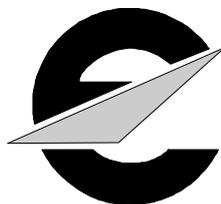


**EUROPEAN ORGANISATION
FOR THE SAFETY IN AIR NAVIGATION**

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PAPERS PRESENTED TO THE FIRST MEETING OF
THE ICAO GLOBAL NAVIGATION SATELLITE
SYSTEM PANEL (GNSSP)

EEC Report No. 281

EEC TASK AT65
EATCHIP - FCO.ET3.ST07

Approved for publication by:
Head of Division B2
Issued: May 1995

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**PAPERS PRESENTED TO THE FIRST MEETING OF THE
ICAO GLOBAL NAVIGATION SATELLITE SYSTEM PANEL (GNSSP)
MONTREAL 17-25 OCTOBER 1994**

SUMMARY

This report contains the contents of the nine Working and Information Papers presented by EUROCONTROL to the inaugural meeting of the ICAO Global Navigation Satellite System Panel held in Montreal on 17th-25th October 1994. An extended Foreword reviews the Papers and situates their contents within the working structure set up by the EUROCONTROL Organisation for the co-ordination and management of its satellite navigation activities.

FOREWORD

At its 175th Session in March 1994, the EUROCONTROL Committee of Management, inter alia, approved a Satellite Navigation Strategy, agreed that work on satellite navigation should be undertaken within the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) and agreed that EUROCONTROL should cooperate with the European Space Agency (ESA) and the Commission of the European Communities (CEC). The creation of the Satellite Navigation Applications Sub-Group (SNASG) and four Task Forces was also endorsed by the Committee of Management at its 175th session. The SNASG reports to the Future Concepts Team of the EATCHIP Working Structure.

The Satellite Navigation Applications Sub-Group Structure is as follows:

Group/Task Force	Acronym	Chairman	Organisation	Country
Satellite Navigation Applications Sub-Group	SNASG	Dr. John Storey	EUROCONTROL	
Cost/Benefit Studies TF	CBS	Paul Wood	CAA/NATS	UK
Institutional Arrangements & Requirements TF	IAR	Mieke Altink-Pouw (up to Sept. 94)	RLD	Netherlands
		Dr. John Storey (current chairman)	EUROCONTROL	
Operational & Certification Requirements TF	OCR	Dr. Norbert Lohl	LBA	Germany
System Research & Development TF	SRD	Dominique Stammler	DGAC/STNA	France

Table 1: Chairmen of SNA Sub-Group and Task Forces

By early October 1994 two cycles of meetings had been completed for the Sub-Group and its Task Forces for which there has been enthusiastic participation with up to 35 representatives of around 20 States and International Organisations.

ICAO GNSS Panel

The ICAO Global Navigation Satellite Systems Panel held its inaugural meeting in Montreal on 17th-25th October 1994 at which EUROCONTROL and the Member States of the European Civil Aviation Conference (ECAC) were strongly represented. The Agency, the CEC and ESA all had Observer status and several participants to the SNASG and its Task Forces were present. The meeting agenda is given in an appendix to this report.

To ensure that Europe presented a common view at the Panel on GNSS, it was agreed that the Chairman of the SNASG, who was the Agency Observer on the Panel, would present nine Working Papers which were prepared in the Task Forces.

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

Working Paper Numbers 40, 44 and 46 were presented under Agenda item 1.

WP/40 described the structure of the SNASG and associated Task Forces and recommended that the GNSSP consider this as a possible model for organising its own activities in order to complete its work programme successfully.

WP/44 presented the satellite navigation strategy approved by the EUROCONTROL Committee of Management which was endorsed and recommended for wider adoption by the Transport Ministers of the European Civil Aviation Conference in June 1994. Although the strategy is regional, it was nevertheless felt that it could serve as a useful model for the development of global strategy to implement satellite navigation in civil aviation.

WP/46 gave an outline of the methodology applied to elaborate the Work Programme of the SRD Task Force. It gave an overview of how the Work Programme was developed and how the areas for research and development were identified.

Agenda Item 2: Determination of performance criteria to support the operational requirements for application of GNSS, based on existing satellite navigation systems

Working Paper Number 47, presented under Agenda Item 2, identified the need to provide operational requirements to enable the development of technical specifications for GNSS and proposed a means of achieving this aim.

Agenda Item 3: Development of technical and performance requirements for GNSS augmentation sub-systems, including integrity monitoring

Working Papers Numbers 45 and 53 were presented under Agenda Item 3. WP/45 called the attention of the Panel to the urgent need to develop Standards and Recommended Practices (SARPs) for the provision of GNSS integrity control and wide and local area differential data. SARPs are urgently required in order to guarantee compatibility between similar systems being developed in different regions.

WP/53 outlined preliminary scenarios for the introduction of satellite navigation in Europe which were developed by the SRD Task Force to provide a basis for identifying potential future system architectures and augmentations for satellite navigation.

Agenda Item 4: Identification, as required, of GNSS elements, conditions or functions that could have institutional implications

Working Papers Numbers 48, 50 and 57 were presented under Agenda Item 4. WP/48 gave an idea of what the likely costs of implementing GNSS in Europe would be. These costs came from a first such study of this type and, although the figures presented were obviously preliminary and will change considerably in subsequent analyses, they can at least indicate the order of magnitude of costs likely to be incurred. The level of costs incurred make a strong case for performing Cost/Benefit Analyses.

WP/50 presented the co-ordinated programme to implement satellite navigation in Europe which is being developed by the CEC, ESA and EUROCONTROL. The three organisations have formed a Tripartite Team to co-operate closely and harness their respective resources to bring earliest benefits to users. It is expected that this programme will complement those of other regions in the development of an initial GNSS based on regional augmentations to GPS and GLONASS.

WP/57 outlined the problems which were encountered by the OCR Task Force when it started to develop a comprehensive set of user requirements for satellite navigation. It gave summaries of the user requirements found in available sources and outlined where further definitions were needed.

Following the presentations of the Working Papers, the respective contents were strongly supported by the representations of Eurocontrol and ECAC members States in the ensuing discussions. Most of the Working Papers are also directly referred to in the report of the meeting.

Acknowledgements

The contents of these nine Working Papers presented to the inaugural meeting of the ICAO GNSSP, and reproduced here, represent a substantial amount of work over a very short period of time. Gratitude has to be expressed to all of the people involved, not only for the value of their contributions, but also for the spirit in which they were made.

J. Storey, Chairman SNASG
A. Watt, Secretary SNASG and its associated Task Forces

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Green Pages: French translation of the Summary and Foreword plus, for each individual paper, translated abstracts, conclusions, recommendations and other sections where appropriate.

Pages Vertes: Traduction en Français du Sommaire, de l'Avant-propos ainsi que du résumé, conclusions et recommandations de chaque document de travail et des autres sections si nécessaire.

**I. A STRUCTURE FOR HANDLING SATELLITE NAVIGATION ON THE
INTERNATIONAL LEVEL**

GNSSP WORKING PAPER NO. 40

presented by

J. Storey

prepared by

J. Storey and A. Watt.

ICAO Global Navigation Satellite Systems Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

A STRUCTURE FOR HANDLING SATELLITE NAVIGATION AT THE INTERNATIONAL LEVEL

Working Paper

presented by

J. Storey

prepared by

J. Storey and A. Watt.

SUMMARY

Satellite Navigation has been successfully incorporated in the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP). A working structure has been established to examine the institutional, operational, certification, research and cost/benefit aspects of satellite navigation with respect to civil aviation. The work is carried out by dedicated Task Forces which recommend courses of action to a Sub-Group responsible for satellite navigation within EATCHIP. The approach described in this Working Paper is easily understood and provides a framework for organising satellite navigation activities at the international level. It is recommended that the Panel consider this as a possible model for organising its own activities in order to complete its Work Programme successfully.

1. Introduction

At its 175th Session, in March 1994, the EUROCONTROL Committee of Management, *inter alia*, approved and adopted a strategy on satellite navigation. It also agreed to the incorporation of satellite navigation in EATCHIP which the EUROCONTROL Agency manages on behalf of the thirty-two States of the European Civil Aviation Conference (ECAC).

The goal of EATCHIP is to develop a fully integrated European Air Traffic Management System, known as EATMS, early in the 21st century. Satellite Navigation is seen as an integral component of EATMS through the implementation of the ICAO CNS/ATM concept developed by FANS. At its 175th Session, the EUROCONTROL Committee agreed that high priority should be given to Satellite CNS as a whole, and to satellite navigation in particular. Subsequently, the EUROCONTROL Agency has set up a working structure to handle satellite navigation activities within EATCHIP. This Working Paper explains the rationale behind this structure, the way it is designed to work and recommends that the Panel may wish to consider this as a model for organising its activities.

2. Working Structure

EATCHIP is made up of a number of "domains" which cover particular aspects of the overall programme: navigation and surveillance, for example, are two such domains. The domain which has responsibility for all work related to EATMS is "Future Concepts" (FCO). Its work is co-ordinated through a Future Concepts Team (FCOT) to which three sub-groups report. One of these has responsibility for satellite navigation and is known as the Satellite Navigation Applications Sub-Group (SNA-SG). Both FCOT and SNA-SG are chaired by officials of the EUROCONTROL Agency, which also provides the secretariat for all meetings.

2.1 Satellite Navigation Applications Sub-Group

The Satellite Navigation Applications Sub-Group (SNA-SG) has the responsibility of ensuring that a work programme is developed, adopted and completed in such a way that satellite navigation

becomes an integral and successful part of the EATMS. It has set up four Task Forces to which responsibility has been delegated for the successful completion of their parts of the work programme. The Sub-Group acts in a supervisory role, overseeing the work of the Task Forces and offering guidance when required.

Membership of the SNA Sub-Group and its Task Forces is open to the ECAC Member States' administrations; ICAO; those administrations of neighbouring regions which have an interest in the development of activities in Europe; the airlines - through IATA; the airframe constructors - through ICCAIA; equipment manufacturers - through AECMA; other trade bodies and professional organisations; research institutes and universities and international organisations such as the European Commission and the European Space Agency.

The Sub-Group's Work Programme is carried out by four Task Forces which have responsibility for the following:

- Cost/Benefit Studies (CBS)
- Institutional Arrangements and Requirements (IAR)
- Operational and Certification Requirements (OCR)
- System Research and Development (SRD)

Each Task Force is chaired by a representative from a EUROCONTROL Member State.

2.2 Chairmen's Forum

The Task Forces have the responsibility of generating work programmes to complete their assigned tasks. The Sub-Group approves the work programmes, receives progress reports, intervenes when there are issues which are not appropriate for discussion at Task Force level and provides high-level guidance. Co-ordination of the Task Force's activities is provided by a "Chairmen's Forum" made up of the Chairman and Secretary of the Sub-Group and the Chairmen of the Task Forces. This meets every three months and provides a forum to resolve eventual conflicts, overlap or general points of concern. It also ensures that the Task Forces' activities are directed towards a common goal.

When issues cannot be resolved either in the Chairmen's Forum or in the Sub-Group, guidance is sought from the Future Concepts Team. It is possible, therefore, to co-ordinate a wide range of activities at the working level, via the Chairmen's Forum, and from above through either the Sub-Group or the Future Concepts Team. This is developing into an efficient way of working. That the Agency acts as Secretary for all meetings has been a powerful means of ensuring that a coherent approach is maintained across the structure.

2.3 Frequency of meetings

The Sub-Group meets twice a year. The Task Forces and the Chairmen's Forum will meet, on average, four times a year. Drafting Groups or Working Groups set up by the Task Forces meet when necessary.

2.4 Working Method

The lines of responsibility between the various Task Forces, the Team, Sub-Group and Chairmen's Forum have been explained above. In practice, these work well. The question may be asked, however, why the structure was set up in such a way. It was felt that a practical approach to satellite navigation had to be adopted, which could provide a framework which both adhered to a working methodology and was flexible enough to take into account important events and/or changing requirements.

In theory, the approach is as follows:

The OCR Task Force develops system-neutral operational and certification requirements for GNSS. (For brevity, GNSS1 and GNSS2 are not separated). The SRD Task Force then attempts to identify a system which can meet these requirements. If this is possible, the system architecture is defined and the CBS TF must then assess the costs of implementing such an architecture and the likely benefits to flow from its adoption. Assuming that the costs outweigh the benefits, it is for the IAR TF to recommend whether the architecture adopted and the means by which an operational service is provided are acceptable from an institutional point of view.

In practice, things will not go so smoothly. For example, the requirements generated by the OCR TF may prove to be so onerous that either a) no system architecture could fulfil them, or b) the system architecture which could meet them would be too costly. Another problem might be that a recommended system architecture which met reasonable user requirements could not be implemented in an institutionally acceptable way. If that were the case, then either the requirements or the architecture would have to change. It is clear, therefore, that the approach adopted is a closed loop where there is constant feedback from the Task Forces (via common membership), the Chairmen's Forum and the SNA Sub-Group. This is only possible, however, if there is a single organisation co-ordinating all meetings, providing secretarial services and ensuring that information is distributed to all participants. This latter function is ensured through the publication and distribution of consolidated minutes for each cycle of Task Force/Sub-Group or Task Force/Chairmen's Forum meetings.

The closed loop approach described above also has to take into account developments in other regions which may, through "force majeure", influence the SNA work programme. In particular, the development of regional complements to GPS and GLONASS has already been taken into account in the work programme.

3. Adoption of Regional Structure by the Panel

The working structure described above suits European needs. It is consequently regional in its scope. The GNSS Panel must address global issues and there will be elements of its work programme, therefore, which are outside the scope of EUROCONTROL's SNA Sub-Group activities. Nevertheless, it may be possible to incorporate the SNA structure in one, or both, of two ways:

3.1 Global Structure

For those GNSS Panel activities which are reflected in the European approach, it may be appropriate to adopt the same Task Force structure within ICAO's normal way of operating. The Panel may wish, therefore, to have four Working Groups dedicated to CBS, IAR, OCR and SRD activities. Further Working Groups could be set up to handle other topics such as Global and Regional Implementation.

Other regions have developed working structures tailored to their own needs. For example, in the United States there is the Satellite Operational Implementation Team, or SOIT, which has had to deal with similar issues to those being encountered in Europe. In Australia, a multi-disciplinary and multi-sectorial group has been established to co-ordinate satellite navigation implementation at the national level. Without doubt, these solutions must also be considered by the panel in establishing its working method.

3.2 Regional Structure

It has already been mentioned that the European approach corresponds to the needs of a particular region. However, because such needs will also be common to other regions, the European working structure could serve as a model for the implementation of satellite navigation in those regions which have not yet defined one of their own.

4. Conclusion

It is clear that the broad range of issues dealt with in EUROCONTROL's CBS, IAR, OCR and SRD Task Forces must also be addressed, among others, by the GNSS Panel. Europe has created a working structure through which it can implement satellite navigation at the regional level. This structure has provided the framework for working successfully on an international basis. The European approach could serve as an organisational model for the work of the GNSS Panel at the global and/or regional level.

5. Recommendations

The Panel is invited to take note of this Working Paper and of its contents. It is also invited to identify whether the organisational approach described here could serve as a model for its own organisation either at the global or regional level.

II. DEVELOPMENT OF A GLOBAL SATELLITE NAVIGATION STRATEGY

GNSSP WORKING PAPER NO. 44

presented by

J. Storey

prepared by

M. Altink-Pouw, M. Asbury, W. Bellen, O. Carel, R. Darby, N. Lohl, D. Stammler, J. Storey,
N. Warinsko, A. Watt, P. Wood.

ICAO Global Navigation Satellite System Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

DEVELOPMENT OF A GLOBAL SATELLITE NAVIGATION STRATEGY

Working Paper

presented by

J. Storey

prepared by

M. Altink-Pouw, M. Asbury, W. Bellen, O. Carel, R. Darby, N. Lohl, D. Stammer, J. Storey,
N. Warinsko, A. Watt, P. Wood.

SUMMARY

A number of European civil aviation administrations, through their membership of the EUROCONTROL Organisation, have developed and adopted a common strategy for the implementation of satellite navigation in their airspace. This strategy was endorsed by the Transport Ministers of the European Civil Aviation Conference at their fourth bi-annual meeting in Copenhagen in June 1994. Although the strategy is regional, it is nevertheless felt that it could serve as a useful model for the development of a global strategy to implement satellite navigation in civil aviation.

1. Introduction

A satellite navigation strategy has been adopted by EUROCONTROL Member States. It has now been endorsed and recommended for wider adoption by the Transport Ministers of the European Civil Aviation Conference. The complete text of the strategy is contained in Annex 1 to this Working Paper, which provides a summary of the strategy's main themes.

The terminology used in this paper is given below:

- A **GNSS** is a world-wide position and time determination system that includes one or more satellite constellations, aircraft receivers, and system integrity monitoring, augmented as necessary to support the required navigation performance of the actual phase of operation.
- A **GNSS2** is a world-wide **civil** navigation satellite system which is internationally controlled and managed, which meets all aviation requirements and which is designed to be certificated for sole means use for all phases of flight.
- A **GNSS1** is a transitional, or intermediate step to a GNSS2. It is based upon **military-controlled** GPS and GLONASS, but it is augmented by **civil** systems designed to provide varying degrees of independent control over the use of satellite navigation in airspace in which it is approved for use.

2. Ultimately Sole Means

Civil aviation must have at its disposal a civil-controlled satellite navigation system that can be certificated for sole-means use for all phases of flight including Category III precision approach and landing. Existing systems, even if augmented, are unlikely to meet user requirements for all operations and, in any case, their significant military component may make it difficult for some States to grant certification for sole means use.

3. Multi-modal service

The system which satisfies the ultimate objective should be one that, independently, meets the needs of all potential users whether at sea, on land or in the air, static or mobile. It must therefore be multi-modal and multi-sectorial.

4. Early benefits from existing systems

It is recognised that a fully civil and independent GNSS will not be developed in the near future. It is also recognised that there are currently two satellite positioning systems - GPS and GLONASS - whose capabilities come close to meeting user requirements for certain phases of flight. However, the fact that they are each under military and single-state control has generated institutional concerns which have still to be resolved. The strategy proposes, therefore, an evolutionary approach to developing an independent civil system which would make use of augmentations to the existing systems so that users could make the earliest possible use of them and so derive immediate benefits. This is an approach which is in line with ICAO policy.

5. Global for aviation

The strategy recognises that development of satellite navigation systems should be co-ordinated at a global level and has ensured that the approach adopted is one which complies with ICAO policy. Co-operation at the global level is being pursued within ICAO through the GNSS Panel and the CNS/ATM Systems Implementation Task Force (CASITAF). Contacts with administrations in other regions are being developed, in particular with the United States' Federal Aviation Administration.

6. Recommendations

The GNSS Panel is invited to endorse the approach outlined in the EUROCONTROL satellite navigation strategy and to identify whether it can be adopted as a basis for the development of a strategy which is acceptable on a global basis.

III. URGENT NEED FOR GNSS AUGMENTATION SARPs

GNSSP WORKING PAPER NO.45

presented by

J. Storey

prepared by

O. Carel, D. Diez, J. Storey, A. Watt

ICAO Global Navigation Satellite System Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

Agenda Item 3: Development of technical and performance requirements for GNSS augmentation sub-systems, including integrity monitoring

URGENT NEED FOR GNSS AUGMENTATION SARPs

Working Paper

presented by

J. Storey

prepared by

O. Carel, D. Diez, J. Storey, A. Watt

SUMMARY

It is the main purpose of this paper to call the attention of the Panel to the urgent need to develop SARPs for the provision of GNSS integrity control and wide and local area differential data. Work is well under way in Europe on planning the implementation of a GNSS augmentation system which will include the above functions. SARPs are urgently required in order to guarantee compatibility with similar systems being, or about to be, implemented in other places.

1. Introduction

At the Tenth Air Navigation Conference in 1991 the USA and then USSR stated that they would make available their military satellite navigation systems (GPS and GLONASS respectively) for civil use. However these systems alone will not satisfy the stringent requirements of civil aviation, and the need for monitoring their integrity and providing augmentation is acknowledged.

2. Developments in Europe

A number of national and international bodies within Europe (including EUROCONTROL, the European Commission and the European Space Agency) are involved in the development and implementation of a European Ranging GNSS Integrity Channel (RGIC) system.

The RGIC, which should also include a Wide Area Differential GPS (WADGPS) function, will:

- Continuously monitor GPS (and probably GLONASS) signals and broadcast integrity information to user avionics in real time, using geostationary satellites.
- Improve the availability of the GPS navigation information by enabling the geostationary satellite payloads to be used as additional GPS satellites.
- Provide wide area differential corrections through the same geostationary satellites, which will enhance accuracy, enabling the GPS to be used for precision approaches.

The major elements of the RGIC are the space and ground segments.

Today, the only geostationary satellites with navigation payloads expected to become available in the near future will be the third generation of Inmarsat communications satellites (Inmarsat III, to be launched starting in early 1996). The main function of the navigation payload is to relay the navigation, integrity monitoring and wide area differential signals generated by the ground segment. Because of the nature of the Inmarsat III footprints, different regions implementing RGIC functions will often require the services of one particular satellite for providing either the operational service or the back-up requirements. Therefore co-ordination between service providers will be required.

The RGIC ground segment will consist of:

- a network of Monitoring and Tracking Stations (MTS) in charge of monitoring and tracking the satellites of the GPS constellation and, for the stations which are within the coverage area of a geostationary satellite, monitoring and tracking this satellite.
- A set of Wide Area Differential GPS (WADGPS) Stations capable of improving GPS accuracy by determining positioning errors at their known locations and subsequently transmitting the determined errors, or corrective factors, to users operating in the same areas. These may be the same stations that perform the monitoring and tracking functions.
- A Master Control Station which will be in charge of carrying out the following processing:
 - * for the monitoring function it will collect the measurements made by the MTS, filter them, and determine the Pseudo-range Mean Error (PME) for each satellite, and will generate the monitoring data. It will also provide the orbitography of the GPS and geostationary satellites.
 - * For the navigation function, using the geostationary satellite orbitography data, the MCS will determine the ephemeris of the geostationary satellite and will generate the navigation data.
 - * For the wide area differential function, it will collect the measurements made by the wide area differential stations, and will combine them with the monitoring and navigational data, into a monitoring, differential and navigation message, which will be sent to the feeder link station.
- A Feeder Link Station (FLS), in charge of sending the monitoring, differential and navigation messages to the geostationary satellites, and ensuring the compliance of the characteristics of the transmitted signal by means of a control loop on the downlink.

In order to achieve the navigation accuracies needed for precision approaches and airport surface movement, it is probable that local area differential stations would have to be implemented in some airports in Europe.

3. Pressing need for SARPs

Avionic receivers must be capable of receiving and processing messages from the different RGIC and wide and local area differential systems over the world. To make that possible, systems must be built in compliance with ICAO standards (SARPs). Europe needs them urgently in order to avoid the need for future retrofit.

SARPs should be developed taking advantage of the work already done by RTCA, EUROCAE, FAA and other organisations. Radio electric characteristics, modulation, encoding, message content, format, frames, binary rates, differential modes to be used, etc. should be covered by SARPs.

The format of the radio signal (signal-in-space) has to be specified, taking into account its physical layer (level and polarisation, etc, the associated tolerances, method of coding additional bits etc.) and its application layer (method of describing the geostationary orbit, contents of the integrity message etc.). This is urgent for the production of receivers.

In addition, the operational objectives must be kept in mind; in particular, when is integrity threatened, when is it lost, what is the length of time acceptable before the message is broadcast etc. These specifications are vital for those who are going to develop the system.

4. Recommendations

The GNSS Panel is invited to consider this Working Paper, and to agree to a course of action to develop, as a matter of urgency, SARPs for RGIC and wide and local area differential systems.

IV. EUROCONTROL'S GNSS SYSTEM RESEARCH & DEVELOPMENT WORK PROGRAMME METHODOLOGY

WORKING PAPER NO. 46

Presented by

J. Storey

Prepared by

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J.-P. Dupont, J. Hammesfahr, T. Helgesen, P. Hoogeboom, R. Idiens, R. Lucas, H. Sarthou,
D. Stammler, J. Storey, L. Tytgat, B. Tiemeyer, N. Warinsko, A. Watt

ICAO Global Navigation Satellite System Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

Agenda Item 2: Determination of performance criteria to support the operational requirements for application of GNSS, based on existing satellite navigation systems

EUROCONTROL's GNSS System Research & Development Work Programme Methodology

Working Paper

Presented by

J. Storey

Prepared by

L. Andrada-Marquez, M. Asbury, H. Brünger, E. Chatre, M. Dieroff, G. del Duca,
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D. Stammler, J. Storey, L. Tytgat, B. Tiemeyer, N. Warinsko, A. Watt

Abstract

This paper outlines the methodology applied to elaborate the Work Programme of the System Research and Development (SRD) Task Force within EUROCONTROL's Satellite Navigation Applications Sub-Group (SNA-SG). It provides a basis for identification of potential future system architectures and augmentations for satellite navigation in Europe. The paper gives an overview of how this Work Programme was developed and how the areas for research and development are identified to initiate the relevant activities defined in an SRD Action Plan.

1. Introduction

During the first two meetings of EUROCONTROL's SRD Task Force, which reports to the SNA Sub-Group, a methodology was developed to derive recommendations for the implementation of satellite navigation in Europe. This is based on system architecture scenarios developed by members of the same Task Force. These scenarios have to be evaluated within a Work Programme and they are intended to be used to generate - in an objective and systematic way - a list of all technical questions raised by the introduction of satellite navigation in Europe. Identified technical issues should then be the subject of R&D activities to be carried out by the EUROCONTROL Agency or EUROCONTROL Member States or other appropriate organisations. When all answers to technical questions are obtained, the SRD Task Force would be in the position to classify Scenarios from a technical point of view and, subsequently, make the relevant recommendations to the Satellite Navigation Applications Sub-Group.

It is foreseen that - in parallel - the other Task Forces (IAR, CBS, OCR), will also establish a classification of these Scenarios according to their own criteria (respectively institutional, economic, operational and certification concerns).

2. Scenarios

The set of Scenarios covers all the potential augmentations identified in the EUROCONTROL satellite navigation strategy and their various combinations. An overview is given in Table 1. Each Scenario consists of a set of augmentations to GPS which are intended to meet civil aviation users' requirements for all phases of flight, from oceanic en-route down to ICAO CAT III precision approach.

Block	No.	Title	En Route-NPA	CAT I	CAT II/III
0	0.0	Today's Situation			
	0.1	Near Future Situation (Transition)			
1	1.0	GPS + n GLONASS	+ RAIM	+ LADGNSS	+ LADGNSS
	1.1	(N1 ≤ n)			only ILS
					only MLS
2	2.0	GPS + n GLONASS	+ RAIM + Ranging + GIC	+ WADGNSS + Ranging + GIC	+ LADGNSS
	2.1	+ GEO Overlay (1 ≤ n < N1) or (n = 0)			+ Ranging
					only ILS
					only MLS
	2.2				+ LADGNSS
	2.3				+ Ranging
2.4		only ILS			
2.5		only MLS			
3	3.0	GPS + n GLONASS + AAIM	+ AAIM	+ LADGNSS	+ LADGNSS
	3.1	(1 ≤ n < N1) or (n = 0)			only ILS
					only MLS
3.2					
4	4.0	GPS + n GLONASS +	+ RAIM	+ LADGNSS	+ LADGNSS
	4.1	Basic Civil Constellation			only ILS
					only MLS
4.2	(1 ≤ n < N1) or (n = 0)				

Table 1: Scenarios

These Scenarios serve as the basis for the Work Programme and its Methodology as described in the following sections.

3. Work Programme Methodology

Table 2 gives a general overview of the methodology from which the SRD Work Programme was derived. Starting from prepared Scenarios, areas of unanswered technical questions are identified. These become the subject of R&D activities to investigate what level of system performance can be achieved within an individual Scenario. Areas of concern are identified where the relevant system architecture might cause unresolvable shortcomings.

This process will identify valid Scenarios and their associated high level system architectures for recommendation to the EUROCONTROL Satellite Navigation Applications Sub-Group. The task of this group, subsequently, is to evaluate these Scenarios and to recommend and propose one Scenario for the implementation of Satellite Navigation in Europe. Therefore, members of this group will consider the results of the SRD Task Force Work Programme together with rankings of the Scenarios established - in parallel - by the other Task Forces (IAR, CBS, OCR). Finally, these decisions will result in the SRD Task Force refining system specifications for the recommended Scenario.

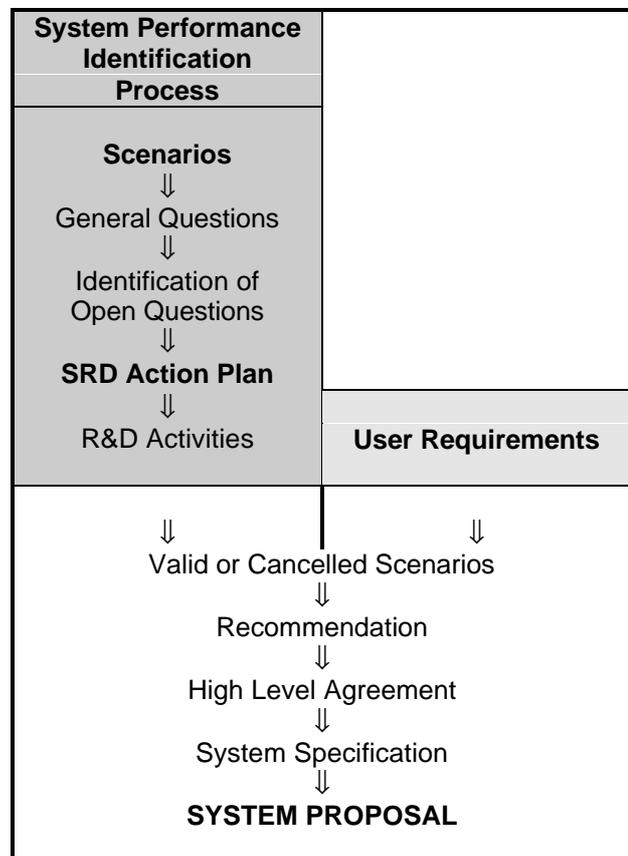


Table 2: Work Programme Methodology

3.1 System Performance Requirements

In close co-operation with the Operational and Certification Requirements (OCR) Task Force,

parameters are identified in order to describe the required system performance of a satellite-based navigation system with respect to the following criteria:

- Accuracy,
- Integrity,
- Availability and
- Continuity of Service.

The definition of these criteria is directly based on available documentation in order

- to adapt to already validated requirements,
- to harmonise with these approaches and
- to avoid setting out on another new and certainly different definition.

3.2 Scenario Validation Process

3.2.1 General Questions

During the systems performance identification process a document is derived which contains general questions: For the individual scenarios, system design parameters were identified which influence the level of performance related to the criteria described above. During the process of generating answers to the questions the range of achievable system performance can be investigated. When answers cannot be obtained from available sources, the related open question will be incorporated in the SRD Action Plan.

The wide range of experience and expertise of the members of the EUROCONTROL Task Forces is used together with library databases to identify whether questions are already answered or where related research activities are under way.

Finally, system performance can be compared against already available user requirements. Where user requirements are currently not available, it will be possible to use the information obtained about system performance to identify useful users requirements.

3.2.2 R&D Activities (SRD Action Plan)

The methodology followed by the SRD Task Force will point out the areas of unanswered questions, which shall be the subject of R&D activities to be carried out by the EUROCONTROL Agency or EUROCONTROL Member States or other appropriate organisations.

In following the methodology presented, potential items have to be assessed for inclusion in the Work Programme according to the following:

Is anybody doing this already ?

If not, the following criteria have to be considered to justify the inclusion of Work Programme items within the R&D activities:

- what are the expected **deliverables** (study report, algorithm, prototype, standards definition, ...),
- **why** is it being done (to answer a question, help make a decision, provide a clear benefit, ...),
- why do it **now** (is it on the critical path of the programme),
- **when** will it be delivered,
- **who** should be involved (EUROCONTROL, States, CEC, ESA, industry, research organisations, airlines, ...).

Finally the open technical questions and subsequent Work Programme items will remain to be incorporated in the SRD Action Plan. Its first version shall be issued by the end of 1994.

3.2.3 Valid Scenarios

When all the answers are obtained a complete picture about the system performance within the individual Scenarios can be drawn. Subsequently, the user requirements have to be considered to indicate the valid Scenarios.

After having taken all information obtained into consideration, together with the feedback from the other Task Forces (IAR, CBS, OCR), the SRD Task Force will be able to initiate a comparison of the remaining Scenarios in the light of the following items:

- Identification of operational benefits,
- Identification of 'Force Majeure',
- Technical comparisons:
 - Simulation,
 - Flight Testing.

Finally, two or three Scenarios shall remain for recommendation to the SNA-SG and consequently to the EUROCONTROL Agency.

3.2.4 System Specification

The results of revision by the SNA-SG and, accordingly, the EUROCONTROL Agency will be returned to the SRD Task Force for final refinement of the Scenario agreed on. The detailed system specifications shall be developed to prepare the proposal of this Scenario for the implementation of Satellite Navigation in Europe.

4. Summary

Following the Work Programme Methodology described, the EUROCONTROL System Research and Development Task Force will issue an SRD Action Plan by the end of 1994.

This Action Plan will outline areas of required investigations and research to prove the applicability and validity of the potential system architecture scenarios for the implementation of Satellite Navigation in Europe.

As a result of the subsequent R&D activities it is expected that two or three Scenarios will remain for recommendation to the EUROCONTROL Satellite Navigation Application Sub-Group and the EUROCONTROL Agency.

These bodies will evaluate the recommendations while considering as well the classifications established - in parallel - by the other Task Forces (IAR, CBS, OCR).

Finally, one Scenario shall be agreed upon by all those bodies as the basis for the implementation of Satellite Navigation in Europe.

5. Recommendation

The ICAO GNSS Panel is invited to take note of this paper and to take best advantage of its contents, which describe EUROCONTROL's GNSS system research and development work programme methodology. Although this approach is one which can identify potential future system architecture scenarios for the implementation of satellite navigation in Europe, the Panel is further invited to consider this methodology for adoption on a global basis.

Abbreviations

AAIM	Aircraft Autonomous Integrity Monitoring
AHRS	Attitude and Heading Reference System
CAT x	ICAO Category x Precision Approach
CBS	Cost/Benefit Studies
FAA	Federal Aviation Administration
GEO	GEOstationary satellite
GIC	GNSS Integrity Channel
GNSS	Global Navigation Satellite System(s)
IAR	Institutional Arrangements and Requirem.
ILS	Instrument Landing System
IRS	Inertial Reference System
LAD-GNSS	Local Area Differential GNSS
MLS	Microwave Landing System
NPA	Non-Precision Approach
OCR	Operational and Certification Requirem.
RAIM	Receiver Autonomous Integrity Monitoring
R&D	Research & Development
SRD	System Research and Development
SNA	Satellite Navigation Applications
WAAS	Wide Area Augmentation System
WAD-GNSS	Wide Area Differential GNSS

**V. OPERATIONAL REQUIREMENTS FOR A GLOBAL NAVIGATION SATELLITE
SYSTEM FOR INTERNATIONAL CIVIL AVIATION OPERATIONS**

WORKING PAPER NO. 47

presented by

J. Storey

prepared by

M. Asbury, J. Lawson, N. Lohl, J. Storey, A. Watt

ICAO Global Navigation Satellite System Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 2: Determination of performance criteria to support the operational requirements for application of GNSS, based on existing satellite navigation systems

OPERATIONAL REQUIREMENTS FOR A GLOBAL NAVIGATION SATELLITE SYSTEM FOR INTERNATIONAL CIVIL AVIATION OPERATIONS

Working Paper

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SUMMARY

This paper identifies the need to provide operational requirements to enable the development of technical specifications for GNSS and proposes a means of achieving this aim.

1. Introduction

- 1.1 Agenda item 2 calls for the determination of performance criteria to support the operational requirements for the application of GNSS, based on existing satellite systems. In particular, work programme item 1c requires the panel to “identify and address any technical and operational requirements needed to support various RNP types through the use of satellite navigation systems as a supplemental and sole means navigation system.”
- 1.2 This paper addresses the need to identify operational requirements for all phases of flight and outlines a means of achieving this identification.
- 1.3 Operational requirements should be seen as the technology driver and should not have to be amended to meet existing or future capabilities. It is essential therefore that operational requirements must be identified prior to the agreement of technical specifications and solutions to meet these requirements.

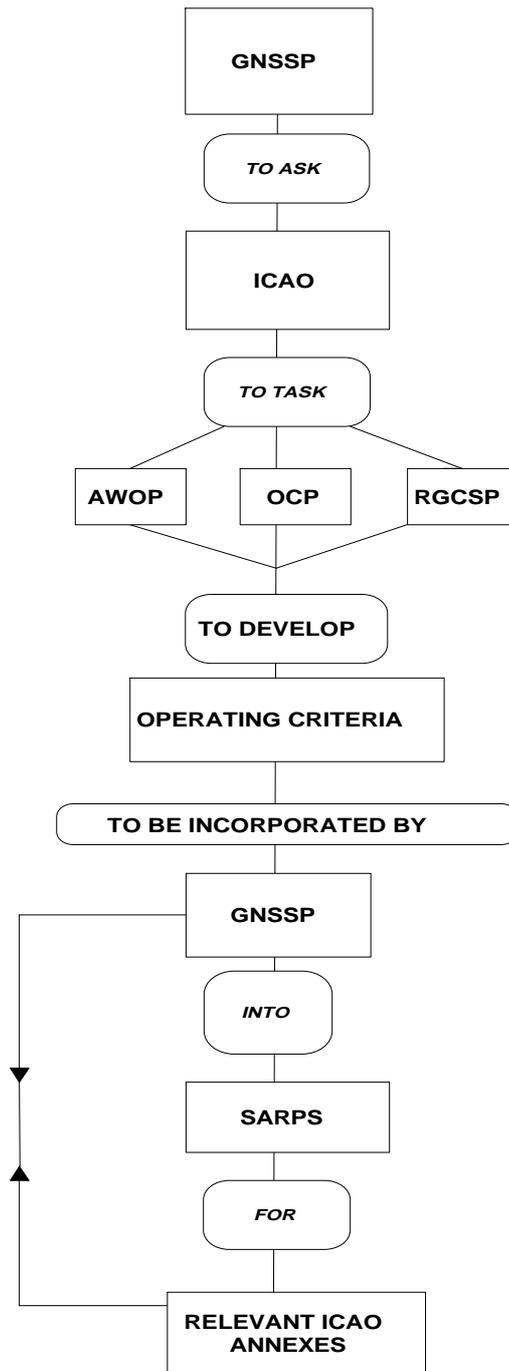
2. Operational Requirement - Definition Process

- 2.1 The first stage in the identification procedure should be to define the operational requirements for each phase of flight on a global basis. Whilst accepting that there may be some overlap in the subject material, it is proposed that the following ICAO panels should be tasked with developing the necessary requirements. Thus:
 - a) The All Weather Operations Panel (AWOP) should develop the requirements for approach, landing and departure.
 - b) The Obstacle Clearance Panel (OCP) should develop the requirements for the terminal area.
 - c) The Review of the General Concept of Separation Panel (RGCSPP) should develop the requirements for en-route operations.
- 2.2 The requirements defined by these 3 panels should then be passed to the GNSS Panel (GNSSP) who should produce the required Standards and Recommended Practices

(SARPS). There should also be an appropriate feedback of information from the GNSSP to the relevant ICAO operational panes.

2.3 Whilst it is recognised that a GNSS service provider may be accommodating non-aeronautical user domains, the requirements of the international aviation community are more demanding; therefore, GNSS service providers will be expected to define, manufacture and operate the system in accordance with the SARPS. The SARPS could be expected to offer the opportunity for the GNSS service provider to construct the system in such a way as to offer several service levels.

2.4 The following flow chart illustrates the suggested path to be followed in order to establish the operational performance characteristics for any future provider of a GNSS.



3. The Requirements

- 3.1 Although, initially, GNSS may only be used in limited phases of operation, in the long term, any GNSS for use by the international civil aviation community should ideally be usable in any phase of flight, namely en-route, terminal and approach and landing.
- 3.2 An indication of the operating environment for each of the phases is given below.

3.3 En-Route Phase

3.3.1 En-route airspace is divided into 4 categories which are defined by the following Required Navigation Performance (RNP) criteria:

- | | | |
|----|----------|--|
| a. | RNP 1 | +/- 1 nm accuracy, 95% containment. |
| b. | RNP 4/5 | +/- 4 nm accuracy, 95% containment. |
| c. | RNP 12.6 | +/- 12.6 nm accuracy, 95% containment. |
| d. | RNP 20 | +/- 20 nm accuracy, 95% containment. |

Notes:

1. In this context, "containment" refers to the percentage of the total time, per aircraft, per flight, during which the required navigation accuracy must be achieved.
 2. Although RNP types may be used to categorise airspace, this does not preclude regional planning bodies from requiring additional measures of navigation performance to be achieved in a particular area. For example, although NAT MNPS airspace may, in the future, be categorised as RNP 12.6 airspace, it is anticipated that existing performance requirements, as detailed in NAT DOC 001, T13.5N would continue to be required. These are attached at Annex A.
- 3.3.2 Current methods of en-route navigation may employ a combination of ground based radio navigation aids and inertial navigation systems.
- 3.3.3 In general terms, prior to the widespread use of GNSS:
- RNP 1 & 4 airspace is expected to be designated where coverage from short range radio navigation aids is sufficient to meet the required criteria.
 - Navigation in RNP 1 airspace is expected to be achieved through the use of automatic DME/DME fixing.
 - In RNP 4 airspace, VOR/VOR or VOR/DME fixing is expected to be used.
 - Oceanic or remote continental airspace is expected to be designated as RNP 12.6 e.g. in existing NAT MNPS airspace where the minimum separation between tracks is 60 nm. Navigation performance RNP 12.6 airspace is expected to be achieved using INS or long range navigation aids such as OMEGA and Loran.
 - A combination of existing navigation aids is expected to be used in RNP 20 designated airspace e.g. in other oceanic or remote continental airspace where the current minimum track spacing may be up to 120 nm.

- 3.3.4 For en-route purposes, the concept of RNP simply requires the laid down criteria for navigation performance - accuracy and containment - to be met. It does not specify what navigation aids are required to achieve the criteria. In order to meet operational requirements for RNP in the en-route phase of flight, GNSS would therefore, in addition to meeting the accuracy and containment parameters, have to demonstrate equivalency with the operational requirements for existing navigation aids that are expected, in the short term, to be used to meet en-route RNP criteria.
- 3.3.5 RGCSP has concluded that, for en-route purposes, any navigation system certified as meeting the RNP requirements would implicitly be providing acceptable levels of reliability and integrity. Therefore, the parameters of accuracy and containment, as provided by GNSS, would be sufficient to determine the suitability of GNSS to be used in different categories of en-route RNP. Nevertheless, any specific and more demanding Regional requirements still apply e.g. NAT MNPS airspace navigation performance requirements.

3.4 Terminal Phase

- 3.4.1 The operational requirements in terminal airspace may be considered to be the same as in en-route airspace.

3.5 Approach and Landing Phase

- 3.5.1 Approach systems are commonly designated as precision or non-precision.
- 3.5.2 A precision aid is designed to guide aircraft, by the use of azimuth and glide path information, along a defined runway approach path to a decision height (DH) ranging from 200 ft to 0 ft above the point of touchdown. Currently, precision approaches normally require a system located at the airfield built for the purpose of landing an aircraft on a specific runway.
- 3.5.3 A non-precision aid is designed to bring the aircraft sufficiently close to an airfield to allow the pilot to have a clear view of the runway to enable the aircraft to be landed without recourse to any other navigation aid. A non-precision approach may utilise a variety of systems to fix position, and in some cases uses the information provided from the en-route system or from systems whose guidance signals do not give position fixes accurate enough for precision approach and landing.
- 3.5.4 With the introduction of a GNSS system, it may be possible for this single system to satisfy the operational requirements for both precision and non-precision approaches without the need for any other ground based navigation system situated within the vicinity of the final approach fix or at the airfield.

4. Future Operational Requirements

- 4.1 Any assessment of future operational requirements for a GNSS will need to recognise the individual requirements of the different phases of operation. Below is a non-exhaustive list of areas to be considered. Points (a) through to (r) are pertinent to all phases of flight whilst the complete list is specific to the approach and landing phase:

- (a) Safety
- (b) Availability
- (c) Reliability
- (d) Integrity
- (e) Accuracy
- (f) Resistance to Interference
- (g) Aircraft types
- (h) Range of Aircraft Speeds and Attitudes
- (i) Weather Considerations
- (k) Geography and Topographical features
- (l) Guidance Presentation

- (m) Identification
- (n) Classes of Service
- (o) Distance Information
- (p) Siting of GNSS Ancillary Ground Equipment
- (q) Flight Inspection
- (r) System Capacity
- (s) Runway environment
- (t) Azimuth Guidance
 - (i) Approach
 - (ii) Landing and Roll out
 - (iii) Missed Approach
 - (iv) Minimum Azimuth Service
 - (v) Uses of Lateral Position Information
 - (vi) Signal protection (The concept [not size] of protection similar to sensitive/critical protection)
- (u) Vertical Guidance
 - (i) Approach
 - (ii) Landing Including Flare
 - (iii) Missed Approach
 - (iv) Minimum Vertical Service
 - (v) Uses of Vertical Position Information

4.2 The operational requirement is designed to meet the needs of present international civil aviation operations and those which can be foreseen within the next 20-30 years. It should be recognised that the system that meets these requirements should also be suitably adaptable to allow the national requirements of individual countries to be met.

5. Conclusions

- 5.1 This paper recognises the need for operational requirements for all phases of flight operation to be identified prior to the application of any GNSS-based technical solutions.
- 5.2 This task should be carried out by the appropriate ICAO Panels wherein lies the relevant expertise.

6. Actions by the Panel

- 6.1 The Panel is invited to consider the plan of action proposed in this paper and to request ICAO to task the relevant panels with developing operational requirements for the particular phases of operation.

NATS MNPS AIRSPACE NAVIGATION PERFORMANCE REQUIREMENTS

1. What follows is an extract from NAT DOC 001, T13.5N - Consolidated Guidance Material North Atlantic Region.
2. Aircraft which are approved for operations within the NATS MNPS Airspace shall have navigation performance capability such that:
 - a) the standard deviation of lateral track errors shall be less than 6.3 NM (11.7 km);
 - b) the proportion of the total flight time spent by aircraft 30 NM (55.6 km) or more off the cleared track shall be less than 5.3×10^{-4} ;
 - c) the proportion of the total flight time spent by aircraft between 50 and 70 NM (92.6 and 129.6 km) off the cleared track shall be less than 13×10^{-5} .

VI. EUROCONTROL'S METHODOLOGY FOR DEFINING OPERATIONAL REQUIREMENTS

WORKING PAPER NO. 57

Presented by

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Prepared by

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ICAO Global Navigation Satellite System Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

Agenda Item 4: Identification, as required, of GNSS elements, conditions or functions that could have institutional implications

EUROCONTROL's Methodology for Defining Operational Requirements

Presented by
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B. Rabiller, H. Rose, G. Solari, W. Steinau, J. Storey, B. Tiemeyer, N. Warinsko, A. Watt

Abstract

This paper outlines the problems which were encountered by the Operational and Certification Requirements (OCR) Task Force within EUROCONTROL's Satellite Navigation Application Sub-Group (SNA-SG) when it started to develop a comprehensive set of user requirements for satellite navigation. This paper summarises the user requirements found in available sources and it outlines where further definitions will be needed.

The purpose of this paper is to present the current status of defining user requirements and related system performance specifications for satellite navigation, highlight the problems encountered and suggest a way forward.

It shall serve as a basis for discussion to initiate the specification of a common set of user requirements on an international basis.

1. Introduction

In execution of EUROCONTROL's satellite navigation strategy a Satellite Navigation Applications Sub-Group was established under the framework of the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) and its Future Concepts (FCO) Domain. The work of this Sub-Group is divided into four Task Forces of which the Operational and Certification Requirements Task Force is one. This Task Force adopted as its initial task the identification of existing sources and documentation to provide information on the likely user requirements for satellite navigation. In parallel a request was submitted to the OCR Task Force by the System Research and Development (SRD) Task Force to provide these parameters. They are needed for the GNSS System Research & Development Work Programme the SRD Task Force intends to carry out. This programme is based on a set of GNSS System Architecture Scenarios which cover all the potential system augmentations and their various combinations. These potential Scenarios shall serve as the basis to identify valid Scenarios which will be recommended by the SRD Task Force to the SNA Sub-Group for the implementation of satellite navigation in Europe. Therefore, figures are requested which describe the required system performance of a satellite-based navigation system with respect to the following criteria:

- Accuracy,
- Integrity,
- Availability and
- Continuity of Service.

The OCR Task Force identified the following potential sources for definitions of these criteria:

- RGCSP
- OCP
- AWOP
- FANS

It was intended to base the methodology for developing a comprehensive set of user requirements directly on such available documentation in order:

- to avoid duplication;
- to ensure maximum benefit from work already in progress;
- to adapt to already validated requirements;
- to harmonise with these approaches, and
- to avoid setting out on another new and certainly different definition.

After a review of the documentation, the OCR Task Force decided to base the definition of the required system performance initially on:

- RGCSP requirements associated with RNP types 20, 12.6, 4 and 1. This is intended to cover phases of flight from oceanic en-route down to terminal flight.
- AWOP requirements associated with NPA and CAT I-III precision approaches.

As a consequence, types of airspace are used instead of oceanic, continental en-route and terminal phases of flight where RGCSP definitions are used.

Phases of flight are kept for approach and landing when AWOP definitions are adopted, however.

Outcomes of the OCR Task Force's work and the problems which were encountered will be described in the following paragraphs.

2. RGCSP

The ICAO Manual on Required Navigation Performances (RNP), Doc 9613, as developed by the RGCSP and accepted by the ICAO ANC, describes the application of RNP mainly for en-route purposes. 4 RNP types are defined, which can be applied to airspace's and/or routes, and which set accuracy requirements to airborne navigation equipment and requirements for the navigation infrastructure. In this context the navigation performance accuracy has to be understood as the combination of the navigation sensor error, airborne receiver error, display error and flight technical error. As an example: to enter RNP4 airspace an accuracy of 4 NM (95%) is required. RNP is described as only one (fundamental) factor in the determination of safe separation standards. Other factors are (ATC) intervention capability and traffic exposure (traffic density). At present, no integrity, availability and continuity of service requirements have been attached to the various RNP types as developed by the RGCSP. Accuracy requirements will not be sufficient for the description of the entire system performance as requested for example by the SRD Task Force. Therefore, key inputs are missing from RGCSP for oceanic, continental and terminal phases of flight. They should be obtained through the joint EUROCAE WG13 and RTCA SC181 working group which has recently undertaken the definition of integrity, availability and continuity of service requirements.

Both processes should lead to the definition of a complete set of requirements for oceanic, continental and terminal phases of flight to be compared to the performances that may be achieved by each of the scenarios in the frame of the SRD Task Force scenarios validation process.

3. OCP

It is not foreseen to define any RNP within this panel. On the contrary, OCP is expecting some RNP definitions to be used as inputs for obstacle separation criteria definition. As with RGCSP, OCP mainly

focused on the accuracy, because separation criteria are directly derived from separation performance. It is most likely that nothing additional can be expected from OCP at present.

4. AWOP

The definition of user requirements for all precision approach phases of flight by AWOP, however still under draft form, is well on the way. These are summarised in Table 3. Required system performance concerning availability has still to be refined in the light of a global, not only local, system. Although non-precision approach is now within the scope of AWOP, related requirements still have to be defined.

5. FANS

Table 4 summarises the provisional requirements for GNSS as developed by the GNSS Technical

ACCURACY	CAT I	CAT II	CAT III
DH	200 ft	100 ft	50 ft
Total System Horizontal at DH (95%)	40.0 m	21.2 m	15.1 m
Total System Horizontal at DH ($1 \cdot 10^{-7}$)	120.0 m	63.6 m	45.5 m
Total System Vertical at DH (95%)	12.1 m	4.5 m	1.5 m
Total System Vertical at DH ($1 \cdot 10^{-7}$)	36.3 m	13.6 m	4.5 m
INTEGRITY			
Total System Probability of Failure	$3.3 \cdot 10^{-7}$	$3.3 \cdot 10^{-8}$	$3.3 \cdot 10^{-9}$
Total System Time to Alarm	6 s	2 s	1 s
AVAILABILITY			
Total System Availability	0.9975	0.9985	0.999
Total System Availability ¹	0.999 993 75	0.999 997 75	0.999 999
CONTINUITY OF SERVICE			
Unplanned Failure Probability	$1.0 \cdot 10^{-5}$	$4.0 \cdot 10^{-6}$ / 15 s	$4.0 \cdot 10^{-6}$ / 30 s

Table 3: Draft AWOP Requirements

Sub-Group of the ICAO FANS II Committee for oceanic en-route, continental en-route, terminal flight and non-precision approach. Not all the FANS figures have been derived from rigorous analysis. Although it is not yet appropriate to rely on them exclusively at this stage, they do provide useful guidance.

6. Situation and Conclusions

For oceanic en-route, continental en-route and terminal phases of flight a lack of requirements concerning Integrity, Availability and Continuity of Service can be identified within the RGCSP definitions. Therefore, the FANS provisional requirements should be used until the successful completion of the work carried out through the joint EUROCAE WG13 and RTCA SC 181 working group.

For the non-precision approach phase of flight, gaps have been identified in the AWOP and OCP figures. In this case the provisional FANS requirements should be used until this phase of flight is tackled by either OCP or AWOP.

Draft AWOP requirements are available for the precision approach phases of flight and should be used as preliminary input.

¹ Applicable to systems for which destination and alternate airports have common transmitters

ACCURACY	Oceanic En Route	Continental En Route	TMA	NPA
Navigation System Horizontal (95%)	150 m			
Navigation System Horizontal (99.9%)	450 m			
Navigation System Vertical (95%)	21 m, H < FL50 42 m, FL50 < H < FL100 52 m, H > FL100			
Time (95%)	1 ms			
INTEGRITY				
Failure Probability	$2.8 \cdot 10^{-7}$ /flight h	$5.0 \cdot 10^{-8}$ /flight h	$4.0 \cdot 10^{-8}$ /flight h	$1.8 \cdot 10^{-8}$ /flight h
Navigation System Time to Alarm	30 s	30 s	10 s	10 s
Navigation System Alarm Limit	2.5 NM	2.5 NM	1.0 NM	0.3 NM
AVAILABILITY				
Planned Unavailability	$4.5 \cdot 10^{-4}$ /flight h	$1.2 \cdot 10^{-4}$ /flight h	$2.5 \cdot 10^{-4}$ /flight h	$1.4 \cdot 10^{-3}$ /flight h
Maximum Outage Duration	60 min	30 min	30 min	30 min
CONTINUITY OF SERVICE				
Unplanned Failure	$1.9 \cdot 10^{-4}$ /flight h	$1.2 \cdot 10^{-5}$ /flight h	$1.6 \cdot 10^{-4}$ /flight h	$7.6 \cdot 10^{-5}$ /flight h
Maximum Outage Duration	60 s	60 s	60 s	60 s

Table 4: Provisional requirements developed by the GNSS Technical Sub-Group of FANS

It has to be clearly outlined that the FANS figures are applicable to the Navigation System Error (NSE), whereas the AWOP requirements are related to the Total System Error (TSE).

This summary of the available requirements has shown that co-ordination between the different Panels will be needed so as to obtain an acceptable consensus on user requirements and, therefore, required system performance specification for satellite navigation.

7. Recommendation

The ICAO GNSS Panel is invited to take note of this paper, to take best advantage of its contents and to seek fruitful co-operation between the various Panels and their expertise. The result should be the definition of a comprehensive set of user requirements for all phases of flight including ground operation, which have global validity and can be accepted on an international basis.

Abbreviations

ANC	Air Navigation Conference
AWOP	All Weather Operations Panel
CAT x	ICAO Category x Precision Approach
DH	Decision Height
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
GNSS	Global Navigation Satellite System
NPA	Non-Precision Approach
NSE	Navigation System Error
OCR	Operational and Certification Requirements.
OCP	Obstacle Clearance Panel
R&D	Research & Development
RGCSP	Review of the General Concept of Separation Panel
RNP	Required Navigation Performance
RTCA	Requirements and Techniques for Civil Aviation
SRD	System Research and Development
SNA	Satellite Navigation Applications
TSE	Total System Error

VII. A FIRST ESTIMATION OF THE COSTS OF IMPLEMENTING GNSS IN EUROPE

WORKING PAPER NO. 48

presented by

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ICAO Global Navigation Satellite System Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

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A FIRST ESTIMATION OF THE COSTS OF IMPLEMENTING GNSS IN EUROPE

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SUMMARY

In late 1993, the EUROCONTROL Agency commissioned two studies to deal, respectively, with the cost of classic radionavigation and the cost of implementing GNSS in the 32 States of the European Civil Aviation Conference (ECAC) for the period 1994-2005. This paper deals with the GNSS costs.

The study concentrated on implementation of a "GNSS1" in which various categories of augmentation to GPS and GLONASS were introduced. It showed that the cost to the service providers of implementing a satellite navigation system capable of Cat I precision approaches was substantially less than the cost of maintaining the existing radionavigation system over the same period. Since removal of any part of the current infrastructure before 2005 is not yet planned, no savings can, unfortunately, be achieved because GNSS implementation would be an additional cost.

The study has also indicated that the cost of installing equipment capable of receiving satellite signals on-board the European fleet is substantial. In most cases this increases the additional cost of implementing satellite navigation to a point where it exceeds the cost of maintaining the existing infrastructure.

It must be stressed, however, that this study did not address benefits, nor did it address the cost of using GNSS for Category II and III precision approaches. It is intended to use the work reported on here as the basis for a detailed Cost/Benefit Analysis to be carried out in 1995 as part of the work of EUROCONTROL's Satellite Navigation Applications Cost/Benefit Studies Task Force.

1. Introduction

In order to have an indication of what the likely costs would be of implementing satellite navigation in Europe, EUROCONTROL commissioned a study on this subject which has now been completed. It concentrated on the period 1994-2005 and covered all phases of flight down to and including Category I precision approach. It was not felt that GNSS was sufficiently mature to extend the study to look at Cat II/III approaches.

A complementary study was commissioned in parallel to examine the cost of maintaining the classic radionavigation infrastructure over the same period. It was recognised that because there are no plans to remove any European nav aids before 2005, all costs incurred in implementing satellite navigation would be in addition to those which would be borne in any case through supporting the current system over the same period. Nevertheless, it was felt that this study would be a useful exercise in that it would a) provide the first, and obviously very "rough", idea of what the cost implications of transitioning to GNSS were likely to be, and b) provide sufficient background information on which to develop a Cost/Benefit Analysis which was always seen as the main goal.

2. Methodology

It was felt that the best way of obtaining the information necessary for the study was to undertake a comprehensive survey of those people and organisations in civil aviation who are most closely involved in the field of satellite navigation. To this end, administrations, international organisations, airlines, airframe manufacturers, avionics suppliers, satellite navigation equipment suppliers and acknowledged experts were all canvassed for their views. A reasonably comprehensive set of cost estimates for various aspects of implementation were provided during this survey and have been aggregated and averaged to maintain confidentiality.

The basis for developing the costs was a series of scenarios for the implementation of GNSS in Europe. These are summarised in the table below.

Scenario	Description	Comments
1	RGIC + WAD	En-route navigation and Cat 1 precision approach provided by Inmarsat geostationary overlay and associated ground system. Airborne WADGPS receiver.
2	RGIC + WAD + hybrid on-board architecture	Same as Scenario 1, except for change in on-board architecture
3	RGIC + LADGPS	WAD excluded. LADGPS provides Cat 1 precision approach. Multi-mode receiver in on-board architecture.
4	RGIC + LADGPS + GLONASS	Same as Scenario 3, except for impact of GLONASS on costs.
5	AAIM	AAIM on-board architecture. GLONASS costs included. LADGPS provides Cat 1 precision approach.
6	Near future case	No ground or space infrastructure. RAIM on-board. All precision approach by ILS.

Table 1: GNSS implementation scenarios used in the study

It is acknowledged that these scenarios require further refinement. This is already underway in EUROCONTROL's System Research and Development Task Force and the refined scenarios will be used as the basis of the Cost/Benefit analysis. The development of the scenarios is the subject of a separate paper to the GNSS Panel.

In order to compare the GNSS implementation costs to those of maintaining the current infrastructure, the cost of a base case scenario was included which is, in fact, the result of the classic radionavigation costs study: that is, the cost of maintaining the classic system between 1994 and 2005. In addition, a variation on the base case was developed in which MLS Cat 1 receivers were introduced in place of ILS and GNSS at certain airports and DME's were assumed to provide Area Navigation (RNAV) capabilities in the ECAC area. These scenarios are described in the following table.

Scenario	Description	Comments
-	Base Case	Current classic radionavigation system
-	RNAV + MLS	DME ground infrastructure providing RNAV capability + MLS Cat 1 receivers and multi-mode receiver on-board.

Table 2: Base case scenarios used in this study.

3. ESTIMATED COSTS OF IMPLEMENTING EACH SCENARIO

The costs of implementing the space, user and ground infrastructures were calculated separately for each scenario as follows:

Scenario	Ground Segment	Space Segment	User Segment	Total Cost
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1 RGIC/WAD	175	41	895	1111
2 Idem+ hybrid	175	41	1267	1483
3 RGIC/LAD	284	41	1465	1790
4 Idem + GLONASS	327	41	1485	1854
5 AAIM	183		1603	1786
6 RAIM			841	841

Table 3: Summary of possible costs for implementing GNSS in Europe, in millions of ECU

It can be seen that the majority of costs is incurred in the user - that is on-board - segment. This is understandable because the implementation of the ground and space segments are relatively inexpensive. Given that the core of each scenario above is GPS, whose costs are already sunk, this was to be expected.

The space infrastructure necessary for a geostationary overlay is relatively inexpensive (Scenarios 1-4); the major cost is the leasing of the payload because the launch costs are borne by the operator of each communications satellite on which the payload "piggy-backs". Scenarios 1 and 2 correspond, more or less, to the FAA's Wide Area Augmentation System, in which ranging, integrity and wide area differential corrections are broadcast via a geostationary overlay. The associated ground segment is expensive to develop but not to maintain so that, to the service provider, this is a remarkably cost-effective way of providing Category 1 capabilities if desired. Scenario 2 is more expensive than scenario 1 because a different on-board architecture has been considered in which hybrid GPS/IRS systems are installed, rather than just a receiver capable of decoding the overlay broadcasts.

If LADGPS is introduced for CAT 1 approaches, so that the overlay is only used for en-route and non-precision approach phases, the ground segment costs increase substantially because of the need to equip airports with LADGPS stations. This is reflected in Scenarios 3 and 4. In order to make use of geostationary and local area differential data, it has been assumed that a multi-mode receiver will be installed. This is currently the focus of much research and development by industry and should provide GPS (including differential), ILS and MLS capabilities when certificated. User segment costs, therefore, have increased due to the need to fit these receivers. Scenarios 3 and 4 are considerably more expensive than scenarios 1 and 2 as a consequence. In scenario 4, a GLONASS capability has been added which increases the costs of both the local area and user installations.

Scenario 5 assesses the costs of implementing a GNSS based on existing GPS and GLONASS. All integrity monitoring is performed on-board by reference to systems such as an IRS. This is known as Airborne Autonomous Integrity Monitoring (AAIM) and, if it were adopted, would not require a geostationary overlay. It has been assumed that LADGPS would be provided at airports, which is slightly more expensive to implement than the ground system for an overlay. Although there are no space segment costs, the cost to the user is highest because of the expense of integrating AAIM on-board.

The cheapest of the six scenarios is the final one which takes today's satellite navigation situation and extrapolates it. That is, it assumes that receivers are installed with no more capability than those in use today and for which no real operational benefit can be foreseen. Although it is (relatively) inexpensive it offers the minimum benefit to users due to its limited operational capabilities.

The large portion of costs to be borne by the airlines is explicable and comes from having to equip new, and retrofit old, aircraft. The equipment itself is not particularly expensive compared to current on-board systems, but the cost of integration and certification will drive up costs. It is to be hoped that as GNSS receivers become more common on new aircraft, these costs will decrease and may eventually be sunk in the cost of buying the aircraft, but it is too early to say. This is one reason why a full Cost/Benefit Analysis is required, so that a balanced assessment can be made.

4. Base Case Costs

The costs of maintaining the current system, or of modifying it to provide RNAV and MLS capabilities are as follows.

Scenario	Ground Segment	Space Segment	User Segment	Total Cost
Base case	1132			1132
RNAV/MLS	269		723	992

Table 4: Summary of base case costs, in millions of ECU

The base case costs do not take into account the cost to the airlines of fitting equipment. It is assumed that this is in fact zero because the receivers are mandatory and hence included in the purchase price of the aircraft. In addition, the cost to the airlines of maintaining these systems has not been assessed. In the RNAV/MLS scenario, there are costs incurred by the airlines to meet RNAV requirements and to install MLS. In addition, the cost of installing MLS at all runway ends has been calculated and is shown above. The cost of maintaining DME's is not shown, but is treated later.

5. Comparison of Scenarios to Base Case

It was stated above that the implementation of GNSS in Europe to provide a system capable of Category 1 precision approaches would be in addition to maintaining the current system. In effect, by 2005, two separate systems with similar performance characteristics could be in place. The table below shows what the total cost - current infrastructure plus additional implementation - could be.

Scenario	Base case cost	Additional cost	Total cost
Base case	1132	0	1132
MLS/RNAV	527	992	1519
1 RGIC/WAD	1132	1111	2143
2 Idem + hybrid	1132	1483	2515
3 RGIC/LAD	1132	1791	2822
4 Idem + GLONASS	1132	1855	2987
5 AAIM	1132	1786	2918
6 RAIM	1132	841	1973

Table 5: Summary of total cost per scenario 1994-2005, in millions of ECU

The effect of implementing a system in parallel is clear. This is, of course, the case in any transition phase, such as the one in which civil aviation currently finds itself. It is important, therefore, that a full Cost/Benefit Analysis starts as quickly as possible.

6. Conclusions

This paper has given an idea of what the likely costs of implementing GNSS in Europe will be. This is the first such study of its type and, although the figures presented are obviously preliminary and will change considerably in subsequent analyses, they can at least indicate the order of magnitude of costs likely to be incurred. It is clear that the geostationary overlay scenarios with Wide Area Differential capabilities (1 & 2) offer the least expensive option for obtaining Cat 1 precision approach from GPS. The difference in cost between scenario 1 and scenarios 3, 4 and 5 is particularly striking (about 700 MECU). Scenario 6 offers little real operational benefit.

It is clear that the airlines may be expected to bear the burden of costs because of installation and certification costs associated with the equipment. Currently, these costs are high since there is little equipment available, and satellite navigation is still a buyer furnished equipment. This may change. Nevertheless, the levels of cost incurred make a strong case for performing detailed Cost/Benefit Analyses.

7. Recommendations

The GNSS Panel is invited to note the contents of this Working Paper. It is further invited to recommend that Cost/Benefit Analyses be carried out at the appropriate levels in order to obtain better ideas of the benefits to be derived by civil aviation through the introduction of satellite navigation.

VIII. A PROGRAMME TO IMPLEMENT GNSS IN EUROPE

INFORMATION PAPER NO. 50

presented by

L. Tytgat

prepared by

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ICAO Global Navigation Satellite System Panel

First Meeting, Montreal, 17-25 October 1994

Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies

Agenda Item 4: Identification, as required, of GNSS elements, conditions or functions that could have institutional implications

A PROGRAMME TO IMPLEMENT GNSS IN EUROPE

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SUMMARY

A co-ordinated programme to implement satellite navigation in Europe is being developed by the European Commission, the European Space Agency and the European Organisation for the Safety of Air Navigation (EUROCONTROL). The three organisations have formed a Tri-Partite Team to manage this programme whose first aim is to implement a regional augmentation to GPS and GLONASS based on a geostationary overlay by the year 2002 (GNSS1). It will also fund extensive R&D into the development of a civil successor to current systems which would, independently, meet the needs of all users whether on land, at sea or in the air (GNSS2). The European GNSS1 is seen as a regional component of a global system which makes use of existing GPS and GLONASS to bring earliest possible benefits to users.

1. INTRODUCTION

The Tri-Partite Team of EUROCONTROL (represented by the Agency), the European Union (through the European Commission) and the European Space Agency has been meeting at frequent intervals at both senior management and working levels throughout 1994. A document outlining the aims of the team is being produced in which the responsibilities of each party are described. This document is still in a draft stage and, as yet, has no legal status. It describes the framework within which the three organisations are jointly preparing proposals for a European development of GNSS1 and for a European contribution to GNSS2. The development of GNSS1 is based on a wide area augmentation for GPS/GLONASS using navigation transponder payloads on geostationary satellites. It also includes development of other augmentations such as airborne autonomous integrity monitoring as well as research into the future civil system.

2. ROLES OF TRI-PARTITE TEAM MEMBERS

The Tri-Partite Team is harnessing the complementary strengths of its members in the development of a common programme by assigning specific roles to each organisation. These roles are discussed below.

2.1 Role of the European Commission (EC)

The EC provides the political focus for the Team's work. It is responsible for institutional and policy matters. In particular, the EC will endeavour to cement a European consensus on key issues such as system operator and service provider. It will also ensure that views and needs of users other than civil aviation are taken into consideration in the framework of the European navigation programme, including GNSS1.

The EC will contribute financially, calling on the resources of the European Union made available to it by the Transeuropean Networks funds as well as by the Fourth Framework Research and Development Programme.

2.2 Role of the European Space Agency (ESA)

ESA will manage the technical implementation of the European programme. In particular, ESA will be responsible for:

- translating mission requirements, as defined by EUROCONTROL (for civil aviation) and the EC (for other users), into system specifications;
- issuing Calls for Tender and placing contracts for the development, deployment and technical/functional validation testing;
- the provision of technical support and expertise for the programme (e.g. specific analysis, simulation test etc.).

Most studies and development activities needed for the implementation of the European GNSS1 programme will be performed under ARTES Element 9, a programme initiated by the European Space Agency.

The ARTES-9 programme should lead to an initial operational capability in a core area of Europe by the year 2000. This date has been advanced with respect to initial project planning because of a French initiative to commence work immediately on the Ranging function for the geostationary overlay as part of its contribution to ARTES-9. This is being undertaken in a joint project of the French Direction Générale de l'Aviation Civile (DGAC) and the French space agency, CNES, which is working closely with ESA. In addition, ESA will initiate on behalf of its partners any contractual action that could be jointly decided in order to complement ARTES-9 and to upgrade the European GNSS1 capability (additional Navigation Land Earth Stations, improved service performance, extension of service areas etc.). ARTES-9 also includes a considerable line of funding for R & D towards GNSS2.

2.3 EUROCONTROL's Role

EUROCONTROL's main contributions to the work of the Tri-Partite Team will be to develop the civil aviation user requirements for GNSS and to make a major contribution to the system test and validation phase of GNSS1 development. It also acts as a forum for co-ordinating work at the regional level through its management of the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) in which satellite navigation has been successfully incorporated.

3 INTERNATIONAL CO-OPERATION

Although the Tri-Partite Team is developing a regional system, this must be seen in the light of a global move to implement a number of regional augmentations to GPS and GLONASS which, through effective international co-operation, will appear transparent to the user. The aim is to ensure that a seamless, global satellite navigation service can become reality. The Tri-Partite team is committed to this goal and has had extensive contact with the United States Federal Aviation Administration in its pursuit thereof. In addition, contacts with Administrations in other regions have also been made, and the first meeting of the ICAO GNSS Panel is seen as an ideal environment for deepening international co-operation.

4. CONCLUSION

A common programme for the implementation of satellite navigation in Europe is being developed. Three regional organisations - the EC, ESA and EUROCONTROL - are co-operating closely and harnessing their respective resources to bring earliest benefits to users. It is expected that this programme will complement those of other regions' in the development of an initial GNSS based on regional augmentations to GPS and GLONASS.

**IX. GNSS SYSTEM ARCHITECTURE SCENARIOS
- SCENARIOS FOR THE IMPLEMENTATION OF SATELLITE NAVIGATION IN
EUROPE**

WORKING PAPER NO. 53

Presented by
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ICAO Global Navigation Satellite Systems Panel

First Meeting, Montreal, 17-25 October 1994

- Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies**
- Agenda Item 3: Development of technical and performance requirements for GNSS augmentation sub-systems, including integrity monitoring**
- Agenda Item 4: Identification, as required, of GNSS elements, conditions or functions that could have institutional implications**

GNSS System Architecture Scenarios

- Scenarios for the Implementation of Satellite Navigation in Europe -

Working Paper

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Abstract

This paper outlines preliminary scenarios for the introduction of satellite navigation in Europe. They were developed by the System Research and Development (SRD) Task Force within EUROCONTROL's Satellite Navigation Application Sub-Group to provide a basis for identifying potential future system architectures and augmentations for satellite navigation. The paper gives an overview of how these Scenarios were set up, which assumptions have been made and explains details of some of the Scenarios.

1. Introduction

The Scenarios detailed in the present document are intended to be used to generate - in an objective and systematic way - a list of all technical questions raised by the introduction of satellite navigation in Europe. Identified technical issues should be the subject of recommended R&D activities to be carried out by the EUROCONTROL Agency, the EUROCONTROL Member States or other appropriate organisations. Once it has identified all the technical solutions, the SRD Task Force will be in a position to classify Scenarios from a technical point of view and, subsequently, make relevant recommendations to the Satellite Navigation Application Sub-Group.

It is foreseen that - in parallel - the other EUROCONTROL Task Forces (IAR, CBS, OCR), will also establish a classification of these Scenarios according to their own criteria (respectively institutional, economic and certification concerns).

The set of Scenarios presented below covers all the potential augmentations identified in the EUROCONTROL strategy paper and their various combinations. Each Scenario consists of a set of augmentations to GPS which are intended to meet civil aviation users' requirements for all phases of flight, from oceanic en-route down to ICAO CAT III precision approach.

The different Scenarios are arranged within five main blocks. Block 0 Scenarios present today's situation and the transition to the future implementation of satellite navigation. Block 1 Scenarios assume enough GLONASS satellites in orbit to enhance the GPS constellation so that RAIM can meet requirements down to non-precision approach. On the contrary, block 2 to 4 Scenarios assume that for some reasons, which may range from technical (no or not enough GLONASS satellites, ...) to institutional (increased civil control, ...), there is a need for a significant civil component. In Europe the combination of GPS and its various augmentations is known as 'GNSS1'. Once civil constellations

are under consideration the terminology changes to 'GNSS2' which provides a greater degree of civil control of the space segment. GNSS2 may eventually be a completely new system, perhaps based on deployment of satellites by various regions.

The 4 main Scenario blocks are (see Table 1):

1. **GPS and GLONASS:** According to the basic assumption, RAIM can meet user requirements down to non-precision approach. Beyond non-precision approach, this set of Scenarios includes various combinations of CAT I local area differential, CAT II and CAT III local area differential or ILS or MLS.
2. **Geostationary overlay:** This set of Scenarios includes the deployment of a geostationary overlay providing additional range measurements (ranging) and integrity information, thereby enhancing the overall system performance so that requirements are met down to non-precision approach. Beyond non-precision approach, this set of Scenarios includes various combinations of CAT I wide or local area differential, CAT II and CAT III local area differential or ILS or MLS.
3. **Aircraft Autonomous Integrity Monitoring:** This set of Scenarios includes the improvement of the avionics, linking GNSS sensors with other onboard sensors to ensure that the entire airborne system will meet user requirements down to non-precision approach. Beyond non-precision approach, this set of Scenarios includes various combinations of CAT I local area differential, CAT II and CAT III local area differential or ILS or MLS.
4. **Basic civil constellation:** Although appearing in the GNSS 1 framework, this set of Scenarios may be seen as the most direct transition to GNSS 2. It includes the launch of civil navigation satellites to ensure that system performance - based on GPS, GLONASS and those additional satellites - will meet requirements down to non-precision approach with RAIM onboard. Beyond non-precision approach, this set of Scenarios includes various combinations of CAT I local area differential, CAT II and CAT III local area differential including the civil satellites or ILS or MLS.

This short presentation of the main blocks of Scenarios clearly demonstrates that the approach has been driven by the number of GLONASS satellites available. As this number - which cannot be driven by civil aviation interests - is still unknown and may range from 0 to 24, three cases have been tackled, based on the following assumptions:

- n is the number of GLONASS satellites,
- N1 is the critical number of GLONASS satellites beyond which requirements from oceanic en-route down to non-precision approach are met with GPS, GLONASS and RAIM in combination.

The three cases are:

- Case 1: $N1 \leq n$,

Status	Block	No.	Title	En Route-NPA	CAT I	CAT II/III	
	0	0.0	Today's Situation				
		0.1	Near Future Situation				
GNSS1 based on GPS	1	1.0	GPS + n GLONASS	+ RAIM	+ LADGNSS	+ LADGNSS	
		1.1	($N1 \leq n$)			only ILS	
		1.2				only MLS	
	2	2.0	GPS + n GLONASS + GEO Overlay	+ RAIM + Ranging + GIC	+ WADGNSS + Ranging + GIC	+ LADGNSS + Ranging	+ LADGNSS
		2.1	($1 \leq n < N1$) or ($n = 0$)			only ILS	
		2.2				only MLS	
		2.3				+ LADGNSS	+ LADGNSS + Ranging
	3	2.4				only ILS	
		2.5				only MLS	
		3.0	GPS + n GLONASS + AAIM	+ AAIM	+ LADGNSS	+ LADGNSS	+ LADGNSS
4	3.1	($1 \leq n < N1$) or ($n = 0$)			only ILS	only ILS	
	3.2				only MLS	only MLS	
	4.0	GPS + n GLONASS + Basic civil constellation	+ RAIM	+ LADGNSS	+ LADGNSS	+ LADGNSS	
towards GNSS2	4	4.1	($1 \leq n < N1$) or ($n = 0$)			only ILS	
		4.2				only MLS	

- Case 2: $1 \leq n < N1$,
- Case 3: $n = 0$.

All block 1 Scenarios are driven by case 1, whereas those of Blocks 2 to 4 are driven by cases 2 and 3. Brief explanations of these Scenarios are given in section 2.

Note that in all cases the number of GPS satellites is assumed to be 24. Space segment degradation and failure models will be taken into account and applied to the nominal number of GPS and GLONASS satellites, respectively 24 and n , when analysing the Scenarios.

2. Description of Scenarios

2.1 General

This section gives brief explanations for each of the Scenarios. Ranging from Today's Situation to a Scenario describing a Basic Civil Constellation, different Scenarios for future Navigation Systems are set up. Different system solutions for CAT II/III are given for Block 1 Scenarios by applying LADGNSS, ILS and MLS. For Blocks 2 to 4 the GNSS-based CAT II/III system could also be replaced by ILS or MLS within these investigations, but it is sufficient to investigate this once only in Block 1, transferring the results in a modular way to Blocks 2 to 4. This explains why those parts of the Scenarios in Blocks 2, 3 and 4 including ILS or MLS are not described.

Details of the Scenarios are described in the tables which are attached in the appendix to this paper. The columns divide the individually required equipment into ground, space and user segments, followed by columns presenting the user equipment separately for different phases of flight. The latter columns are divided vertically: the upper white domain contains the equipment considered to be mandatory, the lower shaded domain contains the non-mandatory equipment.

2.2 Block 0 - Scenarios

2.2.1 Scenario 0.0 - Today's Situation

This Scenario reflects the situation of navigation system implementations today. It is based on international laws and regulations and should serve as the basis for the development of the future Scenarios and it should provide the reference for cost comparisons.

2.2.2 Scenario 0.1 - Near Future Situation (Transition)

The near future situation is described within this Scenario when GPS and RAIM are implemented in addition to current radionavigation equipment (today's situation). It has to be seen as the transition from today's situation to a longer-term future situation, for which potential solutions will be identified based on the proposals contained in this document.

2.3 Block 1 - Scenarios

This first block covers the combination of the two current satellite positioning systems GPS and GLONASS with the application of RAIM algorithms to achieve user requirements down to non-precision approach. Accuracy shall be ensured for CAT I by LADGNSS. While it is expected that RAIM will not meet requirements for precision approach, it is assumed that the LADGNSS ground reference station has to provide integrity information to the aircraft. Special consideration shall be given to the question of how many GLONASS satellites will be necessary for this system solution.

2.3.1 Scenario 1.0 - GPS + n GLONASS + RAIM + LADGNSS

This Scenario combines the basic Block 1 - Scenario described above with the application of LADGNSS techniques for CAT II/III. IRS/AHRS will be necessary for autopilot operation during CAT II approach and is mandatory for CAT III autoland. Today, a radio altimeter is mandatory for CAT II/III operations. Questions to be answered will cover tighter accuracy and integrity requirements compared

to CAT I, together with investigations into the benefit of increasing the number of GLONASS satellites and the impact on the entire system design and the cost/benefit thereof.

2.3.2 Scenario 1.1 - GPS + n GLONASS + RAIM + LADGNSS + ILS

This Scenario assumes for direct comparison with Scenario 1.0 that LADGNSS will be used for CAT I operations only, maintaining, therefore, standard ILS equipment for CAT II/III precision approaches.

2.3.3 Scenario 1.2 - GPS + n GLONASS + RAIM + LADGNSS + MLS

MLS is used instead of ILS for CAT II/III precision approaches to provide a further comparison within the Block 1 - Scenarios.

2.4 Block 2 - Scenarios

Within these Block 2 - Scenarios, GPS and GLONASS will be combined with an overlay of geostationary satellites. The minimum number N_1 of required GLONASS satellites shall be determined and will depend on the number of GEO satellites from the existing number of three visible from Europe to another one or two additional satellites. The case of excluding GLONASS completely will also be investigated. A combination of RAIM, GIC and integrity provision from LADGNSS stations shall be investigated when LADGNSS ground reference stations will be required for precision approach for CAT II/III operation.

2.4.1 Scenario 2.0 - GPS + n GLONASS + GEO Overlay + WADGNSS + LADGNSS

The core of the Scenarios contained in Block 2 (WADGNSS down to and including NPA) will be combined with WADGNSS for CAT I precision approach. This Scenario corresponds to the FAA WAAS approach if no GLONASS satellites are included ($n=0$).

2.4.2 Scenario 2.3 - GPS + n GLONASS + GEO Overlay + LADGNSS

In Scenario 2.3 the application of LADGNSS is considered for CAT I approaches, because installations might be available anyway for CAT II/III. Depending on the number of required installations, the overall costs of WADGNSS and the unit costs of LADGNSS, the decision between WADGNSS and LADGNSS might finally be more on the economic side assuming technical feasibility.

2.5 Block 3 - Scenarios

These Scenarios reflect the application of AAIM algorithms onboard the aircraft. Improving the airborne system functions from RAIM (Block 1 - Scenarios) to AAIM should lead to a reduced number of required GLONASS satellites. The effect of excluding GLONASS completely shall be considered as well. These scenarios have to be seen in a multi-sensor environment, where at least inertial sensors, clock aiding, barometric and radio altimeters will be available.

Scenario 3.0 - GPS + n GLONASS + AAIM + LADGNSS - is the one which shall be investigated within Block 3, applying LADGNSS techniques for precision approach operations. AAIM concepts and design will be points of interest as well as system integration and required IRS/AHRS performance.

2.6 Block 4 - Scenarios

Based on the results derived in Blocks 1 to 3 a future system overlay with civil navigation satellites shall be investigated. Including and excluding GLONASS space vehicles, a system concept and design for civil satellites shall be developed addressing questions such as their required minimum number, their impact on the entire system concept and the compatibility towards GNSS 2.

The first Scenario within this Block 4.0 - Basic Civil Constellation - considers the application of LADGNSS for CAT II/III precision approach. The inclusion of ILS and MLS and their impact can easily be determined by including the related modules from Block 1.

3. Summary

It is considered that the Scenarios presented here cover a wide range of technical solutions to be investigated in the context of GNSS 1. The Scenarios will be used as input for developing the SRD Work Programme whose goal is to put the SRD Task Force in a position to classify Scenarios from a technical point of view and, subsequently, make the relevant recommendations to the Satellite Navigation Applications Sub-Group concerning the applicability of individual Scenarios.

4. Recommendation

The ICAO GNSS Panel is invited to take note of this paper and to take best advantage of its contents which describe an approach to identify potential future system architecture scenarios for the implementation of satellite navigation in Europe. The Panel is also invited to consider these Scenarios for adoption on a global basis.

Abbreviations

AAIM	Aircraft Autonomous Integrity Monitoring
AHRS	Attitude and Heading Reference System
CAT x	ICAO Category x Precision Approach
CBS	Cost/Benefit Studies
FAA	Federal Aviation Administration
GEO	GEOstationary satellite
GIC	GNSS Integrity Channel
GNSS	Global Navigation Satellite System(s)
IAR	Institutional Arrangements and Requirem.
ILS	Instrument Landing System
IRS	Inertial Reference System
LAD-GNSS	Local Area Differential GNSS
MLS	Microwave Landing System
NPA	Non-Precision Approach
OCR	Operational and Certification Requirem.
RAIM	Receiver Autonomous Integrity Monitoring
R&D	Research & Development
SRD	System Research and Development
SNA	Satellite Navigation Application
WAAS	Wide Area Augmentation System
WAD-GNSS	Wide Area Differential GNSS

SCENARIO	SEGMENT			PHASE OF FLIGHT ¹													
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III							
0.0																	
Today's Situation	VOR DME ² VOR/DME ³ NDB LORAN C OMEGA ILS ILS/DME Localizer Marker		IRS/AHRS VOR DME MultiDME ADF LORAN C OMEGA Doppler ILS Marker Barometric Altimeter Radio Altimeter Gyro Compass Artificial Horizon Turn Indicator	2 x IRS or OMEGA + Doppler				ILS Marker	ILS Marker Redundancy Radio Altimeter IRS/AHRS ⁴	ILS Marker Redundancy Radio Altimeter IRS/AHRS ⁴							
											2 x VOR + ADF + DME						
											Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator						
Mandatory Equipment																	
Non-Mandatory Equipment				LORAN C OMEGA INS/IRS/ AHRS	Doppler (Vel/Drift) LORAN C OMEGA IRS/AHRS	Doppler (Vel/Drift) LORAN C OMEGA IRS/AHRS	LORAN C OMEGA IRS/AHRS	IRS/AHRS									
				Clock													

SCENARIO	SEGMENT			PHASE OF FLIGHT													
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III							
0.1 ⁵																	
Near Future Situation (Transition)	VOR DME VOR/DME NDB OMEGA ILS ILS/DME Localizer Marker	24 GPS	Reception of GPS RAIM algo. IRS/AHRS VOR DME ADF OMEGA ILS Marker Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS + RAIM IRS/AHRS or OMEGA	GPS + RAIM	GPS + RAIM	GPS + RAIM	ILS Marker	ILS Marker Redundancy Radio Altimeter IRS/AHRS ⁴	ILS Marker Redundancy Radio Altimeter IRS/AHRS ⁴							
											VOR ⁶ + ADF ⁶ + DME						
											Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator						
Mandatory Equipment																	
Non-Mandatory Equipment				IRS/AHRS or OMEGA	IRS/AHRS	IRS/AHRS	IRS/AHRS	IRS/AHRS									

SCENARIO	SEGMENT			PHASE OF FLIGHT									
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III			
1.0													
GPS and n GLONASS $(N1 \leq n)$ Mandatory Equipment Non-Mandatory Equipment	LADGNSS Stations	24 GPS + n ⁷ GLONASS	Reception of GPS + GLONASS LADGNSS RAIM algo. IRS/AHRS Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM LADGNSS ⁸	GPS GLONASS RAIM LADGNSS ⁹ IRS/AHRS ⁴ Radio Altimeter	GPS GLONASS RAIM LADGNSS ⁹ IRS/AHRS ⁴ Radio Altimeter			
				Barometric Altimeter + Gyro Compass + Artificial Horizont + Turn Indicator							IRS/AHRS	IRS/AHRS	IRS/AHRS

SCENARIO	SEGMENT			PHASE OF FLIGHT									
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III			
1.1													
GPS and n GLONASS (N1 ≤ n) Mandatory Equipment Non-Mandatory Equipment	LADGNSS Stations ILS Marker DME	24 GPS + n ⁷ GLONASS	Reception of GPS + GLONASS LADGNSS RAIM algo. IRS/AHRS ILS/DME Marker Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM LADGNSS ⁸	ILS Marker IRS/AHRS ⁴ Radio Altimeter	ILS Marker IRS/AHRS ⁴ Radio Altimeter			
				Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator							IRS/AHRS	IRS/AHRS	IRS/AHRS

SCENARIO	SEGMENT			PHASE OF FLIGHT						
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III
1.2										
GPS and n GLONASS ($N1 \leq n$)	LADGNSS Stations MLS DME	24 GPS + n ⁷ GLONASS	Reception of GPS + GLONASS LADGNSS RAIM algo. IRS/AHRS MLS Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM	GPS GLONASS RAIM LADGNSS ⁸	MLS/DME IRS/AHRS ⁴ Radio Altimeter	MLS/DME IRS/AHRS ⁴ Radio Altimeter
				Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator						
Mandatory Equipment				IRS/AHRS	IRS/AHRS	IRS/AHRS	IRS/AHRS	IRS/AHRS		
Non-Mandatory Equipment										

SCENARIO	SEGMENT			PHASE OF FLIGHT						
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III
2.0 ¹⁰										
GPS n GLONASS Geo Overlay $(1 \leq n < N1)$ or $(n = 0)$	High density ground network ≈ 20 WRS (some outside Europe TBC) 2+TBD ¹⁴ WMS 2+TBD ¹⁴ GES LADGNSS Stations	24 GPS + n ¹¹ GLONASS + AORE, IOR AORW + X additional GEO (TBD)	Reception of GPS + GLONASS + RANGING + GIC + WADGNSS + LADGNSS RAIM algo. IRS/AHRS Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS GLONASS RAIM RANGING	GPS GLONASS RAIM RANGING	GPS GLONASS RAIM RANGING GIC ¹²	GPS GLONASS RAIM RANGING GIC ¹²	GPS GLONASS RAIM RANGING GIC ¹³ WADGNSS	GPS GLONASS RAIM RANGING LADGNSS ⁹ IRS/AHRS ⁴ Radio Altimeter	GPS GLONASS RAIM RANGING LADGNSS ⁹ IRS/AHRS ⁴ Radio Altimeter
				Mandatory Equipment	Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator					
Non-Mandatory Equipment				GIC IRS/AHRS	GIC IRS/AHRS	IRS/AHRS	IRS/AHRS	IRS/AHRS		

SCENARIO	SEGMENT			PHASE OF FLIGHT						
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III
2.3										
GPS n GLONASS Geo Overlay $(1 \leq n < N1)$ or $(n = 0)$ Mandatory Equipment	Low density ground network ≈ 7 WRS (some outside Europe TBC) 2+TBD ¹⁴ WMS 2+TBD ¹⁴ GES LADGNSS Stations	24 GPS + n ¹¹ GLONASS + AORE, IOR AORW + X additional GEO (TBD)	Reception of GPS + GLONASS + RANGING + GIC + LADGNSS RAIM algo. IRS/AHRS Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS GLONASS RAIM RANGING	GPS GLONASS RAIM RANGING	GPS GLONASS RAIM RANGING GIC	GPS GLONASS RAIM RANGING GIC	GPS GLONASS RAIM RANGING LADGNSS ¹⁵	GPS GLONASS RAIM RANGING LADGNSS ¹⁵ IRS/AHRS ⁴ Radio Altimeter	GPS GLONASS RAIM RANGING LADGNSS ¹⁵ IRS/AHRS ⁴ Radio Altimeter
				Non-Mandatory Equipment	Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator			GIC IRS/AHRS	GIC IRS/AHRS	IRS/AHRS

SCENARIO	SEGMENT			PHASE OF FLIGHT									
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III			
3.0													
GPS GLONASS AAIM $(1 \leq n < N1)$ or $(n = 0)$ Mandatory Equipment Non-Mandatory Equipment	LADGNSS Stations	24 GPS + n ¹⁶ GLONASS	Reception of GPS ¹⁷ + GLONASS LADGNSS IRS/AHRS Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS GLONASS AAIM IRS/AHRS	GPS GLONASS AAIM IRS/AHRS	GPS GLONASS AAIM IRS/AHRS	GPS GLONASS AAIM IRS/AHRS	GPS GLONASS AAIM IRS/AHRS LADGNSS ¹⁸	GPS GLONASS AAIM LADGNSS ¹⁸ IRS/AHRS ⁴ Radio Altimeter	GPS GLONASS AAIM LADGNSS ¹⁸ IRS/AHRS ⁴ Radio Altimeter			
				Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator									
				RAIM	RAIM	RAIM	RAIM						

SCENARIO	SEGMENT			PHASE OF FLIGHT									
	Ground	Space	User	Oceanic en Route	Continental en Route	Terminal	Non-Precision Approach	Precision Approach / CAT I	Precision Approach / CAT II	Precision Approach / CAT III			
4.0 ¹⁹													
GPS GLONASS Basic Civil Constellation $(1 \leq n < N1)$ or $(n = 0)$ Mandatory Equipment Non- Mandatory Equipment	LADGNSS Stations	24 GPS + n ²⁰ GLONASS + m ²¹ CivSat	Reception of GPS + GLONASS + CivSat LADGNSS RAIM algo. IRSAHRS Radio Altimeter Barometric Altimeter Gyro Compass Artificial Horizont Turn Indicator	GPS GLONASS CivSat + RAIM	GPS GLONASS CivSat + RAIM	GPS GLONASS CivSat + RAIM	GPS GLONASS CivSat + RAIM	GPS GLONASS CivSat + RAIM LADGNSS ²²	GPS GLONASS CivSat + RAIM LADGNSS ²³ IRS/AHRS ⁴ Radio Altimeter	GPS GLONASS CivSat + RAIM LADGNSS ²³ IRS/AHRS ⁴ Radio Altimeter			
				Barometric Altimeter + Gyro Compass + Artificial Horizon + Turn Indicator									
				IRS/AHRS	IRS/AHRS	IRS/AHRS	IRS/AHRS	IRS/AHRS					

¹ The mandatory equipment is defined within national and international laws: Flugsicherungs- und Ausrüstungsverordnung (FSAV) § 3, Bonn 23.12.1992, LuftBO § 11.

² Includes the civil service provision of TACAN in some European countries.

³ Includes the civil service provision of VORTAC in some European countries.

⁴ AHRS is used for autopilot operation and required for CAT III autoland.

⁵ GLONASS is not taken into account in this scenario which addresses the very near future situation (1995). There is no doubt that GLONASS cannot be a component of any operational system by 1995.

⁶ Could be phased out after transition to final scenario.

⁷ n greater than or equal to $N1$ where $N1$ is the required minimum number of GLONASS satellites in addition to the 24 GPS satellites to ensure that the RAIM function will allow the user to meet the requirements.

⁸ LADGNSS for CAT I: Carrier-smoothed-code techniques probably satisfy accuracy requirements. The local data link is intended to be the main source for integrity during the precision approach.

⁹ LADGNSS for CAT II and CAT III: More accurate differential techniques such as pseudolites and pure-carrier-phase tracking might be required. Several data links will be investigated for LADGNSS. The local data link is intended to be the main source for integrity during the precision approach. These remarks are valid for all scenarios encompassing LADGNSS.

¹⁰ Scenario equal to FAA's WAAS down to CAT I, when number of GLONASS satellites $n=0$.

¹¹ $N2$ is the required minimum number of GLONASS satellites in addition to the 24 GPS satellites and the geostationary AORW, AORE, IOR to ensure that the RAIM function will allow the user to meet the requirements. Three cases to be considered:

- $n=0$: GPS and GEO overlay.
- $0 < n < N2$: 24 GPS + n GLONASS + RAIM + (Ranging+GIC from AORW, AORE, IOR) do not allow to meet the requirements so that TBD GEOs are needed.
- $N2 \leq n < N1$: 24 GPS + n GLONASS + RAIM + (Ranging+GIC from AORW, AORE, IOR) allow to meet the requirements.

¹² As there are not enough GLONASS satellites to ensure that the RAIM function will meet the requirements on its own down to non-precision approach, GIC is used to enhance the basic RAIM performances up to the required level.

¹³ Because of the higher accuracy requirement of CAT1 and the associated low alarm threshold, RAIM can no longer be used as the basis and GIC is intended to provide the main source for integrity. The final decision (use or do not use a satellite) is nevertheless still on board.

¹⁴ TBD being equal to 1 or 2 depending on the location of additional GEO satellites.

¹⁵ The local data link is intended to be the main source for integrity during the precision approach, thus reducing the GIC usefulness. Above mentioned code/carrier tracking techniques have to be applied to ensure accuracy.

¹⁶ Two cases to be considered:

- $n=0$: GPS and AAIM.
- $0 < n < N1$: where $N1$ is the required minimum number of GLONASS satellites in addition to the 24 GPS satellites to ensure that the AAIM function will allow the user to meet the requirements.

¹⁷ The GPS receiver may or may not have the RAIM capability.

¹⁸ The sharing of integrity functions between LADGNSS ground stations and AAIM has to be investigated. Above mentioned code/carrier tracking techniques have to be applied to ensure accuracy.

¹⁹ Design and orbits of CivSat have to be investigated considering the transition to a full civil system (GNSS 2).

²⁰ Two cases to be considered:

- $n=0$: GPS and CivSat.
- $0 < n < N1$: where $N1$ is the required minimum number of GLONASS satellites in addition to the 24 GPS satellites and m CivSats to ensure that the RAIM function will allow the user to meet the requirements.

²¹ m to be defined so that 24 GPS + n GLONASS + m CivSat would allow the RAIM function to meet the requirements.

²² Two cases to be considered dependent from 24 GPS + n GLONASS + m CivSat:

- The sharing of integrity functions between LADGNSS ground stations and RAIM. Above mentioned code/carrier tracking techniques have to be applied to ensure accuracy.
- Required satellite system constellation to avoid from LADGNSS for CAT I.

²³ The sharing of integrity functions between LADGNSS ground stations and RAIM has to be investigated dependent on satellite system constellation. Above mentioned code/carrier tracking techniques have to be applied to ensure accuracy.

APPENDIX :

Agenda of the First Meeting of the ICAO Global Navigation Satellite System Panel

The agenda for the meeting shown thereunder was approved by the Air Navigation Commission (10 February 1994):

- Agenda Item 1: Review of the work programme and establishment of working methods for the panel and review of work in progress by other bodies
- Agenda Item 2: Determination of performance criteria to support the operational requirements for application of GNSS, based on existing satellite navigation systems
- Agenda Item 3: Development of technical and performance requirements for GNSS augmentation sub-systems, including integrity monitoring
- Agenda Item 4: Identification, as required, of GNSS elements, conditions or functions that could have institutional implications
- Agenda Item 5: Development of technical and performance requirements for the longer-term GNSS for civil aviation use
- Agenda Item 6: Future work

TRADUCTION FRANCAISE

DOCUMENTS PRESENTES A LA PREMIERE REUNION DU GROUPE D'EXPERTS DU SYSTEME MONDIAL DE NAVIGATION PAR SATELLITES (GNSSP) DE L'OACI MONTREAL 17-25 OCTOBRE 1994

SOMMAIRE

Le présent rapport reprend le contenu des neuf documents de travail et d'information présentés par EUROCONTROL à la séance d'ouverture du Groupe d'Experts de l'OACI relatif au système mondial de satellites de navigation qui s'est tenu à Montréal du 17 au 25 octobre 1994.

Un avant-propos détaillé passe les documents en revue et situe leurs contenus dans la structure de travail établie par l'Organisation EUROCONTROL pour la coordination et la gestion de ses activités de navigation par satellites.

AVANT PROPOS

Au cours de sa 175ème session, en mars 1994, le Comité de gestion d'EUROCONTROL a notamment adopté une stratégie de navigation par satellites et a considéré que les travaux qui y étaient associés devraient être effectués dans le cadre du Programme Européen pour l'Intégration et l'Harmonisation du Contrôle du Trafic Aérien (EATCHIP). Il a également estimé nécessaire qu'EUROCONTROL coopère, tant avec l'Agence Spatiale Européenne qu'avec la Commission de l'Union Européenne. La création du Sous-Groupe Applications de la Navigation par Satellites (SNASG - Satellite Navigation Applications Sub-Group) ainsi que de 4 cellules de travail spécialisées a également, à sa 175ème session, fait l'objet d'une approbation du Comité de gestion. Le SNASG rend compte à l'équipe chargée des futurs concepts (Future Concepts Team), elle-même directement reliée à la structure de travail EATCHIP (EATCHIP Working Structure). La structure du SNASG est la suivante :

Cellule de Travail	Sigle	Président	Organisation	Pays
Satellite Navigation Applications Sub-Group	SNASG	Dr. John Storey	EUROCONTROL	
Cost/Benefit Studies TF	CBS	Paul Wood	CAA/NATS	Royaume Uni
Institutional Arrangements & Requirements TF	IAR	Mieke Altink-Pouw (Jusqu'en Sept. 1994)	RLD	Pays Bas
		Dr. John Storey (Président intérimaire)	EUROCONTROL	
Operational & Certification Requirements TF	OCR	Dr. Norbert Lohl	LBA	Allemagne
System Research & Development TF	SRD	Dominique Stammler	DGAC/STNA	France

Tableau 1 : Présidents du SNASG et des Cellules de travail spécialisées

Au début d'octobre 1994, deux séries de réunions se sont déroulées pour le Sous-Grouppe et ses cellules de travail spécialisées; elles ont connu une forte participation, avec jusqu'à 35 représentants provenant d'environ 20 Etats et organisations internationales.

Le Groupe d'Experts de l'OACI

Le Groupe d'Experts de l'OACI relatif aux systèmes mondiaux de navigation par satellites (GNSS Panel) a eu sa réunion d'ouverture à Montréal du 17 au 25 octobre 1994 et EUROCONTROL ainsi que les Etats-Membres de la Conférence Européenne de l'Aviation Civile (CEAC) étaient bien représentés. L'Agence, la Commission de l'Union Européenne et l'Agence Spatiale Européenne avaient un statut d'observateur et plusieurs membres du SNASG et de ses cellules de travail spécialisées étaient présents. L'ordre du jour de la réunion est communiqué dans une annexe au présent rapport.

Afin que l'Europe présente un point de vue commun au Groupe d'Experts GNSS, il fut convenu que le Président du SNASG, qui se trouvait être l'Observateur de l'Agence au Groupe d'Experts, présenterait 9 documents de travail et d'information préparés par les cellules de travail spécialisées.

Point 1 de l'ordre du jour : Examen du programme de travail; mise au point de méthodes de travail pour le Groupe d'Experts; examen des actions d'autres organes

Les documents de travail 40, 41 et 46 furent présentés sous le premier point de l'ordre du jour.

Le document de travail N° 40 décrivait la structure du SNASG et de ses cellules de travail spécialisées et recommandait, afin de mener avec succès son programme de travail, que le Groupe d'Experts GNSS la considère comme un modèle possible pour l'organisation de ses propres activités. Le document de travail N° 44 présentait la stratégie de navigation par satellites adoptée par le Comité de gestion d'EUROCONTROL, approuvée et recommandée, en juin 1994, par les Ministres des Transports de la Conférence Européenne de l'Aviation Civile, aux fins d'une adoption plus large. Bien que cette stratégie soit régionale, il fut néanmoins considéré qu'elle pouvait utilement servir de modèle pour le développement d'une stratégie mondiale d'implantation de la navigation par satellites dans l'aviation civile.

Le document de travail N° 46 donnait les grandes lignes de la méthodologie appliquée dans l'élaboration du programme de travail de la cellule spécialisée SRD (System Research & Development TF) ainsi qu'une vue d'ensemble, d'une part, du développement du programme de travail, d'autre part, de l'identification des zones de recherche et de développement.

Point 2 de l'ordre du jour : Détermination des critères de performances venant à l'appui d'exigences opérationnelles pour l'application du GNSS sur la base des systèmes existants de navigation par satellites

Le document de travail N° 47, présenté sous le point 2 de l'ordre du jour, identifiait la nécessité de fournir les exigences opérationnelles afin de permettre le développement de spécifications techniques pour le GNSS et proposait les moyens d'atteindre cet objectif.

Point 3 de l'ordre du jour : Développement d'exigences techniques et de performances pour l'augmentation des capacités des sous-systèmes du GNSS, y compris celui du contrôle de l'intégrité

Les documents de travail 45 et 53 ont été présentés sous le point 3 de l'ordre du jour. Le document N° 45 appelait l'attention du Groupe d'Experts sur le besoin urgent de développer les standards et pratiques recommandés (Standards and Recommended Practices - SARPs) pour arriver à obtenir un contrôle d'intégrité des systèmes mondiaux de navigation par satellites ainsi que des données différentielles de zones, qu'elles soient régionales ou locales. L'application des standards et pratiques ci-dessus mentionnés est nécessaire de manière urgente afin de garantir la compatibilité entre des systèmes analogues, développés dans différentes régions.

Le document de travail 53 définissait les scénarios initiaux visant à l'introduction de la navigation par satellites en Europe, développés par la cellule spécialisée SRD et destinés à fournir une base éventuelle d'identification des architectures du futur système et d'accroissement du principe de la navigation par satellites.

Point 4 de l'ordre du jour : Indentification, à la demande, d'éléments du GNSS, des conditions ou fonctions pouvant avoir des implications institutionnelles

Les documents de travail 48, 50 et 57 ont été présentés sous le point 4 de l'ordre du jour.

Le document N° 48 donnait une idée des coûts prévisibles d'implantation du GNSS en Europe. Ces coûts dérivait d'une première étude de ce type et, bien que les chiffres présentés étaient manifestement de l'ordre de l'estimation et donc susceptibles de changer considérablement lors d'analyses plus fines, ils pouvaient néanmoins indiquer un certain ordre de grandeur. Le niveau des coûts a démontré un besoin évident d'effectuer une analyse coût/bénéfice.

Le document N° 50 présentait le programme coordonné d'implantation de la navigation par satellites en Europe, développé conjointement par la Commission des Communautés Européennes, l'Agence Spatiale Européenne et EUROCONTROL. Ces trois organisations ont constitué une équipe tripartite chargée de coopérer et de s'atteler à la recherche de bénéfices immédiats pour les utilisateurs en mettant leurs ressources en commun. Il est prévu que ce programme viendra en complément de ceux d'autres régions dans le développement d'un premier programme mondial de navigation par satellites basé sur des accroissements régionaux du GPS (Global Positioning System) et GLONASS (Global Orbiting Navigation Satellite System).

Le document N° 57 mettait en lumière les problèmes rencontrés par la cellule spécialisée OCR (Operational & Certification Requirements TF) lorsqu'elle commença à développer un ensemble complet de spécifications pour la navigation par satellites. Il reprenait le sommaire des besoins des utilisateurs, repris des sources disponibles, et mettait en évidence les points nécessitant de plus amples définitions.

Au cours des discussions qui ont suivi la présentation des documents de travail, leurs contenus respectifs ont été amplement défendus par les représentants d'EUROCONTROL et des Etats-Membres de la CEAC. Dans le procès-verbal de la réunion, il est fait référence à la plupart de ces documents de travail.

Remerciements

Les neuf documents de travail présentés à la session d'ouverture du Groupe d'Experts GNSS de l'OACI et reproduits dans le présent rapport, représentent un travail considérable, effectué durant une très courte

période. Que tous ceux qui ont participé à leur rédaction soient ici remerciés, non seulement pour la valeur de leurs contributions, mais également pour l'esprit dans lequel ils les ont rédigés.

J. Storey, Président SNASG

A. Watt, Secrétaire SNASG et ses Cellules de travail spécialisées.

I. PROPOSITION D'UNE STRUCTURE DE TRAVAIL ADAPTEE A LA GESTION DES ACTIVITES DE NAVIGATION PAR SATELLITES AU NIVEAU INTERNATIONAL

Résumé

La navigation par satellites a été incorporée avec succès dans le programme d'harmonisation et d'intégration des services européens du contrôle aérien (EATCHIP). Une structure de travail a été mise en place afin d'examiner les différents aspects de la navigation par satellites concernant l'aviation civile. Cela couvre les problèmes institutionnels, le domaine opérationnel, la certification, les activités de recherche et enfin les études coûts/bénéfices. Le travail est effectué au sein de cellules de travail spécialisées qui font leurs recommandations à un sous-groupe responsable de la navigation par satellites dans le programme EATCHIP. L'approche décrite dans ce document est simple et constitue l'ossature de l'organisation des activités de navigation par satellites à un niveau international. Le Groupe d'Experts est invité à considérer cette structure comme un modèle possible pour l'organisation de ses propres activités afin de remplir avec succès son mandat.

Conclusion

Il est évident que les nombreux sujets traités au sein des cellules de travail spécialisées d'EUROCONTROL, qu'il s'agisse du CBS, de l'IAR, de l'OCR ou du SRD, doivent également l'être, entre autres, par le Groupe d'Experts. L'Europe a créé une structure de travail permettant l'introduction de la navigation par satellites au niveau régional. Cette structure a fourni le cadre permettant de travailler efficacement dans un environnement international. L'approche européenne pourrait servir de modèle à l'organisation du travail du Groupe d'Experts à un niveau mondial et/ou régional.

Recommandations

Le Groupe d'Experts est invité à prendre note du contenu de ce document et à considérer si l'adoption de la structure qui y est proposée peut servir de modèle pour l'organisation de ses propres activités, que ce soit au niveau mondial ou régional.

II. DEVELOPPEMENT D'UNE STRATEGIE MONDIALE DE NAVIGATION PAR SATELLITES

Résumé

Un certain nombre d'Administrations de l'Aviation Civile des pays membres d'EUROCONTROL ont développé et adopté une stratégie commune visant à l'introduction de la navigation par satellites dans leur espace aérien. Cette stratégie a été ratifiée par les Ministres des transports des pays membres de la Conférence Européenne de l'Aviation Civile (ECAC) lors de leur quatrième rencontre à Copenhague, en Juin 1994. Bien qu'elle soit régionale, cette stratégie pourrait néanmoins utilement servir de modèle au développement d'une stratégie mondiale d'introduction de la navigation par satellites dans l'aviation civile.

Recommandations

Le Groupe d'Experts GNSS est invité à avaliser l'approche exposée dans la stratégie de navigation par satellites proposée par EUROCONTROL et d'examiner si elle peut être considérée comme un modèle au développement d'une stratégie applicable au niveau mondial.

III. BESOIN URGENT DE SARPS RELATIFS A L'AUGMENTATION DES CAPACITES DU GNSS

Résumé

Le but principal de ce document est d'attirer l'attention du Groupe d'Experts sur le besoin urgent de développer les SARPs pour fournir un contrôle d'intégrité du GNSS ainsi que des données différentielles de zones, qu'elles soient étendues ou locales. La planification de l'introduction d'une augmentation des capacités du GNSS comprenant les fonctions mentionnées ci-dessus, est bien engagée en Europe. Les SARPs sont requis de manière urgente afin de garantir la compatibilité du système avec des systèmes similaires en cours ou en voie d'installation dans d'autres régions.

Recommandation

Le Groupe d'Experts GNSS est invité à examiner cette note de travail et à convenir d'une suite d'actions visant à développer de manière urgente des SARPs pour le système RGIC (Ranging GNSS Integrity Channel) ainsi que pour les systèmes différentiels sur zones étendues et locales.

IV. METHODOLOGIE DU PROGRAMME DE TRAVAIL RECHERCHE & DEVELOPPEMENT DU SYSTEME GNSS D'EUROCONTROL

Abrégé

Le présent document expose la méthodologie appliquée pour l'élaboration du programme de travail de la Cellule spécialisée SRD relevant du Sous-groupe SNASG d'EUROCONTROL. Point de départ d'un inventaire des solutions possibles en matière d'architectures de systèmes futurs et de développements de la navigation par satellites en Europe, il donne un aperçu du développement de ce programme de travail et de la manière dont les zones de recherche et développement ont été identifiées pour faire ensuite l'objet d'activités approuvées, définies dans un Plan d'action SRD.

Résumé

Suivant la méthode d'élaboration du programme de travail exposée ci-dessus, la cellule spécialisée « Recherche et Développement » d'EUROCONTROL diffusera un Plan d'action SRD d'ici à la fin de l'année 1994.

Ce Plan d'action indiquera les domaines nécessitant des études et recherches afin de prouver les possibilités d'application et la validité des scénarios d'architecture du système envisagé pour la mise en oeuvre de la navigation par satellites en Europe.

A l'issue des travaux de R&D, il ne devrait subsister que deux ou trois scénarios qui seront recommandés tant au Sous-groupe EUROCONTROL "Applications de la navigation par satellites" qu'à l'Agence EUROCONTROL.

Ces organes évalueront les propositions soumises en tenant compte du classement établi, parallèlement, par les autres cellules spécialisées de travail (IAR, CBS, OCR).

En dernier lieu, ces organes retiendront un scénario unique, qui servira de base à la mise en oeuvre de la navigation par satellites en Europe.

Recommandation

Le Groupe d'Experts GNSS de l'OACI est invité à prendre note du présent document et à exploiter au mieux les informations qui y sont contenues sur la méthode d'élaboration du programme de travail EUROCONTROL pour la recherche et le développement en matière de GNSS. Bien que cette approche constitue l'une de celles permettant d'identifier les scénarios d'architecture du potentiel système futur de mise en oeuvre, en Europe, de la navigation par satellites, le Groupe d'Experts est également invité à examiner cette méthodologie en vue de son adoption à l'échelle mondiale.

V. EXIGENCES OPERATIONNELLES CONCERNANT UN SYSTEME MONDIAL DE NAVIGATION PAR SATELLITES A L'USAGE DE L'AVIATION CIVILE INTERNATIONALE

Résumé

Le présent document met en évidence la nécessité de définir des exigences opérationnelles en vue du développement des spécifications techniques du GNSS et propose une stratégie pour y parvenir

Conclusions

- 1 Le présent document reconnaît la nécessité d'exigences opérationnelles pour toutes les phases de vol devant être identifiées avant toute application de solutions techniques faisant appel au GNSS.
- 2 Ce travail devrait être confié aux Groupes d'Experts de l'OACI ayant les compétences requises.

Mesures à prendre par le Groupe d'Experts

- 1 Le Groupe d'Experts est invité à examiner le plan d'action proposé dans le présent document et à demander à l'OACI de charger les Groupes d'Experts compétents du développement des exigences opérationnelles pour les diverses phases de l'opération.

VI. METHODE APPLIQUEE PAR EUROCONTROL POUR DEFINIR LES EXIGENCES OPERATIONNELLES

Abrégé

Le présent document expose les problèmes que la Cellule spécialisée "Besoins opérationnels et homologation" (OCR), relevant du Sous-groupe EUROCONTROL "Applications de la navigation par satellites", a rencontrés lorsqu'elle a entrepris de recenser les exigences des utilisateurs dans le domaine de la navigation par satellite. Il résume ces exigences, puisées dans les sources d'informations disponibles et précise les domaines dans lesquels de plus amples définitions sont nécessaires.

Ce document a pour buts de faire le point de la situation en matière de définition des exigences des utilisateurs et des spécifications correspondantes de performance du système pour la navigation par satellites, de mettre en évidence les problèmes rencontrés et de proposer une stratégie pour la suite des travaux.

Il servira de base aux débats sur une initiative visant à recenser les exigences communes à tous les utilisateurs et à constituer un ensemble complet applicable à l'échelon international.

Situation et conclusions

Pour les phases de vol en route océanique, en route continentale et terminale, les définitions du RGCSF ne comportent pas suffisamment de données sur les exigences en matière d'intégrité, de disponibilité et de continuité de service. En conséquence, les exigences provisoires définies par le FANS seront utilisées jusqu'au moment où les travaux effectués conjointement par les Groupes EUROCAE WG13 et RTCA SC 181 auront été couronnés de succès.

Pour la phase de vol d'approche non précise, des lacunes ont été observées dans les chiffres de l'AWOP et de l'OCP. Dans ce cas également, les données provisoires du FANS devraient être utilisées jusqu'au moment où cette phase du vol sera traitée, soit par l'OCP, soit par l'AWOP.

Des propositions d'exigences définies par l'AWOP sont disponibles pour les phases d'approche de précision et devraient servir de données de départ.

Il devrait être clairement mis en évidence que les chiffres donnés par le FANS sont applicables en matière de NSE (Navigation System Error), tandis que les exigences de l'AWOP concernent le TSE (Total System Error).

Il ressort de cette synthèse qu'une coordination entre les différents groupes d'experts sera nécessaire afin qu'un consensus acceptable puisse être dégagé sur les exigences des utilisateurs, et partant, sur les spécifications requises en matière de performances des systèmes de navigation par satellites.

Recommandation

Le Groupe d'Experts GNSS de l'OACI est invité à prendre note du présent document, à exploiter au mieux les données qui y sont contenues et à s'efforcer d'établir une coopération fructueuse entre les diverses cellules spécialisées et eux-mêmes. Les travaux du Groupe devraient aboutir à la définition d'un ensemble complet d'exigences des utilisateurs pour toutes les phases de vol, y compris la circulation au sol, étant entendu que ces exigences devront être valables dans le monde entier de façon à être adoptées à l'échelon international.

VII. UNE PREMIÈRE ESTIMATION DES COÛTS RELATIFS À L'IMPLANTATION DU GNSS EN EUROPE

Résumé

Fin 1993, l'Agence EUROCONTROL a lancé deux études chargées d'évaluer, respectivement, les coûts de la radionavigation classique et ceux d'introduction du GNSS dans les trente-deux pays membres de la Conférence Européenne de l'Aviation Civile (CEAC) durant la période 1994-2005. Les résultats concernant l'étude sur les moyens de radionavigation classiques font l'objet d'un papier séparé et ce document de travail ne traite que des coûts d'introduction du GNSS.

L'étude en question est concentrée sur l'introduction du GNSS¹ dans lequel diverses catégories d'améliorations des systèmes GPS et GLONASS ont été introduites. Les résultats de l'étude montrent que les coûts correspondant à l'introduction d'un système de navigation par satellites capable d'assurer des approches de précision de catégorie I sont considérablement plus faibles que les coûts rencontrés pour maintenir les moyens de radionavigation actuels pendant la même période. Etant donné qu'il n'est pas prévu de mettre hors service l'une quelconque des parties de l'infrastructure actuelle avant 2005, aucune économie ne pourra malheureusement être réalisée pour le moment et il est donc probable que les coûts d'introduction du GNSS viendront s'ajouter aux coûts d'entretien.

L'étude montre également que les coûts d'installation à bord de la flotte européenne, d'équipements capables de recevoir les signaux satellites sont importants. Dans la plupart des cas étudiés, ils augmentent le coût supplémentaire d'introduction de la navigation par satellites au point de dépasser les coûts de maintien de l'infrastructure actuelle.

Il est à souligner cependant que cette étude n'a concerné ni les bénéfices, ni le coût d'utilisation des approches de précision des catégories II et III du GNSS. Il est prévu d'utiliser les résultats de la présente étude comme base d'une analyse détaillée du rapport coût/bénéfice à mener en 1995 dans le cadre de la cellule spécialisée d'EUROCONTROL « Etudes coûts/bénéfices de l'application de la navigation par satellites ».

Conclusions

Ce document donne une idée des coûts probables d'introduction de la navigation par satellites en Europe. Cette étude constitue une première de ce type et, bien que les chiffres présentés soient manifestement provisoires et amenés à considérablement changer lors d'études ultérieures, ils

donnent au moins un ordre d'idée des coûts encourus. Il est évident que les scénarios de couverture géostationnaire comprenant des capacités différentielles (1 & 2) de vastes régions (Wide Area Differential Capabilities) offrent l'option la moins coûteuse pour l'obtention de la catégorie 1 en matière de précision d'approche en utilisant GPS. La différence de coût entre le scénario 1 et les scénarios 3, 4 et 5 est particulièrement frappante (approximativement 700 MECU). Le scénario 6 n'offre guère d'intérêts opérationnels.

Les compagnies aériennes devront sans doute supporter la charge des coûts à cause des frais d'installation et de certification associés aux équipements. Ces coûts sont actuellement élevés car peu d'équipements sont disponibles et la navigation par satellites est encore toujours un équipement en option. Cette situation peut évoluer. Toutefois, les niveaux de coûts encourus plaident en faveur d'analyses coûts/bénéfices détaillées.

Recommandations

Le Groupe d'Experts GNSS est invité à considérer les résultats présentés dans ce papier et à recommander, qu'aux niveaux appropriés, des analyses coûts/bénéfices soient effectuées afin d'avoir une idée claire des avantages pouvant être attendus par l'aviation civile de l'introduction de la navigation par satellites.

VIII. UN PROGRAMME POUR LA MISE EN OEUVRE DU GNSS EN EUROPE

Résumé

Un programme coordonné pour la mise en oeuvre de la navigation par satellites en Europe a été développé par la Commission Européenne, l'Agence Spatiale Européenne et l'Organisation Européenne pour la Sécurité de la Navigation Aérienne (EUROCONTROL). Les trois organisations ont formé une équipe tripartite chargée de gérer ce programme, dont le premier objectif est la réalisation de l'augmentation régionale de la capacité du GPS et du GLONASS jusqu'en 2002 par une couverture géostationnaire (GNSS1). L'équipe financera aussi une extension de la recherche et du développement en vue du développement du système civil appelé à succéder au système actuel qui devrait, indépendamment, satisfaire les besoins de tous les usagers que ce soit sur la terre ferme, en mer ou dans les airs (GNSS2). Le GNSS1 européen est considéré comme une composante régionale d'un système global utilisant le GPS et le GLONASS existants pour apporter le plus rapidement possible des avantages aux usagers.

4. Conclusion

Un programme commun pour la mise en oeuvre de la navigation par satellites en Europe a été développé. Trois organisations régionales la Commission Européenne, l'ESA et EUROCONTROL mettent en commun avec détermination leurs ressources respectives pour apporter, le plus rapidement possible, des bénéfices aux usagers. Il est espéré que ce programme complètera ceux d'autres régions dans le développement d'un GNSS initial basé sur des développements régionaux du GPS et du GLONASS.

IX. SCENARIOS D'ARCHITECTURE DU GNSS

Scénarios de mise en oeuvre de la navigation par satellites en Europe

Abrégé

Le présent document donne un aperçu des scénarios préliminaires retenus pour l'introduction de la navigation par satellites en Europe. Conçus par la cellule spécialisée "Recherche et développement du Système" (SRD), qui relève du Sous-Groupe EUROCONTROL "Applications de la navigation par satellites", ces scénarios sont le point de départ d'un inventaire des solutions possibles en matière d'architectures de systèmes et d'améliorations pour la navigation par satellites. Le document

présente une vue d'ensemble de la manière dont ces scénarios ont été élaborés, des hypothèses retenues et expose quelques détails de certains scénarios.

Résumé

On estime que les scénarios présentés dans ce document couvrent une vaste gamme de solutions techniques à étudier dans le cadre du GNSS 1. Ils contribueront à l'élaboration du programme de travail SRD dont le but est de permettre à la cellule spécialisée SRD d'établir un classement des scénarios selon un point de vue technique et, en conséquence, de faire les recommandations appropriées au Sous-Groupe « Applications de la Navigation par Satellites » sur les possibilités d'application de chacun des scénarios.

Recommandation

Le Groupe d'Experts du GNSS de l'OACI est invité à prendre note du présent document et à exploiter au mieux les informations qui y sont contenues sur le recensement des solutions possibles en matière de scénarios d'architecture du futur système d'introduction de la navigation par satellites en Europe. Il est également invité à envisager l'adoption de ces scénarios à l'échelle mondiale.

ANNEXE :

Ordre du jour de la Première Réunion du Groupe d'Experts du Système Mondial de Navigation par Satellites de l'OACI

L'ordre du jour ci-après a été approuvé par la Commission de la Navigation Aérienne le 10 février 1994.

- Point 1 : Examen du programme de travail; mise au point de méthodes de travail pour le Groupe d'Experts; examen des actions des autres organes.
- Point 2 : Détermination des critères de performances venant à l'appui d'exigences opérationnelles pour l'application du GNSS sur la base des systèmes existants de navigation par satellites.
- Point 3 : Développement d'exigences techniques et de performances pour l'augmentation des capacités des sous-systèmes du GNSS, y compris celui du contrôle de l'intégrité.
- Point 4 : Identification, à la demande, d'éléments du GNSS, des conditions ou fonctions pouvant avoir des implications institutionnelles.
- Point 5 : Développement d'exigences techniques et de performances pour le système GNSS à plus long terme utilisé dans le domaine de l'aviation civile.
- Point 6 : Travaux futurs.