UNISPACE III
ACTION TEAM
ON GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS)

DRAFT REPORT TO COPUOS
(Revised on 10 December 2003)

I. INTRODUCTION

A. Background of Action Team

1. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held ***from 19 to 30*** July 1999***, at Vienna, Austria,*** adopted a strategy to address global challenges in the future through space activities. The strategy as contained in ***the*** "Space Millennium: Vienna Declaration on Space and Human Development"[1] included a few key actions to use space applications for human security, development and welfare. One of such actions was "to improve the efficiency and security of transport, search and rescue, geodesy and other activities by promoting the enhancement of, universal access to and compatibility of space-based navigation and positioning systems."

2. In 2001, Member States ~~***of the Committee on the Peaceful Uses of Outer Space (COPUOS)***~~ accorded high priority to a limited number of selected recommendations of UNISPACE III. The Committee on the Peaceful Uses of Outer Space established action teams under the voluntary leadership of member States to implement those priority recommendations. The Action Team on Global Navigation Satellite Systems (GNSS) was ***then*** established under the leadership of the United States of America and Italy to carry out the recommendations relating to global navigation satellite systems.

B. Terms of Reference

3. The Action Team reported to the Committee and its Scientific and Technical Subcommittee at their ***forty-fourth and thirty-eight*** sessions in 2001 ***respectively,*** concerning its objectives, work plan and final product. The terms of reference of the Action Team included ***its*** ~~the~~ purpose, a list of related activities, work plan, product and schedule of meetings as indicated below.

Purpose

i) To survey current international and regional efforts to achieve a seamless multi-modal satellite-based navigation and positioning system throughout the world;
ii) To assess institutional models of international co-operation and co-ordination systems and services and GNSS users interests;
iii) To propose specific recommendations for [the Secretariat and Member States of] the United Nations and other international organisations on actions that should be taken;
iv) To promote GNSS user interests, increase the level of awareness, improve the quality and ~~to~~ facilitate utilisation of GNSS services, particularly in developing countries; ***and***
v) To propose specific recommendations on global co-ordination and co-operation.

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[1] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publications, Sales No. E.00.I.3), chap. I, resolution 1.

Related activities

i) National and international meetings and conferences concerning GNSS applications;

ii) Series of United Nations/United States of America Regional Workshops and the International Meeting of Experts on the Use and Applications of GNSS, organised within the framework of the United Nations Programme on Space Applications in 2001 and 2002;

iii) United Nations Office for Outer Space Affairs/American Institute of Aeronautics and Astronautics International Workshop on Space Cooperation, Working Group on GNSS (Seville, March 2001);

iv) Regular meetings of the Civil GPS Service Interface Committee and its International Subcommittee (CGSIC/ISC);

v) Relevant meetings of the International Telecommunication Union (ITU), including World Radiocommunication Conference 2003 (WRC-2003);

vi) Relevant meetings of the European Union ***(EU)*** and the European Space Agency (ESA);

vii) [Relevant meetings of] the International Maritime Organization (IMO); ***and***

viii) [Relevant meetings of] the International Civil Aviation Organization (ICAO).

Work Plan

i) ***To*** compile information on national and international outreach activities designed to promote the use of GNSS for sustainable development, economic growth and scientific research;

ii) ***To*** compile information on the level of awareness and capacity of developing countries to use GNSS services and applications;

iii) ***To*** conduct an inventory of and identify gaps in meeting the requirements of developing countries for GNSS services and applications;

iv) ***To*** consider ways in which organs of the United Nations system, non-governmental entities and international organisations and Member States of the United Nations could play a role in filling those gaps;

v) ***To*** request other entities of the United Nations, through the Office for Outer Space Affairs, to report on their use of GNSS to meet their respective mandates; ***and***

vi) ***To*** evaluate the results of the series of ***the*** United Nations Regional Workshops on GNSS organised within the framework of the United Nations Program***me*** on Space Applications, with a view to identifying common themes.

Product

4. A ***final*** report, with information on relevant national and international activities on promoting use, access to and quality of GNSS services, ***is to be prepared***. The report would include proposals for specific recommendations for the Committee and other relevant United Nations bodies, non-governmental entities, as well as United Nations Member States and international organisations concerning development, co-ordination and increased use of GNSS, particularly to the benefit of developing countries. The report would be submitted through the Scientific and Technical Subcommittee to the Committee.

Schedule of meetings

5. Meetings of the Action Team have been scheduled on the margins of the meetings of the Committee and its Scientific and Technical Subcommittee ~~and~~ ***as well as*** the activities organised by the Office for Outer Space Affairs.

6. The Action Team has held six meetings as indicated below:

- First meeting (30 November 2001, ***Vienna***), in conjunction with the Second UN/USA Regional Workshop on the Use and Applications of GNSS (Vienna, 26-30 November 2001);
- Second meeting (25 January 2002, ***Rome***), in conjunction with the twenty-second session of the Inter-Agency Meeting on Outer Space Activities (Rome, 23-25 January 2002);
- Third meeting (27 February 2002, ***Vienna***), on the margins of the thirty-ninth session of the Scientific and Technical Subcommittee (25 February – 8 March 2002, ***Vienna***);
- Fourth meeting (4 June 2002, ***Vienna***), in conjunction with the ~~fifty-sixth~~ ***forty-fifth*** session of the Committee on the Peaceful Uses of Outer Space (5-14 June 2002);
- Fifth meeting (15 November 2002, ***Vienna***), in conjunction with the UN/USA International Meeting of Experts on the Use and Applications of GNSS (11-15 November 2002, ***Vienna***);
- Sixth meeting (Vienna, 18 February 2003), on the margins of the fortieth session of the Scientific and Technical Subcommittee (17-28 February 2003, ***Vienna***).

(additional meetings to be inserted)

C. Membership of Action Team

7. The membership of ***the*** Action Team is open to any interested ***M***ember States of the United Nations as well as entities of the United Nations ***system***, other intergovernmental organisations and non-governmental entities. As of April 2003, the membership consists of the following ***M***ember States and organisations:

8. Member States:
Australia, Austria, Belarus, Brazil, Bulgaria, Canada, Chile, China, Colombia, Czech Republic, France, Germany, Hungary, India, Iran (Islamic Republic of), Iraq, Italy, Japan, Lebanon, Malaysia, Mongolia, Morocco, Pakistan, Philippines, Poland, Portugal, Republic of Korea, Russian Federation, Saudi Arabia, Syrian Arab Republic, Turkey ***and*** the United States of America.

9. Organizations:
United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), International Telecommunication Union (ITU), Bureau International des Poids et Mesures (BIPM), European Commission (EC), European Space Agency (ESA), European Organisation for the Safety of Air Navigation (Eurocontrol), American Institute of Aeronautics and Astronautics (AIAA), Civil GPS Service Interface Committee (CGSIC), European Association for International Space Year (EURISY), International Federation of Surveyors (FIG), International Association of Institutes of Navigation (IAIN), International GPS Service (IGS).

II. OVERVIEW OF PLANNED AND EXISTING GNSS AND AUGMENTATIONS

A. Existing and Planned GNSS

1. GPS

Presidential Decision Directive Policy Goals

10. In the management and use of GPS, ***(we) the U.S***. seek***s*** to support and enhance ***(our) its*** economic competitiveness and productivity while protecting U.S. national security and foreign policy interests. ***(Our) The U.S.*** goals are to:

- Strengthen and maintain ***(our) U.S.*** national security;
- Encourage acceptance and integration of GPS into peaceful civil, commercial and scientific applications worldwide;
- Encourage private sector investment in and use of U.S. GPS technologies and services;
- ~~We will~~ ***C***o-operate with other governments and international organisations to ensure an appropriate balance between the requirements of international civil, commercial and scientific users and international security interests;
- ~~We will~~ ***A***dvocate the acceptance of GPS and U.S. Government augmentations as standards for international use;
- ~~we will~~ ***P***urchase, ***to the fullest and feasible extent***, commercially available GPS products and services that meet U.S. Government requirements. ~~and~~ ~~will not~~ ***No*** activities that preclude or deter commercial GPS activities, except for national security or public safety reasons, ***will be conducted; and***
- A permanent interagency GPS Executive Board, jointly chaired by the Departments of Defense and Transportation, will manage the GPS and U.S. Government augmentations.

11. Other departments and agencies will participate as appropriate. The GPS Executive Board will consult with U.S. Government agencies, U.S. industries and foreign governments involved in navigation and positioning system research, development, operation and use. This policy will be implemented within the overall resource and policy guidance provided by the President.

Agency Roles and Responsibilities

12. The Department of Defense will:

- Continue to acquire, operate, and maintain the basic GPS;
- Maintain a Standard Positioning Service (as defined in the Federal Radio ***N***avigation Plan and the GPS Standard Positioning Service Signal Specification) that will be available on a continuous ***and*** worldwide basis;
- Maintain a Precise Positioning Service for use by the U.S. military and other authorised users;
- Co-operate with the Director of Central Intelligence, the Department of State and other appropriate departments and agencies to assess the national security implications of the use of GPS, its augmentations, and alternative satellite-based positioning and navigation systems; ***and***
- Develop measures to prevent the hostile use of GPS and its augmentations to ensure that the United States retains a military advantage without unduly disrupting or degrading civilian uses.

13. The Department of Transportation will:

- Serve as the lead agency within the U.S. Government for all Federal civil GPS matters;
- Develop and implement U.S. Government augmentations to the basic GPS for transportation applications;
- ***T***ake the lead in promoting commercial applications of GPS technologies and the acceptance of GPS and U.S. Government augmentations as standards in domestic and international transportation systems, ***in co-operation with the Departments of Commerce, Defense and State; and***
- ***C***o-ordinate U.S. Government-provided GPS civil augmentation systems to minimise cost and duplication of effort, ***in co-operation with other departments and agencies***.

14. The Department of State will:

- ***C***onsult with foreign governments and other international organisations to assess the feasibility of developing bilateral or multilateral guidelines on the provision and use of GPS services, ***in co-operation with appropriate departments and agencies***;
- Co-ordinate the interagency review of instructions to U.S. delegations to bilateral consultations and multilateral conferences related to the planning, operation, management, and use of GPS and related augmentation systems; ***and***
- Co-ordinate the interagency review of international agreements with foreign governments and international organisations concerning international use of GPS and related augmentation systems.

Reporting Requirements

15. Beginning in 2000, the President ~~will~~ ***is/was to*** make an annual determination on continued use of GPS Selective Availability. To support this determination, the Secretary of Defense, in co-operation with the Secretary of Transportation, the Director of Central Intelligence, and heads of other appropriate departments and agencies, shall provide an assessment and recommendation on continued SA use. This recommendation shall be provided to the President through the Assistant to the President for National Security Affairs and the Assistant to the President for Science and Technology.

16. The President has approved a comprehensive national policy on the future management and use of the U.S. Global Positioning System (GPS) and related U.S. Government augmentations. ~~Background~~ The Global Positioning System (GPS) was designed as a dual-use system with the primary purpose of enhancing the effectiveness of U.S. and allied military forces to provide position, navigation, and timing services to both civil and military users.

17. In 1983, the United States made a policy decision to provide GPS civil service on an open basis, free of direct user charges. This policy decision was further documented in a 1996 Presidential Decision Directive that also set up the Interagency GPS Executive Board to manage the system. GPS provides a substantial military advantage and is now being integrated into virtually every facet of (our) ***U.S.*** military operations. GPS is also rapidly becoming an integral component of the emerging Global Information Infrastructure, with applications ranging from mapping and surveying to international air traffic management and global change research.

18. The growing demand from military, civil, commercial and scientific users has generated a U.S. commercial GPS equipment and service industry that lead~~s~~ in several countries around the world. Augmentations to enhance basic GPS services could further expand these civil and commercial markets. In May 2000, in accordance with the policy stated in the Presidential Decision Directive, Selective Availability, the intentional degradation of GPS civil services was set to zero. Since that time, GPS users frequently see accuracy readings in the range of ten meters or better.

19. The "basic GPS" is defined as:

- The constellation of satellites, the navigation payloads that produce the GPS signals, ground stations, data links and associated command and control facilities which are operated and maintained by the Department of Defense;
- The "Standard Positioning Service" (SPS) is the civil and commercial service provided by the basic GPS; ***and***
- The "Augmentations" as those systems based on the GPS that provide integrity and real-time accuracy greater than the SPS.

20. This policy presents a strategic vision for the future management and use of GPS, addressing a broad range of military, civil, commercial and scientific interests, both national and international.

21. ***Some web sites related to the subject are indicated below:***

- Global Climate Observing System (GCOS): http://www.wmo.ch/web/gcos/gcoshome.html
- Global Positioning System (JPL): http://samadhi.jpl.nasa.gov/msl/Programs/gps.html
- Global Positioning System Product Team (FAA): http://gps.faa.gov/
- Interagency GPS Executive Board: http://www.wmo.ch/web/gcos/gcoshome.html
- International Institute for Applied Systems Analysis (IIASA): http://www.iiasa.ac.at/
- NASA GPS Application Exchange: http://gpshome.ssc.nasa.gov/
- Navstar Global Positioning System Joint: **http://** ***(?)***
- National Aeronautics and Space Administration (NASA): http://www.nasa.gov/home.html
- National Geodetic Survey: http://www.ngs.noaa.gov/
- Office for Outer Space Affairs, UN Office at Vienna: http://www.oosa.unvienna.org/index.html
- Planet Quest: http://planetquest.jpl.nasa.gov/
- U.S. Coast Guard Navigation Center: http://www.navcen.uscg.gov/
- U.S. Mission to the European Union: GPS and the EU's ***GALILEO*** System: http:// ***(?)***
- U.S. Space Objects Registry: http://www.usspaceobjectsregistry.state.gov/

Global Positioning System Description

22. GPS is a Satellite Navigation System. There are many ~~thousands~~ ***millions*** of civil users of GPS worldwide; GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time. Four GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock. ***With a Receiver Autonomous Integrity Monitoring (RAIM) capable receiver and six in view GPS satellites allow the users to achieve ~~Receiver Autonomous Integrity Monitoring~~ RAIM***. The Space Segment of the system consists of the GPS satellites. These space vehicles (SVs) send radio signals from space. The nominal GPS Operational Constellation consists of 24 satellites plus on-orbit spares that orbit the ***E***arth in 12 hours. There are often more than 24 operational satellites as new ones are launched to replace older satellites.

23. The satellite orbits repeat almost the same ground track (as the ***E***arth turns beneath them) once each day. The orbit altitude is such that the satellites repeat the same track and configuration over any point approximately each 24 hours (4 minutes earlier each day). There are six orbital planes (with nominally four SVs in each), ~~equally spaced (60 degrees apart)~~, and inclined at about fifty-five degrees with respect to the equatorial plane. This constellation provides the user with between five and eight SVs visible from any point on the ***E***arth.

Control Segment

24. The Control Segment consists of a system of tracking stations located around the world, ***including the*** GPS Master Control and Monitor Network. The Master Control facility is located at Schriever Air Force Base (formerly Falcon AFB) in Colorado. These monitor stations measure signals from the SVs, which are incorporated into orbital models for each satellite. The models compute precise orbital data (ephemeris) and SV clock corrections for each satellite. The Master Control station uploads ephemeris and clock data to the SVs. The SVs then send subsets of the orbital ephemeris data to GPS receivers over radio signals.

25. The GPS User Segment consists of the GPS receivers and the user community. GPS receivers convert SV signals into position, velocity, and time estimates. Four satellites are required to compute the four dimensions of X, Y, Z (position) and Time.

26. GPS receivers are used for navigation, positioning, time dissemination, ***remote clock comparison*** and ***for*** other research ***purposes***. Navigation in three dimensions is the primary function of GPS. Navigation receivers are made for aircraft, ships, ground vehicles and for hand carrying by individuals. ~~Precise~~ ***Enhanced*** positioning is possible using GPS receivers at reference locations providing corrections and relative positioning data for remote receivers. Surveying, geodetic control, and plate tectonic studies are ***some*** examples.

27. Time and frequency dissemination, based on the precise clocks on board the SVs and controlled by the monitor stations, ~~is~~ ***constitutes*** another use for GPS. Astronomical observatories, telecommunications facilities, and laboratory standards can be set to precise time signals or controlled to accurate frequencies by special purpose GPS receivers. Research projects have used GPS signals to measure atmospheric parameters. ***The elaboration of the international reference time scales relies mostly on clock comparison using the atomic clocks on board GPS satellites.***

Precise Positioning Service (PPS)

28. Authorised users with cryptographic equipment and keys and specially equipped receivers use the Precise Positioning System. U. S. and Allied military, certain U. S. Government agencies and selected civil users specifically approved by the U. S. Government can use the PPS.

29. PPS Predictable Accuracy:

- 22 meter ***h***orizontal accuracy
- 27.7-meter vertical accuracy
- 200-nanosecond time ***Coordinated Universal Time*** (UTC) accuracy

Standard Positioning Service (SPS)

30. Civil users worldwide use the SPS without charge or restrictions. Most receivers are capable of receiving and using the SPS signal. ***~~[The DOD intentionally degrades the SPS accuracy by the use of Selective Availability.]~~***

The GPS Standard Positioning Service

31. The GPS SPS is a positioning and timing service provided on the GPS L1 signal. The L1 signal, transmitted by all GPS satellites, contains a Coarse/Acquisition (C/A) code and a navigation data message. The GPS L1 signal also contains a Precision P (Y) code that is reserved for military use and is not a part of the SPS.

32. The L-band SPS ranging signal is a 2.046 MHz null-to-null bandwidth signal centred about L1. The transmitted ranging signal that comprises the GPS-SPS is not limited to the null-to-null signal and extends through the band 1563.42 to 1587.42 MHz. GPS satellites also transmit a second ranging signal known as L2. The L2 signal is not part of the SPS. Therefore, SPS performance standards are not predicated upon use of L2, or use of L1/L2 carrier tracking for other than code acquisition and tracking purposes.

33. Until such time as a second coded civil GPS signal is operational, the U.S. Government has agreed to not intentionally reduce the current received minimum Radio Frequency signal strength of the P (Y)-coded signal on the L2 link, as specified in ICD-GPS-200C or to intentionally alter the P (Y)-coded signal on the L2 link. This does not preclude addition of codes or modifications to the L2 signal which do not change, or make unusable, the L2 P (Y)-coded signal as currently specified.

Global Positioning System Overview

34. ~~Sufficient~~ ***Detailed*** information is provided below to promote a common understanding of the nominal GPS baseline configuration.

35. The GPS baseline system is comprised of three segments, whose purpose is to provide a reliable and continuous positioning and timing service to the GPS user community. These three segments are known as the Space Segment, Control Segment and User Segment.

36. The User Segment is comprised of receivers from a wide variety of U.S. and international agencies, in addition to the growing private user base. The GPS space segment consists nominally of a constellation of 24 operational Block II satellites (Block II, IIA, and IIR).

37. Each satellite broadcasts a navigation message based upon data periodically uploaded from the Control Segment and adds the message to a 1.023 MHz Pseudo Random Noise (PRN) Coarse/Acquisition (C/A) code sequence. The satellite modulates the resulting code sequence onto a 1575.42 MHz L-band carrier to create a spread spectrum ranging signal, which it then broadcasts to the user community. This broadcast is referred to in this Performance Standard as the SPS ranging signal.

38. Each C/A code is unique and provides the mechanism to identify each satellite in the constellation. A block diagram illustrating the Block IIA satellite's SPS ranging signal generation process is ***[provided in Figure 1-1***]. The GPS satellite also transmits a second ranging signal known as L2, that supports PPS user two-frequency corrections. L2, like L1, is a spread spectrum signal and is transmitted at 1227.6 MHz.

39. The Block II satellites are designed to provide reliable service over a 7.5 - to 10-year design life, depending on the production version, through a combination of space qualified parts, multiple redundancies for critical subsystems, and internal diagnostic logic. The Block II

satellite requires minimal interaction with the ground and allows all but a few maintenance activities to be conducted without interruption to the ranging signal broadcast. Periodic uploads of data to support navigation message generation are designed to cause no disruption to the SPS ranging signal, although Block II/IIA satellites may experience a 6 to 24 second disruption upon transition to the new upload.

40. The GPS Control Segment (CS) is comprised of four major components: a Master Control Station (MCS), Backup Master Control Station (BMCS), four ground antennas, and six monitor stations. The MCS ~~is located~~ at Schriever Air Force Base, Colorado, ~~and~~ is the central control node for the GPS satellite constellation. Operations are maintained 24 hours a day, seven days a week throughout each year.

41. The CS's four ground antennas provide a near real-time Telemetry, Tracking, and Commanding (TT&C) interface between the GPS satellites and the MCS. The six monitor stations provide near real-time satellite ranging measurement data to the MCS and support near-continuous monitoring of constellation performance. The current CS monitor stations provide approximately 93% global coverage, with all monitor stations operational, with a 5° elevation mask angle. The actual elevation angle that a monitor station acquires any given satellite varies due to several external factors.

42. SPS performance standards are based on signal-in-space performance. Contributions of ionosphere, troposphere, receiver, multipath, or interference are not included.

Predictable Accuracy

43. [The U.S. Government commits to maintaining the Position Dilution of Precision (PDOP) in accordance with the following tolerances. Position Dilution of Precision Availability Standard: PDOP Availability Standard = 98% global Position Dilution of Precision (PDOP) of 6 or less = 88% worst site PDOP of 6 or less. In support of the service availability standard, 24 operational satellites must be available on orbit with 0.95 probability (averaged over any day)].

44. [At least 21 satellites in the 24 nominal plane/slot positions must be set healthy and transmitting a navigation signal with 0.98 probability (yearly averaged). The U.S. Government's commitments for maintaining PDOP and constellation SPS SIS URE result in support for a service availability standard as presented in Table 3-3.] ***The SPS Performance combines a constellation availability of 24 operational satellites at 95% probability.***

Service Availability

45. [***The percentage of time over a specified time interval that the predicted position accuracy is less than a specified value for any point within the service volume.]***

Service Availability Standard

46. The U.S. Government commits to maintaining the Position Dilution of Precision (PDOP) in accordance with the following tolerances.

Position Dilution of Precision Availability Standard

47. PDOP Availability Standard
>98% global Position Dilution of Precision (PDOP) of 6 or less;
> 88% worst site PDOP of 6 or less.

Conditions and Constraints

48. Defined for position solution meeting the representative user conditions and operating within the service volume over any 24-hour interval. Based on using only satellites transmitting standard code and indicating "healthy" in the broadcast navigation message (sub-frame 1).

49. ***In support of the service availability standard, 24 operational satellites must be available on orbit with 0.95 probability (averaged over any day). At least 21 satellites in the 24 nominal plane/slot positions must be set healthy and transmitting a navigation signal with 0.98 probability (yearly averaged).***

50. ***SPS Service Availability Standard conditions and Constraints:***

>99% Horizontal Service Availability average location
> 99% Vertical Service Availability average location
> 90% Horizontal Service Availability worst-case location
> 90% Vertical Service Availability worst-case location.

51. ***The U.S Government commits to providing SPS service reliability in accordance with the following tolerances:***

Service Reliability Standard Conditions and Constraints:

>= 99.94% global average 30-meter Not-to-Exceed (NTE) SPS SIS URE.
- ***Standard based on a measurement interval of one year; average of daily values within the service volume.***
- ***Standard based on 3 service failures per year, lasting no more than 6 hours***

>99.79% worst-case single point average,
30-meters not to exceed (NTE) SPS SIS URE.
- ***Standard based on a measurement interval of one year; average of daily values from the worst-case point within the service volume.***
- ***Standard based on 3 service failures per year lasting no more than 6 hours each.***

Standard Global Average Positioning Domain Accuracy:
>13 meters 95% All-in-View Horizontal Error (SIS Only)
> 22 meters 95% All-in-View Vertical Error!

(SIS Only) Worst Site Positioning Domain:
- ***Defined for position solution meeting the representative user conditions***
- ***Standard based on a measurement interval of 24 hours for any point within the service volume Defined for time transfer solution meeting the Accuracy = 36 meters 95% All-in-View Horizontal Error (SIS Only)***

>77 meters 95% All-in-View Vertical Error (SIS Only) Time Transfer Accuracy
>40 nanoseconds time transfer error 95% of time (SIS) Only) representative user conditions Standard based on a measurement interval of 24 hours averaged over all points within the service volume.

3.2 Service Availability Standard

52. The U.S. Government commits to maintaining the Position Dilution of Precision (PDOP) in accordance with the following tolerances.

Table 3-2.

= 98% global Position Dilution of Precision (PDOP) of 6 or less.

= 88% worst site PDOP of 6 or less.

- *Defined for position solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.*
- *Based on using only satellites transmitting standard code and indicating "healthy" in the broadcast navigation message (sub-frame 1).*
- *In support of the service availability standard, 24 operational satellites must be available on orbit with 0.95 probability (averaged over any day). At least 21 satellites in the 24 nominal plane/slot positions must be set healthy and transmitting a navigation signal with 0.98 probability (yearly averaged).*
- *Constellation availability: Representative Performance of 25-28 healthy satellites.*

53. The U.S. Government's commitments for maintaining PDOP (Table 3-2) and constellation SPS SIS URE (see Section 3.3) result in support for a service availability standard as presented in Table 3-3.

Table 3-3. SPS Service Availability Standard

Service Availability Standard Conditions and Constraints

= 99% Horizontal Service Availability average location
= 99% Vertical Service Availability average location

- *36 meter horizontal (SIS only) 95% threshold.*
- *77 meter vertical (SIS only) 95% threshold.*
- *Defined for position solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.*
- *Based on using only satellites transmitting standard code and indicating "healthy" in the broadcast navigation message (subframe 1).*

= 90% Horizontal Service Availability worst-case location
= 90% Vertical Service Availability worst-case location

- *36 meter horizontal (SIS only) 95% threshold.*
- *77 meter vertical (SIS only) 95% threshold.*
- *Defined for position solution meeting the representative user conditions and operating within the service volume over any 24-hour interval.*
- *Based on using only satellites transmitting standard code and indicating "healthy" in the broadcast navigation message (subframe 1);*
- *Constellation RMS User Range Error = SPS Performance Standard (October 2001) = 6 meters with Representative Performance = 1.6 meters;*
- *Service Reliability = SPS Performance Standard (October 2001) = 99.94% global, 99.79% worst site, with Representative Performance = 100% global and 100% worst site.*

GPS Status and Problem Reporting Standard

54. The U.S. Government provides notification of changes in constellation operational status that affect the service being provided to GPS users, or ~~if~~ ***in the case that*** the U.S. Government anticipates a problem in supporting performance standards established in this document. The current mechanism for accomplishing this notification is through the Notice Advisory to Navigation Users (NANU).

55. NANUs are a primary input in the generation of GPS-related Notice to Airmen (NOTAM) and U.S. Coast Guard Local Notice to Mariners (LNM). Most outages affect both PPS and SPS users. However, since the GPS Control Segment currently monitors PPS, not SPS, in near real-time, notification of SPS unique service disruptions may be delayed. Since NANUs are currently

tailored to PPS outages, notification of SPS unique outages may require the use of the general "free text" NANU tailored template.

56. In the case of a scheduled event affecting service provided to GPS users, the U.S. Government ~~will~~ ***would*** issue an appropriate NANU at least 48 hours prior to the event. In the case of an unscheduled outage or problem, notification ~~will~~ ***would*** be provided as soon as possible after the event.

GPS Predictable Accuracy

- ~~100 meter horizontal accuracy~~
- ~~156 meter vertical accuracy~~
- ~~340 nanoseconds time accuracy~~

57. ***The specific capabilities provided by SPS are established by DoD and DOT and are published in the Global Positioning System Standard Positioning Service Performance Standard (formerly known as the SPS Signal Specification), (Ref. 7) available through the USCG Navigation Information Service.*** ~~***These*** GPS accuracy figures are from the 1999 ***Federal Radio Navigation Plan***.~~ The figures are 95% ~~accuracies~~ ***accurate***, and express the value of two standard deviations of radial error from the actual antenna position to an ensemble of position estimates made under specified satellite elevation angle (five degrees) and PDOP (less than six) conditions. For horizontal accuracy figures, 95% is the equivalent of 2drms (two-distance root-mean-squared), or twice the radial error standard deviation. For vertical and time errors, 95% is the value of two-standard deviations of vertical error or time error.

58. Receiver manufacturers may use other accuracy measures. Root-mean-square (RMS) error is the value of one standard deviation (68%) of the error in one, two or three dimensions.

59. Circular Error Probable (CEP) is the value of the radius of a circle, centred at the actual position that contains 50% of the position estimates. Spherical Error Probable (SEP) is the spherical equivalent of CEP, that is the radius of a sphere, centred at the actual position that contains 50% of the three dimension position estimates. As opposed to 2drms, drms, or RMS figures, CEP and SEP are not affected by large blunder errors making them an overly optimistic accuracy measure.

60. Some receiver specification sheets list horizontal accuracy in RMS or CEP and without Selective Availability, making those receivers appear more accurate than those specified by more responsible vendors using more conservative error measures.

GPS Satellite Signals

61. The SVs transmit two microwave carrier signals. The L1 frequency (1575.42 MHz) carries the navigation message and the SPS code signals. The L2 frequency (1227.60 MHz) is used to measure the ionospheric delay by PPS equipped receivers. Three binary codes shift the L1 and/or L2 carrier phase. The C/A Code (Coarse Acquisition) modulates the L1 carrier phase. The C/A code is a repeating 1 MHz Pseudo Random Noise (PRN) Code. This noise-like code modulates the L1 carrier signal, "spreading" the spectrum over a 1 MHz bandwidth.

62. The C/A code repeats every 1023 bits (one millisecond). There is a different C/A code PRN for each SV. Their PRN number, the unique identifier for each pseudo-random-noise code, often identifies GPS satellites. The C/A code that modulates the L1 carrier is the basis for the civil SPS. The P-Code (Precise) modulates both the L1 and L2 carrier phases. The P-Code is a very long (seven days) 10 MHz PRN code. In the Anti-Spoofing (AS) mode of operation, the P-Code is encrypted into the Y-Code.

63. The encrypted Y-Code requires a classified AS Module for each receiver channel and is for use only by authorised users with cryptographic keys. The P (Y)-Code is the basis for the PPS. The Navigation Message also modulates the L1-C/A code signal. The Navigation Message is a 50 Hz signal consisting of data bits that describe the GPS satellite orbits, clock corrections, and other system parameters.

64. The GPS Navigation Message consists of time-tagged data bits marking the time of transmission of each sub frame at the time they are transmitted by the SV. A data bit frame consists of 1500 bits divided into five 300-bit sub frames. A data frame is transmitted every thirty seconds. Three six-second sub frames contain orbital and clock data. SV Clock corrections are sent in sub frame one and precise SV orbital data sets (ephemeris data parameters) for the transmitting SV are sent in sub frames two and three. Sub frames four and five are used to transmit different pages of system data. An entire set of twenty-five frames (125 sub frames) makes up the complete Navigation Message that is sent over a 12.5 minute period.

2. GLONASS

1. Russian satellite navigation policy

65. ***The*** Global Navigation Satellite System “GLONASS” is to provide unlimited number of air, maritime, and any other type of users with all-weather three-dimensional positioning, velocity measuring and timing anywhere in the world or near-***E***arth space.

66. Designed mainly for military purposes, the Russian GLONASS system has been fully deployed in 1995 with ***a*** constellation of 24 satellites. At the same time, GLONASS is available for civil users with the L1 signal of the Standard Accuracy without any selective availability.

67. Since 1999, the Russian ~~authority~~ ***authorities have*** consistently implement***ed*** actions to present GLONASS service for civil users. Two basic decisions (Presidential Directive, February 18, 1999 ~~№~~ 38~~-рп~~ and following Governmental Decision, March 29, 1999 ~~№~~ 346) defined the GLONASS status as a dual-use system opened for international co-operation. Two State Customers of the GLONASS system ~~has~~ ***have*** been defined: ***the*** Ministry of Defence and ***the*** Russian Aviation and Space Agency (civil institution).

68. As a dual-use system GLONASS ***is*** available for ***the*** civil community worldwide ***and includes the following characteristics***:

- ***F***ree use of the civil signal globally;
- ***C***ivil signal specification available for both users and industry (Interface Control Document); ***and***
- ***N***o selective availability for civil signal since start of operation (has not been foreseen by design).

69. In the next ***g***overnmental ***d***ecision on the GLONASS use (August 3, 1999 ~~№~~ 896) the combined GNSS receivers (GLONASS/GPS) application has been recommended for users.

70. GLONASS, as a system opened for international co-operation, has been presented as a basis to implement international global navigation satellite system***s***. The negotiations with ***the*** E***uropean*** U***nion (EU)*** at the beginning phase could lead to the EU/Russia international GNSS based on GLONASS and GALILEO. At the present situation, at least three global basic systems will combine the core GNSS (GPS, GLONASS, GALILEO). The main objective is ***to*** ensure compatibility and interoperability, providing better performance and reliability of the navigation service for users ~~worldwide~~ ***all over the world***.

71. In continuation of practical implementation of the authority decisions, the Federal GLONASS Mission Oriented Program ~~has been~~ ***was*** approved by the Government in August 2001 (Governmental Decision ~~№~~ 587, 20 ***August 200***1). The Program guarantees the GLONASS ***S***tate funding for 10 years, from 2002 to 2011. The budget for the Program has been allocated to be annually adjusted.

72. There are six State Customers of the Program: ***the*** Russian Aviation and Space Agency (Rosaviakosmos), ***the*** Ministry of Defence (MOD), ***the*** Russian Agency of the Control Systems (RACS), ***the*** Ministry of Transport (MOT), ***the*** Ministry of Industry, Science and Technologies (MIST) ***and the*** Russian Mapping and Geodesy Agency (RMGA). Rosaviakosmos has been assigned for general co-ordination of the Program implementation. Each Agency ***or*** Ministry is responsible for their sub-program with specially defined goals.

73. The Program covers the following directions ***and*** subprograms:

- The GLONASS system maintenance, modernisation, deployment, operation and related research & development activities (Rosaviakosmos and MOD responsibility);
- Navigation receiver and user equipment development for civil use, industry preparation for mass production of the GNSS equipment (RACS responsibility);
- GNSS equipment and technology implementation for transport (aviation, maritime, rail-road, land transport, cars and trucks) - (MOT responsibility);
- GNSS technology application***s*** for geodetic provision of the Russian territory. Modernisation of the geodetic system (RMGA responsibility); ***and***
- GNSS receiver and user equipment development for special use (military and special forces) - (MOD responsibility).

74. The main features of the Federal GLONASS Mission Oriented Program are:

1. ***T***his is ~~a~~ ***the*** first case in the Russian (and Soviet) history when a single space mission, to be further developed, modernised and sustained, is in the framework of ***a*** specially dedicated federal program;

2. ***T***he program covers all segments: space, ground control and user ensuring comprehensive and coordinated development;

3. GLONASS system financing is clear***ly*** presented in the State ***b***udget Law with ***g***overnmental obligations for 10 years. Co-ordinator of all activities in the framework of the GLONASS Program now is ***the*** civil institution Rosavia***k***osmos. The State ***b***udget money dedicated for GLONASS flows through Rosavia***k***osmos and Ministry of Defence in about equal shares.

75. The GLONASS Coordination Board ~~has been~~ ***was*** established in 2002 including all Program State Customers with ***a*** Rosaviakosmos representative as a chair. To implement the permanent work for Program co-ordination and to co-ordinate activities to implement the strategy defined by the Co-ordination Board, the Executive Committee has been established including representatives of the Customers, leading research institutes and industry.

76. Since this event happened, the GLONASS system has become ~~really~~ a ***real*** dual use system, not ***restricted to*** military ***activities only. The s***trategy ~~of~~ ***for development of*** GLONASS is generated by the Board of mainly civil institutions. The Ministry of Defence has been assigned for ***the*** operation and maintenance ***of GLONASS***.

2. GLONASS Overview

New paragraph: [Some web sites related to the subject are indicated below]

- **General GLONASS information (Ministry of Defense, Russian Federation Coordination Scientific Information Center):**
  www.glonass-center.ru **(Russian and English)**
- **GNSS Performance and Application (Russian Aviation and Space Agency, Central Research Institute, Mission Control Center, Information Analytical Center):**
  www.mcc.rsa.ru/main_iac.htm ***(Russian and English)***
- ***GNSS Application and User Equipment (Russian Aviation and Space Agency, Russian* Research Institute of Space Device Engineering, Multifunctional Navigation Information Center):**
  www.mnic.rniikp.ru ***(is under development)***
- ***GLONASS Satellite Data (Russian Aviation and Space Agency, Scientific Industry Cooperation of Applied Mechanics):***
  www.npopm.ru ***(Russian)***

77. ***The u***ser equipment performs passive measurements of pseudoranges and pseudorange rate of four (three) GLONASS satellites. ~~as well as~~ ***It also*** receives and processes navigation messages contained within navigation signals of the satellites. The navigation message describes position of the satellites both in space and ~~in~~ time. Combined processing of the measurements and the navigation messages of the four (three) GLONASS satellites allows user to determine three (two) position coordinates, three (two) velocity vector constituents, and to refer user time scale to the National Reference of Coordinated Universal Time UTC (SU). The navigation message includes the data that allows ***for*** planning observations, ~~and~~ selecting and tracking the necessary constellation of satellites.

78. The GLONASS system consists of space and ground control segments and user segment as well. The space segment includes the constellation of 24 satellites in three orbital planes by 8 satellites in each evenly distributed along the orbit and launch. The orbit parameters:

- Height 19100 km
- Inclination 64.8°
- Orbit type circular with revolution of 11h 15m.

79. Three planes are shifted at equator plane by 120°. An interval of repetition for satellite tracks and visibility zones as observed on the ground is equal to 17 orbital periods (7 days, 23 hours 27 minutes 28 seconds).

80. Such orbit parameters ensure the high stability of the constellation, making unnecessary the orbit correction of the GLONASS satellite during ***its*** life-time. GLONASS satellites have been designed for 3 and half years lifetime. Actual mean ***of the*** lifetime for GLONASS is about 4.5 years.

81. The ground control segment includes:

- ***T***he GLONASS system control centre located in Krasnoznamensk Space Center of the Space Forces (Moscow region);
- ***F***our TT&C stations distributed along longitude at the Russian territory (St. Petersbourg, Moscow region, Enisseysk in Siberia, Komsomolsk in Far East);
- ***C***entral system clock based on assemble of precise frequency standards; ***and***
- ***S***ignal monitoring system based on direct comparison of two-way and one way signals.

82. ***T***his architecture design ensure***s*** separate calculation of satellite orbits (ephemeris) based on two-way tracking data by TT&C stations, and clock correction determination by the direct comparison of central clock and satellite clock time scales. This procedure has been

designed to simplify the orbit determination and time correction procedure. ~~But now~~ ***However,*** it ***has*** ~~is~~ not ~~ensuring~~ ***ensured*** the progressing requirements of users. In the modernisation plan of ground segment, the technology based on simultaneous determination of orbits and clock correction using the one way data of spread monitoring network is foreseen.

83. The user segment includes:

- User receivers for different kinds of applications;
- Local and regional differential subsystems;
- Lot of managing and control systems based on combination of navigation, communication and mapping functions.

84. Each GLONASS satellite transmits navigation signals in two sub-bands of L-band (L1 ~ 1.6 GHz and L2 ~ 1.2 GHz).

85. GLONASS uses Frequency Division Multiple Access (FDMA) technique in both L1 and L2 sub-bands. This means that each satellite transmits navigation signal on its own carrier frequency in the L1 and L2 sub-bands. Two GLONASS satellites may transmit navigation signals on the same carrier frequency if they are located in antipodal slots of a single orbital plane.

86. The nominal values of L1 and L2 carrier frequencies are defined by the number of satellite frequency slot from -7 to 13 shifted aside the central frequency (in L1 = 1602 MHz, in L2 = 1246 MHz) by 562.5 kHz for L1 and by 437.5 kHz for L2. In total in L1 band, GLONASS occupies the frequency band from 1597.5 MHz to 1614 MHz and in L2 from 1241.5 to 1256.5 MHz.

87. GLONASS satellites ~~like~~ ***such as*** GPS provide two types of navigation signals in the L1 and L2 sub-bands: standard accuracy signal and high accuracy signal.

88. The standard accuracy signal with clock rate 0.511 MHz is designed for ~~using~~ ***use*** by civil users worldwide.

89. The high accuracy code with clock 5.11 MHz is modulated by ***a*** special code, and its unauthorized use (without permission of ***the*** Ministry of Defence) is not recommended.

90. The standard accuracy signal is available for any users equipped with proper receivers and having visible GLONASS satellites above the horizon.

91. An intentional degradation of the standard accuracy signal is not applied. The ***present*** standard accuracy signal is providing the following accuracy performance (95%) ***for the*** user:

- Horizontal 28 m
- Vertical 60 m
- Velocity 15 cm/s
- User time scale wrt UTC (SU) time: 1 micro second

92. ***The*** GLONASS constellation ***of satellites*** fully deployed in 1995 ~~(~~ 25 satellites ~~)~~ further degraded due to economical reasons in ***the*** Russia***n*** ***Federation*** in ***the*** nineties, ***and*** now consists of 9 ***operational*** satellites. According to the Federal Program, ***the*** GLONASS ***satellite*** constellation will be restored consistently having 18 satellite***s*** in space by 2006 (minimal required constellation) and 24 satellite***s*** by 2010 ***at the*** latest.

93. Based on the present and future user requirements, the GLONASS system will be modernised according to the Modernisation Plan.

3. GLONASS Modernisation and Services

94. The trend of realisation of the long term Federal Mission Oriented Program 'Global Navigation System', adopted by the Government of the Russian Federation in August 2001, opened up the encouraging long-range outlook of GLONASS maintenance and development. The modernisation program is aimed to bring benefits:

- For civil users:
  - More robust navigation against interference, compensation for ionospheric delays due to new signals.
  - Higher accuracy, availability, integrity, reliability.

- For military users:
  - Enhanced ability to deny hostile GLONASS use.
  - More robust navigation against interference.
  - Enhanced time of autonomy operation.
  - Higher accuracy, availability, integrity, reliability.
  - Supplementary tasks.

- For customers:
  - Less expenses for constellation maintenance due to enhanced satellite life-time and group launch up to 6 satellites.
  - Less expenses for ground operation due to operation automation.

- For international co-operation:
  - Compatibility and interoperability of GLONASS, GPS and GALILEO.

95. The development of GLONASS assumes the following phases: Sustaining the current system by launch of the present design GLONASS satellites. The standard service is provided to civil users with limited constellation. The gaps in GLONASS only navigation service can happen up to 3-4 hours. *This gap will reduce as the number of GLONASS satellites in the constellation increases.*

96. The next phase of modernisation is based on deployment from 2003 to 2006 of GLONASS-M satellites with extended lifetime to 7 years (totally 11 satellites). The first civil signal at L1 will be moved to the international conventional frequency band (1593 – 1610.5 MHz). The second civil signal will be implemented at L2 frequency band to be also moved as a sequence of L1 shift (1238 – 1253.5 MHz). The upper limit of positioning accuracy with help of two civil signals shall be less ~~of~~ ***than*** 30 m (95%). In that time period the modernisation of ground control segment is planned assuming the deployment of one–way receiving station network for orbit determination and clock correction determination. The integrity monitoring system based on the spread one-way receiving station network shall be implemented as well.

97. From 2006, the new generation satellites GLONASS-K with extended performances will be launched transmitting the third civil signal at L3 frequency band (1190.5 – 1212 MHz). The search and rescue service is ~~assumed~~ ***expected*** to be implemented on board of GLONASS-K. In total, 27 GLO***NA***SS-K satellites ***are*** to be launched from 2005 to 2012. Positioning accuracy will be available of the order of 5-7 m (95%). Modernisation of ground segment assumes the global integrity monitoring system deployment and global differential system implementation to provide for users the integrity information and higher real-time accuracy of positioning.

98. Study of requirements for the next GLONASS generation (code name is GLONASS-KM) has been initiated in 2002.

99. Generally, the full (24 satellites) GLONASS constellation transmitting two civil signals ~~will~~ ***should*** be available from 2010. Three civil signals from the full GLONASS constellation ~~is~~ ***are*** planned to be available after 2012.

4. GLONASS Application

100. Being a part of ***the*** GNSS system, GLONASS in combination with GPS even now can benefit users ***by*** providing more reliable navigation with better availability of ~~the~~ navigation service, ~~essentially~~ ***particularly*** in urban and canyon conditions. The frequency division of the GLONASS navigation channels provides users the robust navigation in the conditions of interference and greater anti-jam capability.

5. International co-operation

101. GLONASS, as a dual-use system under interagency board control, is opened for international co-operation. The negotiations with ***the*** European Union, ***the*** European Space Agency ***(ESA),*** the United States, China and other countries are under way. The objectives of the international cooperation are:

- ~~Developing~~ ***Develop*** GLONASS, GPS and GALILEO in such a way to ~~get~~ ***have*** compatible, complementary and interoperable systems; ***and***
- Benefit users by reliable, accurate and with high availability the navigation service ***b***eneficial use of SatNav service world market.

3. GALILEO

~~**[Please mention GALILEO E5a and E5b downlink frequencies of satellite vehicles in L-band]**~~

1. European satellite navigation policy

102. ***The*** European Union considers that satellite navigation will become the primary means of navigation for civilian users worldwide ***in the future***. Satellite navigation, positioning and timing will become an integral part of the Trans European Network covering transport, energy and telecommunication links. In addition to general users, many safety-critical services in transport and other areas of economy will ***increasingly*** depend ~~more and more~~ on satellite navigation services. ***Hence the decision by the European Union (EU) and the European Space Agency (ESA) to jointly develop Galileo.***

103. Transport needs are a major factor behind the European satellite navigation policy. The European Commission White Paper on transport policy has highlighted the importance of ~~uncoupling~~ ***decoupling*** economic growth from transport needs to meet the goal of sustainable development. This goal can be achieved by shifting the balance to transport modes, which are more environmentally friendly (in particularly rail and maritime), eliminating bottlenecks and by placing users at the heart of transport policy. ***As a result, the*** GALILEO satellite navigation system is foreseen as an instrument to reach these goals.

104. Rational use of space-based and terrestrial navigation aids is one way to enhance transport safety while keeping costs under control. The European Commission promotes a co-ordinated policy at the European level to efficiently use these facilities across all modes of transport. In the context of ICAO and IMO, the Commission believes that satellite navigation is a key element in improving safety while allowing savings through decommissioning of terrestrial infrastructure. These benefits fall to industrialised and developing countries alike due to the global character and technical design of GALILEO.

105. ***The u***sefulness of GNSS is not limited to the transport community. The studies financed by the European Commission ***and ESA*** conclude that it has obvious applications in future UMTS location-based services, dealing with natural disasters and civil protection matters ***and*** ~~will enable~~ ***enabling*** the emergency services (fire-fighters, police, sea and mountain rescue, etc.) to provide more rapid assistance to persons in danger. The same can apply to managing humanitarian aid in regions hit by natural or man-made disasters. Other proposed applications include guidance for the blind, monitoring of persons affected by Alzheimer's disease with memory loss, and orientation aids for the leisure industry such as hiking.

106. This technology can be used as a surveying tool for town planning purposes and major public works, ***as well as*** for geographical information systems to manage agricultural land more efficiently and help protect the environment. The accuracy of measurements will also provide early warning of earthquakes, ***contributing thus to prevent natural disasters and save human lives.***

107. Time synchronisation is an important "invisible" application of satellite navigation that will penetrate ~~the~~ modern economies. Electricity grids, mobile telephony and banking networks need the extreme accuracy of the satellites' atomic clock for reference purposes. On-line systems and e-commerce have ***already*** created needs for accurate and legally accepted electronic methods such as time stamping to improve the traceability, tractability and liability of the user information.

108. With its global coverage, GALILEO will be of key importance to countries whose infrastructures on the ground are less developed, particularly in tropical and equatorial zones, not least because of the possibilities it offers in the field of mapping and civil engineering. It will help to manage the crucial natural resources, the airspace and to promote international trade.

109. The multitude of already existing applications caused concern in the European Union in ***the*** early ***19***90s about the limits and risks of the adequacy of the existing satellite navigation services in the future.

110. It was, ***in fact,*** questioned ***at that time*** whether systems created to serve primarily the defence interests of the United States (GPS) and the Russian Federation (GLONASS) ~~can~~ ***would be able to*** fulfil the growing needs of Europe in the civilian fields described above.

111. To what degree can the European society depend on services over which it has no control? How ~~to~~ ***does one*** solve the lack of prompt warnings of possible malfunctioning of these services to the users? How ~~to~~ ***does one*** improve the availability and coverage problems of users worldwide and particularly in the areas at geographical disadvantage in the northern and southern hemispheres? Also, should ***the*** European Union remain a "free rider" in this global and strategic technology?

112. Moreover, how far can the risks to reliability and vulnerability of the navigation signal be contained? Cases of service disruption have been reported over the past years and they have had different origins including unintentional interference, satellite failure and signal degradation. ***As a matter of fact, by*** 2007-2008 the dependence of the European Union on GNSS ***and its applications*** will be as far-reaching as that of the United States.

113. The ~~European Union~~ ***EU and ESA have*** concluded in successive stages that uncertainties of this kind, the monopolistic role of the GPS and the lack of civil control ***do*** limit the usefulness of currently available GNSS applications in the service of ~~the economy of tomorrow~~ ***future economies***. ~~The European Union and the European Space Agency~~ ***They have*** committed ***themselves*** to share with the current GNSS States the burden of providing independent satellite navigation services for users worldwide. ***In addition,*** GALILEO aims to contribute significantly ~~to~~ ***by*** ~~reduce~~ ***reducing*** the shortcomings described above ***and*** by providing additional navigation signals broadcast in various frequency bands.

114. Innovative thinking concerning service guarantees, technological solutions, protection methods, services, the role of the private sector and international co-operation constitute elements of the European satellite navigation policy. GALILEO will take us a further step towards a Global Navigation Satellite System where the user can count on a truly continuous and reliable service anywhere in the world backed up by several signals from interoperable constellations.

115. ***This strategy is laid down in the communications of the European Commission on GALILEO in 1999, 2000 and 2002. The Ministries of Transport of the European Union meeting in the Council adopted in 2001 a resolution, highlighting the objective of European autonomy for such a strategic and crucial technology for the benefit of our society and economy. The Research Ministers of ESA then agreed on an integrated vision for the provision of European GNSS Services by the combined use of EGNOS (European Geostationary Navigation Overlay Service) and GALILEO services.***

116. A crucial step was taken on 26 March 2002 when the Council of the European Union ~~launched~~ ***decided on*** the development phase of GALILEO and confirmed their financial support to it, ~~and approved~~ ***approving thus*** the establishment of a GALILEO Joint Undertaking to manage the development activities. ***The Council of ESA agreed on*** ~~their~~ ***half of the contribution by EC and ESA on 26 May 2003. This means that Galileo continues to be financed 50% by the European Commission and 50% by the European Space Agency during the development phase.***

2. From policy to projects: GALILEO and EGNOS

117. The instruments to achieve the European objectives of increased availability, reliability, autonomy and user friendliness in satellite navigation are two-fold ~~comprising~~ ***and comprise*** the regional EGNOS ~~(European Geostationary Navigation Overlay Service)~~ system and the global GALILEO system.

118. Europe ***has*** develop***ed*** since 1993 ~~through the European Space Agency~~ the **EGNOS** system ***in order*** to improve the quality ***of services provided*** and inform users about the integrity of the GPS and GLONASS constellations. ~~It~~ ***EGNOS*** is the forerunner of GALILEO and the first European contribution to global satellite navigation. Since 2000, EGNOS ***has*** ~~provides~~ ***provided*** a test signal in an area covering ***all European States and some demonstrations activities have been performed to provide an EGNOS test signal outside Europe such as in the Middle-East and in Africa. The system will be fully operational by 2004.***

119. Besides its own operational objective as the European Satellite Based Augmentation System along the US WAAS and the Japanese MSAS, EGNOS ***has*** ~~demonstrates~~ ***demonstrated*** the potential of civil GNSS and Europe's determination for interoperability with the other satellite navigation systems. EGNOS and GALILEO will be integrated into each other ~~at~~ ***by*** the end of ~~our~~ ***the*** decade.

120. **GALILEO,** unlike EGNOS, is a global stand-alone system. It will be the first civil satellite positioning and navigation system under control of European public authorities ~~and to~~ ***that will*** be operated by a private entity.

121. GALILEO will provide the required stability for European investments in this area and in industries around the world in innovative market segments. GALILEO will also offer, alongside an open service similar to the GPS civilian service, new features to improve and guarantee services, thereby creating the conditions for responding to obligations imposed by critical ***situations***, safety of life or commercial applications. GALILEO will be compatible and interoperable with other systems at user level to facilitate their combined use all over the

world. For higher reliability, common failure modes between EGNOS and Galileo on one hand, and GALILEO and GPS on the other hand, will be prevented. Special attention has been given to the security aspect of GALILEO, ***with the aim*** to protect its infrastructure and to prevent the potential misuse of its signals.

3. System Description

New paragraph: [Some web sites related to the subject are indicated below]

- http://europa.eu.int/comm/dgs/energy_transport/galileo
- http://www.esa.int/export/esaSA/navigation.html
- http://www.galileoju.com

3.1. Services of GALILEO

122. Four navigation services and one service to support Search and Rescue operations have been identified to cover the widest range of user needs, including professional users, scientists, mass-market users, safety of life and public-regulated domains. ***Following consultations with various user groups and international standardisation organisations such as ICAO and IMO, the following set of GALILEO Satellite-only services will be provided worldwide:***

i. *The* ~~Basic~~ ***Open*** *Service* results from a combination of ~~open~~ ***the basic*** signals, free of user charge to the general public. It provides position and timing performances competitive with the two other GNSS systems.

ii. *The Safety of Life Service* is a service of a very high quality for safety-critical applications, such as aviation and ~~shipping~~ ***maritime transport***. It will improve the ~~basic service~~ ***Open Service*** by providing quick warnings (integrity) to the user if it fails to meet safety margins of accuracy. Guarantees are considered for this service.

iii. *The Commercial Service* facilitat***es*** the development of professional applications and offer***s*** enhanced performance compared with the ~~basic service~~ ***Open Service***, particularly in terms of higher data rates, service guarantees and accuracy.

iv. *The Public Regulated Service* ***(PRS)*** provides position and timing ~~principally~~ to public authorities responsible for civil protection and security. Two PRS navigation signals with encrypted ranging codes and data will provide high continuity of service, access control and ***higher*** resistance to jamming.

v. *The Search and Rescue Service (SAR)* broadcast***s*** globally the alert messages received from distress emitting beacons. It will contribute ***significantly*** to enhance the performances of the international COSPAS-SARSAT Search and Rescue system.

vi. ***GALILEO will provide a basic performance of 4 m horizontal accuracy and 8 m vertical accuracy at 95% confidence level.***

~~***This paragraph needs to be updated in view of the WRC-2003 recommendations***~~

123. Ten signals will be needed to provide these services. They will be broadcast on frequency bands E5A-E5B, E6, E2-L1-E1 allocated to radionavigation systems by the World Radiocommunications Conferences of the International Telecommunication Union ***(ITU)*** in 1997 and 2000.

124. ***Foreseen Galileo carrier frequencies:***

E5a (=L5)	f_{E5a}	***= 1 176.450 MHz***
E5b	f_{E5b}	***= 1 207.140 MHz***
E6	f_{E6}	***= 1 278.750 MHz***
L1	f_{L1}	***= 1 575.42 MH***

125. Considering the limited availability of spectrum for satellite navigation, an overlay of frequency bands used by GPS and GALILEO is inevitable. Such sharing complies with international ITU principles when there is no harmful interference to either of the two systems. It also contributes to interoperability by facilitating the joint use of the GALILEO and GPS for better performance.

4. Technical architecture and programme schedule

126. GALILEO architecture has been designed to meet the service needs explained above. The GALILEO *global component*, comprising the constellation of ***27*** active satellites, plus three in-orbit passive spare satellites on three orbital planes in Medium Earth Orbit and its associated ground segment, will broadcast the signals in space required to achieve the so-called *satellite-only services*. The ground segment includes two control centres, a network of uplink stations, sensor stations and a GALILEO communications network.

127. The *regional components* are foreseen to ***independently*** provide integrity to GALILEO in ~~a~~ certain regions, in addition to the global integrity service.

128. These GALILEO satellite-only services can be enhanced locally with the help of *local elements* that may be deployed for extra accuracy or integrity around airports, harbours, railheads and in urban areas. Consequently, the global component will be designed from the start so as to easily interface with these elements.

129. In the same way, the *interoperability* between GALILEO and external components will be a major driver of the GALILEO design to allow ***for*** the development of applications embedding or combining GALILEO services and external systems services (e.g. navigation or communication systems, mobile phones).

130. For example, the combined use of GALILEO and GPS standard positioning service will result in a 95% availability of satellite signals in an urban environment. For comparison, relying on GPS only gives today a 55% availability.

131. Interoperability, added performance, safety, new applications and wider use of the technology are key factors in ***the definition and development of*** GALILEO.

132. The GALILEO programme involves the following phases:

- Development and in-Orbit validation (***2003***-2005);
- Deployment (2006-2007); ***and***
- ~~***Commercial***~~ Operations (from 2008).

133. The definition phase has been completed ***earlier***. ~~Critical technology is under development by the European Space Agency ESA. The next step consists of~~ ***T***he manufacturing of the satellites and the related ground segment and launching of ***the*** first satellites will be completed during the ~~current~~ Development and In-Orbit Validation Phase. This phase is co-funded by ~~the European Community~~ ***EC*** and ~~European Space Agency~~ ***ESA***. ~~and is entrusted by the GALILEO Joint Undertaking to the European Space Agency ESA.~~ The cost of developing and deploying the system, including the launch of 30 satellites and commissioning of the ground infrastructure is 3.4 billion Euro.

134. The GALILEO Joint Undertaking is an enterprise that ~~will~~ ***has*** oversee***n*** ***the*** program implementation ***since September 2003*** and ***is preparing*** the grounds for the deployment of infrastructure. ~~from 2006 onwards~~.

135. ***The first two experimental Galileo satellites are currently being built so as to retain the priority allocated when the frequencies were applied for within the*** ~~International Telecommunication Union~~ ***ITU.***

136. In the deployment phase the private sector will contribute through a concession scheme to ensure the user-orientation of GALILEO services. ***The Galileo Joint Undertaking published an invitation to tender to this effect on 20 October 2003. The operating revenues will partially remunerate the concession holder.***

137. ***It is foreseen that a Galileo Supervisory Authority will manage public interests relating to the GALILEO programme. It will act as a licensing authority vis-à-vis the future private concessionaire to be designated before the end of 2004 and will endeavour to ensure that the operator complies with the contract, including the public service obligations in terms of continuity and guarantee of services.***

138. Various studies conducted in 2000-2002 demonstrate***d*** the economic viability of the project in comparison to classical infrastructure projects.

5. Open to international co-operation

139. ***Galileo innovates also in bringing non-EU and non-ESA countries in the programme from the start. Hence countries such as Canada, the Russian Federation, and Ukraine have already been involved in the definition of work of Galileo.***

140. On the political level, a formal cooperation agreement was signed by the ~~European Union~~ ***EU and the People's Republic of China on 30 October. Negotiations are ongoing with the United States and the Russian Federation on a similar agreement with focus on interoperability.***

141. Moreover, cooperation on various levels has been initiated i.a. with the Mediterranean partner countries, South Korea and Australia.

142. The GALILEO Joint Undertaking, located in Brussels, is a tool for industrial co-operation, not only between the public and the private sector in ~~the European Union~~ ***Europe***, but also between public and private partners worldwide. It is one of the vehicles of EU policy to promote industrial co-operation with companies from outside the Union.

B. GNSS Augmentations

1. MSAS & QZSS

MSAS

Overview

143. MSAS (MTSAT Satellite-based Augmentation System) is the wide-area augmentation system for GPS. Once in operation, this state-of-the-art system will assure full navigation services for aircraft in all flight phases within the Japanese FIR through MTSAT (Multi-functional Transport Satellite) launched by the Ministry of Land, Infrastructure and Transport. Aircraft can rely on the most efficient navigation system through reception of GPS signals and MSAS augmentation information, ***at*** anytime and any phase of flight.

Schedule

144. MTSAT-1R is scheduled for launch in ***Fiscal Year (FY)*** 2003. After that, MSAS operation is expected to commence once necessary data has been collected and performance levels have been verified. MTSAT-2 is scheduled for launch in FY 2004. Operation of MSAS using MTSAT-1R and MTSAT-2 is expected to commence in the year 2006, given that the system performance levels using both satellites are satisfactory. MSAS is expected to offer highly reliable navigation services by utilising two MTSATs, and also reduction of aircraft separation. MSAS is expected to function as a shared infrastructure within the Asia/Pacific region for GNSS use.

Interoperability and the future potential of MSAS

145. Satellite Based Augmentation Systems such as WAAS (Wide Area Augmentation System) of the ~~U.S~~. ***United States***, EGNOS (European Geostationary Navigation Overlay Service) of Europe, ***GAGAN (GPS And GEO Augmented Navigation) of India*** and MSAS have interoperability at the signal in space level. This global integration of air navigation system allows aircraft to use WAAS, EGNOS, ***GAGAN*** and MSAS services with the same avionics. All service providers continue to examine the establishment of higher-level interoperability. In the future, these wide-area augmentation systems are expected to provide higher-quality services, which are truly global and seamless services through the improvement of system performance and expansion of service areas.

QZSS

Overview

146. The Japanese Quasi-Zenith Satellite System (QZSS) is a regional complementary and augmentative system for GPS. When completed, the QZSS will consist of at least three satellites to be operated on individual circular orbits at an inclination of 45 degrees over a geosynchronous period. Because the elevation angle is more than 70 degrees at all times, this satellite constellation ensures visibility of the region over Japan without blocking from buildings and mountainous features. The QZSS orbital characteristics are ***therefore*** very valuable for high-speed communication and high accuracy navigation services.

Schedule and development structure

147. In 2003, the Japanese ***G***overnment started research and development on the QZSS. The first demonstration satellite is expected to be launched in 2008. The collaboration between the ***G***overnment and the private sector is one of the most important aspects of the development process. Both groups are working together on the QZSS Development and Utilisation Board in order to facilitate the realisation of the QZSS system.

International co-operation

148. International co-operation between the GPS provider, the United States and Japan is essential for the development of the QZSS and the GPS/QZSS Technical Working Group ***that*** was established in October 2002 to encourage ~~it~~ ***co-operation***. With respect to QZSS utilisation, expanding the service area to other countries in the Asia/Pacific region, especially to Australia, could be considered for the future.

149. Additional information about the QZSS, i.e., presentation materials introduced at the 5th action team meeting, is available at the GNSS action team web site (http://forum.itu.int/~gnss).

2. EGNOS

150. EGNOS (European Geostationary Navigation Overlay Service) is the forerunner of GALILEO and the first contribution of Europe to multimodal global satellite navigation. The project started in 1993 by the European Commission, ~~European Space Agency~~ ***ESA*** and ***the*** European Organisation for the Safety of Air Navigation (Eurocontrol) and is supported by several service providers with their own investments.

151. Today, EGNOS ~~provides~~ has reached initial operational capability. An experimental service is available in an area covering Europe ~~and the Middle East~~[7] and has been successfully tested in road, aviation and maritime navigation ~~during 2001-2002~~ ***since 2001. Some demonstrations activities have been performed and others are planned to be conducted outside Europe (e.g. Middle-East, Latin America, Africa, the People's Republic of China)***. It comprises a space segment of two Inmarsat transponders (AOR, IOR) and the newly launched Artemis geostationary satellite. The ground segment includes a number of reference stations (RIMS) in Europe and beyond, a processing centre and uplink facilities.

152. The system will be fully operational by 2004. EGNOS will complement GPS and the Russian GLONASS systems to provide a civil service to European citizens. It warns the users of system malfunctions of the GPS and GLONASS constellations by broadcasting on the L-1 frequency band integrity signals on the health of the two constellations. The provision of this quality control service (integrity) is essential for safety critical applications. ~~Furthermore the correction data will improve the accuracy of the current services from about 20 meters to better than 5 meters.~~

153. EGNOS will also improve the accuracy of GPS and GLONASS by means of differential corrections. ***The correction data will improve the accuracy of the current services from about 20 meters to better than 5 meters.***

154. Besides its own specific operational objective as the European SBAS, EGNOS is a unique instrument to gain experience not only in the development of GNSS technology but also, most importantly, in the operational introduction of GALILEO services.

155. The ICAO ~~(International Civil Aviation Organisation)~~ international SBAS (Satellite Based Augmentation System) standards guarantee the interoperability of EGNOS and the two other inter-regional augmentation systems MSAS and WAAS at user level. EGNOS will serve not only aviation but also other transport and non-transport applications.

156. EGNOS is indeed an example of the European commitment to interoperability with already existing systems.

7 Egnos Test Bed data 2. Oct 2002

3. WAAS

157. ~~The Wide Area Augmentation System (WAAS) uses a system of ground stations to provide necessary augmentations to the GPS SPS navigation signal. A network of precisely surveyed ground reference stations is strategically positioned across the country including Alaska, Hawaii, and Puerto Rico to collect GPS satellite data.~~
157. The Wide Area Augmentation System (WAAS) has been developed by the United States (US) Federal Aviation Administration (FAA) to augment the GPS SPS navigation signal. The system has been operational for non safety of life since August 2000 and has been widely by applications such as agriculture. It is estimated that there are over 1 million users in the agricultural field alone in the United States. In July 2003, the FAA commissioned the system for safety of life service and has been publishing the appropriate procedures for use by its aviation customers.

158. ~~Using this information, a message is developed to correct any signal errors. These correction messages are then broadcast through communication satellites to receiver's onboard aircraft using the same frequency as GPS. The WAAS is designed to provide the additional accuracy, availability, and integrity necessary to enable users to rely on GPS for all phases of flight, from en route through GLS approach for all qualified airports within the WAAS coverage area. This will provide a capability for the development of more standardised precision approaches, missed approaches, and departure guidance for approximately 4,100 ends of runways and hundreds heliport/helipads in the *NAS*.~~
158. WAAS uses a system of master stations and ground reference stations to provide the necessary augmentations to the GPS SPS navigation signal and broadcast those signals via communication satellites to the receivers onboard the aircraft. The initial system consists of a network of 2 master stations and 25 precisely surveyed ground reference stations that are strategically positioned across the US including Alaska, Hawaii and Puerto Rico to collect the GPS data and transmit the information to the master stations for correction. The end state WAAS will add communication satellites to provide dual coverage for the entire US and an additional 12 ground reference stations located in Alaska and along the northern and southern borders with possible locations in Canada and Mexico.

159. ~~WAAS will also provide the capability for increased accuracy in position reporting, allowing for more uniform and high-quality worldwide Air Traffic Management (ATM). In addition, WAAS will provide benefits beyond aviation to all modes of transportation, including maritime, highways and railroads. While WAAS may not provide any direct benefits to ***Air Traffic Control*** (ATC) communications, it may be an enabling technology for the future aviation data link architecture. ***It*** provides an alternative satellite-based system to maintain required levels of safe operations in the NAS. Upon completion of the end-state, WAAS will allow for replacement of *VOR*, *DME*, *NDB*, and most Category 1 ILS receivers with a single WAAS receiver.~~
159. The WAAS is designed to provide the additional accuracy, availability, continuity and integrity necessary to enable users to rely on GPS for enroute through precision approach with vertical guidance for all qualified airports within the WAAS coverage area. This provides a capability for the development of more standardised precision approaches, missed approaches, and departure guidance for approximately 4,100 runway ends and hundreds of heliports/helipads in the US National Airspace System (NAS).

160. ~~***WAAS will provide*** **improved safety when operating in reduced weather conditions due to precision vertical guidance on approach 3-dimensional position guidance for all phases of flight**~~. ~~***WAAS***~~ ~~provides an inexpensive, Instrument Flight Rules (IFR) area navigation system, with global coverage, leading to: greater runway availability, reduced separation,~~

~~more direct en route paths, new precision approach services and reduced disruptions (delays, diversions or cancellations).~~
160. WAAS provides the capability for increased accuracy in position reporting, allowing for more uniform and high-quality worldwide Air Traffic Management (ATM). In addition, WAAS provides benefits beyond aviation to all modes of transportation, including maritime, highways and railroads. While WAAS may not provide any direct benefit to Air Traffic Control (ATC) communications, it may be an enabling technology for the future aviation data link architecture. It provides an alternative satellite-based system to maintain required levels of service in the NAS. Upon completion of the end state, WAAS will allow for the replacement of VORs, DMEs, NDBs and possibly Cat 1 ILS receivers with a single WAAS receiver.

161. ~~There are also significant benefits to be realised by the FAA due to the elimination of maintenance and replacement costs associated with some older, expensive ground-based navigation aids (to include NDB, VOR, DME, and most Category 1 ILSs).~~
161. ***WAAS provides improved safety when operating in reduced weather conditions due to precision vertical guidance on approach with 3-dimensional position guidance for all phases of flight. WAAS provides an inexpensive, instrument flight rules (IFR) area navigation system with global coverage, leading to: greater runway availability, reduced separation, more direct flight paths, new precision approach services and reduced disruptions (delays, diversions or cancellations).***

~~162. The FAA currently has no funded programs to develop surveillance systems based on WAAS. However, proof of concepts for an Automatic Dependent Surveillance system, using positioning by aircraft Broadcasts (ADS-B), have **has** been demonstrated within other FAA Research and Development efforts and may prove to be cost effective additions to the NAS.~~
162. ***There are also significant benefits to the realised by the FAA due to the reduction in maintenance and replacement costs associated with some older, expensive ground-based navigation aids to include NDBs, VORs and DMEs.***

*FAA has commissioned WAAS on **10** July 2003.*

4. GAGAN

163. The Indian Space Based Augmentation System (SBAS), called GAGAN (GPS And Geo Augmented Navigation), is being implemented by the Indian Space Research Organisation (ISRO) in collaboration with the Airports Authority of India (AAI) over the Indian Airspace, for civilian aircraft navigation. The GAGAN system is expected to bridge the gap between the evolving European EGNOS system and the Japanese MSAS system. The GAGAN System will follow the recommendations of the Asia Pacific Air Navigation Plan for ICAO Regional Group (APANPIRG) as per the ICAO SARPs.

164. Three phases have been identified for reaching the Full Operational Capability (FOC) for the GAGAN system:

Phase 1: Technology Demonstration System (TDS);
Phase 2: Initial Experimental Phase (IEP); ***and***
Phase 3: Final Operational Phase (FOP).

Phase 1: Technology Demonstration System (TDS)

165. Under the TDS, the Indian Space Research Organisation shall establish the necessary ground and space segment for demonstration of SBAS functioning for en route, NPA1 and leading up to Cat.I landing capability, ***initially*** over a limited airspace.

166. The ground segment configuration for the TDS phase is as follows:

(i) Up to 8 Indian Reference Stations (INRESs) at widely separated geographical area in India;
(ii) An Indian Master Control Centre (INMCC) located at Bangalore;
(iii) An Indian Navigation Land Uplink Station (INLUS) collocated with the INMCC;
(iv) One Navigation Payload in the Indian Ocean Region (IOR) between the orbital locations 48 deg. E to ~~100~~ 111.5 deg.E, ***compatible with GPS L1 and L5.***

~~Indian Reference Stations (INRESs)~~

~~INRESs collect measurement data and broadcast messages from all the GPS and GEO satellites in view and forward it to the Indian Mission Control Centre (INMCC). As per the present planning, 8 INRESs will be located at the following places in India:~~

- ~~New Delhi~~
- ~~Bangalore~~
- ~~Ahmedabad~~
- ~~Calcutta~~
- ~~Jammu~~
- ~~Port Blair~~
- ~~Guwahati~~
- ~~Trivandrum~~

~~Indian Mission Control Centre (INMCC)~~

~~INMCC will be collocated with the INLUS at Bangalore. The chief functions of the INMCC are~~

- ~~Network Management (communication and computer)~~
- ~~Integrity monitoring~~
- ~~Iono-Tropo Model delay estimation~~
- ~~Wide area corrections~~
- ~~Orbit determination~~
- ~~Command generation~~

~~The INMCC shall consist of a main frame computer and a host of secondary computers connected to a network.~~

~~Indian Navigation Land Uplink Station (INLUS)~~

~~INLUS communicates with the Indian Nav. Payload. This earth station receives messages from the INRESs through the INMCC, format these messages and transmit them to the GEO satellite navigation payload for broadcast to users. The INLUS also provides GEO Ranging information and corrections to the GEO satellite clocks. Message formats and timing shall be as per the WAAS functional and performance specifications No. FAA-E-2892B Change 1 DTFA01-96-C-00025 Modification No. 0051, dated September 21, 1999.~~

~~167. As part of the TDS, it is proposed to fly a Navigation payload compatible with GPS L1 frequency on an Indian satellite to be positioned in the Indian Ocean Region between the orbital arc 48 deg. E to 111.5 deg.E longitude.~~

The Indian Space Research Organisation is looking into incorporating the GPS ~~second civil frequency L2C or~~ the third civil frequency L5.

168. The major function~~s~~ of the Geostationary payload ~~are~~ ***is***:

- To relay Geostationary overlay signal compatible with GPS L1 & L5 frequency for use by modified GPS receivers (*GNSS receivers)*.
- ~~to provide a CxC path for ranging by INRESs with an uplink from the INLUS.~~
- ~~to provide a CxS link for precise time synchronisation with GPS~~

169. The GPS L1 *& L5* EIRP shall be ~~30.5~~ 33.0 dBW. This EIRP can be adjusted within a suitable range through on-board attenuator settings. The total weight and power requirements of this payload are expected to be about 30.5 Kg and 145 Watts.

170. The first payload is expected to be made operational in the year ~~2004/~~2005. A second payload shall be fabricated and flown in Phase 3.

~~**Iono-Tropo Modeling**~~

171. ~~(i)~~ Iono-Tropo modeling and scintillation studies in the L-band will be carried out over the entire Indian *a*irspace as an integral part in the TDS Phase 1.

~~The following strategy has been adopted to develop suitable grid based ionospheric model over the Indian region.~~

~~(a) About 20 total electron content (TEC) receivers shall be located at the Centre of the 25 deg x 5 deg. ionospheric grid points (IGP) over the Indian region.~~
~~(b) The data from these receivers shall be logged into a personal computer and the logged data shall be delivered to all academic and scientific institutions on which contracts are placed to carryout the necessary studies.~~
~~(c) All receivers and PCs shall have an uninterrupted power supply (UPS) and necessary housing at all the 20 sites. The instrumentation at all the sites shall be identical. A suitable Ionospheric Scintillation and TEC monitor receiver equipment which is best suited for these studies shall be deployed at all the sites.~~

Initial Experimental Phase (IEP)

172. After the successful completion of the TDS, redundancies will be provided to the space-segment, INMCC, INLUS and system validation carried out over the entire Indian airspace. The conventional navigational aids will continue to be operational as prime mode. IMCC will be configured for WAD technology and for operations with Indian space-segment. Based on the experience of the TDS, additional augmentation will be worked out.

Final Operational Phase (FOP)

173. During the Final Operational Phase (FOP), additional INRESs will be established as required and the communication systems will be established with all redundancies. INMCC and NLES will be augmented with operational hardware and adequate redundancy.

174. During the IEP and the FOP, parallel attempts will be made to develop SATNAV compatible GNSS receivers of international standards indigenously.

175. The present service coverage (satellite footprint) for WAAS (INMARSAT-III AOR-East & West), EGNOS (INMARSAT-III, AOR-East & IOR), MSAS (INMARSAT-III, POR) & GAGAN (proposed Indian coverages together with INMARSAT-III IOR and MSAS) are shown in **Fig. 1** *(to be included)*.

5. Others

CONTRIBUTION FROM BRAZIL:

1) Existing Training opportunities:

CRECTEALC: UN-Regional Training Center of Science and Space Technology for Latin America and Caribe Region.
Undergraduate courses .

IME- Army Institute of Engineering.
Graduate and undergraduate course on Cartography and Geodesy.

INPE – National Space and Research Institute – São José dos Campos
Education and research on orbital dynamics and Ionosphere modeling.

ITA – Instituto Tecnológico de Aeronáutica
Education and research on aeronautics applications of GNSS: ionosphere modeling and scintillation, GPS software receivers, multipath mitigation, microstrip antennas for GNSS, and related subject.
Graduate courses.

UFPE – Universidade Federal de Pernambuco.
Education and research on Cartography, Geodesy and Photogrammetry.

UFPR – Universidade Federal do Paraná – Curitiba
Education and research on Cartography, Geodesy and Photogrametry.
Graduate and undergraduate courses.

UFRGS-Universidade do Rio Grande do Sul
Undergraduate course on Cartography, Geodesy, Photogrammetry and GIS.

UNICAMP – Universidade de Campinas – Campinas
Education and research on signal processing.
Undergraduate courses

UNESP – Universidade do Estado de São Paulo - Campus Presidente Prudente
Education on cartography, atmosphere modeling, high precision GNSS
Graduate and undergraduate courses.

USP – Universidade de São Paulo
- Campus Piracicaba
Education and Research on geoprocessing, agricultural and natural resources, and precision farming.
Graduate and undergraduate courses

- Campus Sao Carlos
Education on ground transportation
Undergraduate courses

2) Augmentation Systems:

SBAS (Space Based Augmentation System)
Test bed is underway.
Topics related: ionosphere and scintillation modeling.
Project for a geostationary satellite.

GBAS (Ground Based Augmentation System)
Development of DGNSS network.
Development of Pseudolite.

a) Canadian Coast Guard Marine Differential Global Positioning System (DGPS) Navigation Service

176. The Canadian Coast Guard DGPS Navigation Service provides a maritime differential GPS correction service for suitably equipped radio users. These corrections are broadcast from a network of Canadian Coast Guard operated MF marine radio beacons. Canadian coverage areas include the east and west coasts of Canada to approximately 60° N., the Great Lakes and St. Lawrence Seaway. The current network consists of 20 beacons. Broadcast formats are based on international standards and are compatible with the worldwide network of DGPS marine beacon station broadcasts. See http://www.ccg-gcc.gc.ca/dgps/main_e.htm for additional information and updates.

b) Canadian Active Control System and Canada-wide DGPS Service

177. Natural Resources Canada has established the Canadian Active Control System (CACS) through which enhanced GPS positioning is enabled directly (related) to the Canadian Spatial Reference System (CSRS). Real-time and post-processing GPS applications are possible at accuracies ranging from centimetres to metres. The CACS consists of a network of GPS tracking stations across Canada, real-time data links and a central server computing system. CACS products include GPS data, precise GPS orbits and clocks. As part of a global collaboration, CACS data and products are regularly contributed to the International GPS Service (IGS) (http://igscb.jpl.nasa.gov/).

178. A real time wide-area augmentation, based on the CACS, has been implemented to produce real-time GPS corrections (GPS•C) for Canadian users. Real-time broadcast of these corrections via MSAT to the user and development of an initial user receiver is underway through a partnership between the Canadian federal ***G***overnment and the Canadian provinces. This project is known as CDGPS or Canada-wide Differential GPS project (http://www.cdgps.com/). More details about the Canadian Active Control System are available at
http://www.geod.nrcan.gc.ca/index_e/aboutus_e/programs_e/progacp_e.html

NAV CANADA's Role and GPS Augmentation Strategy

179. NAV CANADA is the non-share capital, private corporation that owns and operates Canada's civil Air Navigation Service (ANS). NAV CANADA provides, maintains and enhances an air navigation service dedicated to the safe movement of air traffic throughout the country and through oceanic airspace assigned to Canada under international agreements. The company's infrastructure consists of seven Area Control Centres, one stand-alone terminal control unit, 78 flight service Stations, 42 control towers, 41 radar sites and approximately 1,400 ground-based navigational aids across Canada.

180. For the aviation community, GPS signals meet accuracy requirements for en-route through non-precision approach. GPS by itself does not meet integrity or accuracy requirements for aircraft precision approach operations. NAV CANADA has commissioned over 250 GPS stand-alone approaches providing increased airport usability in many cases.

181. Recent developments in the U.S. Wide Area Augmentation System (WAAS) program suggest that it may be possible to obtain service from WAAS in southern Canada. NAV CANADA is exploring this possibility. The only viable way to obtain full WAAS service in Canada, however, is to field a network of reference stations linked to FAA master stations in the USA; this network would be called the Canadian WAAS, or CWAAS. NAV CANADA and the FAA have been planning accordingly since the mid 1990s. No decision has been made to fund CWAAS; such a decision depends on factors related to the ability of CWAAS to deliver levels of service that would bring benefits to aircraft operating in Canada.

182. NAV CANADA is also investigating the use of the Local Area Augmentation System (LAAS) installations in Canada as this technology develops.
[Reference: NAV CANADA Satnav Transition Strategy May 2002
http://www.navcanada.ca/contentEN/serviceprojects/satnav/
See also http://www.navcanada.ca/contentEN/news/corpDocs/techWatch/default.asp for NAV CANADA updates and http://www.tc.gc.ca/tdc/projects/air/b/9855.htm for information about GPS advanced aviation navigation program at Transport Canada.]

c) University of Calgary's Regional Differential RTK Test Network

183. The University of Calgary is deploying a test network that will initially consist of 16 stations spaced at 40 to 70 km to study multiple reference station DGPS RTK and real-time water vapour estimation on a regional basis.

d) Canadian Commercial GPS Differential Services

184. There are some Canadian companies offering GPS augmentation services covering various parts of Canada. ***This is done*** from wide coverage by broadcasting corrections via a communication satellite to local services broadcasting via radio frequencies from a single base station. The services also range from low accuracy single frequency pseudorange corrections to local, high accuracy, dual frequency RTK type services. Most major cities in Canada have some sort of commercial GPS augmentation service.

III. OVERVIEW OF EXISTING ACTIVITIES TO PROMOTE GNSS

A. Civil GPS Service Interface Committee

185. The Civil GPS Service Interface Committee (CGSIC) is part of the Department of Transportation's program to respond to the needs of civil GPS users, and to integrate GPS into civil sector applications. CGSIC is the recognised worldwide forum for effective interaction between all civil GPS users and the U.S. GPS authorities. CGSIC comprises members from U.S. and international private, government, and industry user groups. Three subcommittees focus on specific user groups: International, Timing, and U.S. States and Localities. CGSIC meets semi-annually and is open to anyone interested in civil GPS issues. A summary record of each meeting is available from the NIS. Information from CGSIC members and meetings is provided to U.S. GPS authorities for consideration in GPS policy development and GPS service operation.

186. The Civil Global Positioning System (GPS) Service Interface Committee (CGSIC) ~~is~~ ***was*** established to identify civil GPS user needs (e.g. navigation, timing and positioning) in support of ***the*** Department ***of Transportation's*** ~~of Transportation's~~ (DOT) program to exchange information concerning GPS with the civil user community, the GPS "outreach" program. In fulfilling this responsibility, the CGSIC will report its activities to the Interagency GPS Executive Board (IGEB) and the Office of the Assistant Secretary for Transportation Policy (OST/P). ***The CGSIC is a support to the committee and to the Interagency GPS Executive Board (IGEB).***

1. **The roles of the CGSIC are to:**

   a. Provide a forum to collect and exchange information on the worldwide civil user community's GPS needs;
   b. Identify information requirements, and methods to distribute this information to the worldwide civil GPS user community;
   c. Conduct ***GPS information*** studies on civil user needs as requested by the IGEB or identified by the Committee; ***and***
   d. Identify any GPS matters of concern - "issues" - that may need resolution ***and submit them to appropriate authorities for consideration.***

2. Committee Composition

187. The CGSIC is comprised of representatives from relevant private, government and industry user groups, both U.S. and international. The Committee structure consists of a Chair, a Deputy Chair, a Secretariat, and an Executive Board. The Committee is chaired by a representative from the Assistant Secretary for Transportation Policy who provides policy guidance and oversight to the Deputy Chair. The Deputy Chair is provided by the US Coast Guard Navigation Center (NAVCEN), and is responsible for the CGSIC Secretariat. The Secretariat manages the Committee, maintains membership lists, co-ordinates Committee meetings, and represents the Committee at GPS related meetings.

188. The Executive Board consists of the Chair, the Deputy Chair, the Deputy Chair for International Affairs, the Sub-Committee officials, and representatives from the Secretariat and the three modal areas:

   a. Aviation: a representative designated by the Federal Aviation Administration to address aviation concerns;
   b. Land: a representative designated by the Federal Highway Administration to focus on land, reference station, and timing concerns; ***and***

c. Marine: a representative designated by the US Coast Guard to address maritime matters.

3. Sub-Committees

189. The CGSIC may create standing sub-committees, ad hoc sub-committees, or special working groups to identify specific areas of civil GPS user needs and facilitate technical information exchange. The following standing sub-committees have been established:

a. International Sub-Committee (ISC);
b. Timing Information Subcommittee (TISC); ***and***
c. U.S. States and Localities Subcommittee (SFSC).

The International Subcommittee officers consist of a Chair, Regional Vice-Chairs, and representatives from industry, government, and academia. Country points of contact are appointed to coordinate activities in a country.

190. ***Standing committee chairs will be elected by the subcommittee members for a two-year term. Elections will be held in conjunction with a general meeting***.

191. The CGSIC is open to anyone with an interest in GPS. It is open to the GPS user community worldwide. To join, ~~send~~ the following information ***should be sent*** to the Executive Secretariat: ***Name, Affiliation, Address, Phone, FAX, E-mail address, and How do you use GPS?***

192. You will then be placed on the mailing list for announcements and meeting summary reports and on the GPS Listserver to receive GPS and radionavigation announcements.

Civil GPS Service Interface Committee Charter

193. ~~The Civil Global Positioning System (GPS) Service Interface Committee (CGSIC) is established by the U.S. Department of Transportation as a function of the Assistant Secretary for Transportation Policy's (OST/P) outreach program to the civil GPS user community. Pursuant to this responsibility,~~ ***T***he CGSIC was chartered by the DOT POS/NAV Executive Committee and ~~will~~ interface***s*** with the Office of the Assistant Secretary for Transportation Policy, the U.S. Coast Guard's Operations Policy Directorate, the DOT POS/NAV Executive Committee, the Interagency GPS Executive Board (IGEB) Executive Secretariat, and the GPS Interagency Advisory Council (GIAC).

~~The roles of the CGSIC are to:~~

- ~~Provide a forum to exchange technical information and collect information on the civil GPS user community's GPS needs,~~
- ~~Identify information requirements and methods to distribute this information to the civil GPS user community,~~
- ~~Conduct GPS information studies on civil user needs as requested by DOT or identified by the Committee, and~~
- ~~Identify any GPS issues that may need resolution and submit them to appropriate authorities for consideration.~~

~~COMMITTEE COMPOSITION~~:

~~The CGSIC is comprised of representatives from relevant private, government, and industry user groups, both U.S. and international. The Committee structure consists of a chair, two deputy chairs, an Executive Secretariat, and an Executive Panel. The Committee is chaired by the Director, Radionavigation and Positioning in OST/P. The first Deputy Chair is Commanding Officer, the U.S. Coast Guard Navigation Center (NAVCEN). The Commanding Officer of NAVCEN is supported by an Executive Secretariat and manages the Committee, maintains membership roles, co-ordinates Committee meetings, represents the Committee Chair at GPS related meetings, and co-ordinates responses to submitted issues. The second Deputy Chair is the Deputy Chair for International Affairs and is a non-U.S. representative appointed by the Chair with the approval of the Executive Panel. The Executive Panel consists of the Chair, Deputy Chairs, Subcommittee chairs, a representative from the GIAC, and representatives from three modal areas:~~

- ~~Aviation - a representative designated by the Federal Aviation Administration to address aviation issues,~~
- ~~Land - a representative designated by the Federal Highway Administration to focus on land, reference station, and timing issues, and~~
- ~~Marine - a representative designated by the U. S. Coast Guard to address maritime issues.~~

~~**SUBCOMMITTEES:**~~

~~The CGSIC may create standing subcommittees, ad hoc subcommittees, or special working groups to work specific areas of civil GPS user needs and facilitate technical information exchange. Standing subcommittees have been established for:~~

- ~~International~~
- ~~Timing~~
- ~~U.S. States and Localities~~

~~Standing committee chairs will be elected by the subcommittee members for a two-year term. Elections will be held in conjunction with a general meeting.~~

ADMINISTRATIVE GUIDELINES:

194. The administrative guidelines for the CGSIC are:

- The committee will meet as often as needed, but not less than annually. The date, time, and location will be announced at least two months before each meeting.
- A Summary Record of each meeting should be mailed to members as soon as possible after the meeting on the U.S. Coast Guard's Navigation Center's Website.
- Attendance is open to anyone with a need to exchange information or provide input regarding civil GPS requirements, both domestic and international.
- The Chair or Deputy Chair will make every effort to attend all sub-committee meetings. If unable to attend, the Chair or Deputy Chair will answer questions submitted in writing.

195. The Commanding Officer of NAVCEN will co-ordinate meeting arrangements, agendas, produce Summary Reports, and maintain membership lists.

Navigation Information Service

The U.S. Coast Guard Navigation Information Service (NIS) is the central point of distribution of GPS information in support of non-aviation users. The NIS distributes operational notices on GPS status and reference documents to facilitate system use and receiver design. The NIS also collects GPS incidents reports, forwarding them for analysis. Notice Advisories to Navstar Users (NANUs), and status messages are available by e-mail subscription, as well as on the website.

The NIS is staffed 24 hours a day, seven days a week supporting users by telephone, fax, and e-mail. The NIS maintains a website (http://www.navcen.uscg.gov) with current GPS information.

B. GLONASS Service Interface

204. ***The*** Coordination Scientific Information Center (KNITs) of ***the*** Ministry of Defense is authorized for official distribution of GLONASS Interface Control Document. It is available at the KNITs web-site ***at*** www.glonass-center.ru

205. In order to support ***activities of the*** GLONASS'***s*** Coordination Board ~~activity~~ two bodies ~~has~~ ***have*** been assigned to exchange information concerning GLONASS with the civil user community: ***the*** GNSS Information Analytical Center of the Mission Control Center Korolyov and ***the*** Multifunctional Navigation Information Center of the Research Institute of Space Device Engineering, Moscow (MNIC RISDE).

206. ***The*** GNSS Information Analytical Center of the Mission Control Center Korolyov (IAC MCC) ~~has been~~ ***was*** established in 1995 by ***the*** Russian Space Agency to support and coordinate civil community in GNSS application***s***. Presently, IAC MCC is officially acting as Analysis Center of ***the*** International Earth Rotation Service (IERS), International Laser Ranging Service (ILRS) and International GLONASS Service - Pilot Project of IGS (IGLOS-PP). In a routine mode IAC MCC is permanently conducting:

- The real-time monitoring and a ***posterior*** analysis of the GLONASS/GPS navigation field;
- GLONASS precise orbit determination based on laser data; ***and***
- GLONASS/GPS precise orbit and time corrections determination based on one-way phase data of global network (experimental service)

The following products of IAC MCC are currently available for users:

- GLONASS/GPS integrity data (real-time, monthly bulletin);
- Precise GLONASS orbits based on SLR and one-way data; ***and***
- PZ-90-GLONASS/ITRF transformation parameters.

207. The information is ~~openly~~ ***freely*** available at the IAC MCC web-site www.mcc.rsa.ru.

208. ***The*** Multifunctional Navigation Information Center of the Russian Institute of Space Device Engineering ***at*** Moscow (MNIC RISDE) ~~has been~~ ***was*** established by the Russian Aviation and Space Agency in 2002 aiming ***at*** the following purposes:

- Realization of a common governmental policy in the field of coordinates-time provision of users;
- Coordination of works in connection with development of perspective systems intended to provide the users with coordinate***s***-time data;
- Establishment and evolution of the market ~~of~~ ***on*** navigation technologies and services in ***the*** Russia ***Federation***;
- Integration with international systems and services;

209. The information is openly available at the RISDE web-site www.rniikp.ru.

210. In close cooperation, all three centers shall provide user community ~~by~~ ***with*** comprehensive information on GLONASS status, development plans and application benefits.

C. UN Agencies (IMO, ITU, ICAO)

211. The International Civil Aviation Organization (ICAO), recognizing the limitations of the present air navigation systems and the need to meet future requirements, has taken steps to promote the introduction of satellite-based technologies for communication, navigation and surveillance (CNS) elements in support of global air traffic management (ATM). A fundamental prerequisite for the implementation of the systems on a global basis includes the development of uniform Standards and Recommended Practices (SARPs).

212. ICAO has developed SARPs for global navigation satellite system (GNSS),[8] which include provisions for core satellite constellations (GPS and GLONASS) and aircraft-based, ground-based and satellite-based augmentation systems, to improve the overall GNSS performance as required for aeronautical applications. Work is also underway to develop ICAO standards for GNSS enhancements and new elements such as GPS L5, an additional civil frequency for GPS, standards for aeronautical applications of ***GALILEO*** and enhancements to GLONASS.

213. The International Telecommunication Union, Radiocommunication Sector (ITU-R) is continuing its technical studies related to the use of GNSS and for the efficient use of associated radio frequency spectrum in the Study Group 8 – Working Party 8D (http://www.itu.int/ITU-R/study-groups/rsg8/rwp8d/index.asp), and ICAO, IMO and ITU are continuing cooperation to protect aeronautical applications of satellite-based CNS systems and radionavigation satellite service (RNSS). ***ITU-R Study Group 7 (Science Services) is concerned with GNSS work through its Working Party 7A on Time signals and frequency standard emissions (http://www.itu.int/ITU-R/study-groups/rsg7/rwp7a/index.asp)*** At the World Radiocommunication Conference 2000 (WRC-2000), spectrum was allocated for additional GNSS applications, including aeronautical applications, and follow-up actions are to be taken at WRC-2003.

214. The World Radiocommunication Conference 2003 (WRC-2003) (Geneva, 9 June – 4 July 2003) will consider the following agenda items related to the RNSS: WRC-2003 will review the results of studies concerning RNSS in accordance with Resolutions 604, 605 and 606, adopted at WRC-2000 (agenda item 1.15). Resolution 604 (WRC-2000) relate***s*** to the compatibility between the RNSS operating in the frequency band 5010-5030 MHz and the radio astronomy services (RAS) operating in the band 4990-5000 MHz. Resolution 605 (WRC-2000) relate***s*** to the compatibility between the RNSS and ARNS operating in the frequency band 1164 – 1215 MHz. ***A***nd Resolution 606 (WRC-2000) relate***s*** to the compatibility between the RNSS and the radiolocation service (RLS) in the frequency band 1215 – 1300 MHz, respectively. WRC-2003 will

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[8] According to the definition of GNSS in ICAO standards, GNSS is the system which comprises two types of elements: core satellite constellations (GPS, GLONASS and future Galileo) and augmentation systems (aircraft-based, ground-based and satellite-based).

also consider use of the band 108-117.975 MHz for the transmission of radionavigation satellite differential correction signals by ICAO standard ground-based systems (agenda item 1.28). More information on the WRC-03 agenda items is available from ITU-R website, ***at*** http://www.itu.int/ITU-R/conferences/wrc/wrc-03/index.asp.

1. 215. The ICAO Assembly at its thirty-second session, in 1998, adopted the Charter on the Rights and Obligations of States relating to GNSS Services (Resolution A32-19), which embodies fundamental principles applicable to GNSS. An ICAO Secretariat study group was established to consider, inter alia, the creation of an appropriate long-term legal framework to govern the operation of GNSS. In 2001, the thirty-third session of the ICAO Assembly decided that further work should be carried out in this respect.

216. ICAO and the International Maritime Organization (IMO) are continuing coordination and exchange of information on various aspects of GNSS development and implementation. IMO, recognizing that requirements of ICAO for accuracy, reliability and availability of GNSSs are more stringent, accepted them as more than adequate for maritime applications. Both organizations continue to exercise a co-ordinated approach to ITU in supporting the evolution of GNSS towards a future system capable of supporting advanced applications for aeronautical and maritime navigation.

217. At its twenty-second session (19-30 November 2001), the IMO Assembly adopted ***R***esolution ***A.915*** (22) on "Revised maritime policy and requirements for a future global navigation satellite system (GNSS)". The revised policy provided ~~revised~~ operational requirements for a future GNSS, revised and updated relevant definitions and a glossary used in GNSS (Appendix 1), ***and*** updated the minimum user requirements for a future GNSS, providing minimum requirements for general navigation (Appendix 2) and minimum maritime user requirements for positioning (Appendix 3), and updated the indicative timetable for development of GNSSs (Appendix 4). It is also expected that the twenty-third session of the Assembly of IMO in November 2003 will adopt a resolution **A….**(23) on the World-Wide Radionavigation System revoking the existing ***R***esolutions A.529(13) and A.815(19) relating to accuracy standards for navigation and operational requirements for worldwide radionavigation systems, respectively.

218. The United Nations Office on Drugs and Crime (UNODC) is extensively and increasingly using GPS devices in the context of its global illicit crop-monitoring programme. The GPS data is mostly used for ground-truthing purposes to support the analysis of satellite imagery. GPS data is also used to establish and update ***a*** list of human settlements in rural areas of the countries where the programme implements annual crop surveys and alternative development programmes.

219. The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) has received from the Inter Agency Standing Committee (IASC) the guardianship of the Humanitarian Information Center (HIC) concept. The work of the HIC requires accurate knowledge of location as a requisite input into the planning and coordination of field operations. The HIC uses the technology of satellite-based navigation, GPS, and geographic information systems (GIS) combined to provide field personnel with a full picture and command of the locations and distribution of populations, roads, distribution centers, and key facilities for all logistics, analysis and planning activities. Associated with the use of GPS and related to the challenging environment in which delivery of humanitarian assistance takes place, the HIC has been championing the development of standard Metadata and geo-codes (P-codes) which define unique identification numbers for areas and facilities in an operating theater. These standard procedures and products have become an increasingly common feature of humanitarian information management systems.

220. The Office of the United Nations High Commissioner for Refugees (UNHCR) is using GPS devices in field operations to collect relevant operational geographical information in order to improve its assistance towards refugees. As of today, more than 45 country operations are using GPS in activities relating to site planning, staff security, environmental assessment, logistics, among other things. The collected GPS data are often combined from satellite imagery and managed within a GIS for further analysis and mapping outputs. Expansion of the use of GPS devices is foreseen in refugee operations for the coming years. Basic training and technical booklets are also developed by UNHCR via its geographic information and mapping unit and provided to staff members and partners.

221. The United Nations Office for Project Services (UNOPS) is implementing the UNOSAT project[9] on behalf of the United Nations Institute for Training and Research (UNITAR). UNOSAT uses GPS to collect field information for inclusion in local GIS and UNOSAT's global web-based database. In addition, GPS is used to geo-reference and field-validate satellite imagery and imagery-derived products.

222. In support of remote field data collection activities, the World Health Organization (WHO) has been routinely using GPS to map and track infectious diseases at the community level. GPS is now routinely used by village outreach teams for onchocerciasis, Guinea worm, African trypanosomiasis (sleeping sickness) and lymphatic filariasis, among others. Such systems are increasingly being used during the investigation of disease outbreaks for rapid mapping of cases and deaths. Within the context of complex emergency situations, they are being used to map internally displaced persons and refugee camps and to carry out rapid epidemiological assessments.

223. Members of the World Meteorological Organization (WMO), as well as international space organizations that operate space-based environmental satellite systems contributing to the World Weather Watch’s space-based component of the Global Observing System, have plans to analyze the time signal from Global Positioning System Occultation Sensors (GPSOS) as described in paragraphs [14] to [17] below.[10]

224. Geometric determinations of location depend on inferences about the atmospheric temperature and moisture concentrations. They provide valuable complementary information to tropospheric infrared and microwave sounders about the tropopause and stratosphere. Ray bending and changes in the phase and amplitude of the transmitted signals allowing inference of the upper atmosphere temperature profile to the order of 1 deg K or better between altitudes of 8 to 30 km in layers (with footprints ranging between 1 km x 30 km to 1 km x 200 km extent) with near global coverage. The coverage would be expected to be evenly spread over the globe, except for polar regions. The system measures upper atmospheric virtual temperature profiles; therefore, data from the lower atmosphere would require alternate data to separate vapour pressure and temperature traces.

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[9] Implemented through a United Nations private sector consortium consisting of UNOPS, UNITAR and several private companies involved in satellite image distribution and analysis and geographical information management, UNOSAT became operational in 2002. The objective of UNOSAT is to encourage, facilitate, accelerate and expand the use of accurate geographical information derived from Earth observation satellite imagery for United Nations entities involved in humanitarian aid and development assistance projects. By providing services for updated and accurate geographical information and promoting universal access to products derived from satellite imagery through the Internet and multimedia tools, UNOSAT contributes to the physical planning process for local authorities, project managers and field operators working in disaster management, risk prevention, peacekeeping operations, environment rehabilitation, post-conflict reconstruction and social and economic development.

[10] The description is an excerpt from the *World Weather Watch, Technical Report No. 20, Observing Systems Technologies and their Use in the Next Decade, WMO/TD No. 1040.*

225. The Global Positioning System Occultation Sensor (GPSOS) will measure the refraction of radio-wave signals from the GPS constellation and GLONASS. This uses occultation between the constellation of GPS satellite transmitters and receivers on LEO satellites. The GPSOS will be used operationally for spacecraft navigation, characterizing the ionosphere, and experimentally to determine tropospheric temperature and humidity. A similar system, GPSMET, flew in 1995. A GPS occultation system was recently provided for launch on the Oersted/Sunsat mission and variations will also be included on CHAMP, SAC-C and GRACE, all scheduled to be launched before 2001. NOAA is planning to manifest a GPSOS on all NPOESS platforms.

226. The European Polar-orbiting Satellite (METOP), due to be launched in 2004, will fly a GPS Radio occultation Atmospheric Sounder (GRAS). GRAS will provide 'all weather' temperature profiles with high vertical resolution in the upper troposphere and stratosphere, and humidity profiles in the lower troposphere.

227. 227. A promising research GPS system is COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate). The National Space Program Office (NSPO) in China, the University Corporation for Atmospheric Research (UCAR), the Jet Propulsion Laboratory (JPL), the Naval Research Laboratory (NRL), the University of Texas at Austin, the University of Arizona, Florida State University and other partners in the university community are developing COSMIC, a project for weather and climate research, climate monitoring, space weather, and geodetic science. COSMIC plans to launch eight LEO satellites in 2002, each COSMIC satellite will retrieve about 500 daily profiles of key ionospheric and atmospheric properties from the tracked GPS radio-signals as they are occulted behind the Earth limb. The constellation will provide frequent global snapshots of the atmosphere and ionosphere with about 4000 daily soundings. (See web site, "http://www.cosmic.ucar.edu/cosmic/index.html")

D. International Organisations

228. The ~~European Union~~ ***EU*** is raising awareness and promoting GNSS through a variety of activities and instruments linked mainly to the GALILEO programme. These include promotion of the technology at high political level by the European Commission and the European Parliament.

229. At user level the European Commission contributes to the work of the standardisation and user organisations, GALILEO user forums, sponsoring of GNSS conferences, through EC publications, the GALILEO newsletter and the GALILEO website (http://europa.eu.int/comm/dgs/energy_transport/GALILEO).

230. At scientific and industrial level the EU finances extensive research and development activities in co-operation with ~~the European Space Agency~~ ***ESA***. A number of non-EU countries have participated in these activities.

231. The GALILEO Joint Undertaking will gradually take over and expand many of these activities particularly in end-user, industrial and scientific arena. The regulatory and international policy activities remain with the European Commission.

232. On a technical level the European Commission and the European Space Agency have performed demonstrations and tests of EGNOS services in various parts of Europe and in Africa together with local authorities. More of these activities will follow in other continents.

European Group of Institutes of Navigation (German Contribution)

233. The European Group of Institutes of Navigation (EUGIN) is an international association, with scientific and educational purposes. More precise, the objectives of EUGIN are:

- Consultancy and advice to European institutions in the fields of navigation, traffic management and related communication and training;
- ***To favour,*** by whatever methods are possible, actions assisting in the development of pan European policies and strategies in the general field of navigation and traffic management and in particular in the emerging field of satellite navigation;
- Foster cooperation and information exchange between its members and any competent authorities or organisations active in the above-mentioned fields of expertise;
- Provide information in its field of expertise to the public by organising conferences and symposia; publishing books and papers; and participating in electronic methods of data dissemination; ***and***
- In general, to undertake anything which has a bearing directly or indirectly in whole or in part on EUGIN's objectives as given here, or which would be liable to facilitate or aid their realisation.

234. Member institutes of EUGIN are: French Institute of Navigation (IFN), German Institute of Navigation (DGON), Italian Institute of Navigation (IIN), Netherlands Institute of Navigation (NIN), Nordic Institute of Navigation (NNF), Royal Institute of Navigation (RIN), Austrian Institute of Navigation (OVN), Spanish Institute of Navigation (INAVE) and the Swiss Institute of Navigation (SION)

International GPS Service

235. The Global Positioning System (GPS) provides unprecedented potential for precise ground and space-based positioning, timing and navigation anywhere in the world. Extremely precise use of GPS, particularly for Earth Sciences applications, stem largely from activities of the International GPS Service (IGS) established in 1994. More than 200 organizations in 80 countries contribute daily to the IGS, which is dependent upon a cooperative global tracking network of over 350 GPS stations. Data is collected continuously and archived at globally distributed Data Centers. Analysis Centers retrieve the data and produce the most accurate GPS data products available anywhere, e.g., GPS orbits at the 3-5 cm level 3D-wrms, sub-centimeter station positions, velocities at the millimeter level and time transfer at the sub-nanosecond level. IGS provides users easy access to the precise international terrestrial reference frame (ITRF), generated in partnership with the International Earth Rotation and Reference System (IERS) and other complementary geodetic techniques such as satellite laser ranging, and very long baseline interferometry. Since 1998 the IGS operates a pilot project based on a sub-network of GLONASS stations. Analysis Centers produce the precise relation between the GPS-GLONASS systems and the best orbits for the GLONASS constellation, ~ 25cm 3D-wrms. IGS plans to incorporate ***GALILEO*** signals when they become available in order to derive the greatest scientific benefit from combined GNSS ***applications***.

236. IGS data and data products are made accessible to users reflecting the ***commitment of the*** organizations to an *open data policy*. The IGS serves many thousands of users and is viewed as very successful scientific federation and a model of international cooperation. IGS is a recognized scientific service of the International Association of Geodesy (IAG).

(SEE BIPM CONTRIBUTION)

Bureau International des Poids et Mesures (BIPM)
The BIPM is located at Sèvres, in the outskirts of Paris (France). The task of the BIPM is to ensure world-wide uniformity of measurements and their traceability to the International System of Units (SI). It does this with the authority of the Convention of the Metre, a diplomatic treaty between fifty-one nations, and it operates through a series of

Consultative Committees, whose members are the national metrology institutes of the member states of the Convention, and through its own laboratory work. The BIPM carries out measurement-related research. It takes part in, and organizes international comparisons of national measurement standards, and it carries out calibrations for Member States.

The International System of Units (SI): The 11th Conférence Générale des Poids et Mesures (1960) adopted the name Système International d'Unités (International System of Units, international abbreviation SI), for the recommended practical system of units of measurement. The 11th CGPM laid down rules for the prefixes, the derived units, and other matters.

The base units are a choice of seven well-defined units which by convention are regarded as dimensionally independent: the metre, the kilogram, the second, the ampere, the kelvin, the mole, and the candela. Derived units are those formed by combining base units according to the algebraic relations linking the corresponding quantities. The names and symbols of some of the units thus formed can be replaced by special names and symbols which can themselves be used to form expressions and symbols of other derived units.

The SI is not static but evolves to match the world's increasingly demanding requirements for measurement.

Scientific activities: The scientific work at the BIPM centres on seven principal topics: length, mass, time, electricity, radiometry and photometry, ionizing radiation and chemistry. In addition, a small activity is maintained in thermometry and in the measurement of pressure and humidity to meet the internal needs of the BIPM laboratories.

Using global navigation satellite systems in the construction of TAI
The Time Section of the BIPM calculates and disseminates the two conventional time scales, International Atomic Time (TAI) and Coordinated Universal Time (UTC). Both scales are elaborated on the basis of clock data from laboratories world-wide distributed.

A network of stations is organised to allow distant clock comparison. Two methods are used at present in TAI to compare remote clocks: time transfer by using the constellation of Global Positioning System (GPS) satellites, and two-way satellite time and frequency transfer (TWSTFT). Research work is conducted at the Time Section to improve the quality of the time links. The BIPM, jointly with the International GPS Service (IGS) investigate the utilisation of geodetic-type receivers in TAI. Time transfer by using GLONASS satellites is also under study.

International Atomic Time is the uniform time scale calculated at the Time Section of the BIPM since 1988. The unit of TAI is the second of the International System of units (SI), defined as a fraction of the period of an atomic transition; it is realized on the basis of the measurements reported by laboratories operating primary frequency standards.

GNSS have a key role in time dissemination and in clock comparison. The navigation message broadcast by the GPS satellites provides the access to precise time. The GPS time is the time scale elaborated by combining the ensemble of clocks operating for that purpose, it is steered to UTC(USNO), one of the best local representations of UTC.

Methods to compare distant clocks are necessary to calculate the clock differences which are the base of the computation of TAI. In the last decade the time community has largely exploited the Global Positioning System (GPS) satellites for time transfer using receivers *adapted for time comparisons. In 1981 the first GPS time links were introduced in TAI. The technique, still in use today, was the GPS common-view single channel C/A-code. It allows time comparison with an uncertainty of one part in 10^{14} for average times of a few days. The stability reached by TAI for periods of a month is of two parts in 10^{15}.*

In the last years multi-channel GPS and GPS-GLONASS receivers have been commercially developed. The stability of time transfer increases in a factor of about three when multi-channel satellite observations are used. GLONASS P-code signal has always been available to civil users; it has been demonstrated that it reduces the noise level by a factor of about five relative to GPS C/A-code time comparisons.

The GPS carrier-phase technique allows frequency comparison at a level of one part in 10^{15}, and it will be a useful tool in accurate time transfer after some remaining problems be investigated and solved.

The technique of two way time and frequency transfer by telecommunication satellite (TWSTFT) has been largely investigated; it has at least the same performance than the GPS time transfer techniques used in TAI.

Present organization of time links

The establishement of TAI and UTC is based on atomic clock data coming from world-wide distributed laboratories, and therefore it is strongly dependent on the means of time comparison. The international time scales computed at the BIPM are based on data of some 220 clocks located in about 50 time laboratories world-wide distributed. The quality of clocks participating in TAI evolved in the last decade, with the development of more precise caesium commercial clocks. Caesium clocks of the new-type are stable in about one part in 10^{14} over periods of a day. Very accurate methods of time transfer are necessary such that the comparison does not degrade the accuracy of the atomic clocks.

The present organization of the international time links at the BIPM is based on two time comparison techniques: common-views on GPS satellites and TWSTFT.

The introduction of GPS into time transfer in the 90's led to an improvement of one order of magnitude or more with respect to other methods used at that moment for clock synchronisation. Clock comparison plays a key role in the elaboration of the international time scales. Clocks situated at distant laboratories, spread all over the world, can be compared with an uncertainty of several nanoseconds by using GPS. About 80% of the clock comparisons for TAI are exclusively done by using the clocks on board GPS satellites, the 20% remnant being provided by another technique, with the corresponding time link by GPS as a backup.

The GPS common-view method is used in the calculation of time links at the BIPM. In the common-view technique, two stations simultaneously observe the same GPS satellite. Both stations record the difference between each local clock and GPS time at the same instant and using the same clock on board the satellite in common view. When making the difference of records in both stations the contribution of the satellite clock vanishes, not biasing with its errors the time comparison. At present, GPS C/A-code common-views allow to obtain 2-10 ns level in time synchronization. The common-view method reduces some uncertainties of physical origin and, a factor which was relevant until the middle of 2000, it cancelled the deliberate degradation introduced in GPS time (Selective Availability); this degradation was eliminated on 2 May 2000.

GPS observations are dependent on the effects of the propagation medium on the signal. One channel GPS C/A-code time receivers track one satellite at a time. As the C/A-code is transmitted in only one frequency, there is no possibility to determine the delay *introduced by the propagation of the signal along the ionosphere. A few dual frequency receivers exist, leading to measurements of the ionospheric delay along the line of sight of satellites with uncertainties at the 1 ns level. Much progress has been done by using the International GPS Service (IGS) products to correct GPS data. All the GPS common-views in TAI are at present corrected by using the IGS total electron content (TEC) maps and precise satellite ephemerides.*

The BIPM establishes and distributes twice a year schedules for the observation of GPS satellites. These schedules are necessary to organize the common-views which are the basis of the clock links.

The development of multi-channel multi-code receivers permits to increase in an order of magnitude the number of observations with respect to the single-channel mode, and to eliminate the ionospheric delay. Multi-channel C/A-code receivers observe all GPS satellites in view using 13-minute tracks every 16 minutes at the standard hours. No GPS schedule is necessary to programme the observations since the receiver automatically tracks all satellites in view. Data is stored in a single file with a standardized format. Under this constraint, the number of satellite tracks increases by a factor of 10 with respect to the number of single-channel common-view tracks. This implies an improvement in the quality of time and frequency transfer. However, multi-channel observations may be subject to systematic variations. Environmental conditions affect receivers by imposing systematic effects. Temperature stabilized antennas (TSA) have been developed at the BIPM and are now commercially available.

TWSTFT is a technique that allows the comparison of two distant clocks by using as transponder a geostationary telecommunications satellite. The theoretical precision expected in time transfer is of several hundred picoseconds. Both laboratories need to be equipped with emitting-receiving stations and modems.

The network of clock comparisons at the BIPM is at present supported by common views on GPS satellites and by links using TWSTFT.

Future prospects

The stability of the atomic time scale has been improved due to the replacement in most laboratories of the old caesium clocks by the more high-performance new-type ones. The algorithm used in the calculation of TAI assigns relative weights to participating clocks, thus assuring that the stability is highly dominated by the best clocks. Primary frequency standards measurements are used to evaluate the departure of the scale unit of TAI relative to the SI second; they are either excellent commercial caesium clocks or clocks developed at some laboratories which have long-term stability. Time transfer techniques need to be accurate enough for the comparison of precise clocks. GPS C/A-code single-channel and multi-channel common views plus TWSTFT are used to compare the clocks participating in TAI, leading to a stability of about 2 parts in 10^{15} for periods of about one month.

Clock comparison by using the GLONASS satellites could be used in TAI in the future provided that the Russian satellite constellation be complete and stable.

When using multi-channel GPS/GLONASS receivers the number of common views increases in a factor of 20 with respect to single-channel one system mode. Both GPS and GLONASS observations can be combined, provided that the differences between the systems are minimized. At the basis, the two systems adopt different references for space and time. While GPS is steered on UTC(USNO), GLONASS relies on UTC(SU). The terrestrial frames respectively adopted (ITRF for GPS and PZ-90 for GLONASS) differed up to 20m. Following the recommendations of the International Committee of Weights and Mesures (CIPM) in

1996, efforts have been done to synchronise GLONASS time reference as close as possible to UTC , and to bring GLONASS terrestrial references in conformity to the ITRF.

Using the precise code transmitted by the GLONASS system in a single channel mode, a stability of about 200ps could be achieved. This value is reduced by a half when operation in multi-channel mode on short baselines.

Glonass P-code has two clear advantages. The chip length being 1/5th that of GPS C/A-code allows more precise pseudo-range measurements. As the precise code is transmitted in both L1 and L2 frequencies, the ionospheric delays can be precisely determined.

The BIPM expects, in the future, to take advantage of the existence of independent global navigation satellite systems to have redundant clock comparisons and thus making them more reliable. The GLONASS satellites cannot be at present officially used for the construction of the international time scales since the system does not completely satisfy the stability required for the purpose. Studies are undertaken at the BIPM concerning the utilisation of GLONASS precise-code for clock comparison. GALILEO will certainly bring much improvement to the international time links for TAI.

E. UN Programme on Space Applications

237. The Office for Outer Space Affairs of the United Nations Secretariat is responsible for planning and managing the United Nations Programme on Space Applications. The Programme was established in 1971 to create awareness of policy makers and interested government agencies of the benefits that could be derived from space applications. The Programme also developed training and education programmes to enable officials from developing countries to gain practical experience in these applications. The mandate of the Programme was expanded by the Second and Third United Nations Conferences on the Exploration and Peaceful Uses of Outer Space, held in Vienna, Austria, in 1982 (UNISPACE 82) and 1999 (UNISPACE III), respectively. The activities of the Programme on Space Applications are funded by regular budget of the United Nations and voluntary contributions through the Trust Fund for United Nations Programme on Space Applications.

238. The overall strategy of the Programme is to concentrate on a few themes of major importance for developing countries and to establish objectives that can be achieved in the short and medium term***s***. For each theme, individual activities will build on the results of previous activities aimed at achieving concrete results in a period of two to five years. The use and applications of global navigation satellite systems is one of such themes of focus of the Programme.

239. With the funds provided by the Government of the United States of America, the Programme organized ~~the~~ ***a*** series of four regional workshops and one international expert meeting on the use and applications of global navigation satellite systems in 2001 and 2002. The regional workshops were held in Kuala Lumpur, Malaysia, in August 2001, Vienna, Austria, in November 2001, Santiago de Chile, in April 2002 and Lusaka, Zambia, in July 2002. Each of the regional workshops aimed to bring the benefits of the availability and use of the GNSS signals to the awareness of decision-makers and technical personnel from potential user institutions and service providers in the private sector, particularly those in developing countries. Each workshop also aimed to identify actions to be taken and partnerships to be established by potential users in the respective region to integrate the use of GNSS signals in practical applications ***in order*** to protect the environment and ~~to~~ promote sustainable development. The results of these workshops and their recommendations were reviewed at the international meeting of experts on GNSS held in Vienna in November 2002.

240. Within the framework of the Programme on Space Applications, the Office intends to provide technical assistance, within the limit***s*** of its resources, in initiating and supporting the pilot projects resulting form the above series of regional workshops and the international meeting.

F. Other Entities

The German Institute of Navigation (DGON)

241. In Germany, ~~a lot of~~ ***many*** conferences in relation with ground-based (e.g. Loran-C) and satellite-based navigation (e.g. ***GALILEO***) take place every year. Technical issues and navigation application***s*** are in the center of interest of the numerous presentations and discussions. One institute which organises navigation conferences should be ~~named~~ ***mentioned*** here: The German Institute of Navigation (DGON). DGON is working as a German umbrella association for several conferences.

242. The German Institute of Navigation (DGON) (www.dgon.de) is a non-profit making organisation of public interest. The institute was founded in 1951. Its main objectives are:

- ***A***ssistance of scientific activities related to navigation and position finding; ***and***
- ***S***upport of research & development activities

243. Finally, the provision of opportunities to present and introduce new applications in the field of navigation, localisation and positioning ***are also part of the Institute's supporting activities***. This is to advance and to offer practicable contributions for improving safety and economy of maritime, air, land, space and inland waterway traffic and adherent means of communication, including telematic, radar, transponder, gyro and robotic engineering.

The Italian Institute of Navigation (IIN)

244. The Italian Institute of Navigation (IIN) (www.iin.it) is a***lso a*** non-profit making organisation of public interest. The institute was founded in 1959. Its main objectives are to promote the development of navigation sciences and technologies and disseminate the knowledge ***related to such fields***. ~~of them.~~

245. To these aims, the Institute fosters co-operation between End Users, Industries and Research Institutes.

246. The Italian Institute of Navigation takes active participation ~~to~~ ***in*** European and International initiatives in the fi***el***d of navigation. It is ***a*** member of EUGIN – The European Group of Institutes of Navigation, and ***it*** is ***also a*** member of IAIN – The International Association of Institutes of Navigation. The Institute takes active participation ~~to~~ ***in*** the works of ICAO and IMO.

247. The Italian Institute of Navigation ***actively*** promotes ***c***onferences in relation to ***n***avigation every year.

IV. GNSS APPLICATIONS

A. General Applications

248. The core constellations of GNSS (GPS and GLONASS) are being used in a variety of applications. Some of the most promising areas of applications are:

- Aviation
- Car ***n***avigation
- Tracking
- Original Equipment Manufacturer (OEM)
- GPS cards
- Survey ***m***apping/GIS
- Marine
- Military
- Timing & frequency dissemination

249. There are many other areas in which ***the*** GNSS market is expected to grow significantly in the near future. These are:

- Mobile ***p***hones
- Development of ***i***ntelligent ***h***ighway system***s***
- Anti-***c***ollision systems in ***r***ailways and land transport
- Precision agriculture

Figures 2, 3, 4 to be added

250. The European GNSS markets in 1999 and 2005 (courtesy: ***GALILEO***) are shown in **[Figure 2 & 3]**. It is seen that, in future, the GNSS market will predominantly ~~consists~~ ***consist*** of the use of GNSS chipsets in mobile phones. GPS is currently the de-facto standard for satellite-based navigation services. The world market projections for GPS are shown in **[Figure 4]**. The GPS market in the year 2000 was worth US $ 8 billion, and in 2003 worth about US $ 15 billion. It is estimated that the world market for GNSS in the year 2005 would be in the vicinity of US $ 20 billion.

251. **[In Figure 4]**, the mobile phone component is missing. The use of GNSS in intelligent ***h***ighway ***s***ystems, ***t***rain collision avoidance systems and precision farming is expected to increase phenomenally after 2005. However, this component of the market is expected to remain concentrated in the developed countries.

Priority themes for use of GNSS Technology for social and economic development of developing countries

252. The existing core constellations from ***the*** U.S., ~~and~~ ***the*** Russian ***Federation,*** ~~and~~ the planned ***European GALILEO and*** space-segment augmentations by U.S., Europe, Japan, India and several other countries have provided an opportunity for the developing countries to use GNSS in various applications for improving the quality of life. Some of the applications are:

1. Use of GNSS chip-sets in mobile phones:

    - The GPS market in the year 2002 was estimated to be about US $ 13 billion. The largest component of sales has been in the ***c***ar ***n***avigation market so far. It is estimated that mobile phones would be equipped with position location chip-sets for emergency services; ***and***

- The mobile phone market for GNSS chip-sets is expected to dominate the sales in future. Many developing countries, where the density of mobile phones is low, are estimated to benefit ~~by~~ ***from*** these new phones which are equipped with position location facilities.

2. Modernisation of the Airspace:

   - ~~To choose~~ ***Selection of*** appropriate technology (SBAS, GBAS etc.) for a given developing country, consistent with the ICAO CNS/ATM regional plans;
   - ***Decision by d***eveloping countries ~~to decide~~ ***on*** the extent and scope of cooperation with the existing and planned constellations; ***and***
   - ~~To assist~~ ***Assistance to*** the developing countries in implementing the ground segment accordingly.

3. Use of GNSS for intelligent vehicle highway systems:

   - Use of GNSS ***t***echnology in ***r***ailway safety as anti-collision systems;
   - Navigation of other land mobile systems together with mobile phones; ***and***
   - Inexpensive ***w***agon tracking and car navigation systems.

4. Meeting the needs of emergency and natural disaster mitigations.

5. ~~Accurate farming~~. ***Precision agriculture.***

6. Applications of GNSS in other lands (car navigation) and marine-based applications.

7. Advancement in other areas of scientific endeavour where navigation techniques can be used such as accurate weather predictions and ***E***arth sciences applications.

8. Timing and frequency transmission for telecom applications.

B. Applications Predominant in Specific Regions

1. [Europe, ***North and Latin America, and the Caribbean***]

253. There is a large and increasing number of satellite positioning and navigation applications in the Eastern and Central European region. The summary of activities given below is by far not exhaustive, rather indicative of the variety by topics and countries. This compilation is largely based on the presentations given at the 2nd UN/USA Regional Workshop on the ***Use and Applications of Global*** Navigation Satellite Systems ***(GNSS) for the benefit of countries in Central and Eastern Europe***, held in Vienna, Austria, ~~in~~ ***from 26 to 30*** November 2001.

254. There is a wide range of existing applications of GNSS in *environmental monitoring*. Among the examples, an air pollution information system ~~is~~ ***has been*** developed in Austria using mobile air quality measurement sites. In Azerbaijan, aircraft experiments are conducted to monitor the critical environmental zones. Land and water bodies are also generally surveyed with GNSS in many countries. Radon field mapping is assisted by GNSS in Slovakia, as well as mapping of climate phenomena. In Hungary, sites of regular soil monitoring are re-occupied using GNSS measurements. ***In addition, to ensure that the system works without interference,*** the radio interference affecting GNSS signals is also investigated.

255. *Agricultural applications* include ***monitoring of*** crop and soil ***as well as*** surveying the fertility of agricultural fields in order to control the application of chemicals and fertilizers.

For example, a GNSS-assisted agricultural monitoring programme on the field scale is going on ~~e.g.~~ in Romania.

256. There is a widespread use of GNSS in the field of *transportation* in this region as well. This includes car navigation, fleet management, journey data logging, car theft reconnaissance, road and railroad surveys, airport surveys, flight navigation, air traffic control, etc.

257. The GNSS (GPS) technique revolutionized the way in which *geodetic measurements* are made. Nowadays, national, regional and global geodetic reference networks are based largely on GNSS measurements. In Hungary, as an example, the GPS-based horizontal land surveying reference network consists of more than 1100 point marks. A ***particular*** technology ~~is~~ ***has been*** developed and now routinely applied for the densification of the levelling network as well. The ***S***tate land surveying authority is building up and maintaining a national reference network of permanently operational GNSS stations. The GNSS technique is also successfully used in ***S***tate border surveys.

258. The *regional cooperation* on the use of GNSS (GPS) technique for high-precision geodetic and geophysical applications has a long-standing tradition in Eastern and Central Europe. Within the framework of the *Central European Initiative (CEI)*, Working Group "Science and Technology", Section C "Geodesy", a project called Central Europe Regional Geodynamics Project (CERGOP) was launched as early as in 1993. The 14 participating countries (Albania, Austria, Bosnia-***Herzegovina***, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, Poland, Romania, Slovakia, Slovenia and Ukraine) realized that the new global space geodetic technique provides a unique opportunity to integrate the geodynamic research in the region, both the reference network (the Central European GPS Geodynamic Reference Network, CEGRN) and the scientific data reduction and interpretation methodology. The main objectives of CERGOP were to investigate the present-day geotectonic features in the Central European region, and to provide a stable reference network for smaller-scale (sub-regional or local) deformation studies.

259. The first phase of CERGOP was concluded in 1998. However, due to the success of the collaboration and the long-term nature of the geotectonic processes, the project is being continued. At present, ***the Consortium for Central European GPS Geodynamic Reference Network (CEGRN)*** contains 63 geodetic sites, ~~among them~~ ***with*** 29 ~~are~~ permanent GPS stations distributed in the participating countries. The network is re-measured at least once in every 2 years. Now, data from 6 monitoring campaigns are available. The measurements are conducted and analyzed with the highest possible precision. The first scientific analysis of GPS data between 1994 and 1997 provided a RMS repeatability of around 2 mm in the horizontal and 5-6 mm in the vertical component of the site positions for each of the four observing campaigns. According to the results concerning the present-day tectonics of the region, the northern part of Central Europe seems generally stable since the velocities are under 2 mm per year. The southern sites close to the plate boundary zone, however, show displacements of several mm per year.

260. In 2001, representatives of 13 Eastern and Central European countries signed the Memorandum of Agreement of the CEGRN Consortium *(www.fomi.hu/cegrn)*. As the new organizational structure of CERGOP, the Consortium is a non-profit organization of institutes that supports and promotes coordinated establishment and maintenance of CEGRN sites. ***It*** ~~monitoring~~ ***monitors*** the network by ***using*** GNSS (GPS) measurements on a permanent and regular basis, ***as well as*** the maintenance of a data centre and processing centres. The scientific work is divided between 13 study groups. By the establishment of the CEGRN Consortium, an organization that conforms to the European research policy trends, the participating countries would like to ensure the long-term continuation of the project. The CERGOP-2 project is now funded within the EU'***s*** ~~5th~~ ***fifth*** Framework Programme.

261. Considerable experience is gained with *differential GNSS* service in many countries of the region. Differential methods are used e.g. in the Czech Republic where the Technical University operates a reference station in Prague. The corrections are transmitted to the roving receivers via FM and long-wave radio. It is ~~realized~~ ***known*** that advanced national and regional DGNSS systems would significantly improve the positioning accuracy and boost the applications. To this end, the establishment of a multi-purpose GNSS reference network (EUPOS, European Position Determination System) is currently under consideration by an international working group of experts. The network would adopt the standards successfully developed in Germany for their SAPOS (Satellite Positioning Service) system.

262. In many countries, there is a need to increase the awareness of policy makers of the benefits of GNSS, and at the same time, to increase funding available to establish national infrastructure. ~~Also~~ ***Furthermore,*** the proper governmental organizational structure to deal with GNSS issues needs to be ~~found~~ ***established,*** which is sometimes difficult due to ~~their~~ ***the*** multi-disciplinary nature ***of GNNS issues***. In Austria, as a good example, satellite navigation activities are coordinated and managed by the *GALILEO Contact Point Austria (www.galileo-austria.at)* established at the *Austrian Space Agency (ASA, www.asaspace.at)*, and by the *Austrian Institute of Navigation (OVN, www.ovn.at)*. A national testbed – the *Austrian Radionavigation Technology and Integrated Satnav services and products Testbed (ARTIST)* - has been established by the *Federal Ministry of Transport, Innovation and Technology (BMVIT)* in order to demonstrate through pilot projects the value of navigation services of the European GALILEO satellite system to be operational by 2008. Through the ARTIST Programme, various application areas will be demonstrated and evaluated with respect to their innovative character and profitability. In particular, the objectives of ARTIST are to test and establish new and promising market segments for satellite navigation applications, to increase the awareness of the capabilities of satellite navigation applications in general, and to stimulate Austrian institutions to increasingly participate in the international navigation applications networks. All Austrian institutions related to navigation and its applications are encouraged to participate in the ARTIST Programme.

263. The main topics of the ~~1st~~ ***first*** "Call for Proposals" opened in April 2002, funded by the BMVIT with an amount of € 2.000.000, were: fleet management, including all modalities and inter-modalities, ~~and~~ agriculture and forestry. The large number of project proposals received (22) was an impressive response to the efforts of the BMVIT to support and strengthen the navigation market in Austria. The duration of the projects shall be approximately one year. Thus, it will be possible to evaluate the project findings and results within a reasonable timeframe to initiate follow-up activities in the most promising areas. In addition to the Call for Proposals, participants were invited to elaborate ideas in the area of satellite navigation, its applications and value-added services. The ideas were not bound to the main topics of the Call for Proposals, but were open to address all areas where satellite-based navigation is expected to play a major role. The project proposals and ideas received by the GALILEO Contact Point Austria are to be evaluated by an international expert committee. A ~~2nd~~ ***second*** Call for Proposals with focus on applications in the areas of tourism and search and rescue is planned to open in mid 2003.

264. The regional activity in the field of GNSS is reflected in various *conferences*. From 1991 to 1999, biennial scientific symposia titled "GPS in Central Europe" were held in Hungary with participants from the region and ~~beyond~~ ***other areas***. The topics covered included geodesy, height determination, geodynamics, reference frames, meteorology, differential GPS, instrumentation, data analysis techniques and several others. The proceedings of the symposia were published by the Satellite Geodetic Observatory of the Institute of Geodesy and Cartography, Hungary *(www.sgo.fomi.hu)* and the Institute of Geodesy and Geodetic Astronomy, Warsaw University of Technology, Poland *(gik.pw.edu.pl/igga.html)* in the Reports of Geodesy series.

265. Another important event in Austria was the holding of the European Navigation Conference ***on*** Global Navigation Satellite Systems, ***hosted by OVN on behalf of EUGIN, from 22 to 25 April 2003 at the Congress Centre in Graz, Styria*** (ENC – GNSS, *www.gnss2003.com*). ***The*** ENC – GNSS 2003 was the seventh conference in the GNSS series held under the auspices of the European Group of Institutes of Navigation (EUGIN). ~~The conference was hosted by OVN on behalf of EUGIN and took place from 22-25 April 2003 at the Congress Centre in Graz, Styria.~~ The conference focused on the actual status as well as on future developments in satellite navigation systems, with special emphasis on GALILEO.

Italy

266. In Italy, the use of satellite-based navigation systems is ***continuously*** growing in the various transport sectors: civil aviation, maritime and ground (road and rail) as well as in ~~a~~ numerous fields of "non-transport" applications such as geodesy, agriculture, GIS, and RTK.

267. The Italian Ministry of Transport, based on the promotional activities conducted by the Italian Space Agency and the Italian Institute of Navigation, has undertaken an attempt to promote the debates for a national Radio Navigation Plan, allowing to coordinate radio navigation systems on the territory in a harmonised and cooperated fashion.

268. The Italian Space Agency (ASI- www.asi.it), ***being one of the major contributors to the European Programme GALILEO,*** is fostering the development of Applications of Satellite Navigation in cooperation with Governmental Operational Entities (ENAC, ENAV, Italian Coast Guard.) in order ~~also,~~ to pave the way for GALILEO. ~~being one of the major contributors to the European Programme.~~

269. As far as the Reference Networks for precise positioning is concerned, the Italian Space Agency is owner of ***the*** main network in Italy, which is part of an international geodesy network.

1. Research Activities ***(Move paragraphs 352 to 357 to "IV. GNSS Applications, B. Applications Predominant in Specific Regions")***

352. [~~***In Western Europe,***~~ The use of GPS techniques in Portugal go back to the ***eighties***, ~~80´s~~, when a large observation campaign was organised by the Faculty of Sciences, University of Porto, in co-operation with the Geodetic Institute, University of the Armed Forces ***of*** Munich, to monitor plate-tectonic movements in the Azores-Gibraltar area ***(http://www…)?]***

353. Since then, many research projects have been carried out, going from studies of plate tectonics and volcanism to the study of high atmosphere from on-board GPS measurements, passing by different projects on Earth, including navigation and attitude determination and control. In some cases, besides GPS, also the GLONASS system has been used. As a result, a large number of scientific papers ~~were~~ ***have been*** published and several Ph.D. ***t***hesis ~~were~~ ***have been*** written in Portuguese Universities as well as in Research Institutes. At present, attention is also ~~been~~ ***being*** given to the development of GNSS and GALILEO.

2. Services

354. The Portuguese Geographical Institute, ~~the Portuguese Institute~~ responsible for ***g***eodesy and ***m***apping, has been using GPS in different applications. The establishment and ***maintenance of a permanent GPS network for EUREF as well as the dissemination of the data*** ~~***is***~~ ***also falls under its*** ~~his~~ responsibility (http://www.igeo.pt).

355. ~~Also~~ ***Similarly,*** the Military Geographical Institute (http://www.igeoe.pt) and the Hydrographical Institute (http://www.hidrografico.pt) have current applications with GPS.

3. Other Activities

356. ***In Portugal,*** GPS is widely used in different fields, both by public institutions as well as by private firms. In areas like environment, forestry, ***E***arth resources, mapping, navigation, fleet management and control, dam monitoring, etc., GPS is a technique of fundamental importance, giving rise to a considerable market of GPS equipment. All of the main trademarks are represented in the country.

357. Since Portugal is a member of the EU and ESA, particular attention is being given to all the development phases of GALILEO.

2. [Latin America and the Caribbean]

Argentina

270. In the late seventies, activities related to GNSS started in Argentina. Most of these activities have been developed at La Plata National University (Universidad Nacional de La Plata), in its Faculty of Astronomical and Geophysical Sciences (FCAGLP).

271. The contribution of the astronomers and geodesists of the FCAGLP covers several aspects of the GNSS work: scientific research, training, development and transfer of "know-how", practical applications.

272. This ***section of the*** report summarizes the contribution of two groups at the FCAGLP to GPS work:

1. Satellite Geodesy Group (SGG), particularly oriented ***towards*** the practical applications of GPS; ***and***

2. Georreferenciación Satelital (GESA) (Satellite referencing on the Earth), ***which*** ~~developing~~ ***develops*** research work on GPS, ~~organizing~~ ***organizes*** lectures, courses and seminars ***and is also*** very acquainted with education at the university ***level*** (pre and post-degree levels).

1. Satellite Geodesy Group (SGG)

273. The activities of the group are concentrated on two regions of the country: Tierra del Fuego, the island in the far ***S***outh of the ***A***rgentin***ean*** territory, and the Province of Buenos Aires, on the Rio de La Plata.

Tierra del Fuego

274. In 1993, the first ***A***rgentine***an*** provincial network was built ***up***, measured and calculated by the SGG in Tierra del Fuego. ~~the island at the extreme south of Argentina.~~ This network has been used to develop a GIS in a modern geodetic frame***work*** in cooperation with the Tierra del Fuego Geodetic Service.

275. This network has been measured several times to detect tectonic movements. In 1999 the first signal of displacements between the Scotia and the South American plates was reported by the SGG (see publicat***i***ons and reports).

276. At ~~the moment~~ 2002 the network ~~is~~ ***was*** being expanded to improve the resolution of

these results. In 1999, the Geographic Military Institute established the first levelling line in Tierra del Fuego. A cooperation agreement was carried out to measure this line with GPS in the frame***work*** of the province network. The differences between mean sea level heights and GPS ellipsoidal heights allowed the SGG to obtain valuable information on the geoid behaviour in the Tierra del Fuego region. However, the spatial distribution of this data is quite poor because there are large regions difficult to reach.

277. This year (2002) a cooperation ***programme*** with the University of Dresden (Germany) ~~started~~ ***was launched***. The project will use the Fagnano lake surface as a gigantic level measuring with GPS in special buoys, together with tide gauges information. These new measurements will significantly improve the Tierra del Fuego geoid model.

278. It is also important to note that a permanent GPS station is operated in Rio Grande (IGS-riog) by SGG in cooperation with the GFZ (Germany).

Buenos Aires

279. ***The*** Buenos Aires province is the richest region of Argentina. Its surface is comparable to that of Germany. In 1977, La Plata University and the ***G***overnment of the Province of Buenos Aires signed an agreement to establish a high precision GPS network in the province. The task was achieved by the SGG working in cooperation with the local geodetic service.

280. In 1998, a first network containing 200 points was finished and recently (2002) a densification was carried out adding 100 new points. This network was developed using the same marks of the national levelling network allowing the direct determination of a ***centimetre*** accurate geoid model for the region. In 2000, the Buenos Aires geodetic service established the obligation to refer all the rural parcels to this network as a first step for a local GIS.

281. It is also important to point out that the first permanent GPS station in Argentina (IGS-lpgs) was installed in 1995 in this Faculty by the SGG in cooperation with the GFZ (Germany).

282. Other activities of the group:

- Measurements and process of about 300 sites along the ***A***rgentine***an*** coastline to define the 200 miles marine border by coordinates (in cooperation with the Hydrographic Naval Service);
- Cooperation in several scientific campaigns (SAGA in cooperation with GFZ, San Juan tectonic displacements with the San Juan National University, Central Andes Project for the Memphis University, etc.);
- Several GPS services (to georeference satellite images, photogrametric plates, to establish local reference frames, to validate GPS equipment, etc.); ***and***
- About 20 courses on GPS applications on different fields.

2. Georreferenciación Satelital (GESA)

283. The GNSS activities developed by the group GESA (Georreferenciación Satelital) in the last fifteen years in Argentina are described in this report. GESA is a group of ***the*** La Plata University specialized in the application of GNSS to scientific research, innovation and technology transfer to the private sector through ~~providing~~ ***the provision of high-quality*** services. Our activities are developed at the Faculty of Astronomical and Geophysical Sciences (FCAG, Facultad de Ciencias Astronómicas y Geofísicas) of the La Plata National University (UNLP, Universidad Nacional de La Plata). The group was created in 1988 and its first goal was

to spread GNSS techniques in the university and ~~in~~ the local surveyors. The first National Seminar on GPS was organized in 1988 with the cooperation of other members of the FCAG.

284. An important achievement has been the design of a national survey network with more than one hundred points based on the new techniques. This has been ***made*** possible thanks to an agreement between the Military Geographic Institute of Argentina (IGM, Instituto Geográfico Militar) and the American University consortium UNAVCO. The potentiality of this network interested the "Economic development and financial cleanse Project for the Argentine***an*** Provinces" (Proyecto de Saneamiento Financiero y Desarrollo Económico de las Provincias Argentinas). Such project asked GESA to perform the calculation and compensation of the net that became the present National Geodetic Reference System POSGAR 94 (IGM resolution 13/97).

285. Since 1992, members of GESA give lectures on GNSS in different regions of ~~our country~~ ***Argentina***. The attendees come mostly from universities and survey organizations. All the members of GESA participate in scientific projects undertaken in cooperation with prestigious universities and international research centres. Since 1994 GESA has established cooperation with the Institut f***ü***r Navigation (Stuttgart University, Germany), the Deutsches Geodätisches Forschungsi***ns***titut (M***ü***nchen, Germany; Observatoire de Paris (Paris, France), the ***Technische Universität*** (TU of ***Wien, at*** Vienna, Austria) and the Aeronomy and Radio-Propagation Laboratory Abdous Salam International Center for Theoretical Physics (ICTP), (Trieste, Italy). Several graduate and postgraduate students developed their Ph.D.s or their research work under the direction of GESA scientists. GESA members have a considerable experience providing technical services to official institutions and private enterprises by means of contracts.

Scientific Research - Terrestrial Reference Frame

286. Space Geodesy has contributed substantially to the study of our planet and to the comprehension of its physical processes. Examples of this are the geometry and kinematics of the solid Earth, the polar caps and the oceans, the irregularities of the Earth rotation and their relationship with the exchange of angular momentum between its inner components and bodies of the Solar System. Similarly, the temporal variations of the terrestrial gravity field due to the balance of masses that take place in the planet are also relevant. ~~These~~ ***This significant*** progress has been ***made*** possible thanks to the global system of observation supported by various organizations in many countries, under the coordination of the International Earth Rotation Service (IERS).

287. The primary goals of IERS are the establishment and maintenance of the Celestial Reference Frame (ICRF) and of the Terrestrial Reference Frame (ITRF) and the monitoring of the Earth Orientation Parameters (EOP). The IERS is supported by the operation of several international services that coordinate the observation programs and analysis of data from different observation techniques –Very Large Baseline Interferometry, VLBI; Satellite Laser Ranging, SLR; Global Positioning System, GPS and DORIS. Particularly relevant for us is the International GPS Service (IGS).

288. The products of the IGS are obtained from the observations collected by a global network formed by more than 300 Permanent Station***s*** (PS). The products are derived by seven global centres of analysis, with which collaborate five regional centers. The regional center for South America is administrated by the Deutsches Geodätisches Forschungsinstitut (DGFI). Since 1995 our group maintains a strong scientific cooperation with the DGFI. More than 200 institutions (among them the FCAG through GESA, the National Commission of Space Activities (Comisión Nacional de Actividades Espaciales-***CONAE***) and the National University of Salta) in more than 75 countries contribute to the IGS. Four Argentinean PS integrate the global network of the IGS: UNSA, CORD, LPGS and RIOG.

289. The ITRF has been expanded in the American continent thanks to the SIRGAS project (Rodríguez y Brunini, 2001). This project started in 1993 under the sponsorship of the IAG (International Association of Geodesy), the Pan American Institute of Geography and History (PAIGH) and the National Imagery and Mapping Agency (NIMA) from ~~USA~~ ***the United States~~.~~*** The activities are coordinated by three working groups:

1. Reference Systems: ~~which~~ ***whose*** objective is to establish a South American reference frame linked to the ITRF, including coordinates and velocities from all the stations;
2. Geocentric Datum: with task of increasing the number of stations in the SIRGAS frame in the Latin American countries; and
3. Vertical System: ~~which~~ ***whose*** aim is to establish a unique vertical frame for the whole continent.

290. GESA defined and calculated the National Reference Frame POSGAR 94, which ***was*** adopted in 1997 as the standard reference frame for Cartography and Geodesy in Argentina (Usandivaras et al., 1995). Later on, we linked it to the ITRF yielding the most precise and accurate geodetic reference frame available in Argentina nowadays, called POSGAR 98 (Moirano 2000). GESA also calculated the geodetic network of eight Argentinean provinces (Gillone and Brunini, 1999).

Earth *R*otation

291. The irregularities of the ***E***arth rotation have focused the interest of astronomers, geodesists and geophysicists from end of the ~~XVIIIth~~ ***eighteenth*** century (Kolaczek et al., 1999). In order to characterize these irregularities, five ***E***arth orientation parameters (EOP) are used: two of them describe the position of the instantaneous pole of rotation in the ITRF; one gives the velocity of rotation with respect to the celestial system; and the other two represent the direction of the instantaneous axis of rotation with respect to the celestial system. The EOP provide***s*** also the tie between the celestial and the terrestrial reference frames.

292. The study of the EOP constitutes an excellent ~~problem~~ ***challenge*** for geophysics because their variations offer important information of the interactions between the different components of the Earth system, that is to say, the atmosphere, hydrosphere, cryosfere and solid Earth. Its determination has practical applications for navigation and satellite positioning, for the study of the dynamics of the Moon by means of Lunar Laser Ranging, for the observations of extragalactic radio sources using precise VLBI and for maneuvers of interplanetary probes.

293. The temporal resolution of the EOP series obtained from VLBI and GPS is better than two hours. Using wavelets transform, we detect temporal variations of EOP at very high frequencies with periods between 5 and 8 hours (Fernández and Gambis, 2000). A resonant effect of the atmosphere could be the excitation source, but the exact origin of such effect is still under discussion.

294. We developed a new method to combine time series of ***E***arth rotation parameters (ERP). This method is based on an Extended Kalman Filtering considering the Earth rotation phenomena as a non-linear effect (Fernández, 2001). We obtained a new multitechnique combined ERP data time series that is in good agreement with all the combined series calculated by the International Services. An advantage of this solution is that it does not require the inclusion of any extra data like atmospheric angular momentum ***nor*** any smoothing process.

Sea Surface Topography

295. A lot of effort is centred ~~in~~ ***on*** the study of some natural phenomena that could indicate that the physical conditions of the ***E***arth's system are changing. The conditions, known as "global changes" are weather, oceanic and geophysical changes, which provoke the increase of ***the*** ***E***arth's average temperature, variations in average temperature of the seasons, in average values of regional rains, etc. A direct consequence of these changes could be the mean sea level (MSL) increase. For many years the MSL was assumed to remain constant and coincident with the geoid.

296. ~~Now~~ ***Up to today,*** it is known that both hypothesis are wrong (Bosch, 2002): on one hand, the MSL vary with time due to changes in the atmospheric pressure, the temperature, etc, and possibly due to the global change too; on the ~~an~~other hand, the MSL differs ~~of~~ ***from*** the geoid due to oceanic current, and it is consequently named sea surface topography (SST). Just to give examples, on East coast of South America maximum variations in the MSL of about -6 mm/year have been detected in the Caribbean and of about +10 mm/year on Uruguayan coast; the SST having changed approximately two meters from Caribbean to Antarctica.

297. The SST and its variations can be studied from satellite altimetry data (Topex-Poseidon, ERS, etc) or from time series of tide gauge records. The combination of both techniques is the key of this kind of study. The IGS has summoned the International community to participate in the pilot project TIGA (GPS Tide Gauge Benchmark Monitoring; http://op.gfz-potsdam.de/staff/schoene/TIGA_CfP.pdf), ~~which~~ ***whose*** principal objective is to establish a service of GPS stations continuously operating near the tide gauges and to detect systematic effects through analysis of their observations. These results will ~~unable~~ ***enable scientists*** to obtain reliable information about the vertical motion of the ***E***arth's crust .

298. In order to decouple from the tide gauge records the movements of the Earth***'s*** crust we have installed four permanent GPS stations (PS) (from 1998) near the tide gauge of Mar del Plata, Puerto Belgrano, Puerto Madryn y Puerto Deseado. From these data we have computed the first vertical velocity estimation of Earth***'s*** crust in some of the tide gauge involved (Natali et al., 2002).

Ionosphere

299. The ionosphere is the part of the upper atmosphere where the free electron density is high enough to disturb the propagation of radio frequency electromagnetic waves (Hargreaves, 1995). Free electrons are mainly produced by the photoionisation of neutral atoms and molecules of the atmosphere evoked by the UV solar radiation. ***However,*** ~~but~~ many complex physical phenomena in the solar-terrestrial environment participate in the production and loosing of electrons and in conditioning their spatial distribution and temporal variations.

300. The first studies that made use of GPS observations to determine empirical ionospheric models can be traced back to the late eighties. GPS can be considered now the most powerful means to study the ionospheric weather. Even if the ionospheric research has not been the objective of the IGS, one of the IGS products provides a real topography of this medium. The IGS maps of total electron content are of high quality and with a good global coverage.

301. We have developed an ionospheric model to analyse the total electron content from GPS observations (Brunini et al., 1998) and we have used it to study the geographic and time variability of this parameter at regional and global scales (Meza et al., 2002a, Brunini et al., 2002), and in quiet and perturbed geomagnetic conditions. We have also developed a three-dimensional topography of the electron density, using GPS ground and space receivers (Meza, 1999, Meza et al. 2002b).

Innovation, development and transference

302. In the last decade, the Argentine***an*** geodetic reference frame has substantially evolved, despite the difficulties of developing geodetic infrastructures in parallel by the individual provinces and the nation (Georgiadou et al., 1998). At the beginning of the nineties, those activities were decentralised by the creation of the program called "Programa de Saneamiento Financiero y Desarrollo Económico de las Provincias Argentinas", ***a program for financial monitoring and economic development of the Argentinean provinces***, supported by international credit allotted to the provinces. ~~On~~ ***During*** the last decade, the Ordnance Survey Offices from different provinces invested ~~a lot of~~ ***a large amount of*** money to establish traditional geodetic networks, with the purpose of eliminating the anarchy in land registry.

303. Until the mid-nineties the geologic, geodetic and geodesic surveys and the general cartography of Argentina were linked to the traditional geodetic network called Campo Inchauspe 69 (Rodríguez et al., 2002). The joint effort of IGM and GESA contributed to a new national geodetic network based on GPS measurements, named POSGAR 94 (Posiciones Geodésicas Argentinas de 1994) (Usandivaras et al., 1995). This new network is ten times more precise and a hundred times more accurate than the previous one (Campo Inchauspe 94); it was officially adopted in Argentin***a*** as the geodetic and cartographic standard (Disposición 13/97 del IGM).

304. The IGM jointly with GESA improved ***the*** POSGAR 94 network, by linking it to SIRGAS (Sistema de Referencia Geocéntrico para las Américas) and to the international system, ITRF. GESA was responsible ~~of~~ ***for*** ~~this~~ ***the*** calculation of this improved network, POSGAR 98, ~~which is more precise and more accuracy than the previous one~~ (Moirano, 2000).

305. ***Argentina*** has at present a "first order" reference frame (POSGAR 98), materialised by about ~~of~~ 130 points, with the addition of points in the different provinces with variable accuracy and precision, with a total of about 2000 points in the Argentine***an*** territory. GESA has also computed the fundamental geodetic net of the ~~following~~ three provinces Chubut, Río Negro and Tucumán and some mining geodetic networks.

306. POSGAR 98 is an excellent ***example of an achievement by*** ITRF ~~realisation~~, but its quality degrades with time. ***Unfortunately***, ~~since~~ we do not ~~dispose of~~ ***have available*** precise tectonic velocities to update the co-ordinates. The modern tendency to solve this trouble is to establish a "zero-order" reference frame materialized by a set of PS operating continuously ~~is~~. In the same way, it is possible to determine very accurate coordinates and tectonic velocities keeping thus the good quality of the reference frame.

307. Several PS have been installed in the country in the last years. ~~Nowadays~~ ***At the time of writing this report, there were approximately*** ~~they are about~~ 17 ***of them***.Most of the GPS receivers ~~came~~ ***were introduced*** by German and American scientific groups. ***Argentina contributes to this programme by providing the necessary infrastructure and the human resources*** by means of agreements with foreign scientific groups. ~~of,~~. Almost twenty local institutions participate in this enterprise with ~~a~~ different level***s*** of commitment.

308. GESA also has responsibility for six fully operative PS located at La Plata, Mar del Plata, Bahía Blanca, Rawson, Puerto Deseado and Río Grande. All of them are the result of the scientific cooperation of GESA with two German institutions: Deutsches Geodätisches Forschungsinstitut (DGFI) and the Geoforschung Zentrum Potsdam (GFZ).

309. Besides the scientific profit, those PS are used by different practical applications. All of them contribute to the Argentinean Network for Continuous Satellite Monitoring (Red Argentina de Monitoreo Satelital Continuo, R.A.M.Sa.C.). The Naval Hydrographic Service (SHN, Servicio de Hidrografía Naval) also uses the PS of Mar del Plata and Puerto Deseado. The surveying

group of Universidad Nacional del Sur utilizes the PS of Bahía Blanca. Finally, the Ordnance Survey and Territorial Information Office of the Province of Chubut (Dirección de Catastro e Información Territorial) uses the PS of Rawson.

310. The cooperation was achieved in the framework of inter-institutional contracts and agreements. Likewise, GESA actively contributes to the formation of human resources by giving lectures in meetings a***n***d courses organized by professional ***surveying*** councils ~~of~~ in the Argentine***an*** provinces as well as by universities. These activities allowed us to create an effective link with a wide sector of the community of users of the geo-positioning by satellite. On one side, we contribute to the dissemination of scientific knowledge among the users, particularly those concepts related to reference frames and coordinates management. On the other side, we grasp the urgent necessities of the users and orient a part of our activities to the development of procedures or technologies for users.

Future activities

311. Our present effort focuses on creating the synergy necessary to set up a group of dispersed potentiality in different universities, research institutes and many organisms with influence over the planning, the carrying out and the control of development policies. This proposal tends to achieve results in the national and international frame***work***, as well as in the scientific and technological domain.

312. In the international frame***work***, the goal is to create a Regional Centre of the IGS to contribute to the densification of the ITRS and to the development of the Tide Gauge Bench Mark Monitoring project (tide gauge control with GPS for the mean sea level study). In the national frame***work***, a "zero order" geodetic reference frame will be materialized in order to develop a modern space data structure and an EP-based GPS service.

313. The technology transfer to the community such as land registry, teledetection ***(remote sensing)***, natural resources, natural environment, agriculture, navigation, GIS surveyor, etc) ~~occupies~~ ***plays*** an important role. ~~and~~ ***It*** can ***also*** contribute with a high academic level ***of*** human resources training.

314. In that sense our priorities are:

- To set up the bas***i***s ~~of~~ ***for*** a very high quality GPS data acquisition, management, storage and distribution permanent service, produced by the EP net in Argentina;
- To develop the procedures for precise coordinates and velocities determination of all the EP, relative to the best global terrestrial reference frame;
- To develop the procedures to produce atmospheric corrections (ionosphere and troposphere) for the GPS users, as well as other technological applications;
- To transfer the development to the IGM, as well as the required training for the maintenance and usage, creating a data and products center with full access to national and international users;
- To encourage other institution***s*** to ***make*** use of the developments for the implementation of new stations or nets;
- To keep on contributing to the ***A***rgentine***an*** vertical frame, into the guidelines defined by the international SIRGAS project;
- To make scientific use of the database;
- To transfer the scientific results to the national and international community;
- To encourage the creation of high level centres working on GPS technique in Argentina; ***and***
- To train human resources for scientific research and to organize updating courses for professionals.

Colombia

315. ***Colombia has been working actively and has shown commitment in implementing the activities for the implementation of and the transition to GNSS systems. Colombia's advantages include a large forest area, two oceans and fairly mountainous terrain, in addition to its strategic geographical location in the centre of the American continent and in the equatorial region. All these factors compel the country to work for improvement of navigation technologies as a way to develop its aviation system and other fields of its national economy. Colombia's policy in respect to GNSS in the first phase of research and development has been that of opening up to international co-operation, in order to technically evaluate all the possibilities of GNSS systems.***

316. ***A working paper presented during the Eleventh Air Navigation Conference, which took place from 22 September to 3 October 2003 in Montreal, Canada, elaborated on the status of GNSS implementation in Colombia, the work that has been made in terms of progress and on strengths and challenges with respect to transition to GNSS (José Riveros Gutierrez). The paper concluded "it is important for States which are neither owners nor developers of a given GNSS technology to evaluate each of the possible technological solutions with respect to satellite navigation". This should be done with a view to obtain more information in order to make a judgement at the time of defining the most suitable technological solution according to cost and benefit criteria. Another important hint for developing countries was based on the conclusion of the paper that "work and progress in GNSS do not necessarily require large investments on the part of States; tasks such as linking up with universities and research centres and appropriate training of human resources are very significant elements in the transition to an contribution by States for GNSS".***

3. Asia and the Pacific

317. The International Civil Aviation Organisation ***(ICAO)*** Asia Pacific Office located in Bangkok, Thailand, has formulated an Asia Pacific Regional Plan for the new Communications, Navigation, Surveillance/Air Traffic Management Systems.

318. In 1998, ICAO published the Global Air Navigation Plan for CNS/ATM systems which was an enhanced version of the "Global co-ordinated plan for transition to the ICAO CNS/ATM Systems" completed by the FANS Committee in 1993. In the light of this new plan, in 1999 the Asia Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) reviewed the regional plan to align it with the new global plan.

319. The following ***c***ountries are covered under the APANPIRG regional Asia Pacific Plan:

- Australia
- Brunei Darussalam
- China
- Fiji
- Hong Kong ***SAR of China***
- India
- Indonesia
- Japan
- Malaysia
- Mongolia
- Nepal
- New Zealand
- Papua New Guinea
- Philippines

- Republic of Korea
- Singapore
- Thailand

320. The Asia Pacific Regional plan for the new CNS/ATM systems is intended to provide guidance towards a harmonised implementation of CNS/ATM systems and has been constructed to enhance inter-regional co-ordination during the planning and implementation processes. The current terms of reference of the APANPIRG for the CNS/ATM sub-groups for the on-going co-ordination, development and maintenance for the regional CNS/ATM plan are as follows:

- Co-ordinate the updating on a regular basis of the Asia/PAC Regional Plan for the new CNS/ATM systems in the light of new development based on Global Air Navigation Plan for CNS/ATM systems (Global Plan);
- Monitor research and development, trials and demonstrations within the Asia and the PAC regions and information from other regions;
- Co-ordinate States, International Organisations Airlines' and industry plans for the implementation of the Asia/PAC Regional Implementation Plan for the new CNS/ATM systems;
- Provide a forum for the active exchange of information between States and for the resolution of planning and implementation plans as they arise;
- Facilitate transfer of CNS/ATM systems expertise, equipment, trials data etc. between States;
- Provide appropriate review and co-ordination of Amendments to the Regional Plan to ensure adoption of the new CNS/ATM requirement including basic operational requirement and planning criteria;
- Review, monitor and identify shortcomings or deficiencies in the present CNS/ATM systems in the region;
- Identify and co-ordinate CNS/ATM priorities for the Asia/PAC region;
- Promote and progress implementation activities in the field of CNS/ATM in the Asia/PAC;
- Review and identify Intra- and Inter-Regional Co-ordination issues and where appropriate, recommend actions to address those issues; ***and***
- Ensure the harmonisation and convergence of National, Asia/PAC and Global CNS/ATM plans.

321. The present ATM systems in the Asia Pacific Region suffer shortcomings which include:

- Lack of surveillance facilities over large areas of the region which require relief from congestion;
- Air route availability constrained by source navigation aids resulting in choke points;
- Dissimilar ATS procedures and separation standards causing Flight Information Region (FIR) boundary changes to flight profiles;
- The uncoordinated provision of present CNS systems resulting in duplication of resources and services;
- A lack of appropriate parallel ATS route structures to relieve route congestion; and
- Poor quality communications facilities and language difficulties.

Communications

322. The Asia Pacific region is characterised by the use of:

- Data and voice communication for direct satellite/aircraft links in some parts of the region. High Frequency (HF) voice is being maintained during the transition period;
- Very High Frequency (VHF) for voice and data communication in many continental and terminal areas;
- SSR Mode S data link in the near future in some parts of the region which will be used for Air Traffic Services (ATS) purposes in some high density airspace; and
- ATN for inter-change of digital data over dissimilar ground to ground and air-ground communication links between end systems in the future.

Navigation

323. The Asia Pacific region is characterised by:

- Progressive expansion of area navigation (RNAV) in conjunction with ICAO Required Navigation Performance (RNP) Standards;
- In addition to INS the use of Global Navigation Satellite Systems (GNSS) for Aircraft Navigation;
- Instrument Landing Systems (ILS), Microwave Landing Systems (MLS) and GNSS are used for approach and landing in accordance with the ICAO strategy; and
- Current navigation aids (NDB/VOR/DME) will be progressively withdrawn.

Surveillance

324. The Asia Pacific region is characterised by the use of:

- SSR Mode A, C and in the near future, Mode S in some terminal and high density continental airspace;
- Automatic Depend***e***nce Surveillance (ADS) in some parts of the region; and
- The diminishing use of primary radar.

325. The ATM and Communication, Navigation, Surveillance plans of the various countries in the region are given in Chapter***s*** 6, 7, 8 and 9 of the APANPIRG Asia/Pacific Regional Plan for the new CNS/ATM systems. The plan contains transition guidelines, transition and implementation time scales, development of Standards And Recommended Practices (SARPs), Aircraft Equipage, trials and demonstrations and implementation and operational use.

326. Though GNSS market for civil aviation is rather limited, the SBAS, GBAS and ABAS developments have been triggered primarily by the civil aviation sector. Aviation generates enormous increase in tourism to remote and developing regions. Almost all tourists to the South East Asian countries are the air passengers. The growth of tourist traffic in a region can be closely linked to the growth of the aviation market in that region and to the growth of the Gross Domestic Product (GDP) and income.

India

327. (The data regarding the number of airports, facilities at these airports, air passenger forecasts etc. given in the paragraph below should be included for other developing countries. If such data is not available for any reason, for the sake of uniformity the Indian data could also be deleted.)

328. There are 449 airports and airstrips in India. Among these, the ***Airports Authority of India*** (AAI) owns and manages 82 airports and 28 civilian enclaves. Most of the airports are equipped with NDB. There are 80 VORs, 76 DMEs and 39 ILSs at the Indian Airports maintained

by ~~Airports Authority of India~~ ***AAI***. The principal communication system in India has been HF, which is progressively being changed to VHF.

329. For surveillance, Airports Authority of India has 14 MSSRs (Mono-pulse Secondary Surveillance Radars), 8 Airport Surveillance Radars (ASRs), 2 Air-Route Surveillance Radars (ARSRs) and 2 ASDEs (Airport Surface Detection Equipments). Two airports (Chennai and Kolkata) have been equipped with Automatic Depend***e***nce Surveillance (ADS) and Controller-Pilot Data Link Communication (CPDLC). There are about 350 registered aircrafts in India with various air carriers, air taxis and ***aircrafts*** for business.

Air Passenger Forecasts

330. A certain study conducted by National Council of Applied Economic Research (NCAER), India, forecasts that for domestic passengers in India, the estimate for income sensitivity is 1.0. In other words, in the long run an increase of 6 per cent in GDP is likely to be associated with 6*1 = 6 per cent increase in air travel assuming prices do not change. For international passengers in India, the estimate of income sensitivity is 1.3 – much higher than the estimates for domestic travel. For Asia and Pacific, ICAO studies have predicted the highest growth rate. It is matched with the rate of GDP growth in those areas.

331. Forecasts by the International Civil Aviation Organisation (ICAO) show that there will be an increase in scheduled passenger traffic. However, for most countries this growth will be in favour of services operated on international routes than those for domestic routes.

332. For the world, passenger traffic will grow, with growth likely to be larger on international routes than on domestic ones. Almost no growth will be recorded in Europe for domestic passenger traffic. Latin American countries will also see very little growth on domestic routes as compared with international routes. Maximum growth will occur in Asia for both international and domestic routes (See Figure 5 below).

333. The Asia Pacific region is expected to grow by 7 per cent per annum till 2003 and the same trends can be expected to continue till 2010, accounting for more than half of the world air travel by then. And India, already with its strategic position as an air corridor linking Western Europe and South East Asia, is expected to contribute largely to this increase in air travel. With increasing economic linkages between India and the Asia-Pacific countries, air travel in the future is likely to see increased scales.

334. To forecast figures for India, GDP is the single most important determinant in forecasting air transport. As mentioned before, income sensitivity of domestic air passengers of 1.1, consistent with the world trends - with an estimate being 1.3 for international passengers and the estimate being 1 for domestic passengers. The estimate of price sensitivity is taken to be – 0.6, so a 5 per cent decline in prices would lead to a 3 per cent increase in air passengers.

335. GPS is being used in conjunction with the GSM mobile phones for vehicle tracking systems. The car navigation market in India is still in its nascent stages. There is a potentially huge market for GNSS in train anti collision systems, intelligent highway systems and leisure which remains to be exploited. There is as yet no service requirement for mobile phones to be equipped with positioning devices such as the US E911 or the equivalent European standard E112.

~~(SEE JAPANESE CONTRIBUTION)~~

~~Page 51: (SEE JAPANESE CONTRIBUTION) could be changed as follows,~~

Japan

FM-DGPS (for car navigation, etc.)

336. GPS utilization is wide ranging in Japan, and with the car navigation system — a key user of GPS in Japan — the economic benefits to the information technology industry are noticeable. A nationwide DGPS service using a FM sub-carrier has been contributing to further growth of the car-navigation business, since the service went into operation in May 1997. This commercial DGPS service is provided by a private sector, "GPex" established by 17 companies within the Japan GPS Council. GPex operates seven (7) DGPS Reference Stations throughout the country, and the set of DGPS augmented data are broadcast all over Japan, with DARC type FM multiplex formula one of the ITU-R standards, via the public FM broadcasting network of the existing 41 transmitting stations. The DGPS data has compatibility with the RTCM SC-104 format and NRSC/RBDS format.

337. The user can obtain accurate navigation guidance free of charge, if only DGPS receiver and FM auto-tuning hardware are installed. As the VICS service (Vehicle Information and Communication Systems, traffic information services), one of the ITS programs in Japan, is also using the same DARC type FM multiplex, many components can be commonly used for the designing of receivers and antennas. This may result in reduced production costs for hardware and could also, have a synergetic effect in both marketing and improving ecology. It is estimated that approximately 1.2 billion liters fuel can be saved as a result of significant increases in the sale of car-navigation products and VICS services by 2010. As a consequence, there will be a large decrease in CO2 emissions.

338. The car navigation market in Japan is continuing to grow even after reaching an annual sales level of over a million units in 1998. Annual sales in fiscal year 2000 were nearly 2 million units. The DVD display especially has gained popularity and is the driving force in the car navigation market creating new demand instead of replacement demand. Also, the users of the FM-DGPS service have been steadily increasing. The FM-DGPS shipping ratio has come to exceed 50 % of all car navigation products in fiscal year 2000, in spite of the SA being turned off.

339. New trends in "car-multimedia", a topic discussed in many educational seminars which is also associated with sophisticated car navigation products combined with DVD display, mobile communications, traffic control information and other attractive information contents, have become popular recently.

Differential GPS (DGPS)

340. Differential GPS (DGPS), using maritime radio beacon signal, is a system enhancing accuracy of GPS into less than 1m, and also broadcasting warning information such as unscheduled outage. DGPS is based on international standards. In DGPS, A GPS Receiver located at an exactly defined point (reference point) measures the position, and then calculates differential correction of GPS signal using the difference between the measured position and the reference point. These calculated errors are processed as Differential Data, and then sent through MF radio beacon station. The DGPS receiver corrects the position by using this Differential Data.

341. *An additional important function of DGPS is Integrity Monitoring. Once troubled with GPS satellites or DGPS data and, as a result, decreased in the positioning accuracy remarkably, users of this system may be in serious danger without warning. However, the DGPS center has the function to monitor the whole GPS system and DGPS itself in 24 hours operation. So, if an inappropriate correction is detected, the DGPS center provides warning message to users through the related DGPS site.*

342. The user is requested to install both DGPS-ready GPS receiver and DGPS beacon receiver to determine the position (these combined receivers are prepared by manufacturers). For more detail information on receivers, it is recommended to contact dealers to check whether a GPS receiver may be available for DGPS.

343. Japan Coast Guard (JCG) provides maritime DGPS service for all coastal water around Japan except for some of the isolated islands (Ogasawara Islands, etc).

GEONET

344. The agency of Geographical Survey Institute (GSI) has employed many GPS-based precision-surveying systems since ~~its earlier stage,~~ 1987. As a result, Japan achieved the establishment of the continuous GPS fixed reference station network throughout Japan, named GPS Earth Observation Network (GEONET).

345. The main purpose of GEONET is to monitor crustal deformations helpful to the research on earthquakes and volcanic eruptions. Data obtained by GEONET are also available for surveying and other applications.

346. The crust of the ***E***arth can be deformed by various reasons. Tectonic events such as ***a*** large earthquake or seismic swarms cause sudden and large deformation of the crust, whereas plate motions or magma movements deform the crust slowly and gradually. For the prediction of earthquake or volcanic eruptions, the accurate detection of such deformation is essential.

347. Because of its around-the-clock operation and highly accurate positioning capability, GEONET is an ideal tool for detecting crustal deformations. The observation data collected at GPS-based Control Stations is expected to play a key role in the study on earthquake prediction.

348. The data and information about crustal deformation detected by GEONET are provided to the public on ***the*** GSI Web page (http://www.gsi.go.jp).

4. Africa

1. Training Opportunities

349. There are at Portuguese Universities and Research Institutes different opportunities for training of professionals from tropical countries, mainly residents from previous Portuguese colonies in Africa, ***o***n GNSS and their ***a***pplications. African students are currently following studies in Portugal for the Degrees mentioned in the paragraph on Training Opportunities in GNSS.

350. Since a large amount of work was done in the past in the field of surveying and ***m***apping and ***taking into account that*** ~~now,~~ GNSS is ***now*** of primary importance for the continuation of the related activities, there are special opportunities for training of professionals from tropical countries at the Portuguese Tropical Research Institute (IICT). The Portuguese Institute ***is*** devoted to the co-operation with tropical countries, mainly the previous Portuguese colonies in Africa (http://www.iict.pt).

2. GNSS Activities

351. Several co-operation activities are currently underway between IICT and African countries in the area of ***s***urveying and ***m***apping involving GNSS techniques. Recent GPS observations for such purposes were carried out in the Republic of Mozambique. At the Republic of Cape Verde, besides activities of that kind, co-operation work has extensively used GPS for monitoring volcanic activity in Fogo Island.

5. ~~***Western Europe and***~~ North ***(and South)*** America

1. Research Activities ***(Move paragraphs 352 to 357 to "IV. GNSS Applications, B. Applications Predominant in Specific Regions")***

352. [***In Western Europe,*** the use of GPS techniques in Portugal go back to the ***eighties***, ~~80´s~~, when a large observation campaign was organised by the Faculty of Sciences, University of Porto, in co-operation with the Geodetic Institute, University of the Armed Forces ***of*** Munich, to monitor plate-tectonic movements in the Azores-Gibraltar area ***(http://www…)?]***

353. Since then, many research projects have been carried out, going from studies of plate tectonics and volcanism to the study of high atmosphere from on-board GPS measurements, passing by different projects on Earth, including navigation and attitude determination and control. In some cases, besides GPS, also the GLONASS system has been used. As a result, a large number of scientific papers ~~were~~ ***have been*** published and several Ph.D. ***t***hesis ~~were~~ ***have been*** written in Portuguese Universities as well as in Research Institutes. At present, attention is also ~~been~~ ***being*** given to the development of GNSS and GALILEO.

2. Services

354. The Portuguese Geographical Institute, ~~the Portuguese Institute~~ responsible for ***g***eodesy and ***m***apping, has been using GPS in different applications. The establishment and ***maintenance of a permanent GPS network for EUREF as well as the dissemination of the data*** ~~***is***~~ ***also falls under its*** ~~his~~ responsibility (http://www.igeo.pt).

355. ~~Also~~ ***Similarly,*** the Military Geographical Institute (http://www.igeoe.pt) and the Hydrographical Institute (http://www.hidrografico.pt) have current applications with GPS.

3. Other Activities

356. ***In Portugal,*** GPS is widely used in different fields, both by public institutions as well as by private firms. In areas like environment, forestry, ***E***arth resources, mapping, navigation, fleet management and control, dam monitoring, etc., GPS is a technique of fundamental importance, giving rise to a considerable market of GPS equipment. All of the main trademarks are represented in the country.

357. Since Portugal is a member of the EU and ESA, particular attention is being given to all the development phases of GALILEO.

V. DEVELOPING COUNTRIES' NEEDS AND CONCERNS

358. GNSS is an extremely valuable tool across a broad range of applications and requirements. GNSS technology provides an opportunity for developing countries to take advantage of applications that improve the quality of life, benefit social and economic progress, and support priorities for sustainable development. The technical advances in GNSS over the last 20 years have resulted in streamlined processes, software, instrumentation, and relatively inexpensive basic user equipment.

359. However, the benefits of GNSS are not fully recognised and taken advantage of particularly in developing countries for a variety of reasons. In order to help developing countries benefit from GNSS applications, the United Nations Office for Outer Space Affairs (OOSA) ***has*** organised, within the framework of the United Nations Programme on Space Applications, a series of workshops focusing on capacity building in the use of GNSS in various areas of applications. Four regional workshops (Kuala Lumpur, Malaysia, August 2001; Vienna, Austria, November 2001; Santiago de Chile, April 2002, and Lusaka, Zambia, July 2002) and one international expert meeting ~~were~~ ***have been*** organised with the technical and financial support of the Government of the United States of America. Co-sponsorship was also provided by ~~the European Space Agency~~ ESA.

360. The regional workshops provided an opportunity for outreach and assessment of the particular needs of developing countries. A questionnaire was developed and circulated to participants by ~~the~~ OOSA and the results made available to the meeting of experts in November ~~of~~ 2002. This information along with communications with various workshop participants aided in the identification of key areas of interest and the challenges facing people wishing to integrate GNSS into their field***s*** of work or application.

361. The needs of developing countries are concentrated in the following directions:

Institutional Needs

1. ~~Education of~~ *Improve**ment of*** *communication between GNSS service providers and* decision- and policy makers to support application efforts. Government support for GNSS technology, and increasing level of interest and awareness of 'new way' to do things. Lack of official policies related to use of GNSS as a key factor for social and economic development. View beyond national borders;

2. ~~Capacity building~~ *Each developing country* ~~*to*~~ ***should*** *take measures for capacity building in the use of GNSS Technology in terms of infrastructure, training and manpower development;*

3. Reports and recommendations should be sent via UN channels to governments of all countries involved. Benefits of GNSS technology and applications should be highlighted to ***decision- and*** policy makers to increase financial and political support;

4. ~~Explore~~ ***Possibility of*** establishment of an international GNSS organization to promote and foster technology and applications; ***and***

5. ***Continuation of*** Workshops should ~~continue~~ ***be encouraged and the*** resulting recommendations should be implemented. These are seen as very valuable in building capacity and understanding, providing network of professionals, educators and students.

Technical Needs

6. Ionospheric effect, integrity, continuity, availability accuracy. Understanding ionospheric effects on GNSS applications especially at equatorial areas; ***and***

7. Future developments of GPS/***GALILEO*** and various augmentations – how developing countries should approach. Difficult***ies*** to follow and understand plans and technical impact.

Resources and Financial Needs

8. Required instrumentation, ancillary equipment, computer and software costs have generally declined, it is still too expensive in comparison to economic levels of developing countries. Maintenance and recurring costs are difficult to obtain.

Training and Education

9. Training programs should be recommended by the UN and developed. Observations, analysis and implementation – covering all aspects. Specialty, or professional training programs and opportunities, e.g., civil aviation, precision measurements, remote sensing.

10. Education, training, and access to qualified people and information. Scarce availability of experts, new students, university or other training programs. Lack of experts in the various areas noted above. Networking with GNSS experts in other fields ***is also*** difficult. Language books (GNSS in Spanish, etc.)

Priorities in Application

a) Regional Spatial Data Infrastructure (SDI), Geographic Information Systems (GIS), National SDI

11. The use of GNSS positional information was stressed in each region as the method for referencing SDI and GIS which are critical elements of any national cartographic infrastructure.

b) Surveying, Mapping, Land Use

12. Precise reference frame (global, international, continental and national), e.g., AFREF project. Updating of maps, initial mapping of land use, land use planning and evaluation, urban planning. Cadastral mapping, land ownership and boundary control. Environmental protection. Topographic and thematic mapping. Geological surveys.

c) Asset Tracking, Automated Vehicle Tracking

13. Use of GNSS in real-time for charting moving platforms, cars, buses, supply trucks, safety device for auto anti-theft.

d) Precision Agriculture

e) Natural Hazards & Disaster Mitigation, Disease Vector Mapping

14. Location information of disasters, positional information for emergency and relief vehicles.

f) Civil Aviation (see below)

374. Improvements are being made to CNS/ATM systems in the African and Indian Ocean Region through the work of such organisations such as ICAO, the International Air Transport Association (IATA) and the regional workshops on the use and applications of GNSS. GNSS procedures are providing some airports with accurate landing, approach and departure procedures which result in enhanced safety and efficiency together with reduced dependency on ground aids. However, ~~but~~ little has been done so far to improve the standards of Air Traffic Management. ATM can be improved by the use of proven satellite procedures. The difficulties are institutional, not technical, and should benefit from UN expertise in this respect.(Insert paragraph 374)

~~15.~~ Aviation community is ***well*** generally organized with respect to GNSS ***through ICAO***. ~~(an international organization for aviation exists (ICAO) utilizing GNSS as a tool, while for GNSS it does not).~~

362. The overview of existing activities in [Chapter IV, Section B, Sub-section 3, "Asia and the Pacific"] of this report describes how the International Civil Aviation Organization (ICAO), recognizing the limitations of the present air navigation systems in the Asia Pacific region and the need to meet future requirements, has taken steps to promote the introduction of satellite-based technologies for communication, navigation and surveillance (CNS) elements in support of global air traffic management (ATM). These systems will fulfil future civil aviation requirements well into the present century. Any developing country desirous of modernizing the CNS/ATM system over their airspace would need to coordinate its activities through the regional ICAO offices.

363. As long ago as 1983 it was realised that the existing systems and procedures supporting air navigation had reached their limits and ICAO established a Special Committee on Future Air Navigation Systems (FANS Committee) to develop a system for the future. This became known as the 'FANS concept' and combined CNS and ATM systems and depended largely upon satellite techniques. In 1991, after further development work, the Tenth Air Navigation Conference endorsed this concept for the future worldwide air navigation system.

364. By 1996 the proposed CNS/ATM concept had matured and developed into a detailed and definitive plan and was published as the ICAO Global Air Navigation Plan for CNS/ATM Systems. This plan was envisaged as a "living document" offering practical guidance to regional planning groups and states covering technical, operational, economic, financial, legal and institutional matters and providing advice on implementation strategies and technical co-operation. The Global Plan has a clear relationship with the Regional Air Navigation Plans to be used to move towards the ultimate goal of a global, integrated ATM system. It is intended that the Global Plan will "offer, under one cover, a global snapshot of progress achieved and the work remaining toward implementation of CNS/ATM systems".

365. At an early stage in its work the FANS Committee noted that while CNS/ATM systems, depending largely upon satellite techniques, are able to serve a large number of states, or even regions of the world, implementation often needs major investments calling for international cooperation. However, ICAO has suggested that, in some cases, the costs of CNS/ATM systems ~~could~~ be included in the cost basis for air navigation services charges.

366. In some areas of the world, currently having no effective air route infrastructure, the best course of action may be to move directly to the use of the new CNS/ATM systems and avoid the difficulty and expense of providing the point source radio aids and communications required by the older type of infrastructure. This procedure has been successful in the Pacific Region.

367. At present, for historical and economic reasons, the African/Indian Ocean Region provides aviation with communications, air traffic control and navigation facilities of variable quality. Some States are able to meet the required standards but many are unable to do so. With limited resources and many problems, aviation and air route requirements have a low priority despite the fact that efficient air services are essential both for growth and for emergency services. Some areas have seen no improvement for many years. For example, one procedure introduced over twenty-five years ago, as an emergency measure to prevent collisions, is still necessary today as an important safeguard.

~~***368. Effective Air Traffic Management requires:***~~

- ~~***Accurate navigation by the aircraft;***~~
- ~~***Reliable communications with air traffic control; and***~~
- ~~***Effective surveillance: the means for air traffic control to monitor the progress of the aircraft.***~~

Navigation

369. Until recently most aircraft navigated over the African/Indian Ocean Region using MF Radio Beacons or VHF Omni Directional Beacons. These do not support accurate navigation (by today's standards) and usually require aircraft to route from beacon to beacon, thereby adding mileage. These beacons are often unreliable, proving difficult to maintain in a number of locations.

370. Most commercial aircraft now have inertial reference systems as a standard fit and an increasing number also have satellite navigation equipment (GPS and possibly Differential GPS with the option of ***GALILEO*** later which will provide improved integrity). In this context accurate navigation is no longer a problem.

Communications

371. The lack of reliable communications between neighboring air traffic control (ATC) units and between ATC and aircraft in many parts of the Region has been the cause of a significant number of incidents. Work on the present communications system is unlikely to achieve any further improvement except in the case of the VHF communications used for aerodrome control. The increased use of satellite communications between ATC units and between ATC units and aircraft, as proposed by the ICAO Global Air Navigation Plan, has been proven in other regions and offers a solution to an unsatisfactory situation. In addition, the combination of navigation and communication has a tremendous market potential for various other applications. ~~and~~ ***Therefore,*** aviation should also profit from this development.

Surveillance

372. Radar coverage in the region is sparse and mainly limited to a few aerodrome terminal areas. With the use of satellite communications it would be possible to introduce Automatic Dependent Surveillance (ADS) over the entire region. This procedure is already in use in the Pacific and if, as usual, the aircraft uses GPS to automatically update its inertial systems the reported position is more accurate than that normally produced by radar and is also easily transmitted to all ATC units requiring the information, in a format suitable for computerized use.

373. Thus, the use of Satellite Navigation, Satellite Communications and ADS offers:

- A chance to leapfrog a stage of development;
- An opportunity to finance improvements without unacceptable local expenditure;

- An efficient air traffic control system in the upper airspace throughout the region with the minimum number of centres;
- Significant reduction in collision risks;
- Reduction of the risk of flight into high ground;
- Free flight (Direct routings and optimum altitudes) with significant operating economies; ***and***
- Improved approach and landing procedures throughout the region.

Civil Aviation ~~Conclusion~~

374. Improvements are being made to CNS/ATM systems in the African and Indian Ocean Region through the work of such organisations ***such*** as ICAO, ***the International Air Transport Association*** (IATA) and the ***r***egional ***w***orkshops on the use and applications of GNSS. GNSS procedures are providing some airports with accurate landing, approach and departure procedures which result in enhanced safety and efficiency together with reduced dependency on ground aids. ***However,*** ~~but~~ little has been done so far to improve the standards of Air Traffic Management. ATM can be improved by the use of proven satellite procedures. ***T***he difficulties are institutional, not technical, and should benefit from UN expertise in this respect. (Moved to after para.

Conclusion

375. *There is a need for ~~the~~ developing countries to recognise the benefits of GNSS technology and its applications in many areas of economic and infrastructure development. Prominent among the application areas is modern CNS/ATM systems, safe land transportation system, surveying mapping and remote sensing applications, telecommunication infrastructure, etc.*

VI. EXISTING TRAINING OPPORTUNITIES IN GNSS

A. Universities and Research Institutes

Argentina

Faculty of Astronomical and Geophysical Sciences of La Plata National University (Facultad de Ciencias Astronómicas y Geofísicas de la Universidad Nacional de La Plata) : The group GESA (Satellite referencing on the Earth), integrated by astronomers, geodesists and geophysicists graduated in Argentina develops scientific and practical activities on GNSS and organizes educational and training activities at different levels : pre and post-graduate courses for university students; courses for updating of professionals in GNSS activities. Contact person : Dr. Claudio Brunini, cbrunini@fcaglp.fcaglp.unlp.edu.ar. [Argentina]

Canada

376. Significant research and development (R&D) in GNSS takes place at three Canadian universities known for GPS-related studies. The three Canadian Universities actively offering GPS-related study programs are: University of Calgary (Geomatics Engineering) www.geomatics.ucalgary.ca, University of New Brunswick (Geodesy and Geomatics Engineering) http://www.unbf.ca/eng/GGE/HomePage.html and Laval University (Department of Geomatics Sciences of the Faculty of Forestry and Geomatics) http://www.scg.ulaval.ca/ **[Canada]**

377. The University of Calgary's graduate program includes at any time some 40 M.Sc. and Ph.D. graduate students involved in GNSS-related research. Two thirds are non-Canadian.
Some of the research is described on:
www.geomatics.ucalgary.ca/research/GPSRes/GPSResIndex.html.

378. ***The GNSS R&D facilities include two top of the line GPS simulators, software simulators, dozens of GPS receivers, several inertial navigation platforms, an antenna range, and a 16-station DGPS RTK test network. [Canada]***

379. The Department of Geodesy and Geomatics Engineering at the University of New Brunswick (UNB) is one of Canada's leading centres for research in positioning and precision navigation using global navigation satellite systems (GNSS). The department has a long history of making important contributions in satellite-based positioning, stretching back to the early 1970s when it pioneered the use of the U.S. Navy Navigation Satellite System in geodetic studies. By 1980 or so, interest turned to the Global Positioning System even though only a few prototype satellites were in orbit at that time. Working with government agencies and industry, the department researchers tested some of the first commercially available GPS receivers and developed software for the planning, execution, and analysis of GPS surveys. GPS research activity grew in the 1990s and into the new millennium with contributions in many application areas including hydrographic surveying, engineering and deformation surveys, geodetic positioning, aviation, machine control, augmentation systems such as WAAS and the Canada-wide Differential GPS Service, atmospheric science, and the use of GPS on Low-Earth-Orbiting spacecraft. Recently, the department inaugurated work on aspects of Europe's ***GALILEO*** system. UNB's targeted GNSS research is helping to provide accurate, reliable, and cost-effective positioning and navigation for Canadians and others around the world. **[Canada]**

380. The Department of Geomatics Sciences at the University of Laval started its GPS (GNSS) research activities in 1990. About 25 M.Sc. and Ph.D. students graduated since then in this field. The research activities are described in the following bilingual Web site: www.scg.ulaval.ca/gps-rs/. The team publications can also be obtained via this site. The GPS facility includes about 35 GPS receivers (12 GPS-GIS receivers, 4 dual frequency geodetic receivers and 6 GPS-RTK units as well as 2 GPS-G***LONASS*** and 12 handheld GPS receivers). **[Canada]**

381. Many other GNSS-related education and training opportunities exist in Canada ***and are*** offered by other academic institutions and the GNSS-related industry in support to the many applications enabled through GNSS. **[Canada]**

Chile

382. The Universidad de Concepción offers a course on Geodesy and GNSS, Surveying and Applications. This course***'s cost*** is just 20% with student's assistance and 80% by distance. ***The f***ocus ***of the course*** is to increase knowledge on GNSS technologies for positioning and engineering applications, such as forestry, mining, car tracking and deformation structure. **[Chile]**

Germany

383. The list of universities that offer training in GNSS is contained in annex […]. **[Germany]**

Indonesia

384. Indonesia offers training opportunities in GNSS based at the Department of Geodetic Engineering Institute of Technology. The courses offered cover: **[Indonesia]**

- Positioning by GPS: Concepts and Theory;
- GPS Survey: Planning, Execution and Data Processing;
- The Use of GPS for Cadastral Surveys;
- The Use of GPS for Forest Survey and Mapping; ***and***

- The Use of GPS Survey for Natural Hazard Mitigation.

Italy

385. In Italy there are many ***u***niversities skilled in ***s***atellite ***n***avigation which also perform training activities. The Italian Space Agency (ASI) organises dissemination and training initiatives. (see Annex…) **[Italy]**

Poland (To be included)

*(I have attached a paper titled "Independent atomic time scale in Poland – Organisation and results". This is an excellent paper on the **Polish** infrastructure in related field and would merit reference in this document.)*

386. The paper entitled "Independent atomic time scale in Poland - Organisation and results" (J. Azoubib, J. Nawrocki and W. Lewandowsk) elaborated on the Polish infrastructure in the related field. The Polish independent atomic time scale TA (PL) officially started on 4 July 2001. It is currently based on the indications of nine clocks from several Polish laboratories and Lithuania. The clocks at the laboratories are compared using TTS-2 multi-channel GPS receivers developed in cooperation with the Bureau International des Poids et Mesures (BIPM). The participating institutions are linked to the Central Office of Measures (GUM) in Warsaw. TA (PL) is computed as a weighted average of the participating clocks. The paper presented the clock ensemble, the data processing outline, and some experimental results.

387. The paper concluded that the results obtained, especially the long-term stability of TA (PL), were quite satisfactory. The simplest way to improve stability was to add more clocks. Two new clocks, one at the Tele-Radio Research Institute in Warsaw and the other at the Development Center of Polish Telecom were already working and being tested. Two more, from another Telecom laboratory, will be added before the end of 2003. The short-term stability will also be improved by the addition of an active H-maser working at the Astronomical Observatory of Toruń University.

388. Future developments include the following:

- ***Another active H-maser will be added by the GUM in 2004;***
- ***TA (PL) will be computed every week;***
- ***A number of local fibre-optics links will be installed between clocks in Warsaw;***
- ***The GUM, the pivot laboratory of TA(PL), will be linked to TAI using the Two-Way Satellite Time and Frequency Transfer (TWSTFT) method; and***
- ***From January 2003, the Coordinated Universal Time (UTC/PL) will take place based on TA (PL) and a phase micro-stepper.***

Portugal

389. ***In Portugal,*** the normal curricula for the B.Sc. degree in surveying engineering in universities include various subjects related to the use of GNSS in the field. The curriculum at the Faculty of Sciences, University of Porto, for example, includes "Satellite Positioning and Navigation" (see web site, "http://sa.fc.up.pt/pe/(ENGENHARIAGEOGRÁFICA)" in the last year of the degree course. Under this subject, students analyse GPS and GLONASS and the work to implement GNSS, including ***the*** future ***GALILEO***. **[Portugal]**

390. The Faculty of Sciences, University of Porto, offers a Master's degree course in satellite positioning and navigation. The course work consists of four semesters, with the first two

devoted to a specialized course leading to a diploma; and the last two for writing a thesis. The specialized course includes such subjects as reference systems, space dynamics, mapping and GIS, satellite positioning and navigation, positioning and navigation systems, field work in satellite positioning and satellite navigation. **[Portugal]**

391. The Portuguese authorities have approved the project entitled "The Space Technology and the Automatic Computing in the Teaching/Learning Process", which aims to disseminate the practical use of GPS in various positioning and navigation applications to high schools. The project is underway with the participation of a large number of high school teachers and students. **[Portugal]**

Russian Federation

392. Moscow Aviation Institute (State Technical University status) ***has been*** historically dedicated to student education in the field of navigation. Currently, the special comprehensive course ~~of~~ ***on*** GNSS is proposed ***and ranges*** from satellite design to GNSS applications.

393. Moscow Institute of Geodesy and Mapping (State Technical University status) ~~is~~ ***has been*** traditionally proposing courses for students in the field of GNSS application.

394. ***The special satellite navigation training program has been developed*** ~~running~~ ***on the basis of the Institute for Advanced Training of Rosaviakosmos (IPK "Mashpribor"). It has been*** recently initiated and sponsored by ***the*** Russian Aviation and Space Agency. The program includes the following priority directions:

- Theory and practice of GNSS space vehicle control;
- Principles of navigation measurements and data processing;
- Differential navigation and GNSS augmentations;
- GNSS applications; ***and***
- Practical training with GNSS instruments.

395. The course is intended for specialists with high technical education who are willing to ~~raise~~ ***gain more practical experiences and improve*** their professional competencies.

396. This training program has been developed and tested by a team of leading Russian scientists and experts in the field of satellite navigation who represent ***the*** Russian aerospace industry and research institutes such as: ***the*** Mission Control Center of ***the*** Central Research Institute ~~of~~ ***for*** Machine Building (TsNIIMASH) of Rosaviakosmos, ***the*** Research Institute of Space Systems (NIIKS), a subsidiary of "Khrunichev" Research and Production Center, ***and the*** Russian Institute of Space Device Engineering (RISDE). **[Russian Federation]**

South Africa

397. In South Africa, universities and technikons (tertiary technical training institutions) provide GPS and GNSS training as part of survey***s*** and in various engineering courses. In addition, personnel of these institutions are prepared to provide short courses, either of a practical, hands-on or theoretical nature for appropriate fees. These can be and have been done beyond South Africa's borders. The two major ***u***niversities providing training in GPS and GNSS in their degree courses for surveying are the University of Cape Town and the University of Natal; ~~but~~ ***however***, most engineering faculties include such training. For instance, ~~it~~ ***GPS and GNSS training*** is an important factor ~~in~~ ***for*** the training of mining engineers at the University of the Witwatersrand. **[South Africa]**

398. The University of Cape Town offers approximately 40 lectures on GNSS (mainly GPS), with the emphasis on GPS applications in surveying and geodesy (carrier phase differential

GPS). These lectures are taught as part of a 4-year course in Geomatics and cannot be taken separately. It also offers a two-day short course on GPS, with the emphasis on GIS/surveying applications of GPS (aimed at scientists/engineers needing to use GPS for data collection). The University of Natal offers similar courses. **[South Africa]**

United Kingdom

399. Through the Institute of Engineering Surveying and Space Geodesy, the University of Nottingham offers ***a*** degree course dedicated to satellite positioning technology. Details can be found at "http://www.nottingham.ac.uk/iessg/MSc2.html". **[United Kingdom]**

400. Through ***the*** EPSRC project of the Department of Geomatic Engineering, the University College London offered Ph.D. ~~opportunity~~ ***opportunities*** in satellite geodesy and astrodynamics. Details can be found at http://www.ps.ucl.ac.uk/people/vacancies/PhDOpportunity.html". **[United Kingdom]**

423. The National Physical Laboratory organized a short-term course and workshop on next-generation global navigation satellite systems. Details can be found at "http://www.npl.co.uk/npl/training/courses/nggnss.html". **[United Kingdom]**

United States of America

401. There are numerous research and training institutions in the United States that provide training on GNSS. Listed in Annex […] are only a few of those institutions. This is not an endorsement that these are the best or only institutions that provide GNSS training, but are simply a sample. **[United States of America]**

402. Navtech Seminars, Innovative Solution International and Advanced Management Technology Incorporated ~~all~~ provide technical courses and advanced GPS training in support of the FAA's SATNAV Program Office. Contact details for these organisations can be found in Annex […]. **[United States of America]**

B. United Nations, UN agencies and other intergovernmental organizations

403. ICAO is conducting activities to face new challenges concerning human resources involved in the introduction of advanced satellite-based CNS/ATM. ICAO addresses human resource planning and training issues through its TRAINAIR programme. The programme provides a mechanism for cooperation among training centres for the development of the many new training courses that are required to support the introduction of CNS/ATM. ICAO will continue to organize seminars/workshops on the implementation of GNSS-based aeronautical systems and procedures. **[ICAO]**

404. ***The*** European Commission carries out a series of information activities in order to raise awareness of satellite navigation and to involve European and non-European parties in the conception of the GALILEO programme. Preparations are underway to move from ad hoc training activities towards more regular structures. Further co-operation is foreseen with ~~the European Space Agency~~ ESA in this context. **[EC]**

405. The involvement of a number of non-EU countries in Europe, North America, Africa, Asia, Middle East and Latin America ~~are in the definition of~~ ***in the*** GALILEO ***project*** is an example of "learning by doing" ***that combines*** ~~combining~~ scientific and industrial co-operation. **[EC]**

C. Non-governmental entities

406. There are some suppliers of GPS equipment in South Africa, the major being Optron, supplying navigation and positioning systems for use in coastal and deep sea navigation, land navigation, land surveying, precision agriculture and forestry applications and precision excavation. In addition, applications in nature conservation include tracking of animal species being studied and location of examples of rare plant species. ***Since 1996,*** the Electricity Supply Commission and Telcom have also~~, since 1996,~~ been using global positioning technology to assist in electrification and telephonic infrastructure development of rural areas ***in order*** to establish exact location of very remote users and equipment. All of this has given rise to a market for GPS equipment, which has gone hand in hand with training on that equipment provided ad hoc to purchasers and users. Optron supplies equipment and training to clients in most of sub-Saharan Africa and is prepared ~~,~~ on a commercial basis to provide training to non-client users. Their main supplier of equipment is from the USA and, for business reasons, they do not support the Russian GLONASS system, though the principles of the GLONASS and other satellite systems are essentially the same. **[South Africa]**

407. There are many companies in Italy which are working in the research and development area as well as in navigation application. Large suppliers and small and medium enterprises ***not only*** ~~participating~~ ***participate*** in the European navigation programmes like EGNOS and ***GALILEO*** but ***are*** also involved in ground-based navigation equipment. (see Annex 2) **[Italy]**

D. Government

Azerbaijan

408. While Azerbaijan is planning to establish a global navigation satellite system in the near future for application in various areas of navigation, there is currently a lack of training opportunities in GNSS. However, within the framework of FAO, a group of remote sensing specialists of the Azerbaijan National Aerospace Agency (ANASA) as well as other interested organizations of Azerbaijan were provided with training in GNSS, such as the use of GPS- 12 CX Garmin. **[Azerbaijan]**

Germany

409. The Ministry of Transport and Ministry of Research and Education are responsible for the activities relating to GNSS. As the space agency, the German Aerospace Center (DLR) has many activities in the research area, and it finances national GNSS studies and contributes to the ESA GNSS programmes, such as EGNOS and ***GALILEO***. However, neither the Ministry nor DLR has training activities. **[Germany]**

Hungary

410. No governmental organization currently provides GNSS training opportunities. Only universities, high schools, commercial organizations and research institutions are involved in GNSS (GPS) education and training. **[Hungary]**

India

411. India has developed a detailed plan for introduction of satellite-based navigation services for civil aviation in phases. India is building a ***Satellite Based Augmentation System (SBAS)*** system over the Indian Airspace. This is a joint project between the Indian Space Research Organisation (ISRO) and the Airports Authority of India (AAI). The SBAS is being implemented by ISRO. To support the development of an SBAS system of international standards, several organisations, research institutes and academic institutions offer training in

satellite-based navigation. The list of organisations that may be contacted for training is contained in annex […]. Annex […] is categorised in terms of the subject such as: SBAS system studies, navigation payload, master control centre, iono-tropo models, research and training and receivers, academic institutions and receiver manufacturers. Apart from these, ISRO conducts several training courses specially design for developing countries on various related subjects from time to time. **[India]**

Italy

412. Some limited training opportunities exist in public authorities. **[Italy]**

Nigeria

413. The Federal Government of Nigeria offers no training opportunities in the fields relating to GNSS. **[Nigeria]**

Russian Federation

414. The Russian Aviation and Space Agency in the framework of ***the*** Federal GLONASS Mission Oriented Program initiated and ***is*** ~~now~~ ***currently*** sponsoring the special program for educational satellite navigation course preparation. **[Russian Federation]**

Saint Lucia

415. The Government of Saint Lucia does not offer any training opportunities in the fields relating to GNSS. **[Saint Lucia]**

Senegal

416. While Senegal does not have training activities, the personnel of the civil aviation authorities have been trained at the Air Safety and Navigation Agency in Madagascar (ASECNA) and at the National School of Civil Aviation (ENAC) in France. **[Senegal]**

South Africa

417. The South African Government has three institutions, which particularly deal with ~~Global Navigation Satellite Systems (~~GNSS~~)~~ and ~~Global Positioning Systems (~~GPS~~)~~. These are the Satellite Applications Centre, the Air Traffic Navigation Systems company and the Chief Directorate: Surveys and Mapping in the Department of Land Affairs. **[South Africa]**

418. The Satellite Applications Centre (SAC), at Hartebeeshoek, near Johannesburg, together with the Hartebeeshoek Radio Astronomy Observatory make use of permanent GPS stations for calibration purposes. They provide in-house training to personnel and visiting trainees, but they do not have formal programmes of training in this area as such training is provided on an ad hoc, needs basis. **[South Africa]**

419. The Air Traffic Navigation Services Company (ATNS) provides air traffic control and associated services for continental South Africa and a large oceanic region. In addition to controlling all upper airspace and terminal control areas in South Africa, ATNS also provides services at 21 airports. Surveillance of the South African oceanic sectors is achieved through the use of satellites and communications, through datalink with aircraft that are suitably equipped and certified. In addition, ATNS provides GNSS charts for a number of African countries. The ATNS has an Aviation Training Academy, situated at Johannesburg International

Airport. Training in Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM) is provided for air traffic service personnel, air traffic service planners and for senior management to equip them appropriately. The practical application of GNSS and GPS applies only to the first two categories of personnel. Certain courses can be provided in other states, if the requirement exists. Training has been provided at various locations beyond South African borders to meet client needs. **[South Africa]**

420. Surveys and Mapping in the Department of Land Affairs, which maintains the South African national mapping programme and trigonometric survey, has a training component which provides practical training for Technical Institute students and in-house trainees. However, most in-depth GPS application training is informal ***and*** on the job training. From time to time seminars are run on specific areas of interest such as the implementation of the network of permanent GPS base stations (known as TrigNet, established and maintained by the survey office) outside of the office. **[South Africa]**

421. In addition, there are training possibilities outside of the Government controlled bodies. In fact most formal training is done outside of Government bodies. **[South Africa]**

Thailand

422. Thailand does not have training in the field of GNSS. **[Thailand]**

United Kingdom

423. ***The*** National Physical Laboratory organized a short-term course and workshop on next-generation global navigation satellite systems. Details can be found at "http://www.npl.co.uk/npl/training/courses/nggnss.html". **[United Kingdom] (move para. 423 to page 73, after para. 400)**

VII. INSTITUTIONAL MODELS FOR INTERNATIONAL COOPERATION

424. As future components of the overall GNSS architecture develop worldwide, the need for an international framework to support operational co-ordination and exchange of information among system designers and operators and national and international user communities will be increasingly important. The focus should no longer be on explaining the basic principles of GNSS or on trying to educate the general public, the scientific community at large or policymakers about the benefits of GNSS. System operators of GNSS and their augmentations must move beyond simple outreach. The assumption is that current and future system operators will soon move from a strictly competitive to a more collaboration mode where there is a shared interest in the universal use of GNSS services regardless of the system. If this is to be the case, then the real challenge now is to provide assistance and information for those countries seeking to integrate GNSS and its augmentations into their basic infrastructure at all levels (i.e. commercial, scientific and government).

425. The framework to be discussed will be most favourable to service providing governments if flexible mechanisms are pursued ***then*** the focus of these mechanisms is providing improved service to users.

426. The following categories of ~~the~~ international co-operation of the GNSS service providers are considered for implementation:

- Coordination
  - among the core GNSS service and augmentation providers
  - national planning and/or regional planning;
- Dissemination - of information on GNSS to users and provision of technical assistance for the integration of GNSS into national infrastructures; ***and***
- Collection - of users needs and desires regarding GNSS.

A. Coordination

1. Coordination among the GNSS service providers

427. On the basis of work done at the UN workshops and Action Team meetings the following objectives for international GNSS co-operation ha***ve*** been identified with respect to GNSS development and the provision of basic GNSS services:

- To reduce the complexity and cost of user equipment, GNSS providers should pursue greater compatibility and interoperability among all future systems (GPS III, G***LONASS*** K, ***GALILEO***, augmentations) in terms of signal structures, time and geodetic reference standards;
- To protect the investment of the current user base, GNSS providers should ensure that current services are continued for existing user equipment on a free and non-discriminatory basis for a reasonable time frame (e.g. existing user equipment life time);
- To ensure continuity and integrity of GNSS services and augmentations, operators should take steps with national administrations to protect against interference with national and regional infrastructures (satellite, ground stations);
- To ensure continuous reception of GNSS services, all nations should prioritise the protection of radio spectrum allocated for GNSS services from interference, both domestically and internationally;

- It is essential to develop appropriate security mechanisms to prevent hostile use of civil GNSS services in areas of conflict without degrading civil service on a global basis. Core GNSS components such as GPS, GLONASS, ***GALILEO*** and augmentations (local, regional or global) must be taken into account; ***and***
- *To promote Global User Organisations such as, IGS for **GALILEO**, GLONASS and regional augmentations.*

428. In order to collectively discuss each of these recommendations and to identify actions for ***their*** implementation, the establishment of a service provider co-operation mechanism such as a "GNSS Co-ordination Board" (GCB) could be established. This would be achieved through a multilateral arrangement between the governments and/or organisations that currently provide or plan to provide global GNSS services and maintain corresponding infrastructure, i.e. the United States, the Russian Federation, and the European Union.

429. The GCB could also include current and future providers of regional augmentation systems (India and Japan). In addition to the objectives above the Board should look into ways of optimising compatibility, interoperability, availability and reliability of the core systems. Among other things, the GCB could facilitate information exchanges between GNSS providers on system modernisation/development to ensure compatibility and interoperability. The GCB should also identify mechanisms for and implementation of measures to protect the reliability and integrity of signals at the national, regional and global levels; and co-ordinate modernisation/development activities to meet user needs, particularly in the developing world.

430. Since compatibility and interoperability are highly dependent on the establishment of standards for service provision and user equipment, standard setting will be another topic that the Co-ordination Board would need to address. However, the Board should probably avoid efforts to set standards itself and should instead look for applications where no standards currently exist, such as land transport, and recommend possible organisations that could appropriately set new standards. Consultation with existing standard setting bodies such as the International Civil Aviation Organization ***(ICAO),*** the International Maritime Organization ***(IMO),*** and the International Telecommunication Union ***(ITU)*** will also be required. In addition, the UN Committee on the Peaceful Uses of Outer Space (***COPUOS),*** through it***s*** Programme on Space Applications, could play a useful role in demonstrating for developing countries the practical benefits of GNSS and assisting the GCB in integrating GNSS into developing country infrastructures.

431. [Such a ***B***oard would provide a mechanism for coordination among service providers:

- Coordination of activity and plans of system modernisation and development;
- ***T***o ensure compatibility and interoperability in terms of signal structure, time and geodetic reference standards;
- ***T***o establish standards for service provision and user equipment;
- ***T***o reduce the complexity and cost of user equipment;
- ***T***o ensure continuity of existing services for a reasonable time frame to protect the investment of the current user base;
- ***T***o maintain the use of the systems on a free and non-discriminatory basis; ***and***
- ***T***o advocate long-term protection of the spectrum reserved for GNSS.]

432. Elaboration and implementation of security measures:

- ***T***o protect against threats to physical GNSS infrastructure of satellites and ground stations to ensure continuity of GNSS services; ***and***

- To prevent hostile use of civil GNSS services in areas of conflict without degrading civil service on a global basis.

433. The following membership could be envisaged for the GNSS Co-ordination Board:

- Core GNSS system providers, and developers/customers of GPS, GLONASS, GALILEO;
- Global user organisations such as the International GPS Service (IGS) *and equivalent organisations for **GALILEO** and GLONASS; **and***
- Providers of augmentation systems such as WAAS, EGNOS, *GAGAN,* MSAS and the Quasi-Zenith Satellite System (QZSS).

434. Preparation of major user equipment suppliers in the GCB sessions may benefit in further GNSS applications.

2. National/Regional Planning and Governance

435. Establishing national and/or regional planning groups for GNSS that would address regulations, user needs, etc., is clearly an important objective. Many countries are searching for an organisational model to use at the national level for co-ordinating and governing GNSS use. The existing GNSS service providers or new entities could be used as such co-ordinating bodies. In some cases the bodies are ~~lead~~ ***run*** by various science and transport authorities (e.g. air navigation service providers).

436. The United Nations Regional Centers for Space Science & Technology are a possible avenue that could be given the task, in conjunction with the GCB, ~~for~~ ***of*** GNSS planning and organisation on the regional level. However, due to lack of resources, some governments might have to consider delegating the responsibility of co-ordinating the development of relevant national navigation infrastructure to the existing service providers.

Australian GNSS Coordination Committee
(www.agcc.gov.au)

437. ***The Australian Government Minister for Transport and Regional Services, the Hon. John Anderson MP, established the Australian GNSS Coordination Committee (AGCC) in May 2000. The Committee provides advice and recommendations to the Government on GNSS implementation. The Committee's terms of reference call for it to:***

- ***Coordinate all land, sea and air aspects of GNSS;***
- ***Promote the safe and effective utilisation and development of GNSS in Australia; and***
- ***Coordinate national security issues, the application of augmentation systems, and the national use of GNSS in non-transport applications.***

438. ***Membership is drawn from a range of users and providers across the following sectors: aviation, defence, emergency services, land and maritime transport, academia, communications, timing, geomatics and geophysics, ~~and~~ security and industry providers.***

439. ***Some of the Committee's achievements have been:***

- ***Development of Australia's strategic policy on satellite navigation, Positioning for the Future, which was launched by the Minister for Transport and Regional services in August 2002;***

- *Initiation of action to ban GPS jamming devices in Australia;*
- *A study into the potential for interference to civil GNSS applications by sources such as UHF television transmissions;*
- *A study into GNSS usage and needs in agriculture;*
- *Facilitation of GPS spectrum band licensing under the Radiocommunications Act; and*
- *Maintenance of links with the United States to contribute to cooperation on GPS, and with the European Union to keep abreast of developments with the proposed Galileo system.*

440. The national strategic policy on satellite navigation Positioning for the Future, which was developed by the AGCC, is aimed at obtaining the best and most efficient use from GNSS technology. The policy is based ~~around~~ upon eight principles:

- *National coverage;*
- *Safety;*
- *Efficiency, economic and social benefits;*
- *Industry development;*
- *Flexibility of policy and strategy;*
- *Appropriate standards;*
- *Benefits to the environment; and*
- *National security.*

441. The AGCC has recently been reviewed after its first three years of operation~~,~~. The Committee ~~and~~ will continue its work with some minor amendments to its terms of reference and membership.

(*Department of Transport and Regional Services*
Canberra, Australia
November 2003)

B. User Support and Information Dissemination

442. The need for a link between users, equipment manufacturers, service providers and core system providers was highlighted in several of the regional workshop reports and in the deliberations that occurred during the Vienna ***m***eeting of GNSS ***e***xperts. The objective is to increase awareness among users, provide information that is critical to users with respect to GNSS service provision, and to ensure that core system providers take into account user feedback.

443. The type of information that needs to be relayed from service providers to users includes, but is not limited to the following:

- Dissemination of GNSS system status information such as satellite health and satellite maintenance and testing schedules — scheduled and unscheduled satellite outages within the core GNSS architecture have a direct impact on the level of service that is available for a given GNSS application. Predictive tools exist in some application sectors such as aviation that can allow users to determine when poor service availability is likely and then plan accordingly; ***and***
- Provision of timely notification of service denial or degradation through intentional or unintentional interference is critical. The dependency of users on GNSS is comparable to if not greater, to other familiar services and utilities such as telecommunications and electrical services. The intentional disruption of GNSS

services could, therefore, pose great risks to users that could lead to life-threatening situations. Such intentional disruptions could be hostile in nature, or they could be the result of necessary actions taken by sovereign nations whose national security may be at risk from the potentially hostile use of GNSS by other nations or terrorists. Such denials of service, even for appropriate national security reasons, can potentially jeopardise the safety of civil users. Therefore, users could benefit from a mechanism that allows for timely notification of local and/or regional service denial.

Implementation mechanism

444. User Information Centers should be established by each individual service provider. The maintenance of a globally focused web site would be a major task of these centres.

445. For GPS, the Navigation Information Service managed by the U.S. Coast Guard Navigation Center is the primary means of disseminating information to civil users. This is primarily accomplished through a web site that includes links to many sources of GPS information.

446. For GLONASS, similar web sites exist that are managed by the Russian Military and the Russian Aviation and Space Agency.

447. Similarly, the European Commission also provides a web-based portal for the ***GALILEO*** project.

448. Regionally focused web pages would be the responsibility of selected regional or national points of contact.

449. Dissemination of information between users themselves can also be improved by organising national GNSS user groups as providers of input to the consolidated web site. Existing user groups with government sponsorship include the U.S. Civil GPS Service Interface Committee. Industry groups include the U.S. GPS Industry Council, Japan GPS Council, and the Scandinavian GNSS Industry Council. The federated web-based information system of the International GPS Service serves the scientific and research community, as well as high-accuracy users of any category.

450. This web-based information resource should probably take advantage of existing web sites such as those previously mentioned to the maximum extent possible. However, since this resource will be used by all nations of the world and their GNSS user communities, great care will need to be taken to ensure that the information available is easy to access for all. This will require web site design or re-design that includes options for text only to allow usable access to those with low data throughput rates. Translation of as many documents, and materials included in the nested set of web sites, as possible should also be considered.

451. The UN Office for Outer Space Affairs, could combine all web sites into a single site to act as portal for any user of any GNSS service or regional component of a service (International GNSS User Information Center).

C. Collection of users needs and desires regarding GNSS

452. Collection of information from user community could be implemented by the following means:

- ***W***ith help of information exchange based on the means of international GNSS User Information Center ***I***nternet technique; ***and***

- ***B***ased on the regional workshops with participation of the GNSS Co-ordination Board representatives.

453. Meetings between GCB and User Community should be organised under UN leadership twice a year in the regions. Conducting workshops in connection with well-attended international GNSS meetings may be desirable.

VIII. RECOMMENDATIONS [*COMMENT: These recommendations are too specific to Africa. It would be useful if the term Africa is replaced by a more generic term as "Developing Countries"]*

(To be inserted into draft report of Action Team on GNSS)

The following recommendations are made for the United Nations Office for Outer Space Affairs to submit to the United Nations General Assembly for consideration:

It is recommended that:

1) *A GNSS Coordination Board be set up with the following objectives (refer to para. 431, page 78, Chapter VIII of draft report and TOR of GCB);*

E. Objectives

The GCB has the following primary objectives:

1. *To optimize the benefits of GNSS and their augmentations through cooperation of its Members in mission planning and in the development of compatible services, applications and policies;*

2. *To assist both its members and the international user community by inter alia, serving as the focal point for international information exchange related to GNSS activities;*

3. *To exchange policy and technical information among current and future operators of GNSS and their augmentations to encourage complementarity and compatibility of their systems;*

4. *To respond to current and future user needs, particularly in developing countries, and to promote GNSS applications;*

5. *To identify mechanisms for implementing measures to protect the reliability and integrity of signals at the national, regional and global levels; and*

6. *To assist national and regional authorities, particularly in developing countries, with the integration of GNSS services into their civil, commercial, and governmental infrastructures and to monitor and protect the integrity of GNSS signals at the national and regional levels.*

Coordination of activity and plans of system modernisation and development:

7. *To ensure compatibility and interoperability in terms of signal structure, time and geodetic reference standards;*

8. *To establish standards for service provision and user equipment;*

9. *To reduce the complexity and cost of user equipment;*

10. *To ensure continuity of existing services for a reasonable time frame to protect the investment of the current user base;*

11. *To maintain the use of the systems on a free and non-discriminatory basis; and*

12. *To advocate long-term protection of the spectrum reserved for GNSS.*

2) *The membership of GCB could be composed of national or international entities responsible for GNSS and their implementations.*

- *International organizations and associations dealing with global GNSS service and applications - United Nations Office for Outer Space Affairs (OOSA), International GPS Service, ICAO, IMO, IAIN, CGSIC and ITU.*

3) *Developing countries may be invited to derive benefits from the establishment of the GCB to introduce services relevant to their needs in a cost-effective manner.*

4) *There is a need to evolve compatible technical standards and users equipment among different users of GNSS worldwide.*

5) *In order to disseminate information about the formation of the GCB and to benefit from this Board, there is a need to organize regional workshops through OOSA, development of user information centers and web sites, and to take up projects such as AFREF, ITRF, EUPOS, SIRGAS and similar projects to achieve these objectives.*

454. A number of sources provided a series of recommendations for promoting a more efficient use of the technology of GNSS around the world. The four regional workshops held in 2001 and 2002, the International Meeting of Experts held in late 2002, responses to questionnaires sent to experts, participants and service providers at those meetings as well ***as*** input from members of the Action Team on GNSS ~~are~~ ***represent*** just a few ***examples of such sources***. ~~These~~ ***The recommendations*** are summarised below.

Recommendations Regarding Institutional Framework to Service Providers

~~455. Creation of a GNSS Coordinating Board **that** would provide a mechanism for co-ordination among service providers to address, among others, the following recommendations:~~

~~i) Co-ordination of activity and plans of system modernisation and development:~~

- ~~***T**o encourage compatibility and interoperability in terms of signal structure, time and geodetic reference standards;~~
- ~~***T**o establish standards for service provision and user equipment;~~
- ~~***T**o reduce the complexity and cost of user equipment;~~
- ~~***T**o ensure continuity of existing services to protect the investment of the current user base;~~
- ~~***T**o maintain the use of the systems on a free and non-discriminatory basis; **and**~~
- ~~***T**o advocate long-term protection of the spectrum reserved for GNSS.~~ (delete para. 455: duplication of para. 431)

ii) Elaboration and implementation of security measures to protect against threats to physical GNSS infrastructure of satellites and ground stations to ensure continuity of GNSS services.

456. The GNSS Coordinating Board could be established through a multi-lateral agreement among providers of GNSS and regional augmentations systems. The Board might be modelled after the Committee on Earth Observation Satellites (CEOS[11]), with secretariat responsibility rotating among the members on an annual basis. This possibility could be examined. The UN

[11] www.ceos.org/pages/overview.html

Office for Outer Space Affairs ***(OOSA)*** and ICAO could be affiliated at some level in order to provide an exchange of information on user needs and to support the broader objective of integrating GNSS and its augmentations into the basic infrastructures of developing countries.

457. ***Development of User Information Centers and Websites.*** Each GNSS and/or regional augmentation provider should establish ***U***ser Information Centers. The maintenance of a web site would be a major task of these centers. The United Nations, the GNSS Coordinating Board or ***an***other international body should combine all web sites into a single site to act as a portal for any user of GNSS and/or augmentations. Such a portal could become part of OOSA web site to be maintained by OOSA in co-operation with the GNSS Coordination Board.

Recommendations Regarding Institutional Framework to the UN Office of Outer Space Affairs

458. ***Continue to hold regional workshops.*** The UN regional workshop series has been ***very*** helpful to service providers as a means of collecting inputs from users. It ~~was~~ ***has been*** very useful as a means of promoting the use of GNSS and their augmentations in developing countries. Therefore, the workshops should continue in ***the*** same manner with a focus on user inputs. Conducting workshops in connection with well-attended international GNSS meetings may be desirable.

459. Support the establishment of national (and perhaps even regional) GNSS planning and co-ordination groups. Appropriate organisational models and best practices should also be provided.

460. Commission an assessment of current institutional models. Assess international co-operation and co-ordination, and identify those with potential applicability to evolving GNSS systems and services. Careful consideration should be given to flexible, informal mechanisms and existing organisations that already attempt to provide informational services in GNSS users.

461. There is loose organisation at the national level with regards to provider-user coordination and no ~~one~~ organisation that assumes end-to-end responsibility for GNSS. Applications are often fragmented and atomised~~.~~; ~~And~~ developments are under-funded. There is a lack of knowledge and understanding at high decision-makers level on how to utilise the new technology and incorporate appropriate processes at the organisational level. Clearly, there is a need to improve communications between service providers and these decision-makers to demonstrate the cost-effectiveness of GNSS technology by showing examples of applications and solutions to problems.

462. The main difficulty is to find common interest with specialists in various fields, e.g. aeronautics, marine, land navigation, mobile robots etc. Effort is required to unify an approach to navigation and positioning to optimise synergy that will include many diverse applications and users.

463. Stimulate Capacity Building for GNSS Education and Training. The regional conferences have identified that there are very few experts in this new technology, particularly in the least developed nations of the world. This underscores the need to:

- Develop the skills and knowledge of university educators, research and scientists, through theory, research, field exercises and pilot projects;
- The Centers for Space Science and Technology Education affiliated to the United Nations should consider including GNSS programs in their training activities; ***and***
- Train the final users in the multiple GNSS applications to create a critical mass of trained personnel at the regional and national levels.

464. It was also noted that there is a need for publication of GNSS-related materials in languages other than English.

465. The national, regional ***and*** international symposia ***and other*** events on development and application of modern space technologies organised by national, regional ***and*** international associations ***and*** organisations ***could be considered*** as a way for increasing the awareness and qualification to be supported by ***the*** UN (for example annual symposium in Sofia, ***Bulgaria***).

466. Help promote the use of GNSS. Reports of the UN/USA workshops should be sent, through official UN channels, to governments of developing countries in particular. This would assist in promoting GNSS applications.

Recommendations Specific to GNSS Applications

Aviation

[Inputs in this section need to be harmonised with the ICAO Regional recommendations for developing countries. Similarly the write-ups on non-civil aviation applications such as telecommunications, surveying, natural resources and protection of environment need to be harmonised with international bodies such as ITU for telecom, CEOS for Earth Observation, etc.]

467. Encourage research activities related to the development of ionospheric models including measurements related to GNSS and the exchange of such information.

468. GNSS signal has been available over many years. However, parameters such as GNSS integrity, continuity, availability and accuracy still do not meet more stringent requirements that certain applications, ~~like~~ ***such as*** aviation, expect. Region-specific phenomena such as geomagnetic equator anomaly have significant impact on determining regional solutions for ***the*** Central and Southern Hemisphere rather than the Northern Hemisphere. Collecting and analysing ionosphere data to determine optimal algorithms for ionosphere model of the region ~~will~~ ***could*** be a challenge that would increase international understanding for sharing information between independent GPS augmentation systems, and the shared use of communication satellites.

469. The ionosphere interference of GNSS (GPS) signal, due to the geomagnetic equator effect, prevents meeting some specific requirements (parameters) of aeronautical activities in terms of integrity, continuity, availability and accuracy.

470. Consider the implementation of a “One African Sky” concept in the upper end route similar to the “Single European Sky” initiative currently underway in Europe.

471. Successful implementation of GNSS in other parts of the world show that utilisation of this technology and receipt of associated benefits will require that institutions that were built around ground-based aviation must change to fully exploit the technology. They must also allow for the expansion of air travel and resulting expansion of the African economies. The timing of the new African Union allows the opportunity for a fresh look at these structures and processes.

472. UN/OOSA and ICAO should continue to encourage adoption of GNSS within the African continent.

473. Toward that end, it is recommended that UN/ICAO host within a short period of time a GNSS Executive Level Session with all the African Directors General of Civil Aviation to begin to address the challenges above.

Telecommunications

[The benefits of GNSS technology cut across applications and across countries. It is further emphasized that the importance of simultaneous development of Information and Communications Technology (ICT) and related infrastructure is necessary for sustainable use of GNSS. Policy and decision-makers should be made aware of the critical importance of the ICT in the development and success for the utilization of GNSS. **[*This paragraph should be moved to* a new section on Telecommunications after civil aviation on page 69 above]**

~~Specific recommendations for the session are:~~

- ~~Agree to a small number of regions;~~
- ~~Set up a Task Force within each region to begin to harmonise structures;~~
- ~~Establish cross-region mechanisms so those problems are solved once standardised procedures are adopted;~~
- ~~Establish a uniform model for cost recovery;~~
- ~~Have an existing higher education institution develop an academic program to support the implementation of GNSS under the leadership of the regional "advocates";~~
- ~~Today's safety statistics should be base lined, and targets for improvements be implemented with specific projects to enable these improvements.~~

Surveying, Mapping and Earth Science

474. Establish a continental reference for Africa (AFREF), consistent with the International Terrestrial Reference Frame (ITRF).

475. A uniform coordinate reference system is fundamental to any project, application, service or product that requires some form of georeferencing. Many developing countries, and particularly the African nations, would benefit greatly from a modern GNSS-based reference system that ~~can~~ ***could*** be used for national surveying, mapping, photogrammetry, remote sensing, Spatial Data Infrastructure (SDI), Geographical Information Systems (GIS), development programs, and hazard mitigation (earthquake studies, fault motion, volcano monitoring, severe storms). Many existing national coordinate systems are based on reference figures of the Earth which are generally outdated and are restricted to a particular country, making cross-border or regional mapping, development, and project planning very difficult. A continental reference system for Africa should be organized through an international project to be known as AFREF with common goals and objectives throughout Africa, and with the commitment of African nations and the support of international partners. [The benefits of GNSS technology cut across applications and across countries. It is further emphasized that the importance of simultaneous development of Information and Communications Technology (ICT) and related infrastructure is necessary for sustainable use of GNSS. Policy and decision-makers should be made aware of the critical importance of the ICT in the development and success for the utilization of GNSS. **[*This paragraph should be moved to* a new section on Telecommunications after civil aviation on page 69 above]**

476. Expand the development of integrated Differential GNSS "full scale accuracy" infrastructure with well-defined unified standards on regional levels (i.e. in Europe: EUPOS).

477. A subject of further discussions within the framework of UN/USA regional workshops would be the problems on the multi-functional DGNSS applications in Central and Eastern ~~European~~ ***Europe*** like EUPOS, its development for entire Europe and eventually as an element of GALILEO and EGNOS. Similar DGNSS systems ~~can~~ ***could*** be developed for other regions in the world.

478. Increase the density of the Continuous Operating Reference Station (CORS) for the SIRGAS area of Latin America and the Caribbean in order to promote the use of GNSS, CORS (covering all the Americas) must complement the SIRGAS frame. In spite of the existence of the SIRGAS structure, these activities are facing deep financial difficulties that are obstructing the development of GNSS applications.

479. Other recommendations in this area included: the development of Spatial Data Infrastructure (SDI) based on a consistent geodetic reference frame enabled by GNSS; the monitoring of GNSS frequencies for interference on local and national levels; and the development of accurate geoid models.

Management of Natural Resources and Protection of the Environment

480. Precision agriculture has attracted many new users to GNSS application in management of natural resources and protection of the environment. The growth of GNSS users in these areas is expected to increase as seen from the four regional workshops. Other sources of funding should be explored to implement the establishment of a global information exchange network related to precision agriculture and GNSS applications. Many suggestions and recommendations were made in these area at all four regional workshops. The significance of GNSS in the area of disaster preparedness and management was particularly highlighted.

481. However, the plight of the African region is such that we have selected the following two initiatives as deserving the most attention on the part of the international community:

1. Initiate demonstration projects in the area of agriculture and health to convince and attract the attention of government policy and decision-makers in Africa.

482. Agriculture is the mainstay of the economies of most African nations. However, there is a lack of knowledge of the economic, political and professional benefits of the effective use of GNSS in agricultural development and diversification (in areas such as crop production, processing and planning, animal health and production and fisheries).

2. International donors should support disease vector mapping projects in Africa using GNSS.

483. This will enhance understanding of the spread of killer epidemics such as AIDS and malaria prevalent in Africa. Governments do not appreciate the impact the technology of GNSS can have in enhancing health resources management and disease control.

Conclusion

484. These recommendations were selected among a host of proposals and recommendations made at the four regional workshops and the international meeting of experts. Many of them included additional information and suggestions as to whom and how they should be carried out. Reference should be made to the individual workshop reports.

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Space Applications Centre	K. Bandyopadhyay P/L,iono-models, System Studies	SAC P.O Ahmedabad, India	380 053	Ahmedabad	+91 79 2691 2326	+91 79 2676 5824
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ViCon Engineering GmbH	Niklasch	Senftenauer Str. 95	80689	München	+49 89-7409432
Geo Forschungszentrum Potsdam	Reigber	Telegrafenberg A 17	14473	Potsdam	+49 331-288-1100
Telematica	Lechner	Baiernrainer Weg 6	83623	Linden	+49 8027-931-0
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Krupp Timtec Telematik GmbH	Tombült	Heinrichstr. 51	44536	Lünen	+ 49 231-9860-211
DFS German Air Traffic Service Provider	Naerlich	Am DFS Campus 10	63225	Langen	+49 69-8054-2210
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Aerodata Flugmeßtechnik GmbH	Vörsmann	Hermann-Blenk-Str. 36	38108	Braunschweig	
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APPENDICES

List of Web Sites and Resource Documents

References:

Fejes I. (2002): Consortium for Central European GPS Geodynamic Reference Network (CEGRN Consortium). Concept, Objectives and Organization. in: *Proc. 27th General Assembly of the European Geophysical Society, Symposium G10*, Reports on Geodesy 1(61) (in press)

Sledzinski J. (2001): Satellite Navigation Systems in geodetic and geodynamic programmes initiated and coordinated by the CEI (Central European Initiative). Results and achievements of the long-term international cooperation of 17 countries. *2nd UN/USA Regional Workshop on the use of Global Navigation Satellite Systems,* Vienna, Austria, 26-30 November 2001

Grenerczy Gy., Kenyeres A., Fejes I. (2000): Present crustal movement and strain distribution in Central Europe inferred from GPS measurements, *Journal of Geophysical Research*, Vol. 105, No. B9, 21835