Updated Requirements Document

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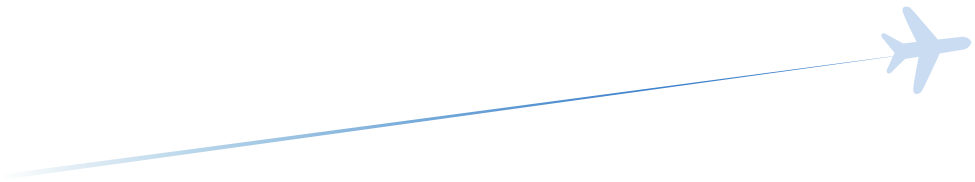

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HAAWAII

HIGHLY ADVANCED AIR TRAFFIC CONTROLLER WORKSTATIONS WITH ARTIFICIAL INTELLIGENCE INTEGRATION

This General document is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 884287 under European Union's Horizon 2020 research and innovation programme.

Abstract

Advanced automation support developed in Wave 1 of SESAR IR includes using of automatic speech recognition (ASR) to reduce the amount of manual data inputs by air-traffic controllers. Evaluation of controllers' feedback has been subdued due to the limited recognition performance of the commercial of the shell ASR engines that were used, even in laboratory conditions. Past exploratory research funded project MALORCA, however, has shown (on restricted use-cases) that satisfactory performance can be reached with novel data-driven machine learning approaches. HAAWAII project aims to research and develop a reliable, error resilient and adaptable solution to automatically transcribe voice commands issued by both air-traffic controllers and pilots. The project will build on very large collection of data, organized with a minimum expert effort to develop a new set of models for complex environments of Icelandic en-route and London TMA. HAAWAII aims to perform proof-of-concept trials in challenging environments, i.e. to be directly connected with real-life data from ops room. HAAWAII aims to significantly enhance the validity of the speech recognition models to even enable pilot read-back error detection. HAAWAII will improve both safety and reduce controllers' workload. The digitization of controller and pilot voice utterances can be used for a wide variety of safety and performance related benefits including, but not limiting to pre-fill entries into electronic flight strips and CPDLC messages. Another HAAWAII application is to objectively estimate controllers' workload utilising digitized voice recordings of the complex London TMA.

This document it is not legally binding the consortium partners to fully comply with the written requirements, this document contains the System Requirements of the HAAWAII project describing in detail each requirement and shall be used as a guidance during the development and implementation process of THE SYSTEM. It is even a living document. This is the final version of the document, which can be used as input by other Speech Recognition Projects e.g. in SESAR-3.

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1 Executive Summary

This System Requirements Specification document collects and describes the requirements which shall guide the development and implementation process of THE SYSTEM, based on speech recognition in ATM environment.

The intention of the document is to define a common understanding of expected features and applications that should be implemented and provided during the development, training and testing phases of the implementation. Also outlines the necessary common effort to transcribe and understand the voice and surveillance data that will be used during train and assessment of the artificial intelligence models.

Part of the requirements describe the applications implementation requests for the use cases defined in D1.1 like Human Performance Metric Extraction, Readback error detection, Call sign highlighting etc. On top of the application requirements there are requirements that define the input and output interfaces, the machine learning training process and environment and expectations from the machine learning algorithms like performance, reaction time and operational modes. As operational modes THE SYSTEM is intended to be trained and assessed offline and then connected in live online traffic in the operational environment.

This is a living document and will be updated and maintained throughout the lifetime of the project.

The current version has minor changes to make the document public.

2 Introduction

2.1 Purpose of the document

The purpose of this System Requirements Specification document for the HAAWAII project is to provide a structured list of generic requirements for the controller support tool based on speech recognition (THE SYSTEM) as formalized in Grant Agreement [3] between The Single European Sky ATM (Air Traffic Management) Research Joint Undertaking and HAAWAII partners. The project objectives and scope as well as how the project is executed and monitored can be found in [4]. The requirements then shall serve as a basis for THE SYSTEM development. These here specified requirements consider the outputs from the OCD [1].

This document describes also the generic requirements of THE SYSTEM as a whole. This particularly applies for the learning component of THE SYSTEM, one of the concrete objectives of the HAAWAII 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 HAAWAII 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.

2.2 Intended readership

This document is mainly intended for:

- **SESAR JOINT UNDERTAKING (SJU)** as Horizon 2020 Programme coordinator.
- **HAAWAII** consortium project members, who need to implement the requirements,
- **HAAWAII** consortium project members of management,
- Other stakeholders that are interested in voice recognition, within but not limited to SESAR Programme. These stakeholders will get access to the final version of this deliverable which will be public as deliverable D6.3. The current version, however, is private.

2.3 Background

SESAR 2020 PJ.16-04-02 solution ASR has partly achieved TRL4 with the development of TVALR describing and consolidating the formerly performed work of the contributing partners in the field of Automatic Speech Recognition, (ASR) in particular the prototypes that have been developed and demonstrated as well as a literature analysis of the progress and achievements in the field of ASR.

The Horizon 2020 SESAR project MALORCA (Machine Learning of Speech Recognition Models for Controller Assistance) –funded by SESAR Joint Undertaking (Grant Number 698824), proposes a general, cheap and effective solution to automate the re-learning, adaptation and customisation processes associated with local accents, phraseology deviations, environmental constraints etc. This is achieved by automatically learning local speech recognition and controllers' models from radar and

speech data recordings. Vienna and Prague were first demonstration approach areas for this new solution. PJ.16-04-02 solution ASR consortium members DLR (AT-One), ACG and ANS CR (B4) participate in and contribute to the MALORCA project.

Other PJ.16-04-02 solution ASR consortium members have undertaken projects to test and develop ASR related solutions within their own organisations.

- Thales has developed and is continuously improving an ASR system as part of the Shape platform, an immersive control system for air traffic controllers of the future.
- DFS has performed R&D work on voice recognition prototypes since 1994, including eventual real time simulations to evaluate integration of voice recognition into an ATC operational environment and the use of Voice Recognition and Response (VRR) in the area of ATC training.
- The Spanish Reference Centre for Research, Development and Innovation in ATM (CRIDA) together with the Spanish air navigation service provider, ENAIRE (and European Media Laboratory EML who do not collaborate in PJ.16-04-02 ASR) commenced the development of an ASR prototype VOICE in 2008 and the companies continue to work together to improve the ASR models.
- SINTEF is conducting a research on conversational robots and human-robot interactions and has in the past also worked with speech recognition for disabled people.
- Indra has developed an ASR System that will help and enhance the efficiency and performance of the ATCos by allowing the ATCo to introduce commands without the need to establish voice communications with an aircraft, contributing to workload reduction.
- Frequentis has developed an ASR system that could be integrated into the electronic flight strips. In this sense the ASR component is used as an additional input device.

The CWP Human Factors Design project (P10.10.02) deliverables (such as the Innovation Analysis Reports) developed during SESAR1 performed usability evaluation of new interaction technology, including ASR.

The HAAWAII project addresses both Automatic Speech Recognition for ATM applications and Machine Learning for training the needed Speech Recognition Models. The following Figure 1 shows the roadmap of both.

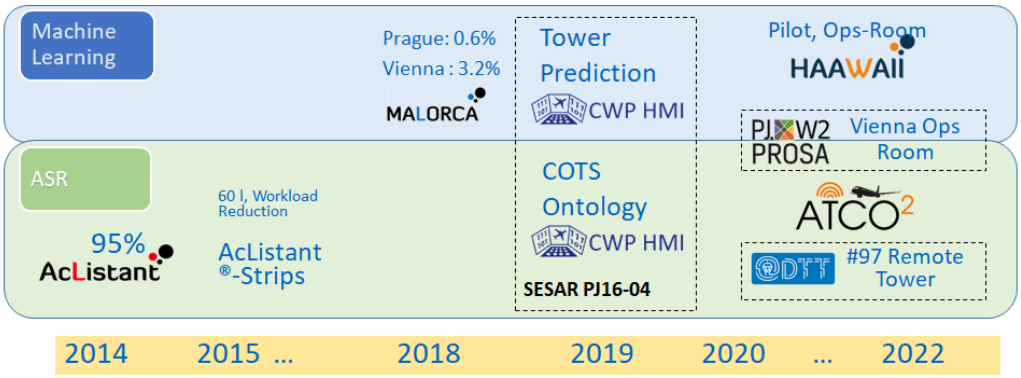

Figure 1 Speech Recognition and Machine Learning Roadmap for Speech Recognition Applications in ATM

The data formats of dynamic and static data can also be reused by other projects that are running in parallel to HAAWAII.

2.4 Structure of the document

The structure of this document is based on the Horizon 2020 template for project deliverables. It is organized as follows:

- **Chapter 1: Executive Summary**. Provides a summary of the key information and elements contained in the Technical Validation Report document.
- **Chapter 2: Introduction** (this chapter). It describes the purpose and structure of the document.
- **Chapter 3: Requirement Definitions**. It describes the methodology used to document the requirements.
- **Chapter 4: Overall system description**. Gives an overall presentation of the system, describing the context and data flows.
- **Chapter 5: Functional Requirements**. Describes the functional requirements that define what a service/system is supposed to do
- **Chapter 6: Non-Functional requirements.** Describes the non-functional requirements that define how a service/system is supposed to be
- **Chapter 7: Machine Learning/Offline Training Requirements.** Describes the requirements needed to be able to perform the training of the machine learning models.
- **Chapter 8: References.** Contains the references related to HAAWAII and also the ones that are not directly related.

The appendix contains the list of commands that are planned to be modelled and recognized for NATS and Isavia ANS.

2.5 Glossary of terms

HAAWAII project has more than 20 different deliverables. Therefore, HAAWAII project decides to have one separate document containing the glossary of terms, so that maintenance of the terms is eased and errors or misunderstandings only need to be changed in one place.

The following glossary of terms was copied from the master document 2020-10-08.

Term	Definition	Source of the definition
AcListant®	Venture Capital funded project Active Listening Assistant being conducted by DLR and Saarland University from 2013 to 2015.	PJ.16-04
Annotation	This task extracts the semantic concepts from the Transcription (i.e. text-to-concepts transformation), e.g., "DLH2BA DESCEND 80 FL, DLH2BA REDUCE 220 kt" and "AFR273 CORRECTION, AFR273 CONTACT VIENNA_RADAR, AFR273 CONTACT_FREQUENCY 129.500".	D3.1 and here
Assistant Based Speech Recognition (ABSR)	Special Instance of Automatic Speech Recognition which needs an assistant system to provide context in order to improve recognition rate and/or reduce error rate	See definition in [1]
Automatic Speech Recognition	An Automatic Speech Recognition (ASR) system gets an audio signal as input and transforms it into a sequence of words, i.e. "speech-to-text" following the recognition process. The sequence of words is transcribed into a sequence of ATC concepts ("text-to-concepts") using an ontology. The word sequence "lufthansa two alpha altitude four thousand feet on qnh one zero one four reduce one eight zero knots or less turn left heading two six zero" is transcribed into "DLH2A ALTITUDE 4000 ft, DLH2A INFORMATION QNH 1014, DLH2A REDUCE 180 OR_LESS, DLH2A HEADING 260 LEFT". The resulting concepts can be used for further applications such as visualization on an HMI.	PJ.16-04
Callsign (Recognition) Error Rate	The number of callsign, which are wrongly recognized by ABSR and which are not rejected divided by the number of total given callsigns; in other words: the percentage of given callsigns wrongly shown on the controllers' HMI. "oscar kilo one" must be mapped to "OACK1" if this is the only "O..K1" in the air. Otherwise it is counted as an error.	Here and in D1.2
Callsign Recognition Rate	The number of callsigns, which are correctly recognized by ABSR and are not rejected before divided by the number of total given callsigns; in other words: the percentage of given callsigns correctly shown on the controllers' HMI. "oscar kilo one" must be mapped to "OACK1" if this is the only "O..K1" in the air.	Here and in D1.2

Term	Definition	Source of the definition
Callsign Rejection Rate	The number of callsigns, which are said by the ATCo, but mapped to NO_CALLSIGN divided by the number of total given callsigns; in other words: the percentage of given callsigns not shown at all on the controllers' HMI.	Here and in D1.2
Chunk		D3.1 and here
Clearance transmission identifier	The Clearance transmission identifier is part of the readback information and represents the Transmission unique identifier from the Transmission information. This will be used to trace and check a specific transmission from the multiple transmissions. See example in Table 1	Here and in D1.2
CoCoLoToCoCo	Controller Command Logging Tool for Context Comparison that provides a user-friendly interface to carry out transcriptions and various annotations for air traffic control voice commands.	D3.1 and here
Command Prediction Error Rate	The number of controller commands which are given but not predicted (by the Command Hypotheses Predictor) divided by number of total given commands; in other words: the percentage of errors of the Command Hypotheses Predictor.	See definition in [1]
Command Recognition Rate	The number of controller commands which are correctly recognized by ASR and are not rejected before divided by number of total given commands; in other words: the percentage of given commands correctly shown on the controllers' HMI.	See definition in [1]
Command (Recognition) Error Rate	The number of controller commands which are wrongly recognized by ASR and which are not rejected divided by number of total given commands; in other words: the percentage of given commands wrongly shown on the controllers' HMI.	See definition in [1]
Communication group	Communication group is part of transmission information and it is a generated value or index that is used to identify and group multiple ATCO/Pilot transmissions that represent a single communication/dialogue. The single communication/dialogue is for example when pilot asks for higher flight level and the ATCO provides clearance for that flight level. See example of multiple transmissions grouped into communication groups in Table 1.	Here and in D1.2

Term	Definition	Source of the definition
Concept of Operations [ConOps]:	**Concept of Operations [ConOps]:** The ConOps is jointly elaborated by all ATM stakeholders, from the civil and military airspace users and service providers, to airports and the manufacturing industry to gain common understanding of the ATM system. It describes the operational targets, to move ATM towards trajectory-based operations whereby aircraft can fly their preferred trajectories, taking into account the matching between constraints and optimization. The ConOps allows all ATM stakeholders, from the civil and military airspace users and service providers, to airports and the manufacturing industry to gain common understanding of the ATM system. In this context, the ConOps is the operational answer to reach the ATM Performance improvements targeted by the ATM MP. Furthermore the ConOps is an important reference for global interoperability and harmonization, as it has been adapted for Europe from the ICAO Global Air Traffic Management Operational Concept.	See definition in [2]
Controlling Working Position Identifier	The controlling working position identifier is part of the Transmission information and represents a name or index to identify the position that generated that specific transmission. See example in Table 1.	Here and in D1.2
Exploratory Research	The exploratory research investigates relevant scientific subjects (during the ATM Excellent Science & Outreach phase) and conducts feasibility studies looking for potential application areas in ATM (during the ATM application-oriented research phase).	See definition in [2]
Horizon 2020	The EU Framework Programme for Research and Innovation.	SESAR 1, WP14, SESAR 2020
MALORCA		
PMP deliverable	Output produced by the projects that is submitted to the SJU via the SESAR 2020 collaborative platform and that is subject to quality assessment by the SJU. However, these deliverables do not appear in the grant agreement as contractual deliverables. The production of PMP deliverables is done in support of subsequent contractual deliverables and is described in the PMP.	See definition in [2]

Term	Definition	Source of the definition
Project Management Plan	Formal, approved document, provided by each SESAR 2020 Solution Project, used to manage its execution. It defines how the project is executed, monitored, controlled, and closed.	See definition in [2]
Read-back error detection rate	The number of correctly detected read-back errors (with or without correction) divided by the total number of read-back errors (with or without correction).	
Read-back error false discovery rate	The number of detected read-back errors, which are not a read-back error, divided by the total number of detected read-back errors (with or without correction).	
SESAR 2020	The SESAR 2020 (Single European Sky ATM Research) Research and Innovation (R&I) Programme will demonstrate the viability of the technological and operational solutions already developed within the SESAR R&I Programme (2008-2016) in larger and more operationally-integrated environments. At the same time, SESAR 2020 will prioritise research and innovation in a number of areas, namely integrated aircraft operations, high capacity airport operations, advanced airspace management and services, optimised network service performance and a shared ATM infrastructure of operations systems and services. SESAR 2020 will retain its founding members, the European Union and Eurocontrol.	SESAR 1, WP14, SESAR 2020, PJ.17-03
Transcription	This task involves the speech-to-text transformation, writing down word-by-word, what the ATCo has said. Examples are: “lufthansa two bravo alfa descend flight level eight zero and reduce speed two two zero knots” and “bonjour air_france two seven three [unk] confirm vien* correction contact vienna radar on one two nine decimal five”.	D3.1 and here
Transmission Direction	This is either “ATCo” when the ATCo (ground) speaks to the pilot or “Pilot”, if the pilot (air) speaks to the ATCo.	D1.2 and here
Transmission unique identifier	Transmission unique identifier is part of transmission information and represents a generated unique value or index that is used to distinguish one single transmission from either ATCO or Pilot.	D1.2 and here
TRL 2 (V1)	**Technology concept and/or application formulated:** Applied research. Theory and scientific principles are	See definition in [2]

Term	Definition	Source of the definition
	focused on very specific application area(s) to perform the analysis to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.	
TRL 3	**Analytical and experimental critical function and/or characteristic proof-of concept:** Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies including verification of technical feasibility using early prototype implementations that are exercised with representative data.	See definition in [2]
TRL 4 (V2)	**Component/subsystem validation in laboratory environment:** Standalone prototyping implementation and test with integration of technology elements and conducting experiments with full-scale problems or data sets.	See definition in [2]

Reference used in Glossary of terms

[1] H. Helmke, J. Rataj, T. Mühlhausen, O. Ohneiser, H. Ehr, M. Kleinert, Y. Oualil, and M. Schulder, "Assistant-Based Speech Recognition for ATM Applications," in 11th USA/ Europe Air Traffic Management Research and Development Seminar (ATM2015), Lisbon, Portugal, 2015.

[2] SESAR 2020 Execution guidance of ER4 projects : https://ec.europa.eu/research/participants/data/ref/h2020/other/guides_for_applicants/jtis/h2020-guide-project-handbook-er4-sesar-ju_en.pdf

Transmission unique identifier	ATCO/Pilot Transmission	Clearance transmission Identifier	Controlling Working Position Identifier	Communication Group
1	ATCO: XYZ descend flight level three one zero	1	CWP1	1
2	Pilot: XYZ descending level three one zero	1	CWP1	1
3	ATCO: ASD here Reykjavik control 1, 2,3,4,5 audio check.	NULL	CWP1	2
4	Pilot: I hear you 5 by 5.	NULL	CWP1	2
5	ATCO: ABC descend flight level three one zero	2	CWP1	3
6	Pilot: ABC level one three zero	2	CWP1	3

7	Pilot : ABC correction descending flight level three one zero	2	CWP1	3
8	ATCO: XYZ descend flight level one zero zero	3	CWP1	4
9	Pilot: XYZ descending level one zero zero	3	CWP1	4
10	Pilot: And how is the weather in Keflavik?	NULL	CWP1	4
11	ATCO: Its always still wind and sunny.	NULL	CWP1	4

Table 1 Example of transmission information and identifiers.

2.6 Acronyms and terminology

HAAWAII project has more than 20 different deliverables. Therefore, HAAWAII project decides to have one separate document containing the acronyms, so that maintenance of the acronyms is eased and errors or misunderstandings only need to be changed in one place.

The following acronyms were copied from the master document 2020-10-08.

Term	Definition
ABSR	Assistant Based Speech Recognition
ACC	Area Control Centre
ACG	Austro Control Österreichische Gesellschaft (Austria ANSP)
ADS-B	Automatic dependent surveillance–broadcast
AEC	Approach executive controller
AFIS	Aerodrome Flight Information Service
AG	Attention Guidance
AI	Artificial Intelligence
ANRIC	Aeronautical Radio Incorporated
ANSP	Air Navigation Service Provider
ANS-CR	Air Navigation Services of the Czech Republic
APC	Approach planning controller
APP	Approach
ARR	Arrival
ARTAS	ATM suRveillance Tracker And Server
ASR	Automatic Speech Recognition

Term	Definition
ASTERIX	All Purpose Structured Eurocontrol Surveillance Information Exchange
ASW	Air situation window
ATC	Air Traffic Control
ATCo	Air Traffic Controller
ATM	Air Traffic Management
Avg	Average
BUT	Brno University of Technology
CBA	Cost Benefit Analysis
CER	Context (Prediction) Error Rate
Cmd	Command (files containing annotations)
CmDER	Command Error Rate
CmDRR	Command Recognition Rate
CoCoLoToCoCo	Controller Command Logging Tool for Context Comparison
Cor	Correct (files containing transcriptions)
COTS	Commercial of the shell
CPP	Context Portion Predicted
CONOPS	Concept of operations
CPDLC	Controller Pilot Data Link Communications
CTA	Control area
CTR	Controlled traffic region
CV	Clearance verification
CWP	Controller Working Position
DASC	Digital Avionics Systems Conference
DEC	Departure executive controller
DEP	Departure
DFS	Deutsche Flugsicherung GmbH (German ANSP)
DLR	German Aerospace Center, Deutsches Zentrum für Luft- und Raumfahrt e.V.
DNN	Deep neural network
DVI	Direct Voice Input
DVO	Direct Voice Output

Term	Definition
EATMA	European Air Traffic Management Architecture, An architectural Model of European ATM for each SESAR Concept Story board step containing information relating to Operational activities.
EDR	Event Detection Rate
EML	European Media Laboratory
ENAIRE	Spanish ANSP
ER	En-Route
Err	Error (files containing errors)
EU	European Union
EXE	Exercise
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FDPS	Flight Data Processing System
FL	Flight level
FIR	Flight Information Region
ft	Feet
GUI	Graphical User Interface
HF	Human factors
HMI	Human Machine Interface
HUP	Human Performance
ICAO	International Civil Aviation Organization
ICE	Intelligent Communications Environment
ID	Identifier
Idiap	Idiap Research Institute
IEC	Information executive controller
ILS	Instrument landing system
IFR	Instrument Flight Rules
ISA	Instantaneous self assessment
khz	Kilo hertz
KPA	Key Performance Area
kt	Knots

Term	Definition
LAC	London Area Control
LTCC	London Terminal Control Centre
LTMA	London Terminal Manouvering Area
MALORCA	Horizon 2020 funded project MACHINE LEARNING OF SPEECH RECOGNITION MODELS FOR CONTROLLER ASSISTANCE
MWM	Mental Workload Model
N/A	Not applicable
NASA TLX	NASA Task load index
NATS	United Kingdom ANSP
NAT OTS	NORTH ATLANTIC ORGANIZED TRACK SYSTEM
Nm	Nautical miles
No.	Number
NOK	Not Ok
NPR	Noise Preferential Route
Obj	Objective
OSED	Operational services and environment description
OTS	ORGANIZED TRACK SYSTEM
PC	Prestwick Centre
PEC	Director executive controller
PERF	Performance
PJ	Project
POK	Partly Ok
PST	Performance Stability
PSS	Paperless Strip System
PTT	Push to talk
R/T	Radio Telephony
REF	Reference
REQ	Requirement
ReTi	Reaction Time
RMA	Radar Manoeuvring Areas

Term	Definition
RNAV	Area navigation
RWY	Runway
(S)VFR	(Special) Visual Flight Rules
SA	Situation Awareness
SAR	Safety assessment report
SASHA	Situation Awareness for SHAPE (Solutions for Human Automation Partnerships in European ATM)
SAF / SAFE	Safety
SC APP	Approach Senior Controller
Scn	Scenario
SDK	Software Development Kit
SDDS	Surveillance Data Distribution
SESAR	Single European Sky ATM Research
SID	Standard instrument departure
SJU	SESAR Joint Undertaking
SME	Subject Matter Experts
SOL	Solution
STAR	Standard terminal arrival route
STCA	Short Term Conflict Alerting
T2C	Text-to-Concept
T2S	Text-to-Speech
TC	Terminal Control
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level
TS	Technical Specification
TSWR	Tower
TTC	Text-to-Concept
TTS	Text-to-Speech
TVALP	Technical Validation Plan
TVALR	Technical Validation Report

Term	Definition
V2T	Voice to Text
V&V	Validation & Verification
VFR	Visual flight rules
VieAPP	Vienna Approach
VRR	Voice Recognition and Response
VTT	Voice to Text
WDR	Word Detection Rate
WL	Workload

3 Requirement Definitions

This section is to cover requirement definitions. According to ISO/IEC/IEEE standard 29148:2011, each requirement should fulfil the specific quality criteria. Pohl et al. [5] 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 [5] generic requirement shall be written in the following way:

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

3.1 Template for Text of Requirement

Rupp et al. [5] propose the complete requirements template with conditions in Figure 1 for structuring the text of the requirement.

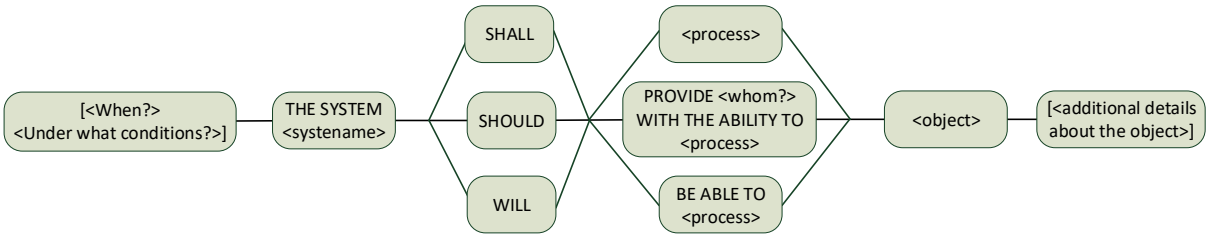

Figure 2 Requirements-Template (taken from [5], p.117)

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, i.e. after the HAAWAII project, these requirements are mandatory to achieve higher TRL. These requirements are not tested now[1]. To make this clearer we try to add the word sequence "in the future" to a WILL requirement.

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.

[1] The project partners try to implement all SHALL and SHOULD requirements in the HAAWAII project. Due to budget constraints and time limitation not everything all SHALL and SHOULD requirements will be possible in the context of HAAWAII. Priority, however, is then on SHALL requirements. It is not intended to implement already WILL requirements in the HAAWAII project. For a real product, however, the implementation of SHOULDALL and WILL requirements is also mandatory. The WILL requirements are, therefore, more an input for system suppliers and SESAR partners after the HAAWAII project.

The above requirement could also be formulated as:

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.

3.2 Template for Process of Requirement Definition and Negotiation

For HAAWAAII 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 HAAWAII project.		
Rationale / Why this requirement	Description for the others (not the author) why this requirement		
RQ from (Who benefits)?	Partner 1 acronym	Status: unknown 2020-xx-yy	
	Partner 2 acronym	Status: unknown 2020-xx-yy	
RQ for (Who has to implement RQ)?	Partner 1 acronym	Status: unknown 2020-xx-yy	
	Partner 2 acronym	Status: unknown 2020-xx-yy	
Priority	Shall / Should / Will – see template in section 3.1		
Category	FR for functional requirement of NFR for non-functional requirement		
Test Method / Acceptance Criteria	e.g. demonstration, Inspection, Analysis, Unit-Test, offline 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 2 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
- Offline
- Test1: On site Isavia test / Test2: On site NATS test
- 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.

Evaluation phase is described in WP5 that will focus on evaluating the Readback Error Detection, Pre-filling Radar Labels and CPDLC Messages and Human Performance Metrics Prediction. After the evaluation phases are finished WP5 will generate a Final Project Results Report.

4 Overall system description

4.1 Context

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

Evaluation of controllers' feedback has been subdued due to the limited recognition performance of the commercial of the shell ASR engines that were used, even in laboratory conditions. The reasons for the unsatisfactory conclusions include e.g. inability to distinguish controllers' accents, deviations from standard phraseology and limited real-time recognition performance.

HAAWAII project aims to research and develop a reliable, error resilient and adaptable solution to automatically transcribe voice commands issued by both air-traffic controllers and pilots. The project will build on very large collection of data, organized with a minimum expert effort to develop a new set of models for complex environments of Icelandic en-route and London TMA. HAAWAII aims to perform proof-of-concept trials in challenging environments, i.e. to be directly connected with real-life data from ops room.

As pilot read-back error detection is the main application, HAAWAII aims to significantly enhance the validity of the speech recognition models. The proposed work goes far beyond the work planned for the Wave 2 IR program and will improve both safety and reduce controllers' workload. The first step in the project is to have the possibility to see in real time the readback error indications on a separate interface that will refresh automatically. If the readback error detection accuracy level is following the expectations the next step is to have a radar label indication on the ATC surveillance working position screen that will flag the ATCO that a readback error has occurred.

The digitization of controller and pilot voice utterances can be used for a wide variety of safety and performance related benefits including, but not limiting to pre-fill entries into electronic flight strips and CPDLC messages. Another application to be demonstrated during proof-of-concept of the HAAWAII project will be to objectively estimate controllers' workload utilizing digitized voice recordings of the complex London TMA. The aim is to explore the use of a variety of measures (e.g. changes in speed of speech, identification of workload related phrases, use of filler words, etc.) to understand the suitability of these parameters to identify changes in workload and to feed back this information to supervisors. It is expected that this functionality, together with other sources of information, can support more efficient management of staffing levels and airspace management.

The Pre-filling Radar Labels application, i.e. digitization of the spoken words in concepts and showing the commanded values in the radar labels will demonstrate, which recognition performance is possible when machine learning is applied on massive amounts of unlabelled data from the operational environment. Potential workload benefits could also be explored given that the controller could save on time spent to input data into the system.

The application Human Performance Metric Extraction might itself already create benefits for the participating ANSPs, because they do not need interfaces from third party companies: The ABSR engine is developed within HAAWAII and the application is developed and evaluated also in the project. The main advantage of this demonstration application is, however, to enable follow-up applications. ANSPs

get a tool in their hands, which is trained especially for their application area and which enables a transfer of voice to concepts. ANSPs get access to their voice recordings in digital form. Many offline analytics are possible (how many aircraft get a direct approach, how many aircraft fly a visual approach and how many an RNP approach, how many commands a controller gives per hour …)

Figure 3 shows at high level the applications that will be developed using the ABSR software and the communication between the ATC and pilot using the voice communication system and also the interconnection between the ABSR and the ATC systems (VCS and the surveillance system).

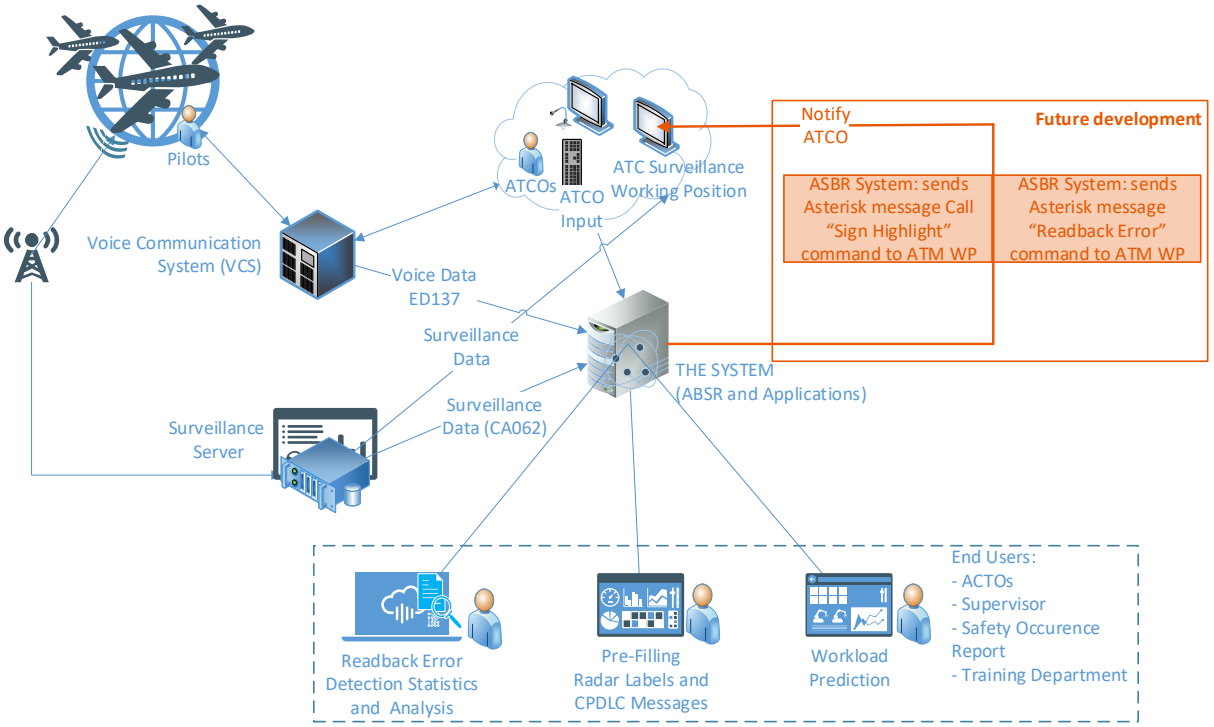

Figure 3 High level diagram of the ABSR applications and interconnection with the ATC environment

The following Figure 4 shows an even higher abstraction level of the integration of ABSR into the EATMA (European ATM Modelling Architecture).

Readback Error Detection, Pre-Filling Radar Labels, and Workload Prediction are the "Usage of Speech Information". The bottom part of Figure 3 is just zooming into the "Usage of Speech Information" for different applications relevant in the HAAWAII project.

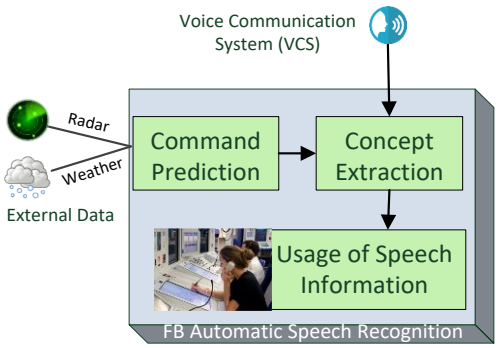

Figure 4 Integration of ABSR into the EATMA architecture (Figure taken from [6])

To have the possibility to implement the described applications the aim of this project is to develop a voice recognition system that needs to:

- Provide reliable and error resilient results
- Adapt to the specific ATC environment in a cost-efficient manner
- Provide sufficient performance for operational use

To improve the performance of the voice recognition system the ABSR will not only use the voice and context information from the VCS, but also the surveillance data, environment data and flight data as so-called context information to predict a situation dependent set of commands, which are plausible in the current air traffic situation. The context can be used both in the online version of the speech recognition process, but also in offline process of learning the recognition models of the ABSR system in the machine learning algorithms.

4.2 System description and operation modes

THE SYSTEM defines the supervisor and controller support tools that are based on speech recognition which are developed. The following modules are defined in THE SYSTEM:

- Assistant Based Speech Recognition (ABSR): converts a controller utterance into a sequence of commands by using different speech recognition models.
- HAAWAII Learning System (HLS): It automatically or semi-automatically learns/adapts from a huge data base the speech recognition models, which can be used by THE SYSTEM
- Web Interface module: displays the results of the applications based on defined search filters and groups the ABSR data according to the application requirements.

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

- Operational
- Offline training
- Online training
- Test offline
- Test online

These modes are detailed in the following subsections.

4.2.1 Operational mode

THE SYSTEM is operational, connected to the ATC systems (VCS and Surveillance) available with full capabilities.

In Operational mode the ABSR is connected to the ANSP Network and receives live SURVEILANCE (CAT062) and VOICE (ED137) streams and the SYSTEM provides real time feed for the applications like Readback Error Detection, Pre-filling Radar Labels and CPDLC Messages and Human Performance Metric Extraction.[2]

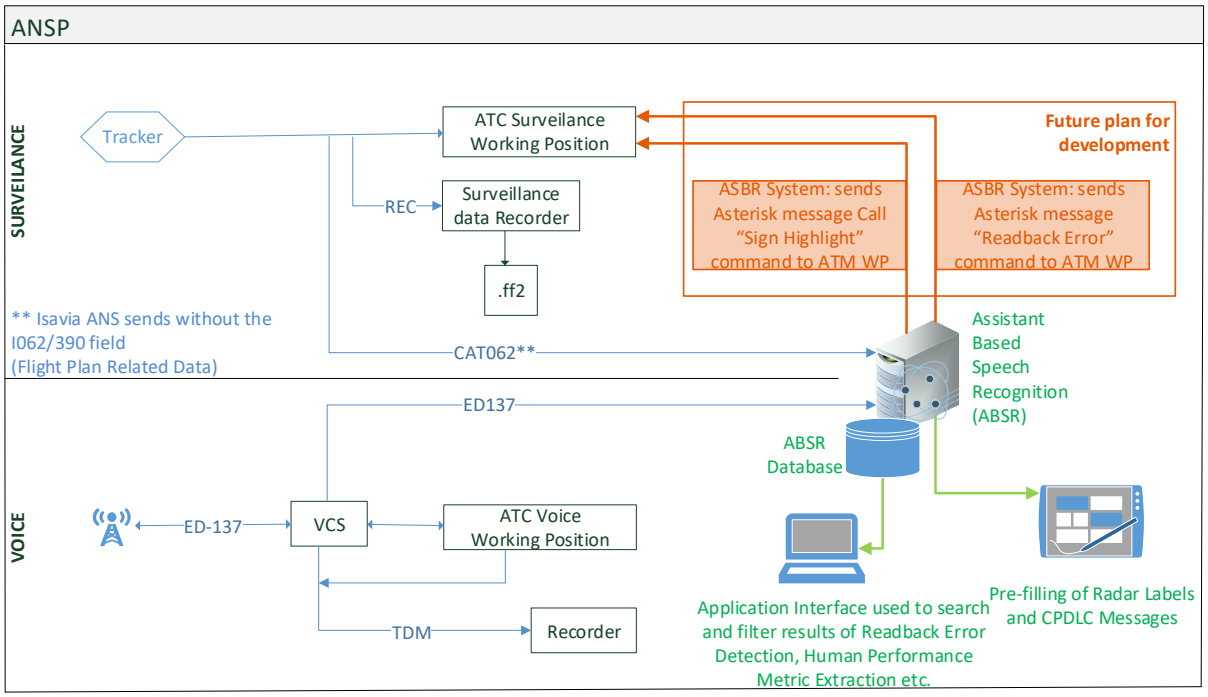

Figure 5 Operational mode

4.2.2 Offline learning/training mode

THE SYSTEM is not connected to the ATC systems (VCS and Surveillance). In offline learning state THE SYSTEM will be trained to improve its internal recognition models, to improve the recognition and command detection performance using exported voice and surveillance data, which of course result from previous recordings from the operational environment.

Figure 6 describes the data used for offline training of the ABSR speech recognition models. The surveillance data (radar data) is recorded; one file for each 12-hour slot. If the data contains incidents

[2] For the ED137 implementation at Isavia the VCS does not send a PTT signal, the PTT detection is based on Voice Activity detection. The splitting of the speech signal into single utterance is therefore also a source of error, reducing command recognition rate.

(including military events) the data is completely deleted or the incidents are removed before handover to research.

The controller and pilot utterances of each controller working positions are recorded separately. The wave files include also a 12 hours slots, i.e. more than controller will be speaking (shift changes) during that time. Incidents are removed from the voice data. In that case, the 12 hours files can be split into smaller wave files. The splitting and removal of silence will be normally done by research partners. Fine splitting (into wave files just containing one utterance) will be even done during the transcription tasks in WP3.

The output of the flight data processing is also provided as json files. From the files it can be derived e.g. the aircraft type of a callsign or the source and destination airport. Research will, however, first try, if the needed information can also be derived from the surveillance data itself. If an aircraft is landing at Reykjavik airport, then it is an arrival etc. This is possible, because in offline training mode also the future surveillance data of a callsign is available and not only the past surveillance data, when the ATCo is speaking to the pilot.

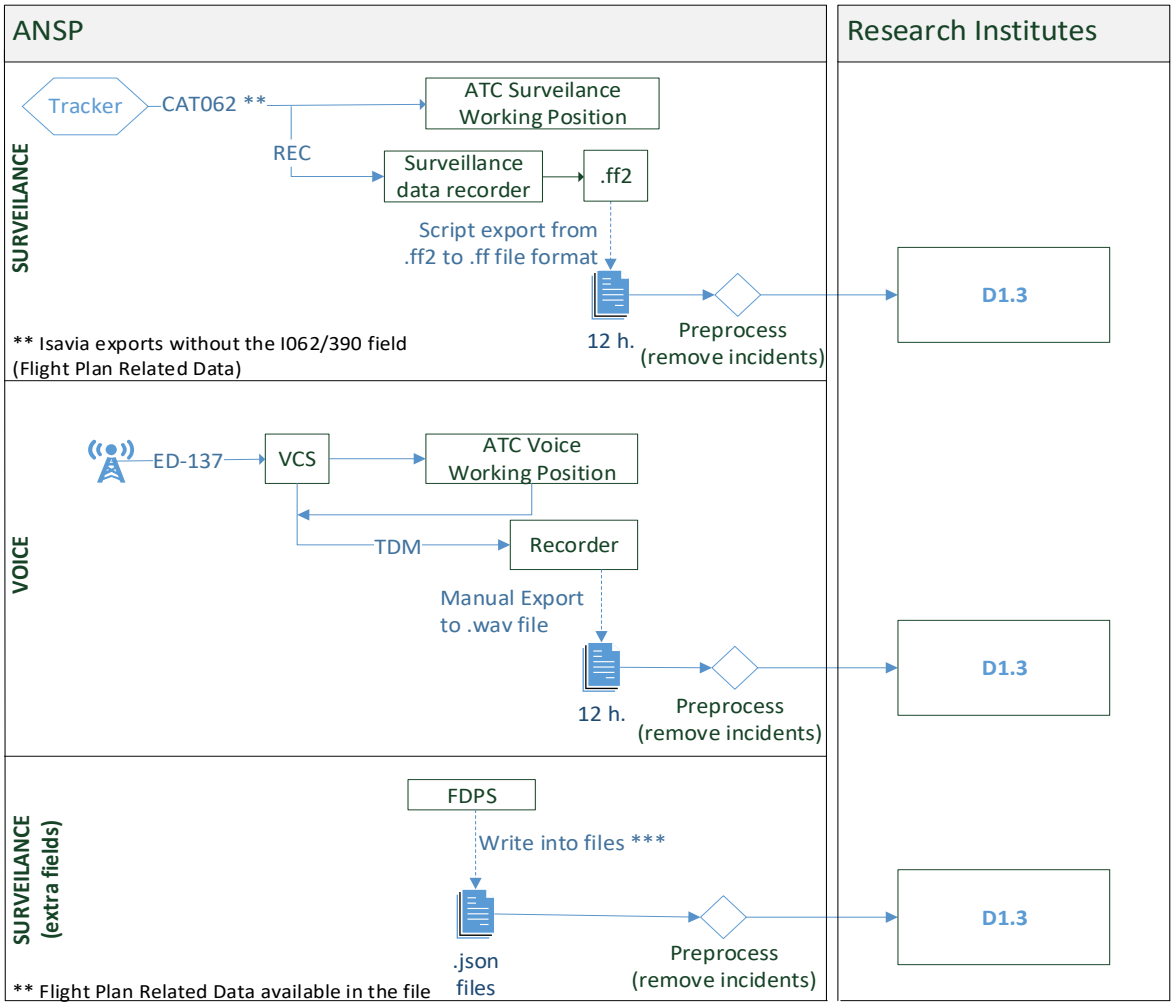

Figure 6 Offline training mode

The voice and surveillance data will be split into the training data set and evaluation data set. In this mode the ABSR will be feed with training data set. The evaluation data will be used in WP5 for proof-of-concept evaluation.

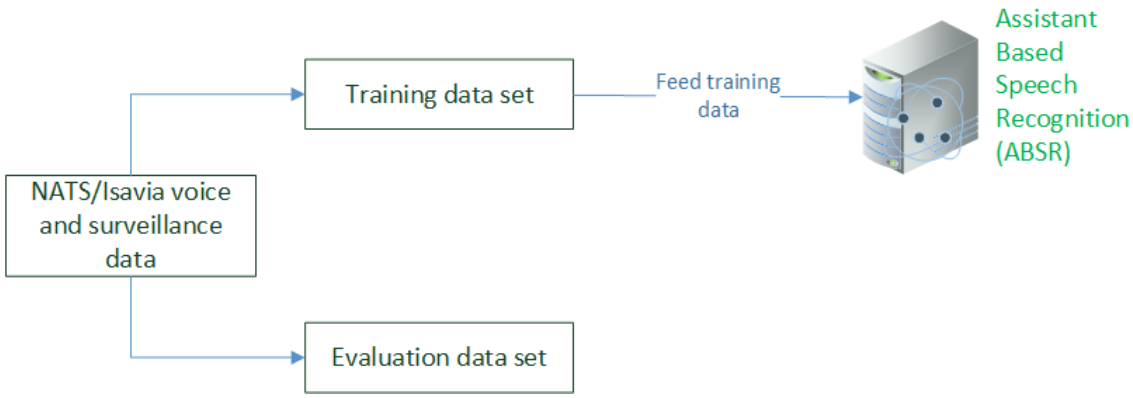

Figure 7 Offline Training, feeding training data set

4.2.3 Online learning/training mode

THE SYSTEM is connected directly to the ATC systems (VCS and Surveillance). In online learning state THE SYSTEM will be trained to improve the performance using live voice and surveillance feed directly from the ATC system.

More important, however, is the difference to the offline training mode that the voice and surveillance recordings will not leave the premises of the ANSPs, so that no data privacy or data access challenges need to be faced. This means that the training mode does not require real-time capabilities. Even in online training mode, the SYSTEM can be trained with historic data, but it is done by the ANSPs (with software provided by research and ANSPs).

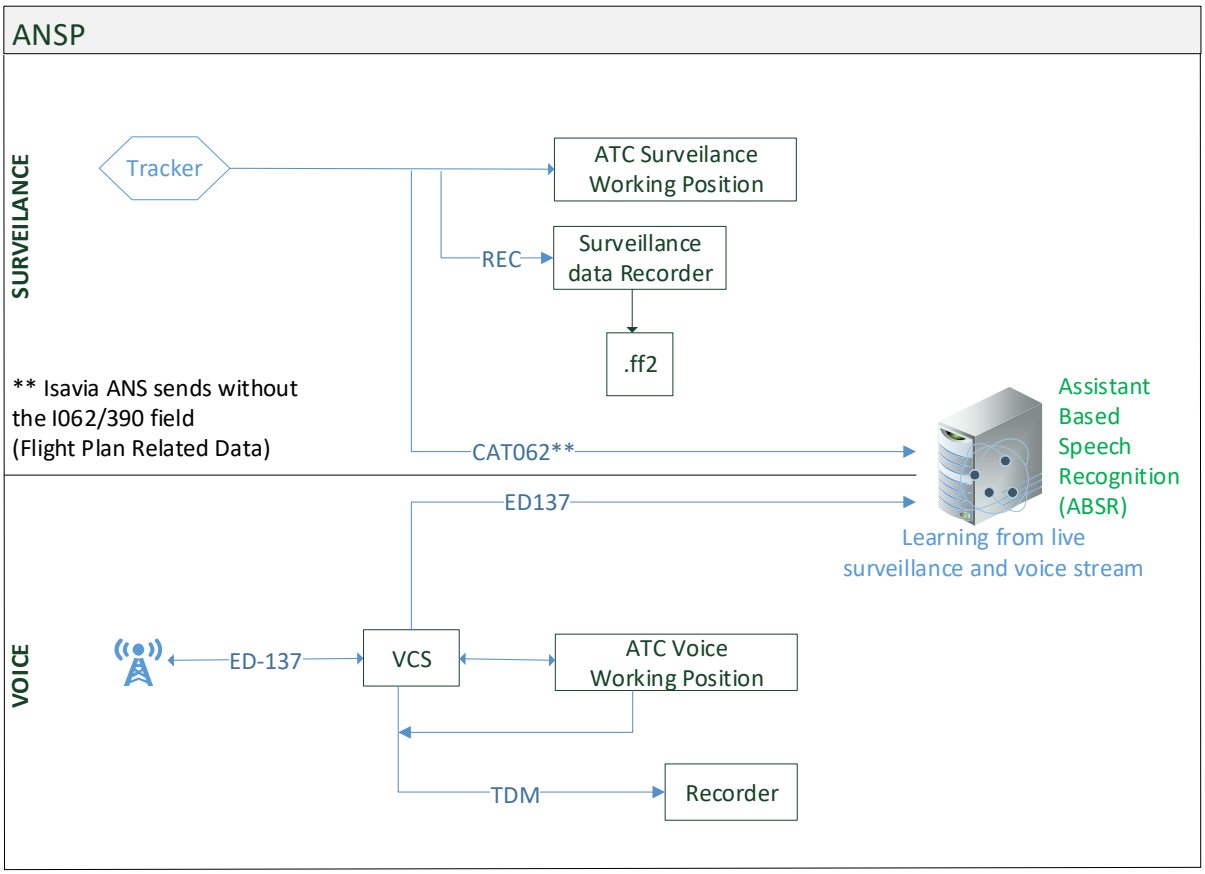

Figure 8 Offline training mode

4.2.4 Test offline mode

THE SYSTEM is connected to an automatic feed of test specific transcribed voice and surveillance data (not the utterances and surveillance files used for training) to test the accuracy for maintenance purposes (e.g. after a software upgrade). The voice and surveillance data will be split in training data set and evaluation data set, in this mode the ABSR will be feed with evaluation data set.

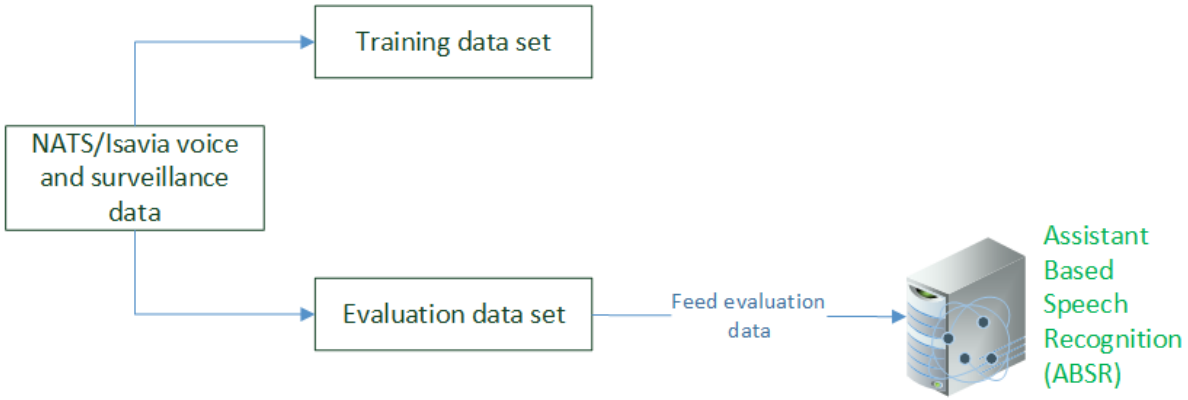

Figure 9 Test data feed to ABSR

The evaluation data is the data that will not be used for training the model. The evaluation data is the data that the ABSR has never seen before. It has never been trained with. It is maybe the 20% of data that are used to evaluate the system.

4.2.5 Test online mode

THE SYSTEM is tested in operational mode, connected to the ATC systems (VCS and Surveillance) available with full capabilities. The purpose is to test the accuracy with live (real-time) feed in controlled conditions to test the behaviour during maintenance situations (e.g. after a software upgrade). The step has always a predecessor step of "test offline mode". In this mode user feedback is the decisive evaluation data.

4.3 User characteristics

The readback error application interface users are the **ATC supervisors** that will use it to monitor the readback errors. In case that the ATCOs have not detected a read-back error and based depending on severity the supervisor can decide to flag it to the ATCO.

After the readback error application is proven to be reliable, the end users will be the **air traffic controller,** the implementation involves highlighting at the ATCO workstation the call sign with the readback error.

Using the readback error output already at the ATCO's workstation is not intended during the HAAWAII project. It is, however, the final objective: Readback errors should be highlighted to the ATCO at the workstation rather than to the supervisor. Readback errors usually require prompt correction in order to not lead to a safety critical event. Presenting the information to the supervisors only will not bring as much safety benefits but could lead to an undesirable increase in supervisor workload. Highlighting at the ATCO's Workstation involves developments at the ATCO's Workstation and a protocol between THE SYSTEM and the ATCO Workstation. Therefore, this is not intended to happen in a TRL2 research project.

Nevertheless, also the intermediate step of only presenting the results to the supervisor has already benefits:

The **Safety Occurrence Report team** can extract reports about the numbers of readback errors that have been detected and corrected by ATCOs and the number of readback errors that have not been detected and corrected by ATCOs. These reports and scenarios can be used in the training department

to identify and correct the most frequent detected readback error mistakes. Depending on the accuracy level achieved the readback error indication can be used to flag the ATCO using the surveillance working position.

For the pre-filing of radar labels and CPDLC messages applications the main users targeted are the **air traffic controllers**.

For workload and human performance application there shall be two modes implemented, the online workload prediction and the offline human performance metrics extraction. The online workload prediction can support **ATC supervisors** in decision making around changes of ongoing sectorisation in ATC environment and in changing the load of the ATCOs during live traffic situations. The offline human performance metrics extraction can be used by the **human performance specialists** to analyse the ATCOs workload during different traffic patterns and plan the traffic accordingly for similar situations. The application output can be used for training purposes.

To be able to change some parameters (described as “Offline” in [1]), the system administrators and technicians will be involved users.

4.4 Use Cases

The use cases are already detailed in the deliverable D1.1 [1].

4.5 Functional Part and Data Flows

The main data flow of THE SYSTEM is depicted in Figure 10.

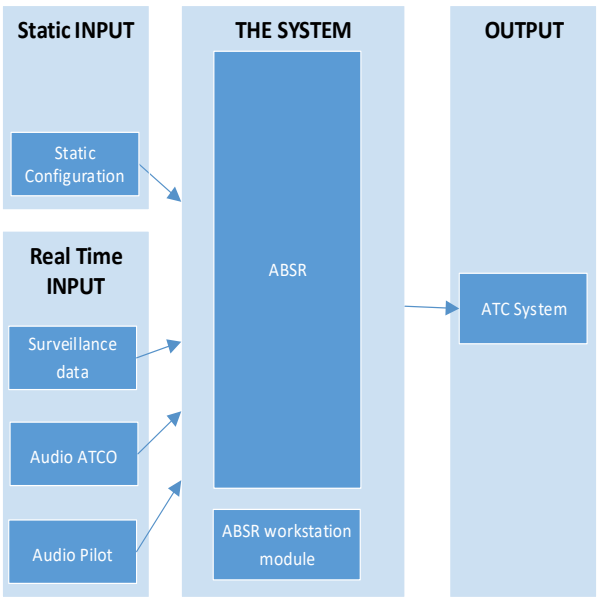

Figure 10 Input / Output system diagram

From the Pilot/Controller voice communication, the ABSR SYSTEM will have to identify and extract the important information like call sign, command types, and command values to define the pilot-controller context to be able to provide valuable feedback for the applications.

4.6 Readback error flow diagrams

Pilot/Controller communication loop is presented in the image below:

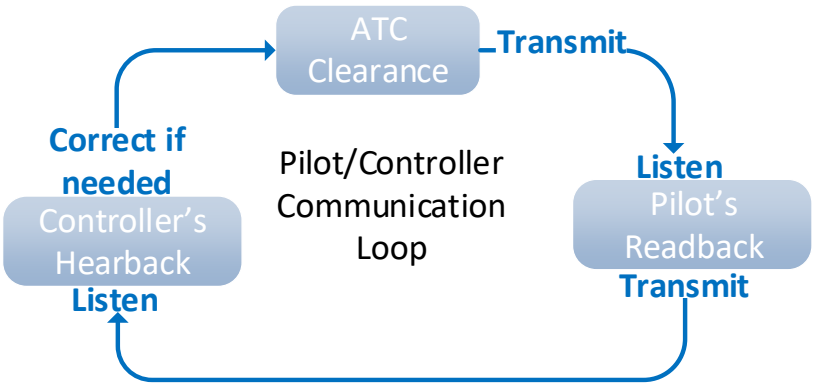

Figure 11 Pilot/Controller communication loop [7]

Figure 12 shows a more detailed flow diagram which still does not cover all use cases detailed in D1.1.

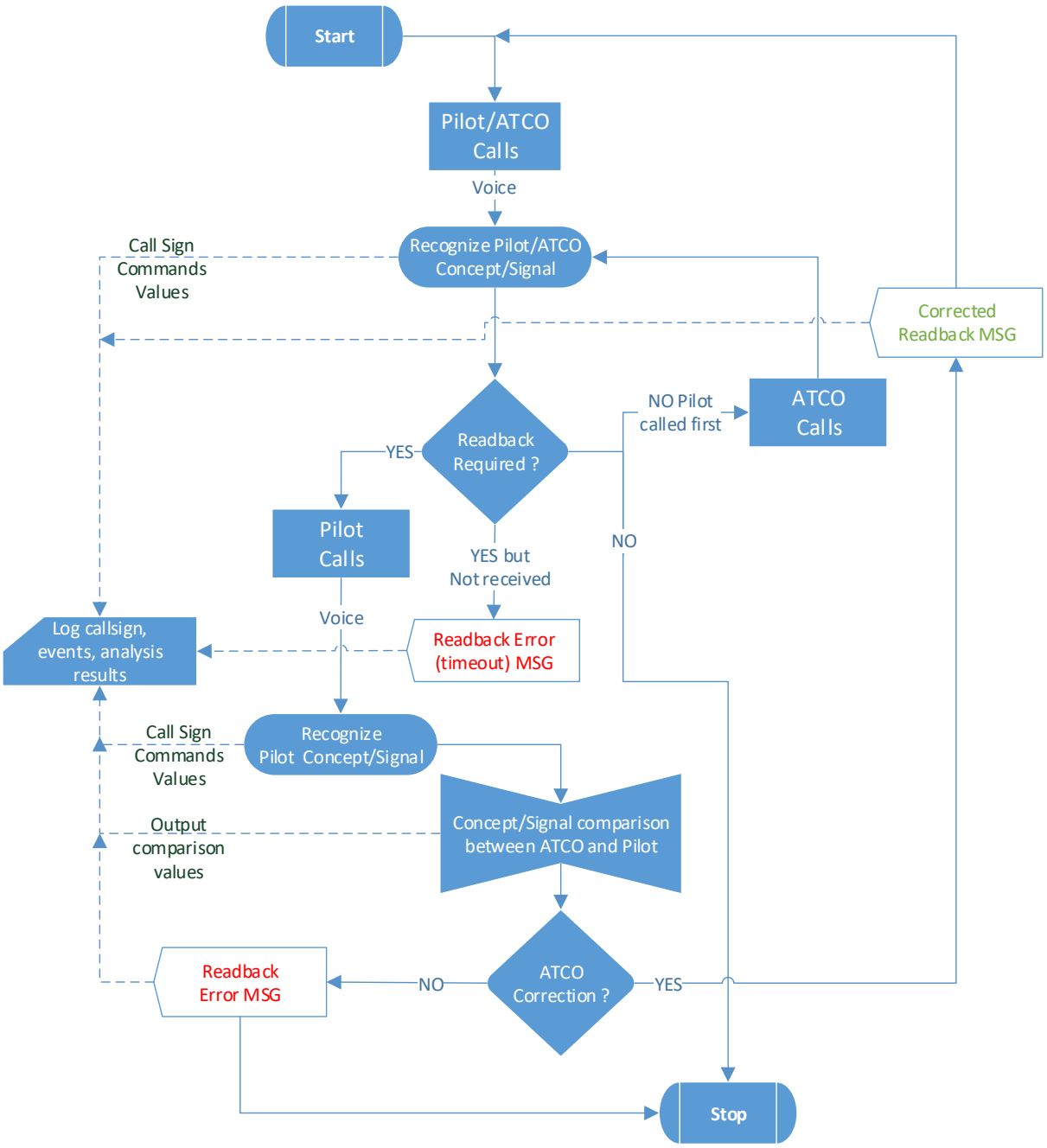

Figure 12 Readback Error detection data flow for Voice data

5 Functional requirements

Requirements are subdivided into functional requirements (FR) and Non-functional requirements (NFR). In Requirements Engineering, a Non-functional Requirement specifies criteria that can be used to assess the operation of a system. In contrast, the Functional Requirements are used to define specific behaviours or functions of a service/system, based on the user operations. In broad terms:

- Functional requirements define what a service/system is supposed to do
- Non-Functional requirements define how a service/system is supposed to be

Non- Functional Requirements are also known as the '**quality attributes'** of a service/system.

They have the following attributes:

- A name (two-time three capital letters separated by a hyphen), e.g. GEN-FUN
- Number with three digits, e.g. 001 or 025

Category: The SESAR2020 Requirements and Validation Guidelines distinguishes the following categories

- <Functional>
- <Safety>
- <Security>
- <Adaptability>
- <Maintainability>
- <Reliability>
- <Performance>: Performance requirements are here typically response times, such as how quickly after a user input the required output is generated. In ASR application response times are related to the time the system needs for a first output after the controller has pushed the "push-to-talk" button and the time the system needs for a "final" output after the controller has released the "push-to-talk" button. However, performance requirements also include recognition accuracy, which is defined by command recognition and command recognition error rates.
- <Data>
- <IER>
- <Design>
- <Interface>
- <Interoperability>
- <HMI>: These requirements are concerned with the understanding of human behaviour such as abilities, characteristics, and limitations. This knowledge is applied to the design of equipment, environments in which they function, and jobs they perform. The requirements also seek to improve the understanding of human resilience and to set forth recommendations on how to manage and improve it, to prevent events triggered by human error such as cognitive overload, fatigue etc.

In green we marked the categories, which are used and covered in this document.

5.1 Generic Functional Requirements

The requirements of this section are relevant for more than one application. Requirements only relevant e.g. for the readback error detection functionality are described in the following sections.

5.1.1 GEN-FUN-010

Identifier	GEN-FUN-010		
Title	System modes of operations		
Requirement	THE SYSTEM WILL support following modes: • Operational Mode • Offline Training Mode The modes are used to distinguish between input and output capabilities. When THE SYSTEM is in operational mode it SHALL support voice stream (ED137) and surveillance stream (ASTER CAT062).		
Rationale / Why this requirement	The requirements are relevant for DLR, developing the command extraction and command prediction modules, t Voice-to-Text module developed by BUT and Idiap needs to implement a speaker diarization functionali segmentation functionality and a speech-to-text functionality, which all requires realtime capabilities. For the HM the requirements are also important, but we repeat the requirement again, when the subject is the HMI.		
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-28	
	NATS	Status: Accepted 2020-09-10	
RQ for (Who has to implement RQ)?	DLR	Status: Accepted 2020-08-29	
	BUT	Status: Accepted 2020-09-27	
	Idiap	Status: Accepted 2020-09-25	
Category	FR		
Test Method / Acceptance Criteria	Offline evaluation and Demonstration		
Conflicts			
Additional Information	HHe suggest to delete this requirement, because it was not validated and is in conflict with other ED1 requirements, which are not agreed resp. have a WILL level		
History	2020-02-07	T. Simiganoschi	First Version
	2020-07-10	H. Helmke	Adding more information

	2020-08-19	H. Pálsson	Consistency verification
	2020-08-29	H. Helmke	Adding relevance of Idiap and BUT
	2020-08-30	P. Motlicek	Checking
	2020-09-10	J. Harfmann	Consistency review
	2022-10-03	H. Helmke	Changed to WILL

5.1.2 GEN-FUN-020

Identifier	GEN-FUN-020
Title	Traffic flows within en-route and terminal control area
Requirement	THE SYSTEM SHALL be able to process all traffic flows within the Area of Interest of en-route and terminal control area (Arriving traffic, Departing traffic, Overflights). CONDITION: The available data used for training must contain sufficient examples to train and learn commands occurring in en-route and terminal control area traffic (Arriving traffic, Departing traffic, Overflights).
Rationale / Why this requirement	To cover the whole traffic within the en-route and terminal control area.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-07-10 NATS — Status: Accepted 2020-08-04
RQ for (Who has to implement RQ)?	DLR — Status: Accepted 2020-07-10
Category	FR
Test Method / Acceptance Criteria	Offline evaluation and Demonstration The requirement is achieved.
Conflicts	
Additional Information	The requirements are relevant only for DLR, developing the command extraction and command prediction modules, the Voice-to-Text module developed by BUT and Idiap is area of interest are independent. For the HMI, the requirements are also important, but we repeat the requirement again, when the subject is the HMI
History	2020-02-07 — T. Simiganoschi — First Version 2020-07-10 — H. Helmke — Adding more information

	2020-08-19	H. Pálsson	Consistency verification

5.1.3 GEN-FUN-030

Identifier	GEN-FUN-030		
Title	Start voice recognition immediately		
Requirement	When the ATCO or the Pilot starts transmitting THE SYSTEM SHALL start the recognition process immediately.		
Rationale / Why this requirement	Recognition of the speech signal begins when the controller and pilot start to talk. The speech recognizer should start immediately and not wait until the controller has released the push-to-talk button. This is important so the system can extract the callsign from the transmission irrelevant whether it is still ongoing.		
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-18	
	NATS	Status: Accepted 2020-08-13	
RQ for (Who has to implement RQ)?	BUT / Idiap	Status: Accepted 2020-07-25	
	DLR (due to Cmd Extraction)	Status: Accepted 2020-07-10	
Category	FR		
Test Method / Acceptance Criteria	Demonstration		
Conflicts			
Additional Information	The requirement is achieved, although a PTT was never provided. A “virtual” PTT is emulated by the voice activity detection.		
History	2020-02-07	T. Simiganoschi	First Version
	2020-08-13	S. Myezwa	Consistency of text
	2020-08-19	H. Pálsson	Consistency review and improved.

5.1.4 GEN-FUN-040

Identifier	GEN-FUN-040
Title	Provide callsign information
Requirement	THE SYSTEM SHALL identify the callsign (aircraft identifier) in the voice from the ATC system when the ATCO or the Pilot are transmitting. The callsign information shall

	be sent to the Controlling Working Position and logged within 250ms after being fully pronounced. If the callsign is not recognized immediately after the callsign is pronounced, THE SYSTEM SHALL send the 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 or pilot gives the callsign information at the end of the utterance).
Rationale / Why this requirement	Callsign is one of the most important information. If a long command is 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 either by highlighting the aircraft label on the radar screen or automatically refresh the information on a supervisor PC.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-18-08 NATS — Status: accepted 2020-09-10
RQ for (Who has to implement RQ)?	BUT / Idiap — Status: Accepted 2020-07-25 DLR (for Cmd Extraction) — Status: Accepted 2020-07-10
Category	NFR with respect to performance
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	Currently it is not clear, if this requirement is fulfilled by using the command extraction functionality or directly implemented within Voice-to-Text block, in the latter case DLR is not involved. The requirement can only be achieved with the command extraction functionality. Voice-to-Text has no information of the callsigns in the air. No special callsign extraction module was implemented. The requirement is achieved, although it is not clear whether the 250 ms constraint is mostly achieved.
History	2020-07-02 — T. Simiganoschi — First Version 2020-07-10 — H. Helmke — Additional information filed added, Category changed 2020-08-19 — H. Pálsson — Consistency review and improved.

	2020-08-29	H. Helmke	Category changed from FR to NFR and added performance category
	2020-09-10	J. Harfmann	Consistency review

5.1.5 GEN-FUN-050

Identifier	GEN-FUN-050	
Title	Identify whether the transmission is Air to Ground (ATCO) or Ground to Air (Pilot)	
Requirement	THE SYSTEM SHALL identify Air to Ground (ATCO) or Ground to Air (Pilot) for each transmission.	
Rationale / Why this requirement	The expected voice stream does not include PTT, SQU, destination or origin information, therefore THE SYSTEM has to differentiate between ATCO and Pilot voice.	
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-18-18
	NATS	Status: Accepted 2020-09-10
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2020-07-25
	Idiap	Status: Accepted 2020-09-25
Category	FR	
Test Method / Acceptance Criteria	Offline and Demonstration	
Conflicts		
Additional Information	The system is able to detect the transmission is Air to Ground (ATCO) or Ground to Air (Pilot). The accuracy of this detection however is below 95%. For a future system PTT is a must and also that both streams are separated and not merged.	
History	2020-07-02	T. Simiganoschi	First Version
	2020-08-19	H. Pálsson	Consistency review and improved.
	2020-09-10	J. Harfmann	Consistency review

5.1.6 GEN-FUN-060

Identifier	GEN-FUN-060
Title	Detect Start and End of Transmission

Requirement	THE SYSTEM SHALL detect Start of the transmission and End of transmission. • dB levels indicating silence versus voice. • minimum transmission duration • transmission closure duration
Rationale / Why this requirement	Because the expected voice stream does not include PTT or SQU.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-18 NATS — Status: Accepted 2020-09-10
RQ for (Who has to implement RQ)?	BUT (pilot) — Status: Accepted 2020-07-25 Idiap (controller) — Status: Accepted 2020-09-25
Category	FR
Test Method / Acceptance Criteria	Offline and Demonstration
Conflicts	
Additional Information	Following data characteristics can be used when detecting Start and End of transmission: - dB levels indicating silence versus voice. - minimum transmission duration - transmission closure duration The requirement is achieved not using ATCO/Pilot detection but using separate signalling for PTT (ABSR keyboard). Nevertheless, will PTT signal significantly improve accuracy and recognition and extraction speed.

History			
	2020-07-02	T. Simiganoschi	First Version
	20-08-13	S.Myezwa	Consistency of text
	2020-08-19	H. Pálsson	Consistency review and improved.
	2020-08-30	P. Motlicek	Checking
	2020-09-10	J. Harfmann	Consistency review

5.1.7 GEN-FUN-070

Identifier	GEN-FUN-070
Title	Provide complete command information

Requirement	THE SYSTEM SHALL process the complete command information after each transmission. The complete command information shall be sent to the Controlling Working Position and logged within 250ms after end of transmission.
Rationale / Why this requirement	Complete command information includes for each command of the transmission the callsign, type, value, qualifier, unit and condition, if the command type requires value, qualifier, unit and condition
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-19 NATS — Status: Accepted 2020-08-14
RQ for (Who has to implement RQ)?	BUT for pilot — Status: Accepted 2020-07-25 Idiap for ATCO — Status: Accepted 2020-09-25 DLR for Cmd Extraction — Status: Accepted 2020-07-10
Category	FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	Without PTT information the requirement does not make sense because ATCO and also pilot do not continuously speak. They make pauses between the words of more than 250 ms. If the system, however, has wrongly or correctly decided, whether the transmission has ended, the average processing time is below 250 ms. The most time-consuming part is still PTT part.
History	2020-07-02 — T. Simiganoschi — First Version 2020-08-13 — Sine — Consistency of text 2020-08-19 — H. Pálsson — Consistency review and improved.

5.1.8 GEN-FUN-080

Identifier	GEN-FUN-080
Title	Classifying transmissions into communication groups
Requirement	THE SYSTEM SHALL classify transmissions into communication groups where the communication is a single dialogue between ATCO and Pilot consisting of multiple Air Ground and Ground Air transmissions.

	The single dialogue is for example when pilot asks for higher flight level and the ATCO provides clearance for that flight level. It is suggested that each communication (consisting of many transmission) has a communication identifier. Also, each transmission has a transmission identifier and a communication identifier to which it adheres to.
Rationale / Why this requirement	It is important to classify transmissions into communication groups to ensure a clear link between multiple transmissions when analysing readbacks and Human Performance results.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-19 NATS — Status: Accepted 2021-04-29
RQ for (Who has to implement RQ)?	BUT for pilot — Status: Accepted 2020-08-21 Idiap for ATCO — Status: Accepted 2020-09-25 DLR for Cmd Extraction — Status: Accepted 2020-07-10
Category	FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	This requirement must be detailed in the interface descriptions in D1-3. The requirement is achieved and implemented in the provided excel sheet for each utterance, which is generated in real-time. The fulfilment of the requirement was a must for the REDA implementation.
History	2020-07-02 — T. Simiganoschi — First Version 2020-08-13 — Sine — Consistency of text 2020-08-19 — H. Pálsson — Consistency review and improved. 2020-08-30 — P. Motlicek — checking

5.1.9 GEN-FUN-090

Identifier	GEN-FUN-090
Title	Transmission information
Requirement	For each transmission THE SYSTEM SHALL process at least the following information: • Transmission unique identifier

	• Date and Timestamp • Controlling Working Position Identifier • Frequency • Communication group, see GEN-FUN-080 • Direction (ATCO-Air Ground/ Pilot-Ground Air) • Extracted Command Information, see GEN-FUN-100 • Extracted Readback Information, see RBE-FUN-050
Rationale / Why this requirement	The requirement gives a structure on transmission information which will be sent to the Controlling Working Position and logged. The transmission information will be used to analyse the results during validation and verification phase, during operation phase in the future the same information is used to build the business logic within the Controlling Working Position.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-19 NATS — Status: Accepted 2021-04-29
RQ for (Who has to implement RQ)?	DLR responsible for interface to ANSPs — Status: Accepted 2020-08-29
Category	FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	The requirement needs to be detailed in the interface description in D1-3. The requirement is achieved, see excel sheet.

History

2020-07-02	T. Simiganoschi	First Version
2020-0710	H. Helmke	Priority and text are now consistent
2020-08-19	H. Pálsson	Consistency review and improved.
2020-08-19	H. Helmke	Splitted into part for complete transmission/ utterance and command part

5.1.10 GEN-FUN-100

Identifier	GEN-FUN-100

Title	Command information

Requirement	For each extracted command of a transmission THE SYSTEM SHALL process at least the following information:
	
	• For callsign information (i.e. aircraft Identification)
	  ○ Recognition status
	  ▪ Predicted / not Predicted = callsign is recognized but not found in the surveillance data
	  ○ Recognition output (recognized aircraft identification)– if no callsign is extracted from the transmission NO_CALLSIGN will be provided
	• Command Type including second type (ILS, RNAV for e.g. CLEARED)
	  ○ Title of command type according to ontology (e.g. HEADING...))
	  ○ Recognized command attributes, which depend on the command type according to the ontology
	• If no command is extracted for a callsign, the output is NO_CONCEPT instead of the command type
	• If neither a callsign nor a command type is extracted, the output is just NO_CALLSIGN NO_CONCEPT (e.g. for “good morning” or just coughing)
	• Callsign Information Processing time, see GEN-FUN-040
	• Command Information Processing time, see GEN-FUN-070
	• Accuracy rate, see
	
	A transmission can also contain multiple callsign (separated by break or not). The callsign is provided in each extracted command, even only said once.

Rationale / Why this requirement	The requirement gives a structure on transmission information which will be sent to the Controlling Working Position and logged. The transmission information will be used to analyse the results during validation and verification phase, during operation phase in the future the same information is used to build the business logic within the Controlling Working Position. The transmission information will also be used to: • Extract Human Performance (HP) Metrics. • Facilitate prefiling of clearances into aircraft labels and/or electronic flight strips at the Controlling Working Position • Facilitate prefilling of clearances into CPDLC messages at the Controlling Working Position
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-19 NATS — Status: Accepted 2021-04-29
RQ for (Who has to implement RQ)?	DLR responsible for Command Extraction — Status: Accepted 2020-08-29
Category	FR

Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	Readback error detection is not performed during command extraction. This is an addition block, which is part of Usage of Speech Information. The requirement is achieved.

History

2020-07-02	T. Simiganoschi	First Version
2020-0710	H. Helmke	Priority and text are now consistent
2020-08-19	H. Pálsson	Consistency review and improved.
2020-08-19	H. Helmke	Splitted into part for complete transmission/ utterance and command part, readback error detection also splitted and move to RBE-FUN-xxx
2020-09-11	J. Harfmann	Consistency review

5.1.11 GEN-FUN-110

Identifier	GEN-FUN-110
Title	Audio recordings
Requirement	THE SYSTEM WILL support audio recordings for validation and testing. THE SYSTEM WILL be configurable to automatically delete audio recordings after configurable number of minutes. Default value is 30 minutes.
Rationale / Why this requirement	Audio recordings will be used to assess THE SYSTEM during validation and testing. If audio recordings are not implemented, it is expected that more validation efforts will be performed offline using logs and presenting results to users.

RQ from (Who benefits)?

Isavia ANS	Status: Accepted 2020-08-19
NATS	Status: Accepted 2021-04-29

RQ for (Who has to implement RQ)?

Idiap	Status: Accepted 2020-09-25

	BUT	Status: Accepted 2020-09-27
Category	FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information	The requirement is not relevant for TRL2 projects, but is of importance for future projects aiming to achieve TRL6 and higher.	
History	2020-07-02	T. Simiganoschi	First Version
	2020-09-11	J. Harfmann	Consistency review
	2020-09-25	P. Motlicek	check
	2020-09-27	P. Smrz	Comments for clarification
	2022-10-03	H. Helmke	Changed to WILL

5.1.12 GEN-FUN-120

Identifier	GEN-FUN-120	
Title	Classification of pilot or ATCo utterance	
Requirement	The SYSTEM SHALL be able to decide whether a wave files results from the pilot or from the ATCO	
Rationale / Why this requirement		
RQ from (Who benefits)?	DLR (creating the text-to-concept extraction blocks)	Status: Accepted 2020-07-30
RQ for (Who has to implement RQ)?	BUT (for providing the pilot V2T block)	Status: Accepted 2020-08-21
	Idiap (for providing the ATCo V2T block)	Status: Accepted 2020-09-25
Category	FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts	None	
Additional Information	The requirement is redundant to GEN-FUN-050. Therefore GEN-FUN-120 and GEN-FUN-050 should be merged to one.	

History	2020-07-30	H. Helmke	First Version
	2020-07-30	H. Helmke	Minor reformulation, to align with RQ template, moved from SYS-V2TML-040 to GEN-FUN-230
	2020-09-25	P. Motlicek	check

5.2 Recognition Functionality Requirements

The recognition functionality requirements are based on standard phraseology described in ICAO Doc.4444. It means that the corresponding phraseology in each requirement reflects standard phraseology.

5.2.1 GEN-RFN-010

Identifier	GEN-FUN-010	
Title	Recognition of commands based on phraseology described in the ontology XLS sheet document.	
Requirement	THE SYSTEM SHALL recognize all command types specified in Appendix A for the different applications CONDITION: Enough training data is available for the different command types. For each command at least 10 examples are necessary. Recognition of commands based on phraseology described in 2020-08-10-CommandTypeValues-V-1-03 document.	
Rationale / Why this requirement		
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-19
	NATS	Status: Accepted 2020-08-28
RQ for (Who has to implement RQ)?	BUT for pilot	Status: Accepted 2020-07-25
	Idiap for controller	Status: Accepted 2020-09-29
	DLR for Cmd Extraction	Status: Accepted 2020-07-10
Category	FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts	None	

Additional Information	The requirement is achieved, see D5-2 and D5-3 with respect to extraction rates and SID publication		
History	20-02-07 2020-07-02	T. Simiganoschi	First Version
	2020-07-10	H. Helmke	Making RQ more precise
	2020-08-19	T. Simiganoschi	Reviewed and removed the ontology XLS file name.
	2020-08-30	P. Motlicek	checking

5.2.2 GEN-RFN-020

Identifier	GEN-RFN-020
Title	Support mapping between operator 3 letter code and telephony name of the operator (short name)
Requirement	THE SYSTEM SHALL support mapping between operator 3 letter code and telephony name of the operator (short name). THE SYSTEM SHALL recognize commands based on phraseology described in ICAO Doc 8585 „Manual on Designators for Aircraft Operating Agencies, Aeronautical Authorities and Services “. THE SYSTEM SHALL support update of mapping between operator 3 letter code and telephony name of the operator (short name) without the need to retrain the model. THE SYSTEM SHOULD support ICAO API for Doc 8585, see URL: https://www.icao.int/safety/iStars/Pages/API-Data-Service.aspx. CONDITIONS: • The three letter codes together with their telephony codes are provided in machine readable form, see descriptions of files designators.json, additions.json and deletions.json below in test method. • The telephone codes (e.g. “speed bird”) should be in the test data. If the three letter code for “iceair” changes from “ICE” changes to “TEO”, this should not be a problem. If the telephone code for “ICE” is changed to “simiganoschi airlines” this will be a problem for the ABSR system, if “simiganoschi arilines” has not been in the test data. If the telephone code for “ICE” changes to “speed lufthansa” this should also recognized very often, because both words “speed” and “lufthansa” are in the training data, but the combination is not expected, which might have an influence on recognition accuracy. A retraining of the language model, with training examples for “speed lufthana” helps..

Rationale / Why this requirement	During controller pilot communication callsigns are changed to telephony names of the operators, example: DLH123 is communicated as Lufthansa 123, AFR is air France etc.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2021-06-02 NATS — Status: Accepted 2020-08-04
RQ for (Who has to implement RQ)?	DLR for Cmd Extraction — Status: Accepted 2021- 06-20
Category	FR
Test Method / Acceptance Criteria	Offline and demonstration The SVN contains three files in the folder: ..\SVNs\HAAWAII\SpeechData\xxx\ConfFiles The files are: • designators.json • additions.json • deletions.json Each files has the same format, we see here a subpart from additions.json: , "HAWK": ["hawk"] , "HOP": ["air_hop", "air hop"] , "ICE": ["ice air"] , "ICG": ["coast guard", "icelandic coast guard"] , "IFA": ["red angel"] , "IRA": ["iran_air"] , "ISA": ["island", "isa"] , "JEI": ["executive", "jet_executive", "jet executive"] , "KAL": ["korean_air", "korean air"] , "LAN": ["latam"] The semantics is, that the words in the second part are mapped to the three letter codes in the first part. If the ABSR system recognizes that the word sequences “jet executive” is part of the callsign (e.g. of “jet executive alfa six papa”) the callsign would contain “JEI” (in the example “JEIA6P”, if this callsign is in the air). Three letter codes are taken, if they are either found in designators.json or additions.json and not found in deletions.json. In the best case designators.json contains all the relevant three letter codes and additions.json and deletions.json are just empty. The idea, however, is that designators.json is updated seldom (kept stable). It is automatically created from the ICAO documents and contains currently 7500 entries. ATCOs and pilots sometimes

	deviate from the official names. These will be added to additions.json and if the official names from designators.json should not be used, they are inserted into deletions.json. designators.json should be the same for all implementations of DLR/BUT/Idiap implementations, e.g. being the same for Isavia and NATS and additions.json and deletions.json can be different.
Status	Implemented and tested
Conflicts	
Additional Information	This requirement is detailed by the needed static information of THE SYSTEM. The requirement is achieved by DLR.
History	2020-07-02 | T. Simiganoschi | First Version 2021-06-02 | T. Simiganoschi | Reference to Doc 8585 added 2021-06-20 | H. Helmke | Clarification in test method added, condition added status set to implemented and tested

5.3 Readback Error Functionality Requirements

This section collects the requirements which are related to the readback error detection functionality.

5.3.1 RBE-FUN-010

Identifier	RBE-FUN-010
Title	Flag readback errors immediately, not wait for the whole transmission to end.
Requirement	THE SYSTEM SHOULD flag readback errors immediately after each transmission, i.e. the SYSTEM SHOULD not wait for the whole communication to end. The SYSTEM SHOULD flag the readback error even if the readback error is corrected afterwards or after the whole communication has ended the readback error is corrected/cleared.
Rationale / Why this requirement	Waiting for the whole communication to end introduces delay into the controller/pilot feedback loop. Flagging it early provides enough response time for the ATCO even if the readback error is corrected afterwards. It is up the "Usage of Speech Information" (see Figure 3) to decide whether this information is shown to the ATCO/Supervisor or not and when.

RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-18
	NATS	Status: Accepted 202009-14
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2020-07-25
	Idiap	Status: Accepted 2020-09-29
	DLR developing first prototype in task 4.1	Status: Accepted 2020-08-29
Category	FR	
Test Method / Acceptance Criteria	Demonstration, user questionnaires	
Conflicts		
Additional Information	Example of readback error not flagged: ATCO: … descend flight level three one zero Pilot : … level one three zero correction descending flight level three one zero Example of readback error flagged: ATCO: … descend flight level three one zero Pilot: … level one three zero SYSTEM: flags readback error Pilot : … correction descending flight level three one zero Immediately after the transmission ends THE SYSTEM flags the readback error. Immediately flagging is not implemented, but would be no show stopper in principle, future HITL validation are however necessary to validate whether this really helps the ATCOs or just increases their work load.	

History			
	2020-07-02	T. Simiganoschi	First Version
	2020-08-19	H. Pálsson	Consistency review and improved.
	2020-08-29	H. Helmke	Previous requirement GEN-FUN-070 moved to this section and splitted GEN_FUN-070 into multiple requirements, changed to SHOULD
	2020-09-22	T. Simiganoschi	Improved requirement after split.
	2020-09-30	P. Motlicek	checked

	2021-06-16	T. Simiganoschi	Removed conflict and added extra text.

5.3.2 RBE-FUN-020

Identifier	RBE-FUN-020		
Title	Flag readback errors within 250 ms		
Requirement	THE SYSTEM SHOULD flag readback errors within 250 ms after it has the information's available to detect it.		
Rationale / Why this requirement	This requirement details RBE-FUN 010 with performance requirements. The readback error detection time is important for ATCo if THE SYSTEM is tested in operational environment.		
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-18	
	NATS	Status: Accepted 2020-09-11	
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2020-07-25	
	Idiap	Status: Accepted 2020-09-29	
	DLR developing prototype in task 4.1	Status: Accepted 2020-08-29	
Category	NFR with respect to performance		
Test Method / Acceptance Criteria	Demonstration		
Conflicts			
Additional Information	See RBE-FUN-010		
History	2020-08-29	H. Helmke	Previous requirement GEN-FUN-070 moved to this section and splitted GEN_FUN-070 into multiple requirements, changed to SHOULD
	2020-09-11	J. Harfmann	Consistency review
	2021-06-16	T. Simiganoschi	Modified the requirement and remove the conflict.

5.3.3 RBE-FUN-030

Identifier	RBE-FUN-020
Title	Flag readback errors even if they are corrected.
Requirement	THE SYSTEM SHALL detect and flag the readback errors even if they are corrected by the ATCO or Pilot.
Rationale / Why this requirement	It is expected that THE SYSTEM provides readback errors even if the controller/pilot has begun correcting the readback or will correct the readback later in the communication. This is considered an alert for the controller.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-18 NATS — Status: Accepted 2021-04-29
RQ for (Who has to implement RQ)?	BUT — Status: Accepted 2020-07-25 Idiap — Status: Accepted 2020-09-29 DLR developing prototype in task 4.1 — Status: Accepted 2020-08-29
Category	NFR performance with respect to performance
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	This is implemented, but no HITL simulations were performed, whether this requirement makes sense.

History			
	2020-08-29	H. Helmke	Previous requirement GEN-FUN-070 moved to this section and splitted GEN_FUN-070 into multiple requirements
	2020-08-22	T. Simiganoschi	Improved requirement after split.
	2020-09-30	P. Motlicek	The example above already describes the situation when the error is corrected. This requirement is thus covered by the above one.
	02.06.2021	T. Simiganoschi	Deleted Conflict and Accepted for NATS

			after discussion with Jules on 29.04.2021.

5.3.4 RBE-FUN-040

Identifier	RBE-FUN-040		
Title	Detect missing readbacks		
Requirement	THE SYSTEM SHALL detect also a missing readback as a readback error.		
Rationale / Why this requirement	If the ATCO gives a command to pilot1 and pilot1 answers without a readback of that command it SHALL be flagged as a readback error (missing readback). If pilot 1 does not answer within a given time frame of 10 seconds this SHALL be flagged as a readback error (missing read back).		
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-18	
	NATS	Status: Accepted 2021-04-29	
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2020-07-25	
	Idiap	Status: Accepted 2020-09-29	
	DLR developing prototype in task 4.1	Status: Accepted 2020-08-29	
Category	FR performance		
Test Method / Acceptance Criteria	Demonstration		
Conflicts			
Additional Information	This is implemented.		
History	2020-08-29	H. Helmke	Previous requirement GEN-FUN-070 moved to this section and splitted GEN_FUN-070 into multiple requirements
	02.06.2021	T. Simiganoschi	Deleted Conflict and Accepted for NATS after discussion with Jules on 29.04.2021.

5.3.5 RBE-FUN-050

<table>
<tr><td>Identifier</td><td>RBE-FUN-050</td></tr>
<tr><td>Title</td><td>Readback information</td></tr>
<tr><td>Requirement</td><td>For each pair of pilot/controller or controller/pilot utterance the readback error detection functionality of the SYSTEM SHALL extracted at least the following information:
Presence (YES/NO) – if it is a transmission with readback
Readback alert (YES/NO)
Corrected (YES/NO/Not Applicable)
Clearance transmission identifier (link to the clearance)
If the transmission is a readback alert the actual difference between clearance and readback shall be structurally defined.
Link to original transmission which the readback adheres to.
Readback Information processing time.</td></tr>
<tr><td>Rationale / Why this requirement</td><td>The readback Information shall contain sufficient structure so that the difference between the clearance and the readback is easily deduced by log readers or subsequent systems.

Example:<table><tr><td>ATCO:</td><td>Climb</td><td>FL300</td></tr><tr><td>Pilot</td><td>Climb</td><td>FL340</td></tr><tr><td>Readback Structure:</td><td>OK</td><td>NOT_OK</td></tr></table></td></tr>
<tr><td>RQ from (Who benefits)?</td><td><table><tr><td>Isavia ANS</td><td>Status: Accepted 2020-08-19</td></tr><tr><td>NATS</td><td>Status: Accepted 2020-09-11</td></tr></table></td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td><table><tr><td>DLR responsible for prototype in task 4.1</td><td>Status: Accepted 2020-08-29</td></tr><tr><td>BUT responsible for task 4.3</td><td>Status: Accepted 2020-09-27</td></tr></table></td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Demonstration</td></tr>
<tr><td>Conflicts</td><td></td></tr>
<tr><td>Additional Information</td><td>Details are provided in the interface description of D1.3</td></tr>
<tr><td>History</td><td><table><tr><td>2020-08-19</td><td>H. Helmke</td><td>Splitted into part for complete transmission/ utterance and command part, readback error detection also splitted</td></tr></table></td></tr>
</table>

			and move to RBE-FUN-xxx
	2020-09-11	J. Harfmann	Consistency review

5.4 Human Performance Functionality Requirements

5.4.1 HPF-FUN-010

Identifier	HPF-FUN-010		
Title	Speed of speech – HP Metrics		
Requirement	The SYSTEM SHALL be able to measure the speed at which the syllables are spoken.		
Rationale / Why this requirement	If the speech can be measured at such a detailed level it is possible to get a very good indication of workload on the basis that controllers adjust their speed of speech to the situation. Ideally speed of speech would be logged somewhere (excel export?) to allow offline analysis.		
RQ from (Who benefits)?	NATS	Status: Accepted 2020-08-14	
	Isavia ANS	Status: Accepted 2020-08-19	
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2020-08-21	
	Idiap	Status: Accepted 2020-08-21	
Category	FR		
Test Method / Acceptance Criteria	Demonstration		
Conflicts			
Additional Information	This is implemented on word level.		
History	2020-08-05	J. Harfmann	First Version
	2020-08-19	T. Simiganoschi	Reviewed
	2020-08-29	H. Helmke	RQ for changed, This is a requirement for BUT/Idiap
	2020-10-08	H. Helmke	Deleted “RQ for” line of DLR, because BUT/Idiap have accepted to

			implement and DLR was checking

5.4.2 HPF-FUN-020

Identifier	HPF-FUN-020	
Title	Extract the Changes in speed of speech – HP Metrics	
Requirement	The SYSTEM SHALL be able to extract the words spoken per transmission.	
Rationale / Why this requirement	The system needs to provide a way to allow the speed of speech to be calculated. If the words spoken per transmission is known an average speed can be calculated.	
RQ from (Who benefits)?	NATS	Status: Accepted 2020-08-14
	Isavia ANS	Status: Accepted 2020-08-19
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2020-08-21
	Idiap	Status: Accepted 2020-08-21
Category	FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information	This is implemented by NATS based on existing provided data.	

History			
	2020-08-05	J. Harfmann	First Version
	2020-08-19	T. Simiganoschi	Reviewed
	2020-08-30	P. Motlicek	checking

5.4.3 HPF-FUN-030

Identifier	HPF-FUN-030
Title	Recognition of workload related phrases – HP Metrics
Requirement	The SYSTEM SHALL be able to identify the following workload related phrases and any changes in their number of occurrences: • “Say again” (mapped to command type CALL_YOU_BACK) • “Stand by” (mapped to command type CALL_YOU_BACK) • “Break” (at least two different callsigns are in the output) • “Correction” (mapped to command type CORRECTION)

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

“Traffic information” (mapped to command type INFORMATION TRAFFIC)
“Avoiding action”
Any greetings (e.g. good morning/day/afternoon/evening, hello, etc.)

</td></tr>
<tr><td>Rationale / Why this requirement</td><td>If the system can identify these phrases and any changes in their number of occurrences, changes in workload could be anticipated and consequently managed.

This information should be presented to the supervisor rather than the controller themselves to avoid making them feel conscious about their phraseology.</td></tr>
<tr><td>RQ from (Who benefits)?</td><td>
<table>
<tr><td>NATS</td><td>Status: Accepted 2020-08-14</td></tr>
<tr><td>Isavia ANS</td><td>Status: Accepted 2020-08-19</td></tr>
</table>
</td></tr>
<tr><td>RQ for (Who has to implement RQ)?</td><td>
<table>
<tr><td>DLR for command extraction</td><td>Status: Accepted 2021-05-24</td></tr>
<tr><td>BUT/Idiap</td><td>Status: Accepted 2020-08-21</td></tr>
</table>
</td></tr>
<tr><td>Category</td><td>FR</td></tr>
<tr><td>Test Method / Acceptance Criteria</td><td>Demonstration</td></tr>
<tr><td>Conflicts</td><td>None</td></tr>
<tr><td>Additional Information</td><td>In D1.1 the following utterances are provided as examples for avoiding actions:

CSA-LINES triple two, turn right immediately heading two five five to avoid traffic
Kilo tango kilo two, turn right 30 degrees immediately to avoid unidentified traffic at your twelve o clock two miles,
Fox fox india, squawk three seven seven five
Lucky air six six, low altitude warning, check your altitude immediately, qnh is low nine seven two at Bildudalur airport, minimum flight altitude is six thousand feet.

The yellow parts are currently not modelled via the defined ontology. Either some command types get an optional additional qualifier or a new command type AVOID_TRAFFIC is invented.

Greetings and hesitations are currently ignored by the ontology, which requires an ontology update.</td></tr>
<tr><td>History</td><td>
<table>
<tr><td>2020-08-05</td><td>J. Harfmann</td><td>First Version</td></tr>
<tr><td>2020-08-19</td><td>T. Simiganoschi</td><td>Reviewed</td></tr>
<tr><td>2020-08-29</td><td>H. Helmke</td><td>Additional Information provided</td></tr>
<tr><td>2020-08-30</td><td>P. Motlicek</td><td>checking</td></tr>
<tr><td>2021-05-24</td><td>H. Helmke</td><td>Conflict state deleted, because more details are provided in the</td></tr>
</table>
</td></tr>
</table>

			implementation of the excel sheet, hesitations deleted, currently not possible to recognize, transcription not very consistent done

5.4.4 HPF-FUN-040

Identifier	HPF-FUN-040		
Title	General R/T loading – HP Metrics		
Requirement	The SYSTEM SHALL be able to measure the controller's overall R/T loading in % per definable time interval (default setting 5 min) The CSV/Excel Export file will be used including rolling 5 min average which fulfils this requirement.		
Rationale / Why this requirement	If the system can measure overall R/T loading and significant changes it would provide a good indication of workload changes on the sector. This information SHALL be presented to the supervisor rather than the controller themselves, such that the supervisor could use this information to support any sector configuration decisions.		
RQ from (Who benefits)?	NATS	Status: Accepted 2021-06-04	
	Isavia ANS	Status: Accepted 2020-08-19	
RQ for (Who has to implement RQ)?	NATS to implement the mapping from ABSR output to HP Metrics	Status: Accepted 2021-06-04	
	DLR/BUT/Idiap Export file	Status: Accepted 2021-06-04	
Priority	SHALL		
Category	FR		
Test Method / Acceptance Criteria	Demonstration		
Conflicts			
Additional Information	This is implemented by NATS based on exported data (D5.4).		
History	2020-08-05	J. Harfmann	First Version
	2020-08-19	T. Simiganoschi	Reviewed
	2020-08-29	H. Helmke	Adding the information for whom it is a requirement

	2021-05-24	H. Helmke	Default value is 5 min
	2021-04-29	J. Harfmann	DLR has provided first version of Excel Export including rolling 5 min average which fulfils this requirement.

5.4.5 HPF-FUN-050

Identifier	HPF-FUN-050	
Title	Presentation of HP metrics to supervisors – HP Metrics	
Requirement	The SYSTEM SHALL be able to present the HP metrics extractions to the ATC supervisors in a meaningful way.	
Rationale / Why this requirement	This is to ensure that we keep thinking about the way we want to present data to the end users. Ultimately, HP metrics extraction will bring the biggest benefit to operational supervisors who can support their decision making by interpreting the objective workload measurements.	
RQ from (Who benefits)?	NATS	Status: Accepted 2020-08-28
	Isavia ANS	Status: Accepted 2020-08-19
RQ for (Who has to implement RQ)?		
Priority	SHALL	
Category	FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information	This is implemented by NATS based on exported data (D5.4).	
History	2020-08-05	J. Harfmann	First Version
	2020-08-19	T. Simiganoschi	Reviewed
	2020-08-29	H. Helmke	Adding the information for whom it is a requirement

5.4.6 HPF-FUN-060

Identifier	HPF-FUN-060
Title	Extraction of clearance types
Requirement	The SYSTEM (Usage of Speech Information) SHALL be able to extract the following types of clearances, their specific combinations and especially their occurrence frequency • Level • Heading • Speed • Route
Rationale / Why this requirement	If the system can identify the types of clearances and their combinations it could give a good indication of workload changes. For example, a combination of a level and heading instruction during one transmission indicates a higher cognitive load than a simple route change during one transmission. This information should be presented to the supervisor to support their sector configuration decisions.
RQ from (Who benefits)?	NATS / Status: Accepted 2021-06-24
RQ for (Who has to implement RQ)?	NATS to implement the mapping from ABSR output to HP Metrics / Status: Accepted2021-06-24
Category	FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	
Additional Information	This is implemented by NATS based on exported data (D5.4).
History	2020-08-05 / J. Harfmann / First Version 2020-08-19 / T. Simiganoschi / Reviewed 2020-08-29 / H. Helmke / Adding the information for whom it is a requirement and changed the whole requirement

5.5 Input Requirements

5.5.1 SYS-INP-010

Identifier	SYS-INP-010
Title	Aircraft State: Processing of ASTERIX CAT062
Requirement	THE SYSTEM SHALL be able to process aircraft state in ASTERIX CAT062 format. THE SYSTEM SHALL support ASTERIX CAT062 THE SYSTEM SHALL decode the message structure for the transmission of System Track Data within ASTERIX Cat. 062 formats, Edition 1.18 or newer with User Application Profile (UAP), received online using the UDP protocol. THE SYSTEM SHALL be capable of decoding information in the Reserved Expansion Field of SDPS Track Messages from ASTERIX Cat 062, Edition xx or newer with User Application Profile (UAP), received online using the UDP protocol. THE SYSTEM SHOULD be capable of decoding information in the SDPS Service Status Reports from ASTERIX Cat065, edition 1.4 or newer to monitor the alive status of the tracker. THE SYSTEM SHALL be capable of processing data item I062/380 (Aircraft Derived Data) if received but not depended on the data item. THE SYSTEM SHALL be capable of processing data item I062/390 (Flight Plan Related Data) if received but not depended on the data item.
Rationale / Why this requirement	ASTERIX CAT062 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)?	Isavia ANS — Status: Accepted 2020-08-19 NATS — Status: Accepted 2021-06-04
RQ for (Who has to implement RQ)?	DLR for processing — Status: Accepted 2020- 07-10 Isavia must provide the data — Status: Accepted 2020-08-19 NATS must provide the data — Status: Unknown 2020-xx-yy
Category	FR
Test Method / Acceptance Criteria	Offline and Demonstration
Conflicts	
Additional Information	**Note:** Isavia ANS will not send the Data Item I062/390 (Flight Plan Related Data) in the ASTERIX CAT062. All flight plan related information, provided by ground-based systems are omitted from ASTERIX CAT062. Trackers which provide I062/390 are

	interconnected to other ATM systems (Flight Data Processing Systems) and it is not the case at Isavia. Data Item I062/380 (Aircraft Derived Data) is data derived directly by the aircraft and the surveillance system needs to be capable of receiving the data. This means in practice that the aircraft needs to be equipped and within coverage of surveillance systems such as: ADS-B, Multi-lateration, Mode-S radars etc. This is implemented.		
History	2020-07-02	T. Simiganoschi	First Version

5.5.2 SYS-INP-025

Identifier	SYS-INP-025		
Title	Real time voice data and PTT input from Controller Workstation.		
Requirement	The SYSTEM SHALL be able to receive real time feed of voice and PTT signal from the Controller Working Position. One way to connect the voice is to use the analogue (E&M/RJ45/Jack) interfaces from the Controller Working Position. The PTT signal indication will be taken directly from the headset using an open/closed contact. This is a plausible scenario if the voice and the PTT signal are synchronized.		
Rationale / Why this requirement	To be able to see the ABSR functionality in operational the ABSR needs the voice source from ATCo and Pilot and identify if the speaker is ATCO or Pilot based on the PTT open/close contact signal: On-ATCo, Off-Pilot.		
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2021-06-02	
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2021-06-06	
	Isavia ANS connect	Status: Accepted 2021-06-06	
Category	FR		
Test Method / Acceptance Criteria	Demonstration		
Conflicts	None		
Additional Information	This is implemented using RJ45 audio connection from the Trainer/Trainee plug and a specific keyboard key to identify ATCO/Pilot		
History	2021-06-16	T. Simiganoschi	Modified the ED137 requirement into analogue.

5.5.3 SYS-INP-026

Identifier	SYS-INP-026		
Title	Voice Data using microphone input.		
Requirement	The SYSTEM SHALL be able to receive voice inputs from microphones offering the possibility to simulate either ATCO or Pilot during testing and trials.		
Rationale / Why this requirement			
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2021-06-02	
	NATS	Status: Accepted 2021-06-04	
RQ for (Who has to implement RQ)?	BUT	Status: Accepted 2021-06-04	
	Idiap	Status: Accepted 2021-06-04	
Category	FR		
Test Method / Acceptance Criteria	Demonstration		
Conflicts	None		
Additional Information	This is implemented using RJ45 audio connection from the Trainer/Trainee plug and a specific keyboard key to identify ATCO/Pilot.		
History	2021-06-02	T. Simiganoschi	First Version
	2021-06-04	T. Simiganoschi	Changed to accepted

5.5.4 SYS-INP-030

Identifier	SYS-INP-030	
Title	Voice Data and surveillance data files	
Requirement	The SYSTEM SHALL be able to process voice recorded files in .wav format. THE SYSTEM SHALL be able to process surveillance recorded files in .ff format.	
Rationale / Why this requirement	These files are used during training mode of the system.	
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-28
	NATS	Status: Accepted 2021-06-04

RQ for (Who has to implement RQ)?	BUT		Status: Accepted 2020-07-25
	Idiap		Status: Accepted 2020-09-30
	DLR for ff format of surveillance data		Status: Accepted 2020-08-29
Category	FR		
Test Method / Acceptance Criteria	Demonstration		
Conflicts			
Additional Information	This is implemented.		
History	20-02-07 2020-07-02	H. Pálsson	First Version
	2020-08-30	P. Motlicek	checking

5.6 System Configuration Requirements

This subsection contains requirements for offline configuration of system parameters.

5.6.1 SYS-OFF-020

Identifier	SYS-OFF-020
Title	Waypoint List
Requirement	THE SYSTEM SHALL support waypoint lists, which consists of at least the following items: - Name/Identifier - Word sequence spoken for the waypoint (e.g. “cheb” for “OKG” or “whiskey, whiskey four one eight” for “WW418” - Latitude and longitude THE SYSTEM SHALL support update of waypoint list without the need to retrain the model. This is to support AIRAC (Aeronautical Information Regulation And Control) cycle which is used for operationally significant changes in aviation, published within Aeronautical Information Publication. THE SYSTEM should update airspace information using access to European AIS Database, EAD. https://www.eurocontrol.int/service/european-ais-database. - HAAWAII note: We need to discuss this requirement, whether this includes sufficient data for Iceland for example – Isavia does not have the coverage of EAD. Another approach is to depend on AIXM format, e.g. AIXM 5.1. Another approach is just use simple csv and JSON files.

	THE SYSTEM SHALL enhance the waypoint list with possible clearances which can be associated with every waypoint. Eg: DIRECT-TO, TRANSITION or HOLDING advisories maybe recognized. THE SYSTEM SHALL enhance the waypoint list with the pronunciation of every waypoint.
Rationale / Why this requirement	The waypoints are airspace / aerodrome dependent. 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.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-19 NATS — Status: Accepted 2020-08-28
RQ for (Who has to implement RQ)?	DLR for the json file — Status: Accepted 2020- 07-10 BUT/Idiap for recognition the new waypoint — Status: Accepted 2020-07-25
Category	FR
Test Method / Acceptance Criteria	Test. The requirement is fulfilled, DLR has provided the AtcConcept.json file for all partners, and integrated feedback from Isavia in March 2021.
Status	Implemented and accepted
Conflicts	None
Additional Information	If just a new waypoint BF080 (bravo foxtrot zero eight zero) needs to be added, no update of the speech recognition models itself is necessary. This is not the case if the waypoint GUNPA is added. The system needs to know how a Chinese pilot after 12 hours of flight time is pronouncing this new word. Extraction from European AIS Database is not aim of the project, showing that new waypoints can be added, however. If ANSPs know how to add a waypoint, they will find by themselves ways to add also ten waypoints coming from other sources.
History	2020-07-02 — T. Simiganoschi — First Version 2020-07-10 — H. Helmke — Priority now consistent with requirement text 2020-08-30 — P. Motlicek — checking 2021-05-24 — H. Helmke — Updated status

5.6.2 SYS-OFF-030

Identifier	SYS-OFF-030
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)?	Isavia ANS — Status: Accepted 2020-09-29 NATS — Status: Accepted 2020-09-11
RQ for (Who has to implement RQ)?	DLR — Status: Accepted 2021-06-04 BUT — Status: Accepted 2021-06-04 Idiap — Status: Accepted 2021-06-04
Priority	SHOULD
Category	FR
Test Method / Acceptance Criteria	Test; The requirement is fulfilled, DLR has provided the AtcConcept.json file for all partners, and integrated feedback from Isavia in March 2021.
Status	Implemented and accepted
Conflicts	None
Additional Information	The requirement will be discussed with DLR, Idiap, BUT in the next version of this document, so that Unknown status can be detailed.

History

2020-07-02	T. Simiganoschi	First Version
2020-07-10	H. Helmke	Priority now consistent with requirement text
2020-08-30	P. Motlicek	checking
2021-05-24	H. Helmke	Updated status

6 Non-functional requirements

6.1 ABSR Performance requirements

6.1.1 PER-REC-010

Identifier	PER-REC-010
Title	Recognition accuracy rate for command recognition in operation
Requirement	THE SYSTEM SHALL deliver the performance of at least 85% accuracy rate for ATCO and 75% accuracy rate for Pilot for command recognition in operation. The SYSTEM SHALL minimize the error rate for command recognition. Recognition accuracy rate should also be measured with evaluation sets.
Rationale / Why this requirement	It is necessary to prove the accuracy rates in order to establish ATCOs confidence to the system. HAAWAII performance model is defined as three values, accuracy rate, unknown rate and error rate, i.e. the accuracy rate + unknown rate + error rate >= 100%. An example for command recognition for ATCO where unknown is 10%: 100% = 85% + 10% + 5%. The rationale of defining unknown is that in many ATC applications the unknown feedback is better than false information(error) that could mislead ATCO to make wrong assumptions. In other words, if 85%/75% accuracy rate is not achievable within the HAAWAII project, it can be better to lower the recognition rate limit if it is proven the error rate can still be kept at a low margin.
RQ from (Who benefits)?	Isavia ANS: Status: Accepted 2020-08-25 NATS: Status: Accepted 2020-09-11
RQ for (Who has to implement RQ)?	DLR: Status: Accepted 2020-10-08 BUT: Status: Accepted 2021-06-04 Idiap: Status: Accepted 2021-06-04
Category	Non FR
Test Method / Acceptance Criteria	Demonstration

Conflicts			
Additional Information	Implemented and accepted.		
History	2020-07-02	T. Simiganoschi	First Version
	2020-08-25	H. Pálsson	Review
	2020-09-11	J. Harfmann	Consistency review

6.1.2 PER-REC-011

Identifier	PER-REC-011	
Title	Recognition accuracy rate for call sign recognition in operation.	
Requirement	THE SYSTEM SHALL deliver the performance of at least 95% for ATCOS and 90% for pilots accuracy rate for call sign recognition in operation. The SYSTEM SHALL minimize the error rate for call sign recognition. Recognition accuracy rate should also be measured with evaluation sets.	
Rationale / Why this requirement	It is necessary to prove the accuracy rates in order to establish ATCOs confidence to the system. As already stated in the requirement (Rationale) the error rate is also an important factor in ATCO confidence of the system.	
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-25
	NATS	Status: Accepted 2020-09-11
RQ for (Who has to implement RQ)?	DLR	Status: Accepted 2020-10-08
	BUT	Status: Accepted 2021-06-04
	Idiap	Status: Accepted 2021-06-04
Category	Non FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information	Implemented and accepted.	
History	2020-07-02	T. Simiganoschi	First Version
	2020-08-25	H. Pálsson	Review

	2020-09-11	J. Harfmann	Consistency review

6.1.3 PER-REC-012

Identifier	PER-REC-012	
Title	Recognition recall for readback recognition in operation	
Requirement	THE SYSTEM SHALL deliver the performance of at least 50% recall (some of the readback can be ignored but at least 50% will be recognized) for readback recognition in operation. The SYSTEM SHALL minimize the error rate for readback recognition. Recognition accuracy rate should also be measured with evaluation sets.	
Rationale / Why this requirement	It is necessary to prove the accuracy rates in order to establish ATCOs confidence to the system. As already stated in the requirement (Rationale) the error rate is also an important factor in ATCO confidence of the system.	
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-25
	NATS	Status: Accepted 2020-09-11
RQ for (Who has to implement RQ)?	DLR not relevant for ontology-based prototype	Status: Accepted 2020-10-08
	BUT relevant for signal base prototype	Status: Accepted 2021-06-04
	Idiap	Status: Accepted 2021-06-04
Category	Non FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information	This was implemented but due to the lack of readback errors used for training and discovered this could not be assessed properly.	
History	2020-07-02	T. Simiganoschi	First Version
	2020-08-25	H. Pálsson	Review
	2020-09-11	J. Harfmann	Consistency review

	2020-10-08	H. Helmke	Changed to accepted by DLR and reason for RQ for detailed

6.1.4 PER-REC-020

Identifier	PER-REC-020	
Title	Command recognition error rate in operation.	
Requirement	THE SYSTEM SHALL deliver the performance of not higher than 5% command recognition error rate in operation for ATCO and Pilot. Recognition error rate should also be measured with evaluation sets.	
Rationale / Why this requirement	It is necessary to prove the command recognition error rate in order to establish ATCOs confidence to the system.	
RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2020-08-25
	NATS	Status: Accepted 2020-09-11
RQ for (Who has to implement RQ)?	DLR	Status: Accepted 2020-10-08
	BUT	Status: Accepted 2021-06-04
	Idiap	Status: Accepted 2021-06-04
Category	Non FR	
Test Method / Acceptance Criteria	Demonstration	
Conflicts		
Additional Information		
History	2020-07-02	T. Simiganoschi	First Version
	2020-08-25	H. Pálsson	Review
	2020-09-11	J. Harfmann	Consistency review
	2020-10-08	H. Helmke	Status of DLR changed to accepted

6.1.5 PER-REC-021

Identifier	PER-REC-021
Title	Call sign recognition error rate in operation
Requirement	THE SYSTEM SHALL deliver the performance of not higher than 1% call sign recognition error rate in operation for ATCO and Pilot. Recognition error rate should also be measured with evaluation sets.
Rationale / Why this requirement	It is necessary to prove the command recognition error rate in order to establish ATCOs confidence to the system.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-25 NATS — Status: Accepted 2020-09-11
RQ for (Who has to implement RQ)?	DLR — Status: Accepted 2020-10-08 BUT — Status: Accepted 2021-06-04 Idiap — Status: Accepted 2021-06-04
Priority	SHALL
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	None
Additional Information	Implemented and accepted.

History			
	2020-07-02	T. Simiganoschi	First Version
	2020-08-25	H. Pálsson	Review
	2020-09-11	J. Harfmann	Consistency review
	2020-10-08	H. Helmke	Status of DLR changed to Accepted

6.1.6 PER-REC-022

Identifier	PER-REC-022
Title	Readback error false discovery rate in operation.
Requirement	THE SYSTEM SHALL deliver the performance corresponding to the rate of at least 1 real readback error in 8 indicated potential ones.

	The rate should be measured with evaluation sets.
Rationale / Why this requirement	It is necessary to prove the Readback Error discovery rate in order to establish ATCOs confidence to the system.
RQ from (Who benefits)?	Isavia ANS — Status: Accepted 2020-08-25 NATS — Status: Accepted 2020-09-11
RQ for (Who has to implement RQ)?	DLR — Status: Accepted 2020-10-08 BUT — Status: Accepted 2021-06-23 Idiap — Status: Accepted 2021-06-23
Priority	SHALL
Category	Non FR
Test Method / Acceptance Criteria	Demonstration
Conflicts	None
Additional Information	This was implemented but due to the lack of readback errors used for training and discovered this could not be assessed properly.
History	2020-07-02 — T. Simiganoschi — First Version 2020-08-25 — H. Pálsson — Review 2020-09-11 — J. Harfmann — Consistency review 2020-10-08 — H. Helmke — DLR status changed to accepted

6.2 System Maintenance and Monitoring Interface (MMI)

6.2.1 SYS-MMI-055

Identifier	SYS-MMI-055
Title	Readback error candidate checking
Requirement	THE SYSTEM MMI SHALL support the checking of ATCo and pilot utterance sequences with emphasis on verifying readback error detection performance.
Rationale / Why this requirement	Audio recordings will be used to evaluate THE SYSTEM's performance during validation of readback error detection performance and testing.

RQ from (Who benefits)?	Isavia ANS	Status: Accepted 2021-06-20
RQ for (Who has to implement RQ)?	DLR	Status: Checking 2021-06-20
Priority	SHALL	
Category	Non- FR	
Test Method / Acceptance Criteria	Demonstration via CoCoLoToCoCo	
Conflicts	This is just a suggestion of DLR. Implementation effort needs to be checked.	

Additional Information	CoCoLoToCoCo enables a replay of each wave utterances (in the order they are given/recorded), provided the utterances are splitted and the file naming conventions YYYY-MM-DD__HH_MM_SS_MS.wav are followed.
	
	The (offline) Readback Error detection function classifies for each wave file, whether it is the start of an ATCo-pilot conversation, the second utterance, the third etc.
	
	Furthermore, each utterance gets a classification whether the ATCo-pilot dialog is in one for the following states, after this utterance.[3]
	
	`READBACK_OK,`
	`READBACK_ERROR,`
	`CORRECTED_READBACK,`
	`MISSING_READBACK,`
	`EXPECTING_READBACK,`
	`EXPECT_REQUEST_ANSWER,`
	`PILOT_REPORTING`
	
	An excel file contains this information, with a new row for each extracted command of an utterances, e.g. utterance containing e.g. five commands is split into five rows in the excel file.
	
	CoCoLoToCoCo contains (under implementation) a functionality to load the excel file and visualize the information. [4]
	
	It will be possible to navigate only through the utterances, which belong to this special ATCO-pilot dialog. A dialog consists normally of
	
	• ATCo command, pilot correct readback	

[3] The is the current status of the implementation (June 2021). It is expected that further states follow.

[4] Default implementation of CoCoLoToCoCo is that it shows the gold (the correct and manual checked) transcriptions and annotations. In this special mode, it shows the recognized word sequences and annotations, which sometimes are different from the really said utterance, due to not achieving 100% of word recognition and command extraction.

	• ATCo command, wrong pilot readback, ATCo correction, pilot's correct readback • Pilot reporting (in initial call), ATCo command, pilot readback (with above subcases) • Pilot request, ATCo command, Pilot readback readback (with above subcases) More subcases split over more files are however possible and are the interesting ones. CoCoLoToCoCo also contains a functionality that only the files, which are involved in a readback error, are shown, so that experts can concentrate on those cases, with the possibility to correct the output of the speech recognizer (normal CoCoLoToCoCo functionality). Implemented and accepted.
History	2021-06-20 | H. Helmke | First Version, as an update of SYS-MMI-050 | |

6.3 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.

6.4 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.

7 Machine Learning/Offline Training Requirements

7.1 Requirements for Voice-To-Text

7.1.1 SYS-V2TML-010

Identifier	SYS-V2TML-010
Title	Minimum data for learning/offline training
Requirement	Each ANSP SHALL provide at least 720 hours of recordings with silence (approx. 1 month) of real communication between ATCO and pilots. The recordings SHOULD be delivered in the agreed format (8 kHz WAV files, filenames indicating the date/time and airport/segment covered), together with surveillance data related to the same time and place.
Rationale / Why this requirement	Although not all the recordings provided will be manually transcribed, the development of the ABSR will benefit from the significant data and will use it also for estimating the frequency of rare events (such as significant read-back errors).
RQ from (Who benefits)?	BUT: Status: Accepted 2020-07-24 Idiap: Status: Accepted 2020-07-26 DLR: Status: Accepted 2020-08-29
RQ for (Who has to implement RQ)?	Isavia must provide the recordings and the surveillance data: Status: Accepted 2020-08-28 NATS must provide the recordings and the surveillance data: Status: Accepted 2020-09-18
Category	NFR
Test Method / Acceptance Criteria	Offline counting the amount of data
Conflicts	The requirement needs to be discussed again in the light of COVID-19 pandemic because amount of voice data is less than expected. It was not fully achieved, but the data used was more than sufficient to achieve the needed performance.
Additional Information	As also the surveillance data is included it is clear that the voice data including silence is counted. Section 1.3 Q1 of HAAWAII proposal states: “For example in case of Isavia enroute airspace, more than 4,000 hours of controller pilot communication (speech only

	segments) were produced in 2018. For London TMA we have on average 14,000 hours of silence reduced voice data. For Prague TMA we could expect 2'500 hours of ATCos speech and for Vienna 5'000 hours. Unfortunately, the manual transcriptions of the communications are very costly.
History	

2020-07-24	P. Smrz (BUT)	First Version
2020-07-28	H. Helmke (DLR)	Clarification that the recordings include silence
2020-08-21	P. Smrz (BUT)	Split the recordings and the transcription (next requirements)
2020-08-28	H. Pálsson	Tile change and review
2020-08-29	H. Helmke	Making one month more precise
2020-09-22	T. Simiganoschi	Changed to one month of data not 10.000 hours of recordings.
2020-09-30	P. Motlicek	checked
2021-05-24	H. Helmke	Added conflict

7.1.2 SYS-V2TML-020

Identifier	SYS-V2TML-020
Title	Manual transcription and checks for training
Requirement	Manual transcription and checks of automatically segmented (and preliminary transcribed) speech of at least 10 hours per partner (Isavia/NATS) of silence-reduced controller-pilot communication SHALL be provided for initial model training.
Rationale / Why this requirement	The accuracy of the speech transcribed by the developed ABSR and all modules using its output critically depends on the domain- and task-specific training data that will be used to adapt general speech recognition models. The machine-learning techniques need the transcribed (and annotated) data for training purposes. A part of the transcribed data will be also held out as the development and final testing/evaluation datasets. Recordings provided by Isavia and NATS will be automatically segmented, preliminary transcribed by existing general speech recognition models, and prepared for manual checks and transcriptions by BUT and Idiap.
RQ from (Who benefits)?	

BUT	Status: Accepted 2020-08-21
Idiap	Status: Accepted 2020-08-21

	DLR for pre-training of Command Extraction	Status: Accepted 2020-08-29
RQ for (Who has to implement RQ)?	Isavia must provide the transcripts for Isavia airspace	Status: Accepted 2020-08-28
	NATS must provide the transcripts for London TMA	Status: Accepted 2020-09-18
	ACG must provide the transcripts for London TMA and Isavia airspace	Status: Accepted 2021-06-02
Category	FR	
Test Method / Acceptance Criteria	Offline counting the amount of data.	
Conflicts		
Additional Information	The manual transcription always includes the information whether the utterance corresponds to the pilot or the ATCO and whether it contains a readback error (very seldom).	

History	2020-08-21	P. Smrz (BUT)	First Version
	2020-08-29	H. Helmke	Clarification in "RQ for" and that data is used for training; changed to SHALL

7.1.3 SYS-V2TML-025

Identifier	SYS-V2TML-025	
Title	Manual transcription and checks for evaluation	
Requirement	Manual transcription and checks of automatically segmented (and preliminary transcribed) speech of at least five hours per partner (Isavia/NATS) of silence-reduced controller-pilot communication SHALL be provided for evaluation purpose for WP5. In addition, the corresponding surveillance data is needed.	
Rationale / Why this requirement	Validation data must be separated from training data.	
RQ from (Who benefits)?	BUT	Status: Accepted 2020-09-27
	Idiap	Status: Accepted 2020-09-28
	DLR for evaluation of Command Extraction and Command prediction	Status: Accepted 2020-08-29

RQ for (Who has to implement RQ)?	Isavia must provide the transcripts for Isavia airspace	Status: Accepted 2020-09-17
	NATS must provide the transcripts for London TMA	Status: Accepted 2020-09-18
	ACG must provide the transcripts for London TMA and Isavia airspace	Status: Accepted 2020-06-02
Priority	SHALL	
Category	FR	
Test Method / Acceptance Criteria	Offline counting the amount of data	
Conflicts		
Additional Information	The manual transcription always includes the information whether the utterance corresponds to the pilot or the ATCO and whether it contains a readback error (very seldom).	

History			
	2020-08-21	P. Smrz (BUT)	First Version
	2020-08-29	H. Helmke	Clarification in "RQ for" and that data is used for training

7.1.4 SYS-V2TML-030

Identifier	SYS-V2TML-030	
Title	Manual checks of automatically annotated communication	
Requirement	Manual checks of automatically annotated communication (call signs, the structure of commands…) SHALL be provided for five hours for NATS and Isavia ANS transcriptions.	
Rationale / Why this requirement	To be able to train the command prediction model for NATS approach and Isavia enroute, DLR needs correct call-sign and commands annotation from the real recorded data. The same applies for implementation of the command extraction block. Transcribed speech data will be passed to DLR's CoCoLoToCoCo tool, preliminary annotated, and presented for manual checks. Isavia ANS and NATS will also verify the annotation.	
RQ from (Who benefits)?	DLR	Status: Accepted 2020-08-29
RQ for (Who has to implement RQ)?	Isavia must provide the manual validations of the commands	Status: Accepted 2020-09-17

	NATS must provide the manual validations of the commands	Status: Accepted 2020-09-18
Priority	SHALL	
Category	FR	
Test Method / Acceptance Criteria	Offline counting the amount of data	
Conflicts	None	
Additional Information	The manual annotation always includes the information whether the utterance corresponds to the pilot or the ATCO and whether it contains a readback error (very seldom).	

History			
	2020-08-21	P. Smrz (BUT)	First Version
	2020-08-29	H. Helmke	Changed from SHOULD to SHALL
	2020-10-08	H. Helmke	Status Unknown for DLR changed to Accepted

7.1.5 SYS-V2TML-035

Identifier	SYS-V2TML-025	
Title	Manual checking of automatic annotations for evaluation	
Requirement	The evaluation data of SYS-V2TML-025 SHALL also be manually annotated	
Rationale / Why this requirement	Validation data must be separated from training data.	
RQ from (Who benefits)?	DLR for evaluation of Command Extraction and Command prediction	Status: Accepted 2020-08-29
RQ for (Who has to implement RQ)?	Isavia must provide the transcripts for Isavia airspace	Status: Accepted 2020-09-17
	NATS must provide the transcripts for London TMA	Status: Accepted 2020-09-18
Category	FR	
Test Method / Acceptance Criteria	Offline counting the amount of data	
Conflicts	None	

Additional Information	The manual annotation always includes the information whether the utterance corresponds to the pilot or the ATCO and whether it contains a readback error (very seldom).		
History	2020-08-29	H. Helmke	First Version

7.2 Requirements for Text-To-ATC-Concept Transformation

7.2.1 SYS-T2C-009

Identifier	SYS-T2C-009		
Title	Annotation focus on new phraseology		
Requirement	The automatic annotation SHALL highlight interesting and new cases during the annotation process to focus the effort on new phraseology and command type instead of repeating annotation of the same phraseology and command types.		
Rationale / Why this requirement	ATCOs and pilots sometimes stick to standard phraseology and sometimes not. In order also to recognize common deviations and especially to automatically learn them from transcription/annotation examples, they must be in the learning data and they must be correct if the expected performance requirements should be achieved. This requirement helps the project to find enough cases of deviations from standard phraseology and command types.		
RQ from (Who benefits?):	Isavia	Status: Accepted 2020-08-31	
	NATS	Status: Accepted 2020-09-18	
RQ for (Who has to implement RQ?):	DLR	Status: Accepted 2020-10-08	
	BUT	Status: Accepted 2021-06-23	
Priority	SHALL		
Category	NFR		
Test Method / Acceptance Criteria	Offline and demonstration		
Conflicts			
Additional Information	This was partly implemented in CoCoLoToCoCo.		
History	2020-07-28	H. Pálsson (Isavia)	First Version

	2020-10-08	H. Helmke	Status of DLR changed from Unkn

7.2.2 SYS-T2C-010

Identifier	SYS-T2C-010
Title	Enough manually checked annotations per command type
Requirement	a) The ANSPs SHOULD provide for each command type of the ATCO from Isavia, which should be recognized, at least 10 manually transcribed and annotated utterances, if the expected performance requirements should be achieved. b) As a), but for pilots entering Isavia airspace c) As a), but for NATS ATCOs responsible for London TMA d) As b), but for pilots entering London TMA CLEARED ILS is a different command type than CLEARED RNAV, i.e. the main type and the second type of the type of the ontology are important.
Rationale / Why this requirement	ATCOs and pilots sometimes stick to standard phraseology and sometimes not. In order also to recognize common deviations and especially to automatically learn them from transcription/annotation examples, they must be in the learning data and they must be correct; therefore, the requirement for manually checked annotations.
RQ from (Who benefits?):	DLR implements the automatic learning — Status: Accepted 2020-07-28
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings — Status: Accepted 2020-08-31 NATS must provide the voice recordings — Status: Accepted 2020-09-18 Others (ANSPs have to provide the transcriptions, BUT, Idiap have to support the manual transcription via good automatic transcription support, DLR has to provide the annotations) — Status: Accepted 2020-07-28 (DLR) Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-07-28 (Idiap) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2021-06-02 (ACG)
Category	NFR
Test Method / Acceptance Criteria	Offline and demonstration
Conflicts	
Additional Information	If less than 10 utterances can be provided, the risk is higher than only the standard phraseology is modelled and recognized, but it does not mean these command types are not recognized at all.

	See SYS-T2C-009 supported annotation should figure out interesting test cases, to that no time is wasted during the second phase of annotations with ever and ever the same phraseology and command types.
History	2020-07-28 | H. Helmke (DLR) | First Version 2020-08-30 | H. Helmke (DLR) | Reformulated so that Isavia has a chance to accept, changed to SHOULD 2020-08-31 | H. Pálsson | Small correction in the Additional Information text.

7.2.3 SYS-T2C-020

Identifier	SYS-T2C-020
Title	Enough manually checked annotations for phraseology deviations
Requirement	a) The ANSPs SHOULD provide for each phraseology deviation and each command type of the ATCO from Isavia, which should be recognized, at least 5 manually transcribed and annotated utterances. b) As a), but for pilots entering Isavia airspace c) As a), but for NATS ATCOs responsible for London TMA d) As b), but for pilots entering London TMA CLEARED ILS is a different command type than CLEARED RNAV, i.e. the main type and the second type of the type of the ontology are important.
Rationale / Why this requirement	ATCOs and pilots sometimes stick to standard phraseology and sometimes not. In order also to recognize common deviations and especially to automatically learn them from transcription/annotation examples, they must be in the learning data and they must be correct; therefore, the requirement for manually checked annotations.
RQ from (Who benefits?):	DLR implements the automatic learning | Status: Accepted 2020-07-28
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings | Status: Accepted 2020-08-31 NATS must provide the voice recordings | Status: Accepted 2020-09-18 Others (ANSPs have to provide the transcriptions, BUT, Idiap have to support the manual transcription via good automatic transcription support, DLR has to provide the annotations) | Status: Accepted 2020-07-28 (DLR) Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-08-31 (Idiap) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2021-06-02 (ACG)
Category	NFR

Test Method / Acceptance Criteria	Offline and demonstration
Conflicts	
Additional Information	For the command NO_SPEED_RESTRICTION the following phraseology was observed: • free speed • no speed restrictions • no speed restriction • no speed limit • no speed limits • own speed • reduction is up to you • speed up to you • speed is up to you • speed your convenience • speed at your convenience • speed is yours To be on the safe side, each of these phraseologies should be observed at least 5 times in combination with the command type NO_SPEED_RESTRICTIONS. The good news is that from other application areas already a lot of tests cases exist, but for phraseology deviation, which are local for NATS or Isavia, five new examples are needed. "no speed" was also observed for NO_SPEED_RESTRICTIONS, but "no speed" also occurs in the context of "no sir you are wrong speed is two five zero knots", i.e. ATCO says "no speed two five zero". This is only seldom observed in the context of NO_SPEED_RESTRICTIONS and should therefore not be recognized. Therefore, at least five positive examples are required. If less than 5 utterances can be provided, the risk is higher than only the standard phraseology is modelled and recognized, but it does not mean these command types are not recognized at all. See SYS-T2C-009
History	2020-07-28 | H. Helmke (DLR) | First Version 2020-08-30 | H. Helmke (DLR) | Changed from SHALL to SHOULD

7.2.4 SYS-T2C-030

Identifier	SYS-T2C-030
Title	Enough manually checked annotations for ATC concept
Requirement	a) The ANSPs SHOULD provide for each Isavia ATC concept, with "non standard wording" at least five transcription / annotation pairs for Isavia airspace b) As a), but for NATS ATCOs responsible for London TMA

	ATC concepts are waypoints names, runway names, holding names, runway names, frequency values, frequency positions etc.
Rationale / Why this requirement	The phraseology “whiskey whiskey four one eight” for the waypoint “WW418” is standard wording. So in this five examples are not required. The same applies for the waypoint “GUNPA” if spoken as “gunpa” or as “golf uniform november papa alfa”, but if the word “cheb” is used for the waypoint “OKG”, then the five examples are needed. The same applies for the frequency value “119.800”, if the word sequence “nineteen eight” or “nineteen eight hundred” is used.
RQ from (Who benefits?):	DLR implements the automatic learning — Status: Accepted 2020-07-28
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings — Status: Accepted 2020-08-31 NATS must provide the voice recordings — Status: Accepted 2020-09-18 Others (ANSPs have to provide the transcriptions, BUT, Idiap have to support the manual transcription via good automatic transcription support, DLR has to provide the annotations) — Status: Accepted 2020-07-28 (DLR) Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2020-06-02 (ACG)
Category	NFR
Test Method / Acceptance Criteria	Offline and demonstration
Conflicts	
Additional Information	See SYS-T2C-009
History	2020-07-28 — H. Helmke (DLR) — First Version 2020-08-30 — H. Helmke (DLR) — Changed from SHALL to SHOULD

7.2.5 SYS-T2C-040

Identifier	SYS-T2C-040
Title	Enough manually checked annotations for airline designators.
Requirement	a) The ANSPs SHOULD provide for each telephony code used by the Isavia operator for three letter code of the callsign at least five examples if the used telephony code deviates from the standard published in ICAO documents. b) As a), but for NATS ATCOs responsible for London TMA “lufthansa” and “speedbird” are telephony codes. The three letter codes are here “DLH” and “BWABAW”.

Rationale / Why this requirement	Phraseology deviations can only be learned if enough examples are available. Examples are: "german airforce", "german_airforce", "german government" for GAF. The official spelling is here “german air force”. Another example is JEI with the official telephony code “jet executive”, but , "executive" and "jet_executive" are also used.
RQ from (Who benefits?):	DLR implements the automatic learning — Status: Accepted 2020-07-28
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings — Status: Accept 2020-08-31 NATS must provide the voice recordings — Status: Accepted 2020-09-18 Others (ANSPs have to provide the transcriptions, BUT, Idiap have to support the manual transcription via good automatic transcription support, DLR has to provide the annotations) — Status: Accepted 2020-07-28 (DLR) Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2021-06-02 (ACG)
Category	NFR
Test Method / Acceptance Criteria	Offline and demonstration
Conflicts	
Additional Information	“german air force”, german airforce", and "german_airforce” should not be a problem of the text-to-concept building block, but the output of the manual transcriptions and the Voice-to-Text block should take care of this, as specified in D3-1 [2], if telephony codes for the same three letter code only deviate by blanks or underscores. “german airforce” is preferred for GAF. See SYS-T2C-009
History	2020-07-28 — H. Helmke (DLR) — First Version 2020-08-30 — H. Helmke (DLR) — Changed from SHALL to SHOULD

7.2.6 SYS-T2C-050

Identifier	SYS-T2C-050
Title	Enough manually checked annotations for commands with units
Requirement	a) The ANSPs SHOULD provide for each command type used by Isavia that can have a ‘unit’, at least five examples of the command with and without the unit specified in the utterance. b) As a), but for NATS ATCOs responsible for London TMA

Rationale / Why this requirement	Altitude values can be given either in “feet” or in “flight level”. Sometimes, no unit is specified (Eg: “climb three five zero”). There must be at least 5 examples of commands with each of the possible units and with no unit specified.
RQ from (Who benefits?):	DLR implements automatic annotation — Status: Accepted 2020-07-29
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings — Status: Accepted 2020-08-31 NATS must provide the voice recordings — Status: Accepted 2020-09-18 Others (ANSPs have to provide the transcriptions, BUT, Idiap have to support the manual transcription via good automatic transcription support, DLR has to provide the annotations) — Status: Accepted 2020-07-29 (DLR) Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2021-06-02 (ACG)
Category	NFR
Test Method / Acceptance Criteria	Offline and demonstration
Conflicts	
Additional Information	See SYS-T2C-009
History	2020-07-29 — S. Shetty (DLR) — First Version 2020-08-30 — H. Helmke (DLR) — Changed from SHALL to SHOULD

7.2.7 SYS-T2C-060

Identifier	SYS-T2C-060
Title	Enough manually checked annotations for commands with qualifiers.
Requirement	a) The ANSPs SHOULD provide for each command type used by Isavia that can have a ‘qualifier’, at least five examples of the command with each of the possible qualifiers and without the qualifier specified in the utterance. b) As a), but for NATS ATCOs responsible for London TMA
Rationale / Why this requirement	DIRECT_TO commands are associated with a direction qualifier with values “LEFT”, “RIGHT” and “none” (when no direction is specified). There must be at least 5 examples of commands with each of the possible qualifiers and with no qualifier specified.
RQ from (Who benefits?):	DLR implements automatic annotation — Status: Accepted 2020-07-29

RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings	Status: Accepted 2020-08-31
	NATS must provide the voice recordings	Status: Accepted 2020-09-18
	Others (ANSPs have to provide the transcriptions, BUT, Idiap have to support the manual transcription via good automatic transcription support, DLR has to provide the annotations)	Status: Accepted 2020-07-29 (DLR) Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2021-06-02 (ACG)
Category	NFR	
Test Method / Acceptance Criteria	Offline and demonstration	
Conflicts		
Additional Information	See SYS-T2C-009	
History	2020-07-29	S. Shetty (DLR)	First Version
	2020-08-30	H. Helmke (DLR)	Changed from SHALL to SHOULD

7.2.8 SYS-T2C-070

Identifier	SYS-T2C-070	
Title	Enough manually checked annotations for commands with conditions.	
Requirement	a) The ANSPs SHOULD provide for each command type used by Isavia that can have a 'condition', at least five examples of the command with each of the possible conditions and without the condition specified in the utterance. b) As a), but for NATS ATCOs responsible for London TMA	
Rationale / Why this requirement	CONTACT commands may sometimes be associated with a condition, eg. AFTER AIRBORNE, etc. There must be at least 5 examples of commands with each of the possible conditions and with no condition specified.	
RQ from (Who benefits?):	DLR implements automatic annotation	Status: Accepted 2020-07-29
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings	Status: Accepted 2020-08-31
	NATS must provide the voice recordings	Status: Accepted 2020-09-18
	Others (ANSPs have to provide the transcriptions, BUT, Idiap have to support the manual transcription via good automatic transcription support, DLR has to provide the annotations	Status: Accepted 2020-07-29 (DLR) Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2021-06-02 (ACG)

Category	NFR		
Test Method / Acceptance Criteria	Offline and demonstration		
Conflicts			
Additional Information	See SYS-T2C-009		
History	2020-07-29	S. Shetty (DLR)	First Version
	2020-08-30	H. Helmke (DLR)	Changed from SHALL to SHOULD

7.3 Requirements for Command Prediction Model

7.3.1 SYS-CPM-010

Identifier	SYS-CPM-010	
Title	Exact mapping of voice utterance to surveillance data	
Requirement	The ANSP SHALL provide accurate time stamps, so that a mapping of the start of a voice utterance to the corresponding surveillance data is possible with an accuracy of least 5 seconds. The requirement applies for historic data used for model training (learning) and also for data provided during online demonstrations.	
Rationale / Why this requirement	Assistant Based Speech Recognition requires that the commands, which are possible in the current situation, are predicted. The used surveillance data must match to the current situation. Otherwise, the prediction is relevant for the situation of e.g. one minute ago, but not for the current situation.	
RQ from (Who benefits?):	DLR implements the automatic learning and command prediction	Status: Accepted 2020-07-28
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings and surveillance data	Status: Accepted 2020-08-27 (Isavia will just provide timestamped data)
	NATS must provide the voice recordings and surveillance data	Status: Accepted 2020-08-14
	Others (ANSPs, BUT, Idiap have to keep the timestamp information in the filenames, when splitting is performed)	Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-08-14 (NATS) Status: Accepted 2020-08-27 (Isavia) Status: Accepted 2021-06-02 (ACG)
Priority	Shall	
Category	NFR	

Test Method / Acceptance Criteria	Offline and demonstration		
Conflicts			
Additional Information	Currently the idea is that the filename convention of e.g. 2020-03-12__06-45-00-86 is used for the wav files. The corresponding timetick as key to the corresponding surveillance data can be calculated directly.		
History	2020-07-28	H. Helmke (DLR)	First Version

7.3.2 SYS-CPM-020

Identifier	SYS-CPM-020	
Title	Enough Training data for each command type	
Requirement	The ANSP SHOULD provide more than 50 examples for each command type, which needs to be predicted and also for each recording configuration. The examples could be within manual or automatic annotations. The output of the training shall highlight missing examples for each command type.	
Rationale / Why this requirement	Automatic learning requires examples (data) in the training set. 50 examples are needed for the ATCO, if the ATCO takes the initiative and the pilot just performs the read back. 50 examples are, however, needed for the pilots, if the initiative comes from pilot (CHECK, REQUEST, REPORT). Command types are: CLIMB, DESCEND; INFORMATION QNH, INFORMATION ATIS etc.. Recording configuration are the current runway configuration, the responsible area (one sector, two sector, splitted sector, one minor airport, …). The training examples do not need to result from manual annotation, but just need to be in the “more than 1000 hours”.	
RQ from (Who benefits?):	DLR implements the automatic learning and command prediction	Status: Accepted 2020-07-28
RQ for (Who has to implement RQ?):	Isavia must provide the voice recordings and surveillance data	Status: Accepted 2020-08-31
	NATS must provide the voice recordings and surveillance data	Status: Accepted 2020-09-18
	Others (ANSPs provide manual transcription as input for automatic/manual annotations, BUT/Idiap provide automatic transcriptions)	Status: Accepted 2020-08-21 (BUT) Status: Accepted 2020-09-18 (NATS) Status: Accepted 2020-08-31 (Isavia) Status: Accepted 2021-06-02 (ACG)

Priority	SHOULD
Category	NFR
Test Method / Acceptance Criteria	Offline and demonstration
Conflicts	
Additional Information	
History	2020-07-28 | H. Helmke (DLR) | First Version 2020-08-30 | H. Helmke | Clarification, that automatic annotation is enough 2020-08-31 | H. Pálsson | Changed from SHALL to SHOULD and added to requirement text.

7.3.3 SYS-CPM-030

Identifier	SYS-CPM-030
Title	Good Quality with respect to command recognition rate
Requirement	The automatic transcription and the following automatic annotation SHALL provide a command recognition error of at least 70% for ATCO and pilot commands. The quality is only needed for commands, when the initiative comes from the ATCO (for ATCO commands) resp. from the pilot.
Rationale / Why this requirement	Automatic learning requires correct examples (data). If the recognition rate is lower, not filtering of false recognition will be possible or will result in too few data elements.
RQ from (Who benefits?):	DLR implements the automatic learning and command prediction | Status: Accepted 2020-07-28
RQ for (Who has to implement RQ?):	BUT must provide the automatic transcriptions for pilot commands | Status: Accepted 2020-08-21 Idiap must provide the automatic transcriptions for ATCO commands | Status: Unknown 2020-xx-yy
Priority	Shall
Category	NFR
Test Method / Acceptance Criteria	Offline and demonstration

Conflicts	The requirement will be discussed with Idiap in the next version of this document, so that Unknown status can be detailed		
Additional Information			
History	2020-07-28	H. Helmke (DLR)	First Version

7.4 Requirements for Readback Error Detection Application

7.4.1 SYS-RBEML-010

Identifier	SYS-RBEML-010	
Title	Training data set for read-back errors	
Requirement	At least 25 cases of read-back errors SHALL be identified from each ANSP in the transcribed and annotated data and it should be used for the development and the evaluation of the data-driven readback error detection. The types of the errors should be annotated and classified according to severity of the errors, as described in the concept specification documents.	
Rationale / Why this requirement	The data-driven readback error detection depends on the machine learning model built on the provided data. It is expected that the system will be partially trained on the data augmented by automatic generation processes but real cases of readback errors need to be used for evaluation and the extraction of statistics used in the augmentation processes. The ANSPs cannot guarantee readback errors in data from live traffic, as ANSPs are only exporting one month of data 25 cases for each ANSP is even difficult to reach.	
RQ from (Who benefits)?	BUT	Status: Accepted 2020-07-24
	Idiap	Status: Accepted 2020-07-27
RQ for (Who has to implement RQ)?	Isavia must identify the cases of real readback errors	Status: Accepted 2020-08-28
	NATS must identify the cases of real readback errors	Status: Accepted 2020-09-18
	DLR should check that all the error type annotations correspond to the ontology used in T4.1	Status: Accepted 2020-07-28
Priority	SHALL	
Category	FR	

Test Method / Acceptance Criteria	Offline and demonstration
Conflicts	
Additional Information	The challenge is here to automatically detect the interesting test cases. Only two percent of the utterances contain read back errors. This would mean that at least 200,000 test cases would need to be manually annotated. The challenge is that from the huge amount of recordings interesting candidates are pre-selected, so that in the best case only less than 3,000 test cases need to be checked.
History	2020-07-24 | Pavel | First Version 2020-08-31 | H. Helmke | Additional Information added 2020-09-23 | T. Simiganoschi | Modified from 1000 to 25. 2020-09-30 | P. Motlicek | checked

8 References

The documents listed below become part of this System Requirements to the extent referenced herein:

8.1 References related to the HAAWAII project (e.g. deliverables)

[1] Hörður Arilíusson, Hartmut Helmke et al.: HAAWAII project: D1-1 Operational Concept Document; version 1.0, July 2020

[2] Shruthi SHETTY, Hartmut HELMKE, Oliver OHNEISER, Frantisek GREZL et al.: HAAWAII project: D3-1: Transcription and Annotation Handbook - CoCoLoToCoCo, version 0.07. 21 July, 2020.

[3] SESAR Joint Undertaking & DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV (DLR), VYSOKE UCENI TECHNICKE V BRNE (BUT), FONDATION DE L'INSTITUT DE RECHERCHE IDIAP (IDIAP), AUSTRO CONTROL OSTERREICHISCHE GESELLSCHAFT FUR ZIVILLUFTFAHRT MBH (AUSTRO CONTROL), ISAVIA ANS EHF (ISAVIA), NATS (EN ROUTE) PUBLIC LIMITED COMPANY (NATS), CROATIA CONTROL, CROATIAN AIR NAVIGATION SERVICES LTD (CCL), Grant Agreement number: 884287 — HAAWAII - H2020-SESAR-2020-2

[4] Hartmut Helmke et al.: HAAWAII project: D7-1 Project Management Plan; version 0.96, July 2020

8.2 References, which are not directly related to HAAWAII project deliverables

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

[6] M. Kleinert, H. Helmke, S. Moos, P. Hlousek, C. Windisch, O. Ohneiser, H. Ehr, and A. Labreuil, “Reducing Controller Workload by Automatic Speech Recognition Assisted Radar Label Maintenance,” 9th SESAR Innovation Days, Athens, Greece, 2019.

[7] https://flightsafety.org/asw-article/failure-to-communicate/ - Pilot controller communication loop Figure 1 (Source: Flight Safety Foundation Approach-and-Landing Accident Reduction (ALAR) Task Force)

Appendix A Command Types

The ATCO and Pilot are using standard ICAO phraseology to communicate on the Air Ground frequencies. Most of the ICAO phrases where transformed into ontology commands to have a structured way of transforming and presenting the ATCO and Pilot phraseology. The columns from the ontology command figures below that are extracted from the XLS ontology document are splitting the ATCO and Pilot sentences into Command-Name, 2nd part of the cmd, value, Unit and QUALIFIER. The column named RB indicates on what Command-Name the Pilot readback is mandatory.

NATS and Isavia ANS have filled out the importance level of command recognition and the relevance for readbacks in the following columns:

- Isavia: indicates the importance of recognition and the relevance for Readback Error Detection by Isavia.
- NATS RB: indicates the importance of recognition and the relevance for Readback Error Detection by NATS.
- NATS HP: indicates the importance of recognition for Human Performance calculation by NATS.

The column indicating the importance of recognition and the relevance of readbacks under Isavia and NATS column have the following meanings:

RB	must be recognized and important for readback
Rb	must be recognized, but less important for readback
rB	should be recognized, important for readback
nice	should be recognized, less important for readback
y	must be recognized, but not readback necessary
n	does not occur in this area

A.1 Command Types to be modelled for Isavia Readback Error Detection Application

RB	Command-Name	2nd part of cmd	Value	Unit	QUALIFIER	Isavia
RB	CLEARED	TO	destination			nice
RB	CLEARED	VIA	SIDs /STARs			Rb
RB	CANCEL	CLEARANCE				y
RB	HOLDING		Holding-Name			y
RB	LEAVE_HOLDING		Holding-Name			y
RB	ORBIT		waypoint / none		Dir-Qualifier	y
RB	CONTACT		ATSU/none			y
RB	CONTACT_FREQUENCY		Frequency			y
RB	LEAVE_FREQUENCY		Frequency			y
RB	SQUAWK		4-digit-squawk-value, spec-squawk-values			RB
RB	CONTINUE	PRESENT_HEADING				RB
RB	DIRECT_TO		waypoint(s)		Dir-Qualifier	RB
RB	FOLLOW_ROUTE		Route-Name			RB
RB	HEADING		Head-Value-3		Dir-Qualifier	RB
RB	HEADING		RUNWAY_DIR		CROSS	RB
RB	MAINTAIN	HEADING	Heading-value			y
RB	NAVIGATION_OWN					RB
RB	TURN				Dir-Qualifier	RB
RB	TURN_BY		Head-Value-2		Dir-Qualifier	RB
	EXPECT_ROUTE		Route-Name			RB
RB	INFORMATION	QNH	qnh-value			RB
	CORRECTION					y
	DISREGARD					y
	AFFIRM					y
	NEGATIVE					y
	REPORT					y
	REPORT_NOW	Report-Now-2nd-Parameter				y
	REPORT_NOW	ALTITUDE	flight level / altitude	FL/ft/none		y
	REPORT_NOW	FLIGHT_LEVEL	flight level / altitude	FL/ft/none		y
RB	CONFIRM_ACCEPT	Approach_Type	runway			y
	REPORT_MISCELLANEOUS					nice
RB	MAINTAIN	PRESENT_SPEED			LessGr-Qualifier2	RB
RB	INCREASE		Speed-Value, none	kt/MA/none	LessGr-Qualifier	RB
RB	INCREASE_BY		Speed-Value-2	kt/MA/none	OR_GREATER	RB
RB	MAINTAIN	SPEED	Speed-Value	kt/MA/none	LessGr-Qualifier	RB
RB	NO_SPEED_RESTRICTIONS					RB
RB	REDUCE		Speed-Value, none	kt/MA/none	LessGr-Qualifier	RB
RB	REDUCE_BY		Speed-Value-2	kt/MA/none	OR_GREATER	RB
RB	RESUME_NORMAL_SPEED					RB
RB	SPEED		Speed-Value, none	kt/MA/none	LessGr-Qualifier	RB
RB	ALTITUDE		flight level / altitude	FL/ft/none	Alt-Qualifier	RB
RB	CLIMB		flight level / altitude	FL/ft/none	Alt-Qualifier	RB
RB	MAINTAIN	PRESENT_ALTITUDE			Alt-Qualifier2	RB
RB	DESCEND		flight level / altitude	FL/ft/none	Alt-Qualifier	RB
RB	MAINTAIN	ALTITUDE	flight level / altitude	FL/ft/none	Alt-Qualifier	RB
RB	STOP_ALTITUDE		flight level / altitude	FL/ft/none	Alt-Qualifier	RB
RB	STOP_CLIMB		flight level / altitude	FL/ft/none	Alt-Qualifier	RB
RB	STOP_DESCEND		flight level / altitude	FL/ft/none	Alt-Qualifier	RB
RB	RATE_OF_CLIMB		vertical_rate	ft_min, none	LessGr-Qualifier	rB
RB	RATE_OF_CLIMB	OWN, EXPEDITE, MAX				rB
RB	RATE_OF_DESCENT		vertical_rate	ft_min, none	LessGr-Qualifier	rB
RB	RATE_OF_DESCENT	OWN, EXPEDITE, MAX				rB
RB	VERTICAL_RATE		vertical_rate	ft_min, none	LessGr-Qualifier	rB
RB	VERTICAL_RATE	OWN, EXPEDITE, MAX				rB
RB	EXPEDITE_PASSING		flight level / altitude	FL/ft/none		rB

Figure 13 Command Types which need to be recognized for Readback Error Detection in Isavia Enroute Airspace (Part 1)

A.2 Command Types to be modelled for NATS Readback Error Detection and Human Performance Estimation Application

RB	Command-Name	2nd part of cmd	Value	Unit	QUALIFIER	NATS RB	NATS HP
RB	CLEARED	LOW_APPROACH	runway			RB	y
RB	CLEARED	LANDING	runway			RB	y
RB	CLEARED	Approach_Type	runway			RB	y
RB	CLEARED	MISS_APP_PROC				RB	y
RB	CONTINUE	APPROACH	runway			RB	y
RB	GO_AROUND					RB	y
RB	INTERCEPT_GLIDEPATH		runway			RB	y
RB	INTERCEPT_LOCALIZER		runway			RB	y
RB	CANCEL	LOW_APPROACH	runway			RB	y
RB	CANCEL	CLEARANCE				RB	y
RB	HOLDING		Holding-Name			RB	y
RB	LEAVE_HOLDING		Holding-Name			RB	y
RB	ORBIT		waypoint / none		Dir-Qualifier	RB	y
RB	CONTACT		ATSU/none			RB	y
RB	CONTACT_FREQUENCY		Frequency			RB	y
RB	LEAVE_FREQUENCY		Frequency			RB	y
RB	SQUAWK		4-digit-squawk-value, spec-squawk-values			RB	y
RB	CONTINUE	PRESENT_HEADING				RB	y
RB	DIRECT_TO		waypoint(s)		Dir-Qualifier	RB	y
RB	FOLLOW_ROUTE		Route-Name			RB	y
RB	HEADING		Head-Value-3		Dir-Qualifier	RB	y
RB	HEADING		RUNWAY_DIR		CROSS	RB	y
RB	MAINTAIN	HEADING	Heading-value			RB	y
RB	NAVIGATION_OWN					RB	y
RB	TRANSITION		Transition-Name			RB	y
RB	TURN				Dir-Qualifier	RB	y
RB	TURN_BY		Head-Value-2		Dir-Qualifier	RB	y
	EXPECT	Approach_Type_plus_RWY	runway			y	y
	EXPECT_ROUTE		Route-Name			y	y
	INFORMATION	Approach_Type	runway			y	y
RB	INFORMATION	WINDDIRECTION	wp-angle-value			RB	y
RB	INFORMATION	WINDSPEED	wp-speed-value	kt		RB	y
	INFORMATION	ACTIVE_RWY	runway_without_none			y	y
RB	INFORMATION	QNH	qnh-value			RB	y
RB	INFORMATION	ATIS	Alphabet-Letter			RB	y
	INFORMATION	TRAFFIC	Gnd-Acft-none			y	y
	INFORMATION	MISCELLANEOUS				y	y
	CALL_YOU_BACK					y	y
	CAUTION	WINDSHEAR	wp-speed-value	kt		y	y
	CAUTION	WAKE_TURBULANCE				y	y
	CORRECTION					y	y
	DISREGARD					y	y

Figure 14 Command Types which need to be recognized for Readback Error Detection resp. Human Performance Metric Evaluation in London TMA Airspace (Part 1)

RB	Command-Name	2nd part of cmd	Value	Unit	QUALIFIER	NATS RB	NATS HP
	AFFIRM					y	n
	NEGATIVE					y	n
	INIT_RESPONSE					y	y
	STATION		ATSU			y	y
	NO_CONCEPT					y	y
RB	VFR_CLEARANCE					RB	y
RB	ENTER_CTR	VIA	waypoint(s)			RB	y
RB	LEAVE_CTR	VIA	waypoint(s)			RB	y
RB	JOIN_TRAFFIC_CIRCUIT		runway		Dir-Qualifier	RB	y
RB	DIRECT	Approach_Leg				RB	y
	REPORT					y	y
	REPORT_NOW	Report-Now-2nd-Parameter				y	y
	REPORT_NOW	ALTITUDE	flight level / altitude	FL/ft/none		y	y
	REPORT_NOW	FLIGHT_LEVEL	flight level / altitude	FL/ft/none		y	y
RB	CONFIRM_ACCEPT	Approach_Type	runway			RB	y
	REPORT_MISCELLANEOUS					y	y
RB	MAINTAIN	PRESENT_SPEED			LessGr-Qualifier2	RB	y
RB	HIGH_SPEED_APPROVED					y	y
RB	INCREASE		Speed-Value, none	kt/MA/none	LessGr-Qualifier	RB	y
RB	INCREASE_BY		Speed-Value-2	kt/MA/none	OR_GREATER	RB	y
RB	MAINTAIN	SPEED	Speed-Value	kt/MA/none	LessGr-Qualifier	RB	y
RB	NO_SPEED_RESTRICTIONS					y	y
RB	REDUCE		Speed-Value, none	kt/MA/none	LessGr-Qualifier	RB	y
RB	REDUCE_BY		Speed-Value-2	kt/MA/none	OR_GREATER	RB	y
RB	REDUCE_FINAL_APPROACH_SPEED					RB	y
RB	REDUCE_MIN_APPROACH_SPEED					RB	y
RB	REDUCE_MIN_CLEAN_SPEED					RB	y
RB	RESUME_NORMAL_SPEED					RB	y
RB	SPEED		Speed-Value, none	kt/MA/none	LessGr-Qualifier	RB	y
RB	ALTITUDE		flight level / altitude	FL/ft/none	Alt-Qualifier	RB	y
RB	CLIMB		flight level / altitude	FL/ft/none	Alt-Qualifier	RB	y
RB	MAINTAIN	PRESENT_ALTITUDE			Alt-Qualifier2	RB	y
RB	DESCEND		flight level / altitude	FL/ft/none	Alt-Qualifier	RB	y
RB	MAINTAIN	ALTITUDE	flight level / altitude	FL/ft/none	Alt-Qualifier	RB	y
RB	STOP_ALTITUDE		flight level / altitude	FL/ft/none	Alt-Qualifier	RB	y
RB	STOP_CLIMB		flight level / altitude	FL/ft/none	Alt-Qualifier	RB	y
RB	STOP_DESCEND		flight level / altitude	FL/ft/none	Alt-Qualifier	RB	y
RB	RATE_OF_CLIMB		vertical_rate	ft_min, none	LessGr-Qualifier	RB	n
RB	RATE_OF_CLIMB	OWN, EXPEDITE, MAX				RB	n
RB	RATE_OF_DESCENT		vertical_rate	ft_min, none	LessGr-Qualifier	RB	n
RB	RATE_OF_DESCENT	OWN, EXPEDITE, MAX				RB	n
RB	VERTICAL_RATE		vertical_rate	ft_min, none	LessGr-Qualifier	RB	n
RB	VERTICAL_RATE	OWN, EXPEDITE, MAX				RB	n
RB	EXPEDITE_PASSING		flight level /	FL/ft/none		RB	n

Figure 15 Command Types which need to be recognized for Readback Error Detection resp. Human Performance Metric Evaluation in London TMA Airspace (Part 2)

Founding Members