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EUROCONTROL Specification

EUROCONTROL Specification for ATM Surveillance System Performance (Volume 1)

EUROCONTROL

EUROPEAN ORGANISATION
FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

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Abstract

This document provides performance requirements for ATM surveillance system when supporting 3 and 5 NM horizontal separation applications. This specification has been developed by an international group of experts from air navigation service providers, system manufacturers and national supervisory authorities. This document can be used by air navigation service providers to define, as required by Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011, the minimum performance that their surveillance system must meet. This specification also defines how the associated conformity assessment must be performed.

Keywords

Surveillance	ATM	Specification	Performance
Horizontal separation	Quality of service	Data item	SES

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The following table identifies all management authorities who have successively approved the present issue of this document.

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EXECUTIVE SUMMARY

This document provides performance requirements for ATM surveillance systems when supporting 3 and 5 NM horizontal separation applications. This specification has been developed by an international group of experts from Air Navigation Service Providers (ANSP), system manufacturers and National Supervisory Authorities (NSA).

This specification was developed in parallel with the draft Surveillance Performance and Interoperability Implementing Rule (SPI IR). On 21 November 2011 the final rule (Commission Implementing Regulation (EU) No 1207/2011) was published within the European Union Official Journal. This specification therefore complements and refines the requirements included in this Single European Sky (SES) regulation.

This document can be used by air navigation service providers to define, as required by Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011, the minimum performance that their surveillance system must meet. This specification also defines how the associated conformity assessment must be performed.

This specification is generic and independent of technology. It must be supplemented by specific local requirements that may be due to safety constraints, to local technological choices, to the need to support other services and functions and other local requirements. This specification is written to be compatible with recently published industry standards (EUROCAE) applicable to specific surveillance sensor technologies (ADS-B RAD and NRA and WAM).

The requirements defined in this specification are mainly derived from practical experience, operational needs analysis studies and technical studies.

Particular attention was paid to ensuring that each performance requirement is measurable and accompanied by an associated conformity assessment process. In this regard, measurements made on the basis of opportunity traffic are preferable as they fully reflect the system performance in its operational environment. Alternatively flight trials may also be undertaken. Proof offered through system design files or by system design assurance, the use of a test transponder or an injected test target is also acceptable when the other options are impracticable.

For the time being this specification is addressing the ATM surveillance systems performance needed to support 3 and 5 NM horizontal separation. In the future this specification may be extended to address other air traffic services (e.g. other horizontal separation minima) and/or functions.

This volume 1 contains the mandatory and recommended requirements whereas volume 2 [RD 1] contains informative appendices.

1 INTRODUCTION

1.1 Aim, scope and object of the document

This document has been developed to specify performance requirements applicable to surveillance system[1] and to define how the associated conformity assessments must be performed. Although the specified performance requirements are derived from operational requirements, it is not a document to verify operational acceptability of surveillance systems and it does not include a surveillance system generic safety assessment.

The aim of this document is to support ANSPs and NSAs in the implementation of [AD1].

This document introduces the concept of a surveillance application. A surveillance application is the support of a specific Air Traffic Service (ATS) or function using a specific category of surveillance system.

It also describes associated conformity assessment methods allowing ANSP to demonstrate compliance with this specification.

For each quality of service requirement this document provides specific quality indicators to assess the actual performance based on output data. It does not provide data quality indicators that might be used to select/reject information.

The content of this document is the consolidated and agreed result of work and inputs from different members of the ATM surveillance community including ANSP's, NSA's and Industry based on their experience with their surveillance systems.

The performance requirements defined in the main body of this document are minimum requirements independent of the environment and applicable to all surveillance systems.

Meeting these requirements alone is insufficient to demonstrate that the supported operation is safe. For example, availability of the system is not covered as it is strongly dependent on the local environment. The safe operation is proven through the development of a local surveillance system safety assessment produced in accordance with the provisions contained within [AD1].

1.2 The supported Air Traffic Services and functions

The different air traffic services and main functions that are based on surveillance information are described in ICAO PANS-ATM Document 4444 ([RD 9]) and are summarised in [RD 1] Appendix IV.

The air traffic services that are currently addressed in this document are:

- 3 NM horizontal separation combined with 1000 ft vertical separation when providing approach control service,
- 5 NM horizontal separation combined with 1000/2000 ft vertical separation when providing approach control service or area control service.

In the future, this document may be extended to the support of other air traffic services and functions for which technical performance specification could be defined. It may address other types of air traffic services (aerodrome control service) and/or the same ATC services when providing other separation minima and/or air traffic functions (e.g. safety net) provided either on the ground or in the air.

[1] In the context of this document surveillance system is restricted to equipment only, not covering people and procedures.

1.3 Category of surveillance system

In this document a surveillance system is the set of equipment providing surveillance information under the form of digitized messages.

This document considers both cooperative and non-cooperative categories of surveillance systems:

- A cooperative surveillance system relies on and requires equipment on board the aircraft. Such a system can provide all the surveillance data items pertaining to an aircraft including information coming from the aircraft itself (e.g. pressure altitude, aircraft identity).
- A non-cooperative surveillance system does not require equipment on board the aircraft but cannot provide information coming from the aircraft.

1.4 Structure of the document

This document is structured in 2 volumes.

Volume 1 contains:

- Section 1 (this section) presents the aim of the document and the addressed air traffic services and functions, explains its structure and describes the intended readers.
- Section 2 details the approach and the rationale that have been followed to develop this document. Additionally it describes the role of the document in the design process of a surveillance system.
- Section 3 provides the ATM surveillance system performance specifications.
- Section 4 defines the conformity assessment criteria corresponding to each of the requirements defined in section 3.
- Annex - A describes the scope of the ATM surveillance system and its functions.
- Annex - B provides the list of the referenced documents and the definitions of the acronyms used.
- Annex - C provides the definitions of the data items, performance characteristics and environments referenced in this document.

Volume 2 [RD 1] contains:

- Appendix I provides high level justifications of the selection of the qualities of service specified in section 3.
- Appendix II provides traceability and justification links towards referenced documents.
- Appendix III summarises the different air traffic services and functions that are based on surveillance information.
- Appendix IV analyses the ability of different surveillance system designs meeting the performance requirements specified in Volume 1.
- Appendix V provides further details on the OPA scenarios defined in section 3.
- Appendix VI provides an approach based on a specific collision risk model to justify a sub-set of the requirements.

1.5 Intended readers

The intended readers of this document include:

- The departments of the civil and military ANSP of ECAC countries who are responsible for procuring/designing, accepting, and maintaining ATM surveillance systems.
- The departments of the National Supervisory Authorities of ECAC countries who are responsible for verifying ATM surveillance systems.
- International standardisation bodies.
- The engineering industry department who are responsible for developing ATM surveillance systems and/or their components.

1.6 Relationship with ICAO approach

ICAO has recognised the benefit of defining the required performance of a surveillance system independent of the technologies that could be used. To this end a Required Surveillance Performance (RSP) concept is currently being developed by ICAO. This document can contribute to these ICAO activities.

2 DOCUMENT DEVELOPMENT APPROACH AND ROLE

2.1 Document development context

In order to develop this document several aspects have been taken into account:

- The lessons learnt from the application of the EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas [RD 2].
- The Single European Sky legislation.

These 2 aspects are further detailed in the following paragraphs.

2.1.1 Lessons learnt

This document takes into account the lessons learnt from the application of the EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas [RD 2], which are:

- Difficulties in practically assessing some specified requirements.
- Only applicable to SSR and PSR whereas new surveillance technologies are now available (Mode S, WAM, ADS-B) and difficulties to transpose requirements to other technologies (e.g. MSPSR).
- Imposed high level implementation choices (2 SSR for en-route and one PSR + 2 SSR for major TMA) and difficulties to transpose requirements for other architectures.
- Lack of traceability between supported air traffic services or functions (i.e. users needs) and technical requirements.
- …

It also takes into account lessons learnt from past and ongoing EUROCONTROL surveillance deployment programmes and surveillance performance appraisal activity.

2.1.2 Single European Sky (SES) regulation

The SES regulation is based on the 4 following EC regulations

- EC Regulation 549/2004 (the framework Regulation) amended by Regulation (EC) 1070/2009 (SES II)
  - Objective to establish a harmonized regulatory framework for the creation of the single European sky
- EC Regulation 550/2004 (the service provision Regulation) amended by Regulation (EC) 1070/2009 (SES II)
  - Objective to establish common requirements for the safe and efficient provision of air navigation services in the Community
- EC Regulation 551/2004 (the airspace Regulation) amended by Regulation (EC) 1070/2009 (SES II)
  - Objective to support the concept of progressively more integrated operating airspace and to establish common procedures for airspace design, planning and management
- EC Regulation 552/2004 (the interoperability Regulation) amended by Regulation (EC) 1070/2009 (SES II)
  - Objective and scope
    - Ensure interoperability between systems, constituents and associated procedures of the EATMN
    - Ensure the coordinated and rapid introduction on new agreed and validated concepts of operations or technology

Figure 1 further explains the "Interoperability Regulation" in which this document is aimed to fall.

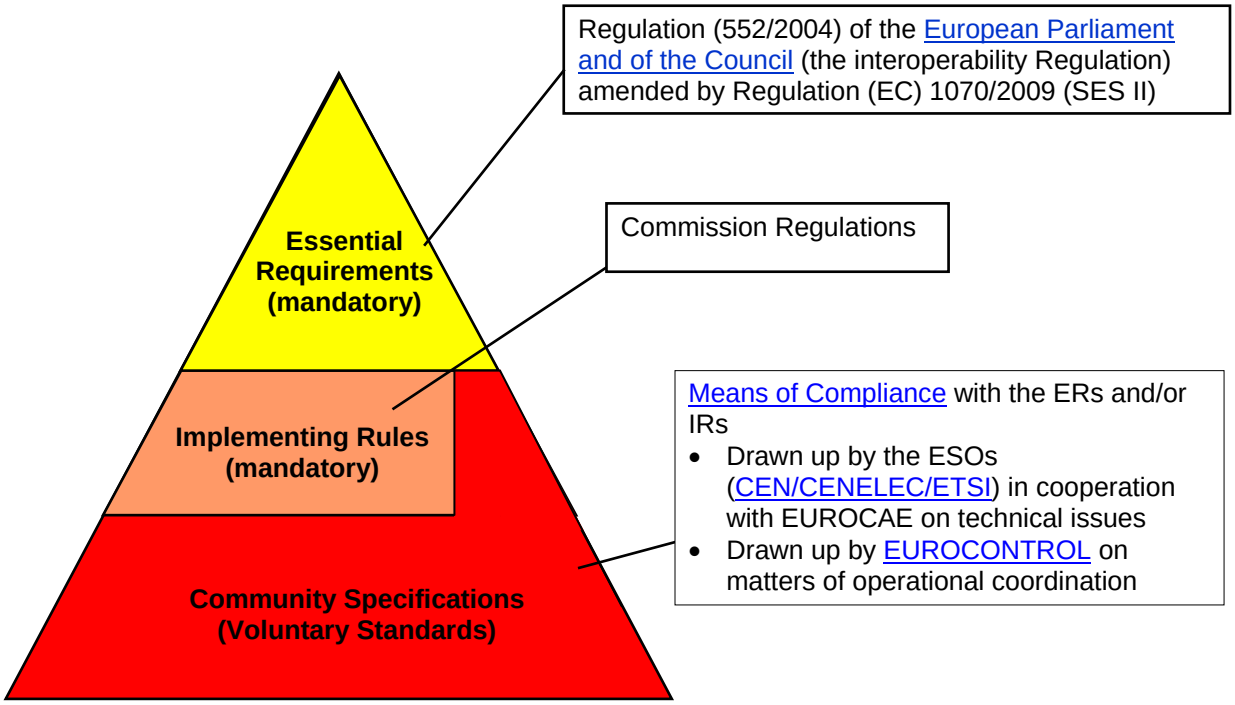

Figure 1: Single European Sky interoperability regulation framework

As such the provisions detailed herein support the following Essential Requirements:

- Seamless of operation by:
  - Ensuring seamless operation of aircraft with surveillance systems over all of Europe.
  - Ensuring a defined minimum level of performance of surveillance systems in Europe and therefore facilitating and enhancing surveillance data sharing in Europe.
- Support new concept of operations by:
  - Facilitating the introduction of new surveillance technologies.

The provisions detailed herein could also be used as an input to a surveillance system safety assessment, the production of which is required by [AD1].

2.2 Document development approach

Taking into account the context of the document development, it has been agreed that this document will identify a set of requirements that are:

- Service or function specific
- Independent of environment in order to be applicable everywhere in Europe
- Easily verifiable/measurable on a regular basis
- Representing a minimum baseline to be supplemented by additional requirements dictated by the local environment and by a local safety assessment.
- Allowing maximum flexibility in the surveillance system design process and associated technology choices.

The sub-sections below further justify these 5 objectives that have been assigned to the development of this document.

In order to prepare the evolution of this document to support these objectives and in addition to the current mandatory requirements, a set of recommended requirements have been defined. These requirements are provided as a reasonable target for surveillance systems that are being procured in the near future.

2.2.1 Service/function specific

The objective is to define these requirements for each supported air traffic services or functions.

Being service/function specific will permit ANSP's to tailor the surveillance system requirements in accordance with its intended use (e.g. the services and functions it supports).

2.2.2 Environment independent

The objective of this specification is to define requirements that are as much as possible independent of environment – applicable everywhere in Europe. Whereas the number of supported services and functions is reasonable and they are well defined, the range of environments that can be met in Europe is currently wide and it is difficult to classify objectively these different environments. Thus a generic approach has been adopted.

2.2.3 Measurable

To be of use it is recognised that the requirements specified in this document can be easily measurable and regularly monitored.

Section 4 specifies the conformity assement method for each specified requirement.

2.2.4 Interoperability and seamless operation

This specification defines a level of performance (quality of service) that a surveillance system shall provide to ensure both a defined minimum level of interoperability with neighbouring systems and for the seamless operation of flights over all of Europe.

It is to be noted that this document does not address interoperability from a data format point of view.

2.2.5 Design flexibility

The objective is to define these requirements at a level which will allow as much design flexibility as possible. For this reason the surveillance system performance requirements are defined end-to-end (see Annex A - 2). The objective is to leave the maximum freedom to system designers in their choices.

2.3 Role of this document within the surveillance system design process

The performance requirements detailed in this document are an initial input in the complex process of designing a surveillance system.

The document contains requirements to cover generic scenarios for identified air traffic services. These requirements should be supplemented by local criteria addressing particular features of the local surveillance system environment and/or local business objectives. Such criteria may include, for example:

- system capacity (business objectives)
- additional data items (e.g. Downlink Aircraft Parameters -DAP)

Surveillance systems have been developed and are used to improve ATM safety. However, infrequent failures of its functions may contribute to ATM risk. A role of surveillance system safety assessment is to analyse such failures, to verify that the potential contribution of surveillance system failures to ATM risk remains within agreed limits and to define, if necessary, mitigations.

As an integral part of the design process, any surveillance system either being put in operation or being modified, will be subject to a complete safety assessment process as required in [RD 28].

[AD1] also introduces mandatory requirements for a safety assessment to be conducted for existing surveillance system.

The surveillance system mandatory performance requirements defined in this document can be used as an input to local surveillance system safety assessment. For example, when using the EUROCONTROL SAME (Safety Assessment Made Easier) framework ([RD 4]) these requirements can be used as an input to the “Success approach”.

2.4 Choice of the category of surveillance system to deploy

A cooperative surveillance system, provided that all the aircraft to which the service is provided are equipped in accordance with the local regulation, can support the full range of air traffic environment in Europe, therefore wherever possible such category of system should be deployed. A safety assessment demonstrating that the system (equipment, procedure and people) can support the intended services and functions in its environment is nevertheless required.

A non-cooperative surveillance system may also be used, provided that the local traffic density is compatible with the ATCO workload needed to “manually” establish and maintain the correlation of aircraft horizontal position with the aircraft pressure altitude, the aircraft identity and the other surveillance data items. The required safety assessment demonstrating that the system (equipment, procedure and people) can support the intended services and functions in its environment shall take into account this specific workload.

An association of cooperative and non-cooperative surveillance systems may also be used to cope with a mixed environment (equipped and non-equipped aircraft) provided that the non-cooperative traffic density is compatible with the additional ATCO workload described above. The required safety assessment demonstrating that the system (equipment, procedure and people) can support the intended services and functions in its environment shall take into account this specific workload.

In that case, the two systems may be, plus or minus, integrated into a single system or may even be operated as two independent systems providing two parallel data streams to the ATCO.

The following chapters define separate performance requirements for cooperative and non-cooperative surveillance systems. The conformity assessment procedures describe how to separate the assessment of cooperative and non-cooperative performance requirements in case of association of the two categories of surveillance systems.

In summary, the choice of the category of surveillance system(s) to be deployed, cooperative, non-cooperative or association of both, is the decision of the ANSP depending on the local environment and constraints such as the percentage of transponder equipped aircraft, traffic density, airspace structure and design, business objectives, etc. Therefore there are no generic criteria to define which category of system needs to be deployed.

2.5 Performance metrics/indicators

In order to define the performance metrics/indicators, this document uses the International Organization for Standardization (ISO) Quality of Service framework (see document [RD 23]). This could allow a transition to a more structured required surveillance performance approach.

The ISO 13236 framework ([RD 23]) defines 8 generic quality of service characteristics, which are then refined so as to reflect correctly the salient features of ATM surveillance systems:

- **Time**: time-related characteristics fall into two main groups: absolute timing and time intervals between events, which can be specialised further in terms of transfer delays etc.
- **Coherence**: coherence-related characteristics correspond to the notion of having a certain piece of information available over a certain area, which can be defined geographically or as a logical abstraction (e.g. as the inter networked set of computers over which a certain function is distributed). An important variant denoted as "temporal consistency" introduced by ISO 13236 is to attach a maximum duration to the transient state that exists when a piece of information is being updated over a certain area.
- **Capacity**: capacity-related characteristics represent the capability to provide a certain number of units of service to the users.
- **Integrity**: integrity-related characteristics appreciate the influence of errors and inaccuracies on the Quality of Service. In a narrow sense, "integrity" is traditionally associated to error rate issues while "accuracy" is introduced to convey a notion of precision. An important specialisation of integrity in this wider sense of "accuracy" is the notion of "relevance", understood as the subjective degree of adequacy of the service to its intended use.
- **Safety**: safety-related characteristics deal with the overall impact of the service on user operations in terms of the potential risk entailed by its failures (whatever their nature: human error, hardware breakdown, software bug, security breach/leak).
- **Security**: security-related characteristics address the issue of protecting the users of the service against voluntary of involuntary interference by third parties.
- **Reliability**: reliability-related characteristics are used to assess the frequency and duration of service failures. Important generic specialisations are "availability" and "maintainability". In a narrow sense "reliability" denotes the failure rate/probability.
- **Priority**: priority-related characteristics address issues of precedence hierarchies among users competing for the service.

From the previous list the following quality of service characteristics have been selected and further refined:

- **Time** is translated in processing delay for the data items that are forwarded from the aircraft to the surveillance system user on the ground.
- **Coherence** is translated in the time consistency of the provided aircraft positions.
- Capacity is not retained because it depends on surveillance system environment and cannot be defined generically.
- **Integrity** is further refined in three different performance characteristics: core errors, correlated errors, spurious and large errors of data items.
- Safety and security are deliberately not addressed in this document, but must be addressed separately.
- **Reliability** is further refined in availability and continuity of the data items and of the complete surveillance system.
- Priority has not been retained because it was not found applicable to the current applications addressed in this document.

For each data item and for the complete system, performance metrics will be chosen within the 7 columns corresponding to the different quality of service that have been considered in this document. For each of the addressed application, a table (see example Table 1) will map for the provided data items and for the system (rows), the specified performance requirements/metrics onto the retained quality of service (columns).

	Availability	**Continuity**	**Integrity**			**Time**	**Coherence**
			Core error	Correlated error	Spurious error		
Data item 1	X	X	X	X	X	-	X
Data item 2	X	X	-	-	-	X	-
…							
System	X	X	-	-	-	-	-

Table 1: Example of mapping of performance metrics on quality of service characteristics

3 PERFORMANCE REQUIREMENT SPECIFICATION FOR SURVEILLANCE APPLICATIONS

3.1 3/5 NM horizontal separation operational services

This document considers two families of elementary services:

- horizontal distance-based separation with a minimum of 5 NM, it is called “5 NM horizontal separation”.
- horizontal distance-based separation with a minimum of 3 NM, it is called “3 NM horizontal separation”.

As aircraft separation has to be provided horizontally or vertically, these two families of elementary service have to be considered in conjunction with vertical separation minima (VSM), i.e. 1000 ft or 2000 ft.

5 NM and 3 NM are the more generally applied horizontal separation minima as specified in ICAO Document 4444 [RD 9] § 8.7.3.

3.2 3/5 NM horizontal separation application definitions

This version of the document covers 4 applications, corresponding to the combination of the two selected elementary ATC services with the two categories of surveillance systems. They have been chosen as the first to be addressed as they are deemed to correspond to the most commonly applied applications using surveillance information in Europe.

		Provided ATC service	
		5 NM horizontal separation	3 NM horizontal separation
Category of surveillance system	Cooperative	5N_C	3N_C
	Non-cooperative	5N_N	3N_N

Table 2: Addressed application

3.3 3/5 NM horizontal separation operational performance assessment (OPA) scenarios

In order to be independent of traffic density (see § 2.2.2) the performance requirements are based on a set of elementary OPA scenarios that are derived from ICAO Document 4444 [RD 9].

These scenarios are expected to cover all the cases of operational separation between two aircraft.

The performance requirements figures specified in this document are based on these basic OPA scenarios. In practice an air traffic controller will have to face a number of these scenarios, either combined and/or duplicated, at the same time and/or within a short time frame, therefore increased surveillance system performance may be needed to cope with the cumulated number of scenario cases (e.g. due to traffic density).

The following OPA scenarios have been defined for 3 NM and 5 NM horizontal separation:

- Crossing track scenarios (3 and 5 NM separation) see Volume 2 [RD 1] Appendix V - 1 and 2
- Same track scenario (3 and 5 NM separation) see Volume 2 [RD 1] Appendix V - 3 and 4
- Reciprocal track scenario (3 and 5 NM separation) see Volume 2 [RD 1] Appendix V - 5 and 6
- Vertical crossing track scenario (3 and 5 NM separation) see Volume 2 [RD 1] Appendix V - 7 and 8
- Vertically separated track scenarion (3 and 5 NM separation) see Volume 2 [RD 1] Appendix V - 9 and 10

3.4 Environment description and requirements for 3/5 NM horizontal separation provided by ATCO using cooperative surveillance system

3.4.1 Environment description

This environment descrition together with the operational service is described in § 3.1 form the OSED (Operational Service and Environment Description) for 3/5 NM separation provided by ATCO using cooperative surveillance system.

A fundamental assumption of the OSED is that the operational service is provided to cooperative aircraft that are fully compliant with the avionics requirements detailed in [AD1].These requirements will be further detailed in a forthcoming EASA Certification Specification ACNS.

The local surveillance system safety assessment will therefore address instances in which the aircraft's avionics presents an anomaly as well as the possible intrusion of aircraft that are not equipped in accordance with the requirements detailed in [AD1] and in the upcoming EASA Certification Specification ACNS.

Any differences in local environments from that defined in this sub-section shall be accounted for in accompanying analysis prior to local implementation.

The airspace classes in which separation services must be provided are described in Annex C - 4.1.

The airspace structure is further defined in Annex C - 4.2.

3.4.2 Required data items

The following information elements are required from the cooperative surveillance system for the provision of surveillance separation. This list does not include flight plan elements.

The following data items shall be provided by the cooperative surveillance system under the form of message-structured and digitised information:

Positional data:

- Horizontal (2D) position;
- Time of applicability of horizontal position(for conformity assessment);
- Vertical position based upon pressure altitude received from the aircraft;
- Time of applicability of vertical position (for conformity assessment).

Operational identification data:

- Aircraft identity (ICAO Aircraft Identification and/or Mode 3/A code) reported by the aircraft.

Supplementry indicators:

- Emergency indicator (General emergency, radio failure and unlawful interference);
- Special Position Identification (or Indicator) SPI.

Surveillance data status:

- Cooperative/non-cooperative/combined;
- Coasted/not coasted (position).

The provision of the above data items is compliant with Annex I § 1.1 and 1.2 of [AD1] when using a cooperative surveillance system.

The following data items should be provided:

- Track velocity vector;
- Rate of climb/descent (this data item may be reduced to a trend).

These data items are further described in Annex C - 1.

3.4.3 Mandatory and recommended performance requirements for 5 NM horizontal separation provided by ATCO using cooperative surveillance system

Req. #	Quality of service	Mandatory performance	Recommended performance	Ref. / Justif.	Conf. method
5N_C-R1	Measurement interval for probability of update assessments (R2, R7 and R14)	Less than or equal to 8 seconds	Less than or equal to 6 seconds	2.1.1 2.1.2	4.2.1
5N_C-R2	Probability of update of horizontal position	Greater than or equal to 97% for 100% of the flights, any flight below 97% shall be investigated as defined in R22	Greater than or equal to 97% for 100% of the flights, any flight below 97% shall be investigated as defined in R22 and greater than or equal to 99 % global	2.1.3 2.1.4	4.2.2.1
5N_C-R3	Ratio of missed 3D position involved in long gaps (larger than 26.4 s = 3 x 8 s + 10%)	Less than or equal to 0.5 %		2.1.5	4.2.3
5N_C-R4	Horizontal position RMS error	Less than or equal to 500 m global and less than 550 m for 100% of the flights, any flight below 550 m shall be investigated as defined in R22	Less than or equal to 350 m global and less than 385 m per flight	2.1.6 2.1.7	4.2.4
5N_C-R5	Ratio of target reports involved in series of at least 3 consecutive correlated horizontal position errors larger than 926 m - 0.5 NM		Less than or equal to 0.03 %	2.1.9	4.2.5
5N_C-R6	Relative time of applicability of horizontal position for aircraft in close proximity (less than 18520 m - 10 NM)		Less than or equal to 0.3 second RMS for relative data age	2.1.10	4.2.6
5N_C-R7	Probability of update of pressure altitude with correct value	Greater than or equal to 96 % global		2.1.11	4.2.2.2
5N_C-R8	Forwarded pressure altitude average data age (see Note 7 in § 3.4.5)	Less than or equal to 4 seconds		2.1.12	4.2.7
5N_C-R9	Forwarded pressure altitude maximum data age	Any forwarded pressure altitude data item with an age greater than or equal to 16 s shall be considered as not available when assessing R3, R7, R8 and R10		2.1.13	4.2.7
5N_C-R10	Ratio of incorrect forwarded pressure altitude (see Note 7 in § 3.4.5)	Less than or equal to 0.1 %		2.1.14	4.2.8

Req. #	Quality of service	Mandatory performance	Recommended performance	Ref. / Justif.	Conf. method
5N_C-R11	Pressure altitude unsigned error (see Note 7 in § 3.4.5)	Less than or equal to 200/300 ft in 99.9% of the cases for stable flights and less than or equal to 300 ft in 98.5% of the cases for climbing / descending flights		2.1.15	4.2.9
5N_C-R12	Delay of change in emergency indicator/SPI report	Less than or equal to 12 s for 100% of the cases, case above 12 s shall be investigated as defined in R22		2.1.16	4.2.10
5N_C-R13	Delay of change in aircraft identity	Less than or equal to 24 s for 100% of the cases, case above 24 s shall be investigated as defined in R22		2.1.17	4.2.11
5N_C-R14	Probability of update of aircraft identity with correct value (see Note 8 in § 3.4.5)	Greater than or equal to 98 % global	Greater than or equal to 98 % per flight	2.1.18 2.1.19	4.2.2.2
5N_C-R15	Ratio of incorrect aircraft identity	Less than or equal to 0.1 %		2.1.20	4.2.12
5N_C-R16	Rate of climb/descent RMS error		Less than or equal to 250 ft/mn for stable flights and less than or equal to 500 ft/mn for climbing/descending flights	2.1.21	4.2.13
5N_C-R17	Track velocity RMS error		Less than or equal to 4 m/s for straight line and less than or equal to 8 m/s for turn	2.1.22	4.2.14
5N_C-R18	Track velocity angle RMS error		Less than or equal to 10° for straight line and less than or equal to 25° for turn	2.1.22	4.2.14
5N_C-R19	Density of uncorrelated false target reports		Less than 10 false target reports per area of 900 NM^2 and over a duration of 450 applicable measurement intervals	2.1.23	4.2.15
5N_C-R20	Number per hour of falsely confirmed track close to true tracks		Less than or equal to 2 non-coincident falsely confirmed tracks per hour that are closer than 13000 m - 7 NM from true tracks	2.1.24	4.2.16
5N_C-R21	Continuity (probability of critical failure)		Less than or equal to $2.5\ 10^{-5}$ per hour of operation	2.1.25	4.2.17
5N_C-R22	Investigations	Flights/cases for which requirements R2, R4, R12 or R13 are not achieved shall be investigated and an impact assessment conducted and appropriate risk mitigation/reduction measures introduced if necessary.		NA	

Table 3: Cooperative surveillance system requirements for supporting 5 NM horizontal separation (5N_C)

3.4.4 Mandatory and recommended performance requirements for 3 NM horizontal separation provided by ATCO using cooperative surveillance system

Req. #	Quality of service	Mandatory performance	Recommended performance	Ref. / Justif	Conf. method
3N_C-R1	Measurement interval for probability of update assessments (R2, R7 and R14)	Less than or equal to 5 seconds	Less than or equal to 4 seconds	2.2.1 2.2.2	4.2.1
3N_C-R2	Probability of update of horizontal position	Greater than or equal to 97% for 100% of the flights, any flight below 97% shall be investigated as defined in R22	Greater than or equal to 97% for 100% of the flights, any flight below 97% shall be investigated as defined in R22 and greater than or equal to 99 % global	2.2.3 2.2.4	4.2.2.1
3N_C-R3	Ratio of missed 3D position involved in long gaps (larger than 16.5 s = 3 x 5 s + 10%)	Less than or equal to 0.5 %		2.2.5	4.2.3
3N_C-R4	Horizontal position RMS error	Less than or equal to 300 metres global and less than 330 metres for 100% of the flights, any flight below 550 m shall be investigated as defined in R22	Less than or equal to 210 metres global and less than 230 meters per flight	2.2.6 2.2.7	4.2.4
3N_C-R5	Ratio of target reports involved in sets of 3 consecutive correlated horizontal position errors larger than 555 m - 0.3 NM		Less than or equal to 0.03 %	2.2.9	4.2.5
3N_C-R6	Relative time of applicability of horizontal position for aircraft in close proximity (less than 11110 m - 6 NM)		Less than or equal to 0.3 seconds RMS	2.2.10	4.2.6
3N_C-R7	Probability of update of pressure altitude with correct value	Greater than or equal to 96 % global		2.2.11	4.2.2.2
3N_C-R8	Forwarded pressure altitude average data age (see Note 7 in § 3.4.5)	Less than or equal to 2.5 seconds		2.2.12	4.2.7
3N_C-R9	Forwarded pressure altitude maximum data age	Any forwarded pressure altitude data item with an age greater than or equal to 16 s shall be considered as not available when assessing R3, R7, R8 and R10		2.2.13	4.2.7
3N_C-R10	Ratio of incorrect forwarded pressure altitude (see Note 7 in § 3.4.5)	Less than or equal to 0.1 %		2.2.14	4.2.8

Req. #	Quality of service	Mandatory performance	Recommended performance	Ref. / Justif	Conf. method
3N_C-R11	Pressure altitude unsigned error (see Note 7 in § 3.4.5)	Less than or equal to 200/300 ft in 99.9% of the cases for stable flights and less than or equal to 300 ft in 98.5% of the cases for climbing/descending flights		2.2.15	4.2.9
3N_C-R12	Delay of change in emergency indicator/SPI report	Less than or equal to 7.5 s for 100% of the cases, case above 7.5 s shall be investigated as defined in R22		2.2.16	4.2.10
3N_C-R13	Delay of change in aircraft identity	Less than or equal to 15 s for 100% of the cases, case above 15 s shall be investigated as defined in R22		2.2.17	4.2.11
3N_C-R14	Probability of update of aircraft identity with correct value (see Note 8 in § 3.4.5)	Greater than or equal to 98 % global	Greater than 98% per flight	2.2.18 2.2.19	4.2.2.2
3N_C-R15	Ratio of incorrect aircraft identity	Less than or equal to 0.1 %		2.2.20	4.2.12
3N_C-R16	Rate of climb/descent RMS error		Less than or equal to 250 ft/mn for stable flights and less than or equal to 500 ft/mn for climbing/descending flights	2.2.21	4.2.13
3N_C-R17	Track velocity RMS error		Less than or equal to 4 m/s for straight line and less than or equal to 8 m/s for turn	2.2.22	4.2.14
3N_C-R18	Track velocity angle RMS error		Less than or equal to 10° for straight line and less than or equal to 25° for turn	2.2.22	4.2.14
3N_C-R19	Density of uncorrelated false target reports		Less than or equal to 2 false target reports per area of 100 NM^2 and over a duration of 720 applicable measurement intervals	2.2.23	4.2.15
3N_C-R20	Number per hour of falsely confirmed track close to true tracks		Less than or equal to 1 falsely confirmed track per hour that are closer than 16700 m - 9 NM from true tracks	2.2.24	4.2.16
3N_C-R21	Continuity (probability of critical failure)		Less than or equal to 2.5 10^{-5} per hour of operation	2.2.25	4.2.17
3N_C-R22	Investigations	Flights/cases for which requirements R2, R4, R12 or R13 are not achieved shall be investigated and an impact assessment conducted and appropriate risk mitigation/reduction measures introduced if necessary.		NA	

Table 4: Cooperative surveillance system requirements for supporting 3 NM horizontal separation (3N_C)

These performance requirements are mainly derived from the experience gained in Europe over the last decades on the basis of radar technology.

In addition some specific studies have been undertaken to further refine performance requirement specifications when necessary.

The following conventions are applied in Table 3 and Table 4:

- Mandatory performance requirements are in **bold font**
- Recommended performance requirements are in normal font

The 5th column “Ref./Justif.” provides the corresponding paragraph of Volume 2 [RD 1] Appendix II where further references and justifications can be found.

Volume 2 [RD 1] Appendix II provides links between the requirements specified in this document and requirements specified in similar documents, in particular the EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas ([RD 2]) and the ADS-B specifications developed by the ADS-B Requirement Focus Group ([RD 14], [RD 15]).

Volume 2 [RD 1] Appendix II also provides links with study reports that have produced to support the development of this document and to decisions of the Surveillance Standard Task Force (SSTF) who is the group in charge of the writing of this document.

The last column “Conf. method” provides the corresponding sub-section of section 4 Conformity assessment.

3.4.5 Mapping of performance metrics on quality of service characteristics

A mapping of the performance requirements detailed in Table 3 and Table 4 on the quality of services described in sub-section 2.5 is provided in Table 5 below and additional justifications are provided in Volume 2 [RD 1] Appendix I. A cell populated by a "-" indicates that it was considered not necessary to define corresponding detailed requirements.

	Availability	**Continuity**	**Integrity**			**Time**	**Coherence**
			Core error	Correlated error	Spurious error		
Horizontal position	R1-R2	R3	R4	R5 & R20	R19	Note 1	R6
Pressure altitude	R1-R7	R3	R11 & R7	Note 2	R10	R8 & R9	Note 3
SPI/Emergency indicator	Note 4					R12	-
Aircraft identity	R1-R14	-	R14	-	R15	R13	-
Rate of climb/descent	Note 5	Note 6	R16	Note 7		Note 1	-
Track velocity	Note 5	Note 6	R17 & R18	Note 7		Note 1	-
System	Note 8	R21	-	-	-	-	-

Table 5: Mapping of performance metrics on quality of service characteristics for 5N_C and 3N_C applications

Note 1: Impact of information latency is taken into account within error calculation method.

Note 2: Pressure altitude correlated error due to ground surveillance system is assumed to be addressed by R10. Pressure altitude correlated error due to the airborne system cannot be assessed by a ground surveillance system. It has to be assessed by specific systems like the Height Monitoring Unit's (HMU) deployed in the frame of RVSM monitoring.

Note 3: Time consistency of pressure altitude data item is partly addressed through R8 and R9.

Note 4: Data items are checked procedurally by ATCO (SPI is requested by ATCO, if it does not appear the ATCO will check with the pilot – in case of emergency indicator the ATCO will call the pilot for further information).

Note 5: Requirements are to be defined locally when these data items are provided and used.

Note 6: Because of the way these data items are calculated (by a tracker), once started they will continue to be provided, so continuity is 100% by design.

Note 7: No specific requirement when supporting 3 or 5 NM horizontal separation, requirement likely to be needed when supporting safety nets.

Note 8: Requirements are to be defined locally when these data items are provided and used.

Note 9: The performance of the pressure altitude data item can be specified in two ways. These depend upon whether the pressure altitude is calculated by the ground based components of the surveillance system or if the value of the data-item was declared by the aircraft and forwarded, unchanged, by the ground based components of the surveillance system.

If the pressure altitude data-item is calculated by the ground based components of the surveillance system then requirement R11 applies.

If the value of the data-item was declared by the aircraft and forwarded by the ground based components of the surveillance system then either requirement R11 applies or the 2 requirements R8 and R10 can be applied.

Note 10: The requirement on the probability of update of the aircraft identity data item is a requirement on the provision of the correct data item at the output of the system and does not require the systematic extraction of that data item at each measurement interval.

3.5 Environment description and requirements for 3/5 NM horizontal separation provided by ATCO using non-cooperative surveillance system

3.5.1 Environment description

This environment descrition together with the operational service is described in § 3.1 form the OSED (Operational Service and Environment Description) for 3/5 NM separation provided by ATCO using non-cooperative surveillance system.

The operational service can be provided to all aircraft provided they have the minimum physical characteristics (e.g. Radar Cross Section) that need to be locally defined in accordance with the specifications of the non cooperative surveillance system. The presence and the possible proximity of aircraft not meeting these minimum physical characteristics shall be taken into account in the surveillance system safety assessment.

When a non-cooperative surveillance system is used in stand-alone the traffic environment is assumed to be low density. The local surveillance system safety assessment will define the limit in terms of quantity of traffic that can be managed with a non–cooperative surveillance system. This is locally defined taking into account the complexity of the airspace and the complexity of the environment.

3.5.2 Required data items for 3/5 NM horizontal separation provided by ATCO using non-cooperative surveillance system

The following information elements are required from the surveillance system for the provision of surveillance separation. This list does not include flight plan elements.

The following data items shall be provided by the surveillance system under the form of message-structured and digitised information[2]:

Positional data:

- Horizontal position (2D).

Surveillance data status:

- Coasted/not coasted;
- Time of applicability (for conformity assessment).

The provision of the above data items is compliant with Annex I § 1.1 of [AD1] when using a non-cooperative surveillance system.

The following data item should be provided:

- Track velocity vector.

These data items are further described in Annex C - 1.

[2] Although excluded for supporting separation application, analogue or digitised video can be presented to ATCO as mitigation and/or as a confidence re-enforcement.

3.5.3 Mandatory and recommended performance requirements for 5 NM horizontal separation provided by ATCO using non-cooperative surveillance system

Req. #	Quality of service	Mandatory performance	Recommended performance	Ref. / Justif.	Conf. method
5N_N-R1	Measurement interval for probability of update assessment (R2)	Less than or equal to 8 seconds	Less than or equal to 6 seconds	2.1.1 2.1.2	4.2.1
5N_N-R2	Probability of update of horizontal position in accordance with selected measurement interval	Greater than 90 % global	Greater than or equal to 97 % for 100% of the flights, any flight below 97% shall be investigated as defined in R10	2.1.3 2.1.4	4.2.2.1
5N_N-R3	Ratio of missed horizontal position involved in long gaps (larger than 26.4 s = 3 x 8s + 10%)	Less than or equal to 0.5 %		2.1.4	4.2.3
5N_N-R4	Horizontal position RMS error	Less than or equal to 500 metres	Less than or equal to 350 metres	2.1.5 2.1.6	4.2.4
5N_N-R5	Ratio of target reports involved in series of at least 3 consecutive horizontal position correlated errors larger than 926 m - 0.5 NM		Less than or equal to 0.03 %	2.1.7	4.2.5
5N_N-R6	Relative time of applicability of horizontal position for aircraft in close proximity (less than 18520 m – 10 NM)		Less than or equal to 0.3 second RMS for relative data age	2.1.9	4.2.6
5N_N-R7	Track velocity RMS error		Less than or equal to 4 m/s for straight line and less than or equal to 8 m/s for turn	2.1.22	4.2.14
5N_N-R8	Track velocity angle RMS error		Less than or equal to 10° for straight line and less than or equal to 25° for turn	2.1.22	4.2.14
5N_N-R9	Continuity (probability of critical failure)		Less than or equal to 2.5 10^{-5} per hour of operation	2.1.25	4.2.17
5N_N-R10	Investigations		Flights for which requirement R2 is not achieved shall be investigated and an impact assessment conducted and appropriate risk mitigation/reduction measures introduced if necessary.	NA	

Table 6: Non-cooperative surveillance system requirements for supporting 5 NM horizontal separation (5N_N)

3.5.4 Mandatory and recommended performance requirements for 3 NM horizontal separation provided by ATCO using non-cooperative surveillance system

Req. #	Quality of service	Mandatory performance	Recommended performance	Ref. / Justif	Conf. method
3N_N-R1	Measurement interval for probability of update assessment (R2)	Less than or equal to 5 seconds	Less than or equal to 4 seconds	2.2.1 2.2.2	4.2.1
3N_N-R2	Probability of update of horizontal position in accordance with selected measurement interval	Greater than 90 % global	Greater than or equal to 97 % for 100% of the flights, any flight below 97% shall be investigated as defined in R10	2.2.3 2.2.4	4.2.2.1
3N_N-R3	Ratio of missed horizontal position involved in long gaps (larger than 16.5 s = 3 x 5 s + 10%)	Less than or equal to 0.5 %		2.2.4	4.2.3
3N_N-R4	Horizontal position RMS error	Less than or equal to 300 metres	Less than or equal to 210 metres	2.2.5 2.2.6	4.2.4
3N_N-R5	Ratio of target reports involved in sets of 3 consecutive horizontal position correlated errors larger than 555 m - 0.3 NM		Less than or equal to 0.03 %	2.2.7	4.2.5
3N_N-R6	Relative time of applicability of horizontal position for aircraft in close proximity (less than 11110 m - 6 NM)		Less than or equal to 0.3 seconds RMS	2.2.9	4.2.6
3N_N-R7	Track velocity RMS error		Less than or equal to 4 m/s for straight line and less than or equal to 8 m/s for turn	2.2.22	4.2.14
3N_N-R8	Track velocity angle RMS error		Less than or equal to 10° for straight line and less than or equal to 25° for turn	2.2.22	4.2.14
3N_N-R9	Continuity (probability of critical failure)		Less than or equal to $2.5\ 10^{-5}$ per hour of operation	2.2.25	4.2.17
3N_N-R10	Investigations		Flights for which requirement R2 is not achieved shall be investigated and an impact assessment conducted and appropriate risk mitigation/reduction measures introduced if necessary.	NA	

Table 7: Non-cooperative surveillance system requirements for supporting 3 NM horizontal separation (3N_N)

These performance requirements are identical to the performance requirements specified for a cooperative surveillance system but are adapted to take account for the non-provided data items.

The following conventions are applied in Table 6 and Table 7:

- Mandatory performance requirements are in **bold font**
- Recommended performance requirements are in normal font

The 5th column "Ref./Justif." provides the corresponding paragraph of Volume 2 [RD 1] Appendix II where further references and justifications can be found.

Volume 2 [RD 1] Appendix II provides links between the requirements specified in this document and requirements specified in similar documents, in particular the EUROCONTROL Standard Document for Radar Surveillance in En-route Airspace and Major Terminal Areas ([RD 2]).

Volume 2 [RD 1] Appendix II also provides links with study reports that have been produced to support both the development of this document and the decisions of the Surveillance Standard Task Force (SSTF), the group responsible for the drafting of this document.

The last column "Conf. method" provides the corresponding sub-section of section 4 Conformity assessment.

3.5.5 Mapping of performance requirements to quality of service

A mapping of the performance requirements detailed in Table 6 and Table 7 on the quality of services described in sub-section 2.5 is provided in Table 8 below and additional justifications are provided in Volume 2 [RD 1] Appendix I. A cell populated by a "-" indicates that it was considered not necessary to define corresponding detailed requirements.

	Availability	**Continuity**	**Integrity**			**Time**	**Coherence**
			Core error	Correlated error	Spurious error		
Horizontal position	R1/R2	R3	R4	R5	Note 1	Note 2	R6
Track velocity	Note 3	Note 4	R7 & R8	Note 5		Note 2	-
System	Note 3	R9	-	-	-	-	-

Table 8: Mapping of performance metrics on quality of service characteristics

Note 1: There is not yet an agreed criterion for horizontal position outliers in case of non cooperative system.

Note 2: Impact of information latency is taken into account within horizontal position error calculation method.

Note 3: Requirements are to be defined locally when this data item is provided and used.

Note 4: Because of the way this data item is calculated (by a tracker), once started it will continue to be provided, so continuity is 100% by design.

Note 5: No specific requirement when supporting 3 or 5 NM horizontal separation, requirement likely to be needed when supporting safety nets.

Note 6: In principle the required probability of update of horizontal position should be the same for cooperative and non-cooperative surveillance systems. However, because the probability of update of horizontal position of non-cooperative surveillance sytems is a performance characteristic which depends on the environment conditions, it is only recommended to apply the same performance specification for non-cooperative surveillance system as for cooperative one's. As a matter of consistency, 90 % is being required as it is the usual required value for primary surveillance radars since 1997. In any case this performance characteristic will have to be confirmed by the system safety assessment.

4 CONFORMITY ASSESSMENT

4.1 Generalities

4.1.1 Conformity assessment approaches

The conformity assessment of surveillance systems can be undertaken on the basis of one or more of the five following approaches and in accordance with its associated priority:

- Opportunity traffic (priority 1),
- Flight trials (priority 2),
- Proof offered through system design files or by system design assurance (priority 3),
- Test transponder (priority 3),
- Injected test target (priority 3).

The priorities have been allocated on the basis of the operational relevance of each approach. The approach based on opportunity traffic has priority 1 as it is fully representative of the operational traffic and of the operational environment. The remaining 3 approaches are rather partially representative of the operational traffic and operational environment and have the lowest priority.

The conformity assessment of a surveillance system against the cooperative surveillance performance requirements shall be performed on the basis of cooperative and, if provided, combined target reports delivered by the system.

The conformity assessment of a surveillance system against the non-cooperative surveillance performance requirements shall be performed on the basis of non-cooperative target reports delivered by the system except for requirements R2 & R3 for which combined target reports, if provided, shall also be taken into account.

It is to be noted that a statistical measurement uncertainty may be generated if a low number of data samples are used when performing the assessment of an individual aircraft. The application of an additional measurement margin or concession may be required to address such an eventuality.

4.1.2 Conformity assessment volume

The conformity assessment measurements shall be performed within the volume of airspace where the corresponding application/service is supported/provided and **limited to the aircraft to which the separation service is provided** (see Annex C - 4.1 for the identification of these aircraft with respect to airspace classes). This set of aircraft target reports is called the Conformity Assessment Volume (CAV).

A target report is belonging to the CAV and is to be assessed if its reference flight trajectory 3D position is located in the CAV.

A false target report is belonging to the CAV and is to be assessed if its 3D position is located in the CAV or if there is no pressure altitude data item if the horizontal position is located in the largest horizontal footprint of the CAV.

Some aircraft target reports, although located within the CAV, may be excluded from the conformity assessment process:

- Aircraft to which the corresponding service is not provided based on individual aircraft or on specific temporary area (e.g. military exercise).
- Aircraft whose avionics exhibit a functional anomaly (with respect to applicable regulations), when assessing a cooperative surveillance system and if anomaly is confirmed by data analysis.

The aircraft to which the service is provided (IFR or VFR) can be identified taking into account the class of the airspace (see Annex C - 4.1 and Figure 17).

For example, when analyzing the performance to support the 3/5NM separation service, aircraft not expected to be in the controlled airspace (e.g. intruding non-equipped VFR) may be excluded of the conformity assessment process. The detection of intrusion within the controlled airspace is a separate application requiring a different level of performance.

Aircraft whose avionics exhibit a functional anomaly shall be analysed separately to verify that the assumptions of the system safety assessment remain valid. Such cases and their consequences (assessed or assumed) on the performance of the surveillance system shall be reported to the local safety monitoring process. Additionally, as foreseen in [AD1] Article 4(4), ANSP will inform aircraft operators of any aircraft whose avionics exhibit a confirmed functional anomaly. Similar requirements are placed upon the aircraft operator to investigate and resolve anomalies identified in this manner.

In case of association of cooperative and non-cooperative surveillance systems to support the service, the cooperative and non-cooperative surveillance performance may be assessed in different CAV's.

4.1.3 Conformity assessment datasets

Assuming an assessment is made periodically (as opposed to continuously) using opportunity traffic data, the performance requirements should be assessed on the basis of opportunity traffic datasets containing at least 50.000 position reports from the system under assessment obtained from flight trajectories for which the system has provided target reports during at least 50 measurement intervals.

4.1.4 Conformity assessment periodicity

The assessment shall be made periodically on each ground surveillance system and after each system or environment modification that may have an impact on its performance characteristics.

The periodicity of the conformity assessment is to be defined depending on the system design and the type of technology used.

When assessing the surveillance system performance on the basis of opportunity traffic, the system is only evaluated where there are flights. If airspace design modifications are to be implemented, a study will have to be undertaken to check that the system will still meet the required performance with the new traffic and specific flight trials may be needed.

4.1.5 Conformity assessment measurement point

The performance shall be assessed at the point where surveillance data is used to provide the service (e.g. 3 or 5 NM horizontal separation).

In practice, performance shall be measured at a point where surveillance data can be recorded in a digitised way and which is as close as possible to where the service is delivered.

If a data processing stage is located in between that recording point and the point where the service is delivered, an analysis shall be performed to determine the contribution of this processing stage to the surveillance system end-to-end performance.

Should the provider of the 3/5 NM horizontal separation not be the provider of the surveillance data used to support the service, it is up to the separation service provider to derive the performance of the provided surveillance data, in order to meet the requirements described in this document and provided that he has chosen to apply the present specification.

4.1.6 Definitions

4.1.6.1 Valid data item

A valid data item means that the data item (e.g. horizontal position or pressure altitude) is provided to the user and can be used by the ATCO to perform the application. It could be that specially tagged data items (e.g. a coasted horizontal position) may not be allowed to be used to maintain separation, in which case the data item is considered as not “valid“, although it has been delivered by the surveillance system.

The precise criteria, for deciding whether a data item is valid or not, are assumed to be defined locally in accordance with the local procedures. These criteria are not to be confused with the “validity bit” that can be included in Asterix data items, although these criteria may be based on that piece of information. These criteria have to be based on pieces of information included in the target report provided by the surveillance system.

4.1.6.2 Outlier criteria

The horizontal position outlier criteria for cooperative surveillance are:

- horizontal position error greater than 2100 m for 5 NM separation service.
- horizontal position error greater than 1690 m for 3 NM separation service.

Further justifications on the definition of these thresholds are provided in Volume 2 [RD 1] Appendix II - 2.1.8 and 2.2.8.

As there is no definition of non-cooperative false target reports there are no horizontal position outlier criteria for non-cooperative surveillance.

4.1.6.3 False target reports

A false target report is a target report that does not correspond to the position of a true aircraft (no corresponding reference aircraft trajectory at this position and at that time) and that contains at least the following data items:

- Horizontal position,
- Time of applicability,
- Aircraft identity (Mode A or Aircraft Identification) for cooperative target reports only.

Although cooperative outlier target reports meeting the criteria defined in § 4.1.6.2 have been associated to a reference trajectory, they are also considered as false target reports because the distance between the outlier target report and the reference trajectory is too large.

At this stage, the mechanisms (e.g. reflection) providing the false target information are not addressed. It is to be noted that false target reports are not necessarily duplicate target reports. It may happen that, in case of reflections, the aircraft is not in radar line of sight whereas the reflected path is free of obstacle.

4.1.7 Specific events to be investigated

In addition to investigations required in R22, it is recommended to investigate the following cases in order to determine the causes and to apply corrective and/or risk reduction measures if necessary:

- horizontal position error above the outlier criteria,
- pressure altitude data item with a data age greater than the threshold defined in R9,
- flight with abnormal rate of incorrect pressure altitude,
- falsely confirmed track close to true traffic.

4.2 Conformity assessment procedures and criteria

The following sections detail for each performance indicator how it shall be calculated.

For the conformity assessment procedures and criteria described in § 4.2.2 to 4.2.14, the population of target reports to be assessed shall only consider:

- target reports that belong the CAV as defined in § 4.1.2;
- data items that are valid as defined in § 4.1.6.1; therefore non valid data items will be considered as being not available.

For the conformity assessment procedures and criteria described in § 4.2.2 to 4.2.14, the population of target reports to be assessed shall not consider the false target reports as defined in § 4.1.6.3.

For the conformity assessment procedures and criteria described in § 4.2.15 and 4.2.16, the population of target reports to be assessed shall only consider respectively the false target reports belonging to the CAV and as defined in § 4.1.6.3.

Note on the assessment of the quality of pressure altitude data item

Two alternative requirement approaches are defined to address the performance of pressure altitude data item.

Within the first approach, which is only applicable to forwarded pressure altitude, the integrity and the latency of the pressure altitude are assessed independently (see § 4.2.7 & 4.2.8).

Within the second approach, which is applicable to both forwarded and calculated pressure altitude, the accuracy of the pressure altitude is assessed, which combines in a single performance indicator, both the error due to integrity issue and the error due to latency (see § 4.2.9).

4.2.1 Measurement interval

The measurement interval is a parameter that is used to assess the probability of update of data items.

The surveillance system applicable measurement interval will be used to assess the probability of update of horizontal position, pressure altitude and aircraft identity data items (§ 4.2.2).

4.2.2 Data item(s) probability of update

4.2.2.1 Horizontal position probability of update

Method

In order to verify that a surveillance system achieves the required probability of update (PU) of horizontal position in accordance with the applicable measurement interval (MI), the following measurement procedure shall be applied:

- Consider one flight reconstructed trajectory.
- Subdivide reconstructed trajectory into portions of time frames of length MI.
- Consider the trajectory portions that are entirely located within the CAV and count them (N_T).
- Count the number of these portions in which there is at least one horizontal position data item (N_R).
- Calculate the probability of update for a given flight (PU) as the ratio N_R / N_T (see Equation 1) if N_T is greater than or equal to 100.
- Or calculate the probability of update for a given flight (PU) in accordance with Equation 2) if N_T is smaller than 100.
- Calculate the global probability of update (PU) as in Equation 3 where n is the number of flights.

$$PU = \frac{N_R}{N_T}$$	**Equation 1**
$$PU = 1 - \frac{N_T - N_R}{100}$$	**Equation 2**
$$PU = \frac{\sum_n N_R}{\sum_n N_T}$$	**Equation 3**

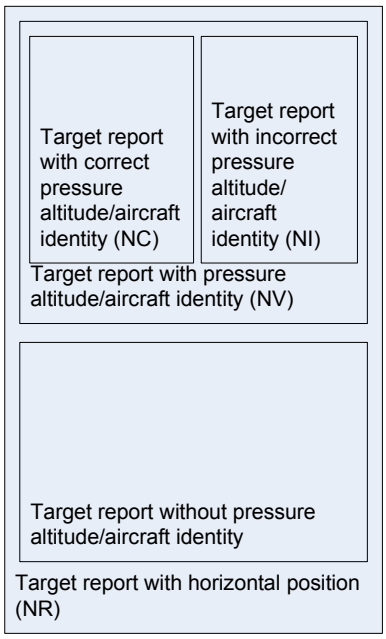

Figure 2: Numbers of target reports used for the calculation of PUC and the ratios of incorrect pressure altitude / aircraft identity

Figure 2 above illustrates the different numbers (N_X) that are used for the calculation of PUC and the calculation of the ratio of incorrect pressure altitude (§ 4.2.8) and the ratio of incorrect aircraft identity (§ 4.2.12).

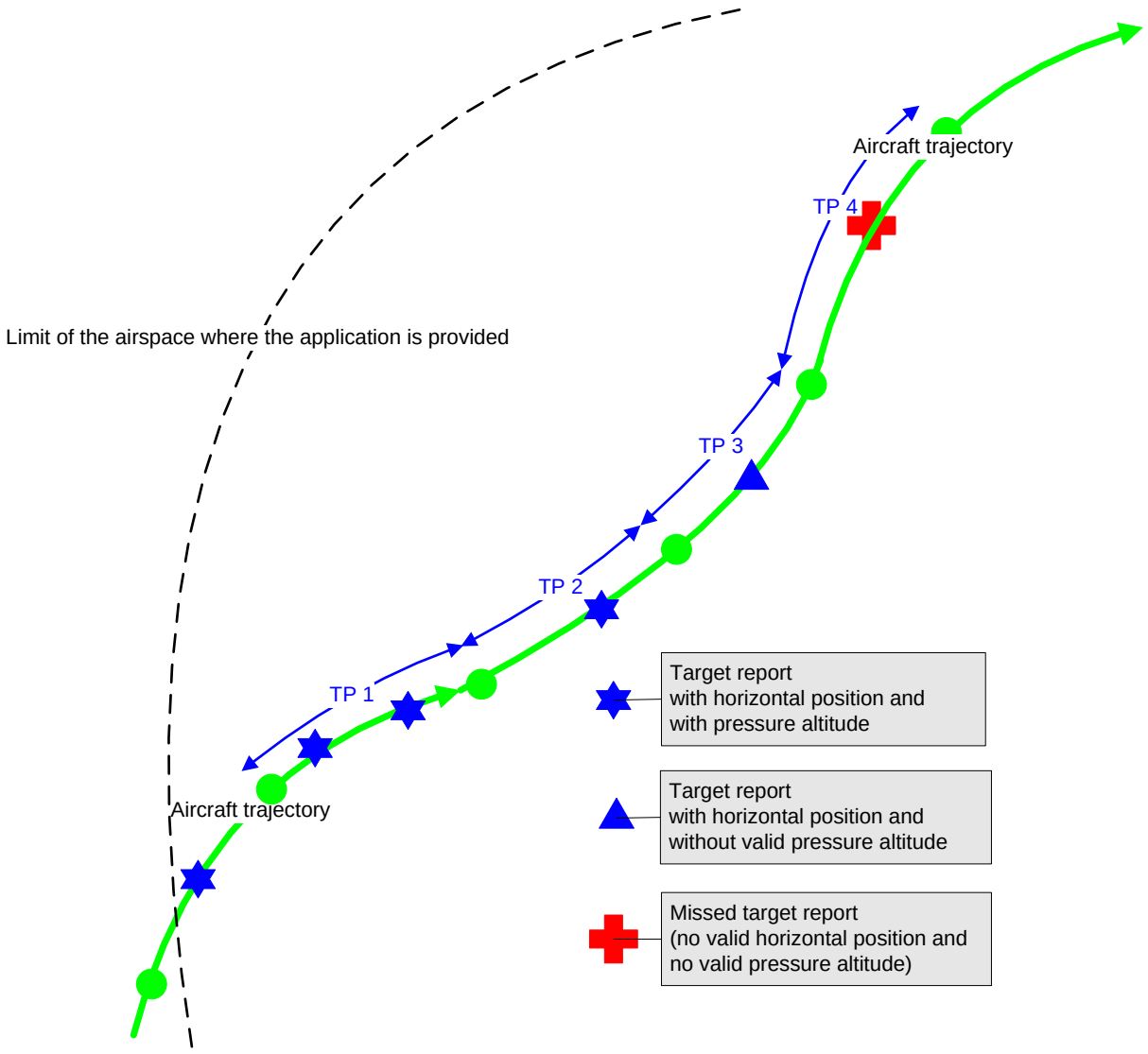

Figure 3: Illustration of horizontal position probability of update calculation

In the example provided in Figure 3 above and assuming that for the remaining of the flight there is at least one horizontal position data item in each of the other MIs and a total of 70 MIs then N_T = 70 and N_R = 69, therefore PU = 99% for that flight for the horizontal position.

Assuming there are 120 MIs for that flight then N_T = 120 and N_R = 119 and PU = 119/120 = 99,2 %.

Notes

This method does not allow the detection of small areas where there is no detection or a lack of detection. This issue could be addressed with a requirement for cellular calculation of update probability.

In order to make a calculation of the PU that is the least sensitive to the possible variations of the actual measurement interval between consecutive target reports, it is recommended to ensure that the first target report is time-located in the middle of the first MI, as shown in Figure 3.

4.2.2.2 Correct data item probability of update

Method

In order to verify that a surveillance system achieves the required probability of update of correct (PUC) data items (pressure altitude or aircraft identity) in accordance with the surveillance system applicable measurement interval (MI), the following measurement procedure shall be applied:

- Consider one aircraft reconstructed trajectory.
- Subdivide reconstructed trajectory into portions of time frames of length MI (as in § 4.2.2.1).
- Count the number of these portions in which there is at least one horizontal position data item (N_R).
- Count the number of these portions in which there is at least one correct[3] data item (N_C). If the data item is not present it is to be considered incorrect.
- Calculate the probability of update for a given flight (PUC) as the ratio N_C / N_R (see Equation 4) if N_R is greater than or equal to 100.
- Or calculate the probability of update for a given flight (PUC) in accordance with Equation 5) if N_R is smaller than 100.
- Calculate the global probability of update of correct data item (PUC) as in Equation 6 where n is the number of flights.

$$PUC = \frac{N_C}{N_R}$$	**Equation 4**
$$PUC = 1 - \frac{N_R - N_C}{100}$$	**Equation 5**
$$PUC = \frac{\sum_n N_C}{\sum_n N_R}$$	**Equation 6**

[3] Correctness criteria for pressure altitude and aircraft identity are respectively defined in § 4.2.8 and § 4.2.12.

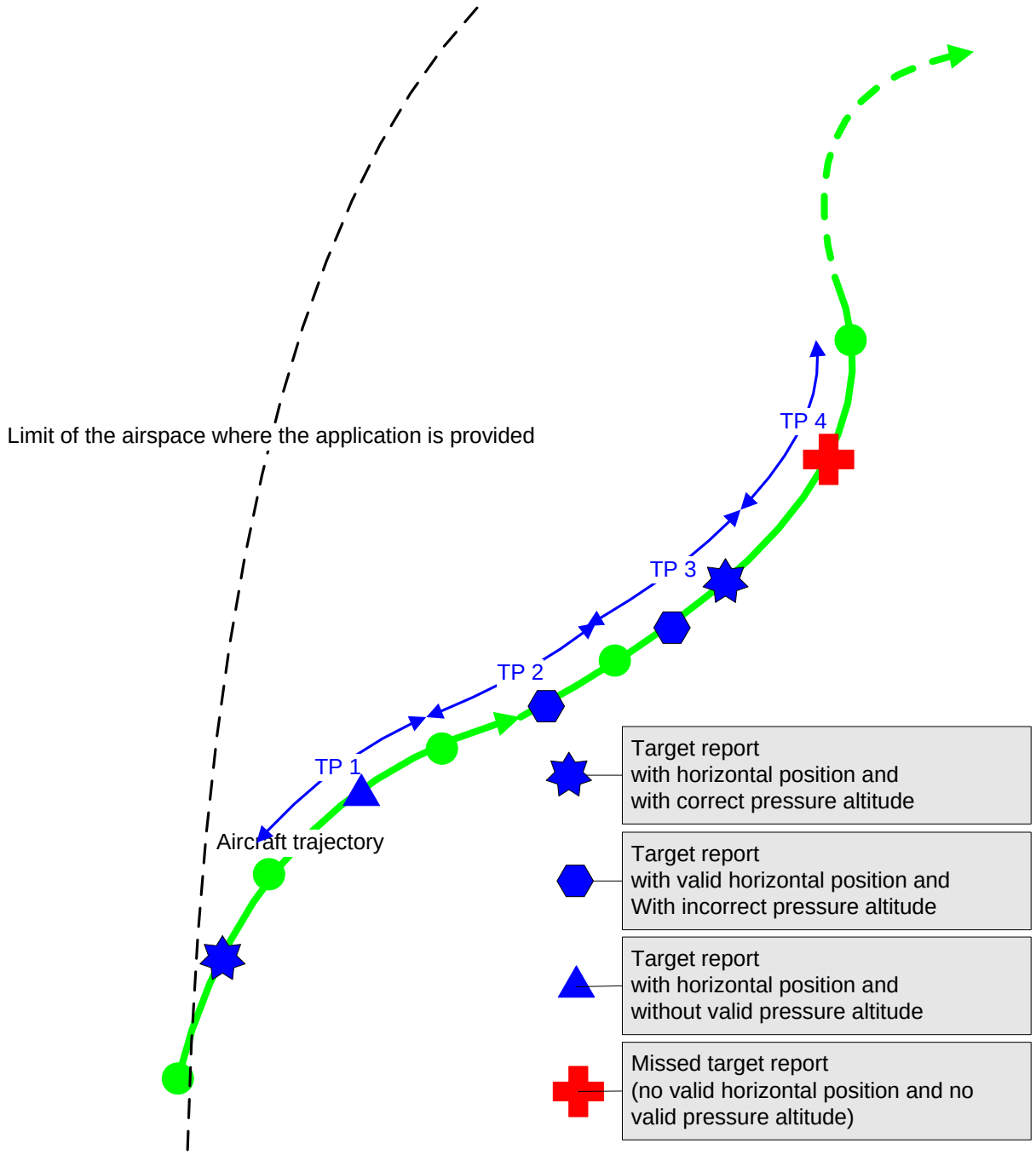

Figure 4: Illustration of calculation of probability of update of correct pressure altitude

In the example provided in Figure 4 above and assuming that for the remainder of the flight there is at least one pressure altitude data item in each of the other MIs and a total of 70 MIs then N_T = 70, N_R = 69 and N_C = 67, therefore PUC = 98% for that flight for the pressure altitude.

Assuming there are 120 MIs for that flight then N_T = 120 and N_R = 119, Nc = 117 and PUC = 117/119 = 98,3%.

Notes

The requirement on the probability of update of the aircraft identity data item is a requirement on the provision of correct information at the output of the system and does not require the extraction from the aircraft at each measurement interval. The rate of incorrect and the processing delay of these two data items are assessed through other requirements (see § 4.2.7, 4.2.8, 4.2.11 and 4.2.12).

In order to make a calculation of the PUC that is as less sensitive as possible to the possible variations of the actual measurement interval between consecutive target reports it is recommended to ensure that the first target report is time-located in the middle of the first MI, as shown on Figure 4.

4.2.3 Ratio of missed 3D/2D position involved in long gaps

A gap is a portion of aircraft reference trajectory between 2 consecutive target report updates including full update of the position (i.e. with horizontal position and pressure altitude for cooperative surveillance system and with horizontal position for non-cooperative surveillance system). The size of the gap is the time difference between these two target report updates. If the gap is partially located outside the CAV, it shall not be taken into account.

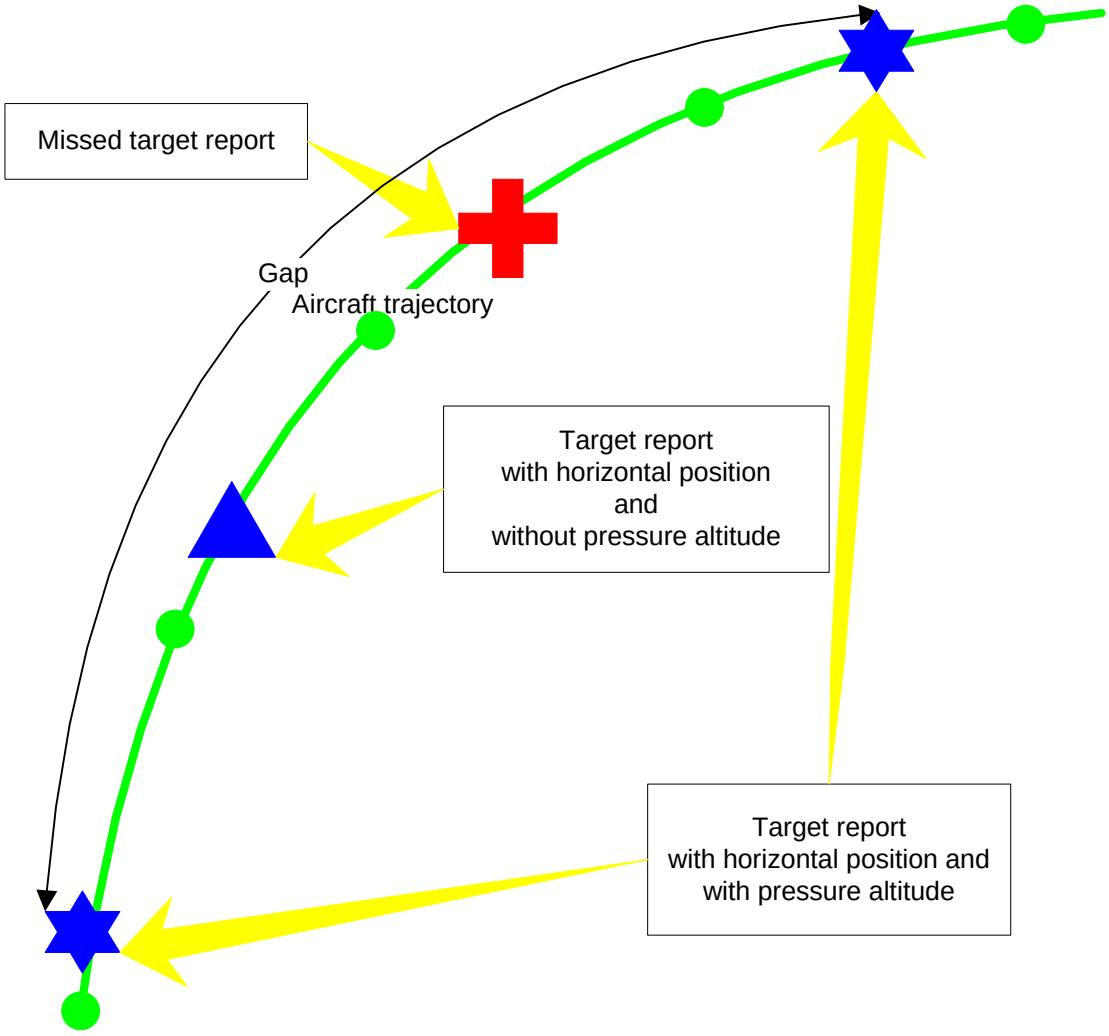

Figure 5: Illustration of gap for cooperative system

Method

Determine the gaps of a size (G_S) larger than 3 times the maximum measurement interval (8 s for 5 NM separation, 5 s for 3 NM separation) + 10% (i.e. long gap).

Count the number (N_G) of MIs (as determined in § 4.2.2.1) fully included in these gaps.

Calculate N_A as the sum of all the N_T calculated for the update probability.

$$N_A = \sum_n N_T$$ **Equation 7**

Calculate the long gap ratio as R_G in accordance with Equation 8 where n is the number of flights and g the number of long gaps.

$$R_G = \frac{\sum_g N_G}{N_A}$$ **Equation 8**

This ratio does not depend on the applicable measurement interval of the system both N_G and N_A are proportional to 1/MI.

4.2.4 RMS error of the horizontal position

The error on the provided horizontal position is the 2D Euclidian distance between the horizontal position provided by the surveillance system and the reference horizontal position of the corresponding aircraft at the time when the updated position was output/delivered (see Figure 6 below). This error takes into account any uncompensated latency between the time of applicability of the provided horizontal position and the time when the horizontal position was delivered to another system.

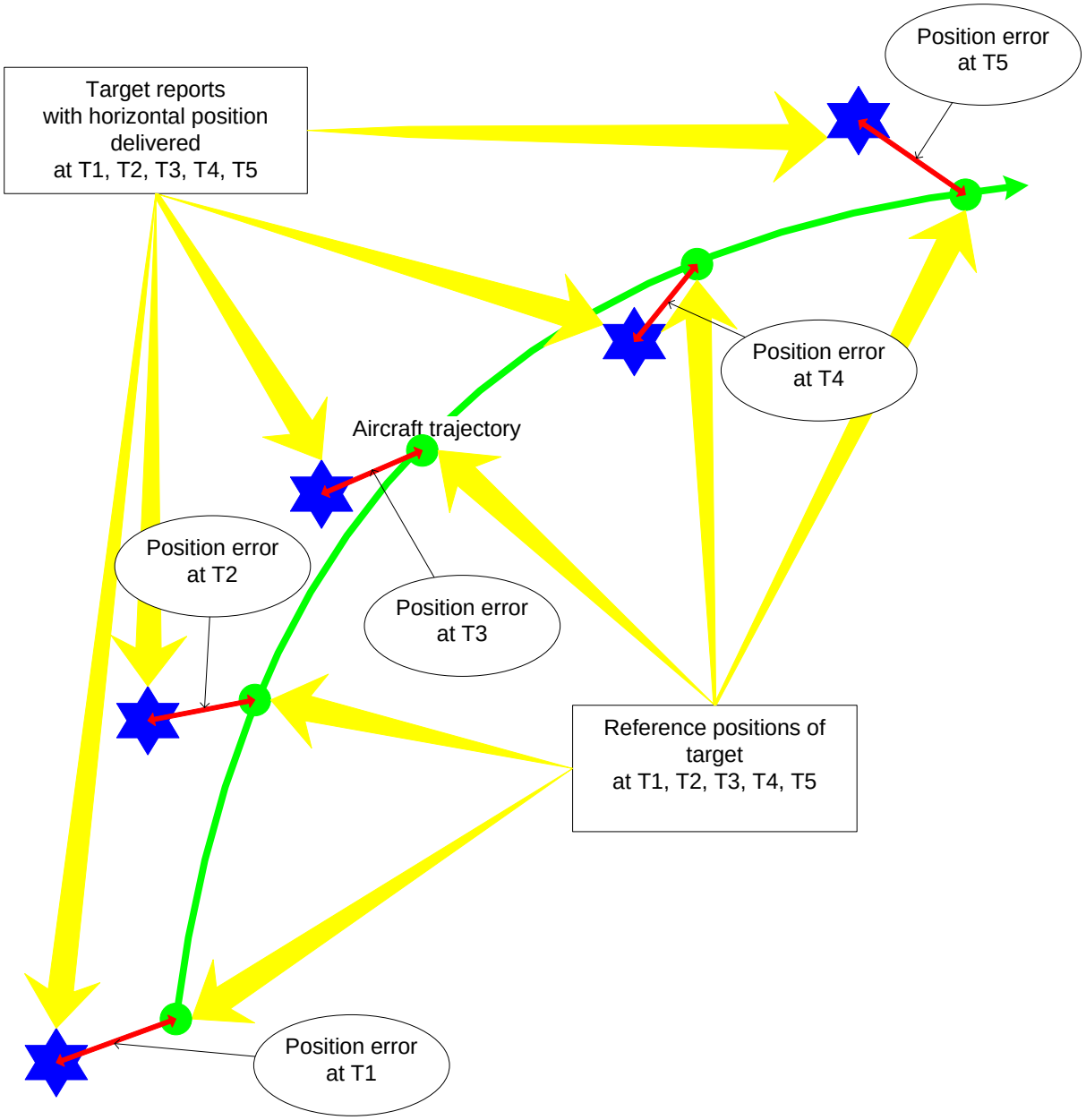

Figure 6: Horizontal position error assessment

Note

The horizontal position error shall be calculated in accordance with the coordinate system in which the horizontal position is displayed to the ATCO. Should this calculation not be practically possible, an additional error budget should be taken into account when assessing this performance characteristic.

Method

The horizontal position error shall be calculated for each target report, then the RMS shall be calculated for all target reports corresponding to the same flight and/or for all target reports globally.

The Equation 9 below provides the definition of the RMS value of n samples E_i, in our case the horizontal position errors.

$$RMS = \sqrt{\frac{\sum_{1}^{n} E_i^2}{n}}$$ **Equation 9**

4.2.5 Ratio of correlated horizontal position errors

The horizontal position error shall be calculated as specified in § 4.2.4 above.

A correlated position error is a series of at least 3 consecutive horizontal positions showing errors in the same direction and above the specified threshold.

For the specific purpose of this conformity assessment method, any missed or false target report will be considered to present the same horizontal position error as the previous target report with horizontal position from the same flight, provided it is followed by a target report with a horizontal position (i.e. lack of detections at the end of a flight will not be taken into account).

Method

Each horizontal position error vector shall be decomposed in an along (i.e. along the reference ground speed vector) position error component and an across (i.e. perpendicular to the reference ground speed vector) position error component.

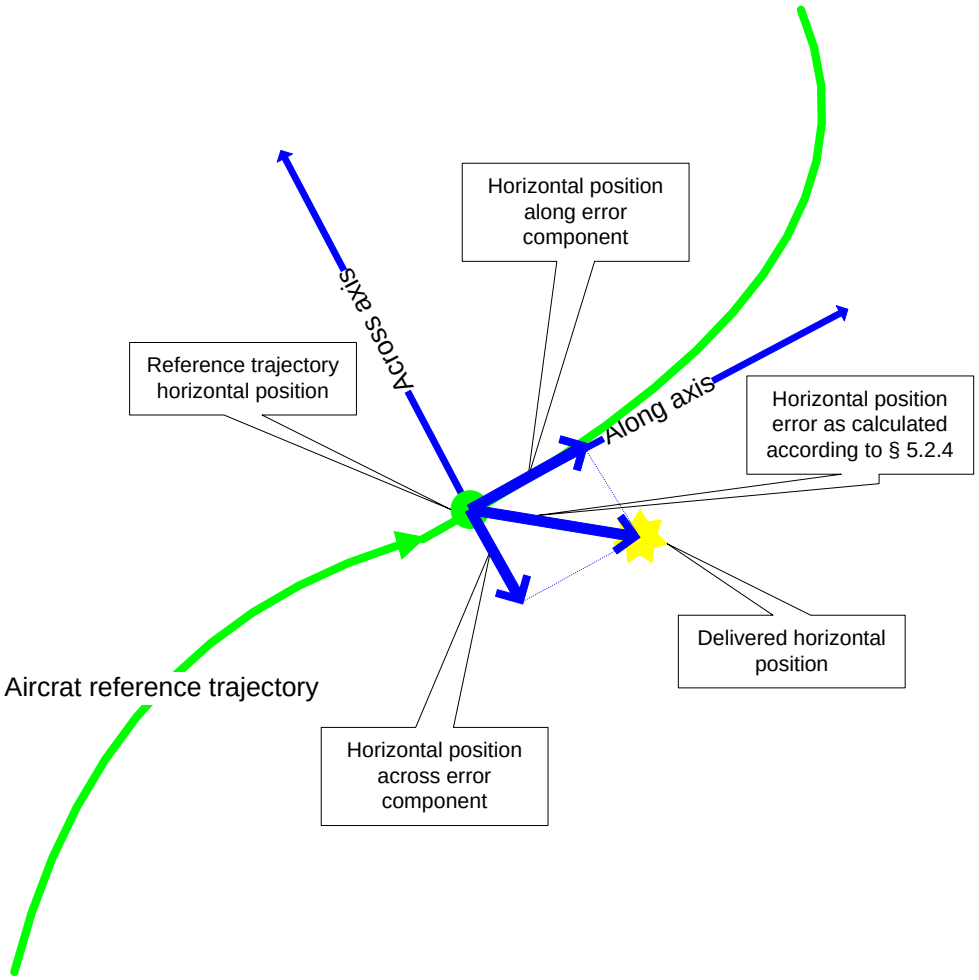

Figure 7: Illustration of horizontal position error components

Four (4) main directions shall be considered: positive across error, negative across error, positive along error, negative along error.

Identify sets of at least 3 consecutive errors in the same main direction greater than the specified value. Count the number of target reports involved in such scenario and divide it by the total number of target reports.

Note

As this kind of event may be relatively rare, it could be difficult to collect a reasonable number of samples in dataset of opportunity traffic so as to get a reliable statistical figure.

4.2.6 RMS value of the relative time of applicability of target reports in close proximity

The time to be considered is the time of applicability (e.g. the time data item of the Asterix message).

Method

Identify pair of target reports that are close in horizontal position (less than 18520/11110 m – 10/6 NM horizontally for respectively 5/3 NM horizontal separation service) and close in time (less than half the applicable measurement interval).

For each pair calculate the unsigned difference between times of applicability of the two target reports. Then calculate the RMS (see Equation 9) of these values.

Note

In case of rotating surveillance system the population may be limited to discard target reports located near the rotation axis.

4.2.7 Average and maximum data age of forwarded pressure altitude

Method

The age of forwarded pressure altitude shall be the time difference between when it was output and when it was time stamped by the receiving sensor (it is assumed that in the case of the pressure altitude data item, the airborne latency and the transmission latency are negligible).

In case of a single sensor system, the age is the difference between the time of output and the pressure altitude time of applicability reported within the sensor target report.

In the case of a tracker, this age shall be derived from the time of output and from information provided by the tracker (e.g. MFL sub-field of data item I062/295 “Track Data Ages” and “Time of Track Information” data item I062/070 of Asterix category 062 for system track data ([RD 5])).

4.2.8 Ratio of incorrect forwarded pressure altitude

Definitions

To determine the correctness of the forwarded pressure altitude, the value at the output of the surveillance system shall be compared with the reference value.

This reference value is the altitude of the reference trajectory sampled at the time the target report was output, minus the pressure altitude data age (as defined in § 4.2.7).

The tolerance being +/- 200 ft for aircraft reference position located in airspace where VSM = 1000 ft and +/- 300 ft for aircraft reference position located in airspace where VSM = 2000 ft.

Method

The percentage incorrect pressure altitude shall be calculated as the ratio R_I between the number N_I of target reports including an incorrect (see definitions above) pressure altitude and the total number of target reports including a pressure altitude N_V.

$$R_I = \frac{N_I}{N_V} \qquad \textbf{Equation 10}$$

Figure 2 illustrates the numbers used for the calculation of this indicator.

Notes

In case it is not possible to calculate pressure altitude date age, it will not be possible to perform the assessment of pressure altitude correctness.

The assessment of the correctness of pressure altitude does not take into account the time needed to process the information (i.e. its latency or data age); pressure altitude data age is assessed in accordance with a specific performance characteristic (see § 4.2.7 above).

Therefore this method does not apply to extrapolated/calculated pressure altitude. Should an extrapolated/calculated pressure altitude be provided, the requirement detailed in § 4.2.9 shall be verified.

4.2.9 Unsigned error of pressure altitude

Definitions

This assessment can be performed for whatever type of pressure altitude (e.g. forwarded or calculated).

The error of pressure altitude shall be calculated in accordance with the principle applicable for horizontal position error (see 4.2.2 above).

Method

Unsigned pressure altitude error = |Output pressure altitude – Reference trajectory pressure altitude at the time it was output|

The percentage of cases within the containment value shall be calculated separately for stable flights and for climbing/descending flights.

Stable flight means when reference trajectory climbing/descending speed that is lower than or equal to 300 ft/mn.

Climbing/descending flight means when reference trajectory climbing/descending speed that is greater than or equal to 200 ft/mn and is lower than or equal to 8000 ft/mn.

Note

There is some overlapping of target reports between stable flights and climbing/descending flights. This is deliberate because trajectory reconstruction of transition between stable and climbing/descending flights may be difficult; in any case the number of target reports belonging to the overlapping area is in general very small and would not influence the measurements.

4.2.10 Delay of change in emergency indicator / SPI report

Method

The delay of forwarded emergency indicator / SPI report shall be calculated as the difference between the time when the new information is present at the output of the surveillance system and the time when the emergency indicator / SPI report has been reported for the first time by one of the ground sensors.

4.2.11 Delay of change in aircraft identity

Method

The delay of change in aircraft identity shall be calculated as the difference between the time when the new aircraft identity data item is present at the output of the surveillance system and the time when new aircraft identity has been reported for the second time by a ground sensor.

Note

The reference assessment shall be performed on the specified data item, which is the aircraft identity reported by the aircraft and which is not to be confused with the aircraft identity reported by the Flight Data Processing System (FDPS). Further explanations are provided in Annex A - 2.

4.2.12 Ratio of incorrect aircraft identity

Aircraft identity (Mode A code or Aircraft Identification) shall be considered correct if the provided value is matching (exactly no tolerance) one of the values of the reference trajectory within the last applicable measurement interval.

Method

The percentage of incorrect aircraft identity (Mode A or Aircraft Identification) shall be calculated as the ratio R_I between the number N_I of target reports including an incorrect (see definitions above) pressure altitude and the total number of target reports including a aircraft identity N_V.

$$R_I = \frac{N_I}{N_V}$$ **Equation 11**

Figure 2 illustrates the numbers used for the calculation of this indicator.

The following Figure 8 and Figure 10 provide examples of correct and incorrect aircraft identity based on the method above.

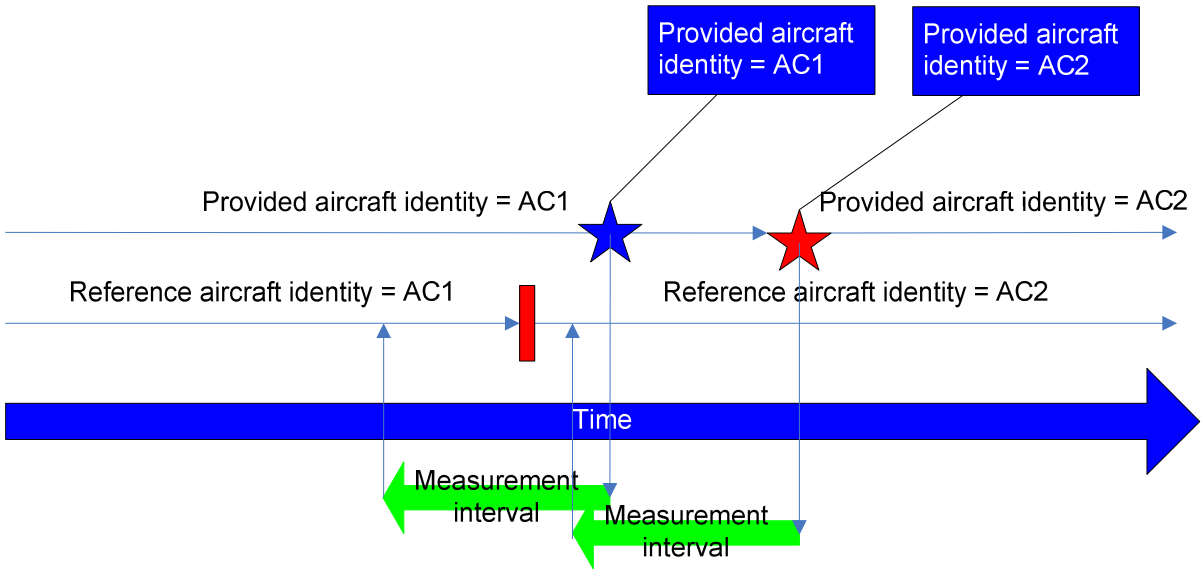

Figure 8: Examples of correct aircraft identity

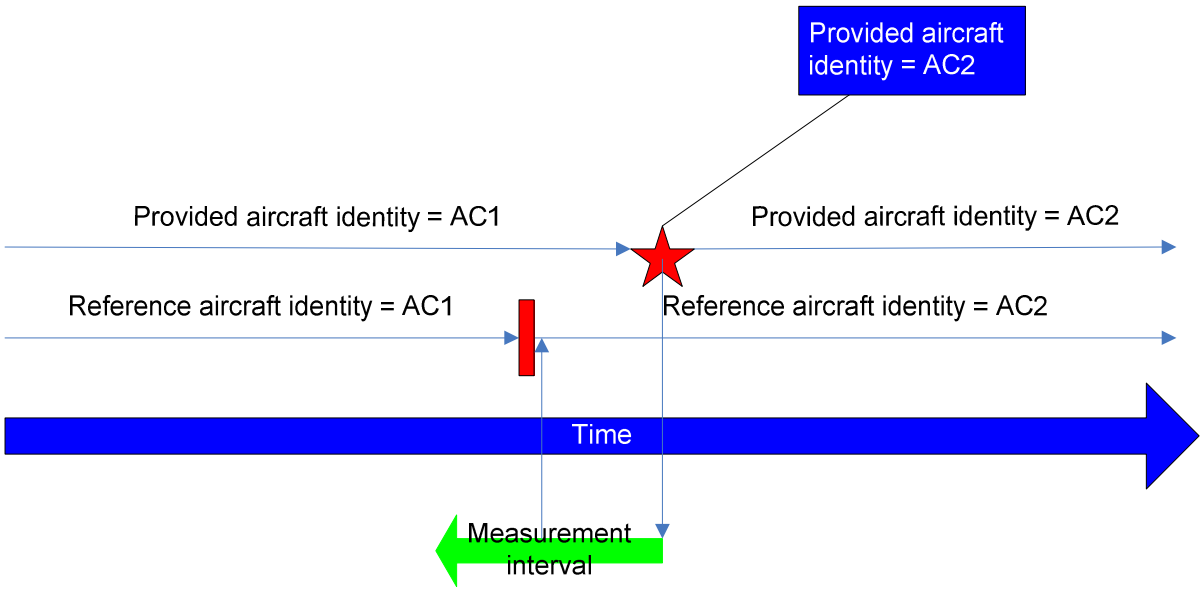

Figure 9: Other example of correct aircraft identity

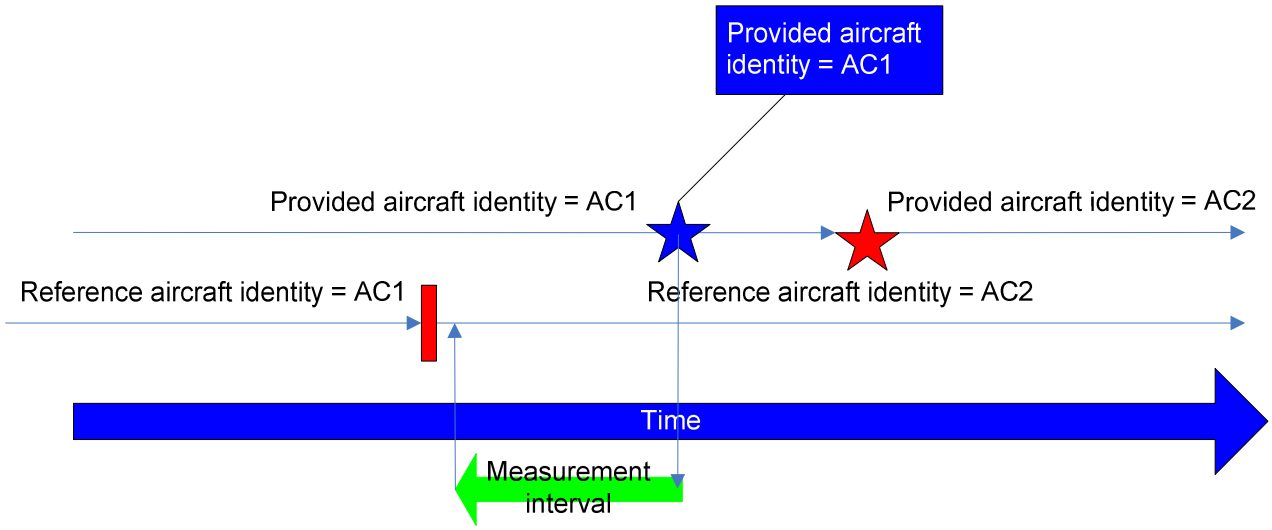

Figure 10: Example of incorrect aircraft identity

Note

The reference assessment shall be performed on the specified data item, which is the aircraft identity (Mode A code or Aircraft Identification) reported by the aircraft and which is not to be confused with the aircraft identity reported by the Flight Data Processing System (FDPS). Further explanations are provided in Annex A - 2.

4.2.13 RMS error of rate of climb/descent

This is applicable when rate of climb/descent data item is provided. A conformity assessment procedure is not yet defined when only the trend is provided.

Method

The calculation of the reference aircraft rate of climb/descent will follow the same principle as for horizontal position error (§ 4.2.2) i.e. the provided value will be compared with the reference value at the time the target report including the rate of climb/descent data item was output.

For a target report, the rate of climb/descent error is the difference, in absolute value, between the reference aircraft rate of climb/descent (as defined above) and the aircraft rate of climb/descent provided in the target report.

The reference trajectory rate of climb/descent shall be used to determine if the flight is stable and/or climbing/descending.

Comment

If the system is only providing a trend and not the actual value of the rate of climb/descent, a specific conformity assessment procedure will have to be defined.

4.2.14 RMS error of track velocity characteristics

This is applicable when track velocity data item is provided by the surveillance system.

Method

The calculation of the reference aircraft velocity amplitude and angle will follow the same principle as for horizontal position error (§ 4.2.2) i.e. the provided value will be compared with the reference value at the time the target report including track velocity data item was output.

For a target report, the track velocity error is the difference between the reference aircraft velocity amplitude (as defined above) and the aircraft velocity amplitude provided in the target report.

For a target report, the track velocity angle error is the difference between the reference aircraft velocity angle (as defined above) and the aircraft velocity angle provided in the target report. The calculation of that error shall be performed in the system of coordinates in which the track velocity data item has been provided.

The following Figure 11 provides an example of the calculation of track velocity error components based on the method above.

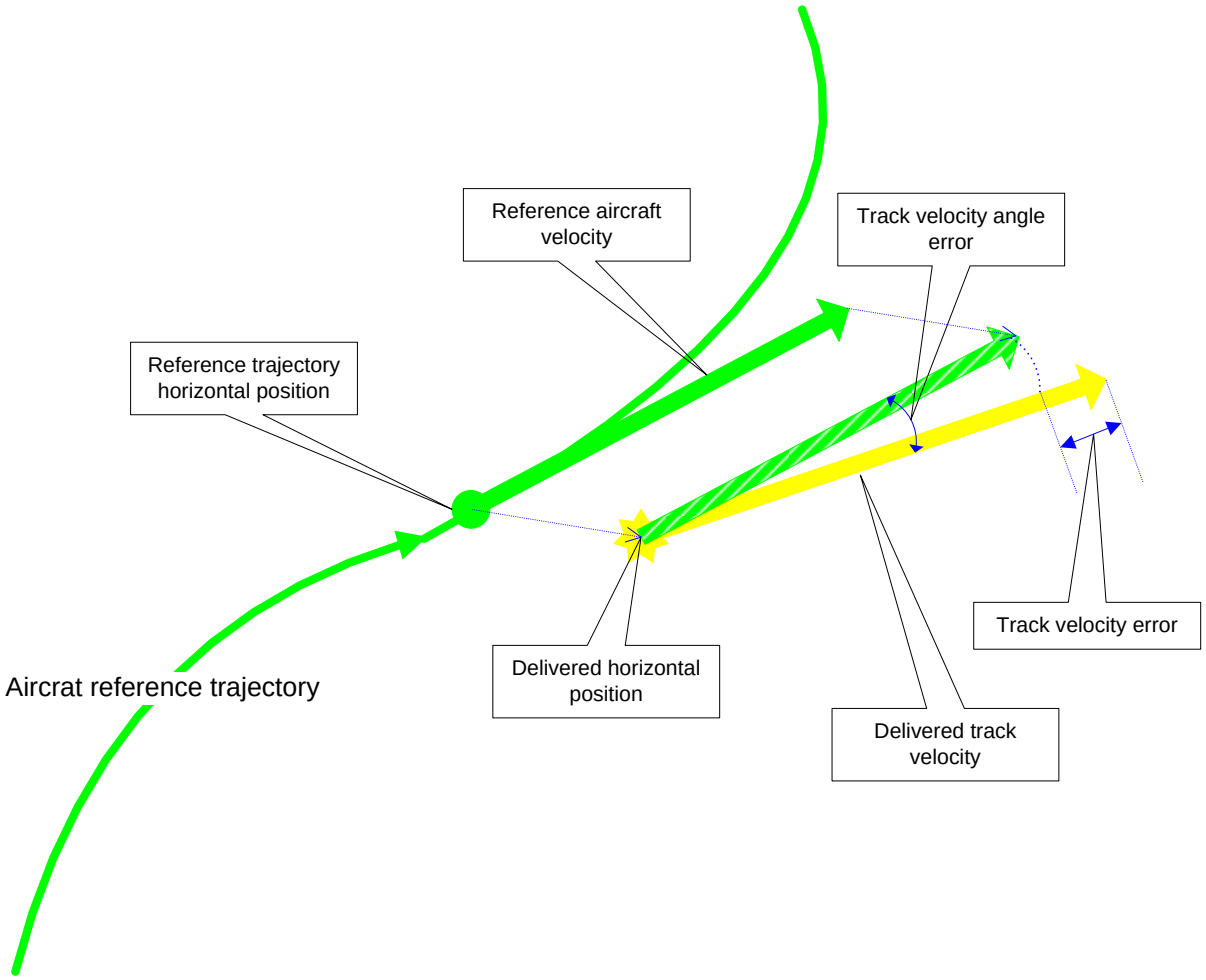

Figure 11: Example of calculation of track velocity error components

The portions of trajectories considered in this document are defined below:

- Straight line: reconstructed trajectory transversal acceleration is less than or equal to 1.5m/s².
- Turn: reconstructed trajectory transversal acceleration is greater than 1.5 m/s².

The table below provides the turn rate corresponding to 1.5 m/s² acceleration at different speeds.

Speed (knots)	Turn rate (°/s)
100	1,67
200	0,84
300	0,56
400	0,42
500	0,33
600	0,28
700	0,24
800	0,21
900	0,19
1000	0,17

Table 9: Turn rate as a function of speed for an acceleration of 1.5 m/s²

4.2.15 Density of uncorrelated false target reports

Definition

The uncorrelated false target reports are those false target reports which do not form a falsely confirmed track as defined in § 4.2.16.

Method

Identify the uncorrelated false target reports in accordance with the definition above.

For each false target report count, over a period of one hour, how many other false target reports are located in a circular area (900 NM^2 or 100 NM^2) centred on the initial false target report and in the CAV. The initial false target report shall also be counted.

The maximum value is the performance indicator.

4.2.16 Number of falsely confirmed tracks near to true tracks

Definition

A falsely confirmed track is a time (during at least 16/10 seconds for respectively 5/3 NM separation) and space (maximum the horizontal outlier criteria) correlated set of at least 3 false target reports with the same aircraft identity and belonging to the CAV.

The identification of falsely confirmed tracks shall be performed independently of the tracking information that may be provided by the surveillance system. For that reason, these 3 false target reports may not necessarily belong to the same track as declared by the surveillance system.

Method

Identify the falsely confirmed tracks in accordance with the definition above.

Once the falsely confirmed tracks are identified; select those that are close to the true tracks (corresponding to a true aircraft trajectory) and count them per time frames of one hour.

To determine if a falsely confirmed track is close to true tracks, the following process is proposed:

- Select a falsely confirmed track.
- Around each update of the falsely confirmed track open a geographical cylindrical analysis window of a radius equal to the proximity criteria.
- Identify the true tracks that have at least one track update located within this geographical window and within a time window of +/- half the applicable measurement interval centred on the falsely confirmed track update time.
- Repeat the operation for each update of the falsely confirmed track.
- If a true track has been identified at the third stage for at least two updates, the falsely confirmed track is considered to be close to that real track.
- Repeat the operation for each falsely confirmed track.
- Count, for each hour of operation, the number of falsely confirmed tracks that are close from at least one real track and record the start and end times of these falsely confirmed tracks.
- 2 falsely confirmed tracks are coincident if the time difference between the first update of the later false track and the last update of the earlier false track is less than the applicable measurement interval.

4.2.17 Surveillance system continuity

The continuity of the surveillance system shall be verified by design and if sufficient data is available on the basis of operations. The definition of continuity is provided in Annex C - 2.4.

4.3 Common requirement for time reference

As the time is an essential element when exchanging, comparing or assessing data items provided by a surveillance system, it is required to define a common time reference.

Absolute time information within surveillance target reports shall be provided in UTC as required in § 2.25.1 of ICAO Annex 11 [RD 10].

4.4 Conformity assessment framework

When developing conformity assessment methodology, it is necessary to insure that an appropriate combination of test techniques is applied. Use of opportunity traffic and of dedicated flight trials is of particular value as they demonstrate system performance in the actual operational environment.

4.4.1 Conformity assessment framework based on opportunity traffic

Assessing opportunity traffic provides a relatively cheap means to access a potentially large data set exhibiting the ‘real life’ characteristics in the real environment that are beyond the most complex simulations. However, to utilise the data for a specific trajectory, it is necessary to construct a reference against which comparisons can be made. There are test tools available which can be used for this purpose.

To permit an accurate assessment it is essential to ensure that the reference aircraft trajectories that are created in the analysis tool are of better quality than the trajectories that could be derived from the surveillance system outputs. This can be achieved as the construction of the reference trajectory can be conducted off-line and can thereby benefit by using information from future plot data.

An accurate assessment requires a sufficiently large data sample to reduce the impact of spurious data that could otherwise introduce statistical anomalies. The data sample used shall be of sufficient duration to examine all the characteristics of the surveillance system under assessment. It is recognised that to be able to assess some of the parameters identified in this document, a significant amount of time and data recording would be required in order to obtain a statistically relevant assessment. To assess the parameters described in this document it is recommended that a minimum of 50 000 target reports from the system under assessment are used in the analysis. To assess some parameters through the use of opportunity traffic would need considerably larger data sets. The introduction of cheaper memory and improved processing has allowed many ANSPs to assess data sets significantly larger than 50 000 reports. It is recognised that in areas of low traffic density additional tests using simulated data can be used to supplement the verification process.

All portions of flights belonging to the CAV shall be taken into account within the assessment. This is necessary to ensure that the Surveillance system is 'fit for purpose' and capable of supporting the service. However if anomalies are noted, stemming from identified avionics failings or a lack of data arising from a valid exemption, then the anomalous data may be discounted from the scope of the performance assessment of the ground based surveillance system components, if such events are covered by the system safety assessment. Similarly the CAV may vary with time. For example if there is a military exercise in a portion of the system coverage. In that case the CAV will be temporarily reduced or the aircraft involved will be filtered out.

A valid exemption is an exemption that has been granted by an NSA of one of the EUROCONTROL member states or, on behalf of one of these NSA's, by a recognised and appropriate body (e.g. the European Commission).

When conducting an assessment based upon targets of opportunity, it is recommended that:

- The conformity assessment process shall remove possible side effects due to the limited duration of datasets (at the beginning and at the end).
- The conformity assessment process shall remove possible side effects due to analysing data at the boundary edges of the CAV (e.g. performing the trajectory reconstruction over a larger volume than the CAV).

It is advised that data is recorded at various points in the system to permit traceability of cause of anomalies.

4.4.2 Conformity assessment framework based on flight trials

Flight trials are normally conducted to address the performance of a specific sensor and its input into the existing surveillance infrastructure rather than a test of an entire multi-sensor surveillance system. Their extensive use is limited due to their high cost.

An objective of the flight trials is to check the performance of the system:

- in specific volume of airspace (e.g. areas of low traffic density);
- against specific aircraft characteristics (e.g. transponder power, radar cross section);
- to establish a repeatable baseline.

The objective of a flight trial is to validate the performance simulations particularly in areas where difficulties are predicted.

The route flown by the trials aircraft is chosen to probe specific points of weak coverage at various heights and locations within the CAV. It should be noted that these may not only be at extremes of instrumented range. Flights over or near wind farms and motorways can also provide an ANSP with an improved appreciation of the impact that such environments could introduce to surveillance operations.

The trials shall be designed to address the specific characteristics of the surveillance sensors under test. A different approach to flight trial design may be necessary when testing a Mode S SSR type of system compared with a WAM system.

The flight trials shall be designed to address the case when the aircraft presents the worst but still compliant characteristics, e.g. smallest radar cross section (RCS) in case or primary radar, lowest transponder transmitter power output, least transponder receiver sensitivity.

Flight trials aircraft may be equipped with an accurate position recording device to permit a comparison of the surveillance data with the trajectory actually flown.

Flight trials may be used to prove performance when the system is configured to replicate failure conditions e.g. if a WAM receiver is unserviceable. Such an approach can confirm the impact of a degraded mode of operation.

Further information, mostly concerning radar systems but that can be generalised to surveillance systems in general, can be found in document [RD 12] and its Appendix A and in particular about the different combinations of transponder transmitter output power and transponder receiver sensitivity.

4.4.3 Conformity assessment framework based on proof offered through system design files or by system design assurance

The use of design files may be appropriate where demonstration of parameters is either difficult, expensive or if it is destructive. Design files may also be considered if the aspect has being tested before and no significant changes have been introduced.

Design files may also be assembled using previous tests based on injected test targets – e.g. simulations conducted using large Monte Carlo runs or software loading may not change from one configuration to another.

4.4.4 Conformity assessment framework based on test transponder

Cooperative surveillance systems often utilise remote static mounted transponders to support the built in test equipment and may also be used to provide the Air Traffic Controller with a visual confidence check regarding the performance of the system. Similar techniques exist for non cooperative surveillance systems.

Whilst the support offered by simple remote transponders is very limited, an ‘intelligent’ remote transponder may provide a more comprehensive yet non-intrusive means of verifying certain performance characteristics, such as the time taken to recognise a change of the Mode A code within the system, without the need to take an operational system off line.

4.4.5 Conformity assessment framework based on injected test target

Within surveillance sensors a self generated test target is often used to support Built In Test (BIT) assessments to provide a general indication of the 'health' of the system and to ensure that the system is operating as required. This aspect of conformity assessment does not include the use of BIT signals but refers to injected test targets and similar signals that are generated by laboratory equipment that is not an integral part of the surveillance sensor. It refers typically to tests conducted by the manufacturer to demonstrate system performance against specific requirements.

The benefit of an injected test target is that it permits detailed and specific tests to be conducted relatively cheaply and consistently. This approach can be of particular use in proving load testing (peak and average) or performance against complex scenarios that are not possible for cost and/or safety reasons to be proven through flight trials.

The use of detailed software controlled scenarios allows for the introduction of slight variations to established test configurations. It also permits the introduction of a parameter change at a specific point in time with the subsequent assessment of how long the system takes to reflect the change. Through such an approach it can also be used to optimize system performance.

Test targets are typically injected at the RF front end of the system, however they may also be injected at opportune points within the system chain where they can be used to assess in detail, the performance of a specific element of a surveillance sub-system.

As the antenna and several other front end components are 'by-passed' or simulated, such testing may not reflect real life site effects nor exercise the entire surveillance chain. However, with that limitation established, the use of an injected test target provides a comprehensive method of conducting a detailed performance assessment of numerous system characteristics that it would not be possible to test in any other way.

Such testing, which is to be conducted using appropriately calibrated test equipment, is to be considered as supplementary testing and whilst acceptable for specific aspects of performance, it is insufficient for determining actual total system performance achieved on site.

ANNEX - A SURVEILLANCE SYSTEM FUNCTION AND SCOPE

A - 1 Surveillance system function

The function of an ATM Surveillance System is to provide to local users information pertaining to aircraft located within its responsibility domain including:

- Aircraft position (i.e. Horizontal and altitude), i.e. where it is;
- Aircraft identity (including SPI and emergency state), i.e. who it is;
- Aircraft short term intentions (i.e. horizontal and vertical velocity); where it will be.

These 3 sets of data items are linked together by the time parameter.

All these data items are regrouped under the term surveillance information.

This surveillance information is used to provide air traffic services (e.g. horizontal separation) and/or to perform ATC functions (e.g. safety nets).

A - 2 Surveillance system scope

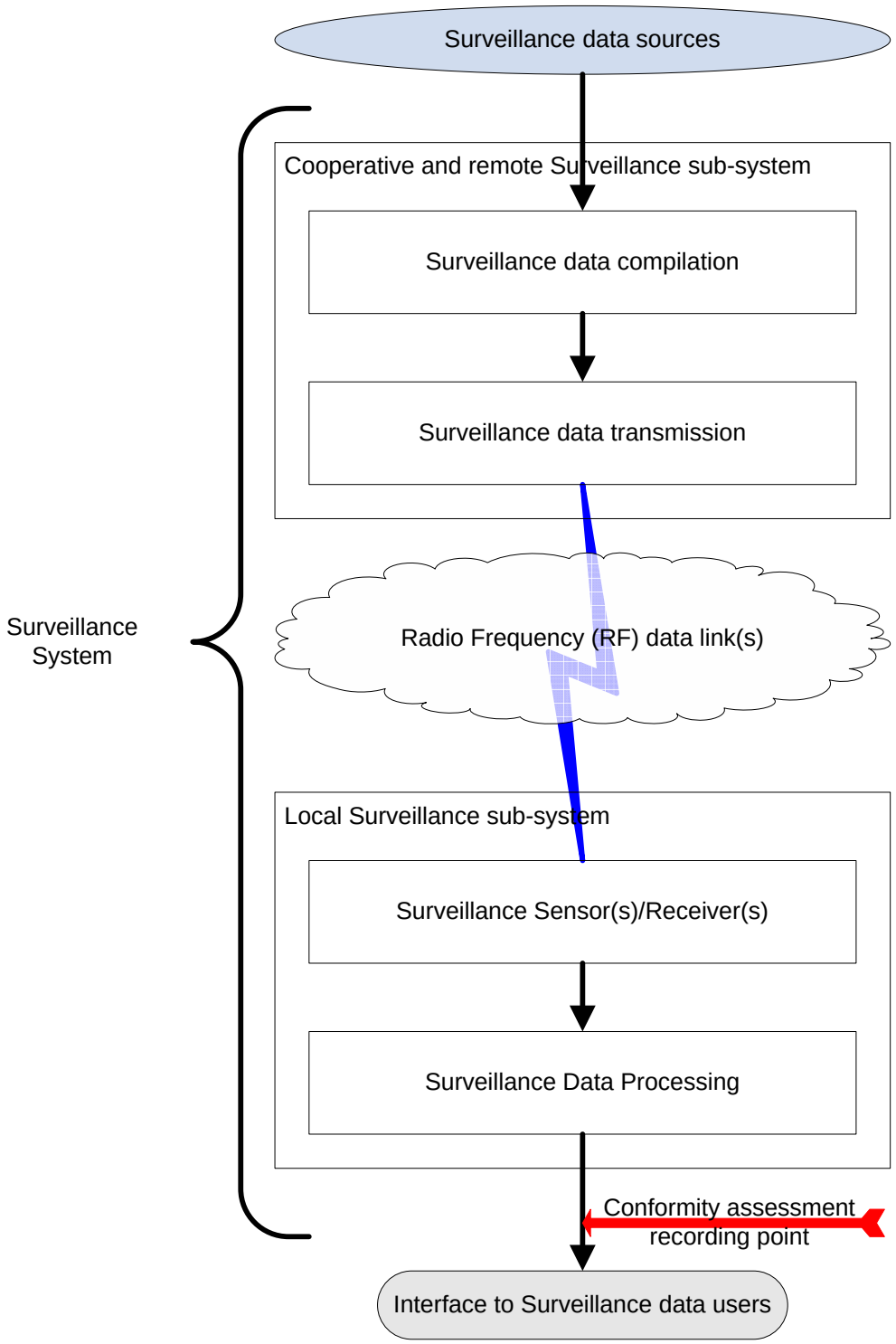

Figure 12: Generic functional diagram of a surveillance system

The diagram on Figure 12 provides a generic functional decomposition of a Surveillance system in charge of providing surveillance data items (see Annex A - 3 - Surveillance data items).

It is to be noted that the correlation function between the surveillance information and the flight plan information is considered outside the scope of the surveillance system. Similarly the function providing QNH/QNE corrected altitude on the basis of the pressure altitude is also considered outside the scope of the surveillance system. It is nevertheless recognised that the inputs of these functions can be provided to the surveillance data users through the surveillance system.

Within some surveillance system architecture it may be that the aircraft identity as reported by the aircraft is sent to the Flight Data Processing System (FDPS) which sends back a “flight plan correlated aircraft identity”. This latter information is then sent to the controller by the surveillance system. As specified in [AD1], the aircraft identity data item to be provided by the surveillance system, is the aircraft identity reported by the aircraft, therefore it is not the aircraft identity reported by the FDPS.

In the case of such architecture, the conformity assessment shall be adapted in such a way that the performance indicators corresponding to the aircraft identity data items are based on the aircraft identity reported by the aircraft and not the aircraft identity reported by the FDPS.

The next figures (Figure 13 and Figure 14) provide examples of current and future physical implementations of local airborne and ground surveillance systems based on 1030/1090 MHz data link. Figure 14 is fully consistent with the Generic RFG ADS-B Functional Architecture as described in EUROCAE ED-126 (document [RD 14]) and in EUROCAE ED-161 (document [RD 15]).

If the remote aircraft is not cooperative, there is no remote surveillance sub-system.

The cooperative and remote surveillance sub-system receives information acquired locally (sensors or HMI) and compiles these data items to make them consistent before being transmitted to the local surveillance sub-system through RF data links.

The local surveillance sub-system is performing measurements (sensors) and is receiving (receivers) the data items transmitted by remote surveillance sub-systems. The surveillance data processing function compile all these data items to make them consistent and to adapt them to the needs of the local users (synchronisation, format, etc.).

The surveillance system performance is considered end-to-end, therefore the performance measurements are undertaken at the interface with the surveillance data users so as to be compared with the corresponding needs/requirements.

The functional components of the previous diagram are still shown; in addition physical elements are shown with a folded corner and examples of surveillance data sources and surveillance data users are provided. On Figure 14 optional items are shown dotted.

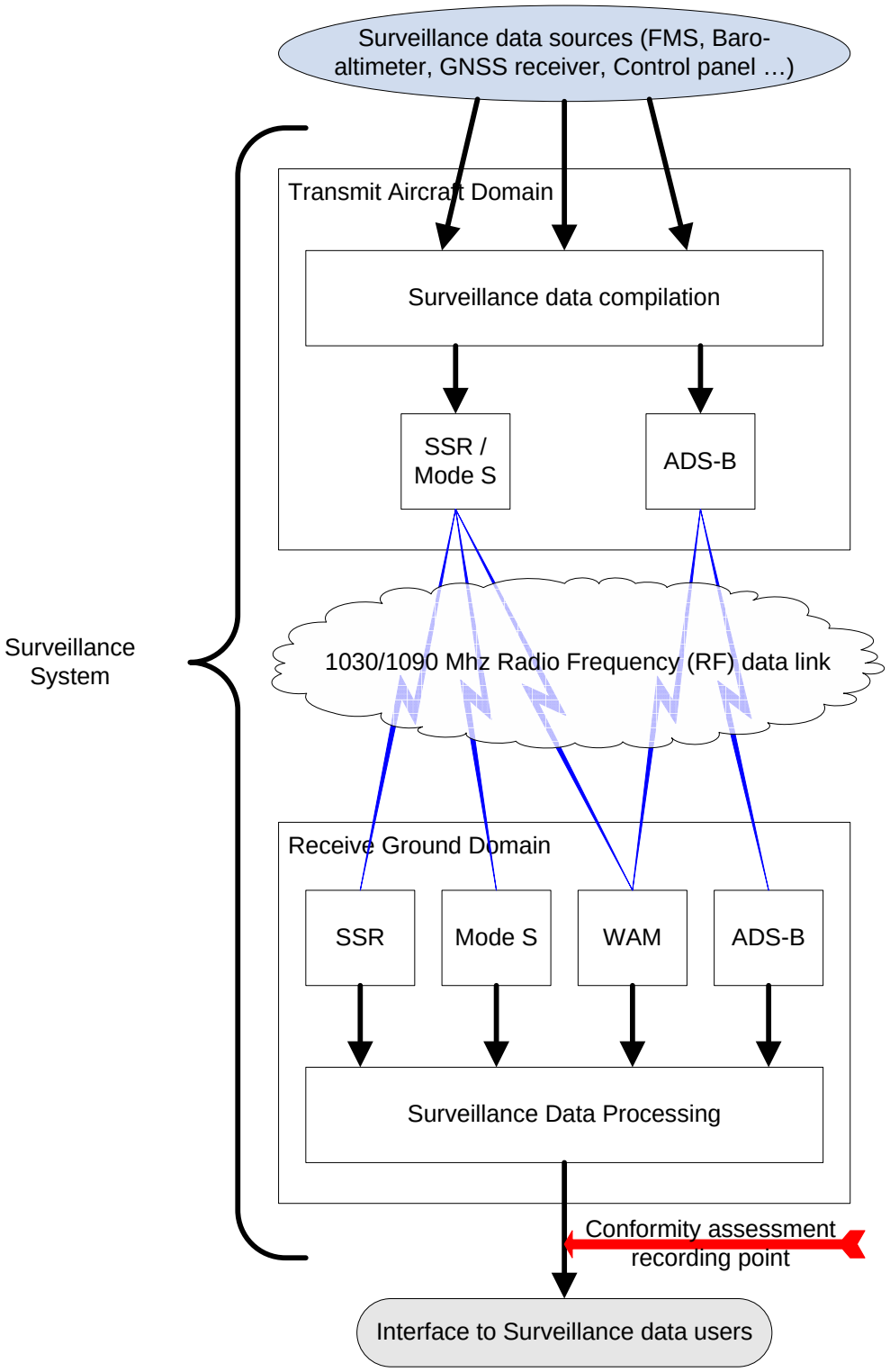

Figure 13: Current Air-Ground Surveillance systems implementation based on 1030/1090 MHz data link

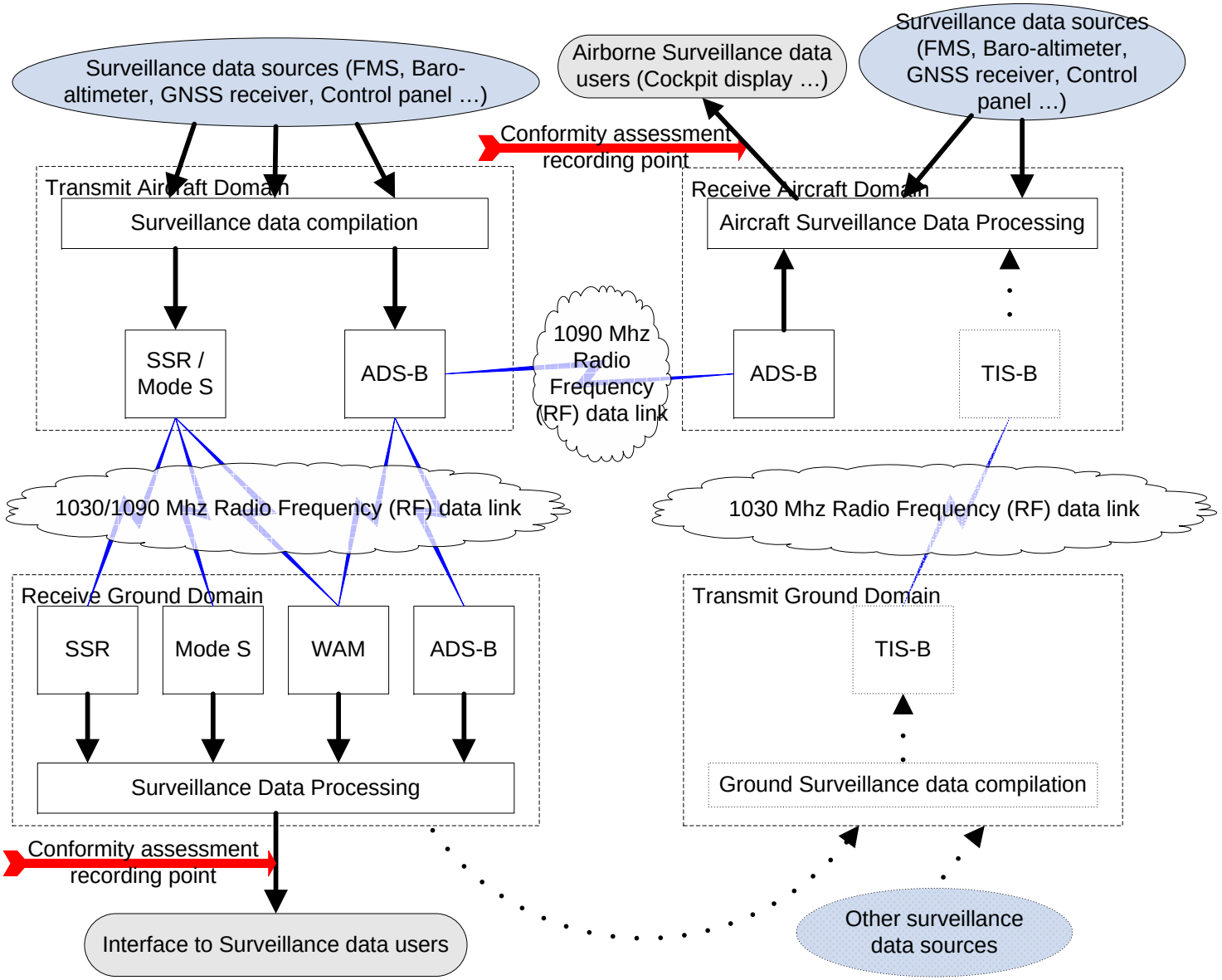

Figure 14: Future Air-Ground, Ground-Air and Air-Air Surveillance system implementation based on 1030/1090 MHz data link

In the frame of this document, the considered Surveillance system encompasses all the components and elements (either functional or physical) shown on the above figures and the RF data links used.

This document is independent of the environment; it is up to the surveillance system designer to ensure that the designed system is capable of providing the required performance when operated under the range of local environments.

For instance, the weather conditions may impact the quality of the RF data link; they will have to be taken into account in the frame of the surveillance system design process to ensure that the required performance can be met under all the locally specified weather conditions.

The performance of the surveillance system shall be measured at the input interface of the system using surveillance data. The measured performance characteristics can then be compared to the required performance characteristics.

From these diagrams one can see that the performance of the surveillance system not only depends on the performance of its different components and elements but also on the performance characteristics of its inputs.

Concerning the quality of the inputs to the aircraft domain it is assumed that they are in accordance with the requirements specified in the Annex II of [AD1]. These requirements will be further detailed in the forth coming EASA Certification Specification ACNS.

A - 3 Surveillance data items

A - 3.1 Surveillance data item categories

When looking at the different pieces of surveillance information in detail, one can sub-divide them into two categories, which correspond to two different types of processing by the surveillance system:

- Calculated surveillance data items, i.e. data items that are calculated and/or that are re-calculated at a given time and for a given time on the basis of externally/internally provided data (e.g. horizontal position). These two times are not necessarily equal.
- Forwarded data items, i.e. data items that are received by the surveillance system and which are provided without modification of its value at the output of the surveillance system. This is in particular the case for the identification data item (e.g. Mode A or Aircraft Identification). For such data items the system may apply integrity checking which could introduce a delay in the declaration of a new or change in value (e.g. the system may delay the output of a new Mode A awaiting for a stable reporting from the aircraft).

These two categories were taken into account when defining the ATM surveillance system key performance characteristics and associated indicators.

When the surveillance system extrapolates or transforms (e.g. from geodetic to Cartesian) input data, the resulting data item falls under the calculated data item category.

When the surveillance system only decodes a data item to reformat it (e.g. an Aircraft Identification from IA-5 to ASCII characters); the data item falls under the forwarded data item category.

When providing a calculated data item, the objective of the surveillance system is to produce a piece of information that is as close as possible to the reality at the time it is provided.

When providing a forwarded data item the objective of the surveillance system is to output the same value as in input with the shortest possible delay.

Given that the objectives of the surveillance system when processing one category or the other are rather different, the performance characteristics and indicators will also be different depending on the data item category.

A - 3.2 Calculated surveillance data item

The data items that are calculated by surveillance systems are:

- Calculated horizontal position
- Calculated velocity
- Calculated rate of climb/descent
- Calculated mode of movement
- Calculated acceleration
- Calculated geometric altitude
- Calculated pressure altitude (e.g. smoothed or extrapolated)
- Any data item which is specified as “calculated” by the system even though it is extrapolated on the basis of an airborne provided data item.

A - 3.3 Forwarded surveillance data item

The data items that are forwarded by surveillance systems are:

- Airborne Standard pressure altitude, e.g. Mode C.
- Mode 1, 2, 3/A codes.
- Target identification, e.g. Aircraft Identification, SPI, emergency states.
- Any Downlink Aircraft Parameter (DAP), e.g. Selected Altitude, True Track Angle, Ground Speed, Track Angle Rate, Magnetic Heading.
- Any data item provided to the system and which is directly output without any modification of its value.

A - 3.4 Extraction/calculation of surveillance data items

Depending on their nature, surveillance data items are either extracted/calculated periodically or on event.

All the data items related to the trajectory (position, velocity, etc.) of the aircraft that are constantly changing with time are calculated periodically.

On the other hand, data items such as the identity of the aircraft, which do not change or very rarely, are only extracted from the aircraft on event, i.e. when there is a change.

It is to be noted that in order to avoid the possiblity of a change being missed,, the system may also be designed to extract periodically these data items that are in principle “event driven”.

ANNEX - B REFERENCE DOCUMENTS AND ACRONYMS

B - 1 Applicable documents

[AD1] Commission Implementing Regulation (EU) No 1207/2011 of 22 November 2011 laying down requirements for the performance and the interoperability of surveillance for the single European sky (Link to document)

B - 2 Referenced documents

The study reports listed in B - 2.4 and B - 3.3 can be obtained upon request from EUROCONTROL.

B - 2.1 EUROCONTROL documents

[RD 1] EUROCONTROL Specification for ATM Surveillance System Performance (Volume 2 Appendices) SPEC-0147 Dated 30/03/2012.

[RD 2] EUROCONTROL Standard Document for Radar Surveillance in En-Route Airspace and Major Terminal Areas SUR.ET1.ST01.1000-STD-01-01 Ed. 1.0 March 1997 (link to document)

[RD 3] European Mode S Station Functional Specification SUR/MODES/EMS/SPE-01 version 3.11 dated 9 May 2005 (Link to document)

[RD 4] "Safety Assessment Made Easier" Part 1 - Safety Principles and an introduction to Safety Assessment Edition 1.0 15 January 2010 (Link to document)

[RD 5] EUROCONTROL standard document for surveillance data exchange. Part 9: Category 062 SDPS track messages Ref. SUR.ET1.ST05.2000-STD-09-01 Edition 1.15 Dated September 2011 (Link to document)

[RD 6] Preliminary Safety Case for Enhanced Air Traffic Services in Non-Radar Areas using ADS-B surveillance PSC ADS-B-NRA Edition 1.1 Dated 12 December 2008 (Link to document)

[RD 7] Generic Safety Assessment for ATC Surveillance using Wide Area Multilateration Edition 6.0 Dated 13/08/2009

[RD 8] Mode S Controller Working Position Preliminary System Safety Assessment Edition 1.1 Dated October 2007

B - 2.2 ICAO documents

[RD 9] ICAO Procedures for Air Navigation Services – Air Traffic Management. Doc 4444 ATM/501 fifteenth edition Amendment 5 Dated 22/11/2007

[RD 10] ICAO Annex 11 Air Traffic Services Thirteenth Edition July 2001

[RD 11] ICAO, Manual of the ICAO Standard Atmosphere Doc 7488/3, Third Edition, 1993

[RD 12] Manual of testing radio navigation aids – Testing of surveillance radar systems ICAO Document 8071 Volume III 1st Edition – 1998 including amendment N° 1 19/10/2002

[RD 13] ICAO Annex 15 Aeronautical Information Services 12th Edition July 2004.

B - 2.3 EUROCAE documents

[RD 14] Safety, Performance and Interoperability Requirements Document for ADS-B NRA Application ED-126 Dated December 2006 (EUROCAE)

[RD 15] Safety, Performance and Interoperability Requirements Document for ADS-B RAD Application ED-161 Dated September 2009 (EUROCAE)

[RD 16] Technical specification for Wide Area Multilateration (WAM) systems ED-142 Dated September 2010 (EUROCAE)

B - 2.4 Reports of EUROCONTROL studies

[RD 17] Review of horizontal surveillance performance – Final Report (D3) CSS/C1853/TRS99_D3_V1.0 11/08/2006

[RD 18] Study to Analyse Horizontal Positional Performances Draft Version 3.2 22/12/2006

[RD 19] Study on Maximum Data Age Required at the Output of a Surveillance System Draft Version 2.2 12/12/2006

[RD 20] Surveillance Standards Performance Characteristics P740D005 version 1.0 dated 10/10/2007

[RD 21] Comparative study of Surveillance performance indicators for false target performance P890D004 Dated 30/09/2008 Version 1.1

[RD 22] A surveillance performance model incorporating dynamic factors Version 1 Dated 12/06/2009

B - 2.5 Other documents

[RD 23] Information technology – Quality of service: Framework ISO/IEC 13236 First Edition Dated 15/12/1998

[RD 24] Référentiel technique pour l'établissement d'un Dossier relatif à un Minimum de Séparation Radar (DMSR) DO/DTI/MSQS/NT05-572 Décembre 2005 V2

[RD 25] ARTAS V7 Safety Assessment Report CF407/01/102 Edition 3.0 Dated 31/08/2006

[RD 26] RSP for surveillance systems supporting 3 and 5 NM separations Working paper reported to the Aeronautical Surveillance Panel Working Group of the Whole (ASP WGW) 1st meeting Montreal 8-12/12/2008 Agenda Item 5

[RD 27] EASA Decision N° 2003/11/RM of the Executive Director of the Agency of 5 November 2003 on definitions and abbreviations used in certification specifications for products, parts and appliances (« CS-Definitions ») (Link to document)

[RD 28] Commission Implementing Regulation (EU) 1035/2011 of 17 October 2011 laying down common requirements for the provision of air navigation services and amending Regulations (EC) No 482/2008 and (EU) No 691/2010 (Link to document)

B - 3 Reference documents

B - 3.1 EUROCONTROL documents

[RD 29] Air Navigation System Safety Assessment Methodology (SAM), SAF.ET1.ST03.1000-MAN-01, Edition 2.1 Dated 2007

B - 3.2 ICAO documents

[RD 30] ICAO Annex 10 Vol I Radio Navigation Aids (including Amendment 80) 24/11/05

[RD 31] ICAO SASP – Assessment of ADS-B Surveillance to support air traffic services and state implementation roadmap

[RD 32] ICAO Annex 10 Aeronautical Telecommunications Vol IV Surveillance radar and Collision Avoidance System 3rd Edition July 2002

[RD 33] ICAO Annex 6 Operation of Aircraft Part 1 International Commercial Air Transport – Aeroplanes 8th Edition July 2001

[RD 34] Manual on Airspace Planning Methodology for the Determination of Separation Minima ICAO Doc 9689-AN/953 First Edition 1998

[RD 35] ICAO Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum between FL 290 and FL 410 Inclusive. 2nd Edition 2002 Document 9574 AN/934.

[RD 36] ICAO Document 9536, Review of the General Concept of Separation (RGCSP).

[RD 37] ICAO Document 8168, Aircraft Operations Volume 1 Flight Procedures Fifth Edition 2006

[RD 38] ICAO Document 8168, Aircraft Operations Volume 2 Construction of Visual and Instrument Flight Procedures Fifth Edition 2006

B - 3.3 Reports of EUROCONTROL studies

[RD 39] Guidance Material for Required Surveillance Performance QINETIQ /05/00819 Dated May 2005

[RD 40] Assessment Report Surveillance Standards 200300-REP-07-0090 version 2.3 dated 16/07/2007

B - 3.4 Other documents

[RD 41] International Standard Information Technology – Vocabulary Part 14 ISO/IEC 2382-14:1997(E/F) 2nd Edition Dated 01/12/1997

[RD 42] Electronic Reliability Design Handbook MIL-HDBK-338b 01 October 1998

[RD 43] Surveillance and Conflict Resolution System Panel (SCRSP) SCRSP-2/WG-B WP B8-07 26 May 2005 Agenda Item 5.2

[RD 44] Verification procedures of surveillance system applied by DSNA/France – Information paper V1 11/05/2006

[RD 45] JAA Administrative and Guidance Material. Section 3: General Part 1: Temporary Guidance Leaflets. Leaflet N° 6 Revision 1 Guidance Material on the Approval of Aircraft and Operators for Flight in Airspace above Flight Level 290 where a 300 m (1000 ft) Vertical Separation Minimum is Applied. Dated 1/10/1999.

[RD 46] JAA Administrative and Guidance Material Section 1 Part 3 Leaflet 13 Revision 1 Certification of Mode S Transponder Systems for Elementary Surveillance date 01 May 2001

[RD 47] SESAR – The ATM target concept D3 DLM-0612-001-02-00a - September 2007

[RD 48] SESAR – The Performance target D2 DLM-0607-001-02-00a December 2006

B - 4 Acronyms

Acronym	Definition
ACID	AirCraft IDentification
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic COntroller
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
BIT	Built In Test
CAV	Conformity Assessment Volume
DAP	Downlink Aircraft Parameter
DSNA/DTI	Direction des Services de la Navigation Aérienne/Direction de la Technique et de l'Innovation
EASA	European Aviation Safety Agency
EATMN	European Air Traffic Management Network
EC	European Commission
ECAC	European Civil Aviation Conference
FCU	Flight Control Unit
FHA	Functional Hazard Analysis
FL	Flight Level
FMS	Flight Management System
HMI	Human Machine Interface
HSM	Horizontal Separation Minima
IAS	Indicated Air Speed
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ISA	International Standard Atmosphere
ISO	International Standardisation Organisation
JAA	Joint Aviation Authorities
MCP	Mode Control Panel
MRT	Mean Response Time
MSPSR	Multi-Static Primary Surveillance Radar
MTBCF	Mean Time Between Critical failure
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair/Restore
NM	Nautical Mile
NRA	Non Radar environment (in the context of the ADS-B RFG)
NSA	National Supervisory Authority
OHA	Operational Hazard Analysis
OPA	Operational Performance Assessment
OSED	Operational Service and Environment Description
PSR	Primary Surveillance Radar
PSSA	Preliminary System Safety assessment
PU	Probability of Update
PUCV	Probability of Update with Correct and Valid value
RAD	RADar environment (in the context of the ADS-B RFG)
RCS	Radar Cross Section
RF	Radio Frequency
RFG	Requirement Focus Group
RMS	Root Mean Square
RPS	Radar Position Symbol
RSP	Required Surveillance Performance

Acronym	Definition
RVSM	Reduced Vertical Separation Minimum
SDP	Surveillance Data Processing
SDPS	Surveillance Data Processing System
SES	Single European Sky
SPI	Special Position Identification
SPI IR	Surveillance Performance and Interoperability Implementing Rule
SSR	Secondary Surveillance Radar
SSTF	Surveillance Standard Task Force
TAS	True Air Speed
TBC	To Be Confirmed
TBD	To Be Defined
TMA	Terminal Manoeuvring Area
MI	Measurement interval
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VSM	Vertical Separation Minima
WGS	World Geodetic System

Table 10: Acronym list

ANNEX - C DEFINITIONS

C - 1 Data item definitions

C - 1.1 Position data items

Geodetic Position – This is the position of the aircraft projection on the earth's ellipsoid, as defined in WGS84. It is expressed as latitude and longitude. This data item can be forwarded and/or calculated depending on surveillance system architecture.

Horizontal Position – This is the 2D projected position which is used to display the aircraft position onto the ATCO HMI. This data item is calculated by the ground surveillance system.

Pressure altitude – This is the altitude in Flight Levels (FL) of the aircraft derived from an airborne pressure measurement in accordance with the ICAO International Standard Atmosphere (defined in ICAO document 7488 [RD 11]). In principle, this data item can be forwarded and/or calculated depending on surveillance system architecture. One FL is equal to 100 feet, pressure altitude when measured on board the aircraft is expressed with a resolution of 25 ft (1/4 FL) or with a resolution of 100 ft (1 FL).

QFE corrected Pressure Altitude – This is the height of the aircraft in feet above a local aerodrome. This height is derived from the Pressure altitude reported by the aircraft in accordance with the pressure datum corresponding to the pressure measured on the ground of the aerodrome. This data item is calculated by the ground surveillance system.

QNH corrected Pressure Altitude – This is the altitude of the aircraft in feet above mean sea level for a given area. This altitude is derived from the Pressure altitude reported by the aircraft in accordance with the pressure datum corresponding to mean sea level for the corresponding area. This data item is calculated by the ground surveillance system.

Vertical Geometric Altitude – This is the vertical distance between the aircraft and the position of its projection on the earth's ellipsoid, as defined in WGS84. This data item can be forwarded and/or calculated depending on surveillance system architecture.

C - 1.2 Aircraft Identity data items

Aircraft identification – This is the data item 7 in the ICAO flight plan or the Tail number / Registration if there is no associated flight plan. This data item is forwarded by the surveillance system.

Mode A Code – This is the code (4 octal digits) that has been allocated to the aircraft by the ATC. This data item is forwarded by the surveillance system.

C - 1.3 Supplemental indicator data items

Emergency indicator – This data item reports the type of emergency; it can be conveyed via special Mode A codes (i.e. 7500 unlawful interference, 7600 radio-communication failure, 7700 state of emergency). This data item is forwarded by the surveillance system.

SPI – Special Position Identification – This is special information that is sent by the aircraft when requested to by the ATCO. This data item is forwarded by the surveillance system.

C - 1.4 Velocity data items

The projection system(s) used to calculate those data items need to be clarified.

Ground Speed – This is the speed (amplitude) of the aircraft over the ground. This data item is calculated on-board the aircraft. If available, this data item may be forwarded by the surveillance system.

Indicated Airspeed (IAS) – This is the speed of the aircraft as shown on its pitot static airspeed indicator calibrated to reflect standard atmosphere adiabatic compressible flow at sea level uncorrected for airspeed system errors. This definition is extracted from the EASA document [RD 27]. This data item is calculated on-board the aircraft. If available, this data item may be forwarded by the surveillance system.

Inertial vertical velocity – This is the vertical velocity of the aircraft as measured by an inertial device on board the aircraft. This data item is calculated on-board the aircraft. If available, this data item may be forwarded by the surveillance system.

Magnetic heading – This is the direction over the ground to which the aircraft axis is pointed. The reference is the Magnetic North at the aircraft position. This data item is calculated on-board the aircraft. If available, this data item may be forwarded by the surveillance system.

Pressure altitude rate – This is the variation over time of the aircraft pressure altitude. This data item is calculated on-board the aircraft. If available, this data item may be forwarded by the surveillance system.

Track Angle Rate – This is the variation over time of the aircraft True track angle. This data item can be forwarded and/or calculated depending on surveillance system architecture.

True Airspeed (TAS) – This is the speed (amplitude) of the aircraft in the air. It can only be calculated on board the aircraft on the basis of the Indicated Airspeed. This data item is forwarded by the surveillance system.

True Track Angle (or Course) – This is the direction over the ground of the aircraft track. This data item is calculated on-board the aircraft. If available, this data item may be forwarded by the surveillance system.

Track velocity vector – This is speed vector of the aircraft track as calculated by the surveillance ground system, it may take into account down-linked aircraft parameters such as the ground speed and the true track angle. The naming of this data item is consistent with the naming adopted in ASTERIX category 062 ([RD 5]) and has been chosen to avoid confusion with similar data items that can be down-linked by the aircraft.

Rate of climb/descent – This is the variation over time of the aircraft pressure altitude as calculated by the ground surveillance system, it may take into account down-linked aircraft parameters such as pressure altitude rate. It may also be reduced to a trend with discrete values (climbing, descending, straight level flight or unknown). The naming of this data item is consistent with the naming adopted in ASTERIX category 062 ([RD 5]) and has been chosen to avoid confusion with similar data items that can be down-linked by the aircraft.

C - 1.5 Intent data items

FMS Selected altitude – This is the altitude input by the pilot on the FMS. This data item is forwarded by the surveillance system.

MCP/FCU Selected altitude – This is the altitude input by the pilot on the MCP/FCU. This data item is forwarded by the surveillance system.

C - 1.6 Target report surveillance data status data items

Coasted status – This indicates whether the horizontal position data item is based on a measured horizontal position that is older (coasted) or not (non-coasted) than the surveillance system applicable measurement interval. This data item is calculated by the ground surveillance system.

Flight status – This indicates whether the aircraft is airborne or on the ground or unknown (either on the ground or airborne). This data item is defined on board the aircraft, in general based on a weight on wheel mechanism. This data item is forwarded by the surveillance system.

Surveillance technique source (cooperative, non-cooperative, combined) – This reflects whether the data contained in the target report is based on information provided by a cooperative surveillance source only or by a non-cooperative surveillance source or both. This data item is calculated by the ground surveillance system.

C - 1.7 Time data items

Time of applicability – This reflects the time at which the system considers the provided calculated data item is applicable. This data item is determined by the ground surveillance system.

Data age – This indicates the age of a particular data item, i.e. the elapsed time since it was measured or extracted from the aircraft by the ground sensor. This data item is calculated by the ground surveillance system.

C - 1.8 Other definitions

ICAO International Standard Atmosphere – This is an atmospheric model of how the pressure, temperature, density, and viscosity of the Earth's atmosphere change over a wide range of altitudes. It consists of tables of values at various altitudes, plus some formulas by which those values were derived. The International Organization for Standardization (ISO), publishes the ISA as an international standard, ISO 2533:1975. ICAO published an extension (the altitude coverage is extended up to 80 kilometres (262,500 feet)) of the same atmospheric model under their own standards-making authority.

C - 2 Performance characteristic definitions

It is to be noted that a performance characteristic can be defined at data item level or at system level.

C - 2.1 Accuracy definition

Accuracy is applicable to a data item that is provided by the system (e.g. measured and/or calculated). It is the degree of conformity of the provided value of a data item with its actual value at the time when the data item is considered.

In ICAO Annex 15 [RD 13], **accuracy** is defined as the degree of conformance between the estimated or measured value and the true value.

It is also agreed that the accuracy specification will also cover the case where information not related to a true aircraft is reported. This will need to be specified independently as there will be no actual value. It is also agreed that, to be credible, the false information must contain at least the horizontal position and aircraft identity.

C - 2.2 Integrity definition

Integrity is applicable to a data item that is transferred by the system (provided externally by another system and forwarded to another system, e.g. Mode A code, Mode C code). It is the degree of undetected (at system level) non-conformity of the input value of the data item with its output value. In that case the system is only a communication medium so it should not modify the value of the data item.

In ICAO Annex 15 [RD 13], **integrity** is defined as the degree of assurance that a data item and its value has not been lost or altered since the data origination or authorised amendment.

C - 2.3 Availability definition

Availability: The probability that a system will perform its required function at the initiation of the intended operation.

The **availability** is composed of two independent and distinct availabilities: the planned availability (A_P) and the operational availability (A_O).

The planned availability (A_P) is derived from the planned outage rate (F_P), which is a local requirement depending on local constraints.

$$A_P = 1 - F_P$$

The operational availability calculation excludes all planned downtimes.

The Operational Availability (A_O) and shall be calculated using the following equation:

$$A_O = MTBCF / (MTBCF + MTTR + MRT)$$

Where:

- MTBCF = Mean Time Between Critical Failures in hours.
- MTTR = Mean Time To Repair in hours.
- MRT = Mean Response Time in hours (i.e. the average time from notification of failure for a technician to be ready to commence repair action).

The availability of the system/service is $A = A_P * A_O$

For a surveillance system the critical failure to be considered for MTBCF is the loss of horizontal positions of all aircraft during at least 10 seconds at the output of the Surveillance system.

C - 2.4 Continuity definition

Continuity: Continuity is the probability that a system will perform its required function without unscheduled interruption, assuming that the system is available at the initiation of the intended operation. (Continuity is expressed per unit time). The continuity can be related to the Mean Time Between Critical Failures (MTBCF).

Continuity = 1 / MTBCF

The definition of what is a surveillance system critical failure is provided in the previous paragraph of this annex.

C - 2.5 Reliability definition

Reliability: The probability that a system or service will be available throughout a specified geographic volume for a specified amount of time without degradation or failure to the service or system.

C - 2.6 Time related definitions

The latency or data age is the difference between time of output of a data item and the time of applicability of the data item.

The latency represents the system capability to provide a calculated value of a data item that is consistent with its time of output and to provide a forwarded data item in a timely manner.

It is assumed that any information is time stamped in accordance with a common time reference (i.e. UTC in general). This time stamp represents the instant when the information is declared applicable. If information is not provided with time stamping it is assumed that, by default, it is time stamped by the receiving system/sub-system with its time of arrival.

The update interval is the difference in time between two consecutive deliveries of the same data item.

The diagram below shows the different times in the case of a data item that is forwarded by the ground surveillance system.

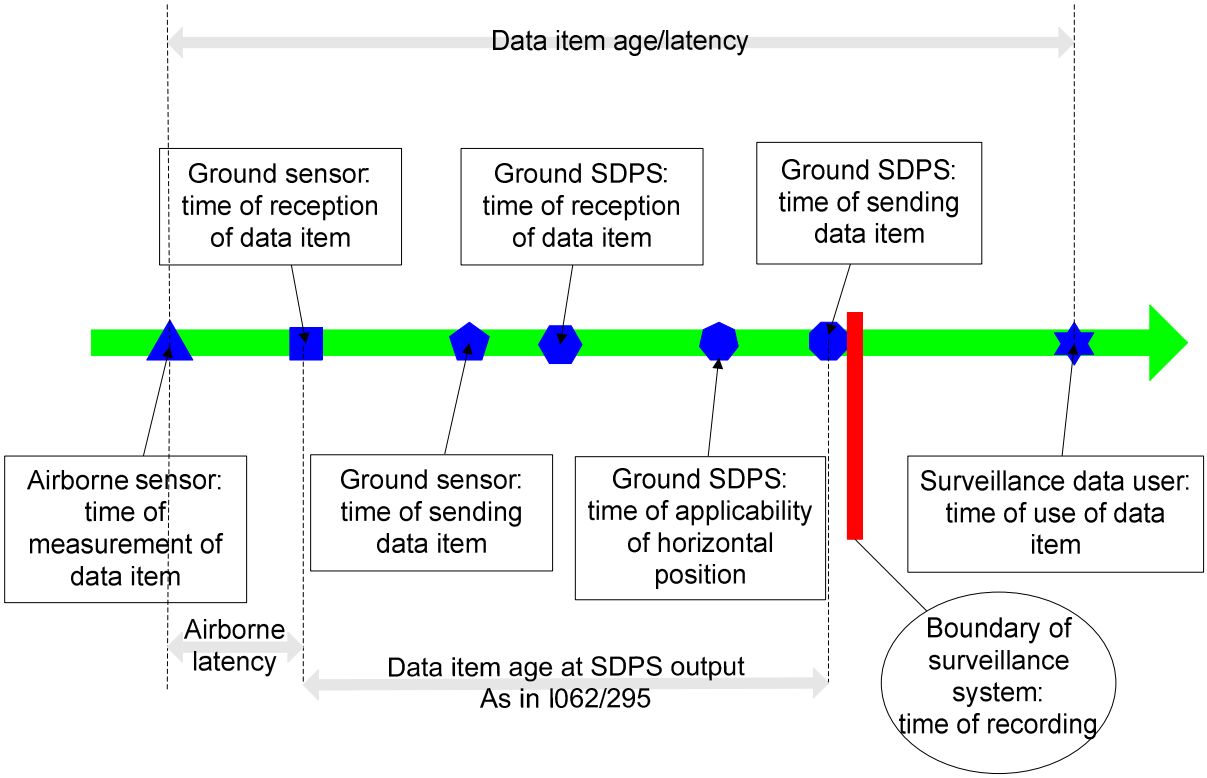

Figure 15: The different stages of surveillance system data processing (forwarded data item)

Assuming a ground surveillance system that is composed of:

- Mode S sensor
- Sensor data distribution system (network)
- Surveillance data processing system (e.g ARTAS tracker)
- Surveillance data distribution system (network)
- ATC centre display system

Applying the generic diagram above on the same surveillance system further illustrates the definitions in the case of pressure altitude data item

- Time of airborne measurement (T1) of aircraft pressure altitude by the aircraft altimeter.
- Time of arrival of a Mode S reply (DF5) from the aircraft containing the pressure altitude, e.g. Mode C code.
- From this Mode S reply the Mode S sensor decodes the Mode C code and copies it in a Mode S target report that is dated (Time of arrival at sensor level T2) in accordance with the time of arrival of the reply.
- The Mode S target report is transmitted to the tracker through the sensor network.
- This Mode C is copied in the next update of the track dated Time of applicability (T3) that is output by the tracker. This track is processed by the ATC centre system and the aircraft vertical position is transferred through the surveillance network and delivered at Time of output of surveillance system (T4), then the ATCO uses this information to undertake vertical separation with another aircraft.

In this case the pressure altitude data age is equal to $T_4 - T_1$.

In the case where the measurement of a data item is performed on board the aircraft, the date of the measurement is not forwarded to the ground surveillance system, nevertheless:

- In the case of an SSR/Mode S target report, the delay between T2 and T1 is normally below a specified threshold.
- In an ADS-B report, all data items are dated “on the basis[4]” of the time of arrival of the last transmitted data item. In any case the exact time of measurement is not known.

[4] The position may be extrapolated; in that case the date will correspond to the one of the extrapolation, which is itself based on the previous received position dated with its time of arrival.

The diagram below shows the different times in the case of a data item that is elaborated by the ground surveillance system.

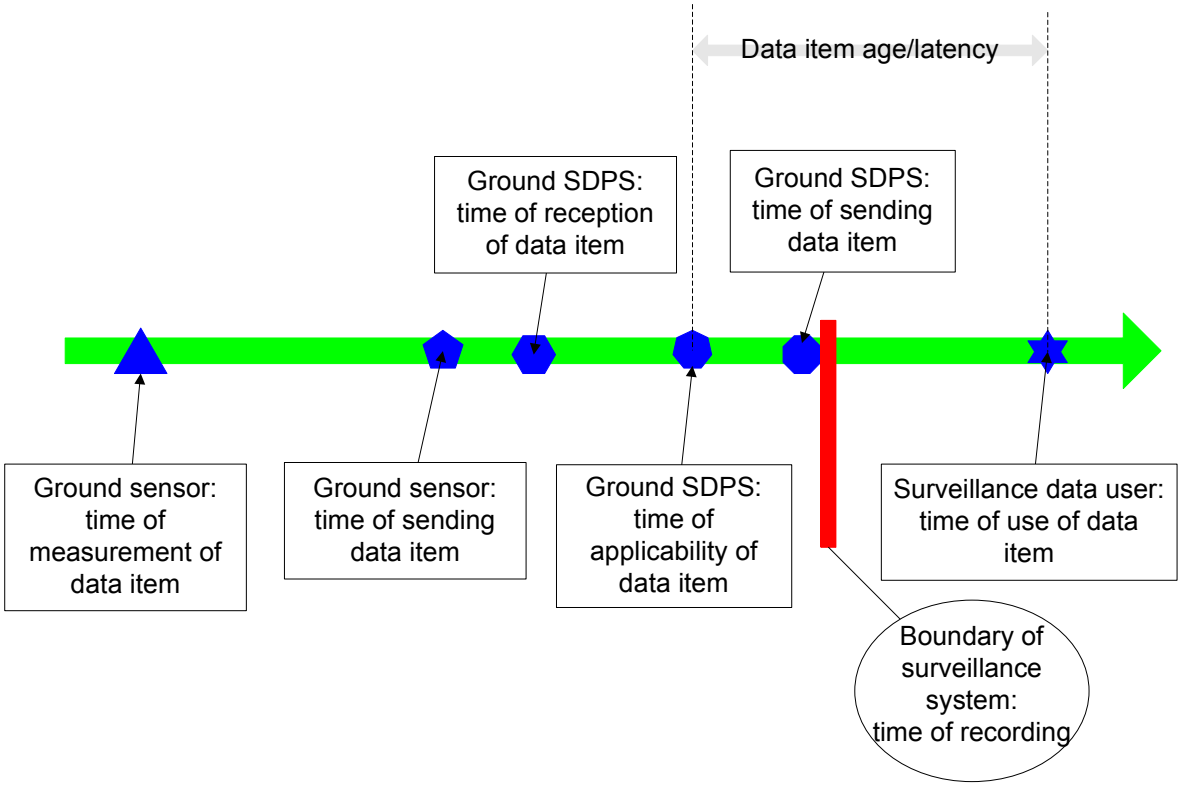

Figure 16: The different stages of surveillance system data processing (calculated data item)

Applying the generic diagram above on this specific surveillance system further illustrates the definitions in the case of the horizontal position data item:

- Time of arrival of a Mode S reply from an aircraft.
- From this Mode S reply the Mode S sensor elaborate the horizontal position (azimuth and range) of a Mode S target report that is dated (Time of arrival at sensor level T1) in accordance with the time of arrival of the reply.
- The Mode S target report is transmitted to the tracker through the sensor network.
- From the Mode S target report the tracker extrapolate a horizontal position for the Time of applicability (T_2). The track data items are transferred through the surveillance network and the horizontal position is delivered at the Time of output of the surveillance system (T_3), and then the ATCO uses this information to undertake horizontal separation with another aircraft.

In this case the data age of the horizontal position at the output of the surveillance system is equal to $T_3 - T_2$.

C - 2.7 Responsibility domain and interest domain definitions

The responsibility domain of an ATC centre/organism is a geographical volume with vertical and horizontal boundaries within which the centre/organism has the responsibility of the air traffic control and in which it provides air traffic services (e.g. surveillance separation).

The interest domain of an ATC centre/organism includes its responsibility domain plus some horizontal and vertical margins needed to survey traffic in the vicinity of the responsibility domain and traffic that is about to be transferred to the centre/organisation. The centre/organisation may provide air traffic services (e.g. surveillance separation) in this domain.

The above definitions are derived and translated from document [RD 24]

C - 2.8 Capacity, Total Load, Throughput and Density definitions

The three following definitions are extracted from document [RD 10].

Capacity: It relates to the maximum numbers of aircraft in the system for which all the service surveillance performance parameters have to be provided. Capacity will depend upon the particular environment characteristics (i.e. traffic densities, area of coverage required).

Total load: Maximum number of aircraft in coverage.

Density: Maximum number of targets within a confined area.

The two following definitions are extracted from document [RD 23].

Throughput: The rate of item provided for a service over a time interval.

Capacity: The number of service provisions able to be delivered to the end user in a period of time.

C - 3 Other definitions

C - 3.1 False target report definition

A false target report is either an horizontal outlier target report or a target report (including at least horizontal position and aircraft identity data items) that does not correspond to a true aircraft at the reported position and at the reported time.

C - 3.2 Falsely confirmed track

A falsely confirmed track is a suite of at least 3 false target reports used to form a track.

C - 3.3 Outlier target report definition

An outlier target report is a target report corresponding to a true aircraft but showing a horizontal position error larger than a defined threshold.

C - 3.4 Track termination delay

It is the delay between the last target report corresponding to a given aircraft and the “theoretical” exit of this aircraft out of the operational volume (volume where the service is provided/supported) of the surveillance system.

C - 3.5 Track initiation delay

It is the delay between the first target report (horizontal position at least) corresponding to a new aircraft and the “theoretical” entry of this aircraft in the operational volume (volume where the service is provided/supported) of the surveillance system.

C - 4 Environment definitions

C - 4.1 Airspace classes

The scope of this document is limited to the classes/sections of airspace where the provision of air traffic services or functions apply and in particular to those in which the surveillance is used to separate aircraft.

Concerning the separation service it is further stated in [RD 9] that:

Vertical or horizontal separation shall be provided:

a) between all flights in Class A and B airspaces;

b) between IFR flights in Class C, D and E airspaces;

c) between IFR flights and VFR flights in Class C airspace;

d) between IFR flights and special VFR flights; and

e) between special VFR flights, when so prescribed by the appropriate ATS authority;

Furthermore in [RD 10] it is specified that in Class A airspace only IFR are permitted whereas IFR and VFR are permitted in Class B, C, D, E, F and G airspaces.

In class F and G airspaces separation service is not provided.

Therefore separation service is only provided between IFR flights in Class A, B, C, D and E airspaces, between VFR flights in class B airspace and between IFR flights and VFR flights in Class B and C.

This is illustrated in Figure 17 below (special VFR flights are not shown).

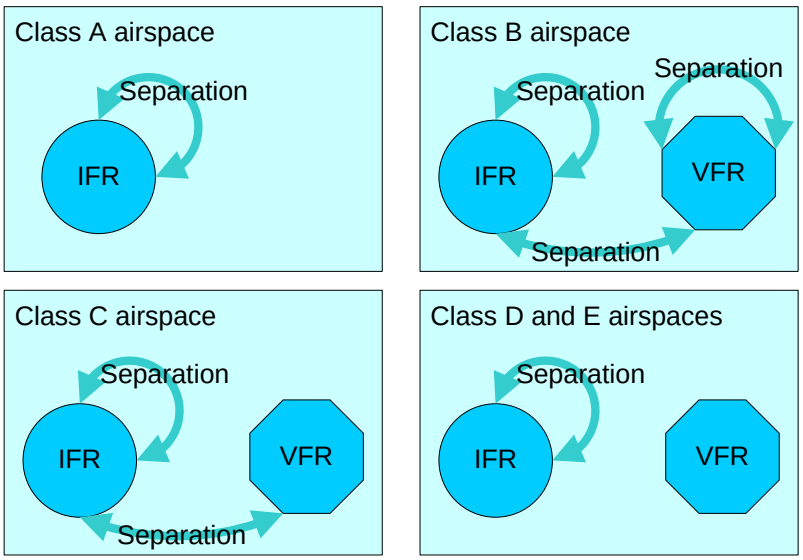

Figure 17: Provision of separation service in Class of airspaces

C - 4.2 Airspace Design and Complexity

The airspace structure is one of the factors that influence the determination, by a local authority, of the separation minima to be applied by ATCOs [RD 9]. Different airspace characteristics and environments must be taken into account and some of these include:

- Use of parallel routes or opposite routes
- Frequency of use of separation minima
- Traffic demand, peaks, averages and general patterns.
- Aircraft types or population
- The existence and location of special use airspace
- Meteorological conditions

C - 4.3 Traffic Characteristics

C - 4.3.1 5 NM horizontal separation traffic characteristics

Aircraft maximum horizontal speed is equal to 600 knots.

C - 4.3.2 3 NM horizontal separation traffic characteristics

Aircraft maximum horizontal speed is equal to 400 knots.

C - 4.4 Aircraft equipage requirements

Assumption 1: All aircraft flying IFR in the considered airspace are equipped with an SSR transponder functioning as specified in [AD1] (Article 5 and Annex II) and further detailed in forth coming EASA Certification Specification ACNS.

Note: Aircraft flying VFR in the considered airspace may be equipped with an SSR transponder functioning as specified in [AD1] or with a less capable SSR transponder (e.g. Mode A/C only).

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