boundary” means that no special acceptance criteria is planned, because the requirements describe the limitation of the system. If a situation is out of the described system boundaries the behaviour of the system is undefined.

The Tests O1, O2, T1 and T2 are detailed in D5-1 (the validation plan). Test O2 includes a replay of historic radar data and recorded speech data. These test data is input into the ABSR system. The output of the system is displayed to SME (subject matter experts), which can evaluate the performance. Advantage of this procedure is that ABSR support is possible; the set of predicted commands is available.

T1-Live means that the ABSR system is connected to a microphone and a controller can give clearances to the system. However in this mode no radar data is considered, i.e. especially the callsign recognition will be not very good.

2 Overall system description

2.1 Context

In current ATC operations environment, the controller issues ATC clearances and provides information to the flight crews by voice communications. The flight crew is expected to confirm the clearance by a readback or acknowledge the information – this means instant feedback to the ATCO.

For their effective operation, ATC systems need accurate data in timely manner. One of the necessary input data are the ATC clearances.

This input is manually done by the ATCO using the mouse or another control device through the interaction with a flight strip or label of the flight. The ATCO is expected to input the clearance into the system as he speaks. This increases ATCO workload and decrease overall efficiency.

Currently there is no link between the voice communication system and cooperating ATC system. As a result, ATCO needs to perform two those actions:

- Issue the ATC clearance by voice **and**
- Input the ATC clearance into the ATC system.

The scheme in **Figure 2** depicts the current situation in which the missing link between voice communication system and cooperating ATC system is shown by a dotted red line.

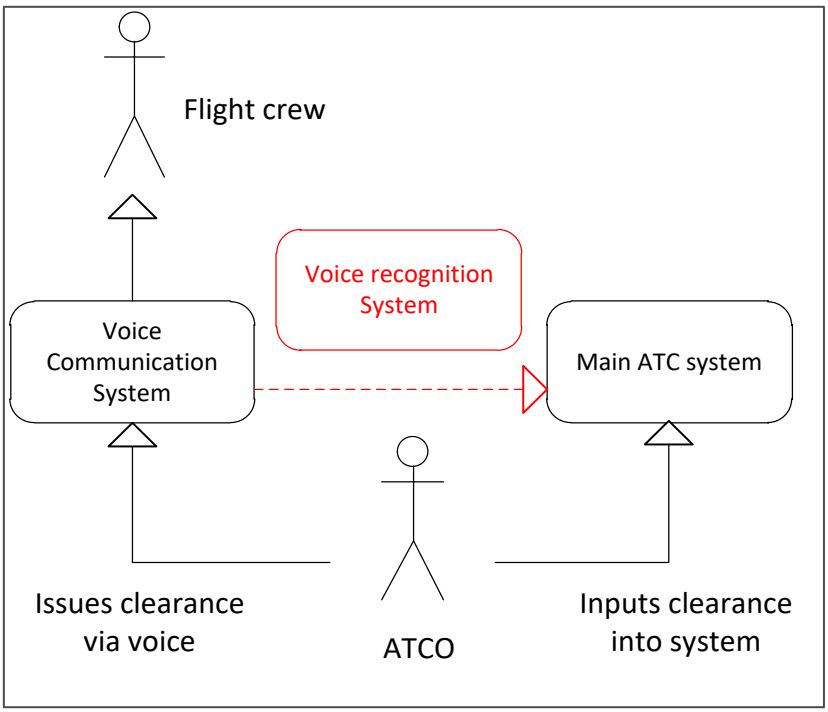

Figure 2 Current Situation

However, the way of inputting ATC clearances into the system could be automated by the application of voice recognition system on the ATCO voice communications.

As the ATCO speaks, voice recognition system would automatically extract ATC clearances and other data for particular flight and feed them into the ATC system for further processing and display.

Therefore, the aim of this project is to develop a voice recognition system for this purpose.

Such voice recognition system needs to:

- be adaptable to the specific ATC environment in a cost efficient manner
- have sufficient performance for operational use

The adaptability and performance of such voice recognition system would be improved by using context information derived from not only the voice communication, but also from surveillance data, environment data and flight data and the application of machine learning algorithms.

2.2 System and Modes of Operation

THE SYSTEM defines the controller support tool based on speech recognition which we are developing. We are working with the following modules of THE SYSTEM:

- Assistant Based Speech Recognition (ABSR): it online converts a controller utterance into a sequence of commands by using different speech recognition models.
- MALORCA Learning System (MLS): It automatically or semi-automatically learns/adapts from a huge data base the speech recognition models, which can be used by the THE SYSTEM.[4]

At the early stage of THE SYSTEM development, it is expected that THE SYSTEM will support the following modes of operations:

- **Operational mode**: THE SYSTEM is operational, connected to Cooperation ATC system and all the system capabilities are available.
- **Sim-Training mode**: THE SYSTEM is connected to an ATM Simulator and in training system state, which encompasses the Simulator-Training needs.
- Learning mode:
    - **Online Learning mode**: THE SYSTEM is connected to Cooperation ATC system and in learning system state.
    - **Offline Learning mode**: THE SYSTEM is not connected to Cooperation ATC system, but in learning system state
- **Test mode**: THE SYSTEM is connected to Cooperation ATC system on the test platform in order to facilitate maintenance of THE SYSTEM (e.g. software upgrade).

Theses modes of operation are further detailed in requirement GEN-FUNC-009 (subsection 3.1.9).

2.3 User characteristics

The main users of the system are air traffic controllers, more specifically the approach air traffic controllers are targeted as user group within the scope of MALORCA project. The attributes of speech recognizing shall be tailored to their needs. To be able to change some parameters (described as “Offline” in [1]) it is crucial to consider the system administrators and technicians as involved users as well.

2.4 Use cases

The following use cases are based on the use-cases specified in [1], section 5. While we focus on particular situations of an individual flight in greater detail and also covering scenarios that might occur not very frequently in [1], here we describe very general situations from the perspective of a controller on an individual sector and put the emphasis on how the air traffic controller benefits from the system in different situations and how system support should look like.

[4] Requirements with respect to MLS are, however, mostly covered in the Annex document [3].

2.4.1 Final director, heavy workload

Pre-Condition:

Aircraft calling in on ATCO´s frequency

All use-cases from [1] might be applicable.

Actors:

- Final director (ATCO)
- Pilots of (only) arriving flights (PIC)

The duty of the final director is mainly to line-up aircraft on final approach track closely spaced from each other to meet certain capacity expectation (specified e.g. in terms of number of landing aircraft within one hour).

Trigger:

Final directors almost only use the following commands:

- Vertical movement
- Lateral movement
- Speed adjustment
- Approach clearance
- Handover
- Go around

In peak traffic periods the workload for a final director naturally is very high. Frequency load is high as well and as a consequence it is difficult to cope with the high number of required inputs in the ATM-system. If a final director faces an overload-situation it is proven that efficiency goes down rapidly. Avoidance of this triggers the requirement for support by these inputs generated by speech recognition.

Main Flow:

A. ATCO: Identifies the aircraft, might give instructions at first contact

→ The System: Recognize the callsign → ATM-System: performs the predefined action e.g. assume flight

B. ATCO: gives instruction to line-up aircraft on final approach track

→ The System: Recognize callsign and commands (lateral/vertical/speed) → ATM-System: performs inputs received

C. ATCO: clears the aircraft for approach

→ The System: Recognize callsign and command (approach clearance) → ATM-System: set aircraft to state “cleared approach”

D. ATCO: hands the aircraft over to tower

→ The System: Recognize callsign and command (handover) → ATM-System: set aircraft to state “transfer initiated”

Alternative Flow:

E. ATCO: requests the aircraft to go around

→ ASR: Recognize callsign and command (go around) → ATM-System: set aircraft to state “missed approach”

Effort without The System:

(Minimum) 13 Mouse click and 4 Mouse wheel actions (scroll):

Assume; Label, scroll, Level; Label, scroll, Speed; Label, scroll, Heading; Label, C/A (cleared for approach); Label, scroll, Speed; Label, Transfer;

Gain with The System:

No mouse input’s necessary; ATCO can concentrate on traffic situation; ATCO capacity increases for situational awareness; average spacing decreases therefore landing quantity increases.

2.4.2 Departing Flight

Pre-Condition:

Aircraft calling in on ATCO´s frequency

Use-cases no. 3, 4, 5, 6 and 7 from [1] might be applicable.

Actors:

- Approach Sector (ATCO)
- Pilots of (only) departing flights (PIC)

Approach Sectors within the TMA are normally involved with departing traffic, except Final director (Feeder Positions) which normally only handle landing Traffic.

Depending on the airspace and ATC structure APP sectors either handle exclusively inbound or outbound traffic, or handle inbound AND outbound traffic (Overflights are handled by all APP sectors).

The duty of the involved sectors is to bring the departing traffic after Take Off via the SIDs (Standard Instrument Departure Routes) and the planned routes or by means of radar vectoring to the next involved Sector outside the TMA.

Trigger:

Approach sectors who handle departing traffic use normally the following commands:

- Identification of aircraft
- Vertical movement
- Lateral movement
- Speed adjustment
- Rate of climb
- Handover

Main Flow:

A. ATCO: Identifies the aircraft, issues instructions at first contact

→ The System: Recognize the callsign → ATM-System: Assume flight

→ The System: Recognize callsign and commands → ATM-System: perform inputs received

B. ATCO: issues instructions

→ The System: Recognize callsign and commands → ATM-System: perform inputs receive

ATCO: hands the aircraft over to next sector

→ The System: Recognize callsign and command (handover) → ATM-System: set aircraft to state "transfer initiated"

Alternative Flow:

Special request from PIC (e.g. to land back because of unusual situation)

C. ATCO: issues instructions

→ The System: Recognize callsign and commands (lateral/vertical/speed) → ATM-System: perform inputs received

D. ATCO: clears the aircraft for approach

→ The System: Recognize callsign and command (approach clearance) → ATM-System: set aircraft to state "cleared approach"

E. ATCO: hands the aircraft over to tower

→ The System: Recognize callsign and command (handover) → ATM-System: set aircraft to state "transfer initiated"

Effort without The System:

(Minimum) 9 Mouse click and 3 Mouse wheel actions (scroll):

Assume; Label, scroll, Level; Label, scroll, Waypoint; Label, scroll, Level; Label, Transfer;

Gain with The System:

No mouse input's necessary; ATCO can concentrate on traffic situation; ATCO capacity increases therefore flying time decreases.

2.4.3 Arriving flight

Pre-Condition:

Aircraft calling in on approach frequency initially.

All use-cases from [1] might be applicable.

Note:

Lining up the aircraft on the final track and handover to Tower is done by the final director.

Actors:

- Approach executive controller (ATCO)
- Pilot of arriving flight (PIC)

On initial contact of an arriving flight with an approach control unit it receives confirmation of the assigned landing runway, the type of approach to be carried out and the actual code of the ATIS-message transmitted. Normally it is also cleared for the applicable STAR or Transition to final approach.

Giving an approach controller substantial support in terms of a release from the duty to input all given commands into the ATM-system by numerous mouse clicks is proven to increase both safety and sector capacity. Furthermore, the accuracy of given commands and therefore the overall efficiency of a controller's work is improved.

Trigger:

Therefore, the following command types are mostly used in this early phase of the approach:

- Identification of aircraft
- Runway information[5]
- STAR/Transition to final

The main intention of an approach controller in regard to arrivals is to establish an optimized sequence for landing and handover to the final director. To do so the following commands are used mainly:

- Vertical movement
- Lateral movement
- Speed adjustment

If too many flights arrive within a narrow timeframe it might not be possible to fulfil that job and a holding stack needs to be created. Pilots shall be informed about how long they have to hold (expected approach time/expected further clearance time). When leaving the holding the appropriate STAR or Transition to final approach track shall be cleared. To operate holding traffic the following commands are used:

- Hold
- (Vertical movement)
- (STAR)

Main Flow:

A. ATCO: Identifies the aircraft, confirms the landing runway, type of approach (ILS, VOR, etc.) and the code of the actual ATIS broadcast

→ The System: Recognize callsign and commands → ATM-System: Assume flight, perform inputs received as much as applicable

B. ATCO: gives instruction what STAR or Transition to final approach shall be carried out. Alternatively, other lateral movement and speed adjustment could be requested (radar vectoring, direct to, etc.) to establish the arrival sequence

→ The System: Recognize callsign and commands (STAR/lateral/vertical/speed) → ATM-System: perform inputs received

[5] Currently the runway information is not a command type, see Appendix B. The output of the SYSTEM will be NO_COMMAND. However, a given runway information must still be recognized by the SYSTEM so that it does not result in a false recognition.

C. ATCO: hands the aircraft over to final director

→ The System: Recognize callsign and command (handover) → ATM-System: set aircraft to state “transfer initiated”

Alternative Flow:

D. ATCO: requests the aircraft to hold

→ ASR: Recognize callsign and command (hold) → ATM-System: set aircraft to state “hold”

Effort without The System:

(Minimum) 15 Mouse click and 6 Mouse wheel actions (scroll):

Assume; Label, scroll, Level; Label, scroll, Speed; Label, scroll, Waypoint; Label, scroll, Level; Label, scroll, Speed; Label, scroll, Level; Label, Transfer;

Gain with The System:

No mouse input’s necessary; ATCO can concentrate on traffic situation; ATCO capacity increases for situational awareness; average spacing decreases therefore flying time decreases and landing quantity increases.

2.5 Functional Part and Data Flows

THE SYSTEM environment as well as main data flows among the systems context are described in **Figure 3** and corresponding **Table 2** and **Table 3**.

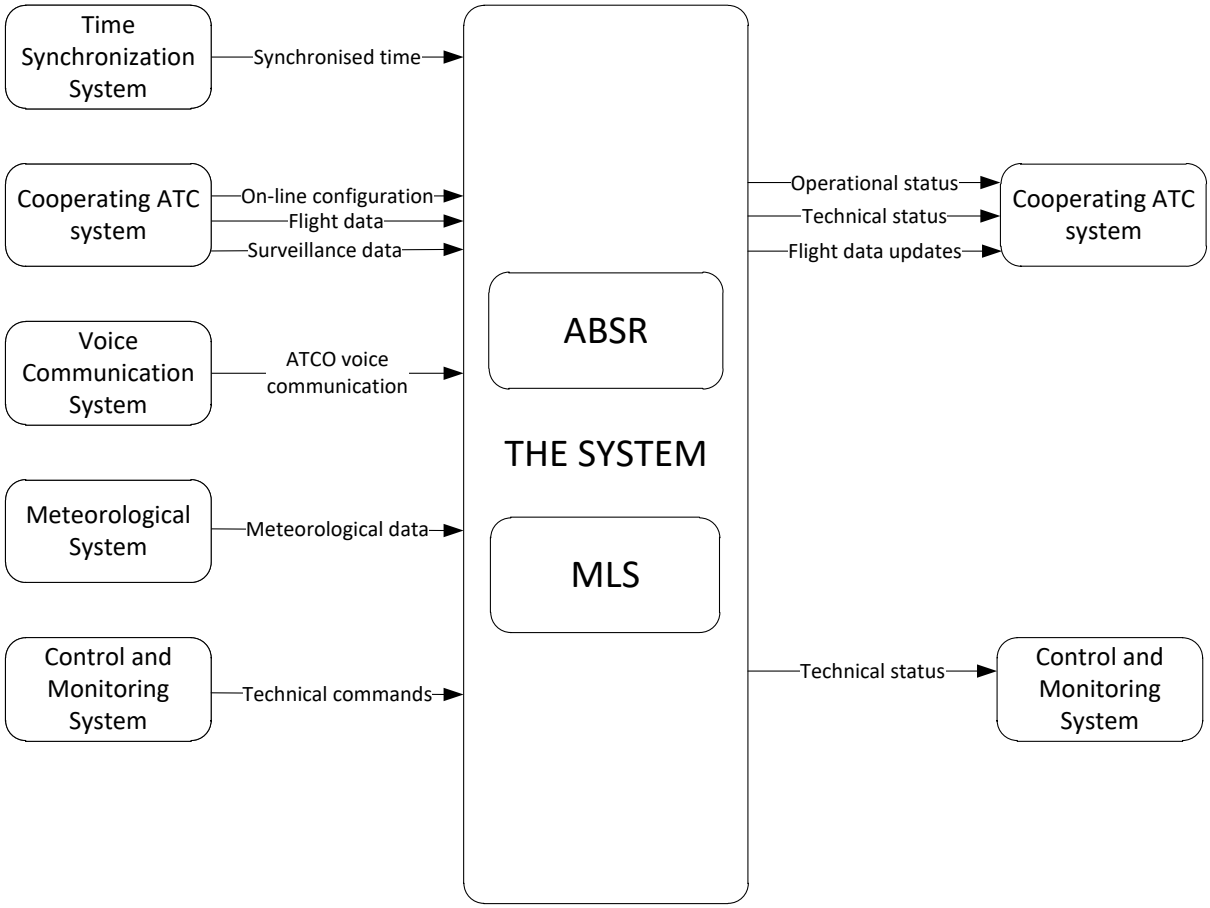

Figure 3 Context diagram and data flows

Data IN

Source system	Data in	Details/comments	Expected data format
Time synchronization system	Synchronised time	To provide synchronised time	NTP protocol
Cooperating ATC system	Flight data	To provide flight plan data and their updates	
Cooperating ATC system	On-line configuration	To provide on-line configuration items such as: RWY in use, voice recognition status (ON/OFF)	

Source system	Data in	Details/comments	Expected data format
Cooperating ATC system	Surveillance data	System track data (e.g. radar tracks) with Mode-S and flight data	ASTERIX CAT62, edition 1.10 or newer
Voice Communication system	ATCO voice communication	Real time ATCO voice communication	
Meteorological system	Meteorological information		
Control and monitoring system	Technical commands	To have means of limited system control like switch on/off the application processes	SNMPv2

Table 2: Data IN

Data OUT

Target system	Data out	Details/comments	Expected data format
Cooperating ATC system	Operational status	To receive system status that THE SYSTEM could be used operationally	
Cooperating ATC system	Flight data updates	The main output – recognised commands for a particular flight (ATC clearances as flight data updates)	
Control and monitoring system	Technical status	To receive system status information and present it at consolidated picture together with other systems	SNMPv2

Table 3: Data OUT

3 Functional requirements

3.1 Generic Functional Requirements

3.1.1 GEN-FUN-001

Identifier	GEN-FUN-001	
Title	Area of interest	
Requirement	THE SYSTEM SHALL be able to process all traffic flows within the Area of Interest of Approach Control Unit (Arriving traffic, Departing traffic, Overflights). CONDITION: The training and unsupervised learning data contain sufficient examples to train and learn commands occurring during the different approach control units (Arriving traffic, Departing traffic, Overflights).	
Rationale / Why this requirement	To cover the whole traffic within the Approach Unit Area of Interest.	
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen)	Status: accepted 2016-06-09
	USAAR	Status: accepted 2016-06-01
	Idiap	Status: accepted 2016-07-21
Priority	SHALL	
Category	FR	

Test Method / Acceptance Criteria	O2, T1-Live
Conflicts	Currently none
Additional Information	
History	16-05-30 MN First Version 16-06-09 HHe Clarification and accepted, priority set to should 16-06-27 AC New identifier 16-07-13 AC priority changed (SHALL)

3.1.2 GEN-FUN-002

Identifier	GEN-FUN-002
Title	Sector dependent setting of SYSTEM operational status
Requirement	THE SYSTEM SHOULD provide the ATCO with the ability to switch the operational status ON/OFF at the level of a sector, i.e. at a working position.
Rationale / Why this requirement	To provide the ATCO on a particular sector with means of not using the system if he/she determines to do so.
RQ from (Who benefits)?	ACG Status: accepted 2016-07-13 ANS CR Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen) Status: accepted 2016-06-09 USAAR Status: accepted 2016-06-01 Idiap (requirement for ABSR system) Status: accepted 2016-07-21
Priority	Should
Category	FR
Test Method / Acceptance Criteria	O2 see validation plan: The controller can press F9 button and the speech recognition output is not shown to him.
Conflicts	Currently none, the requirement is nealy the same as SYS-ON-001

Additional Information	If the SYSTEM is switched off (at a working position) it produces no output for the controller at this working position.
History	16-05-30 MN First Version 16-06-27 AC New identifier 16-07-13 AC priority changed (SHOULD) 16-07-31 HHe Clarification of switching off added in additional information

3.1.3 GEN-FUN-003

Identifier	GEN-FUN-003
Title	Start recognition immediately
Requirement	When the controller has pressed the push-to-talk-button THE SYSTEM SHOULD start the recording/recognition process immediately (not later than configurable time parameter, e.g. 0.5 seconds). CONDITION: The ABSR system has access to the audio signal directly at the PTT microphone.
Rationale / Why this requirement	Recording of the speech signal starts when the controller starts to talk. The speech recognizer should not waste time until the controller has released the push-to-talk button.
RQ from (Who benefits)?	ACG Status: accepted 2016-07-13 ANS CR Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	USAAR (requirement for ABSR system) Status: accepted 2016-06-09 Idiap (requirement for ABSR system) Status: accepted 2016-07-21
Priority	should

Category	FR, and also a NFR
Test Method / Acceptance Criteria	Test Demonstration: it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.
Conflicts	none
Additional Information	During the MALORCA project the SYSTEM does not have direct access to the signal of the PTT microphone. The process is simulated by replay functionality. This requirement reflects the Assumption 1 from [1] which might have an influence on the acceptance of the end-users.
History	16-06-09 | Hhe | First version 16-06-27 | AC | New identifier 16-09-06 | HHe | Additional information added 16-09-12 | AC | Link to [1] created. 18-01-25 | HHe | Test method edited

3.1.4 GEN-FUN-004

Identifier	GEN-FUN-004
Title	Provide callsign information immediately
Requirement	THE SYSTEM WILL send immediately (not later than configurable time parameter, e.g. 1.0 seconds) recognized callsign to the cooperating ATC system when the controller has pressed the push-to-talk-button and said the callsign (aircraft identifier). If the callsign is not recognized immediately after the callsign is said, THE SYSTEM WILL send recognized callsign as soon as possible even if it is recognized during the utterance (e.g. if THE SYSTEM needs the other contextual information to recognize the callsign properly or the controller gives the callsign information at the end of the utterance). CONDITION: The SYSTEM has access to the audio signal directly at the PTT microphone to avoid additional latency.
Rationale / Why this	Callsign is one of the most important information. If a long command is

requirement	given (e.g. duration > 3 seconds) the controller wants an early feedback, that THE SYSTEM has recognized the correct callsign. This could immediately be displayed by highlighting the aircraft label on the radar screen.	
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	USAAR (requirement for ABSR system)	Status: accepted 2016-06-09.
	Idiap (requirement for ABSR system)	Status: accepted 2016-07-21
Priority	WILL (in MALORCA no push-to-talk information is available)	
Category	FR, and also a NFR	
Test Method / Acceptance Criteria	Test Demonstration: it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.	
Conflicts	none	
Additional Information	If a command is not started with a callsign, the callsign information will be sent first followed (maybe immediately) by the rest of the recognized command.. If an utterance contains more than one callsign (break, break), only the first callsign will be sent first. Further discussion and evaluation is needed as sending parts of a recognized command might complicate recognition process and in case of a correction keyword even might contain false information. Therefore decision about the operational need to have THE SYSTEM that SHOULD be able to provide recognized commands immediately after the command was spoken will be done at the later stage. During the MALORCA project the SYSTEM does not have direct access to the signal of the PTT microphone. The process is simulated by a replay functionality	

History	16-06-09	Hhe	First version
	16-06-27	AC	New identifier
	16-07-14	AC	Requirement text changed
	16-07-29	AC	Priority WILL set
	16-07-31	HHe	Priority constantly set to will, additional information moved from GEN-FUN-005 to 004.
	16-09-06	HHe	Additional information added
	18-01-25	HHe	Test method edited

3.1.5 GEN-FUN-005

Identifier	GEN-FUN-005	
Title	Provide complete command information when utterance is completed	
Requirement	When the controller has released the push-to-talk-button THE SYSTEM SHALL send the complete recognized commands (including callsign already sent) to the cooperating ATC system.	
Rationale / Why this requirement		
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	USAAR	Status: accepted 2016-06-09
	Idiap (requirement for ABSR system)	Status: accepted 2016-07-21
Priority	SHALL	
Category	FR	
Test Method / Acceptance Criteria	Test Demonstration O2 see validation plan	
Conflicts	none	
Additional Information	Current behaviour of the AcListant® system: When controllers release PTT button, the whole recognized command is sent to ATC system. This is	

<table>
<tr><td></td><td>independent of the requirement GEN-FUN-004, which requires sending the call sign information already earlier.

Examples:

• Utterance: Good morning Lufthansa two one descend flight level two one zero turn left heading zero one zero

First (as soon as possible) the callsign DLH21 is sent. Then after the controller releases the PTT button the two commands are sent, i.e. the information (see Appendix B for syntax in AcListant)
- DLH21 DESCEND 210 FL
- DLH21 TURN_LEFT_HEADING 010

• Utterance: Lufthansa two one descend altitude tree thousand feet on QNH one zero one eight break break air france one echo papa turn right, turn right one one zero

First (as soon as possible) the callsign DLH21 is sent. Then the second callsign AFR1EP is sent. Maybe also the commands for DLH21 are already sent at the end however (when controllers releases the PTT button, the following commands shall be sent:
- DLH21 DESCEND 210 FL
- AFR1ERP TURN_RIGHT_HEADING 110

• Utterance: Good morning Lufthansa two one descend correction air france one eight zero reduce two two zero knots

First (as soon as possible) the callsign DLH21 might be sent, but then the correct callsign AFR180 should be sent or only AFR180 is sent.

Then after the controller releases the PTT button the following command is expected
- AFR180 REDUCE 220</td></tr>
<tr><td>History</td><td>
<table>
<tr><td>16-06-09</td><td>HHe</td><td>First version</td></tr>
<tr><td>16-06-27</td><td>AC</td><td>New identifier</td></tr>
<tr><td>16-07-14</td><td>AC</td><td>Additional information added</td></tr>
<tr><td>16-07-31</td><td>HHe</td><td>Additional information moved to GEN-FUN-004</td></tr>
</table>
</td></tr>
</table>

	16-08-01	HHe	Detailed examples added
	18-01-25	HHe	Test method edited

3.1.6 GEN-FUN-006

Identifier	GEN-FUN-006
Title	Recognition of callsign
Requirement	THE SYSTEM WILL be able to recognize callsign from the ATCO utterance in one of the following ways: • In case callsign is present in the ATCO utterance, THE SYSTEM WILL send it immediately (before recognizing the rest), if possible.. • In case callsign is not present in the ATCO utterance THE SYSTEM WILL use the recognized callsign from the last ATCO utterance if the time difference between current and previous utterance is small enough (specified by a configurable time parameter). • In case callsign is not present in the ATCO utterance and the time difference between current and previous utterance is too big (specified by a configurable time parameter) THE SYSTEM WILL create NO_CALLSIGN.
Rationale / Why this requirement	It must be unambiguously clear to which flight the recognised commands are related to.
RQ from (Who benefits)?	ACG: Status: accepted 2016-07-13 ANS CR: Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen): Status: accepted 2016-09-06 USAAR (requirement for ABSR system): Status: accepted 2016-06-01 Idiap (requirement for ABSR system): Status: accepted 2016-07-21
Priority	Will
Category	FR
Test Method / Acceptance Criteria	Test Demonstration: it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.

Conflicts	There may be a conflict with a low command error rate.
Additional Information	It is essential to recognize the aircraft identification In the AcListant project DLR/USAAR, have already shown by statistical evaluation of recognition data that sending the previously recognized callsign (the previously said callsign is not known) does not improve recognition result. The MALORCA project partners will evaluate what alternatives provide best results. See chapter 5.4 in [1] for utterance without callsign The list of operators covered in ICAO Doc. 8585 may be used for the callsign recognition.
History	16-05-30 MN First Version 16-06-09 HHe Changed from SHALL to WILL 16-06-27 AC New identifier 16-07-14 AC Additional information added 16-07-31 HHe DLR status set to checking due to provided additional information 16-09-06 HHe Status of DLR set to accepted and added information what happens if time difference is too big 18-01-25 HHe Test method edited

3.1.7 GEN-FUN-007

Identifier	GEN-FUN-007
Title	Linking of commands to callsign
Requirement	THE SYSTEM SHALL link each recognised command types to callsign. If no callsign is recognized, THE SYSTEM SHALL send this information to the output channel (e.g. recognition status = not recognized).
Rationale / Why this	It must be unambiguously clear to which flight the recognised commands

<table>
<tr><td>requirement</td><td colspan="3">are related to. Otherwise, no flight data could be updated.</td></tr>
<tr><td>RQ from (Who benefits)?</td><td colspan="3"><table><tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr><tr><td>ANS CR</td><td>Status: accepted 2016-05-30</td></tr></table></td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td colspan="3"><table><tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-06-09</td></tr><tr><td>USAAR (requirement for ABSR system)</td><td>Status: accepted 2016-06-01</td></tr><tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr></table></td></tr>
<tr><td>Priority</td><td colspan="3">Shall</td></tr>
<tr><td>Category</td><td colspan="3">FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td colspan="3">Test
Demonstration: O2, The command value is display in the label of the recognized callsign in the descend, reduce, direction or miscellaneous field.</td></tr>
<tr><td>Conflicts</td><td colspan="3">Currently none</td></tr>
<tr><td>Additional Information</td><td colspan="3">This requirement directly reflects the Assumption 1 from [1] as it is essential to recognize the aircraft identification.

See chapter 5.4 in [1] for utterance without callsign.

Note:

In the AcListant project, ABSR system sent NO_CALLSIGN instead of a callsign. If the airline name was not recognized NO_AIRLINE is sent followed by the rest of the callsign (e.g. NO_AIRLINE_1AE7 instead of DLR1AE7).</td></tr>
<tr><td>History</td><td colspan="3"><table><tr><td>16-06-06</td><td>MN</td><td>First Version</td></tr><tr><td>16-06-09</td><td>HHe</td><td>NO_CALLSIGN, added, priority SHALL</td></tr><tr><td>16-06-27</td><td>AC</td><td>New identifier</td></tr><tr><td>16-07-14</td><td>AC</td><td>Requirement text changed</td></tr><tr><td>16-07-31</td><td>HHe</td><td>Additional information provided what ABSR modules internally exchange.</td></tr></table></td></tr>
</table>

3.1.8 GEN-FUN-008

<table>
<tr><td>Identifier</td><td>GEN-FUN-008</td></tr>
<tr><td>Title</td><td>Output of recognition from THE SYSTEM</td></tr>
<tr><td>Requirement</td><td>For each utterance THE SYSTEM WILL provide at least following information:
Timestamp
For Aircraft Identification (i.e. callsign)
Presence (YES/NO)
Recognition status (Recognized/Rejected/Not Recognized)
Recognition output (recognized aircraft identification)
For each command type
Title of command type (e.g. heading...)
Presence (YES/NO)
Recognition status (Recognized/Rejected/Not Recognized)
Recognized command attributes of command type</td></tr>
<tr><td>Rationale / Why this requirement</td><td>End system – Cooperating ATC system shall receive the output of THE SYSTEM containing all necessary information for possible flight data updates and appropriate presentation on the controller HMI.

As written in the OCD, the foreseen final output at the level of the HMI is in two ways:
Visualisation in the label for particular flight
Table with the last given clearances for all flights (OCD ref. section 4.2.1)
Columns
Timestamp
Flight identification
Output of the recognition using shortcuts, e.g. DES FL 280, SPD 280, HDG 090 R etc.
Used for flight data update or not
The following table just should help to understand the rational of this requirement. It could be a requirement for the HMI associated with THE SYSTEM.

<table><tr><th>Time</th><th>Flight identification</th><th>Commands</th><th>Update flight data</th></tr></table></td></tr>
</table>

	19:25:01	CSA123	DES FL 80, HDG 210 L	YES	
	19:25:25	-	ROC 2500.	NO	
	19:25:34	DLH8P	DES FL 80, HDG ??? R	???	
	19:25:37	DLH8P	DES FL 80, HDG ??? R		

RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-05-30
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen)	Status: accepted 2016-07-21
	USAAR (requirement for ABSR system)	Status: accepted 2016-06-01
	Idiap (requirement for ABSR system)	Status: accepted 2016-07-21
Priority	WILL	
Category	FR	
Test Method / Acceptance Criteria	Test Demonstration: : it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.	
Conflicts	Currently none	
Additional Information		

History			
	16-06-06	MN	First Version
	16-06-27	AC	New identifier
	17-07-27	HHe	Priority changed from SHALL to WILL
	18-01-25	HHe	Test method edited

3.1.9 GEN-FUN-009

Identifier	GEN-FUN-009
Title	Mode of operation
Requirement	THE SYSTEM SHOULD support the following modes of operation: • **Operational mode**: THE SYSTEM is operational, connected to

<table>
<tr><td></td><td>Cooperating ATC system and all the system capabilities are available.
• Sim-Training mode: THE SYSTEM is connected to an ATM Simulator and in training system state
• Learning mode:
○ Online Learning mode: THE SYSTEM is connected to Cooperation ATC system and in learning system state.
○ Offline Learning mode: THE SYSTEM is not connected to Cooperation ATC system, but in learning system state
• Test mode: THE SYSTEM is connected to Cooperation ATC system on the test platform</td></tr>
<tr><td>Rationale / Why this requirement</td><td>THE SYSTEM needs to support different modes of operation independent of the purpose and actual operational need e.g. in order to facilitate maintenance of THE SYSTEM (e.g. software upgrade) or reflect the simulator specifications correctly.</td></tr>
<tr><td>RQ from (Who benefits)?</td><td><table><tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr><tr><td>ANS CR</td><td>Status: accepted 2016-05-30</td></tr></table></td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td><table><tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-07-21</td></tr><tr><td>USAAR (requirement for ABSR system)</td><td>Status: accepted 2016-06-01</td></tr><tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr></table></td></tr>
<tr><td>Priority</td><td>Should</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration: : it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>The consequences and requirements for the different modes will be detailed later on.</td></tr>
<tr><td>History</td><td><table><tr><td>16-07-19</td><td>AC</td><td>First Version</td></tr></table></td></tr>
</table>

	16-07-31	HHe	Additional information provided

3.1.10 GEN-LOG-001

Identifier	GEN-LOG-001		
Title	External Data Flows Logging		
Requirement	THE SYSTEM WILL provide recording of input and output data flows into daily data flow log files containing all data messages, exchanged (received or sent) by THE SYSTEM with other systems, mainly the Cooperating ATC system and Technical commands from the Control and Monitoring System.		
Rationale / Why this requirement	It is a must for supporting Recording and Traceability requirements from ICAO Annex 11 “Air Traffic Services” to allow analysis of system behaviour and inspection of possible malfunctions.		
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13	
	ANS CR	Status: accepted 2016-05-30	
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen)	Status: checking 2016-07-31	
	USAAR	Status: checking 2016-07-21	
	Idiap (requirement for ABSR system)	Status: checking 2016-07-21	
Priority	WILL		
Category	FR		
Test Method / Acceptance Criteria	Demonstration: : it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.		
Conflicts	Currently none		
Additional Information			
History	16-06-28	AC	First version
	16-06-29	MF	Accepted by DLR
	16-07-13	AC	Title changed
	16-07-31	HHe	Priority changed to WILL, effort and semantics not clear for DLR
	16-08-03	AC	Requirement text completed and Rationale added,

			status changes to checking for DLR
	18-01-25	HHe	Test method edited

3.1.11 GEN-LOG-002

Identifier	GEN-LOG-002
Title	Internal Activity Logging
Requirement	THE SYSTEM WILL provide recording of internal processing information into daily internal processing log files to enable tracing of initiators and decisions made by THE SYSTEM, the log files containing at least: • Recording of start and stop of processes, which comprise THE SYSTEM, • Recording of any errors, which are observed by processes comprising THE SYSTEM, • Recording of voice recognition resolutions, including parameters of decisions made by THE SYSTEM when selecting the flight identifications, ATCO-pilot commands and their parameters and merit (probability of correctness) of the output sent to the Cooperating ATC system.
Rationale / Why this requirement	It is a must for supporting Recording and Traceability requirements from ICAO Annex 11 “Air Traffic Services” to allow analysis of system behaviour and inspection of possible malfunctions.
RQ from (Who benefits)?	ACG: Status: accepted 2016-07-13 ANS CR: Status: accepted 2016-05-30
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen): Status: checking 2016-06-29 USAAR (requirement for ABSR system): Status: checking2016-06-01 Idiap (requirement for ABSR system): Status: checking 2016-05-30
Priority	Will

Category	FR
Test Method / Acceptance Criteria	Demonstration: it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.
Conflicts	
Additional Information	
History	16-06-28 AC First version 16-07-31 HHe Effort and semantics not clear for DLR, condition added 16-08-03 AC Requirement text completed and Rationale added, status changes to checking for DLR 18-01-25 HHe Test method edited

3.1.12GEN-LOG-003

Identifier	GEN-LOG-003
Title	Archive period
Requirement	The required archive period for log files WILL be a minimum of 30 days.
Rationale / Why this requirement	
RQ from (Who benefits)?	ACG: Status: accepted 2016-07-13 ANS CR: Status: accepted 2016-05-30
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen): Status: accepted 2016-06-29 USAAR: Status: accepted 2016-06-01 Idiap (requirement for ABSR system): Status: accepted 2016-05-30
Priority	WILL
Category	FR
Test Method / Acceptance Criteria	Demonstration: : it is not implemented within MALORCA project, because concentrates on machine learning and not on HMI aspects.

Conflicts	Currently none
Additional Information	Duration might be changed if any legal requirement appears.
History	16-06-28 AC First version 16-06-29 MF Accepted by DLR 16-07-13 AC Additional information added 17-07-27 HHe Priority changed to WILL from SHALL 18-01-25 HHe Test method edited

3.2 Recognition Functionality Requirements

The recognition functionality requirements are based on standard phraseology described in ICAO Doc.4444 [8]. It means that the corresponding phraseology in each requirement reflects standard phraseology and the expressions not covered in [8] but frequently used in ATCO utterances need to be also taken into account and will be a part of [3] as far as possible.

3.2.1 REC-FUN-001

Identifier	REC-FUN-001
Title	Recognition of commands for lateral movement
Requirement	THE SYSTEM SHALL be able to recognize standard phraseology commands for lateral movement of the flight: • Corresponding phraseology: ○ HEADING (value) ○ CONTINUE PRESENT HEADING ○ TURN LEFT/RIGHT BY ○ TURN LEFT/RIGHT HEADING ○ DIRECT TO (waypoint) ○ PROCEED DIRECT TO (waypoint) Recognised command for lateral movement shall contain following attributes: • Command Type (HEADING)

<table>
<tr><td></td><td>

DIRECTION <-|LEFT|RIGHT> (if provided)
VALUE<-|VALUE>

Command Type (TURN BY)

DIRECTION <LEFT|RIGHT> (if provided)
VALUE <VALUE>

Command Type (CONTINUE)

VALUE<-|VALUE> (if provided)

Command Type (DIRECT TO)

FIX NAME

In order to flag command for lateral movement as recognised THE SYSTEM shall recognise ALL of its attributes.
CONDITION:
The training data contains enough examples of each of these commands to train the ABSR system.
</td></tr>
<tr><td>Rationale / Why this requirement</td><td></td></tr>
<tr><td>RQ from (Who benefits)?</td><td>
<table>
<tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr>
<tr><td>ANS CR</td><td>Status: accepted 2016-07-13</td></tr>
</table>
</td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td>
<table>
<tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-06-29</td></tr>
<tr><td>USAAR</td><td>Status: accepted 2016-06-01</td></tr>
<tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr>
</table>
</td></tr>
<tr><td>Priority</td><td>Shall</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration of full set of command types: O2 and T1-Live</td></tr>
<tr><td>Conflicts</td><td></td></tr>
<tr><td>Additional Information</td><td>Details concerning recognition quality are specified by the non-functional requirements. It is not possible to recognize all commands with an accuracy of 100%.

Recognition and Error rate is best, when standard phraseology is strictly used; Recognition and Error rate will be worse for non-standard phraseology.

Remark: The change of Aneta from 2016-10-07 is not documented in the</td></tr>
</table>

	change history. The output of the system in case of a “continue present heading” or “maintain heading” utterance is MAINTAIN_HEADING followed by a value of not.
History	<table><tr><td>16-05-23</td><td>AC</td><td>First Version</td></tr><tr><td>16-05-30</td><td>MN</td><td>Test Method changed</td></tr><tr><td>16-06-06</td><td>MN</td><td>Change in requirement text</td></tr><tr><td>16-06-09</td><td>HHe</td><td>Conflict added</td></tr><tr><td>16-06-27</td><td>AC</td><td>New identifier</td></tr><tr><td>16-06-29</td><td>MF</td><td>Slight changes</td></tr><tr><td>16-07-13</td><td>AC</td><td>Requirement text changed</td></tr><tr><td>16-07-31</td><td>HHe</td><td>Detailed information that direction information may be missing.</td></tr><tr><td>17-07-27</td><td>HHe</td><td>Adding a remark for MAINTAIN_HEADING and CONTINUE</td></tr></table>

3.2.2 REC-FUN-002

Identifier	REC-FUN-002
Title	Recognition of commands for vertical movement
Requirement	THE SYSTEM SHALL be able to recognize standard phraseology commands for vertical movement of the flight: • Corresponding phraseology: ○ CLIMB TO Flight Level / Altitude (value) ○ CLIMB TO Flight Level / Altitude(value) or above ○ DESCEND TO Flight Level / Altitude (value) ○ DESCEND TO Flight Level / Altitude (value) or below ○ MAINTAIN_ALTITUDE Flight Level / Altitude (value) ○ STOP CLIMB ○ STOP DESCEND Recognised command for vertical movement shall contain following

<table>
<tr><td></td><td>information:

• Command Type (VERTICAL MOVEMENT)
  ○ SENSE <-|CLIMB| DESCEND| MAINTAIN>
  ○ LEVEL TYPE <-|FL|ALT>
  ○ LEVEL <VALUE>
• Command Type (STOP CLIMB)
• Command Type (STOP DESCEND)

In order to flag command for vertical movement as recognised THE SYSTEM shall recognise ALL of its attributes.

CONDITION:

The training data contains enough examples of each of these commands to train the ABSR system.</td></tr>
<tr><td>Rationale / Why this requirement</td><td></td></tr>
<tr><td>RQ from (Who benefits)?</td><td><table><tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr><tr><td>ANS CR</td><td>Status: accepted 2016-07-13</td></tr></table></td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td><table><tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-06-29</td></tr><tr><td>USAAR</td><td>Status: accepted 2016-06-01</td></tr><tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr></table></td></tr>
<tr><td>Priority</td><td>Shall</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration of full set of command types (O2, T1-Live)</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>It is not possible to recognize all commands with an accuracy of 100%. Details concerning recognition quality are specified by the non-functional requirements.

Recognition and Error rate is best, when standard phraseology is strictly used; Recognition and Error rate will be worse for non-standard phraseology.</td></tr>
<tr><td>History</td><td><table><tr><td>16-05-23</td><td>AC</td><td>First Version</td></tr></table></td></tr>
</table>

	16-05-30	MN	Test Method changed
	16-06-06	MN	Change in requirement text
	16-06-09	HHe	Conflict added
	16-06-27	AC	New identifier
	16-06-29	MF	Slight changes
	16-07-13	AC	Requirement text changed
	17-07-27	HHe	Output not MAINTAIN, but MAINTAIN_ALTITUDE
	18-02-06	HHe	Test method edited

3.2.3 REC-FUN-003

Identifier	REC-FUN-003
Title	Recognition of commands for rate of climb/descent
Requirement	THE SYSTEM SHALL be able to recognize standard phraseology commands for rate of climb/descent of the flight: • Corresponding phraseology: ○ RATE OF CLIMB (value) ○ RATE OF CLIMB (value) or less ○ RATE OF CLIMB (value) not below ○ RATE OF DESCEND (value) ○ RATE OF DESCEND (value) or greater ○ RATE OF DESCEND (value) not above Recognised command for rate of climb/descent shall contain following information: • Command Type (VERTICAL MOVEMENT RATE) ○ SENSE <ROC|ROD> ○ RATE <value|MIN|MAX>

<table>
<tr><td></td><td>
TOLERANCE <OR LESS|OR GREATER>
In order to flag command for rate of climb/descent as recognised THE SYSTEM shall recognise ALL of its attributes.
CONDITION:
The training data contains enough examples of each of these commands to train the ABSR system.
</td></tr>
<tr><td>Rationale / Why this requirement</td><td></td></tr>
<tr><td>RQ from (Who benefits)?</td><td>
<table>
<tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr>
<tr><td>ANS CR</td><td>Status: accepted 2016-07-13</td></tr>
</table>
</td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td>
<table>
<tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-06-30</td></tr>
<tr><td>USAAR</td><td>Status: accepted 2016-06-01</td></tr>
<tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr>
</table>
</td></tr>
<tr><td>Priority</td><td>Shall</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration of full set of command types (O2, T1-Live)</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>
It is not possible to recognize all commands with an accuracy of 100%. Details concerning recognition quality are specified by the non-functional requirements.
Recognition and Error rate is best, when standard phraseology is strictly used; Recognition and Error rate will be worse for non-standard phraseology.
In some cases controllers use “Own rate of climb”. The semantics with respect to desired output will be defined later.
</td></tr>
<tr><td>History</td><td>
<table>
<tr><td>16-05-23</td><td>AC</td><td>First Version</td></tr>
<tr><td>16-05-30</td><td>MN</td><td>Test Method changed</td></tr>
<tr><td>16-06-06</td><td>MN</td><td>Change in requirement text</td></tr>
</table>
</td></tr>
</table>

	16-06-27	AC	New identifier
	16-06-30	MF	Slight changes
	16-07-13	AC	Requirement text changed
	16-08-01	HHe	Own rate of climb added and test method edited

3.2.4 REC-FUN-004

Identifier	REC-FUN-004
Title	Recognition of commands for speed adjustment
Requirement	THE SYSTEM SHALL be able to recognize standard phraseology commands for speed adjustment of the flight: • Corresponding phraseology: ○ SPEED (value) ○ SPEED (value) or greater ○ SPEED (value) or less ○ MAINTAIN SPEED (value) or less ○ MAINTAIN SPEED (value) or greater ○ INCREASE SPEED TO (value) ○ INCREASE SPEED TO (value) or greater ○ REDUCE SPEED TO (value) ○ REDUCE SPEED TO (value) or less ○ REDUCE SPEED TO (value) or greater ○ REDUCE TO FINAL APPROACH SPEED ○ REDUCE TO MINIMUM CLEAN SPEED ○ REDUCE TO MINIMUM APPROACH SPPED ○ SPEED OWN Recognised command for speed adjustments shall contain following information: • Command Type (SPEED CHANGE) ○ ADJUSTMENT <-|INCREASE|REDUCE> ○ SPEED <-|VALUE> ○ TOLERANCE <OR LESS|OR GREATER> • Command Type (SPEED MAINTAIN) ○ SPEED <-|VALUE> (if provided)

<table>
<tr><td></td><td>

TOLERANCE <OR LESS|OR GREATER>

Command Type (FINAL APPROACH)
Command Type (MINIMUM CLEAN)
Command Type (MINIMUM APPROACH)
Command Type (OWN SPEED)

In order to flag command for speed adjustment as recognised THE SYSTEM shall recognise ALL of its attributes.
CONDITION:
The training data contains enough examples of each of these commands to train the ABSR system.
</td></tr>
<tr><td>Rationale / Why this requirement</td><td></td></tr>
<tr><td>RQ from (Who benefits)?</td><td>
<table>
<tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr>
<tr><td>ANS CR</td><td>Status: accepted 2016-07-13</td></tr>
</table>
</td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td>
<table>
<tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-06-30</td></tr>
<tr><td>USAAR</td><td>Status: accepted 2016-06-01</td></tr>
<tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr>
</table>
</td></tr>
<tr><td>Priority</td><td>Shall</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration of full set of command types (O2, T1-Live)</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>
It is not possible to recognize all commands with an accuracy of 100%. Details concerning recognition quality are specified by the non-functional requirements.
Recognition and Error rate is best, when standard phraseology is strictly used; Recognition and Error rate will be worse for non-standard phraseology.
</td></tr>
<tr><td>History</td><td>
<table>
<tr><td>16-05-26</td><td>AC</td><td>First Version</td></tr>
<tr><td>16-05-30</td><td>MN</td><td>Test Method changed</td></tr>
<tr><td>16-06-06</td><td>MN</td><td>Change in requirement text</td></tr>
</table>
</td></tr>
</table>

	16-06-27	AC	New identifier
	16-06-30	MF	Slight changes
	16-07-13	AC	Requirement text changed
	16-08-02	HHe	Comments added with respect to “or less” resp. “or greater”.
	16-08-03	AC	Attribute TOLERANCE added
	16-09-08	HHe	Maintain speed could also contain a value
	17-01-06	AC	MINIMUM APPROACH command type added
	18-02-06	HHe	Test method edited

3.2.5 REC-FUN-005

Identifier	REC-FUN-005
Title	Recognition of commands for STAR

Requirement	THE SYSTEM SHOULD be able to recognize ASSIGN STAR.
	• Corresponding phraseology:
	  ○ (STAR name)
	  ○ TRANSITION (name)
	Recognised command for STAR adjustments shall contain following information:
	• Command Type (STAR)
	  ○ NAME <VALUE>
	CONDITION:
	The training data contains enough examples of each of these commands to train the ABSR system.

Rationale / Why this requirement	

RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen)	Status: accepted 2016-06-09
	USAAR	Status: accepted 2016-06-01
	Idiap (requirement for ABSR system)	Status: accepted 2016-07-21
Priority	will	
Category	FR	
Test Method / Acceptance Criteria	Test Demonstration of full set of command types: This functionality is not implemented in MALORCA project due to lack of transcribed training data.	
Conflicts	Currently none	
Additional Information	Local STAR / Transition will be specified in dataset table. It is not possible to recognize all commands with an accuracy of 100%. Details concerning recognition quality are specified by the non-functional requirements. Recognition rate will be the highest when standard phraseology is strictly used; Recognition rate will significantly decrease for non-standard phraseology.	

History			
	16-05-26	AC	First Version
	16-05-30	MN	Test Method changed
	16-06-06	MN	Change in requirement text
	16-06-27	AC	New identifier
	16-07-13	AC	Requirement edited
	18-02-06	HHe	Test method edited

3.2.6 REC-FUN-007

Identifier	REC-FUN-007
Title	Recognition of commands for approach clearance

<table>
<tr><td>Requirement</td><td>THE SYSTEM SHALL be able to recognize standard phraseology command for approach clearances of the flight:

• Corresponding phraseology:
○ CLEARED ILS APPROACH RWY (name)
○ CLEARED RNAV APPROACH RWY (name)
○ CLEARED NDB APPROACH RWY (name)
○ INTERCEPT LOCALIZER RWY (name)
○ CLEARED APPROACH RWY (name)

Recognised command for approach clearance shall contain following information:

• Command Type (APPROACH CLEARANCE)
○ CLEARANCE <YES|NO>
○ TYPE <ILS|RNAV|NDB|APPROACH|other> if applicable
○ RWY <VALUE|->
• Command Type (LOCALIZER)
○ RWY <VALUE|->

In order to flag command for approach clearance as recognised THE SYSTEM should recognise ALL of its attributes.</td></tr>
<tr><td>Rationale / Why this requirement</td><td></td></tr>
<tr><td>RQ from (Who benefits)?</td><td><table><tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr><tr><td>ANS CR</td><td>Status: accepted 2016-07-13</td></tr></table></td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td><table><tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-07-25</td></tr><tr><td>USAAR</td><td>Status: accepted 2016-06-01</td></tr><tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr></table></td></tr>
<tr><td>Priority</td><td>Shall</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration of full set of command types: This functionality is only partly impelemented in MALORCA project due to lack of transcribed</td></tr>
</table>

<table>
<tr><td></td><td>training data.</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>It is not possible to recognize all commands with an accuracy of 100%. Details concerning recognition quality are specified by the non-functional requirements.

Recognition rate will be the highest when standard phraseology is strictly used; Recognition rate will significantly decrease for non-standard phraseology.</td></tr>
<tr><td>History</td><td>
<table>
<tr><td>16-05-23</td><td>AC</td><td>First Version</td></tr>
<tr><td>16-05-30</td><td>MN</td><td>Minor change to req. text, Test Method changed</td></tr>
<tr><td>16-06-06</td><td>MN</td><td>Change in requirement text</td></tr>
<tr><td>16-06-09</td><td>HHe</td><td>Changed from rejected to accepted, if the output format is specified accordingly</td></tr>
<tr><td>16-06-27</td><td>AC</td><td>New identifier</td></tr>
<tr><td>16-06-30</td><td>MF</td><td>Slight changes</td></tr>
<tr><td>16-07-13</td><td>AC</td><td>Requirement edited</td></tr>
<tr><td>16-08-02</td><td>HHe</td><td>Localizer added</td></tr>
<tr><td>16-08-03</td><td>AC</td><td>Localizer phraseology and command type changed</td></tr>
<tr><td>17-01-06</td><td>AC</td><td>CLEARED APPROACH RWY (name)</td></tr>
<tr><td>18-02-06</td><td>HHe</td><td>Test method edited</td></tr>
</table>
</td></tr>
</table>

3.2.7 REC-FUN-008

Identifier	REC-FUN-008
Title	Recognition of commands for handover process
Requirement	THE SYSTEM SHALL be able to recognize standard phraseology command for handover of the flight: • Corresponding phraseology: ▪ CONTACT (sector name) (value) Recognised command for handover shall contain following information: • Command Type (HANDOVER) ○ NAME <NEXT SECTOR|-> if applicable ○ FREQUENCY <VALUE|-> if applicable CONDITION: The training data contains enough examples of each of these commands to train the ABSR system.
Rationale / Why this requirement	
RQ from (Who benefits)?	ACG — Status: accepted 2016-07-13 ANS CR — Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen) — Status: accepted 2016-05-13 USAAR — Status: accepted 2016-06-01 Idiap — Status: accepted 2016-07-21
Priority	Shall
Category	FR
Test Method / Acceptance Criteria	Test Demonstration of full set of command types (O2, T1-Live)
Conflicts	Currently none

Additional Information	It is not possible to recognize all commands with an accuracy of 100%. Details concerning recognition quality are specified by the non-functional requirements. Recognition rate will be the highest when standard phraseology is strictly used; Recognition rate will significantly decrease for non-standard phraseology.
History	16-05-23 AC First Version 16-05-30 MN Update, clarifications needed. 16-06-06 MN Change in requirement text 16-06-27 AC New identifier 16-06-30 MF Slight changes 16-07-13 AC Requirement edited 18-02-06 HHe Test method edited

3.2.8 REC-FUN-009

Identifier	REC-FUN-009
Title	Recognition of commands for published holding

Requirement	THE SYSTEM SHOULD be able to recognize standard phraseology commands for published holding over a fix or facility or waypoint:
	
	• Corresponding phraseology:
	  ○ HOLD AS PUBLISHED
	
	Recognised command for published holding shall contain following information:
	
	• Command Type (HOLD)
	  ○ NAME <fix|facility|waypoint>
	
	CONDITION:
	
	The training data contains enough examples of each of these commands to train the ABSR system.

Rationale / Why this requirement	To be able to provide information about a clearance to a published holding pattern.

RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen)	Status: accepted 2016-06-09
	USAAR	Status: accepted 2016-06-01
	Idiap (requirement for ABSR system)	Status: accepted 2016-07-21
Priority	Should	
Category	FR	
Test Method / Acceptance Criteria	Test Demonstration. This functionality is only partly implemented in MALORCA project due to lack of transcribed training data.	
Conflicts	Currently none	
Additional Information		

History			
	16-05-30	MN	First Version
	16-06-09	HHe	accepted
	16-06-27	AC	New identifier
	16-06-30	MF	Slight changes
	16-07-13	AC	Requirement edited
	18-02-06	HHe	Test method edited

3.2.9 REC-FUN-012

Identifier	REC-FUN-012-
Title	Recognition of information for (future) landing RWY assignment.
Requirement	THE SYSTEM WILL be able to recognize the expected landing runway: • Corresponding phraseology:

<table>
<tr><td></td><td>
EXPECT RWY (rwy identification)
Recognised command for change of assigned RWY for landing shall contain following information:
Command Type (EXPECT_RUNWAY)
VALUE
CONDITION:
The training data contains enough examples of each of these commands to train the ABSR system.
</td></tr>
<tr><td>Rationale / Why this requirement</td><td>To be able to provide information about change of assigned RWY for landing.</td></tr>
<tr><td>RQ from (Who benefits)?</td><td>
<table>
<tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr>
<tr><td>ANS CR</td><td>Status: accepted 2016-07-13</td></tr>
</table>
</td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td>
<table>
<tr><td>DLR (requirement for Hyp Gen)</td><td>Status: accepted 2016-07-25</td></tr>
<tr><td>USAAR</td><td>Status: accepted 2016-06-01</td></tr>
<tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr>
</table>
</td></tr>
<tr><td>Priority</td><td>Will</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration (O2, T1-Live)</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>This usually applies to the situations when assigned runway is different from global landing runway in use.</td></tr>
<tr><td>History</td><td>
<table>
<tr><td>30-05-2016</td><td>MN</td><td>First Version</td></tr>
<tr><td>09-06-16</td><td>HHe</td><td>Changed to accepted</td></tr>
<tr><td>16-06-27</td><td>AC</td><td>New identifier</td></tr>
<tr><td>16-07-13</td><td>AC</td><td>Requirement edited</td></tr>
<tr><td>16-07-21</td><td>MF</td><td>Slight changes</td></tr>
</table>
</td></tr>
</table>

	16-07-25	Hhe	Command changed to information
	16-07-29	AC	Priority WILL set
	16-08-01	Hhe	Command changed again to information
	16-08-04	AC	Additional information added, text of req changed
	18-02-06	HHe	Test method edited

3.2.10 REC-FUN-013

Identifier	REC-FUN-013	
Title	Recognition of commands for go around.	
Requirement	THE SYSTEM SHOULD be able to recognize command for go around: • Corresponding phraseology: ○ GO AROUND Recognised command for go around shall contain following attribute: • Command Type (GO AROUND) CONDITION: The training data contains enough examples of this command train the ABSR system.	
Rationale / Why this requirement	To be able to provide information about go around.	
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen)	Status: accepted 2016-06-09
	USAAR	Status: accepted 2016-06-01
	Idiap (requirement for ABSR system)	Status: accepted 2016-07-21

Priority	Should
Category	FR
Test Method / Acceptance Criteria	Test Demonstration: This functionality is not implemented in MALORCA project due to lack of transcribed training data.
Conflicts	Currently none
Additional Information	
History	16-05-30 MN First Version 16-06-27 AC New identifier 16-07-13 AC Requirement edited 16-07-21 MF Slight changes 18-02-06 HHe Test method edited

3.2.11 REC-FUN-014

Identifier	REC-FUN-014
Title	Recognition of command to indicate the separation between messages transmitted to different aircraft in a very busy environment.
Requirement	THE SYSTEM should be able to recognize and process a command to indicate the separation between messages transmitted to different aircraft in a very busy environment: • Corresponding phraseology: ○ BREAK, BREAK Recognised BREAK BREAK command shall have following effect: • Command before BREAK BREAK needs to be recognized. • Command after BREAK BREAK needs to be recognized as new command for a new aircraft callsign. CONDITION: The training data contains enough examples of this command to train the ABSR system.
Rationale / Why this requirement	To be able to indicate the separation between messages transmitted to different aircraft in a very busy environment.

RQ from (Who benefits)?	ACG	Status: accepted 2016-07-13
	ANS CR	Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	USAAR	Status: accepted 2016-06-01
	Idiap (requirement for ABSR system)	Status: accepted 2016-07-21
Priority	should	
Category	FR	
Test Method / Acceptance Criteria	Test Demonstration: This functionality is only partly implemented in MALORCA project due to lack of transcribed training data.	
Conflicts	Currently none	
Additional Information	BREAK BREAK has nearly the same semantics as releasing the PTT button, but the behaviour could be different because detecting break, break might be more difficult for the system than releasing the PTT, see also addition information with examples in REC-FUNC-005.	

History

16-05-30	MN	First Version
16-06-09	HHe	Priority set to should
16-06-27	AC	New identifier
16-07-21	MF	DLR deleted from list for “RQ for”. “Break Break” could occur between any commands, so no special requirement for hypothesis generation.
16-08-01	HHe	Addition information provided.
18-02-06	HHe	Test method edited

3.2.12 REC-FUN-015

Identifier	REC-FUN-015
Title	Recognition of command to indicate that an error has been made in

<table>
<tr><td></td><td>transmission and to correct this error</td></tr>
<tr><td>Requirement</td><td>THE SYSTEM SHOULD be able to recognize and process a command to indicate that an error has been made in transmission and to correct this error:

• Corresponding phraseology:
○ CORRECTION

CONDITIONS:

The training data contains enough examples of this command to train the ABSR system.

The standard phraseology for correction is respected.</td></tr>
<tr><td>Rationale / Why this requirement</td><td>To be able to indicate that an error has been made in transmission and to correct this error.</td></tr>
<tr><td>RQ from (Who benefits)?</td><td><table><tr><td>ACG</td><td>Status: accepted 2016-07-13</td></tr><tr><td>ANS CR</td><td>Status: accepted 2016-07-13</td></tr></table></td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td><table><tr><td>USAAR</td><td>Status: accepted 2016-06-01</td></tr><tr><td>Idiap (requirement for ABSR system)</td><td>Status: accepted 2016-07-21</td></tr></table></td></tr>
<tr><td>Priority</td><td>Should</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Test
Demonstration: This functionality is only partly implemented in MALORCA project due to lack of transcribed training data.</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>The effect of CORRECTION needs to be discussed furthermore and requires deep operational analysis; however, this is out of the scope of this project.</td></tr>
<tr><td>History</td><td><table><tr><td>16-05-30</td><td>MN</td><td>First Version</td></tr><tr><td>16-06-09</td><td>HHe</td><td>DLR deleted from list of “RQ for”. Correction could occur in any command, so no special requirement for hypothesis generation
Priority set to should</td></tr><tr><td>16-06-27</td><td>AC</td><td>New identifier</td></tr></table></td></tr>
</table>

	16-07-14	AC	Additional information added
	18-02-06	HHe	Test method edited

3.2.13 REC-FUN-016

Identifier	REC-FUN-016
Title	Recognition of command to indicate the transmission shall be ignored.
Requirement	THE SYSTEM SHOULD be able to recognize and process a command to indicate the transmission shall be ignored: • Corresponding phraseology: ○ DISREGARD Recognised DISREGARD command shall have following effect: • Ignore the utterance, i.e. the SYSTEM SHOULD send no output. CONDITION: The training data contains enough examples of this command to train the ABSR system.
Rationale / Why this requirement	To be able to indicate to indicate the transmission shall be ignored.
RQ from (Who benefits)?	ACG: Status: accepted 2016-07-13 ANS CR: Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	USAAR: Status: accepted 2016-06-01 Idiap (requirement for ABSR system): Status: accepted 2016-07-21
Priority	should
Category	FR
Test Method / Acceptance Criteria	Test Demonstration: This functionality is not impelemented in MALORCA project due to lack of transcribed training data.

Conflicts	Currently none
Additional Information	The effect of DISREGARD needs to be discussed furthermore and requires deep operational analysis, however, this is out of the scope of this project.
History	16-05-30 | MN | First Version 16-06-09 | HHe | DLR deleted from list of "RQ for". Correction could occur in any command, so no special requirement for hypothesis generation Priority set to should 16-06-27 | AC | New identifier 16-07-14 | AC | Additional information added 18-02-06 | HHe | Test method edited

3.2.14 REC-FUN-017

Identifier	REC-FUN-017
Title	Offline configuration of command types properties.
Requirement	THE SYSTEM WILL have the ability to offline define properties and content of each command type: • Processed Y|N • Sent to external system Y|N • Item Mandatory|Optional • […]
Rationale / Why this requirement	To be able to offline configure the system with regard to command types and their properties and content.
RQ from (Who benefits)?	ACG | Status: accepted 2016-07-13 ANS CR | Status: accepted 2016-07-13
RQ for (Who has to implement RQ)?	DLR (requirement for Hyp Gen) | Status: accepted 2016-07-25
Priority	should
Category	FR
Test Method /	Test

Acceptance Criteria	
Conflicts	Currently none
Additional Information	This requirement reflects the Assumption 2 from [1] which might have an impact on the overall reliability of the SYSTEM. Example: Normally, the system would recognize the commands determining vertical movement of the flight. By means of offline configuration, it should be possible to e.g. supress recognition send to the external system. It should be possible to specify that e.g. all ALTITUDE/SPEED/HEADING etc. commands are not shown to the controller anymore, because recognition of them is today very bad. The semantics of "Item Mandatory|Optional" need to be detailed in the future.
History	16-05-30 MN First Version 16-06-27 AC New identifier 16-07-25 HHe Additional Information added 16-07-29 AC Slight changes 16-09-06 HHe Question to semantics of item added 16-09-12 AC Link to [1] created.

3.3 Input Requirements

3.3.1 SYS-INP-001

Identifier	SYS-INP-001
Title	Aircraft State: Processing of Asterix CAT62
Requirement	THE SYSTEM SHALL be able to process aircraft state in ASTERIX Cat 62

	format.
Rationale / Why this requirement	ASTERIX Cat 62 is the standard format. The aircraft state consists e.g. of aircraft position, aircraft altitude, aircraft speed, aircraft heading, rate of climb, time information. This information is needed to determine future aircraft sequences, trajectories, advisories etc. This information is needed to derive the command hypothesis.
RQ from (Who benefits)?	ACG — Status: accepted 2016-07-14 ANS CR — Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	DLR — Status: accepted 2016-05-13
Priority	Shall
Category	FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	Currently none
Additional Information	DLR's 4D-CARMA Systems Input data are status information of all active flights. These data must cover callsign, position data, speed, heading, aircraft type, weight category, Destination airport, etc. Data are included in Asterix Cat 62 format.
History	16-05-02 HHe First Version 16-05-13 MF Minor changes 16-06-27 AC New identifier

3.3.2 SYS-INP-002

Identifier	SYS-INP-002
Title	Dynamic Airport Data
Requirement	THE SYSTEM WILL be able to process dynamic airport data (e.g. meteorological data).
Rationale / Why this	Filtering algorithms and hypothesis generating routines may depend on

requirement	such data.
RQ from (Who benefits)?	ACG: Status: accepted 2016-07-14 ANS CR: Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	DLR: Status: accepted 2016-05-13
Priority	Will
Category	FR
Test Method / Acceptance Criteria	None. This is not implemented during MALORCA project. Only QNH information is extracted from the recognized commands.
Conflicts	Currently none
Additional Information	The format has to be defined by the ANSPs.
History	16-05-11 HHe First Version 16-05-13 MF Minor changes 16-06-27 AC New identifier

3.3.3 SYS-INP-003

Identifier	SYS-INP-003
Title	Flight plan data, flight data and their updates
Requirement	THE SYSTEM SHALL be able to receive and process flight plan data, flight data and their updates from FDPS. The system **should** receive, from the FDP, flight status information for each flight covering such information as current controlling position, hand-in-first flag, cleared FL, assigned speed, assigned heading, direct-to-point,etc. CONDITION Test data contains enough data examples.

Rationale / Why this requirement	For e.g. THE SYSTEM feedback from the ATCOs actions.		
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-14	
	ANS CR	Status: accepted 2016-07-14	
RQ for (Who has to implement RQ)?	DLR	Status: accepted 2016-05-30	
Priority	Shall		
Category	FR		
Test Method / Acceptance Criteria	Test O2: Aircraft which enter scenario as inbound, land and start as outbound get an updated flight plan. The updated flight plan is taken into account, when it can be shown that commands are predicted for the inbound and the outbound (sharing the same callsign).		
Conflicts	Currently none		
Additional Information			
History	16-05-30	MN	First Version
	16-06-27	AC	New identifier
	18-02-06	HHe	Test method edited

3.4 System Configuration Requirements

3.4.1 SYS-OFF-001

Identifier	SYS-OFF-001	
Title	Offline configuration support tool	
Requirement	THE SYSTEM WILL provide HMI tool to maintain the datasets and other configuration parameters	
Rationale / Why this requirement	To be able to manage the dataset and other offline configuration	
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-14
	ANS CR	Status: accepted 2016-07-14

RQ for (Who has to implement RQ)?	DLR	Status: accepted 2016-05-30
Priority	WILL	
Category	FR	
Test Method / Acceptance Criteria	Test	
Conflicts	Currently none	
Additional Information		
History	06-06-2016 / MN / First Version	
	2016-06-24 / AC / Requirement text changed	
	16-06-27 / AC / New identifier	
	16-08-01 / HHe / Condition added	
	17-07-28 / HHe / Priority changed from SHALL to WILL, comment added that more details are needed.	

3.4.2 SYS-OFF-002

Identifier	SYS-OFF-002
Title	Waypoint List
Requirement	THE SYSTEM SHALL provide the ANSP's maintenance staff with the ability to define a list of waypoints for which DIRECT-TO advisories maybe recognized. THE SYSTEM SHALL provide the ANSP's maintenance staff with the ability to define a list of transitions for which TRANSITION advisories maybe recognized. THE SYSTEM SHALL provide the ANSP's maintenance staff with the ability to define a list of fixes for which (Enter and Leave) HOLDING advisories

<table>
<tr><td></td><td>maybe recognized.

Waypoint and IFR procedure data will contain the geographical position(s), the published identifier and the pronunciation. Regarding waypoints, it will be possible to indicate the affiliation to any other IFR procedure.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Rationale / Why this requirement</td><td>The waypoint and IFR procedure data are airspace / aerodrome dependent, i.e. different in Prague and Vienna. In principle this data could be automatically learned, but then it must be guaranteed, that all cases are often enough in the training data. Learning, however, will not enable to determine the geographical data as well as pronunciation.

On the one hand DLR has to provide an interface for easy adding and deleting waypoints and procedure data.

ACG / ANS CR have to provide the data, which are relevant in the recognition context.

Depending on the demand and the project progress, other commands related to local IFR procedures will be implemented (e.g. full NDB / VOR / LOC / DME / RNAV approach procedures).</td></tr>
<tr><td>RQ from (Who benefits)?</td><td><table><tr><td>ACG</td><td>Status: accepted 2016-07-14</td></tr><tr><td>ANS CR</td><td>Status: accepted 2016-07-14</td></tr></table></td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td><table><tr><td>DLR</td><td>Status: accepted 2016-05-13</td></tr></table></td></tr>
<tr><td>Priority</td><td>Shall</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Unit Test: DLR add the waypoint (which is often use in training data) to the list and delete another. The speech recognition interface is restarted. The generated set of possible commands will never contain the deleted one and will (sometimes) contain the new one.</td></tr>
<tr><td>Conflicts</td><td>Currently none</td></tr>
<tr><td>Additional Information</td><td>See glossary in annex for

• ANSP’s maintenance staff
• List of waypoints for which DIRECT-TO advisories maybe recognized.
• List of waypoints for which HOLDING advisories maybe recognized.
• List of waypoints for which TRANSITION advisories maybe recognized.</td></tr>
</table>

History	16-05-02	HHe	First Version
	16-05-13	MF	Minor changes
	16-06-27	AC	New identifier
	18-02-06	HHe	Test method edited

3.4.3 SYS-OFF-003

Identifier	SYS-OFF-003	
Title	Control Region Boundary	
Requirement	THE SYSTEM SHOULD provide the ANSP's maintenance staff with the ability to define a region of interest for a given controller positions.	
Rationale / Why this requirement	Each controller position has a defined area of responsibility. This area of responsibility may be amended from time to time or may be subject to a combination with another working position.	
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-14
	ANS CR	Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	DLR	Status: accepted 2016-05-13
Priority	Should	
Category	FR	
Test Method / Acceptance Criteria	Unit Test: The boundary of a region is manually changed. It is tested for different aircraft positions (before and afterwards) whether command hypothesis are only generated for aircraft which are inside the specified regions.	
Conflicts	Currently none	
Additional Information	It is expected that areas of responsibility can also be machine learned with an acceptable accuracy.	
History	16-05-02	HHe	First Version

	16-05-13	MF	Rational changed and other minor changes
	16-06-27	AC	New identifier
	18-02-06	HHe	Test method edited

3.4.4 SYS-OFF-004

Identifier	SYS-OFF-004		
Title	Runway-Configuration		
Requirement	THE SYSTEM SHOULD provide the ANSP's maintenance staff with the ability to define a runway configuration for the airport the approach controller is responsible for.		
Rationale / Why this requirement	All the runways currently in use need to be defined in the direction of operation (e.g. "25R", "07L", or "25R and 25L")		
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-14	
	ANS CR	Status: accepted 2016-07-14	
RQ for (Who has to implement RQ)?	DLR	Status: accepted 2016-05-13	
Priority	Should		
Category	FR		
Test Method / Acceptance Criteria	Unit Test: The runway configuration is changed. It is tested for different aircraft (before and afterwards) whether command hypothesis are only generated for active runway configurations.		
Conflicts	Currently none		
Additional Information			
History	16-05-06	OOh	First Version
	16-06-27	AC	New identifier
	18-02-06	HHe	Test method edited

3.4.5 SYS-OFF-005

Identifier	SYS-OFF-005
Title	Controller-Working-Position-Configuration
Requirement	THE SYSTEM SHOULD provide the ANSP's maintenance staff with the ability to define a controller working position configuration for the airport the approach controller is responsible for.
Rationale / Why this requirement	The controller may act as a Pickup (Arrival), Feeder (Director), Final controller etc. only or incorporate a combination thereof in one person. The knowledge about control region boundaries may then be applied.
RQ from (Who benefits)?	ACG — Status: accepted 2016-07-14 ANS CR — Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	DLR — Status: accepted 2016-05-06
Priority	Should
Category	FR
Test Method / Acceptance Criteria	Unit Test:
Conflicts	Currently none
Additional Information	

History

16-05-06	OOh	First Version
16-05-13	MF	Minor changes
16-06-27	AC	New identifier

3.4.6 SYS-OFF-006

Identifier	SYS-OFF-006
Title	Recording configuration is changeable

Requirement	THE SYSTEM WILL provide the ANSP's maintenance staff with the ability to change the recording configuration.
Rationale / Why this requirement	This is a requirement for the future. If the recording configuration changes during the proof-of-concept trials the THE SYSTEM will be restarted.
RQ from (Who benefits)?	ACG: Status: accepted 2016-07-14 ANS CR: Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	DLR: Status: accepted 2016-05-30
Priority	Will
Category	FR
Test Method / Acceptance Criteria	Unit-Tests, Demonstration (in the future) The Unit-Tests will read two different recording configuration files and the output of predicted commands will be different.
Conflicts	
Additional Information	See glossary • Recording configuration

History			
	16-05-11	HHe	First Version
	16-06-27	AC	New identifier
	18-02-06	HHe	Test method edited

3.4.7 SYS-OFF-007

Identifier	SYS-OFF-007
Title	System offline configuration options

Requirement	THE SYSTEM SHALL allow following OFFLINE configuration options:
	• Detailed configuration of Sectors and controller positions:
	  ○ Name
	  ○ Type
	  ○ Boundary
	  ○ Area of responsibility
	  ○ Area of Interest
	  ○ Frequency

<table>
<tr><td></td><td>

Including adjacent units

Detailed configuration of airspace, its structure and layout

Airspace limits
Airspace restrictions
Route structure
Configuration ofSTARs
Configuration of SIDs
Configuration of waypoints (SYS-OFF-002)
Configuration of holdings

Detailed configuration of Aerodrome

Configuration of RWYs (SYS-OFF-004)
Configuration of types of Approaches

Detailed configuration of Command types and their properties (REC-FUN-017)

Processing Y|N
Sending to external system Y|N
Item Mandatory | Optional

Detailed configuration options for recognition
Detailed configuration of interfaces
Detailed configuration of Recording (SYS-OFF-006)
Detailed configuration of user roles
Detailed configuration options of HMI

</td></tr>
<tr><td>Rationale / Why this requirement</td><td></td></tr>
<tr><td>RQ from (Who benefits)?</td><td>
<table>
<tr><td>ACG</td><td>Status: accepted 2016-07-19</td></tr>
<tr><td>ANS CR</td><td>Status: accepted 2016-07-19</td></tr>
</table>
</td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td>
<table>
<tr><td>DLR</td><td>Status: accepted 2016-07-25</td></tr>
</table>
</td></tr>
<tr><td>Priority</td><td>WILL (for HMI part) / SHALL for rest</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Unit-Tests, Demonstration (in the future)</td></tr>
<tr><td>Conflicts</td><td></td></tr>
<tr><td>Additional Information</td><td></td></tr>
</table>

History	16-07-19	MN	First version
	16-07-25	HHe	Priority changed

3.4.8 SYS-OFF-008

Identifier	SYS-OFF-008		
Title	System offline configuration options		
Requirement	THE SYSTEM WILL allow following OFFLINE configuration options: • Parameter defining maximum interval between the controller pushed the PTT button and start of the recognition process (GEN-FUN-003) • Parameter defining maximum interval between the callsign was uttered and the recognised output was sent to external system. (GEN-FUN-004) • Parameter defining maximum interval between end of one utterance and beginning of following utterance for determining the usage of the callsign from one utterance in the following utterance (GEN-FUN-006)		
Rationale / Why this requirement	Offline parameters enable higher flexibility in adaptation process of the deployment.		
RQ from (Who benefits)?	ACG	Status: accepted 2016-07-19	
	ANS CR	Status: accepted 2016-07-19	
RQ for (Who has to implement RQ)?	USAAR	Status: checking 2016-07-25	
	Idiap	Status: checking 2016-07-25	
Priority	WILL		
Category	FR		
Test Method / Acceptance Criteria	Demonstration (in the future)		
Conflicts			
Additional Information	This requirement reflects the Assumption 1 from [1] as it might have a direct impact on the acceptance of the end-users.		
History	16-07-19	MN	First version

	16-07-25	HHe	Priority not SHALL, but WILL, RQ for, not DLR, but USAAR and Idiap
	16-09-12	AC	Link to [1] created and rationale added.

3.4.9 SYS-ON-001

Deleted (Reason: GEN-FUN-002 represents the same requirement.)

4 Machine Learning Requirements

Standard ASR systems are generally based on two main separate components, namely,

1) **The acoustic model** which learns and models the acoustical aspects of speech.
2) **The language model** which captures the structure of a language by learning the possible/allowed sequence of words and possibly their corresponding probabilities of occurrence in a given context.

Additionally, an ABSR requires two additional components,

3) **An assistant system** to generate the dynamic context resulting in a dynamic set of possible commands i.e. it needs a rule hypotheses model. MALORCA will develop generic instances of these components which are adaptable to different approach areas.
4) **A concept generator** which maps the plain text recognized by the speech recognition system, into valid Air Traffic Control (ATC) concepts.

The long term vision of the MALORCA project is that "self-learning" is possible for any airport. Ideally all what the end-user needs to do after recording of hundreds or even thousands of hours of speech data together with the corresponding radar data is to click on a "learn" button, which starts all the learning algorithms developed in this project. Thereby, the system will automatically adapt all its internal models to the new airport, just using un/semi-supervised learning from the untranscribed speech recordings and radar data. After several iterations of learning, we expect the system to achieve a recognition rate comparable to the results of the AcListant® project (i.e. command recognition rate better than 95%, command error rate below 2%.6

On the contrary, the starting point can be described by the situation where an ABSR system is built for Vienna or Prague from scratch, i.e. all the system models are manually adapted using manually transcribed speech (an expensive operation) in order to achieve recognition rates that can reduce the controllers' workload (command recognition rate better than 80%).

MALORCA results are expected in between of these two extreme scenarios. So what is realistic?

Trying to learn/adapt every ATM component might be possible in theory, nevertheless this is probably not the most efficient way. Practically, MALORCA will not automatically learn static information which can be entered manually into the system. MALORCA project, however, will

[6] Recognition rates highly depend on quality of recorded data. If it is very noisy, it complicates learning. If a situation is not in the training data it cannot be learned etc.

provide a framework which manages automatically the adaptation and the deployment of the system. This framework will be based on templates which are used in order to extract knowledge and other useful information from the data. Templates represent basic a priori assumptions or information on system models or processes and need to be automatically parameterized for the actual environment driven by data, i.e. to learn how known basic building blocks are linked, structured and used in the current environment. See the examples below.

In general everything that already exists and does not change frequently over time (e.g. runways) should be manually added to the system, i.e. static knowledge.

The examples of such static knowledge are the following:

- Used runway configurations
- Coordinates and names of relevant waypoints and how they are usually pronounced (e.g. Prague waypoint written as OKG is pronounced as “cheb”)
- STARs and SIDs (Standard Arrival Routes and Standard Instrument Departure Routes)
- Nearby (small) airports in the neighbourhood of main airport, prohibited areas
- Adjacent sectors
- Allowed commands (e-g- DESCEND, REDUCE, HANDOVER, SPEED_OWN, REDUCE_OR_ABOVE etc.)?
- Language model / grammar which is based on ICAO phraseology and normally used for each relevant command (e.g. descend flight level ?value DESCEND ?value)

On the other hand, everything which answers one of the questions “How it is used?”, “In which context it is used?” “Which exceptions from the rule exist?”, etc. should be learned from available data based on initial templates.

The examples are the following:

- Pronunciation alternatives for a waypoint
- User dependent acoustic models or adaptation
- Phraseology alternatives for a command (e.g. down level one twenty for DESCEND 120 FL)
- List of (already defined) possible commands which can be spoken to an aircraft given its airspace information.7

[7] The utterance “Good morning hansa one seven echo praha radar, radar contact expect runway two four descend flight level seven zero echo is correct” was transformed in the AcListant® project into the relevant concepts “DLH17E DESCEND 70 FL”. This was possible, because the DESCEND command is already defined. Without further knowledge it is not possible, that also the concept “DLH17E INFORMATION ECHO” is extracted. If we, however, use transcribed files (the cor files) together with the expected commands (cmd-files) as input,

- Commands which are possible in the current situation (e.g. on north downwind only headings between 50 and 160 degrees are used for the first turn command for an aircraft)
- Responsibility area of the controller [8]
- Minimum and maximum altitudes

The following automatic learning components will be elaborated in MALORCA:

1. Automatic adaptation of the acoustic model: The first step of the project will build a general simple acoustic model that can be used as a basic model that will be automatically adapted (in a short/medium or long term, iterative process) to self-learn the user-specific characteristics such as controller accent, pronunciations for new words, speaking style, etc.
2. Automatic adaptation of language model: The aim here is to have the system automatically detecting and learning deviations from standard, i.e. How some commands or sentences are spoken and integrating them into the language model. This means that deviations from standard ICAO phraseology (which are not already modeled) are learned.
3. Automatic learning of the hypothesis generator models: The goal here is to enable the hypotheses generator to improve the set of all possible commands that can be issued by the controller in a given situation (context).
4. Automatic learning of the concept generator: This part of the project aims at developing an algorithm that is able to automatically learn how to map sequences of plain English words into valid ATC concepts that can be directly integrated into the ATC system.
5. Automatic learning of context integration: The context information is a dynamic part of the ABSR system, therefore, we should be able to automatically detect and adapt the context integration system to the new changes that occur in the context and be able to rebuild the ABSR search space based on these dynamic changes.

The development of these components is expected to result in a 40% to 50% relative improvement of the ConER and CmdER over the basic ASR system. This improvement is obviously highly dependent on the data quality and quantity that will be collected during this project. These numbers, however, do not form an upper bound performance, but rather an early estimate of what can be achieved during the end of this project. The system will be designed such that the learning process can continue for long periods (e.g. months), and, therefore, we expect the system to keep showing an improvement with a learning rate decreasing with time. The decreasing rate, here again, depends on the amount of data that is recorded on a daily basis, its quality as well as the degree of changes in the scenarios that are recorded.

The MALORCA team derives the following requirements for project evaluation:

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more is possible. In this case it could be learned (in principle) that the word sequence ?letter followed by “is correct” is transferred to “INFORMATION ?letter”. In the same way it could be (in principle) possible that the word sequence “expect runway ?runwayname” is transferred to “EXPECT 24”.

[8] This also belongs to the static knowledge which should be provided manually because it is published by ICAO. In reality, however, controllers slightly deviate if special situations are given (e.g. high traffic or low traffic).

4.1.1 SYS-LRN-001

Identifier	SYS-LRN-001
Title	Unsupervised learning improves **static** context
Requirement	The MLS SHALL (automatically) adapt/learn its area of responsibility.
Rationale / Why this requirement	Unsupervised learning should improve the manually created area for which the controller is responsible for. If the manually specified area is too small, aircraft outside this area receive commands that are not in the set of possible commands (ctx-file). As a result, the issued commands can never get detected. Even the callsign of these aircraft is not recognized. If the manually specified area is too large, too many aircraft are in the set of possible commands and therefore the probability of wrong callsign detection increases.
RQ from (Who benefits)?	ACG: Status: accepted 2016-09-23 ANS CR: Status: accepted 2016-09-12 Idiap: Status: accepted 2016-09-01 USAAR: Status: accepted 2016-08-25
RQ for (Who has to implement RQ)?	DLR: Status: accepted 2016-08-25
Priority	Shall
Category	FR
Test Method / Acceptance Criteria	Demonstration: The manually generated responsibility area is the baseline. The adapted responsibility area is compared to that baseline. We calculate the context error rate and the context reduction rate for both. Expectation: context error rate is reduced (if initial responsibility area is too small) or context reduction rate is increased (if initial responsibility area is too large). We also compare the command error rate for both scenarios. We expect a reduction for the adapted responsibility area.

	The amount of improvement is difficult to predict because it depends on the quality of the first guess. Details are specified in the Proof-of-Concept-Plan D5-1 in technical test T2. The test results are already described in D3-6.
Conflicts	Currently none
Additional Information	This requirement reflects the Assumption 2 from [1] which might have an impact on the overall reliability of the SYSTEM.
History	16-08-25 HHe First Version 16-09-01 HHe Set for USAAR and Idiap to accepted, because feedback received 16-09-12 MJ Minor changes in the text 16-09-12 AC Link to [1] created. 16-09-23 HHe Status of Austro Control set to accepted, because this partner has no additional work with requirement, he benefits. 17-07-28 HHe Requirement achieved described in D3-6.

4.1.2 SYS-LRN-002

Identifier	SYS-LRN-002
Title	Unsupervised learning improves dynamic context
Requirement	The MLS SHALL (automatically) adapt/learn its hypothesis rule model.
Rationale / Why this requirement	The initial hypothesis rule model will contain (nearly) all possible commands for the callsign which are in the given responsibility area. Unsupervised learning should reduce the size of the predicted command set.
RQ from (Who benefits)?	ACG Status: accepted 2016-09-23 ANS CR Status: accepted 2016-09-12 Idiap Status: accepted 2016-09-01 USAAR Status: accepted 2016-09-01

RQ for (Who has to implement RQ)?	DLR | Status: accepted 2016-08-25
Priority	Shall
Category	FR
Test Method / Acceptance Criteria	Demonstration: The full set of predicted commands is the baseline. The adapted predicted command set (for the same responsibility area, see req. SYS-LRN-01) is compared to that baseline. We calculate the context error rate and the context reduction rate for both. Expectation: The context error will increase, because the context error of a full set of predicted commands is zero. The context reduction rate should be better than 70%, so that the context error rate is less than two times the command error rate (CmdER = 14% → CtxER < 7%) The improved context should reduce the CmdER by at least 10% (relative), i.e. from e.g. 10% to 9%. Requirement achieved described in D3-6.
Conflicts	Currently none
Additional Information	This requirement reflects the Assumption 2 from [1] which might have an impact on the overall reliability of the SYSTEM.
History	16-08-25 | HHe | First Version 16-09-01 | HHe | Set for USAAR and Idiap to accepted, because feedback received 16-09-12 | AC | Link to [1] created. 16-09-23 | HHe | Status of Austro Control set to accepted, because this partner has no additional work with requirement, he benefits. 17-07-28 | HHe | Requirement achieved described in D3-6.

4.1.3 SYS-LRN-003

Identifier	SYS-LRN-003
Title	Unsupervised learning improves acoustic model
Requirement	The MLS SHALL (automatically) adapt/learn its acoustic model
Rationale / Why this requirement	Acoustic models (AM) generally learn characteristics of the data that they were trained on. When deployed in a new environment later, new acoustic characteristics may be observed that the acoustic model is not familiar with. Hence, the need of an automatic adaptation, where the system automatically detects the new speech features and adapts its model accordingly. The latter can either be user-dependent (for a specific user) or user-independent (for all users).
RQ from (Who benefits)?	ACG: Status: accepted 2016-09-23 ANS CR: Status: accepted 2016-09-12 DLR: Status: accepted 2016-09-01
RQ for (Who has to implement RQ)?	USAAR: Status: accepted 2016-08-25 Idiap: Status: accepted 2016-08-25
Priority	Shall
Category	FR
Test Method / Acceptance Criteria	Demonstration: The development of the new methods will be evaluated after application to the basic acoustic model (baseline). For user independent adaptation, at least data from 10 speakers shall be used, whereas data available from different speakers shall be used for user-dependent adaptation. Comparison between baseline and the adapted models is done based on word error rate, command and concept error rates obtained with the same language models and on the same data set. The system is expected to show at least 10% relative improvement in terms of word error rates over the original acoustic model. This improvement is expected to highly correlate with the data quality and quantity. Details are described in D5-1 in technical test T2.
Conflicts	Currently none
Additional Information	This requirement helps to cope with the impact of Constraint 1 from [1]

	which reflects occurrence of the non-standard phraseology.
History	16-08-25 | YO | First Version 16-09-01 | HHe | Minor changes in wording and request for reformulation of test method 16-09-05 | GSz | Add some concrete numbers 16-09-12 | AC | Link to [1] created. 16-09-23 | HHe | Status of Austro Control set to accepted, because this partner has no additional work with requirement, he benefits.

4.1.4 SYS-LRN-004

Identifier	SYS-LRN-004
Title	Unsupervised learning improves language model
Requirement	The MLS SHALL (automatically) adapt/learn its language model.
Rationale / Why this requirement	Language models (LM) generally learn possible (probable) sequences of words in a given language based on some training data. Therefore, new sequence of words that were not significantly present (or not at all) in the training data will not be (or will be poorly) recognized when the system is deployed. Hence, the need of an automatic adaptation for LM exists. Here, the system automatically detects new (or poorly represented) sequence of words and automatically adapts its statistics. The same stands for system dictionary, closely linked to the LM. Unknown words, especially unknown callsigns (air carriers) and unknown command components should be identified and learned (added to dictionary and/or LM) automatically.
RQ from (Who benefits)?	ACG | Status: accepted 2016-09-23 ANS CR | Status: accepted 2016-09-12 DLR | Status: accepted 2016-09-01
RQ for (Who has to implement RQ)?	USAAR | Status: accepted 2016-08-25

	Idiap	Status: accepted 2016-08-25
Priority	Shall	
Category	FR	
Test Method / Acceptance Criteria	Demonstration: By using the basic LM as baseline, we keep the AM unchanged. We apply automatic LM adaptation and compare performance with baseline and adapted LM on the same test data. The development of the new methods will be evaluated after application to the basic LM. The system is expected to show a 10% to 20% relative improvement of the error rates (WER, CmdER, CptER) over the original LM. This improvement is expected to highly correlate with the data variety and amount of users to have generated it. The ratio of Out-of-Vocabulary (OOV) and Out-of-Grammar (OOG) words is also a measure used for the evaluation. Details are described in D5-1 in technical test T2.	
Conflicts	Currently none	
Additional Information	This requirement helps to cope with the impact of Constraint 1 from [1] which reflects occurrence of the non-standard phraseology.	

History

16-08-25	YO	First Version
16-09-01	HHe	Minor changes in wording and request for reformulation of test method
16-09-05	GSz	Improve demonstration description
16-09-12	AC	Link to [1] created.
16-09-23	HHe	Status of Austro Control set to accepted, because this partner has no additional work with requirement, he benefits.
18-02-06	HHe	Test method edited

4.1.5 SYS-LRN-005

Identifier	SYS-LRN-005
Title	Unsupervised learning improves concept generator
Requirement	The MLS SHOULD (automatically) adapt/learn its concept generator, i.e. to

	be able to generate concepts for new commands or for commands with unseen attributes.
Rationale / Why this requirement	The concept generator should be able to detect new commands or unseen command attributes, new ways of phrasing commands and, therefore, automatically learn how these commands can be mapped into valid ATC concepts that can be directly integrated into the ATC system.
RQ from (Who benefits)?	ACG — Status: accepted 2016-09-23 ANS CR — Status: accepted 2016-09-12 DLR — Status: accepted 2016-09-23
RQ for (Who has to implement RQ)?	USAAR — Status: accepted 2016-08-25 Idiap — Status: accepted 2016-08-25
Priority	Should
Category	FR
Test Method / Acceptance Criteria	Demonstration: The proposed new methods will be evaluated after application to the basic system (baseline) with AM, LM and data set kept unchanged. Evaluation is done for concept error rates. The system is expected to show a 5% to 10% relative improvement of CptER over the baseline system. This improvement is expected to highly correlate with the amount of new concepts in the training/test data and also from the deviation from the standard (completely new phrasing or just deviation). Details are described in D5-1 in technical test T2.
Conflicts	Currently none
Additional Information	This requirement helps to cope with the impact of Constraint 1 from [1] which reflects occurrence of the non-standard phraseology.
History	16-08-25 — YO — First Version 16-09-01 — HHe — Request for reformulation of test method, therefore set to checking for DLR

	16-09-05	GSz	Make this uniquely for concept generation. Did not reset accepts as now this RQ says less than it used to say, so I assume it is OK.
	16-09-07	Hhe	Priority set to SHOULD
	16-09-12	MJ	Minor changes
	16-09-12	AC	Link to [1] created.
	16-09-23	HHe	Status of DLR and Austro Control set to accepted, because these partners have no additional work with requirement, they benefit.
	18-02-06	HHe	Test method edited

4.1.6 SYS-LRN-006

Identifier	SYS-LRN-006	
Title	Unsupervised learning improves context integrator	
Requirement	The MLS SHOULD (automatically) adapt/learn its context integrator.	
Rationale / Why this requirement	The set of possible commands is dynamically changing in the ATC application. The role of the context integrator system is to adapt to dynamic changes in context (search space). This means that the search space can be limited to predictions based on current context. On top of this, the ABSR system should be able to automatically detect unseen context elements and learn to incorporate them by adapting the context integration system itself, i.e. to learn how to incorporate context elements into the search space.	
RQ from (Who benefits)?	ACG	Status: accepted 2016-09-23
	ANS CR	Status: accepted 2016-09-23
	DLR	Status: accepted 2016-09-23
RQ for (Who has to implement RQ)?	USAAR	Status: accepted 2016-08-25
	Idiap	Status: accepted 2016-08-25
Priority	Should	
Category	FR	

Test Method / Acceptance Criteria	Demonstration: The proposed new algorithms will be evaluated by comparing the system to the baseline system running the original context integrator with all other components (AM, LM, test data) unchanged. The system is expected to show 10% to 20% relative improvement of the error rates (WER, CmdER or CptER) over the original system. This improvement is expected to highly correlate with the amount of changes in the context of the training/test data. Details are described in D5-1 in technical test T2.
Conflicts	Currently none
Additional Information	
History	

16-08-25	YO	First Version
16-09-01	HHe	Request for reformulation of test method, therefore set to checking for DLR
16-09-07	HHe	Priority changed from SHALL to SHOULD
16-09-23	HHe	Status of DLR, ANS CR and Austro Control set to accepted, because these partners have no additional work with requirement, they benefit.
18-02-06	HHe	Test method edited

5 Non-functional requirements

5.1 Performance requirements

This section identifies performance requirements.

5.1.1 PER-REC-001

Identifier	PER-REC-001
Title	Recognition Rate
Requirement	The recognition rate of THE SYSTEM SHOULD be at least 90% over 1000 commands under all kinds of situations except adverse weather conditions (e.g. thunderstorm in the vicinity of airport) and other non-standard situations (e.g. diversion). CONDITIONS: The training data satisfies the AcListant® data requirements and processing. The speech data is clean, with noise and pilots segments removed and segmented per utterance. Sampling rate is 16kHz. Using 8kHz for MALORCA will degrade the performance. Good acoustic condition (i.e. SNR level above 20dB).
Rationale / Why this requirement	There is a clear requirement to have very high recognition rate under normal operational situations. When adverse weather condition or other non-standard situation is encountered, the recognition rate may be lower. The same applies if non-standard phraseology is used.
RQ from (Who benefits)?	ANS: Status: accepted 2016-07-14 ACG: Status: accepted 2016-07-14

RQ for (Who has to implement RQ)?	USAAR: Status: accepted 2016-06-09 DLR: Status: accepted 2016-07-26 Idiap: Status: accepted 2016-07-21
Priority	SHOULD
Category	Non FR
Test Method / Acceptance Criteria	Demonstration Details are described in D5-1 in technical test T2.
Conflicts	
Additional Information	The recognition rate is defined in Appendix A. The required recognition rate is for all periods of 1,000 commands (in the morning, in evening etc.). Therefore the required average recognition rate over all time periods is supposed to be even higher.

History

16-05-02	AC	First Version
16-06-29	AC	Identifier changed
16-07-14	AC	Text changed
16-07-21	MF	Slight changes, priority changed to should due to 8kHz
17-07-28	HHe	Conflict added
18-02-08	HHe	Clarification with respect to 1,000 commands in Additional Information; conflict text deleted due to change of PER-REC-003

5.1.2 PER-REC-002

Identifier	PER-REC-002
Title	Error Rate
Requirement	The Error Rate of THE SYSTEM SHOULD be not higher than 2.5% over 1000 commands under clean (controlled) conditions within last 24 hours. CONDITIONS: The training data satisfies the AcListant data requirements and processing. The speech data is clean, with noise and pilots segments removed and segmented per utterance. Sampling rate is 16kHz. Using 8kHz for MALORCA will increase the error rate.
Rationale / Why this requirement	The Error rate is the most important indicator from the operational perspective as it influences the trust of the ATCo in THE SYSTEM.
RQ from (Who benefits)?	ANS: Status: accepted 2016-07-14 ACG: Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	USAAR: Status: accepted 2016-06-09 DLR: Status: accepted 2016-07-25 Idiap: Status: accepted 2016-07-21
Priority	SHOULD
Category	Non FR
Test Method / Acceptance Criteria	Demonstration Details are described in D5-1 in technical test T2.
Conflicts	
Additional Information	The Error Rate is defined in Appendix A. The required error rate is for all periods of 1,000 commands (in the morning, in evening etc.). Therefore the required average error rate over all time periods is expected to be even lower.
History	16-05-02 | AC | First Version

	16-06-29	AC	Identifier changed
	16-07-14	AC	Text changed
	16-07-21	MF	Text changed, priority changed to should due to 8kHz
	17-07-28	HHe	Conflict added
	18-02-08	HHe	Clarification with respect to 1,000 commands in Additional Information; conflict text deleted due to change of PER-REC-003

~~5.1.3 PER-REC-003~~

The requirement removed, the original one was put to Appendix D.

5.1.4 PER-REC-004

Identifier	PER-REC-004	
Title	Multiple Commands	
Requirement	THE SYSTEM SHALL be able to process ATCOs utterance containing up to at least 3 commands. CONDITION: The training data contains enough examples of this command to train the ABSR system.	
Rationale / Why this requirement	To be able to process multiple commands in single utterance.	
RQ from (Who benefits)?	ANS	Status: accepted 2016-07-14
	ACG	Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	USAAR	Status: accepted 2016-06-09
	Idiap	Status: accepted 2016-07-21

Priority	Shall
Category	Non FR
Test Method / Acceptance Criteria	Test Demonstration
Conflicts	Currently none
Additional Information	Due to break, break the commands may be given to different aircraft.
History	2016-05-30 / MN / First Version 16-6-09 / HHe / Additional information added. DLR is not involved in this RQ, but USAAR and Idiap 16-06-29 / AC / Identifier changed 16-07-13 / AC / Requirement edited 17-07-28 / HHe / "at least" added. SYSTEM often recognizes in utterances 5 and more commands

5.1.5 PER-REC-005

Identifier	PER-REC-005
Title	Reaction Time
Requirement	For 100% of the ATCO utterances except callsign itself, THE SYSTEM SHOULD be able to give the output in less than 2 seconds after each utterance or its part if specified.
Rationale / Why this requirement	There is a need to know the aircraft the ATCo is speaking to immediately after the callsign is said (see 3.1.4). To provide sufficient response time under all conditions even in case of long ATCO transmission.
RQ from (Who benefits)?	ANS: Status: accepted 2016-07-14 ACG: Status: accepted 2016-07-14
RQ for (Who has to implement RQ)?	USAAR: Status: accepted 2016-06-09 Idiap: Status: accepted 2016-07-21

Priority	Shall
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	The further discussion is necessary to decide if THE SYSTEM SHOULD process them as the controller speaks. The priority and text of the requirements (GEN-FUN-003, GEN-FUN-004) will be adjusted accordingly to dismiss identified requirement conflicts. For particular flight, multiple commands might be present in one ATCO transmission.
History	

02-05-16	AC	First Version
30-05-16	MN	Update
09-06-16	HHe	THE SYSTEM-Start-001 to 3 added and detected conflict DLR is not involved in this RQ, but USAAR and Idiap
16-06-29	AC	Identifier changed
16-07-14	AC	Text changed
16-08-03	AC	Additional information and Conflicts added
18-02-08	AC	SHOULD priority set, so conflict removed here.

5.2 Maintainability

Maintainability requirements addressing system characteristics such as modularity, reusability, analysability, modifiability and testability are out of scope of this document and will be elaborated in the later stage of THE SYSTEM development.

5.3 Reliability

Reliability requirements addressing system characteristics such as maturity, availability, fault tolerance and recoverability are out of scope of this document and will be elaborated in the later stage of THE SYSTEM development.

5.4 Safety & Security

5.4.1 SYS-SAF-001

Identifier	SYS-SAF-001	
Title	Safety and Security Requirements	
Requirement	THE SYSTEM WILL be compliant with the following requirements: "COMMISSION REGULATION (EC) No 482/2008 of 30 May 2008 establishing a software safety assurance system to be implemented by air navigation service providers and amending Annex II to Regulation (EC) No 2096/2005". (Guiding Material ED-153 Eurocae, „GUIDELINES FOR ANS SOFTWARE SAFETY ASSURANCE".) " Commission Implementing Regulation (EU) No 1035/2011 of 17 October 2011 laying down common requirements for the provision of air navigation services and amending Regulations (EC) No 482/2008 and (EU) No 691/2010 (especially Annex II.) "COMMISSION IMPLEMENTING REGULATION (EU) No 1034/2011 of 17 October 2011 on safety oversight in air traffic management and air navigation services and amending Regulation (EU) No 691/2010", (especially Article 9 and Article 10.) "COMMISSION REGULATION (EC) No 552/2004". DSU (Declaration of suitability for use / DoC (Declaration of Conformity. "Commission Regulation (EC) No 482/2008" Supplier has to deliver a Self-assessment (ED 153) and to give the right for Software Audits done by the ANSP or a representative.	
Rationale / Why this requirement		
RQ from (Who benefits)?	ANS	Status: accepted 2016-07-18
	ACG	Status: accepted 2016-07-18
RQ for (Who has to	N/A	N/A

implement RQ)?	
Priority	WILL
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	Future supplier has to be compliant with all regulations listed in this requirement and has to give the right for Audits done by the ANSP (or a representative) at supplier site.
History	16-07-18 | AC | First Version

5.5 Input interface requirements

This section covers interfaces with external systems. THE SYSTEM is expected to provide the external interfaces to each of the end-system identified further in this chapter.

5.5.1 EXT-IN-001

Identifier	EXT-IN-001
Title	Voice Communication Interfaces
Requirement	THE SYSTEM SHALL process ATCO's voice A/G utterances in the ITU-T G.711 PCM A-law codec with 8 kHz, 8-bit sampled signals (64 kbps data rate), provided by Voice Communication System (VCS). Condition: The voice samples will be accessible in real-time mode, i.e. with minimum transmission delay.
Rationale / Why this requirement	
RQ from (Who benefits)?	ANS | Status: accepted 2016-07-18

	ACG	Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	DLR	Status: checking 2016-06-09
	USAAR	Status: checking 2016-06-09
	Idiap	Status: checking 2016-06-09
Priority	Shall	
Category	Non FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information	The interface for provision of the voice utterances from the VCS can be: • either an E1 trunk, or • IP network according to the ED-137 standard (Interoperability standards for VoIP ATM components) revision B, using the interfaces described in volume 1: Radio or volume 4: Recording.	

History			
	2016-06-24	AC	First Version
	16-06-27	AC	New identifier

5.5.2 EXT-IN-002

Identifier	EXT-IN-002	
Title	Surveillance Data Interfaces	
Requirement	THE SYSTEM SHALL be capable of processing ARTAS Track messages in ASTERIX Cat. 062 format, Edition 1.10 or newer with User Application Profile (UAP) including the data items 380 and 390, received online using the UDP protocol.	
Rationale / Why this requirement		
RQ from (Who benefits)?	ANS	Status: accepted 2016-07-18
	ACG	Status: accepted 2016-07-18
RQ for (Who has to	DLR	Status: accepted 2016-07-21

implement RQ)?	
Priority	Shall
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	For the Prague Eurocat 2000 (E2000) UAP , see Appendix D of [3].
History	2016-06-24 | AC | First Version 16-06-27 | AC | New identifier

5.5.3 EXT-IN-003

Identifier	EXT-IN-003
Title	Flight Status information
Requirement	The system WILL receive, from the FDP, flight status information for each flight covering such information as current controlling position, hand-in-first flag, cleared FL, assigned speed, assigned heading, direct-to-point, etc. The flight status information input interface of THE SYSTEM SHOULD use the FMTP state machine on the relation layer.
Rationale / Why this requirement	
RQ from (Who benefits)?	ANS: Status: accepted 2016-07-18 ACG: Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	DLR: Status: accepted 2016-07-21
Priority	WILL
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	In case FMTP is not used, another link integrity mechanism SHALL be implemented, a minimum being heartbeat messages on the application layer.

History

2016-06-24	AC	First Version
16-06-27	AC	New identifier
16-06-30	MF	Changed wording, corrected priority
16-07-29	AC	Priority WILL set

5.5.4 EXT-IN-004

Identifier	EXT-IN-004
Title	Flight Status Information
Requirement	The flight status information input interface of THE SYSTEM WILL be protected by a link integrity mechanism, a minimum being heartbeat messages on the application layer.
Rationale / Why this requirement	
RQ from (Who benefits)?	ANS — Status: accepted 2016-07-18 ACG — Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	DLR — Status: accepted 2016-07-26
Priority	WILL
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	It is recommended to use the Flight Message Transfer Protocol (FMTP) on the relation layer as the link integrity mechanism. Implementation details of this interface are site specific due to the different nature of each FDP system implementation.

History

2016-06-24	AC	First Version
16-06-27	AC	New identifier
16-07-21	MF	Changed wording, corrected priority
16-07-29	AC	Priority WILL set

5.5.5 EXT-IN-005

Identifier	EXT-IN-005
Title	Flight Status Information
Requirement	The flight status information input interface of THE SYSTEM WILL use XML or ADEXP encoding on the presentation layer.
Rationale / Why this requirement	
RQ from (Who benefits)?	ANS — Status: accepted 2016-07-18 ACG — Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	DLR — Status: checking 2016-07-26
Priority	WILL
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	In case XML encoding is chosen, the template has to be defined by an XSD.

History

2016-06-24	AC	First Version
16-06-27	AC	New identifier
16-06-30	MF	Changed wording, corrected priority
16-07-29	AC	Priority WILL set

5.5.6 EXT-IN-006

Identifier	EXT-IN-006
Title	Time Synchronization
Requirement	THE SYSTEM WILL support time synchronization using the Network Time Protocol (NTP) from external servers.
Rationale / Why this requirement	

RQ from (Who benefits)?	ANS	Status: accepted 2016-07-18
	ACG	Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	DLR	Status: accepted 2016-07-25
	USAAR	Status: checking 2016-07-29
	Idiap	Status: checking 2016-07-29
Priority	WILL	
Category	Non FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information		

History			
	2016-06-29	AC	First Version
	2016-09-14	HHe	Priority changed from SHALL to WILL, time signal no available in MALORCA test data sets

5.6 Output interface requirements

5.6.1 EXT-OUT-001

Identifier	EXT-OUT-001	
Title	Output Interface – network layer.	
Requirement	The speech recognition output of the THE SYSTEM WILL be sent to the cooperating ATC system via a TCP/IP connection.	
Rationale / Why this requirement		
RQ from (Who benefits)?	ANS	Status: accepted 2016-07-18

	ACG	Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	USAAR	Status: accepted 2016-06-09
	DLR	Status: accepted 2016-07-26
	Idiap	Status: accepted 2016-07-21
Priority	WILLl	
Category	Non FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information		

History			
	2016-06-29	AC	First Version
	2016-07-19	MJ	Minor changes
	2016-09-14	HHe	Priority changed from SHALL to WILL, output interface to real system not created in MALORCA project

5.6.2 EXT-OUT-002

Identifier	EXT-OUT-002	
Title	Output interface – application layer	
Requirement	The speech recognition output interface of the THE SYSTEM WILL be protected by a link integrity mechanism, a minimum being heartbeat messages on the application layer	
Rationale / Why this requirement		
RQ from (Who benefits)?	ANS	Status: accepted 2016-07-18
	ACG	Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	DLR	Status: accepted 2016-07-26

Priority	WILL
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	It is recommended to use the Flight Message Transfer Protocol (FMTP) on the relation layer as the link integrity mechanism.
History	2016-06-29 / AC / First Version 2016-07-19 / MJ / Minor changes 2016-09-14 / HHe / Priority changed from SHALL to WILL, output interface to real system not created in MALORCA project

5.6.3 EXT-OUT-003

Identifier	EXT-OUT-003
Title	Output interface – relation layer
Requirement	The speech recognition output interface of the THE SYSTEM WILL use XML encoding on the presentation layer, the template being defined by an XSD.
Rationale / Why this requirement	
RQ from (Who benefits)?	ANS: Status: accepted 2016-07-18 ACG: Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	DLR: Status: accepted 2016-07-18
Priority	WILL

Category	
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	The template has to be defined by an XSD. The Datalink template definition CPDLCMessageSetVersion1-9880, converted from ASN.1 to XSD is a good basis for datatypes and message structure definition.
History	2016-06-29 / AC / First Version 2016-07-19 / MJ / Minor changes 2016-07-29 / AC / Priority WILL set

5.6.4 EXT-OUT-004

Identifier	EXT-OUT-004
Title	Output interface– timestamp
Requirement	THE SYSTEM WILL include the timestamp with millisecond precision of recognizing the last utterance.
Rationale / Why this requirement	
RQ from (Who benefits)?	ANS: Status: accepted 2016-07-18 ACG: Status: accepted 2016-07-18
RQ for (Who has to implement RQ)?	USAAR: Status: accepted 2016-06-09 Idiap: Status: accepted 2016-07-21 DLR: Status: accepted 2016-07-26
Priority	WILL
Category	
Test Method /	Demonstration

Acceptance Criteria			
Conflicts			
Additional Information			
History	2016-06-29	AC	First Version
	2016-07-19	MJ	Minor changes
	2016-09-14	HHe	Priority changed from SHALL to WILL,,output interface to real system not created in MALORCA project

6 Proof of Concept Results

This section contains the results of T1 testing.

The requirements selected for T1 testing (Generic requirements) according to the description laid down in document "D5-1-ProofOfConceptPlan", Section "Procedures" and selected according to checklists for generic requirements, see also Appendix A1 from [4], are listed below.

6.1 Basic overview:

- Testing location: Prague
- Testing platform: provided by DLR
- Participants: Hartmut Helmke, Matej Nesvadba, Aneta Cerna, Christian Windisch
- Date: 23-24.1.2018
- Reference: D1-2 SRS

6.2 Checklist of generic requirements

The following requirements are taken from D1-2. It is complete checklist of selected requirements for T1 testing, see also Appendix A1 from D5-1. If the requirement is not a subject of test, the reason is given.

Identifier	Title	T1-Live (YES/NO)	Reason
GEN-FUN-001	Area of interest	YES	
GEN-FUN-002	Sector dependent setting of SYSTEM operational status	NO	This requirement is generic and relevant for later stage of ASR maturity. It has SHOULD priority.
GEN-FUN-003	Start recognition immediately	NO	This requirement is generic and is related to the operational use. It was not planned for testing, SHOULD priority. Current implementation in MALORCA is that recognition starts at release of PTT button.

Identifier	Title	T1-Live (YES/NO)	Reason
GEN-FUN-004	Provide callsign information immediately	NO	This requirement is generic and is related to the operational use. It was not planned for testing, SHOULD priority. Current implementation in MALORCA is that recognition starts at release of PTT button.
GEN-FUN-005	Provide complete command information when utterance is completed	YES	
GEN-FUN-006	Recognition of callsign	NO	First and third part of requirement was possible to test. The callsign was recognized if present but not sent immediately, see GEN-FUN-004. The requirement is rather related to advanced logic that is to be applied to voice recognition system as black box. However MALORCA focus on voice recognition engine only.
GEN-FUN-007	Linking of commands to callsign	YES	
GEN-FUN-008	Output of recognition from THE SYSTEM	NO	This requirement is needed when integrating with the end system (ATC system). There is no integration btw. ASR and ATC system within the scope of MALORCA project.
GEN-FUN-009	Mode of operation	NO	SHOULD priority + the same reason as for GEN-FUN-008.
GEN-LOG-001	External Data Flows Logging	NO	This requirement is generic and relevant for later stage of maturity.

Identifier	Title	T1-Live (YES/NO)	Reason
			It has WILL priority.
GEN-LOG-002	Internal Activity Logging	NO	This requirement is generic and relevant for later stage of maturity. It has WILL priority.
GEN-LOG-003	Archive period	NO	This requirement is generic and is related to the operational use. Not relevant for the MALORCA project.
REC-FUN-001	Recognition of commands for lateral movement	YES	
REC-FUN-002	Recognition of commands for vertical movement	YES	
REC-FUN-003	Recognition of commands for rate of climb/descent	NO	Not modelled for Prague site, SHOULD priority. Not implemented in MALORCA project due to lack of transcribed training data.
REC-FUN-004	Recognition of commands for speed adjustment	YES	
REC-FUN-005	Recognition of commands for STAR	NO	Should priority. Not implemented in MALORCA project due to lack of transcribed training data.
REC-FUN-007	Recognition of commands for approach clearance	YES	
REC-FUN-008	Recognition of commands for handover process	YES	
REC-FUN-009	Recognition of commands for published holding	NO	Should priority. Not implemented in MALORCA project due to lack of transcribed training data.
REC-FUN-012	Recognition of information for (future) landing RWY assignment	YES	
REC-FUN-013	Recognition of commands	YES	Should priority.

Identifier	Title	T1-Live (YES/NO)	Reason
	for go around		
REC-FUN-014	Recognition of command to indicate the separation between messages transmitted to different aircraft in a very busy environment	NO	Should priority, not implemented in MALORCA project due to lack of transcribed training data. Remarks: During analysing the recorded data, it was recognized that the ATCo usually release PTT button in the middle of utterance. If so, the system will recognize the commands correctly.
REC-FUN-015	Recognition of command to indicate that an error has been made in transmission and to correct this error	YES	SHOULD priority.
REC-FUN-016	Recognition of command to indicate the transmission shall be ignored	NO	This requirement is generic and was not planned for testing within MALORCA project, SHOULD priority.
REC-FUN-017	Offline configuration of command types properties	NO	This requirement is generic and was not planned for testing within MALORCA project, WILL priority.
SYS-INP-001	Aircraft State: Processing of Asterix CAT62	YES	
SYS-INP-002	Dynamic Airport Data	NO	This is not implemented during MALORCA project. Only QNH information is extracted from the recognized commands.
SYS-INP-003	Flight plan data, flight data and their updates	YES	
SYS-OFF-001	Offline configuration support tool	NO	This requirement is generic and was not planned for testing within MALORCA project, WILL priority.

Identifier	Title	T1-Live (YES/NO)	Reason
SYS-OFF-002	Waypoint List	YES (remotely)	It was done by DLR, location: Braunschweig, January 2018, see D5-2 in appendix.
SYS-OFF-003	Control Region Boundary (Unit-Test)	YES (remotely)	It was done by DLR, location: Braunschweig, January 2018, see D5-2 in appendix.
SYS-OFF-004	Runway-Configuration (Unit-Test)	YES (remotely)	It was done by DLR, location: Braunschweig, January 2018, see D5-2 in appendix.
SYS-OFF-005	Controller-Working-Position-Configuration (Unit-Test)	YES (remotely)	It was done by DLR, location: Braunschweig, January 2018, see D5-2 in appendix.
SYS-OFF-006	Recording configuration is changeable (Unit-Test)	YES (remotely)	It was done by DLR, location: Braunschweig, January 2018, see D5-2 in appendix.
SYS-OFF-007	System offline configuration options (Unit-Test)	YES (remotely)	It was done by DLR, location: Braunschweig, January 2018, see D5-2 in appendix.
SYS-OFF-008	System offline configuration options	NO	This requirement is generic and was not planned for testing within MALORCA project, WILL priority
SYS-ON-001	System online configuration options	NO	This requirement is generic and was not planned for testing within MALORCA project, WILL priority
SYS-LNR-001	Unsupervised learning improves static context	NO	Tested in T2.
SYS-LNR-002	Unsupervised learning improves dynamic context	NO	Tested in T2.
SYS-LNR-003	Unsupervised learning improves acoustic model	NO	Tested in T2.
SYS-LNR-004	Unsupervised learning improves language model	NO	Tested in T2.
SYS-LNR-005	Unsupervised learning improves concept	NO	Tested in T2.

Identifier	Title	T1-Live (YES/NO)	Reason
	generator		
SYS-LNR-005	Unsupervised learning improves context integrator	NO	Tested in T2.
PER-REC-001	Recognition Rate Requirement is still in conflict with PE-REC-001 and PER-REC-003.	NO	Tested in T2 (different metrics). It is generic requirement, important for operational use. It is out of scope of MALORCA project to measure with this metrics.
PER-REC-002	Error Rate Requirement is still in conflict with PE-REC-002 and PER-REC-003.	NO	Tested in T2 (different metrics). It is generic requirement, important for operational use. It is out of scope of MALORCA project to measure with this metrics.
PER-REC-003	Rejection Rate Requirement is still in conflict with PE-REC-001 and PER-REC-002.	NO	Tested in T2 (different metrics). It is generic requirement, important for operational use. It is out of scope of MALORCA project to measure with this metrics.
PER-REC-004	Multiple Commands	YES	
PER-REC-005	Reaction Time	YES	
SYS-SAF-001	Safety and Security Requirements	NO	This requirement is generic and was not planned for testing within MALORCA project, WILL priority
EXT-IN-001	Voice Communication Interfaces	NO	No access to live system, for recorded data it is fulfilled already.
EXT-IN-002	Surveillance Data Interfaces	NO	No access to live system
EXT-IN-003	Flight Status information	NO	No access to live system

Identifier	Title	T1-Live (YES/NO)	Reason
EXT-IN-004	Flight Status Information	NO	No access to live system
EXT-IN-005	Flight Status Information	NO	No access to live system
EXT-IN-006	Time Synchronization	NO	No access to live system
EXT-OUT-001	Output Interface – network layer.	NO	No access to HMI of live system
EXT-OUT-002	Output interface – application layer	NO	No access to HMI of live system
EXT-OUT-003	Output interface – relation layer	NO	No access to HMI of live system
EXT-OUT-004	Output interface– timestamp	NO	No access to HMI of live system

6.3 Test Result Catalogue

The test catalogue represents the requirements identified as relevant for T1 testing (see Table in chapter 6.2).

The test result are registered here and copied to D1-2, chapter 6: Proof of concept results.

6.3.1.1 GEN-FUN-001

Identifier	GEN-FUN-001
Title	Area of interest
Revised Requirement	
Priority	SHALL
Test Method / Acceptance Criteria	Test
Result of Testing	OK

6.3.1.2 GEN-FUN-002

Not tested

6.3.1.3 GEN-FUN-003

Not tested.

6.3.1.4 GEN-FUN-004

Not tested.

6.3.1.5 GEN-FUN-005

Identifier	GEN-FUN-005
Title	Provide complete command information when utterance is completed
Revised Requirement	
Priority	SHALL
Test Method / Acceptance Criteria	Test Demonstration
Result of Testing	OK

6.3.1.6 GEN-FUN-006

Not tested.

6.3.1.7 GEN-FUN-007

Identifier	GEN-FUN-007
Title	Linking of commands to callsign
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test Demonstration
Result of Testing	OK

6.3.1.8 GEN-FUN-008

Not tested.

6.3.1.9 GEN-FUN-009

Not tested.

6.3.1.10 GEN-LOG-001

Not tested.

6.3.1.11 GEN-LOG-002

Not tested.

6.3.1.12 GEN-LOG-003

Not tested.

6.3.1.13 REC-FUN-001

Identifier	REC-FUN-001
Title	Recognition of commands for lateral movement
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test
Result of Testing	OK Examples: Turn right heading – OK, turn left heading – OK, present heading – OK, direct to - OK

6.3.1.14 REC-FUN-002

Identifier	REC-FUN-002
Title	Recognition of commands for vertical movement
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test
Result of Testing	OK Examples: descend – OK, **stop descend – recognized but not displayed on HMI (No concept), maintain – recognized but not displayed on HMI (No**

	concept)

6.3.1.15 REC-FUN-003

Not tested.

6.3.1.16 REC-FUN-004

Identifier	REC-FUN-004
Title	Recognition of commands for speed adjustment
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test
Result of Testing	OK Remark: **reduce to 220 kts is recognized as 2200 kts, possible solution can be to introduce limit on speed values (The wrong result however was not shown to controller)**

6.3.1.17 REC-FUN-005

Not tested.

6.3.1.18 REC-FUN-007

Identifier	REC-FUN-007
Title	Recognition of commands for approach clearance
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test
Result of Testing	Cleared ILS approach – OK

	Remark: **Intercept localizer – recognized but assigned to Cleared ILS approach command which is not correct**

6.3.1.19 REC-FUN-008

Identifier	REC-FUN-008
Title	Recognition of commands for handover process
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test
Result of Testing	OK Example: Handover to 118,1 - OK

6.3.1.20 REC-FUN-009

Not tested.

6.3.1.21 REC-FUN-012

Identifier	REC-FUN-012
Title	Recognition of information for (future) landing RWY assignment.
Revised Requirement	
Priority	Will
Test Method / Acceptance Criteria	Test Demonstration
Result of Testing	OK - Expect RWY Remark: **recognized, but Expect ILS is assigned incorrectly on HMI as command.**

6.3.1.22 REC-FUN-0013

Identifier	REC-FUN-013
Title	Recognition of commands for go around.
Revised Requirement	
Priority	Should
Test Method / Acceptance Criteria	Test Demonstration
Result of Testing	OK Remark: **recognized only in 1 of 4 cases, due to lack of training data provided within MALORCA performance is low, additionally it was excluded from training.**

6.3.1.23 REC-FUN-014

Not tested.

6.3.1.24 REC-FUN-015

Identifier	REC-FUN-015
Title	Recognition of command to indicate that an error has been made in transmission and to correct this error
Revised Requirement	
Priority	Should
Test Method / Acceptance Criteria	Test Demonstration
Result of Testing	OK **Correction of callsign – OK, other corrections (e.g. command value) – not OK (is it modelled/in grammar model)**

6.3.1.25 REC-FUN-016

Not tested.

6.3.1.26 REC-FUN-017

Not tested.

6.3.1.27 SYS-INP-001

Identifier	SYS-INP-001
Title	Aircraft State: Processing of Asterix CAT62
Revised Requirement	
Priority	Shall
Category	FR
Test Method / Acceptance Criteria	
Result of Testing	OK

6.3.1.28 SYS-INP-002

Not tested.

6.3.1.29 SYS-INP-003

Identifier	SYS-INP-003
Title	Flight plan data, flight data and their updates
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test
Result of Testing	OK

6.3.1.30 SYS-OFF-001

Not tested.

6.3.1.31 SYS-OFF-002

Not tested.

6.3.1.32 SYS-OFF-003

Not tested.

6.3.1.33 SYS-OFF-004

Not tested.

6.3.1.34 SYS-OFF-005

Not tested.

6.3.1.35 SYS-OFF-006

Not tested.

6.3.1.36 SYS-OFF-007

Not tested.

6.3.1.37 SYS-OFF-008

Not tested.

6.3.1.38 SYS-ON-001

Not tested.

6.3.1.39 SYS-LNR-001

Not tested.

6.3.1.40 SYS-LNR-002

Not tested.

6.3.1.41 SYS-LNR-003

Not tested.

6.3.1.42 SYS-LNR-004

Not tested.

6.3.1.43 SYS-LNR-005

Not tested.

6.3.1.44 PER-REC-001

Not tested.

6.3.1.45 PER-REC-002

Not tested.

6.3.1.46 PER-REC-003

Not tested.

6.3.1.47 PER-REC-004

Not tested.

6.3.1.48 PER-REC-005

Identifier	PER-REC-005
Title	Reaction Time
Revised Requirement	
Priority	Shall
Test Method / Acceptance Criteria	Test
Result of Testing	Not OK The focus of MALORCA was on machine learning and related improvements of ASR. The reaction time during the validation shows higher values (than required) which is not acceptable for further validations on higher TRL or for the operational use. Regarding the actual TRL (low), it is acceptable and does not affect MALORCA proof-of-concept trials and also is not show stopper to reach MALORCA objectives. Briefing with controllers showed that even two seconds are not always a sufficient reaction time.

6.3.1.49 SYS-SAF-001

Not tested.

6.3.1.50 EXT-IN-001

Not tested.

6.3.1.51 EXT-IN-002

Not tested.

6.3.1.52 EXT-IN-003

Not tested.

6.3.1.53 EXT-IN-004

Not tested.

6.3.1.54 EXT-IN-005

Not tested.

6.3.1.55 EXT-IN-006

Not tested.

6.3.1.56 EXT-OUT-001

Not tested.

6.3.1.57 EXT-OUT-002

Not tested.

6.3.1.58 EXT-OUT-003

Not tested.

6.3.1.59 EXT-OUT-004

Not tested.

7 Glossary of Terms

Term	Explanation
Application layer	ISO Open Systems Interconnection network model protocol layer 7.
Command group	Group of commands that are linked together for a particular purpose e.g. Group of commands for vertical movement consists of several commands which are linked to vertical movement of the flight.
Cooperating ATC system	The ATM system that feeds the ABSR with online flight data and receives the recognition output of ABSR with the aim of presenting it to the ATCO and possibly storing the confirmed values into FDP database.
FMTP state machine	Flight Message Transfer Protocol, a relation layer network protocol defined by EUROCONTROL, mandated by EC regulation No 552/2004 for use on OLDI lines, but usable also for other datalinks.
Network layer	ISO Open Systems Interconnection network model protocol layer 3.
Presentation layer	ISO Open Systems Interconnection network model protocol layer 6.
Recognition status	It specifies different status of the output from THE SYSTEM and enable to distinguish at least between recognized, rejected and not recognized commands.
Relation layer	ISO Open Systems Interconnection network model protocol layer 5.
Ctx-file	Radar information converted into a list of possible callsigns and commands given the current situation seen on the radar.
Context generator	A software tool generating the ctx-file.
Acoustic model	A model set with associated parameters describing how phones can be realized acoustically in speech
Language model	A model defining allowed sentences or word sequences in a language.

Context integrator	**A tool adding possible commands and their possible realizations in speech to the language model.**
Hypothesis rule model	**A model, defining the commands (set of possible commands), which are possible, in a given situation. It consists of rules using e.g. the type (arrival, departure, overflight), the position, speed, altitude of an aircraft to predict future commands.**

Appendices

Appendix A Definition of Recognition and Error Rates

The Word Error Rate (WER) is generally used as a metric to analyze Speech Recognition performance. The real spoken word sequence is called gold standard [2]. The WER is derived from Levenshtein distance [8] and defined as the distance between recognized and gold word sequence:

$$WER(s) = \frac{ins(s) + del(s) + sub(s)}{W(s)} \quad (1)$$

The numerator is given by the sum of the number of never spoken word insertions (ins(s)), the number of words ASR missed and thus deleted words (del(s)) and the number of substituted words (sub(s)). The denominator contains the number of actually spoken words (W(s)). Alternatively, the number of sentences with at least one error may be counted as the sentence error rate (SER). Both, WER and SER, are not a good measure for speech analysis in ATC. The command error rate (CmdER) should be preferred. The correct recognition of each word in “Hello Speedbird six seven five descend flight level eight zero” is not crucial. However, extraction of the concept “BAW675 DESCEND FL 80” is important. We used the definitions of command recognition (CmdRR), command error (CmdER) and command deletion rate (CmdDR) according to [7].

$$CmdER(s) = \frac{ins(u) + sub(u)}{C(u)} \quad (2)$$

$$CmdRR(s) = \frac{cor(u)}{C(u)} \quad (3)$$

$$CmdDR(s) = \frac{del(u)}{C(u)} \quad (4)$$

C(u) is the number of commands spoken by a controller in an utterance. cor(u) is the number of commands correctly recognized by the ABSR system, which are not rejected by the Plausibility Checker. del(u) is the number of commands recognized by ABSR, but (correctly or accidently) rejected by the Plausibility Checker plus the number of commands given by the controller, but not recognized at all. ins(u) is the number of commands never spoken by the controller, but recognized and not rejected. subs(u) denotes the number of commands substituted by ASR and not rejected. Table 4 shows the development of recognition and error rates during the AcListant® and AcListant®-Strips project. These results should be seen as an upper limit for the results being possible in MALORCA, due to imperfect learning data (not transcribed) and noisy speech data with 8 kHz instead of 16 kHz.

Table 4: ABSR command Recognition, Deletion and Error rates

Validation Trial	CmdRR	CmdER	CmdDR
Oct. 14 AcListant Pre-Trials	91.2%	2.4%	8.8%
Feb./Mar. 15 AcListant Trials	91.6%	3.0%	8.4%
Nov./Dec. 15 AcListant-Strips Trials	95.2%	1.7%	4.4%

The first two rows were already reported in [7].The last row was reported in [6]

Let's illustrate our definitions with some examples in Table 5

Word Sequence	Expected Commands	Recognized Commands	Counters
air_berlin eight eight five lima reduce speed two two zero knots	BER885L REDUCE 220	BER885L REDUCE 220	C(u)=1; cor(u)=1 del(u)=0; ins(u)=0; subs(u)=0
easy three nine kilo yankee descend three thousand feet qnh one zero one four turn left heading three three zero	EZY39KY DESCEND 3000 ALT EZY39KY TURN_LEFT_HEADING 330	EZY39KY DESCEND 4000 ALT	C(u)=2; cor(u)=0 del(u)=1; ins(u)=0; subs(u)=1
hallo lufthansa three two one five langen radar radar contact proceed direct delta lima four zero five	DLH3215 DIRECT_TO DL405	BAW123 DIRECT_TO DL405 BAW123 REDUCE 120	C(u)=1; cor(u)=0 del(u)=0; ins(u)=1; subs(u)=1
easy three nine kilo yankee reduce speed one eight zero knots	EZY39KY REDUCE 180	EZY39KY NO_CONCEPT	C(u)=1; cor(u)=0 del(u)=1; ins(u)=0; subs(u)=0
easy three nine kilo yankee turn left heading two seven zero clear for ils approach runway two three right	EZY39KY TURN_LEFT_HEADING 270 EZY39KY CLEARED_ILS 23R	EZY39KY TURN_LEFT_HEADING 270 EZY39KY CLEARED_ILS 23R	C(u)=2; cor(u)=2 del(u)=0; ins(u)=0; subs(u)=0
air_berlin four five five hotel contact duesseldorf tower one one eight decimal three bye bye	BER455H HANDOVER TOWER	BER445H DESCEND 4000 Alt BER455H HANDOVER TOWER	C(u)=1; cor(u)=1 del(u)=0; ins(u)=1; subs(u)=0
air_berlin eight eight five lima descend three	BER885L DESCEND 3000 ALT	BER885L DESCEND 3000 ALT	C(u)=3; cor(u)=1 del(u)=0; ins(u)=0;

thousand feet qnh one zero one four turn right heading one five zero	BER885L TURN_RIGHT_HEADING 150 DLH9MN HANDOVER TOWER	BER885L TURN_LEFT_HEADING 150 DLH9MN REDUCE 230	subs(u)=2
air_berlin eight eight five lima turn right heading two one zero clear for ils approach runway two three right and reduce speed one eight zero knots	BER885L TURN_RIGHT_HEADING 210 BER885L CLEARED_ILS 23R BER885L REDUCE 180	BER885L CLEARED_ILS 23R	C(u)=3; cor(u)=1 del(u)=2; ins(u)=0; subs(u)=0
air_berlin eight eight five lima good morning call you back	BER885L NO_CONCEPT	BER885L REDUCE 180	C(u)=1; cor(u)=0 del(u)=0; ins(u)=1; subs(u)=0
Total			C(u)=15; cor(u)=6 del(u)=4; ins(u)=3; subs(u)=4
CmdRR(u) = 6/15 = 40%	CmdER(u) = (3+4)/15 = 47%	CmdDR(u)=4 / 15 = 27%	

Table 5: Example illustrating ABSR command Recognition, Deletion and Error rates

The example also illustrates that the sum of recognition, error and deletion rate can be greater than 100%, in our case 40% + 47 % + 27 % = 113,3%

Appendix B List of Commands and Parameters

In the AcListant project the following commands were possible as direct output of the command extractor component of the Speech Recognizer.

- ALTITUDE AltValue FL / Alt
- ALTITUDE_OR_ABOVE value FL / Alt
- ALTITUDE_OR_BELOW value FL / Alt
- CLEARED_ILS rwyValue
- CLIMB altValue FL / Alt
- CLIMB_NOT_ABOVE altValue FL / Alt
- CLIMB_OR_ABOVE altValue FL / Alt
- DESCEND altValue FL / Alt
- DESCEND_NOT_BELOW altValue FL / Alt
- DESCEND_OR_BELOW altValue FL / Alt
- DIRECT_TO wpNameValue
- GO_AROUND
- HANDOVER posValue
- HANDOVER_FREQUENCY freqValue
- HEADING headValue
- HOLDING holdNameValue
- INCREASE spValue
- INCREASE_NOT_ABOVE spValue
- INCREASE_OR_ABOVE spValue
- INTERCEPT_LOCALIZER rwyValue
- LEAVE_HOLDING holdNameValue
- MAINTAIN_ALTITUDE [altValue FL / Alt]
- MAINTAIN_HEADING [headValue]
- MAINTAIN_SPEED [spValue]
- NO_CONCEPT
- RATE_OF_CLIMB rateValue
- RATE_OF_CLIMB_NOT_BELOW rateValue
- RATE_OF_CLIMB_OR_BELOW rateValue
- RATE_OF_DESCENT rateValue
- RATE_OF_DESCENT_NOT_ABOVE rateValue
- RATE_OF_DESCENT_OR_ABOVE rateValue
- REDUCE spValue
- REDUCE_FINAL_APP
- REDUCE_MIN_CLEAN
- REDUCE_NOT_BELOW spValue
- REDUCE_OR_BELOW spValue
- SPEED spValue

- SPEED_OR_ABOVE spValue
- SPEED_OR_BELOW spValue
- SPEED_OWN
- STOP_CLIMB [altValue FL / Alt]
- STOP_DESCEND [altValue FL / Alt]
- TRANSITION transNameValue
- TURN_BY relHeadValue
- TURN_LEFT_BY relHeadValue
- TURN_LEFT_HEADING headValue
- TURN_RIGHT_BY relHeadValue
- TURN_RIGHT_HEADING headValue

Yellow commands were specified in interface, but not modelled in command extractor component. If a value is specified (e.g. headValue) a value must follow the command. If no value is specified no value parameter is allowed for the command (e.g. SPEED_OWN). “FL/Alt” after vertical commands means that the value is either followed by “Alt” (4 digit altitude value) or “FL” (2 or 3 digit flight level value). If a value is set in brackets, it is an optional parameter.

- headValue is a degree value between 1 and 360 degrees (steps of 10 or 5 are only allowed.
- relHeadValue is either 5, 10, 15, 20 or 25 degrees.
- spValue is an Indicated Air Speed in steps of 10 knots
- rateValue is a vertical rate in feet per minute between 500 and 3500 in steps of 500 feet per minute.
- altValue is an altitude value in feet or flight level
- rwyValue is a runway name, e.g. 25L or 34
- wpNameValue is a waypoint name, e.g. DL405 or AGEDA
- holdNameValue is a waypoint Name specifying a holding
- freqValue is frequency (e.g. 118.64)
- posValue is a position name e.g. TOWER or DIRECTOR

More details can be specified in the file “supportedCommands.json” which is decribed in the architecture document D1.3 [5].

Appendix C Abbreviations

Terms and abbreviations used in this document are defined below:

ABSR	Assistant Based Speech Recognition
ACC	Area Control Center
Acoustic model	Used in ASR to represent relationship between an audio signal and the linguistic units
ACG	Austro Control Österreichische Gesellschaft für Zivilluftfahrt mit beschränkter Haftung
AcListant	Active Listening Assistant
ANS CR	Air Navigation Services of the Czech Republic
ANSP	Air Navigation Service Provider
APP	Approach, Approach Control Unit, working position approach (often also called feeder or pickup position)
ASR	Automatic Speech Recognition
ATCO	Air Traffic Controller
COOPANS	COOPeration between ANSProvider
CTX	Ctx-file = context file automatically generated from radar data
Concept generator	Extraction of semantic concept relevant to the task
Context integrator	Combination of of ASR hypotheses and context information
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre)
DM	Dissemination Manager
DoD	Definition of Done
Hypothesis rule generator	Rule generator
Idiap	Idiap Research Institute
Language model	It represents a probability distribution over sequences of words
MALORCA	Machine Learning of Speech Recognition Models or Controller Assistance
MLS	MALORCA Learning System
LOWW	Vienna Airport
NTP	Network Time Protocol
PIC	Pilot in command
PL	Project Leader
PMP	Project Management Plan
POC	Point of Contact
PRG	Prague
SES	Single European Sky
SID	SESAR Innovation Days
SJU	SESAR Joint Undertaking
tbd	To be defined
TMA	Terminal Manoeuvring Area
TWR	Aerodrome Control Tower

UdS	See USAAR
USAAR	Saarland University
WP	Work Package

Appendix D PER-REC-003

Identifier	PER-REC-003		
Title	Rejection Rate		
Requirement	The Rejection Rate of THE SYSTEM SHOULD be not higher than 7.5% under all situations except the ATCo error(s) occur. CONDITIONS: The training data satisfies the AcListant data requirements and processing. The speech data is clean, with noise and pilots segments removed and segmented per utterance. Sampling rate is 16kHz. Using 8kHz for MALORCA will degrade the performance.		
Rationale / Why this requirement			
RQ from (Who benefits)?	ANS	Status: accepted 2016-07-14	
	ACG	Status: accepted 2016-07-14	
RQ for (Who has to implement RQ)?	USAAR	Status: accepted 2016-06-09	
	DLR	Status: accepted 2016-07-25	
	Idiap	Status: accepted 2016-07-21	
Priority	Should		
Category	Non FR		
Test Method / Acceptance Criteria	Demonstration Details are described in D5-1 in technical test T2.		
Conflicts			
Additional Information	The Rejection Rate is the number of command that were rejected, see Appendix A.		
History	16-07-13	AC	First Version
	16-07-21	MF	Text changed, priority changed to should due to 8

			kHz
	16-08-03	HHe	Hint for conflict added
	18-02-08	AC	Value change increase from 5% to 7.5%
	18-02-08	HHe	Conflict text added and suggestion to delete requirement.
	18-02-23	AC	Upon mutual agreement, the requirement is deleted, conflict removed.

Appendix E References

The documents listed below become part of this Operational Concept Description to the extent referenced herein:

[1] Monhart D., Klamert L et al.: MALORCA project: D1-1: Operational Concept Document; version 1.01, September 2016

[2] D. Jurafsky and J. H. Martin, “Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistic and Speech Recognition,” 2nd edition, Englewood Cliffs, NJ, USA, Prentice-Hall, 9th Feb. 2008.

[3] Hartmut Helmke et al.: MALORCA project: D1-2a: System Requirement Specification Annex, version 0.96; 29. July 2016

[4] Hartmut Helmke et al.: MALORCA project: D5-1: Proof of Concept, version 1.00, xx xx 2017.

[5] Hartmut Helmke, Petr Motlicek et al.: MALORCA project: D1-3: Architecture Design Document, version 1.00; 18. August 2016

[6] Hartmut Helmke, Oliver Ohneiser, Thorsten Mühlhausen, Matthias Wies: Reducing Controller Workload with Automatic Speech Recognition, to be published ed in IEEE/AIAA 35th Digital Avionics Systems Conference (DASC), Sacramento, California, USA, Sept. 2016.

[7] H. Helmke, J. Rataj, Th. Mühlhausen, O. Ohneiser, H. Ehr, M. Kleinert, Y. Oualil, M. Schulder, D. Klakow, D: Assistant-Based Speech Recognition for ATM Applications, 23-26. June 2015, Lisbon, Portugal, 11th FAA/Eurocontrol ATM-Seminar

[8] Helmke, H. et al.: MALORCA project: D6-1; Project Management Plan, 29 April 2016, Edition 1.00

[9] INTERNATIONAL CIVIL AVIATION ORGANIZATION: Procedures for Air Navigation Services. AIR TRAFFIC MANAGEMENT (Doc 4444), 15th Edition, 2007.

[10] V. I. Levenshtein, “Binary codes capable of correcting deletions, insertions, and reversals,” in “Soviet Physics -- Doklady 10.8,” Feb. 1966.

[11] Klaus Pohl & Chris Rupp: Requirements Engineering Fundamentals,A Study Guide for the Certified Professional for Requirements Engineering Exam, Rocky Nook Inc., 2nd Edition, 2015

[12] Chris Rupp & die Sophisten: Requirements-Engineering and –Management, professional, iterative requirements analysis for practical applications (in German), Hanser, 5. Eds. 2009

[13] SESAR Joint Undertaking & DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV; UNIVERSITAET DES SAARLANDES; FONDATION DE L'INSTITUT DE RECHERCHE IDIAP; Řízení letového provozu České republiky; AUSTRO CONTROL OSTERREICHISCHE GESELLSCHAFT FUR ZIVILLUFTFAHRT, Grant Agreement number: 698824 — MALORCA — H2020-SESAR-2015-1/H2020-SESAR-2015-1

