Air-Ground Functional Architecture (AGFA Update)

Marianne Moller
AIRBUS

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1 Introduction

1.1 Purpose

The purpose of this document is to define the set of requirements for the air-ground and ground-air interoperability aspects of A-SMGCS.

It is intended for use in conjunction with other relevant EMMA documents (services description in D131u OSED Update, operational and technical requirements in D135u ORD and D142u TRD, as well as the relevant technical specifications or standards (e.g. 1090 MHz ADS-B), and the guidelines described in ED-78A/DO-264 [4] for each approval type associated with the elements of the CNS/ATM system.

1.2 Scope

This document provides the air-ground interoperability requirements standard for the implementation of the EMMA system. This document covers the full set of operational services identified within EMMA Sub-project SP1 dedicated to the operational concept (D1.3.1u OSED Update).

The Air-Ground Functional Architecture (AGFA) Update version addresses the full set of A-SMGCS services identified by EMMA and specified in the D1.3.1u OSED Update. It is built upon the D1.4.1 AGFA Initial version, delivered to the European Commission, which covers the EMMA Levels I and II as defined by EUROCONTROL.

This document represents the minimum set of interoperability requirements and allocations necessary to provide adequate assurance that the elements of the EMMA aircraft automated systems on one side and ground automated systems on the other side are compatible with each other and when operating together will perform their intended function.

This document has been developed using the EUROCAE ED-78A [4], “Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications.”

1.3 Relationships to other Documents

This Air-Ground Functional Architecture (AGFA) document is linked to the recommendations of ED-78A/DO-264. This D1.4.1 document addresses the interoperability requirements between the elements belonging on one side to the aircraft system and on the other side to the ground system, therefore it contains the high-level air-ground functional architecture for A-SMGCS.

This D1.4.1 is reused as a reference for the development of the Technical Requirement Documents (TRD) D1.4.2a and D1.4.2b that address interfaces aspects. The combination of all these documents provides the high-level interface definition of the EMMA A-SMGCS.
Figure 1-1: Context of D1.4.1u – High Level Air-Ground Functional Architecture
1.4 How to use this Document

1.4.1 Mandating and Recommendation Phrases

This document contains "shall" and "should" statements with the following meanings:

The use of the word "shall" indicates a mandated criterion, i.e. compliance with the particular procedure or specification is mandatory and no alternative may be applied.

The use of the word "should" (and phrases such as "It is recommended that...", etc) indicates that though the procedure or criterion is regarded as the preferred option, alternative procedures, specifications or criteria may be applied to elements of the CNS/ATM system that impact interoperability, provided that the applicant can provide information or data to adequately support and justify the alternative.

1.4.2 Structure of Document

Section 1: Scope of the Document; Introduction, Definitions and Terminology
Section 2: Summary of EMMA Services
Section 3: EMMA Air-Ground Functional Architecture
Section 4: Technical Solutions retained in EMMA
Section 5: EMMA Interoperability Requirements
Section 6: Annex 1 – State of the Art for Mode S
Section 7: Annex 2 – References, lists of figures and tables, acronyms and abbreviations.

1.5 Definition of Interoperability

The following definitions have been developed in the context of the development of the INTEROP Document for the AFAS project (5th FP) and used for the AGFA.

Interoperability. An essential communications link which permits units from two or more different agencies to interact with one another and to exchange information according to a prescribed method (called a protocol) in order to achieve predictable results.

Technical Interoperability Requirements. Technical protocol statements to be followed by remote end systems willing to exchange data in a structured and unlocked way. This includes definition of data structure, data encoding rules, data sequencing rules, and expected actions upon data reception or event occurrence.

Operational Interoperability. Operational protocol statement to be followed by remote operational system (including the operators, non-communicating functions) to ensure that the system is actually providing the intended operational function. This includes interpretation of data, operational actions and procedures upon data reception or event occurrence. A system can be technically interoperable but operationally non-interoperable.

Interoperability Technical Requirement (ITR). The ITR is a technical specification that shall be assumed by the specified system or subsystem: Airborne system (A) or ATS Ground system (G) or Communication Link (C), in order to ensure the interoperability between the three domains.
Interoperability Operational Requirement (IOR). The IOR is an operational specification that shall be assumed by the specified user: Aircrew (A) or Controller (G) or communication service provider (C), in order to ensure the interoperability between the three domains.

1.6 Explanation of Terms

1.6.1 General Terms

Advanced Surface Movement Guidance and Control Systems (A-SMGCS) [ICAO-A-SMGCS]

Systems providing routing, guidance, surveillance and control to aircraft and affected vehicles in order to maintain movement rates under all local weather conditions within the Aerodrome Visibility Operational Level (AVOL) whilst maintaining the required level of safety.

Aerodrome [ICAO-Annex14] [ICAO-A-SMGCS]

A defined area on land or water (including any buildings, installations, and equipment intended to be used either wholly or in part for arrival, departure, and surface movement of aircraft.

Aerodrome Visibility Operational Level (AVOL) [ICAO-A-SMGCS]

The minimum visibility at or above which the declared movement rate can be sustained

Airport authority [ICAO-A-SMGCS]

The entity responsible for the operational management of the airport

Alert [ICAO-A-SMGCS]

An indication of an existing or pending situation during aerodrome operations, or an indication of abnormal A-SMGCS operation, that requires attention and/or action

Alert Situation [EUROCAE-MASPS]

Any situation relating to aerodrome operations, which has been defined as requiring particular attention or action

Apron [ICAO-Annex14] [ICAO-A-SMGCS]

A defined area on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance

A-SMGCS capacity [ICAO-A-SMGCS]

The maximum number of simultaneous movements of aircraft and vehicles that the system can safely support with an acceptable delay commensurate with the runway and taxiway capacity at a particular aerodrome

Conflict [ICAO-A-SMGCS]

A situation when there is a risk for collision between aircraft and/or vehicles

Control [EUROCAE-MASPS]

Application of measures to prevent collisions, runway incursions and to ensure safe, expeditious and efficient movement

Cooperative aircraft / vehicle [EUROCAE-MASPS]

Aircraft / vehicle, which is equipped with systems capable of automatically, and continuously providing information including its Identity to the A-SMGCS

Note: “Target” has been replaced by “aircraft / vehicle” in “Cooperative target” [EUROCAE-MASPS] definition.

Note: as several cooperative surveillance technologies exist, an aircraft or a vehicle is cooperative on an
aerodrome only if the aircraft / vehicle and the aerodrome are equipped with cooperative surveillance technologies, which are interoperable.

Cooperative surveillance

The surveillance of aircraft / vehicles is cooperative when a sensor, named cooperative surveillance sensor, collects information about the aircraft / vehicles from an active element of the transponder type, which equips the aircraft / vehicles. This technique allows collecting more aircraft / vehicle parameters than the non-cooperative surveillance, for instance the aircraft / vehicles identity.

Data Fusion [EUROCAE-MASPS]
A generic term used to describe the process of combining surveillance information from two or more sensor systems or sources.

False Alert [EUROCAE-MASPS]
Alert, which does not correspond to an actual alert situation.

Note: It is important to understand that it refers only to false alerts and does not address nuisance alerts (i.e. alerts which are correctly generated according to the rule set but are inappropriate to the desired outcome).

Guidance [EUROCAE-MASPS]
Facilities, information and advice necessary to provide continuous, unambiguous and reliable information to pilots of aircraft and drivers of vehicles to keep their aircraft or vehicles on the surfaces and assigned routes intended for their use.

Identification [ICAO-A-SMGCS]
The correlation of a known aerodrome movement call sign with the displayed target of that aircraft / vehicle on the display of the surveillance system.

Identity [ICAO-4444]
A group of letters, figures or a combination thereof which is either identical to, or the coded equivalent of, the aircraft / vehicle call sign to be used in air-ground communications, and which is used to identify the aircraft / vehicle in ground-ground air traffic services communications.

Note: “Aircraft identification” [ICAO-4444] definition has been extended to vehicles.

Incursion [ICAO-A-SMGCS]
Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing, take-off, taxiing, and parking of aircraft.

Intruder

Any aircraft / vehicle, which is detected in a specific airport area into which it is not allowed to enter.

Low Visibility
Refers to Visibility Conditions 3 and 4, see Visibility Condition.

Manoeuvring area [ICAO-Annex14] [ICAO-A-SMGCS]
That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.

Modularity [ICAO-A-SMGCS]
Capability of a system to be enhanced by the addition of one or more modules to improve its technical or functional performance.

Movement

The movement of an aircraft / vehicle on the airport movement area.
Movement area

That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and apron(s)

Navigation

Navigation is the determination of position and direction on the surface of the Earth.

Non-Cooperative aircraft / vehicle

Aircraft / vehicle, which is not equipped with systems capable of automatically, and continuously providing information including its Identity to the A-SMGCS

Note: In the definition, “target” has been replaced by “aircraft / vehicle.”

Non-Cooperative surveillance

The surveillance of aircraft / vehicles is non-cooperative when a sensor, named non-cooperative surveillance sensor, detects the aircraft / vehicles, without any action on their behalf. This technique allows determining the position of any aircraft / vehicle in the surveillance area and in particular to detect intruders. Examples of non-cooperative surveillance sensors are the Primary Surveillance Radars

Nuisance Alert

Alert, which is correctly generated according to the rule, set but are inappropriate to the desired outcome

Obstacle

All fixed (whether temporary or permanent) and mobile obstacles, or parts thereof, that are located on an area intended for the surface movement of aircraft / vehicles or that extend above a defined surface intended to protect aircraft in flight

Note 1: The term fixed obstacle designates the elements such as antennas, buildings, ground lights...that present a risk for aircraft during landing, take-off or surface movements, especially for aircraft parts such as wingtips and tail, which are out of sight of the flight crew

Note 2: In the context of EMMA the following option is investigated: the A-SMGCS should detect any new obstacles (i.e. not previously recorded in an aeronautical database), whether moving or stationary, located anywhere on the movement area of the aerodrome and having an equivalent radar cross section of 1 sq. m or more.

Note 3: As specified in ICAO Doc 9137 Airport Service Manual, the responsibility for the control of fixed obstacles is assumed by the Aerodrome Operator.

Protection area

A protection area is a virtual volume around a runway, a restricted area or an aircraft or a vehicle. This protection area is used to detect an alert situation. For instance, an alert situation is detected when a aircraft / vehicle is on a runway and one or more aircraft / vehicles enter the runway protection area

Restricted Area

Aerodrome area where the presence of an aircraft or a vehicle is permanently or temporarily forbidden

Route

A track from a defined start point to a defined endpoint on the movement area

Routing

The assignment of a route to individual aircraft and vehicles to provide safe, expeditious, and efficient movement on the aerodrome movement area. Such route consists in a track from a defined starting point to a defined endpoint on the movement area

Runway Incursion

Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the
protected area of a surface designated for the landing and take-off of aircraft

Stand
A stand is a designated area on an apron intended to be used for the parking of an aircraft

Surveillance
A function of the system, which provides identification and accurate positional information on aircraft, vehicles and obstacles within the required area

Target
An aircraft, vehicle, or obstacle, that is displayed on a surveillance display.

Visibility Conditions

<table>
<thead>
<tr>
<th>Visibility Condition</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility Condition 1</td>
<td>Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, and for personnel of control units to exercise control over all traffic on the basis of visual surveillance.</td>
</tr>
<tr>
<td>Visibility Condition 2</td>
<td>Visibility sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, but insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance.</td>
</tr>
<tr>
<td>Visibility Condition 3</td>
<td>Visibility sufficient for the pilot to taxi but insufficient for the pilot to avoid collision with other traffic on taxiways and at intersections by visual reference, and insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance. For taxiing this is normally taken as visibilities equivalent to a RVR of less than 400 m but more than 75 m.</td>
</tr>
<tr>
<td>Visibility Condition 4</td>
<td>Visibility insufficient for the pilot to taxi by visual guidance only. This is normally taken as a RVR of 75 m or less.</td>
</tr>
</tbody>
</table>

1.6.2 Performance Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert Response Time (ART)</td>
<td>The time delay between an alert situation occurring at the input to the Alert Situation Detection Element and the corresponding alert report being generated at its output.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Display Resolution (DR)</td>
<td>The number of individually addressed picture elements (pixels) along each axis of the display screen. (For a raster-scan display, the resolution is normally expressed in terms of the number of raster lines and the number of pixels per line.)</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Identification Renewal Time-Out Period (IRTOP)</td>
<td>The elapsed time after which the output of valid identification data in target reports for a specific track will be terminated due to a lack of renewed identification data from any sensor system.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Information Display Latency (IDL)</td>
<td>The maximum time delay between a report, other than a target report, being received by the A-SMGCS HMI and the corresponding presentation on the HMI display of the information contained in the report.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Parameter</td>
<td>Definition</td>
<td>Source</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Position Registration Accuracy (PRA)</td>
<td>The difference between the co-ordinates contained in the dynamic input data to the HMI and the corresponding geographical position represented on the HMI display.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Position Renewal Time-Out Period (PRTOP)</td>
<td>The elapsed time after which the output of target reports for a specific track will be terminated due to a lack of new position information from any sensor system.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Probability of Detection (PD)</td>
<td>The probability that an actual target is reported at the output of the Surveillance Element of an A-SMGCS.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Probability of Detection of an Alert Situation (PDAS)</td>
<td>The probability that the Monitoring/Alerting Element correctly reports an alert situation.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Probability of False Alert (PFA)</td>
<td>The probability that the Control service reports anything other than actual alert situations.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Probability of False Detection (PFD)</td>
<td>The probability that the Surveillance Element of an A-SMGCS reports anything other than actual targets.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Probability of False Identification (PFID)</td>
<td>The probability that the identity reported at the output of the Surveillance Element of an A-SMGCS is not the correct identity of the actual target.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Probability of Identification (PID)</td>
<td>The probability that the correct identity of a co-operative target is reported at the output of the Surveillance Element.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Reported Position Accuracy (RPA)</td>
<td>The difference, at a specified confidence level, between the reported position of the target and the actual position of the target at the time of the report.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Reported Velocity Accuracy (RVA)</td>
<td>The difference, at a specified confidence level, between the reported target velocity and the actual target velocity at the time of the report.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Response Time to Operator Input (RTOI)</td>
<td>The maximum time delay between the operator making an input on a data entry device of an A-SMGCS HMI and the corresponding action being completed or acknowledged on the HMI display.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Surveillance Capacity</td>
<td>The number of target reports in a given period, which the Surveillance Element is able to process and output without degradation below the minimum performance requirements.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>System Accuracy</td>
<td>The term accuracy generally describes the degree of conformance between a platform's true position and/or velocity and its estimated position and/or velocity.</td>
<td>[ICAO A-SMGCS]</td>
</tr>
<tr>
<td>System Availability</td>
<td>Availability is the ability of an A-SMGCS to perform a required function at the initiation of the intended operation within an A-SMGCS area.</td>
<td>[ICAO A-SMGCS]</td>
</tr>
<tr>
<td>System Capacity</td>
<td>The maximum number of simultaneous movements of aircraft and vehicles that the system can safely support within an acceptable delay commensurate with the runway and taxiway capacity at a particular airport.</td>
<td>[ICAO A-SMGCS]</td>
</tr>
<tr>
<td>System Continuity</td>
<td>Continuity is the ability of an A-SMGCS to perform its required function without non-scheduled interruption during the intended operation in an A-SMGCS area.</td>
<td>[ICAO A-SMGCS]</td>
</tr>
<tr>
<td>System Integrity</td>
<td>Integrity relates to the trust, which can be placed in the correctness of the information provided by an A-SMGCS. Integrity includes the ability of an A-SMGCS to provide timely and valid alerts to the user(s) when an A-SMGCS must not be used for the intended operation.</td>
<td>[ICAO A-SMGCS]</td>
</tr>
<tr>
<td>Parameter</td>
<td>Definition</td>
<td>Source</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>System Reliability</td>
<td>Reliability is defined as the ability of an A-SMGCS to perform a required function under given conditions for a given time interval.</td>
<td>[ICAO A-SMGCS]</td>
</tr>
<tr>
<td>Target Display Latency (TDL)</td>
<td>The maximum time delay between a target report being received by the A-SMGCS HMI and the corresponding presentation on the HMI display of the target position contained in the report.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Target Report Update Rate (TRUR)</td>
<td>The frequency with which target reports are output from the Surveillance Element of the A-SMGCS.</td>
<td>[EUROCAE MASPS]</td>
</tr>
<tr>
<td>Transaction Expiration Time (ETRCP)</td>
<td>Maximum time for completion of a transaction after which peer parties should revert to an alternative procedure. The rate at which a transaction expiration time can be exceeded is determined by the continuity parameter.</td>
<td>[ED-78A]</td>
</tr>
<tr>
<td>95% Transaction Time (TT95)</td>
<td>Time before which 95% of the transactions are completed. This is the time at which controllers and pilots can nominally accept the system performance and represents normal operating performance.</td>
<td>[ED-78A]</td>
</tr>
<tr>
<td>Continuity (C_RCP)</td>
<td>Probability that the transaction will be completed before the transaction expiration time, assuming that the communication system is available when the transaction is initiated.</td>
<td>[ED-78A]</td>
</tr>
<tr>
<td>Availability (ARCP)</td>
<td>Probability that the communication system between the two parties is in service when it is needed.</td>
<td>[ED-78A]</td>
</tr>
<tr>
<td>Availability (A_Provision)</td>
<td>Probability that communication with all aircraft in the area is in service.</td>
<td>[ED-78A]</td>
</tr>
<tr>
<td>Communication Integrity (IRCP)</td>
<td>Acceptable rate of transactions completed with error undetected.</td>
<td>[ED-78A]</td>
</tr>
</tbody>
</table>

Table 1-1: Performance Parameters
2 Summary of EMMA Services

2.1 Scope for EMMA services

The scope for EMMA services covers the automated support to Air Traffic Controllers (ATCOs), Flight Crews and Vehicle Drivers for airport surface movements (tactical phase and pre-departure).

The following diagram depicts the phases of flight falling within the scope of EMMA as well as the different ATC Controllers providing the air traffic services (Aerodrome Control) for these phases.

![EMMA Scope Diagram](image)

Figure 2-1: Scope for EMMA services

The EMMA OSED Update (D1.3.1u) specifies the list of automated services provided to Air Traffic Controllers (ATCO), Flight Crews and Vehicle Drivers with respect to the guidelines provided by ICAO A-SMGCS Manual and using the Eurocontrol A-SMGCS project deliverables as a basis.

The following sections contain a summary of such automated services.

2.2 Service to Flight Crews

The services to the flight crews comprise the following main services:

- **Surveillance**: concerning own ship position with respect to airport layout and other traffic (position and identity)
- **Conflict Detection**: detection of potentially hazardous situations involving the own ship alone or other traffic as well
- **Control**: support to the Flight Crew for ATC Controller – Pilot dialogs occurring prior and during the surface movements
- **Guidance**: guidance for safe and expeditious surface movements of the own ship

As described in the EMMA OSED Update (D1.3.1u), such services have been decomposed into a number of functions and several steps of implementation are envisaged for such services.
2.2.1 Surveillance

The surveillance service provides to the flight crew information about the position of the own aircraft with respect to the airport layout, the restricted areas such as active runways as well as the position and identification of surrounding traffic.

Such service aims at increasing the situational awareness of the flight crews and improving the efficiency of the surface movements through own-ship positional awareness, especially in low visibility conditions or in case the flight crew is not familiar with the airport layout.

The service provides information that augments the flight crew’s visual information. The sole use of electronic information for aircraft navigation and collision avoidance on the airport surface is not envisaged within the time frame considered for EMMA operational services (15 years).

The surveillance service has been decomposed in three main ones:

- **Airport Layout Awareness**: provides information about the position of the aircraft with respect to airport areas (runways, taxiways, apron, stands), for instance runway layout (thresholds, entries / exit), runway status (configuration, active / closed,) and the related protection areas (runway holding positions for CAT-I up to CAT-III)

- **Runway Occupancy Awareness** (for landing and take-off phases): helps flight crews to visually acquire threatening traffic prior to possible avoidance manoeuvres

- **Traffic Situational Awareness**: provides the flight crew with an enhanced traffic situational awareness on the airport surface for both taxi and runway operations.

2.2.2 Conflict Detection

The conflict detection service aims at preventing the potential incursions of the own ship into restricted areas (e.g. entry onto a closed runway) as well as the risk of collision with other traffic (infringement of protection areas).

The conflict detection service has been decomposed into two main ones:

- **Surface Movement Alerting (SMA)**: warns the flight crew in case a potentially hazardous situation is encountered due to the current position of the aircraft with respect to the aerodrome layout (e.g. proximity of a runway, penetration into a closed runway).

- **Traffic Conflict Detection**: warns the flight crew about potential conflict(s) (risk of collision) with other traffic as a complement to the runway situational awareness and/or to the traffic situational awareness.

Such service raises the awareness of the flight crew about potentially hazardous situations by providing appropriate warnings or alarms and by designating such situation on an electronic display or using synthetic voice (e.g. “Crossing runway 25L holding position”).

From the onboard perspective, the time ahead for alerting of potentially hazardous situations is kept relatively short (approx. 5-10s) in order to keep the rate of potential false alarms acceptable by flight crews.

2.2.3 Control Service (or Ground Clearance Management)

The control services aims at supporting the flight crew for the controller – pilot dialogs during ground movements (for arrival and departure phases) and the reception of routing information dispatched by the ground system (e.g. standard taxi routes).
It is not intended to replace voice communications for time critical messages; therefore such service aims first at supporting departure clearance request and response (approx 20 min before estimated time of departure), start-up and pushback clearance request and response (approx 10 min before off-block time), and taxi clearance request and response (for departures and arrivals).

2.2.4 Guidance

The guidance service aims at supporting the flight crew for aircraft manoeuvres on airport surface (deceleration, turns, braking). Such service covers the provision of advises for braking and steering actions to be taken by the manipulating pilot as a complement to other parts of the A-SMGCS that provide general surface situation awareness information for use by the flight crew.

The guidance service has been decomposed in 3 main ones:

- **Braking and Steering Cues (BSC):** provides to the flight crew braking support for during the landing roll to optimise the runway occupancy time, as well as braking and steering support during the taxi operations.

- **Head-up Surface Guidance:** provides to the flight crew a guidance support for taxi operations using a head-up display and appropriate symbology (position with respect to taxiway layout, stop instructions, braking and steering cues).

- **Automated Steering** (long term perspective): on pilot request, and in specific cases, the service ensures the conversion of the guidance information into steering actions to the nose wheel steering, the rudder, the braking system or the thrust control.

2.3 Service to ATC Controllers (ATCO)

Depending on the level of implementation, the A-SMGCS will provide some or all of the following services:

- **Surveillance service:** situation of all movements on the airport manoeuvring or apron areas

- **Control service:** automated support to the ATCOs to ensure safe and efficient surface movements

- **Routing service:** assignment of taxi routes for aircraft movements (arrivals and departures)

- **Guidance service:** guidance service to flight crews and drivers to follow ATC cleared movements

ATCOs will be provided with functions for some or all of these services according to the level of A-SMGCS implementation and the specific local requirements.

2.3.1 Surveillance

Surveillance is the most fundamental of the A-SMGCS services upon which the other services are dependent (since, in order to provide control, routing and guidance, it is first necessary to know the location of all traffic and obstacles).

The A-SMGCS Surveillance service will assist the ATCO by providing a continuously updated presentation of the Traffic Situation. This will supplement or, in poor visibility conditions, replace visual observation out of the window.

Functions included in the Surveillance service for the ATCO are:
• Provision of Traffic Information, including detection, accurate location, and identification of movements

• Provision of Traffic Context information, including airport layout, operational configuration, time of day, weather, and runway status

• HMI to support the ATCO’s interaction with the Traffic Situation display.

The provision of Traffic Information should ensure that controllers receive all necessary information on aircraft, vehicles and obstacles on the movement area and approaches, including:

• Detection and accurate position of all aircraft, vehicles and obstacles

• Identification of all cooperative aircraft and vehicles

All participating aircraft and vehicles are expected to be cooperative, so the surveillance service will automatically provide their identity on the ATCO display. However, it should also be possible for the ATCO to cope with a limited number of non-cooperative movements (not equipped or out of service). Therefore, the traffic information needs to be collected from different systems:

• A non-cooperative surveillance system (e.g. Surface Movement Radar) capable of detecting and accurately locating all aircraft, vehicles and obstacles on the movement area of the aerodrome surface

• A cooperative surveillance system (e.g. Mode S Multilateration) to detect, accurately locate, and provide the identity of the participating movements on the movement area and in the air in the vicinity of the aerodrome

Depending on the complexity of the aerodrome, multiple sensor systems of each type may be required.

All the traffic information provided by these sources needs to be computed in order to obtain a consistent traffic information picture.

2.3.2 Control

ICAO defines Control as the “application of measures to prevent collisions, runway incursions and to ensure safe, expeditious and efficient movement”.

The current Control function is to be improved by the A-SMGCS by implementing runway incursion monitoring and alerting tools to predict, detect, and warn controllers of possible conflicts between aircraft and other traffic or obstacles.

The A-SMGCS Control function will give assistance to ATCOs in their control tasks by detecting already existing conflicts, anticipating conflicts and generating appropriate short and medium term alerts. Additionally, this function may be able to activate protection devices such as stop bars or to generate alerts directly to pilots or to vehicle drivers.

It should be noted that false alarms should be reduced to acceptable levels in order to provide ATCOs with the necessary confidence in such automated support. Consequently, in order to reduce the false alarms, a control service may initially only detect the most serious alarm situations, and progressively be complemented with other alarm situations when they are well understood.

Depending on the level of implementation, the EMMA Control service should primarily contribute to operations as a safety net, preventing hazards resulting from flight crew or vehicle driver deviations or from operational errors or deviations. In this respect, the implementation of the detection and alerting function will be aerodrome specific.
Every aerodrome has site-specific parameters and situations to be addressed. The following list from the ICAO A-SMGCS Manual provides some of the possible conflict alert scenarios that could be both predictable and detectable by the A-SMGCS:

- **Runway conflicts:**
  1. Aircraft arriving to, or departing on, a closed runway
  2. Arriving or departing aircraft with traffic on the runway (including aircraft beyond the runway-holding positions)
  3. Arriving or departing aircraft with moving traffic to or on a converging or intersecting runway
  4. Arriving or departing aircraft with opposite direction arrival to the runway
  5. Arriving or departing aircraft with traffic crossing the runway
  6. Arriving or departing aircraft with taxiing traffic approaching the runway (predicted to cross the runway-holding position)
  7. Arriving aircraft with traffic in sensitive area (when protected)
  8. Aircraft exiting the runway at unintended or non-approved locations
  9. Unauthorized traffic approaching the runway
  10. Unidentified traffic approaching the runway.

- **Taxiway conflicts:**
  1. Arriving aircraft exiting runway at high speed with converging taxiway traffic
  2. Aircraft on a closed taxiway
  3. Aircraft approaching stationary traffic
  4. Aircraft overtaking same direction traffic
  5. Aircraft with opposite direction traffic
  6. Aircraft approaching taxiway intersections with converging traffic
  7. Aircraft taxiing with excessive speed
  8. Aircraft exiting the taxiway at unintended or non-approved locations
  9. Unauthorized traffic on the taxiways
  10. Unidentified traffic on the taxiways
  11. Crossing of a lit stop bar

- **Apron conflicts:**
  1. Aircraft movement with conflicting traffic
  2. Aircraft movement with conflicting stationary objects
  3. Aircraft exiting the apron / stand / gate area at unintended or non-approved locations
  4. Unidentified traffic in the apron / stand / gate area.

When implementing the detection and alerting function, priorities should be established so as to ensure that the system logic performs efficiently. Since the runway represents the area with the highest risk of a catastrophic event, the detection and prediction of conflicts in this area should have highest priority, followed by taxiway conflicts and apron conflicts, where practicable.

As stated in the ICAO A-SMGCS Manual, the controller concerned will have the primary responsibility to operate and interpret the information coming from the A-SMGCS for aircraft on the manoeuvring area. The concerned pilots and vehicle drivers will be responsible to respond to an A-SMGCS instruction or alert, unless specifically instructed otherwise by the controller. However, conflict detection is an example of a responsibility that may be delegated in some circumstances to an automated system.

<sup>1</sup> Differences for the use of A-SMGCS on apron(s) are not detailed.
Once detected or predicted, a conflict should be resolved according to its severity. There should be sufficient time to resolve a predicted conflict through the planning process. However, an actual conflict requires immediate action, which may be a system- or human-initiated resolution. In this regard, two types of messages to the ATCO should be considered: medium-term information that represents a potentially hazardous situation but which does not require immediate action, and short-term alarms requiring immediate action.

A further aspect of the Control service is the issuance of clearances for surface movements. ASMGCS could provide two types of automated support to the ATCO with respect of clearances:

- Information about cleared movements, time constraints for flights together with surveillance information
- Support for the use of CPDLC for controller-pilot dialogues for non-time-critical clearances such as departure clearance, start-up, push-back, and taxi clearance

The conditions for transfer of control of aircraft between approach and tower controllers and for aircraft and vehicles between ground and tower controllers are predefined and published in letters of agreement between adjacent ATC Centres. Silent handover is the most common practice in European airports.

To support such process, the system should complement the surveillance information with information on what movements have been cleared by the adjacent ATCOs (e.g. aircraft cleared for lining-up on the runway is known by the Ground Controller).

With the introduction of automation of surface movement planning and air-ground data links, the support to ATCO coordination should also cover the acceptance process of taxi routing decisions between Ground and Tower Controllers and the notification of the Flight Crews at the appropriate time.

### 2.3.3 Routing

The Routing service will assist the ATCO in choosing and assigning taxi routes to aerodrome movements. Transmission of a route to a flight crew or to a vehicle driver, by whatever means is part of the Guidance service.

EMMA has adopted the ICAO concept that the route generation in A-SMGCS will be implemented in progressive levels of automation. The more the generation and assignment of a taxi route is automated, the more support of a planning function and other information will be required to guarantee safe and efficient routes.

Three levels of automation are defined:

1. **Manual**: The Routing function allows the ATCO to construct or select a route and to assign it to a movement.
2. **Semi-automatic**: The Routing function will propose an optimal route, based on the shortest taxi distance or duration and current constraints that are known to the function. The ATCO can then assign the proposed route or modify it prior to assignment.
3. **Automatic**: The Routing function will both compute and assign the taxi route. Intervention by the ATCO is possible, but the function then reverts to semi-automatic mode.

To compute the most efficient taxi routes the Routing function must be able to interact with the:

- Flight Plan Data Processing System (FDPS)
- Surveillance function
- Control function
- Aeronautical Information server: for airport layout and configuration information
- Meteorological services

The most advanced systems should provide continuously updated routing and timing information, whereby the Routing function computes the path to be taken and the time needed to perform the movement.

From these sources the Routing function should be able to obtain information about the:

- Start point (e.g. stand for departures, runway exit for arrivals)
- End point (e.g. stand for arrivals, assigned runway entry point for departures)
- Intermediate waypoints (e.g. de-icing, temporary parking positions)
- Local standard routes
- Local taxi restrictions (closed or restricted-use taxiways, restricted areas)
- Type of aircraft
- Obstacles and temporary hazards
- Time constraints

The most advanced systems should provide continuously updated routing and timing information, whereby the Routing function computes the path to be taken and the time needed to perform the movement.

A further enhancement would be to provide the ATCO with a departure management (DMAN) tool that provides an optimal departure time for each flight and an optimal overall departure sequence taking into account wake vortex categories, CFMU slot, departure routes (SID) and arrival sequence (for mixed mode runways).

The DMAN would calculate an optimal departure sequence by taking into account the following constraints:

- CTOT or ETD or confirmed/estimated Off-Block Time
- Earliest ready time (for take-off)
- Separation minima
- Standard Departure Route (SID)
- Runway(s) in operational use (including mixed-mode or single-mode)
- Intersection take-off positions (when agreed with Pilot)
- Prioritised flights
- Runway inspections
- Selected planning strategies
- Arrivals (ETA, ATA)
- Additional constraints set by the ATCO
The output of the DMAN is an optimal target departure time (TDT) that is used by the automatic Routing function to compute an optimal start-up time.

2.3.4 Guidance

The Guidance service of an A-SMGCS is predominantly aimed at helping pilots and drivers to follow clearances and instructions given by the ATCO to keep them on their assigned routes and prevent them from intruding into restricted areas.

Providing guidance is one of the ATCO’s tasks, complementing the planning of ground traffic movements and the control activities in order to have the movements implemented as planned.

There is a close interrelation between control and guidance, since both functions aim at having aircraft movements performed as planned. However, a clear differentiation shall be made:

- **Control** covers ATCO actions to issue a clearance or switch a stop bar off or on, which instructs the pilot to perform a taxi operation or to stop.
- **Guidance** covers ATCO’s information and the activation of technical means (e.g. visual aids), which help the pilot or vehicle driver to comply with the clearance given.

ICAO mentions two categories of guidance means:

- **Ground-based guidance means**: Signs, painted lines, ground lighting and other visual aids.
- **On-board guidance means**: Suitable avionics, such as a moving map display

Ground-based guidance by visual aids has the advantage that guidance can be provided to every aircraft or vehicle, independent of the onboard equipage, and that the controller can interact with every aircraft in the same way. A-SMGCS ground-based guidance means should supplement existing SMGCS by providing additional visual aids, which will consist of:

- Selectively or segment-wise switched centre line lights, and
- Selectively switched stop bars

To fulfill ICAO recommendations, the taxiways should be equipped with green centre line lights, which either can be addressed and switched separately, or are grouped in segments and can be switched segment by segment, with red stop bars in between, respectively at the beginning and end of each segment. Stop bars have to be interlocked with the taxiway centre line lights so that when the centre line lights beyond the stop bar are illuminated the stop bar is extinguished and vice versa.

Switching of the visual aids may occur either manually or automatically, depending on the level of implementation. The ATCO or an assistant will be provided with an interface to operate the visual aids and to monitor their status. For an automated system, it is conceivable that the Guidance function could switch on the respective centre line segments from the actual aircraft/vehicle position up to the intended holding position, where the red stop bar is switched on. As the aircraft/vehicle progressed along its route, the segments behind it would be extinguished. However, such operation would require very high integrity and reliability of the Surveillance function.

In more advanced implementations of A-SMGCS, data link will provide for the transmission of the assigned taxi route to the aircraft or vehicle on-board display. This functionality requires an interface to the ATCO, which indicates whether the automatic transmission of guidance information is possible.
for a specific aircraft, and a service monitoring function which gives feedback on whether the transmission was successful or failed.

2.4 Services to Vehicle Drivers

In order to provide the services to vehicle drivers defined in the ICAO A-SMGCS Manual, the main following functions have been identified in EMMA:

- **Vehicle Airport Moving Map Function** (surveillance service): The airport moving map function displays the vehicle position with respect to aerodrome geographic locations (i.e. geographic features, or ground based facility locations in proximity of the aircraft) and in particular the aerodrome elements referenced in the ATC instructions. This function allows the vehicle driver to determine the actual position of his vehicle on the airport surface. Especially in low visibility conditions and under complex airport layout situations, the use of the airport moving map function will significantly increase the situational awareness of the vehicle driver.

- **Vehicle Surface Movement Alerting Function** (SMA, Control service): This function aims to provide an alert to drivers in case of possible hazardous situations for the vehicle. The SMA function will provide the vehicle driver with several types of control information: runway proximity alerts, runway incursion alerts, taxi route conformance and fixed obstacle avoidance alerting.

- **Vehicle Ground Traffic Display Function** (Surveillance service): the main goal of the ground traffic display function is to reduce the potential for conflicts, errors and collision with others aircraft / vehicles by providing enhanced situational awareness to the vehicle driver operating on the airport surface especially in all weather conditions.

- **Vehicle Dispatch and Guidance by data link** addresses the provision of vehicle dispatch information from ground operators (not further investigated in EMMA).
3 EMMA Air – Ground Functional Architecture

The EMMA Air-Ground Functional Architecture addresses all the information exchanges between ground and aircraft or vehicle systems required to support the EMMA services. Such functional description does not address the constraints from potential technological solutions and does not prescribe data formats for air-ground information exchanges.

3.1 Scope for Air-ground Interactions within EMMA

3.1.1 Aircraft - Ground Interactions

This section contains a high-level description of the interactions between aircraft and the ground system within the scope of EMMA and the considered timeframe for implementation.

The scope of EMMA addresses first operations related to surface movements, therefore emphasis is put on air-ground interactions taking place during (or immediately prior to) the taxi phase of aircraft. Other air-ground interactions prior to the landing or prior the start-up/push-back taxi phase (such as the exchange of airport or aircraft planning information) have not been fully investigated within EMMA.

The following table identifies the aircraft-ground interactions according to the phase of the flight (arrival – turnaround – departure); interactions within the scope of EMMA are highlighted in green.

<table>
<thead>
<tr>
<th>Phase of flight</th>
<th>SURVEILLANCE</th>
<th>CONTROL</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial / Intermediate Approach</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Approach</td>
<td>Aircraft identity, position and state vector required</td>
<td>Other aircraft / vehicles on the airport surface</td>
<td>Voice communications only (between Flight Crew and Runway Controller)</td>
</tr>
<tr>
<td>Lending, deceleration, runway vacation (or missed approach)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Request of information: Allocated stand, runway exits available, standard taxi-routes available</td>
<td>Voice is used for ATC Clearances (Approach Controller)</td>
<td>To be addressed in EMMA-2</td>
<td></td>
</tr>
<tr>
<td>Services ▶</td>
<td>SURVEILLANCE</td>
<td>CONTROL ATCO – Flight Crew Dialogs</td>
<td>Comments</td>
</tr>
<tr>
<td>------------</td>
<td>--------------</td>
<td>----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Phase of flight ▼</td>
<td>Aircraft broadcast</td>
<td>Ground broadcast</td>
<td>Flight Crew Request</td>
</tr>
<tr>
<td>Taxi-in</td>
<td></td>
<td></td>
<td>Request: taxi route information and taxi clearance</td>
</tr>
<tr>
<td>Turnaround and Pre-departure</td>
<td>No information required</td>
<td></td>
<td>Request: Departure information (runway, SID) and Clearance request</td>
</tr>
<tr>
<td>Push-back</td>
<td>Aircraft identity, position (and state vector) required</td>
<td>Other aircraft / vehicles on the airport surface</td>
<td>Request: push-back/start-up clearance</td>
</tr>
<tr>
<td>Taxi-out</td>
<td></td>
<td></td>
<td>Request: taxi route and taxi clearance</td>
</tr>
<tr>
<td>Line-up Take-off</td>
<td></td>
<td></td>
<td>Voice or data link communications</td>
</tr>
</tbody>
</table>

Table 3-1: Aircraft-Ground Interactions considered within EMMA scope (in green)

### 3.1.2 Vehicle – Ground Interactions

Concerning airport vehicles, they are also providing and receiving continuously surveillance information (e.g. position and identity) as long as they are on the manoeuvring area and in some parts of the apron(s).

As part of the control service, it is envisaged to provide vehicles with alerts issued by the ground system designating a potentially hazardous situation in which the vehicle is involved.
Other interaction will also take place to support the service ‘Vehicle dispatch and guidance’ but they have not been investigated during EMMA.

The table below depicts the interaction between vehicles and ground system depending on the area where the vehicle is located.

<table>
<thead>
<tr>
<th>Service ▷</th>
<th>SURVEILLANCE</th>
<th>CONTROL</th>
<th>VEHICLE DISPATCH and GUIDANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airport Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▼</td>
<td>Vehicle Broadcast</td>
<td>Ground Broadcast</td>
<td>From Vehicle</td>
</tr>
<tr>
<td>Manoeuvring Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apron(s)</td>
<td>Vehicle identity, position (and state vector)</td>
<td>Other aircraft / vehicles on the airport surface</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 3-2: Vehicle-Ground Interactions considered within EMMA scope (in green)

3.1.3 Aircraft / Vehicle Interactions

The interactions between aircraft and vehicles are limited to the broadcast of surveillance information.

3.1.4 Air – Ground Information Exchange within EMMA

The section contains a short description of the information exchanged between aircraft, vehicles and ground systems corresponding to the interactions described in the previous sections.

Surveillance Information:
- Identity of the aircraft (ICAO 3-letter code and flight number OR aircraft registration)
- Identity of vehicle
- Position of the aircraft / vehicle
- State vector
  - Heading
  - Ground Speed

Such information is completed by figure of merit (FOM) indicators.

Departure Information:

Departure Clearance request contains:
- Aircraft identification (ICAO 3-letter code and flight number)
- Aircraft stand number
- Aircraft wake vortex category
- Destination (if applicable)
- Ready to start-up in XX minutes (or EOBT)
Departure Clearance contains:

- Approved departure time (off-block time if applicable)
- Runway for departure (QFU)
- SID
- Cleared flight level (if applicable)
- SSR Code (if applicable)

Push-back Clearance Information:

- Push-back approved
- Push-back movement: type (long/short), taxi lane and direction

Taxi Information:

Taxi Clearance request contains:

- Aircraft identification
- Current aircraft position
- Taxi preferences (if applicable): e.g. runway holding point

Taxi Clearance:

- Taxi to: runway holding point / intersection or point / aircraft stand
- Via taxi route: standard route (as sequence of taxiways)
- Proceed before/after/in front of/behind (Aircraft: Airline indicator)
- Transfer voice communications to (frequency)

3.1.5 Overview of Air-Ground Interactions

As introduced in section 2, the EMMA services are realised through a number of interactions between aircraft, vehicles and the ground system(s). The following picture illustrates the aircraft / vehicle / ground services concerned with air-ground interactions.
Figure 3-1: Overview of EMMA Air-Ground Interactions

Each side of this functional architecture is further detailed in the following sections.
3.2 Ground Side

The following data flow chart presents the high-level functional architecture for the Ground side of the A-SMGCS.

![High-Level Functional Architecture for Ground Side](image)

Figure 3-2: High-Level Functional Architecture for Ground Side

The various functions are briefly described in the following section. For each connection between two functions, the information exchanged is defined.

### 3.2.1 Provide Traffic Information Function

This function is a basic element of the A-SMGCS that is supported by both Ground and Airborne systems. Knowledge of its architecture is a pre-requisite for a good understanding of the interoperability requirements.

As shown in the following figure, this function is responsible for the collection and collation of information about mobiles and obstacles relevant to the A-SMGCS application (position, velocity, identity, etc.).
Figure 3-3: Functional Architecture for Provide Traffic Information Function

The separate blocks are explained in the following sections.

3.2.1.1 Acquisition of Traffic Information

Traffic information needs to be acquired by a combination of cooperative and non-cooperative surveillance means. Through the sub-function “Acquisition of traffic information from cooperative surveillance sensors”, the Ground side of the system interoperates with the On-board side to obtain parameters from participating mobiles.

A cooperative surveillance system is needed to detect and provide the identity of the participating mobiles on the aerodrome surface and in the airspace surrounding the aerodrome. The participating mobiles are those known by the aerodrome authority, and likely to move on the manoeuvring area. Ideally, all the participating mobiles should be cooperative, allowing the cooperative surveillance system to collect information about the mobiles, at least their position and identity. In order to ensure rapid deployment, the cooperative surveillance system must be based on current technologies being implemented on aircraft (e.g. ADS-B, Mode S multilateration).

The sub-function “Acquisition of traffic information from non-cooperative surveillance sensors” is a Ground side of the System, which operates independently of the On-board side. A non-cooperative surveillance system is needed to detect any mobile or obstacle on the surface, whether participating or not, including intruders. Depending on the size and complexity of the aerodrome, this system may comprise multiple sensors of different types (e.g. SMR, cameras). The non-cooperative surveillance system shall provide accurate position information and information about the size, and possibly shape, of objects detected on the movement area of the aerodrome surface.

Existing approach Radar Data Processing Systems (RDPS), which are cooperative surveillance systems, will be able to provide the information (at least position and identity) on airborne aircraft needed by the A-SMGCS. In the future, this surveillance data could be collected from other ground sensors such as passive Mode A/C/S multilateration or ADS-B receivers.
3.2.1.2 Acquisition of Other Information about Traffic

The A-SMGCS will require other information about traffic, typically flight plan, stand allocation, etc. Such information should be available from other ground systems at the airport, such as FDPS (for flight plan, etc.), Code-Callign Database (for allocated Mode A code) and Airport Information Databases (for stand allocation, etc.).

3.2.1.3 Data Fusion

The information provided by the different surveillance sensors and traffic information sources is combined by a data fusion process to provide a comprehensive surveillance package. The output is a continuously updated track for each mobile and obstacle, including all necessary parameters and information associated with each track.

Traffic Information will be distributed to all users and to other Ground and On-board functions that require it. Some users may require the information to be filtered prior to transmission.

3.2.2 Provide Traffic Context Function

This function is responsible for the provision of traffic context information such as airport configuration, runways status, separation minima, etc. Some of this information, such as the layout of runways and taxiways, will be relatively static, whereas other, such as runways in use, taxiway closures, weather conditions, may change frequently. The traffic context data may be automatically obtained from other systems (MET systems, etc.), or updated by human operators.

The “Provide Traffic Context” function is composed of sub-functions as shown in the following diagram and described in the following sections.

![Functional Architecture for Provide Traffic Context](image)

3.2.2.1 Acquisition of Traffic Context from Other Ground Systems

This function is responsible for the automatic provision of the traffic context information obtained from other systems. It will interface to Airport Information Databases, Meteorological Information Systems, etc.
3.2.2.2 Manual Update of Traffic Context

This function is responsible for the provision of traffic context information (airport configuration, runways and taxiway status, etc.) updated by human operators.

3.2.2.3 Update Traffic Context

The Traffic Context information provided by the different sources (automatic or manual) is combined to provide a comprehensive traffic context package for distribution to users and to other Ground and On-board functions that require it.

Some users may require the Traffic Context data to be filtered before transmission.

3.2.3 Conflict Detection and Alerting Function

This is a function of the Ground side of the A-SMGCS. It is independent of the On-board side. It monitors the Traffic Information and utilises Traffic Context information in order to detect and predict conflicts involving aircraft and to alert users of hazardous situations. Users are primarily controllers but in some situations, for example when there is imminent collision danger, it may be required to transmit alert information directly to pilots and/or vehicle drivers.

At higher levels of implementation, this function may also monitor a movement’s conformance with the assigned route and provide an alert in the event of deviation.

3.2.4 Provide Taxi Route Function

This function is responsible for the provision and assignment of a suitable taxi route to each aerodrome movement. It will make use of Traffic Information and Traffic Context information to compute a taxi route from a stand to a runway entry point for a departure or from a runway exit point, once detected, to a stand for an arrival. In addition, it should be able to provide routes for other movements of aircraft on the aerodrome movement area and for vehicle movements.

From the Traffic Information, the “Provide Taxi Route” function should be able to obtain information about the:

- Type of aircraft
- Start point (e.g. stand for departures, runway exit for arrivals)
- End point (e.g. stand for arrivals, assigned runway entry point for departures)

From the Traffic Context, the “Provide Taxi Route” function should be able to obtain information about the:

- Layout of the runways and taxiways
- Stand locations
- Intermediate waypoints (e.g. de-icing, temporary parking positions)
- Local standard routes
- Local taxi restrictions (closed or restricted-use taxiways, restricted areas)
- Obstacles and temporary hazards

The “Provide Taxi Route” function distributes its output to the ATCO.

### 3.2.5 Provide Departure Time Function

This function is responsible for the computation of an optimal departure sequence aimed at minimising delays from start-up to take-off and the provision of an optimum start-up time for each departing aircraft. It is independent of the On-board side.

The Provide Departure Time function will make use of Traffic Information to obtain information about:
- ETA and ATA for Arrivals
- CTOT or ETD or confirmed/estimated Off-Block Time for Departures
- Type of aircraft
- Destination
- Prioritised flights

It will make use of Traffic Context to obtain information about:
- Separation minima
- Standard Departure Routes (SID)
- Runway(s) in operational use (including mixed-mode or single-mode)
- Intersection take-offs
- Selected planning strategies
- Additional constraints set by the ATCO (including runway closures for inspection)

The output of the “Provide Departure Time” function is an optimal start-up time proposal to the ATCO.

### 3.2.6 Provide Departure Clearance/Taxi Route Function

This function is responsible for the preparation and provision of the departure clearance and taxi route information to aircraft.

It shall be interoperable with the on-board side to transmit clearances and to receive requests and acknowledgements.

### 3.2.7 Service Monitoring

This function monitors the quality of service of the A-SMGCS (equipment status, performances, operational failures, etc.) and generates an alert when the A-SMGCS must not be used for the intended operation. It shall receive information about the status of on-board systems used for A-SMGCS.
3.2.8 Interface with User

This function is the interface with the Ground Side users, predominantly controllers but also technical staff responsible for monitoring and maintaining the serviceability of the system.

The "Interface with User" function will provide the Ground Side users with the following information:

- Traffic information
- Traffic context information
- Conflict alerts
- Taxi route proposals
- Departure time proposals
- Serviceability alerts

Via the “Interface with User” function, users will have a means to interact with the system to filter the information according to their needs and to input or modify some items of information.
3.3 Aircraft Side

The following diagram shows the different on-board functions and their interactions in the scope of EMMA application.

![Functional Architecture for Aircraft](image)

Figure 3-5: Functional Architecture for Aircraft

3.3.1 Provide Airborne Information (Surveillance Service)

This function shall at least provide the following Aircraft parameters to the ground system or other aircraft:

- Position
- Identity
- Speed (m/s)
- Heading (degree)
- Status and Figure of Merit for position, heading, speed information

3.3.2 Airport Moving Map (Surveillance Service)

The function displays own ship position with respect to aerodrome geographic locations and layout (i.e. geographic features, or ground based facility locations in proximity of the aircraft) and in particular, the aerodrome elements referenced in the ATC instructions.

3.3.3 Provide Traffic Information (Surveillance Service)

The function receives, correlates and merges traffic surveillance data coming from different sources (ADS-B, TIS-B).
3.3.4 Surface Movement Alerting (Conflict Detection Service)
The surface movement alerting (SMA) provides an alert to the flight crew in case a potentially hazardous situation is encountered due to the current position of the aircraft with respect to the aerodrome layout (e.g. proximity of a runway, penetration into a closed runway).

3.3.5 Ground Traffic Display (Surveillance Service)
The main goal of the ground traffic display function is to reduce the potential for conflicts, errors and collision with others aircraft / vehicles by providing enhanced situational awareness to the flight crew operating on the airport surface especially in all weather conditions.
The traffic display function mainly includes the following aspects:
- Receive, correlate and merge passive traffic surveillance data coming from different sources (ADS-B, TIS-B)
- Provide the flight crew with the surrounding traffic information (ground/airborne) on an appropriate display

3.3.6 Traffic Conflict Detection (Conflict Detection Service)
The traffic conflict detection function provides an alert to the flight crew in case the risk of a collision with another aircraft / vehicle exists.

3.3.7 Provide Airport Mapping and Configuration
The function covers the update of the airport mapping data available in the aeronautical database on board as well as the NOTAMs not communicated to the Flight Crews prior to flight and the ATIS information (D-ATIS data link service).

3.3.8 CPDLC Ground Clearance and Taxi Route Uplink (Control Service)
The function supports the ATCO - Pilot dialogs through data link during surface movement operations. It provides an assistance for the following clearance requests and clearance reception: departure clearance, start-up / push-back clearance, taxi clearance for arrival and departure movements.
The routing information covers the movements:
- From the parking stand (gate) to the assigned departure runway holding point
- From the landing runway exit to the assigned stand (gate).

3.3.9 Braking and Steering Cues (Guidance Service)
The Braking and Steering Cues (BSC) function has two roles:
1) Braking support to improve the reliability of runway occupancy times during the landing roll, by assisting the flight crew to control aircraft deceleration in order to exit the runway as planned, or to warn the flight crew as early as possible if actual braking performance is not sufficient to exit as planned. In the event that the actual deceleration is insufficient to leave...
the runway at the planned exit, the BSC function is required to present speed-control cues so that the aircraft can use the next practicable exit with the minimum increase in runway occupancy time.

2) Steering and braking support to the PF during taxi operations.

3.3.10 HUD Surface Guidance (Guidance Service)

The SGS/HUD function has to provide to the Pilot Flying following elements:

1) Guidance cues path to follow with stop information (stop bars, traffic stop) associated to ATC clearance
2) Awareness information relative to aircraft situation on taxiway
3) Additional symbology to represent taxiway limits
4) Steering and braking cues to the PF during taxi operations.

3.3.11 Automated Steering (Guidance Service)

The function covers the use of the auto-pilot for taxi movements following the taxi routing, ATCO clearances and guidance information (braking and steering cues).

3.3.12 Interface with Ground Systems

The function ensures the interface between aircraft functions and ground systems for the surveillance service (broadcast of aircraft identity, position and state vector, upload of traffic information) and control service (controller–pilot exchanges).

3.3.13 Interface other Aircraft / Vehicles

The function ensures the interface between aircraft functions and other aircraft / vehicles on airport surface for the acquisition of identity, position and state vector.
3.4 Vehicle Side

The services to Vehicle drivers are achieved by separate functions:

- **Vehicle Moving Map** enabled by the function Provide own-ship position
- **Vehicle Surface Movement Alerting**
- **Vehicle Ground Traffic Display** enabled by the reception of other aircraft / vehicles position information (ADS-B in)
- **Vehicle Operations Support**
- Interface with aircraft, other vehicles and ground systems: ensures the broadcast of vehicle identity, position and state vector and the acquisition of other traffic information.

The diagram here below depicts the functional architecture for airport vehicles for A-SMGCS:

![Functional Architecture for Vehicles](image)

*Figure 3-6: Functional Architecture for Vehicles*
4 Technical Solutions Envisaged in EMMA

The section presents the envisaged technical solutions to support the Air-Ground Functional Architecture for EMMA.

The next table represents the solutions adopted in the EMMA for the different air-ground interactions between the Ground, airborne and vehicle systems.

<table>
<thead>
<tr>
<th>To From</th>
<th>Aircraft system</th>
<th>Vehicle system</th>
<th>Ground system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft system</td>
<td>1090ES ADS-B</td>
<td>1090ES ADS-B</td>
<td>1090ES ADS-B</td>
</tr>
<tr>
<td>Vehicle system</td>
<td>ADS-B</td>
<td>ADS-B</td>
<td>ADS-B</td>
</tr>
<tr>
<td>Ground system</td>
<td>TIS-B</td>
<td>CPDLC</td>
<td>D-OTIS</td>
</tr>
</tbody>
</table>

Table 4-1: Technical solutions retained in EMMA

4.1 ADS-B/TIS-B

Own-slip position and identity (and possibly state vector) information provided by each aircraft through the ADS-B protocol on the 1090 MHz ES datalink is used by ground ATC systems to provide Surveillance services to ATC controllers.

ADS-B information received from other aircraft/vehicle in the airport vicinity (on ground or in landing/take-off phase) is used for performing the ground traffic display function and the traffic conflict detection function to the flight crews or vehicle drivers.

ADS encompasses both ADS-Contract and ADS Broadcast (ADS-B). It is foreseen that ADS will be utilised operationally in ECAC States from 2007 onwards.

4.1.1 Automatic Dependent Surveillance (ADS)

The Automatic Dependent Surveillance (ADS) application is an ATS ATN application, in which aircraft automatically transmit, via a data link, data derived from on-board navigation systems. As a minimum, the data include three-dimensional position, the corresponding time of the position data, and a Figure of Merit (FOM) that characterises the accuracy of the position data. Additional data may be provided as required.

4.1.2 Automatic Dependent Surveillance Broadcast

The Automatic Dependent Surveillance Broadcast (ADS-B) Surveillance application allows the transmission of on-board data to air or ground-based users via a data link (e.g. Mode S or VHF) using

² The use of the acronym “CPDLC” in this document does not imply any choice between technological environment or applications, such as ATN based CPDLC or ARINC 623 based services.
a broadcast mode. The aircraft originating the broadcast has no knowledge of which systems are receiving the broadcast. Any air or ground-based user may choose to receive and process this information.

Surveillance data which will be transmitted by ADS-B includes the airframe identification, position, time, Figure-Of-Merit and emitter category. The addition of other potential data (such as the ground vector, air vector, short-term intent, rate of turn and aircraft type) and the use of an event driven transmission is possible in the future, but not necessarily relevant for the A-SMGCS application.

There are two principle technologies recognized at ICAO level, these are Mode-S "extended squitter" (1090 ES ADS-B) and VDL Mode-4.

The Universal Access Transceiver (UAT) technology is developed by US industry for general aviation.

4.1.3 Traffic Information System Broadcast (TIS-B)

TIS-B (Traffic Information Service - Broadcast) is a surveillance technique that provides surveillance information from the ground to suitably equipped air or ground-based mobiles (an aircraft in the air or on the ground, or a surface vehicle) on Objects Of Interest (the physical objects for which any TIS-B user may require information, principally the aircraft and airport vehicles, but also significant obstacles). The broadcast traffic information is derived from one or more ground surveillance sources. The related ground system originating the broadcast has no knowledge of which systems are receiving the broadcast.

TIS-B can broadcast predefined sets of traffic information, with an identified Quality of Service (such as availability, continuity, integrity, nominal accuracy and latency characteristics of the broadcast traffic items).

TIS-B can support a number of TIS-B services, a service being defined as a data stream with predefined characteristics made available to the TIS-B Users.

Each TIS-B service can be described through the following attributes:

- **Track Selection**, i.e. the definition of which traffic targets will be broadcast by the TIS-B service
- **Track Data Items Definition**, i.e. the definition of which traffic information items (parameters) will be broadcast by the TIS-B service, with which resolution
- **Transmission characteristics**, i.e. which reporting period for each of the traffic
- **Quality of Service**, i.e.:
  - the nominal accuracy and latency characteristics of the broadcast traffic data items
  - the integrity
  - the availability
  - the continuity.

4.1.4 Rationale for Mode S in EMMA

On 7th April 2000, the Provisional Council of EUROCONTROL agreed to implement Mode S Elementary Surveillance within the core area of Europe subject to high air traffic density. Initially, this will apply in the airspace of Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland.
Following the agreement between EUROCONTROL and the participating States, Aircraft Operators are required to equip their aircraft with Mode S airborne equipment that supports Mode S Elementary Surveillance functionality. This includes Mode S transponders with Surveillance Identifier (SI) code capability and the automatic reporting of aircraft identification in accordance with ICAO Standards and Recommended Practices (SARPs).

In February 2002, three States, France, Germany and the United Kingdom announced their common decision to implement Mode S Enhanced Surveillance in major Terminal Manoeuvring Areas and en-route airspace. Furthermore, Switzerland and the EUROCONTROL Maastricht UAC will also implement Enhanced Surveillance in a similar timescale.

This very positive context, reinforced by the full compliance of MODE-S with ADS-B requirements, leads to the choice of Mode-S as the retained technology (1090 ES ADS-B), which will ensure Airborne/Ground surveillance data, exchanges in the frame of EMMA.

### 4.1.5 1090 MHz ADS-B/TIS-B System Overview

Mode S extended squitter systems supporting ADS-B and TIS-B protocols shall conform to the functional model depicted in the following figure.

![ADS-B/TIS-B System Functional Model](image)

**Figure 4-1: ADS-B/TIS-B System Functional Model**

The term “ADS-B OUT” indicates a capability of an aircraft or surface vehicle to support the transmission of ADS-B messages (i.e. equipped with a transmitting system as described in the previous figure).
The term “ADS-B IN” indicates a capability of an aircraft, surface vehicle or ground system to support the receiving of ADS-B messages (i.e. equipped with a receiving system as described in the previous figure).

Ground systems may also transmit TIS-B messages with an associated transmitting system (“TIS-B out” capability).

The term “TIS-B IN” indicates a capability of an aircraft or surface vehicle to support the receiving of TIS-B messages (i.e. equipped with a receiving system as described in the previous figure).


Note that the “Report Assembly Function” is not necessary for ADS-B IN ground receiving systems as ADS-B messages can directly feed ground surveillance data fusion algorithms.

The 1090 MHz ADS-B/TIS-B System uses the Mode S Extended Squitter defined in the ICAO Annex 10, Volumes III and IV, [23] to broadcast the aircraft/vehicle position, velocity and other relevant information over the RF medium.


4.1.6 ADS-B/TIS-B Standard Documents

The main input standard documents for interoperability about ADS-B and TIS-B exchanges supported by 1090 MHz Extended Squitters are the following:

- SARPs Modes S (ICAO Annex 10, Vol III, Chapter 5 and ICAO Annex 10, Vol IV) [23]

SARPs Mode S have to be updated for extended squitter transmitting and receiving systems to include support to ADS-B and TIS-B services as already described in the DO-260A MOPS 1090 ES document.

The second edition of the RTCA MOPS for 1090 MHz ADS-B has been approved by SC-186 and published as DO-260A. This update to the MOPS includes many changes including substantial new material related to the required capabilities of the Mode S extended squitter receiving systems and some updates to the material related to the categories of extended squitter transmitting systems. Integrity and accuracy of the data being transmitted has been modified by the introduction of the NIC (Navigation Integrity Category), NAC (Navigation Accuracy Category) and SIL (Surveillance Integrity Level).

RFG (Requirement Focus Group) involving EUROCONTROL-FAA-RTCA and EUROCAE are currently working on the normalisation of the ASAS package 1 applications through ED-78A methodology. This activity should result in the update of the data-link interoperability as described in the MOPS by the end of 2005.

Concerning EMMA constraints for the capturing of interoperability requirements, the most relevant document to consider is the RTCA/DO260A document.

However, as the ICAO SARPS have not yet evolved and as current installed transponders are compliant with existing SARPS, it seems reasonable to also retain the former RTCA/DO260 document as an acceptable interoperability source.
4.1.7 Current Issues with ADS-B for Surface Movements

The first implementations and use of ADS-B on airport and onboard aircraft have revealed several technical issues:

- Discrepancy between the aircraft positions given by the ADS-B system and the position given by other sensors (MLAT, SMR), which are considered as more accurate. The same may apply also for the identification, when the Pilot inputs the aircraft identification.

- Discrepancy with ADS-B report update rate: some targets are not updated for several seconds, while others are and other target reports sometimes simply cease for a while, and re-appear later on.

Note that the Mode S ADS-B standard (RTCA DO-260A) and EMMA AGFA requirements (see 5.1.2.1) state that stationary targets shall enter, after a while, a low rate mode which means:

- positional update (surface position extended squitter ADS-B message) once every 5 seconds
- identity update (identity and type extended squitter ADS-B message) once every 10 seconds.

Such requirement shall be further investigated in order to ensure that aircraft moving again after a stationary state (30s at a holding point for instance) immediately update their target reports accordingly.

- Latency of target reports: there can be an unacceptably high delay (> 1 second) between the calculation of the target position by the on-board system and the receipt of the target position report by the ground system.

- Missing heading information: heading of ADS-B targets is usually lost when they stop, and recovered when they start moving again.

- Inaccurate ground speed information. (This is not a serious problem for ground systems since they are able to perform their own calculations of target velocity).

- Multipath effects due to buildings and other obstructions: not investigated yet.

In addition, the introduction of the surveillance service to flight crews (see 2.2.1) requires that the surveillance data provided to the aircraft is of adequate quality to ensure:

- Correctness and Completeness of the traffic situation picture provided to the flight crew (the traffic situation picture must include all relevant traffic, including targets not equipped with cooperative surveillance means)
- Consistency between the traffic situation picture provided to flight crew and the one provided to the ATCOs

These critical issues will be addressed in EMMA2. The following guidelines have been devised by the EMMA consortium:

- The first task is to ensure that the technical standard for ADS-B/TIS-B are sufficient to fulfil A-SMGCS operational requirements, without inducing controller and pilot confusion or additional workload.

The related requirements in this document and the TRD (D1.4.2 for aircraft and ground architecture) [6], [7], on identification / position / state vector accuracy, update rate and integrity shall be adequate.
In addition, abnormal events, for instance an aircraft transmitting erroneous information, shall be detected by the ground system (this is currently realised during the sensor data fusion) and the correction shall be broadcast to other aircraft.

- The current procedure for operating the Mode-S transponder on airports (defined by Eurocontrol) may need to be amended to ensure that the correct setting for ADS-B are made PRIOR to ANY MOVEMENT.

The current procedure ensures that the departing aircraft are correctly transmitting the correct identification PRIOR to ANY MOVEMENT.

It is not expected to create new flight crew procedures during surface movements for the inspection of ADS-B information.

4.2 CPDLC for Ground Clearance and Taxi Route Uplink

4.2.1 Controller-Pilot Data Link Communication (CPDLC)

The Controller Pilot Data Link Communication (CPDLC) application is an air traffic service (ATS) application in which pilots and controllers exchange messages via a data link.

CPDLC includes a set of clearance/information/request message elements, which correspond to existing phraseology employed by current Air Traffic Control procedures.

The pilot is provided with the capability to request clearances and information, to respond to messages, to report information and to declare an emergency.

The controller is provided with the capability to issue clearances and give information, to respond to pilot’s requests and to issue warnings or alerts.

Note: The use of the acronym “CPDLC” in this document does not imply any choice between technological environment or applications, such as ATN based CPDLC or ARINC 623 based services.

4.2.2 Rationale for CPDLC in EMMA

In the context of EMMA and airport surface movements in general, the use of CPDLC is aimed at reducing the use of voice communications between ATCO and Flight Crews for NON TIME-CRITICAL COMMUNICATIONS.

The expected benefits of using data link instead of voice communication is the reduction of potential communication errors and the decrease of workload on the Flight Crew side (no hand copy of ATC instructions, use of pre-defined messages) and on the ATCO side (use of pre-defined messages).

In the context of EMMA, only a limited subset of the defined CPDLC services is intended for operational use:

- **DCL – Departure Clearance:** encompasses the request for departure clearance from Pilots and subsequent changes of estimated off-block time (EOBT), the issue of departure clearance by ATCO, which includes the approved off-block time (OBT), the take-off runway and SID, and subsequent changes to the approved OBT

- **D-TAXI:** encompasses the request for start-up / push-back clearances (when applicable), for taxi clearance from Pilots and the issue of such clearance including taxi route information (and subsequent changes) from ATCO.
4.2.3 Data Link Systems for CPDLC

Within the timeframe of EMMA (up to 2020), 2 main types of aircraft supporting CPDLC need to be considered:

1. ARINC 623 services or FANS-1/A compliant aircraft:

Several air-ground data link services are currently provided via VHF radio and satellites links to aircraft equipped using the Aircraft Communications Addressing and Reporting System (ACARS) avionics, standardized by the Airlines Electronic Engineering Committee (AEEC).

Originally ACARS was designed to support aircraft operator communications (AOC) but a limited subset of Air Traffic Service (ATS) communications using the ARINC 622 or ARINC 623 standards have been defined. ARINC 623 is currently used for the request/issue of ATIS information and departure clearance (DCL) at several European Airports.

Since ACARS was designed, the ATS providers have defined a Future Air Navigation System (FANS) that will provide improved services through use of new technologies including data link, and a first generation of FANS applications has been implemented using ACARS air-ground data links (ARINC 622).

FANS-1/A is primarily intended for communications within oceanic or remote airspace but is also currently used for the request/issue of FAA pre-departure clearance at several US airports.

2. ATN compliant aircraft:

To define a new data link system designed to meet the long term needs of ATS applications the International Civil Aviation Organization (ICAO) has developed standards for the Aeronautical Telecommunication Network (ATN) and the VHF Digital Link (VDL) Mode 2.

These ICAO standards provide the framework for the transition to a new ATS data link communications infrastructure from the current ACARS system.

ATN is primarily intended for air-ground communications within high traffic density airspace (core area of Europe for instance).

The long term target for the Pilot - Controller exchanges for airport surface movements is to make use of the ATN data link applications that are currently planned (CPDLC) for deployment in European airspace.

During the transition period towards ATN deployment, some of the Pilot - Controller data link services for airport operations will be available using the existing ARINC-623 ATC or FANS-1/A applications (as the Departure Clearance DCL service today). It is recognised that these applications are not necessarily suited to cover the full scope of Pilot-Controller exchanges particularly to support the taxi movements.

From ground system perspective, the development of communication systems able to accommodate both types of aircraft at the same time (i.e. multiple ground communication stacks) is recommended as typical lifecycle for avionics equipments is above 10 years. The proposed architecture for the ground system is included in the D1.4.2a document.

4.2.4 Status of CPDLC Services and Standard Documents

The standard specifications for CPDLC services relevant in the context of EMMA have been achieved or are currently in progress, the reference documentation is described below:

Operational Service Specification
• DCL: departure clearance, standard specification is included in the Eurocontrol ODIAC ORD, see [19]
• D-TAXI: the specification of this data link services is currently under development as part of the Eurocontrol AIDA project (Airport Integrated Data link Applications part of CASCADE Programme), a draft version of the specification, see [20], has been used for this document.

Safety and Performance Requirements
EUROCAE ED-120, Safety and Performance Requirements Standard For Initial Air Traffic Data Link Services In Continental Airspace, see [15], constitutes the basis for performance and safety requirements related to the use of CPDLC in the context of EMMA.

EUROCAE ED-85A for Service Definition, Safety, Performance and Interoperability Requirements for DCL Data Link Service using the ACARS/ARINC 623 Technology (DLASD - Data Link Application Service Document)
The DCL service is covered both by ED-120 (ATN service) and by ED-85A (ARINC 623 based service). A set of initial safety and performances requirements for D-TAXI are currently identified in EMMA D2.4.1 FRD for CPDLC [9] but their consolidation with Eurocontrol AIDA project is not achieved yet.

ARINC 623, FANS-1/A and ATN Standards
The reference documents are:
• ARINC specification 623-1 - Character Oriented Air Traffic Services (ATS) applications, December 12, 1997, or further applicable edition (e.g. ARINC 623-2) and/or further improvement necessary for EMMA Air-Ground Data Link Services enhancement
• ARINC specification 622-2 - Processes for ATS Data-link applications over ACARS air-ground network, December 20, 1994, or further applicable edition (e.g. ARINC 622-3) and/or further improvement necessary for EMMA Air-Ground Data Link Services enhancement
• EUROCAE ED-100A, Interoperability Requirements For ATS Applications Using ARINC 622 Data Communications
• EUROCAE ED-110A document, Interoperability requirements standard for ATN Baseline 1 (prepared by WG53) and the ICAO Doc 9705, Manual of Technical Provisions for the Aeronautical Telecommunication Network.

4.2.5 CPDLC Services Overview
In the context of EMMA, the use of data link services is intended for non time-critical communications between Pilots and ATCO for the request and issue of clearances:
• Departure clearance (DCL service): approx. 20 min before start-up/push-back of the aircraft, the Pilots request the departure clearance, which contains departure information (runway assigned, SID), possibly amended by revisions of the departure time (off-block time)
• Start-up / Pushback clearance (D-TAXI service): depending on the airport configuration and the stand allocated to the aircraft, the Pilots request start-up and/or push-back clearances prior to any surface movement. Potential delay for start-up/pushback may also be notified by the Pilots.
• Taxi clearance: when ready to taxi (on apron or runway exit), the Pilots request the taxi clearance, which contains the taxi route information (from runway exit to stand or from stand to runway
entry and then line-up and take-off or runway crossing).

The data link exchanges to support such clearance request/issue follow a generic pattern for information exchange between the aircraft and the current ATS Unit in charge of the aircraft (C-ATSU) as depicted in the following diagram.

![Diagram showing generic information exchange for DCL and D-TAXI]

Figure 4-2: Generic Information Exchange for DCL and D-TAXI

### 4.2.6 Current Issues for D-TAXI

A number of operational constraints and issues for the use of D-TAXI have been identified and are currently investigated by the EMMA Consortium and the Eurocontrol CASCADE programme:

- **ATC Controllers (ATCOs)** will have to cope with mixed datalink-equipped and non-equipped aircraft population
- **Head-down time** associated with the taxi clearances preparation/issue/read-back for ATCOs and their review/validation by Pilots is seen as an issue during taxi movements
- **How effective will taxi negotiations via data link be?** How to maintain quick decision making and execution allowed by voice communications for ‘tactical’ holdings to cope with large traffic on the taxiways and aprons?
- **How to handle “revert to voice”?**
  When the communication reverts to voice for safety purposes:
  - Is the datalink lost for the entire life of the aircraft on the airport surface
  - only for the remaining part of the sub-service, i.e. either start-up, pushback or taxi

In addition, several additions to the service have been identified during the preparation of the EMMA FRD for CPDLC [9].

- **How to handle “Crossing Runway Clearance” by datalink?**
An aircraft with a route to the holding point that crosses another runway:

- Should the route transmitted by DL only include intermediate points up to the clearance limit before the runway to cross

OR

- the full route to the holding point

OR

- transmission of a non-cleared overall route up to the holding point for informational purposes ("guidance"), and single clearances for cleared sections of the overall route ("control").

- Taxi-in and information message before aircraft has landed
  
  Information such as preferred runway exit, arrival stand, planned taxi route (standard), etc. may be uploaded during the intermediate approach (typically during the flight crew approach briefing):
  
  - This is not a clearance but information
  
  - The benefit of having this information in the cockpit before landing should be looked at by questioning pilots during the trials.

- Line-up and take-off clearances by datalink
  
  Should the clearances related to the runways, like crossing (or backtracking), lining-up, and take-off, be sent by datalink and/or by voice?

  The benefits of doing so are relating to the detection of runway incursions instead of potential collision. However, it has to be studied if the datalink performances are compatible with the criticality of such clearances.

4.3 FIS-B

4.3.1 Flight Information Service Broadcast (FIS-B)

The FIS-B service allows the broadcast of flight information via text messages transmitted in the 1090 MHz band used for ADS-B and TIS-B.

4.3.2 Rationale for using FIS-B

While developing the EMMA OSED Update, the issue of using datalink for providing safety alerts has been raised.

During a flight, the pilot is in charge of the navigation of his/her own aircraft and the controller is in charge of managing safely and efficiently the airport traffic.

When considering to whom and when to give an alert, one has to keep in mind this general principle and the time needed to solve the potentially hazardous situations before emergency actions shall be taken by flight crews.

From the operational perspective, the time ahead for ATCOs to receive safety alerts is higher than for flight crews or vehicle drivers. If time ahead is sufficient, the alert should be given only to the controller who is the only one to know the whole situation and so be in the best position to resolve it.
Emergency actions for vehicle drivers may be advised by the ground system ("stop" or "leave runway") taking the benefit that vehicles can easily vacate runways or taxiways at any point (moving on the grass).

It is required that such messages should not have a strong impact in terms of bandwidth on the 1090 data link (see requirement FIS-B_MODE_S_01) and not impact on primary services such as Surveillance.

Within EMMA, the proposal to potentially use FIS-B to transmit safety alerts to vehicles using FIS-B has been discussed: the use of 1090 MHz for such critical messages is not recommended.

The same issue may be extended to consider also downlink messages (coming from vehicles) in order to request guidance or vehicle dispatch information from a ground-handling agent.

### 4.4 D-OTIS

The D-OTIS service provides automated assistance to flight crews by delivering updated meteorological and operational flight information (based on METAR, ATIS, NOTAM/SNOWTAM and PIREPS) specifically relevant to the departure, approach and landing phases of flight.

The specification for the use of the D-OTIS service in the context of EMMA for aeronautical information exchange (air-ground) is part of the EMMA2 project.
5 EMMA Interoperability Requirements

This section presents the interoperability requirements identified to ensure the air-ground interactions for EMMA services. The sub-sections include the interoperability requirements associated with the data link services used (ADS-B, TIS-B, CPDLC, FIS-B) and covers:

- Technical standards used for datalinks (aircraft and ground)
- Usage or non-usage of available data elements and message types and reports
- Quality of service requirements associated with exchanged information
- Abnormal event handling and recovery, and interoperability requirements associated with recovery from those modes.

5.1 ADS-B

5.1.1 General Remarks and Rationale

In the A-SMGCS ground domain, the use of ADS-B is to be considered as a supplement to or, in the longer term, perhaps as a replacement for MLAT. By far the most important advantages foreseen as being obtainable with the use of ADS-B are the ability to provide accurate and timely position information about aircraft and to provide the unambiguous identity of each aircraft, while keeping RF pollution within acceptable levels. In this context, the use of ADS-B is seen to offer benefits in terms of safety and increased capacity.

The fact that ADS-B will also permit other information such as speed, heading, turn rate, climb rate, roll angle, waypoints and intent to be down linked is of little or no consequence to the A-SMGCS.

Therefore, the basic requirement for the on-board ADS-B is that it should continuously transmit/receive accurate and timely information on:

- Aircraft / vehicle identity,
- Aircraft / vehicle position,
- Accuracy of position measurement, and
- Time of position measurement

For surveillance purposes, the following parameters are interesting:

- Aircraft parameters required for the surveillance service are: position, identity, track/heading (transmitted through BDS 0.5, BDS 0.6 and BDS 0.8)
- Airborne ESS and ESP parameters required for the surveillance service are: position integrity, position accuracy, Mode S health (transmitted through BDS 0.7).

For control purposes, the following parameters are interesting:

- Aircraft parameters required for the control service: velocity and track/heading and time (transmitted through BDS 0.6 and BDS 0.9)
- Airborne ESP parameter required for the control service: velocity accuracy (transmitted through BDS 0.9).

For routing and guidance A-SMGCS services, the same information as above applies.
5.1.1.1 Aircraft / Vehicle Identity

For an aircraft equipped with a Mode S transponder, there are three possible identifiers:

- Aircraft Mode A code
- Aircraft Address (24-bit Mode S Address)
- Aircraft Identification (Callsign from BDS register 2.0)

The Mode A code is entered into the transponder by the pilot to identify the flight. Because there are only 4096 codes available, the Mode A code may have to be changed during a flight.

The ICAO 24-bit Aircraft Address is an individual and unique identification number assigned to each aircraft. It cannot be changed from the cockpit.

On modern transponders, the pilot can identify the flight by entering the Callsign, as recorded in the associated Flight Plan, into the transponder or flight management system. This information will eventually be used by ATC systems as the primary means of identifying flights and will replace the current usage of Mode A codes for this purpose. Requirements for the format of the Mode S Aircraft Identification are detailed in ICAO Annex 10 [23].

5.1.1.2 Aircraft / Vehicle Position Information

If ADS-B is to be really useful in the A-SMGCS domain, it is essential that the position reports are at least as accurate as those provided by SMR and Multilateration systems, i.e. 7.5 metres or better. It is equally important that ADS-B position reports include Figure of Merit (FoM) data to inform the Ground system that the source of the position measurement (i.e. the on-board navigation system) is operating correctly and that it is indeed providing position data of the required accuracy.

5.1.1.3 Time of Position Measurement

Each ADS-B position report must include a precise timestamp indicating the time at which the position was measured.

5.1.1.4 Latency

Equally as important as the accuracy of the position information is the timeliness of the information. Delays in the processing and downlinking of position information must be kept short or the information will be unusable. For example, a latency figure of 2 seconds between the measurement of the aircraft position and the presentation of the position information to the controller means that a aircraft / vehicle moving at 30 knots will progress approximately 30 metres after the measurement is made. This means that, if the original measurement error is 5 metres, by the time the information is presented to the controller the aircraft / vehicle can be as much as 35 metres from the position shown for the target. Since the operational requirement (yet to be validated) for A-SMGCS is currently stated as 7.5 metres, there is virtually no margin for delay in collecting, transmitting, receiving, processing and displaying the position data.

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3 The Mode A code is not part of an ADS-B transmission; it has to be obtained by interrogation. In the longer term, once ADS-B becomes fully established, Mode A codes will no longer be used.
5.1.1.5 Update Rate

Due to the small distances involved and the rapid changes of speed and direction that aircraft / vehicles can make on the airport surface, the position information should be updated at a high rate. In practice, an update rate of once per second has been found to be acceptable, but a higher rate could be desirable. For identity information, a lower update rate is acceptable. A mobile’s identity should be confirmed at least every 10 seconds.

5.1.1.6 Embedded System Status (ESS) & Performances (ESP)

Embedded System Status messages provide:

- The status of the transmitting ADS-B function
- The status of the navigation system used in ADS-B messages.

The performances of an ADS-B system address the following parameters:

- **Accuracy of the transmitted position**: NAC (Navigation Accuracy Category)
  The NACp is reported so that surveillance applications may determine whether the reported geometric position has an acceptable level of accuracy for the intended use.
  NIC and NACp replace the earlier term NUCp used in the ICAO Annex10 Vol III document [23].
  The NACp is based on the EPU (Estimated Position Uncertainty), which is a 95% accuracy bound on the horizontal position.
  EPU is defined as the radius of a circle, centred on the reported position, such that the probability of the actual position being outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure Of Merit). Likewise, the Vertical EPU stands for the vertical figure of merit for GNSS-based systems.
  For example, NACp=5 for EPU<926 m (0.5NM).

- **Integrity of the transmitted position and velocity**:
  1. NIC (Navigation Integrity Category) for position and velocity
     The NIC is reported so that surveillance applications may determine whether the reported geometric position has an acceptable level of integrity for the intended use. The NIC parameter is intimately associated with the SIL (Surveillance Integrity Level) parameter described below.
     The NIC parameter specifies an integrity containment radius Rc. The SIL parameter specifies the probability of the true position lying outside that containment radius without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used.
     For example, NIC=2 for Rc<14.816 km (8NM).
     NIC is reported by an aircraft because there will not be a uniform level of navigation equipage among all users. Although GNSS is intended to be the primary source of navigation data used to report ADS-B position data (and is the only source with acceptable accuracy for the A-SMGCS application), it is anticipated that during initial uses of ADS-B/TIS-B, or during temporary GNSS outage an alternate source of navigation may be used for transmission.
  2. SIL (Surveillance Integrity Level)
The Surveillance Integrity Level defines the probability of the integrity containment radius used in the NIC parameter being exceeded, without detection, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used by the navigation source.

For example, SIL=2 for a probability of exceeding the \( R_c \) integrity containment Radius without detection of \( 10^{-5} \) per flight hour or per operation.

- **Surface squitter rate selected (High/Low)**

This squitter indicates the selected rate used for surface squitter transmitting (high or low).

### 5.1.1.7 Addressing/Routing Aspects

The interfaces between aircraft and ground systems concern 1090ES ADS-B only, i.e. all exchanges are made via the Mode-S transponder.

- Interoperability between aircraft and the MLAT system is covered by 1090ES ADS-B
- No interoperability is needed between aircraft and non-cooperative surveillance sensors such as SMR
- Interoperability between aircraft and ground MET systems (e.g. D-ATIS data link service) is not in the scope of EMMA
- Interoperability between A-SMGCS and ground systems is addressed in document D142a_TRD-Ground [6] and interoperability between A-SMGCS components and onboard systems is addressed in document D142b_TRD-Airborne [7].

The protocols within the Mode S system permit to uplink messages intended for all aircraft in the coverage area and to downlink messages to be made available to all interrogators.

### 5.1.1.8 Security Aspects

Today, no security functions against malicious attack – jamming – spoofing (to generate false reports) have been defined for dependant surveillance networks.

A special focus shall be paid in the future on aircraft navigation instruments spoofing (GPS), on communication signal spoofing (1090 MHz for Mode S for instance) and on flooding external messages.
5.1.1.9 Interface Specification Issues

Figure 5-1: Interface Specification

Information transferred across the data link must undergo several stages of processing between the information generator (aircraft subsystems) and the information users, either the ATCO or another flight crew. This is summarized in the diagram above.

Issues:

Aircraft internal format changes – between supplier avionic sub-systems and dedicated functions such as the ADS-B message compiler. Data access is not an issue since the necessary data is available on data buses, but to compute performance may be a concern depending on the capacity of the processing platforms.

Data processing and data synchronisation required for the compilation/receiving of the ADS-B message – data compilation/computation latencies, which are acceptable for airborne applications, may be marginal for surface movement support.

Data link technology – the data link will use a standard message format but, depending on the transmission technology selected, it could impose bandwidth limitations and unwanted real-time latency.
## 5.1.2 List of Requirements for ADS-B

### 5.1.2.1 ADS-B-Out Aircraft /Vehicle

The following table provides the technical interoperability requirements for aircraft (also applicable to vehicles if 1090ES is used for them). The detailed description of 1090 ES ADS-B is provided in Annex I - State of the Art for Mode S.

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comments</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_MODE_S_01</td>
<td>Aircraft or vehicle shall be equipped with Class B extended squitter systems (providing a transmission only capability without reception capability)</td>
<td>Mode S extended squitter transmitting/receiving equipment is classified according to the unit’s range capability and the transmitting/receiving capabilities.</td>
<td>RTCA/DO260A MOPS 1090 MHz Extended Squitter</td>
</tr>
<tr>
<td>INT_MODE_S_02</td>
<td>Ground systems shall be equipped with Class C extended squitter systems (providing a reception only capability without transmission capability)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_MODE_S_03</td>
<td>The aircraft/vehicle shall transmit the following extended mode S extended squitters for transmitting position, identity, track/heading and velocity parameters: BDS 0.5: extended squitter airborne position BDS 0.6: extended squitter surface position BDS 0.8: extended squitter aircraft identification and category BDS 0.9: extended squitter airborne velocity</td>
<td>For transmitting Aircraft Parameters as defined in chapter 5.1.1.</td>
<td>RTCA/DO260A MOPS 1090 MHz Extended Squitter</td>
</tr>
<tr>
<td>INT_MODE_S_04</td>
<td>The aircraft/vehicle shall transmit the following extended mode S extended squitters for transmitting system status and performance: BDS 0.7: extended squitter status (provide capability and status of the ES rate of the transponder)</td>
<td>For transmitting Embedded System Status (ESS) and Performances (ESP) as defined in chapter 2.3.3.</td>
<td>RTCA/DO260A MOPS 1090 MHz Extended Squitter</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>INT_MODE_S_05</td>
<td>The aircraft/vehicle shall be compliant with the minimum update rates as defined in the RTCA/DO260A MOPS document, which are summarized below.</td>
<td></td>
<td>RTCA/DO260A MOPS 1090 MHz Extended Squitter</td>
</tr>
<tr>
<td></td>
<td><strong>Airborne Position: 0.4-0.6s</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Surface position High rate: 0.4-0.6s</strong></td>
<td>When navigation source position has been changed more than 10 meters in a 30 seconds sampling interval</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Surface position Low rate: 4.8-5.2 s</strong></td>
<td>When navigation source position has not been changed more than 10 meters in a 30 seconds sampling interval</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Identification: 4.8-5.2 s</strong></td>
<td>If reporting Airborne position Or if reporting Surface position at a High rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Identification: 9.8-10.2 s</strong></td>
<td>If surface is reported at a low rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Velocity: 0.4-0.6 s</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Target State and Status: 1.2-1.3 s</strong></td>
<td>Transmitted only when the aircraft is airborne and transmit Target data</td>
<td></td>
</tr>
</tbody>
</table>
### Air-Ground Functional Architecture (AGFA Update)

#### 5.1.2.2 ADS-B-In Ground

The following table provides the technical interoperability requirements for ground systems supporting ADS-B:

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TECH_GND_01</td>
<td>The ADS-B Ground Station shall be capable of receiving and decoding 1090ES messages from transponders.</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comment</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>INT_TECH_GND_02</td>
<td>The ADS-B Ground Station shall process Mode S ADS-B messages and output the positional information, the target identity, the appropriate validity time, and any quality, mode, or other A-SMGCS relevant information included in the ADS-B message. The system shall be able to decode the ADS-B information as defined in the most recent version of the ICAO Manual on Mode S Specific Services, or its successor.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_03</td>
<td>The ADS-B Ground Station should be capable of interfacing with the A-SMGCS time reference using the Network Time Protocol (NTP) for the purpose of time synchronisation.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_04</td>
<td>The ADS-B Ground Station shall output target report data to the SDF via LAN using the ASTERIX CAT010 data format.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_05</td>
<td>The ADS-B Ground Station shall output a periodic service message at a rate of once per second. As a minimum the system shall report 3 types of status: operational, degraded and NOGO. At a minimum, the message shall contain the following ASTERIX fields:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Message Type</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Data Source Identifier</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Time of Day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• System Status</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_06</td>
<td>The ADS-B Ground Station cases and antennas should be mounted on a suitable building, mast, or tower. The chosen site should permit clear line of sight to all parts of the specified coverage area. If necessary, multiple stations have to be installed, to ensure full coverage for the complete airport movement area.</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comment</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>INT_TECH_GND_07</td>
<td>Power Supplies</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_08</td>
<td>Electromagnetic Compatibility</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_09</td>
<td>Lightning Protection</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_10</td>
<td>Latency</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_11</td>
<td>Capacity</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_12</td>
<td>Probability of Detection</td>
<td></td>
</tr>
</tbody>
</table>

All ADS-B Ground Station electrical equipment should operate from standard mains voltage and frequency at the airport. Consideration should be given to the need for an uninterruptible power supply both for power conditioning and to support the system in the event of a mains power failure for an appropriate time, consistent with the availability and continuity of service requirements.

The ADS-B Ground Station shall have appropriate EMI/EMC characteristics for operation in an airport environment. The ADS-B Ground Station shall not interfere with other airport electrical, electronic, or communications equipment and the performance of the MLAT system shall not be in any way affected by other equipment on or near the airport.

The ADS-B Ground Station and associated data links shall include appropriate lightning conductors and transient protection to ensure continued operation during lightning storms without equipment failure.

The delay between the Mode S signal reception and outputting the target report from the ADS-B Ground Station shall not exceed 0.25 seconds.

The ADS-B Ground Station shall be able to support xx targets (level of performance to be defined) at a time creating one target report per target at least once per second.

For a target that correctly transmits its position, the ADS-B Ground Station shall extract and provide the correct target position with a probability of better than 99.9%.
<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comment</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TECH_GND_13</td>
<td>Probability of Identity</td>
<td>For a target that correctly transmits its identity, the ADS-B Ground Station shall extract and provide the correct target identity with a probability of better than 99.9%.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_14</td>
<td>Probability of False Detection</td>
<td>The probability of the ADS-B Ground Station outputting False Targets shall be less than $10^{-5}$.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_15</td>
<td>Probability of False Identification</td>
<td>The probability that the ADS-B Ground Station incorrectly identifies a target that correctly transmits its identity shall be less than $10^{-6}$ over any 5-second period per target.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_16</td>
<td>Start-up and Restart</td>
<td>The ADS-B Ground Station shall be fully operational within 3 minutes of initial start-up or restart including instances of main power loss.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_17</td>
<td>Continuity of Service</td>
<td>The ADS-B Ground Station shall be capable of sustained operation 24 hours a day throughout the year. An ADS-B Ground Station should be designed and configured for a dual redundant configuration, in order to minimise failure. In most cases, redundancy in the processing and message distribution will be necessary to ensure adequate availability and that essential maintenance could be carried out without interrupting operation.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_18</td>
<td>Switchover to Back-up</td>
<td>For ADS-B Ground Station systems configured with redundant processors, the time for switchover from primary to backup shall be ≤ 3 seconds with no loss of target data.</td>
<td></td>
</tr>
<tr>
<td>INT_TECH_GND_19</td>
<td>Integrity Monitoring</td>
<td>The ADS-B Ground Station should include performance and integrity monitoring based on one or more field-mounted test transponders, enabling the verification of the end-to-end performance of the ADS-B system.</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-2: Ground ADS-B-In Interoperability Requirements
### 5.1.2.3 ADS-B-In Aircraft / Vehicle

The following table provides the interoperability requirements for airborne ADS-B receiving:

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comment</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TECH_AIRB_01</td>
<td>Aircraft or vehicle shall be equipped with <strong>Class A extended squitter systems</strong> (providing both transmission and receiving capabilities)</td>
<td>Mode S extended squitter transmitting/receiving equipment is classified according to the unit’s range capability and the transmitting/receiving capabilities. This class allows ADS-B and TIS-B reception.</td>
<td>DO242A/MASPS ADS-B</td>
</tr>
<tr>
<td>INT_TECH_AIRB_02</td>
<td>The ADS-B receiving system shall be able to decode the ADS-B information (squitters) as defined in the most recent version of the RTCA/DO260A document (version 1) or eventually its former version DO260 (version 0).</td>
<td></td>
<td>RTCA/DO260A MOPS 1090 MHz Extended Squitter</td>
</tr>
<tr>
<td>INT_TECH_AIRB_03</td>
<td>The ADS-B receiving system shall be capable of time-stamping the decoded ADS-B message. For ADS-B message containing position information, the time stamp shall represent the time of applicability of the position. For all other messages, the time stamp shall represent the time of report composition or the time of receipt of the ADS-B message.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TECH_AIRB_04</td>
<td>The delay between the Mode S signal reception and outputting the decoded ADS-B message from the ADS-B receiving system shall not exceed 2.0 milliseconds.</td>
<td>DO260A requirement (section 2.2.6) Added with transmission delays to contribute to report time errors.</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comment</td>
<td>Source</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
</tbody>
</table>
| INT_TECH_AIRB_05 Association | The ADS receiving system shall use the content of the 24-bit address field:  
• to correlate all ADS-B messages transmitted from each aircraft/vehicle  
• To differentiate it from other aircraft/vehicles in the operational domain. | The 24-bit address is provided with each ADS-B squitter.                                               |        |
| INT_TECH_AIRB_06 Availability | ADS-B availability shall be 0.95 for aircraft/vehicle ADS-B receiver subsystems. |                                                                                                         |        |
| INT_TECH_AIRB_07 Integrity | The integrity of an ADS-B system based on 1090 ES link shall be $10^{-5}$ or better per ADS-B message (supporting undetected error data or error rate). | ADS-B system integrity is defined in the MASPS (RTCA DO-242A, §3.3.6.5) in terms of the probability of an undetected error in a report received by an application, given that the transmitting ADS-B system participant is supplied with correct source data. An important component of ADS-B integrity is attributable to radio interference, whose effects are largely controlled by the use of error detection and correction applied upon reception. |        |

Table 5-3: Aircraft/Vehicle ADS-B-In Interoperability Requirements
### 5.1.2.4 Dynamic Functions / Operations

As ADS-B exchanges are not based upon connected communications concept but rely on broadcast communications, there is no specific related dynamic requirements.

The table below provides the operational requirements applicable on the ADS-B exchanges:

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comment</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TECH_ADSB_OP_01</td>
<td>All aircraft/vehicle addresses shall be unique within the dedicated airport domain. ADS-B systems that broadcast vehicle identification information shall be designed and installed such that the identification information must be manually confirmed by the vehicle operator prior to operation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TECH_ADSB_OP_02</td>
<td>Aircraft with Mode-S transponders using an ICAO 24-bit address shall use the same 24-bit address for ADS-B.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TECH_ADSB_OP_03</td>
<td>In case of any failure of ADS-B transmitting or receiving systems, the flight crew/driver or ATC controller shall be notified through adequate means.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TECH_ADSB_OP_04</td>
<td>When the performance levels of ADS-B transmitted information regarding latency or integrity are not reached for a specific target, the flight crew/driver or ATC controller shall be notified through adequate means.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TECH_ADSB_OP_05</td>
<td>The ADS-B receiving system shall operate in high-density airspace.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TECH_ADSB_OP_06</td>
<td>The minimum ADS-B-Out to ADS-B-In Operational Range (95% squitters receiving) is 5 Nm for airport operations.</td>
<td></td>
<td>DO242A/MASPS ADS-B</td>
</tr>
</tbody>
</table>

Table 5-4: ADS-B Dynamic Functions Interoperability Requirements
5.2 TIS-B

5.2.1 General Remarks and Rationale

The main TIS-B service is only to broadcast traffic information about aircraft/vehicle that cannot be adequately obtained directly by ADS-B. This service enhances the availability of surveillance information to users that are not able to receive ADS-B transmissions from other aircraft/vehicles due to a number of possible constraints:

- Some aircraft/vehicles on the airport are not ADS-B equipped
- Aircraft/vehicle may be equipped with different ADS-B datalink than 1090 MHz ES (e.g. UAT, VDL-4)
- ADS-B transfer during ground operations may be limited by line-of-sight blockage or RF co-channel interference. This is in some part due to the layout of the airport and is a potential problem for data acquisition. The ADS-B availability requirement does not take this into account, and other means will be required to cover line-of-sight drop-out (i.e. TIS-B), where this is significant at particular airports.

The content of messages produced by the TIS-B system is standardized within RTCA/DO286 MASPS for TIS-B and adapted to the 1090 MHz ES link in the RTCA/DO260A MOPS for ADS-B/TIS-B document.

The current ICAO SARPs Annex10 Vol III does not treat TIS-B message definition.

The same kind of information as transmitted by ADS-B is expected for A-SMGCS services.

For surveillance purposes, the following parameters are interesting (the name of the associated squitters are extracted from the RTCA/DO260A document and presented in the section “6.3 TIS-B messages”):

- Aircraft parameters required for the surveillance service are: position, identity, track/heading transmitted through:
  - “TIS-B Fine airborne position Extended Squitter” (DO260A section 2.2.17.3.1)
  - “TIS-B Fine surface position Extended Squitter” (DO260A section 2.2.17.3.2)
  - “TIS-B identification & type Extended Squitter” equal to BDS 0.8 used for ADS-B (DO260A section 2.2.17.3.3)
  - “TIS-B Coarse position Extended Squitter” (DO260A section 2.2.17.3.5)

- Airborne ESS and ESP parameters required for the surveillance service are: position integrity, position accuracy (transmitted through “TIS-B airborne velocity Extended Squitter” – DO260A section 2.2.17.3.4)

For control purposes, the following parameters are interesting:

- Aircraft parameters required for the control service: velocity and track/heading (transmitted through “TIS-B Coarse position Extended Squitter” and “TIS-B airborne velocity Extended Squitter”).
- Airborne ESP parameters required for the control service: velocity accuracy (transmitted through “TIS-B airborne velocity Extended Squitter”).
5.2.1.1 Aircraft/Vehicle Identity
The basic identification information conveyed by the TIS-B system shall include the following elements if they are available:

- Target address and Address Qualifier (either ICAO 24-bit address or ICAO Mode A Code)
- Call Sign
- Target Category

5.2.1.2 Aircraft / Vehicle Position Information
Position information is transmitted in a form that can be translated without loss of accuracy, integrity to latitude, longitude, geometric height and barometric pressure altitude.

5.2.1.3 Time of Applicability
The time of applicability of TIS-B messages indicates the time at which the reported values were valid (computed from the reception time). Time of applicability shall be provided in all reports containing State Vector information.

5.2.1.4 Latency
TIS-B system latency is the component of latency attributed to the TIS-B system, which is composed of ground and aircraft systems.

The TIS-B latency is measured from the time of sensor measurement to the TOA computed in the TIS-B receiving system.

5.2.1.5 Update Rate
TIS-B messages use one of two levels of precision (Fine and Coarse) in reporting position. Coarse format data are derived from a ground radar with an update rate of approximately once per 5 seconds and is expected to have a positional accuracy less than that of TCAS.

Fine TIS-B messages derived from multilateration have an update rate of approximately once per second and are expected to have a positional accuracy that is greater than that of TCAS.

5.2.1.6 Embedded System (ESS) & Performance (ESP)
The same considerations apply as for the ADS-B rationale (refer to chapter 5.1.1.5).

The parameters NIC/SIL related to integrity and NACp/NACv related to position and velocity accuracy are also provided through a dedicated TIS-B message.

5.2.1.7 Addressing/Routing/Security Aspects
The same considerations apply as for the ADS-B rationale (refer to sections 5.1.1.6 and 5.1.1.7).
5.2.1.8 Interface Specification Issues

Information transferred across the data link must undergo several stages of processing between the information generator (ground subsystems) and the information users, either the flight crew or driver. This is summarized in the diagram above.

One issue raised by the introduction of the TIS-B link is to fuse on-board traffic information provided by ADS-B and TIS-B systems, which will be the scope of a dedicated airborne function.

The detailed description of 1090 ES TIS-B is provided in Annex I - State of the Art for Mode S.
### 5.2.2 List of Requirements for TIS-B

#### 5.2.2.1 TIS-B Out Ground

The following table lists the interoperability requirements applicable for a TIS-B service in the airport environment. Source references to [10] are maintained for ease of traceability.

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comments</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TISB_01</td>
<td>Ground systems shall be equipped with Class C extended squitter systems (providing a reception-only capability without transmission capability)</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.1-02</td>
</tr>
<tr>
<td>INT_TISB_02</td>
<td>The TIS-B system shall be capable of providing reports for aircraft, vehicles and designated obstacles in the aerodrome movement area.</td>
<td>Could split the requirement into two requirements for implementation in different steps (depending on the evolution of data link capacity)</td>
<td>RTCA MASPS (DO-286) 2.1-03</td>
</tr>
<tr>
<td>INT_TISB_03</td>
<td>Universal Coordinated Time (UTC) shall be used as the standard reference for time to ensure synchronization among all TIS-B system components.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.1-07</td>
</tr>
<tr>
<td>INT_TISB_04</td>
<td>The TIS-B system shall provide sufficient information to the airborne surveillance processing subsystem to enable it to determine the quality of each TIS-B target.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.1-08</td>
</tr>
<tr>
<td>INT_TISB_05</td>
<td>The TIS-B system shall provide sufficient information to the airborne surveillance processing subsystem to enable it to determine the availability of all implemented TIS-B services.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.1-09</td>
</tr>
<tr>
<td>INT_TISB_06</td>
<td>In support of its Fundamental Service, the TIS-B system shall provide traffic information for all targets within its Coverage Volume.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TISB_07</td>
<td>The TIS-B system shall support security measures that ensure data transmitted.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>INT_TISB_08</td>
<td>The TIS-B system shall monitor its ability to provide the implemented services.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.1-13</td>
</tr>
<tr>
<td>INT_TISB_09</td>
<td>The TIS-B system shall report the status of the implemented services.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.1-14</td>
</tr>
<tr>
<td>INT_TISB_10</td>
<td>When the full resolution of available aircraft data cannot be accommodated within a TIS-B message, a common quantization algorithm shall be used to ensure consistent performance across different implementations.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.2-01</td>
</tr>
<tr>
<td>INT_TISB_11</td>
<td>The system shall provide TIS-B reports to the aircraft client application.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.3-01</td>
</tr>
<tr>
<td>INT_TISB_12</td>
<td>Time of applicability shall be provided in all reports containing State Vector information.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.3-03</td>
</tr>
<tr>
<td>INT_TISB_13</td>
<td>The TIS-B system shall convey the ICAO Mode S Address in TIS-B reports about targets for which this address is available.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.3-06</td>
</tr>
<tr>
<td>INT_TISB_14</td>
<td>The TIS-B system shall provide the means for the receiving system application to differentiate TIS-B reports from ADS-B reports.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.3-07</td>
</tr>
<tr>
<td>INT_TISB_15</td>
<td>The TIS-B system shall preserve the anonymity of designated targets.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.3-08</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>INT_TISB_16</td>
<td>The Target Address and Address Qualifier shall be included in all TIS-B reports.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-09</td>
</tr>
<tr>
<td>INT_TISB_17</td>
<td>The TIS-B system shall be able to convey the ICAO Aircraft Identification (call sign) for a target.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-10</td>
</tr>
<tr>
<td>INT_TISB_18</td>
<td>TIS-B shall be able to convey the target category.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-11</td>
</tr>
<tr>
<td>INT_TISB_19</td>
<td>Position information shall be transmitted in a form that can be translated, without loss of accuracy and integrity, to latitude, longitude, geometric height, and barometric pressure altitude.</td>
<td>Height and altitude may not be available for surface targets. “Ground” indication can be sent.</td>
<td>RTCA MASPS (DO-286) 2.3-12</td>
</tr>
<tr>
<td>INT_TISB_20</td>
<td>All geometric position elements shall be referenced to the WGS-84 datum.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-13</td>
</tr>
<tr>
<td>INT_TISB_21</td>
<td>Barometric pressure altitude shall be reported referenced to standard temperature and pressure.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 2.3-14</td>
</tr>
<tr>
<td>INT_TISB_22</td>
<td>The TIS-B system shall convey altitude information in accordance with DO-242A §2.1.2.6.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 2.3-15</td>
</tr>
<tr>
<td>INT_TISB_23</td>
<td>TIS-B reports for which a geometric height is available shall be provided when the accuracy and integrity requirements meet those specified in DO-242A §2.3.9 and §2.3.8 respectively.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 2.3-17</td>
</tr>
<tr>
<td>INT_TISB_24</td>
<td>The TIS-B system shall convey velocity information in accordance with DO-242A §2.1.2.7.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
</tr>
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</tr>
<tr>
<td>INT_TISB_25</td>
<td>The TIS-B system shall use the Navigation Integrity Categories defined in DO-242A Table 2-2 to describe the integrity containment radius, RC, associated with the horizontal position information in TIS-B messages.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-18</td>
</tr>
<tr>
<td>INT_TISB_26</td>
<td>The TIS-B system shall use the Navigation Accuracy Categories defined in DO-242A Table 2-3 to describe the accuracy of positional information in TIS-B messages.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-23</td>
</tr>
<tr>
<td>INT_TISB_27</td>
<td>The TIS-B system shall use the Navigation Accuracy Categories defined in DO-242A Table 2-4 to describe the accuracy of velocity information in TIS-B messages.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-24</td>
</tr>
<tr>
<td>INT_TISB_28</td>
<td>The TIS-B system shall encode the Surveillance Integrity Level (SIL) as indicated in DO-242A Table 2-5.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-25</td>
</tr>
<tr>
<td>INT_TISB_29</td>
<td>The TIS-B system shall be capable of supporting the broadcast of emergency and/or priority status if this information is available to the TIS-B system.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-26</td>
</tr>
<tr>
<td>INT_TISB_30</td>
<td>The TIS-B system shall determine the air/ground state of a target in accordance with the tests one through four that are specified in DO-242A §3.4.3.1.1.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.3-27</td>
</tr>
<tr>
<td>INT_TISB_31</td>
<td>TIS-B report acquisition shall be considered accomplished when all report elements required for an ASA application have been received by the TIS-B participant.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.4-01</td>
</tr>
<tr>
<td>INT_TISB_32</td>
<td>The TIS-B report shall meet the update period and the percentile update period requirements for each ASA application the TIS-B system is supporting.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.4-02</td>
</tr>
<tr>
<td>INT_TISB_33</td>
<td>The TIS-B system shall assure the acquisition of TIS-B reports throughout the</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
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</tr>
<tr>
<td>INT_TISB_34</td>
<td>The TIS-B system latency shall meet or exceed the latency requirements of the associated ASA applications.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.5-01</td>
</tr>
<tr>
<td>INT_TISB_35</td>
<td>The standard deviation and mean report time error for both position and velocity shall be in accordance with DO-242A §3.3.3.2.2.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.5-01</td>
</tr>
<tr>
<td>INT_TISB_36</td>
<td>The TIS-B system shall be capable of meeting the capacity requirements in DO-242A §3.3.4.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.6-01</td>
</tr>
<tr>
<td>INT_TISB_37</td>
<td>The TIS-B system shall use the ADS-B RF medium and meet the requirements in DO-242A §3.3.5.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.7-01</td>
</tr>
<tr>
<td>INT_TISB_38</td>
<td>The probability that the TIS-B system is unavailable during an operation, presuming that the system was available at the start of that operation, shall be no more than [TBD] per flight hour.</td>
<td>[TBD after EMMA 2 tests]</td>
<td>RTCA MASPS (DO-286) 2.8-01</td>
</tr>
<tr>
<td>INT_TISB_39</td>
<td>Using the ADS-B MASPS as guidance, the end-to-end integrity of the TIS-B system shall be $10^{-6}$ or better on a per report basis.</td>
<td></td>
<td>RTCA MASPS (DO-286) 2.8-02</td>
</tr>
<tr>
<td>INT_TISB_40</td>
<td>All data elements within a TIS-B Track Report shall correspond to a common Time of Applicability.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-07</td>
</tr>
<tr>
<td>INT_TISB_41</td>
<td>A TIS-B Track Report shall refer to a single target.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-08</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
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</tr>
<tr>
<td>INT_TISB_42</td>
<td>A TIS-B Track Report shall contain the data elements in Table 3-1.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-09</td>
</tr>
<tr>
<td>INT_TISB_43</td>
<td>Target Address field shall report either an ICAO 24-bit address assigned to the particular target about which the report is concerned or another kind of address that is unique (e.g., combination of tracker identification and track number) within the operational domain, as determined by the Address Qualifier.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-10</td>
</tr>
<tr>
<td>INT_TISB_44</td>
<td>The Address Qualifier field shall indicate whether the Target Address is the ICAO address or another kind of address that is unique within the operational domain.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-11</td>
</tr>
<tr>
<td>INT_TISB_45</td>
<td>Call Sign field shall be reported as specified in DO-242A §3.4.4.4.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-12</td>
</tr>
<tr>
<td>INT_TISB_46</td>
<td>Target Category field shall be reported as specified in DO-242A §3.4.4.5.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-13</td>
</tr>
<tr>
<td>INT_TISB_47</td>
<td>Time of Applicability shall be reported as specified in DO-242A §3.4.3.3.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-14</td>
</tr>
<tr>
<td>INT_TISB_48</td>
<td>NACP shall be encoded as specified in DO-242A Table 2-3.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-15</td>
</tr>
<tr>
<td>INT_TISB_49</td>
<td>NACV shall be encoded as specified in DO-242A Table 2-4.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-16</td>
</tr>
<tr>
<td>INT_TISB_50</td>
<td>NIC shall be encoded as specified in DO-242A Table 2-2.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
</tr>
<tr>
<td>----------</td>
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<td>--------------------------</td>
</tr>
<tr>
<td>INT_TISB_51</td>
<td>SIL shall be encoded as specified in DO-242A Table 2-5.</td>
<td></td>
<td>3.1-17</td>
</tr>
<tr>
<td>INT_TISB_52</td>
<td>Emergency/priority status, if available to the TIS-B system, shall be encoded as specified in DO-242A §3.4.4.8.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>INT_TISB_53</td>
<td>The IDENT Switch Active flag is a 1-bit Operational Mode code. This flag shall be set to the normal condition in accordance with DO-242A (§3.4.10.2).</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>INT_TISB_54</td>
<td>If the Air/ground State cannot be determined, the default value for the Air/Ground State field shall be “Uncertain whether airborne or on the surface”</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>INT_TISB_55</td>
<td>If the Air/ground State cannot be determined, the TIS-B reports shall include all required data elements for an airborne target.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>INT_TISB_56</td>
<td>The TIS-B Version Number shall be defined as specified in Table 3-2.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>INT_TISB_57</td>
<td>The State Vector shall contain the data elements in Table 3-3.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>INT_TISB_58</td>
<td>Horizontal Position shall be reported as specified in DO-242A §3.4.3.4.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>INT_TISB_59</td>
<td>Horizontal Position Valid field shall be encoded as specified DO-242A §3.4.5.</td>
<td></td>
<td>RTCA MASPS (DO-286)</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
</tr>
<tr>
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<td>-----------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>INT_TISB_60</td>
<td>Geometric Altitude shall be reported as specified in DO-242A §3.4.3.6.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 3.1-30</td>
</tr>
<tr>
<td>INT_TISB_61</td>
<td>Geometric Altitude Valid field shall be encoded as specified DO-242A §3.4.3.7</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 3.1-31</td>
</tr>
<tr>
<td>INT_TISB_62</td>
<td>Geometric horizontal velocity (i.e., North and East Velocity While Airborne fields) shall be reported as specified in DO-242A §3.4.3.8.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 3.1-32</td>
</tr>
<tr>
<td>INT_TISB_63</td>
<td>Airborne Horizontal Velocity Valid field shall be encoded as specified DO-242A §3.4.3.9.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 3.1-33</td>
</tr>
<tr>
<td>INT_TISB_64</td>
<td>Ground Speed While on the Surface field shall be reported as specified in DO-242A §3.4.3.10.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 3.1-34</td>
</tr>
<tr>
<td>INT_TISB_65</td>
<td>Surface Ground Speed Valid field shall be encoded as specified DO-242A §3.4.3.11.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 3.1-35</td>
</tr>
<tr>
<td>INT_TISB_66</td>
<td>Heading While on the Surface field shall be reported as specified in DO-242A §3.4.3.12.</td>
<td>Where relevant (airborne targets).</td>
<td>RTCA MASPS (DO-286) 3.1-36</td>
</tr>
<tr>
<td>INT_TISB_67</td>
<td>Heading Valid field shall be encoded as specified DO-242A §3.4.3.13.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-37</td>
</tr>
<tr>
<td>ID</td>
<td>Requirement</td>
<td>Rationale / Comments</td>
<td>Source</td>
</tr>
<tr>
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</tr>
<tr>
<td>INT_TISB_68</td>
<td>Report Mode field is a 1-bit field, which shall be ZERO if only measurement data are used to derive the State Vector.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-43</td>
</tr>
<tr>
<td>INT_TISB_69</td>
<td>The Report Mode field shall be ONE if track data (e.g., estimated) are used to derive the State Vector.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.1-44</td>
</tr>
<tr>
<td>INT_TISB_70</td>
<td>The TIS-B Target Report shall contain the data elements in Table 3-5.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.2-08</td>
</tr>
<tr>
<td>INT_TISB_71</td>
<td>All data elements within a TIS-B Target Report shall correspond to a common Time of Applicability.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.2-09</td>
</tr>
<tr>
<td>INT_TISB_72</td>
<td>Target Reports for targets located within multiple Service Volumes shall be broadcast so as to support the requirements of the Service Volume with the most rigorous requirements.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.2-11</td>
</tr>
<tr>
<td>INT_TISB_73</td>
<td>The Ground Link Specific Processing Subsystem shall broadcast TIS-B Messages on the applicable data link(s), including retransmissions appropriate to provide the expected probability of detection to meet the Application Categories and Service Level for the implemented ASA applications.</td>
<td></td>
<td>RTCA MASPS (DO-286) 3.3-04</td>
</tr>
</tbody>
</table>

Table 5-5: Ground TIS-B-Out Interoperability Requirements
5.2.2.2 TIS-B In Aircraft / Vehicle

The following requirements applicable to the ADS-B receiving system (refer to section 5.1.2.3) are also applicable for TIS-B message reception:

- INT_TECH_AIRB_01 _Input
- INT_TECH_AIRB_03_TimeStamp
- INT_TECH_AIRB_04_Latency
- INT_TECH_AIRB_06_Availability
- INT_TECH_AIRB_07_Integrity

The following table provides specific airborne TIS-B receiving interoperability requirements:

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comment</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TECH_TISB_AIRB_01 Receiving</td>
<td>The TIS-B receiving system shall be able to decode the TIS-B information (squitters) as defined in the most recent version of the RTCA/DO260A document.</td>
<td>No TIS-B messages definition in former version of RTCA/DO260 document.</td>
<td>RTCA/DO260A MOPS 1090 MHz Extended Squitter</td>
</tr>
</tbody>
</table>
| INT_TECH_TISB_AIRB_02 Association | The TIS-B receiving system shall use the content of the 24-bit address or Mode A/Track Number field:  
- To correlate all ADS-B messages transmitted from each aircraft/vehicle  
- To differentiate it from others aircraft/vehicles in the operational domain | The 24-bit address or the Mode A code is provided with each ADS-B squitter.          |                             |

Table 5-6: Aircraft/Vehicle TIS-B-In Interoperability Requirements
5.2.2.3 Dynamic Functions / Operations

As TIS-B exchanges are not based upon the connected communications concept but rely on broadcast communications; there are no specifically related dynamic requirements.

The following requirements applicable to the ADS-B receiving system (refer to section 5.1.2.4) are also applicable for TIS-B message reception:

- INT_TECH_ADSB_OP_03 failure monitoring
- INT_TECH_ADSB_OP_04 performance monitoring
- INT_TECH_ADSB_OP_05 high-density environment
- INT_TECH_ADSB_OP_06 range

The table below provides the specific operational requirements applicable on the TIS-B exchanges:

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comment</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_TECH_TISB_OP_01 Unique address</td>
<td>All aircraft/vehicle Mode A codes (if provided) shall be unique within the dedicated airport domain.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_TECH_TISB_OP_02 Maw Ground Station</td>
<td>The TIS-B receiving system shall manage messages received from up to 2 TIS-B stations simultaneously.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5-7: TIS-B Dynamic Functions Interoperability Requirements
5.3 CPDLC

5.3.1 General Remarks and Rationale

In the context of EMMA, the use of several CPDLC services is envisaged:

- **DCL – Departure Clearance**: encompasses the request for departure clearance from Pilots and subsequent changes of estimated off-block time (EOBT), the issue of departure clearance by ATCO, which includes the approved off-block time (OBT), the take-off runway and SID, and subsequent changes to the approved OBT.

- **D-TAXI**: encompasses the request for start-up / pushback clearances (when applicable), for taxi clearance from Pilots and the issue of such clearance from ATCO (and subsequent changes), which includes taxi route information.

The D-TAXI services is further decomposed into several sub-services:

- **Start-up**

  The request by the flight crew (if applicable) and the delivery by the ATCO of the start up approval as well as all related messages, in accordance with local procedures.

  **Note**: This sub-service is only applicable to operations where the start-up approval is not included in the DCL service (ref: ED 85 a, appendix A, para A.2.3)

- **Pushback**

  The request by the flight crew (if applicable) and the delivery by the ATCO of the pushback as well as all related messages, in accordance with local procedures.

- **Taxi OUT**

  The request by the flight crew of departure aircraft and the delivery by the ATCO of the first taxi clearance in accordance with local operational procedures.

- **Taxi IN**

  The request by the flight crew of arrival aircraft (runway vacated) and the delivery by the ATCO of the arrival taxi clearance in accordance with the local operational procedures.

- **Taxi UPDATE** (temporary note: fusion of previous “taxi update” and “taxi –in” messages)

  Routine ground movement related messages occurring between:
  - the time when the aircraft starts moving on its own power or when the flight crew has acknowledged the Taxi IN / OUT clearance, whichever is later
  - the arrival of the aircraft at destination at the assigned runway holding position or aircraft stand

Other standard CPDLC services such as ACL (ATC Clearance) and DSC (Downstream Clearance) may be used, but outside the context of ground clearance and taxi route uplink; their use is not further investigated in this document.

Such services are based on the exchange of pre-formatted messages between Pilots and Controllers.

5.3.2 Service Availability

Provided the aircraft log on to the air-ground data link network is successful (DLIC), the DCL service shall be available for all departing aircraft having a valid flight plan (validated by CFMU) with an
estimated off-block time (EOBT) within a threshold value (typically within 30 minutes). The DCL service shall remain available until the flight crew requests the start-up/pushback clearance.

The D-TAXI service shall be available for:

- Departure aircraft: when the departure clearance has been issued successfully (using DCL or by voice)
- Arrival aircraft: all aircraft having successfully vacated their landing runway and being transferred from the runway ATCO to the ground ATCO.

N.B.: As explained in 4.2.5, the provision of information about preferred runway exit and standard taxi routes is not yet included in the D-TAXI ORD [20].

5.3.3 Termination of the Services

The CPDLC services have explicit termination conditions:

- DCL, START-UP, PUSH & TAXI-OUT sub-services end when the C-ATSU automatically transfers a logical acknowledgement to the aircraft indicating the reception of the related pilot acknowledgement of the clearance
- D-TAXI sub-services end automatically when the departing aircraft reaches its departure runway holding point, or when the arriving aircraft shuts down its engines at its destination stand.

In addition, termination time-outs are associated to each message exchange (see generic pattern in Figure 4-2) in order to monitor the timely execution of the dialog between flight crews and ATCOs. Specific timeouts are defined for the successful reception of:

- logical acknowledgement of message reception generated by the receiving system (LACK)
- explicit acknowledgement from the flight crew (PAM)

In case a response is not provided within a specified timeframe, the dialog is automatically terminated on both air and ground systems.

The values of termination time-outs are specified in the standard ED-120 [15] and they are currently being specified by the Eurocontrol CASCADE project for D-TAXI [20] (draft version only).

5.3.4 Addressing / Routing / Security

For ATN aircraft DLIC is a data link service that is derived from the Context Management application to provide the necessary information to make data link communications possible between an ATSU and aircraft.

The DLIC service makes it possible to:

- Unambiguously associate flight data from the aircraft with flight plan data stored by an ATSU
- Exchange the supported application type and version information and to deliver application address information.

The DLIC service is air-initiated. The log on parameters provide aircraft identification and application addresses to ATS units for identification and flight plan correlation as well as for use in subsequent CPDLC services.
The ICAO ATN manual [22] contains the high-level security requirements for the ATN. Such technical provisions have not been investigated within the context of this document.

5.3.5 Service Message Structure

The CPDLC service messages have a pre-defined structure, which is initially investigated during the EMMA project, benefiting from the EUROCONTROL AIDA project and will be validated as part of the EMMA-2 project:

- DCL: no change to the EUROCAE standard ED-110A, see [16]
- D-TAXI: information exchanges identified in D1.3.5 ORD, see [4], proposed message structure specified in EMMA D2.4.1 FRD for CPDLC Ground Clearance, see [9]

The quality of service (QoS) requirements for the performance of the dialog between flight crews and ATCOs and for each CPDLC service are “implemented” within each message exchanged through the following attributes:

- Message Category
- Communications Priority
- Information Urgency
- Information Security
  - Data Origin Authentication
  - Access Control
  - Data Integrity
### 5.3.6 List of Requirements for CPDLC

#### 5.3.6.1 General Requirements for Aircraft and Ground Systems

The following table contains the general technical interoperability requirements identified for ground and aircraft systems; these requirements are further refined in the EMMA D2.4.1 FRD [9] for CPDLC Ground Clearances.

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comment</th>
<th>Source</th>
</tr>
</thead>
</table>
| INT_CPDLC_01   | The aircraft shall prepare, send, receive and decode all CPDLC messages for DCL and D-TAXI services in accordance with:  
- the technical requirements for such services  
- the applicable datalink application standard: ATN Baseline 1 standard (ED-110A) OR ARINC 623-1 OR FANS-1/A standard (ED-100A). | ATN service is not expected to be ready to use in the beginning of EMMA time scale. Therefore, it might be needed to use ARINC 623 applications on ACARS/AOA service. | EMMA D2.4.1  |
| INT_CPDLC_02   | The ground system shall prepare, send, receive and decode all CPDLC messages for DCL and D-TAXI services in accordance with:  
- the technical requirements for such services  
- the applicable datalink application standard: ATN Baseline 1 standard (ED-110A) OR ARINC 623-1 OR FANS-1/A standard (ED-100A). |                                                                                   |              |
| INT_CPDLC_03   | Before operating the DCL or D-TAXI service, the aircraft and ground systems shall have first exchanged the datalink application naming and addressing information. |                                                                                   |              |

Table 5-8: General CPDLC Interoperability Requirements for Aircraft and Ground Systems
5.3.6.2 Dynamic Functions / Operations

The following table contains the high-level operational interoperability requirements for CPDLC identified for aircraft and ground systems, these requirements are further refined in the EMMA D2.4.1 FRD [9] for CPDLC Ground Clearances.

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement</th>
<th>Rationale / Comment</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_CPDLC_OP_01</td>
<td>The aircraft and ground systems shall follow the operational rules (availability, sequence of exchanges, normal mode and abnormal mode) for DCL and D-TAXI services as defined in DCL and D-TAXI ORDs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_CPDLC_OP_02</td>
<td>The aircraft and the ground systems shall notify within a specified timeframe respectively the flight crew and the (concerned) ATCO upon the receipt of any CPDLC service message.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_CPDLC_OP_03</td>
<td>The aircraft and the ground systems shall notify within a specified timeframe respectively the flight crew and the (concerned) ATCO about the unexpected termination of on-going CPDLC service (e.g. timeout termination).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INT_CPDLC_OP_04</td>
<td>The aircraft and the ground systems shall notify within a specified timeframe and thus remind the flight crew and the (concerned) ATCO, when upon the transmission of a message the respective the LACK and/or PAM has not been issued.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5-9: CPDLC Dynamic Functions Interoperability Requirements
6 Annex I - State of the Art for Mode S

6.1 Mode S Background

The Mode S messages fall into two types: uplink and downlink.

The name of a Mode S message format begins with UF (Uplink Format) or DF (Downlink Format). Mode S protects the data it transmits thanks to the calculation of parity bits, which are superposed on those of the Mode S address. Surveillance formats (uplink or downlink) include 56 bits that can be divided into 3 parts:

- Format descriptor (5 bits),
- Control and command fields (27 bits)
- Address field/parity (24 bits).

Moreover, there are formats with 112 bits which add to the previous formats a 56-bit field allowing to transfer digitised data in both directions.

Mode S is not only an improvement of SSR technique and logic. It is also a support for air-ground data link. These combined surveillance/data-link formats are called COMM-A in the uplink direction and COMM-B in the downlink direction. This is a generic term and less precise than the UFxx or DFyy terminology. For example, UF16 formats (special long surveillance), UF20 (request of altitude) or UF21 (request of code A) are COMM-A.

Other pure air-ground data-link formats also exist which include a data field of 80 bits, which increases the data-link capacity. These formats are called “COMM-C/D” and are not used for surveillance exchanges.

Thanks to its longer formats and to its roll-call capacity, Mode S enables to exchange digital data with a particular aircraft. To do this, Mode S transmissions between the station and the transponder use highly sophisticated 56 or 112-bit formats called frames that fall into two main categories:

- 56-bit surveillance formats (including that with the Mode A code and that with the Mode C code). 24 of these 56 bits form the address/parity field: Where applicable, Mode A or Mode C is included in the 32 command bits. Formats such as these can be used in the up and down directions.

- 112-bit communication formats with a 56-bit data field, which are in fact “extended” surveillance formats (which therefore also include Mode A or Mode C code in the 32 bits of the command field, as applicable). In the ground-to-air direction, a format such as this is called “COMM-A” and its 56-bit data field “MA field”. In the air-to-ground direction, the letter B is used instead of letter A (COMM-B, MB field). COMM-A and COMM-B carry the name SLM (Standard Length Message). To increase the rate, 4 COMM-A/B frames can be chained together.

In the second case, COMM-B frames can be exchanged through two different protocols:

- GICB protocol (Ground Initiated COMM-B), which allows, on a ground request, to downlink information stored in a given register (BDS). These registers are also accessible for the 1090 Extended Squitter technique.

6.2 ADS-B Messages

Extended squitter, which periodically broadcasts data (ADS-B) relying on specific BDS registers (position 05, 06, velocity 09, identification). Various items of information are distributed in several
squitters transmitted with different update rates. The transponder actually carries a series of 256 BDS registers of 56 bits each, in which information concerning the flight and aircraft status are stored and updated. Each BDS register, identified by an order number, contains data of a precise nature formatted according to a predetermined code. Such formats are described in ICAO Annex10, Vol III and RTCA/DO260A documents.

These 1090 extended squitter messages are those available for the “Message exchange” function of ADS-B transmitting and receiving systems.

The ADS-B on Mode S relies on Extended Squitter format DF17. According to ICAO Annex 10 description, different squitter types are available, though following the same format.

<table>
<thead>
<tr>
<th>Squitter format</th>
<th>Mode S capabilities</th>
<th>ICAO address</th>
<th>ADS-B message</th>
<th>Parity</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF=17</td>
<td>CA</td>
<td>AA</td>
<td>ADS-B message ME field</td>
<td>PI</td>
</tr>
<tr>
<td>[5]</td>
<td>[3]</td>
<td>[24]</td>
<td>[56]</td>
<td>[24]</td>
</tr>
</tbody>
</table>

Table 6-1: Extended Squitter Format

ADS-B messages provide the ICAO 24-bit address of the transmitting aircraft in order to identify the message source.

The ME field of the Extended Squitter is entirely dedicated to ADS-B messages (Mode S registers). The first information conveyed in the ME 56-bit field is the message type coded on 5 bits.

The following tables provide relevant Mode S BDS description compliant with the RTCA/DO260A MOPS 1090 MHz Extended Squitter document.

A detailed description of these messages is given in RTCA DO-260A. Below is a short description of these BDS.

6.2.1 Airborne Position Extended Squitter BDS 0.5

BDS 0.5 means that the content of transponder register 05 is provided in the ME (message field) of the extended squitter (refer to chapter 3.4.4).

This squitter intends to provide the aircraft position in flight. It encodes different parameters such as (first line gives the associated number of bits):

<table>
<thead>
<tr>
<th>[5]</th>
<th>[2]</th>
<th>[1]</th>
<th>[12]</th>
<th>[1]</th>
<th>[1]</th>
<th>[34]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Surveillance status</td>
<td>Single Antenna</td>
<td>Altitude</td>
<td>Time</td>
<td>CPR format</td>
<td>Encoded latitude/longitude</td>
</tr>
</tbody>
</table>

Table 6-2: Airborne Position Extended Squitter BDS 0.5

Type: This parameter allows identifying the squitter type amongst those listed below: (Airborne Position, Surface Position, Aircraft Identity & Category, Airborne Velocity, Target State and Status, Aircraft Operational Status). In the case of Position squitters, the TYPE field also encodes the Horizontal Containment Radius Limit (Rc), the Navigation Integrity Category (NIC) and the altitude format (geometric altitude versus barometric pressure altitude incremented by 25ft or 100ft).

- Surveillance status (used by Transponder for Mode A)
- Single antenna: indicates that the ADS-B transmitting system is operating with a single antenna
- Altitude (either GNSS height or barometric altitude as specified in the type field)
- Time (indicates whether the epoch of validity is an exact 0.2 second UTC epoch or is within 200 milliseconds of the time the message has been transmitted)
- CPR (Compact Position Reporting, indicates following position encoding mode)
- Latitude (GNSS latitude from the GPS or latitude computed by the FMS or the IRS)
- Longitude (GNSS longitude from the GPS or longitude computed by the FMS or IRS)

### 6.2.2 Surface Position Extended Squitter BDS 0.6

The surface position extended squitter encodes the following parameters in the 56-bit ME field:

<table>
<thead>
<tr>
<th>[5]</th>
<th>[7]</th>
<th>[1]</th>
<th>[7]</th>
<th>[1]</th>
<th>[1]</th>
<th>[34]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Movement</td>
<td>Heading Ground track status</td>
<td>Heading Ground track</td>
<td>Time</td>
<td>CPR format</td>
<td>Encoded latitude/longitude</td>
</tr>
</tbody>
</table>

Table 6-3: Surface Position Extended Squitter BDS 0.5

- Movement (a number characterizing the ground speed)
- Heading, ground track status (indicates if the heading or ground track is valid)
- Heading or ground track (clockwise from north indication)
- Time
- CPR format
- Encoded latitude/longitude

### 6.2.3 Extended Squitter Status BDS 0.7

The extended squitter status encodes the following parameters in the 56-bit ME field:

<table>
<thead>
<tr>
<th>[2]</th>
<th>[1]</th>
<th>[53]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission rate (TRS)</td>
<td>Altitude Type (ATS)</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

Table 6-4: Extended Squitter Status BDS 0.7

Transmission rate
- 0 = No capability to determine surface squitter rate
- 1 = High surface squitter rate selected
- 2 = Low surface squitter rate selected
- 3 = Reserved

Altitude Type (Barometric/GNSS)
6.2.4 Aircraft Identification and Category Extended Squitter BDS 0.8

The Identification (Ident) and Category extended squitter encodes the following parameters in the 56-bit ME field:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Emitter category</td>
<td>Ident Char#1</td>
<td>Ident Char#2</td>
<td>Ident Char#3</td>
<td>Ident Char#4</td>
<td>Ident Char#5</td>
<td>Ident Char#6</td>
<td>Ident Char#7</td>
<td>Ident Char#8</td>
</tr>
</tbody>
</table>

Table 6-5: Aircraft Identity and Category Extended Squitter BDS 0.8

- Emitter category: identifies the aircraft or vehicle category (glider, surface vehicle, etc…)
- Characters providing the aircraft call sign, , or if the call sign is not available, the Aircraft Registration Marking.

6.2.5 Airborne Velocity Extended Squitter BDS 0.9

6.2.5.1 Aircraft on the ground transmitting their velocity

The Airborne velocity extended squitter encodes the following parameters in the 56-bits ME field when the aircraft is on the ground:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Sub Type</td>
<td>Intent Change Flag</td>
<td>IFR Capability Flag</td>
<td>NACv</td>
<td>E/W Direction bit</td>
<td>E/W velocity</td>
<td>N/S Direction bit</td>
<td>N/S velocity</td>
<td>Vert rate source</td>
<td>Vert rate</td>
<td>Reserved Diff from baro altitude sign</td>
<td>Diff from baro altitude</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-6: Airborne Velocity Extended Squitter BDS 0.9

- Subtype: relative to subsonic/supersonic flight
- Intent change flag: used to indicate a change in intent
- IFR capability flag: relative to ADS-B equipage class A1 or above
- NACv stands for Navigation Accuracy Category for Velocity: 95% accuracy limits for velocity
- Vertical rate source (Geometric/Barometric)
- The Difference from barometric altitude field reports the difference between Geometric (GNSS or INS) altitude source data and barometric altitude when both are available and valid.
6.2.5.2 Aircraft Airborne Transmitting Heading and Airspeed

The Airborne velocity extended squitter encodes the following parameters in the 56-bit ME field when the aircraft is airborne:

<table>
<thead>
<tr>
<th>[5]</th>
<th>[3]</th>
<th>[1]</th>
<th>[1]</th>
<th>[3]</th>
<th>[1]</th>
<th>[10]</th>
<th>[1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Sub Type</td>
<td>Intent Change Flag</td>
<td>IFR Capability Flag</td>
<td>NACv</td>
<td>Heading status bit</td>
<td>Heading</td>
<td>Airspeed Type</td>
</tr>
</tbody>
</table>

Table 6-7: Aircraft airborne transmitting heading and airspeed part 1

<table>
<thead>
<tr>
<th>[10]</th>
<th>[1]</th>
<th>[1]</th>
<th>[9]</th>
<th>[2]</th>
<th>[1]</th>
<th>[7]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airspeed</td>
<td>Vert rate source</td>
<td>Vert rate Sign</td>
<td>Vert rate</td>
<td>Reserved</td>
<td>Diff from baro altitude</td>
<td>Diff from baro altitude</td>
</tr>
</tbody>
</table>

Table 6-8: Aircraft airborne transmitting heading and airspeed part 2

- Heading status: available/not available
- Airspeed type: Indicated/True Air Speed

6.3 TIS-B Messages

The TIS-B ground-to-air transmissions use the same signal formats as 1090 MHz ADS-B and can therefore be accepted by a 1090 MHz ADS-B receiver. Similarly to ADS-B messages, the receiver can be shared with TCAS or can be a dedicated receiver.

TIS-B information is broadcast using the 112-bit Mode S DF=18 format as shown below:

<table>
<thead>
<tr>
<th>Squitter format</th>
<th>Control Field</th>
<th>Aircraft address</th>
<th>TIS-B message</th>
<th>Parity</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF=18</td>
<td>CF</td>
<td>AA</td>
<td>TIS-B message ME field</td>
<td>PI</td>
</tr>
<tr>
<td>[5]</td>
<td>[3]</td>
<td>[24]</td>
<td>[56]</td>
<td>[24]</td>
</tr>
</tbody>
</table>

Table 6-9: DF=18 Format

The CF Control field identifies the squitter type among those listed below:
- TIS-B Fine airborne position
- TIS-B Fine surface position
- TIS-B Identification & type
- TIS-B Airborne velocity
- TIS-B Coarse position
The “CF” field of DF=18 messages is used by Non-Transponder based installations. The ADS-B Receiving Subsystem accepts and processes DF=18 with Control Field=2 (Fine TIS-B message) and DF=18 with Control Field=3 (Coarse TIS-B message).

The ADS-B Receiving Subsystem interprets the AA field as either:

1. the 24-bit aircraft address or
2. the 12-bit Mode A code followed by a 12-bit track number fixed by the ground TIS-B station.

The “ME” Message Extended Squitter Field includes the different types of TIS-B messages which are presented hereafter in the following section (extracted from RTCA/DO260A document).

### 6.3.1 TIS-B Fine Airborne Position Extended Squitter

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[5]</td>
<td>[2]</td>
<td>[1]</td>
<td>[12]</td>
<td>[1]</td>
<td>[1]</td>
<td>[34]</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Surveillance status</td>
<td>IMF</td>
<td>Pressure Altitude</td>
<td>Reserved</td>
<td>CPR format</td>
<td>Encoded latitude/longitude</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-10: TIS-B Fine Airborne Position Extended Squitter

The parameters already defined in ADS-B chapter are coded the same way as specified in ADS-B formats:

- Type (Type of messages and also NIC/altitude source for Airborne and Surface position messages)
- Surveillance status
- IMF flag: indicates if the aircraft is identified with an ICAO 24-bits address or a Mode A address
- Altitude
- CPR
- Latitude/Longitude

### 6.3.2 TIS-B Fine Surface Position Extended Squitter

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[5]</td>
<td>[7]</td>
<td>[1]</td>
<td>[7]</td>
<td>[1]</td>
<td>[1]</td>
<td>[34]</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Movement</td>
<td>Heading Ground track status</td>
<td>Heading Ground track</td>
<td>IMF</td>
<td>CPR format</td>
<td>Encoded latitude/longitude</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-11: TIS-B Fine Surface Position Extended Squitter

The parameters already defined in ADS-B chapter are coded the same way as specified in ADS-B formats except for the IMF field described in the previous section.
6.3.3 TIS-B Identification & Type Extended Squitter

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Emitter category</td>
<td>Ident Char#1</td>
<td>Ident Char#2</td>
<td>Ident Char#3</td>
<td>Ident Char#4</td>
<td>Ident Char#5</td>
<td>Ident Char#6</td>
</tr>
</tbody>
</table>

Table 6-12: TIS-B Identification & Type Extended Squitter

The above parameters already defined in ADS-B chapter are coded the same way as specified in ADS-B formats.

6.3.4 TIS-B Airborne Velocity Extended Squitter

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Sub Type</td>
<td>IMF</td>
<td>NAC p</td>
<td>E/W direction bit</td>
<td>E/W velocity</td>
<td>N/S Direction bit</td>
<td>N/S velocity</td>
<td>Reserved Vert rate Sign</td>
<td>Vert rate</td>
<td>NIC supp</td>
<td>NAC v</td>
<td>SIL</td>
</tr>
</tbody>
</table>

Table 6-13: TIS-B Airborne Velocity Extended Squitter

- NACp reports the Accuracy for Airborne and Surface Position messages
- NIC supp, makes it possible to encode the NIC together with the NAC provided in the TYPE field of Airborne/Surface Position Messages.
- SIL defines the probability of the integrity containment radius used in the NIC subfield being exceeding without alerting

6.3.5 TIS-B Coarse Position Extended Squitter

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IMF</td>
<td>Surveillance status</td>
<td>Volume Service</td>
<td>Pressure Altitude</td>
<td>Ground track status</td>
<td>Ground track angle</td>
<td>Ground speed</td>
<td>CPR format</td>
<td>Encoded latitude/longitude</td>
</tr>
</tbody>
</table>

Table 6-14: TIS-B Coarse Position Extended Squitter

Volume service: identifies the TIS-B site providing the service
7 Annex II

7.1 References

[3] EMMA D1.3.1u Operational Service and Environmental Description (OSED Update), version 1.0, Jan 2006
[5] EUROCAE ED78-A (RTCA DO-264) Guidelines for approval of the provision and use of air traffic services supported by data communications, Dec 2000
[9] EMMA D2.4.1 Functional Requirements Document (FRD) CPDLC, latest version
[16] EUROCAE ED-110A, Interoperability requirements standard for ATN Baseline 1 (prepared by WQ53), August 2004
[17] EUROCAE ED-100A (RTCA DO-258A) Interoperability Requirements For ATS Applications Using ARINC 622 Data Communications (FANS 1/A+ INTEROP Standard), or further improvement necessary for EMMA Air-Ground Data Link Services enhancement
[18] Eurocontrol LINK 2000+ Baseline 1, version 1.1, May 2005
[19] Eurocontrol ODIAC ORD for DCL service, version 1.0, April 2001
[21] ICAO Doc 4444
[27] ARINC specification 622-2 - Processes for ATS Data-link applications over ACARS air-ground network, December 20, 1994, or further applicable edition (e.g. ARINC 622-3) and/or further improvement necessary for EMMA Air-Ground Data Link Services enhancement
[28] ARINC specification 623-1 - Character Oriented Air Traffic Services (ATS) applications, December 12, 1997, or further applicable edition (e.g. ARINC 623-2) and/or further improvement necessary for EMMA Air-Ground Data Link Services enhancement
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### 7.4 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Long Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC</td>
<td>Area Control Centre</td>
</tr>
<tr>
<td>ADS-B</td>
<td>Automatic Dependent Surveillance - Broadcast</td>
</tr>
<tr>
<td>AIP</td>
<td>Aeronautical Information Publication</td>
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<tr>
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End of the Document