Resolution A.860(20)

Adopted on 27 November 1997
(Agenda item 9)

MARITIME POLICY FOR A FUTURE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING ALSO resolutions A.529(13) on Accuracy Standards for Navigation and A.815(19) on the World-Wide Radionavigation System,

RECOGNIZING the need for a future civil- and internationally-controlled global navigation satellite system (GNSS) to provide ships with navigational position-fixing throughout the world for general navigation, including navigation in harbour entrances and approaches and other waters in which navigation is restricted,

BEING AWARE of the current work of the International Civil Aviation Organization (ICAO) on the aviation requirements for a future GNSS,

RECOGNIZING FURTHER the need to identify early the maritime user requirements for a future GNSS to ensure that such requirements are taken into account in the development of such a system,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-seventh session,

1. ADOPTS the Maritime Requirements for a Future Global Navigation Satellite System (GNSS), set out in the annex to the present resolution, as the IMO policy for a future GNSS;

2. INVITES Governments and international organizations providing or intending to provide services for the future GNSS to take account of the annexed Maritime Requirements in the development of their plans and to inform the Organization accordingly;

3. REQUESTS the Maritime Safety Committee to keep this policy under review and to report, as necessary, to the Assembly.

Annex

MARITIME REQUIREMENTS FOR A FUTURE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

1 INTRODUCTION

1.1 A Global Navigation Satellite System (GNSS) is a satellite system which provides a world-wide position determination, time and velocity capability for multi-modal use. It includes user receivers, one or more satellite constellations, ground segments and a control organization with facilities to monitor and control the world-wide conformity of the signals processed by the user receivers to pre-determined operational performance standards. The relevant definitions are included in appendix 1 to this annex.

1.2 For maritime users IMO is the international organization which will recognize a GNSS as a system which meets the carriage requirements for position-fixing equipment for a world-wide radionavigation system (WWRNS). The formal procedures and responsibilities for the recognition of a GNSS should be in accordance with paragraph 2 of the annex to resolution A.815(19) on WWRNS, as far as applicable.

1.3 The present GNSSs (see paragraph 2) are expected to be fully operational until at least the year 2010. A future GNSS will improve, replace or supplement the present GNSSs, which have shortcomings in regard to integrity, availability, control and system life expectancy.

1.4 Maritime users are expected to be only a small part of the very large group of users of a future GNSS. Land mobile users are potentially the largest group. Maritime users may not have the highest operational requirements.

1.5 Early identification of the maritime user requirements is intended to ensure that these requirements are considered in the development of a future GNSS.

1.6 There are rapid technological developments in the field of radionavigation and radiocommunications. Developments in shipping and maritime navigation in the next 15 to 20 years have to be taken into account, but are not fully predictable.

1.7 The long period required to develop and implement a future GNSS has led the Organization to determine the maritime requirements for a future GNSS at an early stage.

1.8 However, as development of a future GNSS is presently only in a design stage, these requirements have been limited only to basic user requirements, without specifying the organizational structure, system architecture or parameters. These maritime requirements, as well as the Organization's recognition procedures, may need to be revised as a result of any subsequent developments.

1.9 When proposals for a specific future GNSS are presented to IMO for recognition, these proposals will be assessed on the basis of any revised requirements.

1.10 Early co-operation with air and land users and providers of services is essential to ensure that a multimodal system is provided in the time expected.

2 PRESENT SITUATION

2.1 Presently two State-owned military-controlled positioning satellite systems are offered for civilian use. These systems are mainly used in shipping and in aviation, and land mobile transport survey. For maritime use the following aspects of each system are most relevant:

.1 GPS*

.1.1 The Global Positioning System (GPS) Standard Positioning Service (SPS) is a space-based three-dimensional positioning, three-dimensional velocity and time system which is operated for the Government of the United States by the United States Air Force. GPS met full operational capability in 1995.

.1.2 The GPS is expected to be available for the foreseeable future, on a continuous, world-wide basis and free of direct user fees. The United States expects to be able to provide at least six years notice prior to termination of GPS operation or elimination of the GPS. This service, which will be available on a non-discriminatory basis to all users, meets the requirements for general navigation with a horizontal position accuracy of 100 metres (95%).

.1.3 Accordingly, GPS has been offered and recognized as a component of the world-wide radionavigation system (WWRNS) for navigation use in other waters.

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* When GPS and GLONASS are mentioned in this annex the Standard Position Services (SPS) provided by these systems are being referred to.

.1.4 Without augmentation GPS accuracy is not suitable for navigation in harbour entrances and approaches or restricted waters. GPS does not provide instantaneous warning of system malfunction. However, differential corrections using maritime radiobeacons can enhance accuracy (in limited geographic areas) to 10 metres (95%) and also offer integrity monitoring. Integrity provision may be possible by receiver autonomous integrity monitoring (RAIM).

.2 GLONASS*

.2.1 GLONASS (Global Navigation Satellite System) is a space-based three-dimensional positioning, three-dimensional velocity and time system, which is managed for the Government of the Russian Federation by the Russian Space Agency.

.2.2 GLONASS has been offered and recognized as a component of WWRNS. GLONASS has been fully operational since 1996 and is expected to be operational at least until 2010 for unlimited civilian use on a long-term basis and to be free of direct user fees.

.2.3 GLONASS is meant to provide long-term service for national and foreign civil users in accordance with existing commitments. The service will meet the requirements for general navigation with a horizontal position accuracy of 45 metres (95%). Without augmentation, GLONASS accuracy is not suitable for navigation in harbour entrances and approaches.

.2.4 GLONASS does not provide instantaneous warning of system malfunction. However, augmentation can greatly enhance both accuracy and integrity. Differential corrections can enhance accuracy to 10 metres (95%) and offer integrity monitoring. Integrity provision may be possible by RAIM.

2.2 There are several initiatives to improve the accuracy and/or integrity of GPS and GLONASS by augmentation. The use of different differential correction signals for local augmentation of accuracy and integrity and RAIM may be mentioned as example of such initiatives. In addition, integrated receivers are being developed, combining signals from GPS, GLONASS, LORAN-C and/or Chayka. Wide area augmentation systems are also being developed using differential correction signals from geostationary satellites, in particular Inmarsat III satellites, for instance by the United States and Europe.

2.3 Within the overall context of radionavigation the developments concerning terrestrial systems must also be taken into consideration. DECCA will be phased out in many countries by the year 2000. OMEGA was also phased out in 1997. The United States-controlled LORAN-C networks are under consideration for phasing out by the year 2000. However, the Russian Federation-controlled Chayka networks will not be considered for phasing out until at least the year 2010. Civil-controlled LORAN-C and LORAN-C/Chayka networks are being set up in the Far East, north-west Europe and other parts of the world with plans for extension in some areas.

3 MARITIME REQUIREMENTS FOR A FUTURE GNSS

3.1 The maritime requirements for a future GNSS can be subdivided into the following general, operational, institutional and transitional requirements:

General requirements

.1 The future GNSS should primarily serve the operational user requirements for navigation. For maritime use this includes navigation in harbour entrances and approaches, and other waters in which navigation is restricted.

.2 The future GNSS should have the operational and institutional capability to meet additional area-specific requirements through local augmentation, if this capability is not otherwise provided. Augmentation provisions should be harmonized world-wide to avoid the necessity of carrying more than one shipborne receiver or other devices.

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* When GPS and GLONASS are mentioned in this annex the Standard Position Services (SPS) provided by these systems are being referred to.

.3 The future GNSS should have the operational and institutional capability to be used by an unlimited number of multi-modal users at sea, in the air and on land.

.4 The future GNSS should be reliable and of low user cost. With regard to the allocation and recovery of costs, a distinction should be made between maritime users that rely on the system for reasons of safety and other users that primarily profit from the system in commercial or economic terms. Also the interests of both shipping and the coastal States should be taken into consideration when dealing with allocation and recovery of costs.

.5 Three possible cost-recovery options are identified as follows:

- through funding by international organizations concerned (IMO, ICAO, etc.);
- through cost-sharing between Governments or commercial entities (e.g. satellite communication providers); or
- through private investments and direct user charges or licensing fees.

Operational requirements

.6 The future GNSS should meet the maritime user's operational requirements for general navigation, including navigation in harbour entrances and approaches and other waters where navigation is restricted. These requirements for general navigation are given in appendix 2 to this annex.

.7 The service provider would not be held responsible for the performance of the shipborne equipment. This equipment should meet performance standards developed simultaneously with the service provider and adopted by IMO.

.8 The future GNSS should enable shipborne equipment to provide the user with information on position, course and speed over the ground, have a data-link capability and meet the requirements for interoperability with the shipborne GMDSS equipment.

.9 The following are examples of additional applications which should be taken into consideration in the future GNSS:

- *Shipborne applications:*

  ECDIS interface, automatic position reporting interface, GMDSS interface, high-speed craft requirements, track control, docking/mooring, ship motion monitoring, voyage data recorder, ship heading and attitude indication.

- *External applications:*

  SAR, hydrographic survey, buoy positioning, fairway design and dredging.

.10 No user requirements have been included for non-general navigation purposes (e.g. fishing, hydrographic surveys, offshore-resource mining, mine-sweeping, etc.), as these relate to specific areas of activities, each with specific user requirements. These requirements may be addressed by individual Administrations or relevant organizations.

Institutional requirements

.11 The future GNSS should have institutional structures and arrangements for control by an international civil organization in particular representing the contributing Governments and users.

.12 The international civil organization should have institutional structures and arrangements to enable it to provide, operate, monitor and control the system to the predetermined requirements at minimum cost.

.13 These requirements can be achieved either by the use of an existing organization or by the establishment of a new organization. The organization can provide and operate the system by itself or monitor and control the service provider.

.14 IMO itself is not in a position to provide and operate a GNSS. However, IMO has to be in a position to maintain control over the following aspects of a GNSS:

- the continued provision of the service to the maritime users;
- the operation of the GNSS in respect of its ability to meet maritime user requirements;
- the application of internationally established cost-sharing and cost-recovery principles; and
- the application of internationally established principles on liability issues.

Transitional requirements

.15 The future GNSS should be developed in parallel to the present GNSS, or could evolve, in part or in whole, from the present GNSS.

.16 In advance of full system implementation, a regional system that is fully operational and which has the potential to be a component of a global system may be recognized as a component of a future GNSS.

.17 The terrestrial infrastructure (surveillance stations and monitoring centre) forming the ground segments of the future GNSS should, as far as possible, be compatible with the infrastructure used for the present GNSS.

.18 The shipborne receivers or other devices required for a future GNSS should, where practicable, be compatible with the shipborne receiver or other devices required for the present GNSS.

4 REQUIRED ACTIONS AND TIME-SCALE

4.1 A continuing involvement of IMO will be necessary. The maritime requirements given in this annex should be continually reassessed and updated on the basis of new developments and specific proposals.

4.2. The involvement of IMO should be positive and interactive and the Organization should consider establishing a forum whereby meaningful discussions can take place with air and land users, to resolve difficult mutual institutional matters and consider a joint way forward.

4.3 Recognizing that ICAO is also studying the aviation requirements for a GNSS and that there are prospects of a Joint IMO/ICAO Planning Group for the development of the GNSS, close contacts between IMO and ICAO are necessary.

4.4 International, regional and national organizations, as well as individual companies, involved in the development of a future GNSS should be informed of the requirements set by IMO for acceptance of a future GNSS. These IMO requirements should be incorporated in their GNSS plans to be accepted for maritime use.

4.5 The anticipated time-scale for introduction of the future GNSS is given in appendix 3 to this annex. Though radionavigation systems are under the responsibility and/or control of individual States or groups of States, the time-scales for the expected introduction and phasing out of these systems, such as the present GNSS, the augmentation facilities and terrestrial systems, are also included in appendix 3. The time-scales of these systems determine the time-scale for the decision-making process within IMO.

4.6 For the early and orderly participation of IMO in the introduction of the future GNSS the following anticipated time-scale for the IMO process of decision-making is envisaged:

- *Autumn 1999 (A.21):*

  Reassessment of this resolution, if necessary as a result of unforeseen developments on specific proposed future GNSSs.
- *Autumn 2001 (A.22):*

  Consideration of the proposed future GNSS, including the related agreements between interested Governments, other international organizations and/or system providers.
- *2008:*

  Completion of the implementation (system and organization) of the proposed GNSS with final acceptance by IMO of this future GNSS as a WWRNS for maritime use.

Appendix 1

Terms used in GNSS

Accuracy. The degree of conformance between the estimated or measured parameter of a craft at a given time and its true parameter at that time. (Parameters in this context may be position co-ordinates, velocity, time, angle, etc.)

- *Absolute accuracy (Geodetic* or *Geographic accuracy).* The accuracy of a position with respect to the geographic or geodetic co-ordinates of the Earth.
- *Geodetic or Geographic accuracy.* See *Absolute accuracy.*
- *Operational technical accuracy (OTA).* The accuracy with which the craft is controlled as measured by the indicated craft position with respect to the indicated command or desired position. It does not include operator errors.
- *Relative accuracy.* The accuracy with which a user can determine position relative to that of another user of the same navigation system at the same time.
- *Repeatable accuracy.* The accuracy with which a user can return to a position whose co-ordinates have been measured at a previous time with the same navigation system.

Along-track error. A position error in the direction of the intended track.

Ambiguity. The condition obtained when one set of measurements derived from a navigation system defines more than one point, direction, line of position or surface of position.

Augmentation. Any technique of providing enhancement to the GNSS in order to provide improved navigation performance to the user.

- *Satellite-based augmentation system (SBAS).* A system providing additional satellite signals over a wide area in order to enhance the performance of the GNSS service.
- *Ground-based augmentation system (GBAS).* A system providing additional signals from a ground-based station for a limited geographical area in order to enhance the performance of the GNSS service.

Availability. The percentage of time that an aid, or system of aids, is performing a required function under stated conditions.

- *Signal availability.* The availability of a radio signal in a specified coverage area.
- *System availability.* The availability of a system to a user, including signal availability and the performance of the user's receiver.

Circular error probable (CEP). The radius of a circle, centred on the measured position, inside which the true position lies with 50% probability.

Confidence interval. The numerical range within which an unknown is estimated to be with a given probability.

Confidence level. The probability that a given statement is correct, or the probability that a stated confidence interval (numerical range) includes an unknown.

Confidence limits. The extremes of a confidence interval.

Continuity. The ability of a system to function within specified performance limits without interruption during a specified period.

Correction. The numerical value of a correction is the best estimate which can be made of the difference between the true and the measured value of a parameter. The sign is such that a correction which is to be added to an observed reading is taken as positive.

Coverage. The coverage provided by a radionavigation system is that surface area or space volume in which the signals are adequate to permit the user to determine position to a specified level of performance.

Cross-track error. A position error perpendicular to the intended track.

Craft autonomous integrity monitoring (CAIM). This is a technique whereby all navigation sensor information available on the craft is autonomously processed to monitor the integrity of the navigation signals. (See also *Receiver autonomous integrity monitoring.*)

Differential system. An augmentation system whereby radionavigation signals are monitored at a known position and the corrections so determined are transmitted to users in the coverage area.

Dilution of precision. The factor by which the accuracy of the GNSS position and time co-ordinates are degraded by geometrical considerations.

- *Geometric dilution of precision (GDOP).* The factor for the combined 3D position and time accuracy.
- *Position dilution of precision (PDOP).* The factor for the 3D position accuracy.
- *Horizontal dilution of precision (HDOP).* The factor for the 2D horizontal position accuracy.
- *Vertical dilution of precision (VDOP).* The factor for the 1D vertical accuracy.
- *Time dilution of precision (TDOP).* The factor for the time accuracy.

Distance root mean square (dRMS). The root mean square of the radial distances from the true position to the observed positions obtained from a number of trials.

Failure. The unintended termination of the ability of a system, or part of a system, to perform its required function.

Failure rate. The average number of failures of a system, or part of a system, per unit time. (See also *mean time between failures.*)

Fix. A position established by processing information from a number of navigation observations.

Fix rate. The number of fixes per unit time.

Global navigation satellite service. The signal in space provided to the user by GNSS space and ground segments.

GLONASS (Global Navigation Satellite System). This is a space-based, radio positioning, navigation and time-transfer system operated by the Government of the Russian Federation.

Global Navigation Satellite System (GNSS). A world-wide position, time and velocity radio determination system comprising space, ground and user segments.

Global Positioning System (GPS). This is a space-based, radio positioning, navigation and time-transfer system operated by the United States Government.

Gross errors. Gross errors, or "outliers", are errors other than random errors or systematic errors. They are often large and, by definition, unpredictable. They are typically caused by sudden changes in the prevailing physical circumstances, by system faults or operator errors.

Integrated navigation system. A system in which the information from two or more navigation aids is combined in a symbiotic manner to provide an output which is superior to any one of the component aids.

Integrity. The ability to provide users with warnings within a specified time when the system should not be used for navigation.

Marginally detectable bias (MDB). The minimum size of the gross error in an observation that may be detected with given probabilities of type 1 and type 2 errors. A type 1 error occurs when an observation without a gross error is wrongly rejected, and a type 2 error occurs when an observation with a gross error is wrongly accepted.

Marginally detectable error (MDE). The maximum position-offset caused by a MDB in one of the observations.

Mean time between failures (MTBF). The average time between two successive failures of a system or part of a system.

Navigation. The process of planning, recording and controlling the movement of a craft from one place to another.

Pseudolite (pseudo satellite). A ground-based augmentation station transmitting a GNSS-like signal providing additional navigation ranging for the user.

Precision. The accuracy of a measurement or a position with respect to random errors.

PZ-90 geodetic system. A consistent set of parameters used in GLONASS describing the size and shape of the Earth, positions of a network of points with respect to the centre of mass of the Earth, transformations from major geodetic datums and the potential of the Earth, developed in 1990.

Radio determination. The determination of position, or the obtaining of information relating to position, by means of the propagation properties of radio waves.

Radiolocation. Radio determination used for purposes other than radionavigation.

Radionavigation. The use of radio waves in navigation for the determination of position or direction, or for obstruction warning.

Random error. That error which can be predicted only on a statistical basis.

Receiver autonomous integrity monitoring (RAIM). A technique whereby all navigation sensor information available at a receiver is autonomously processed to monitor the integrity of the navigation signals. (See also *craft autonomous integrity monitoring.*)

Redundancy. The existence of multiple equipment or means for accomplishing a given function.

Reliability (of a service). The probability that a service, when it is available, performs a specified function without failure under given conditions for a specified period of time.

Reliability (of an observation). The reliability of an observation ("internal" reliability) is a measure of the effectiveness with which gross errors may be detected. This reliability is usually expressed in terms of the *marginally detectable bias (MDB).*

Reliability (of a position fix). A measure of the propagation of a non-detected gross error in an observation, to the position fix. This "external" reliability is usually expressed in terms of the *marginally detectable error (MDE).*

Repeatability. The accuracy of a positioning system, taking into account only the random errors. The repeatability is normally expressed in a 95% probability circle.

Root mean square error (RMS). RMS error refers to the variability of a measurement in one dimension. In this one-dimensional case, the RMS error is also an estimate of the standard deviation of the errors.

Single point of failure. That part of a navigation system which lacks redundancy, so that a failure in that part would result in a failure of the whole system.

Systematic error. An error which is non-random in the sense that it conforms to some kind of pattern.

Service capacity. The number of users a service can accommodate simultaneously.

Time to alarm. The time elapsed between the occurrence of a failure in the system and its presentation on the bridge.

True position (2D). The error-free latitude and longitude co-ordinates in a specified geodetic datum.

True position (3D). The error-free latitude, longitude and height co-ordinates in a specified geodetic datum.

World geodetic system (WGS). A consistent set of parameters describing the size and shape of the Earth, positions of a network of points with respect to the centre of mass of the Earth, transformations from major geodetic datums and the potential of the Earth.

Appendix 2

List of minimum maritime user requirements for a future GNSS

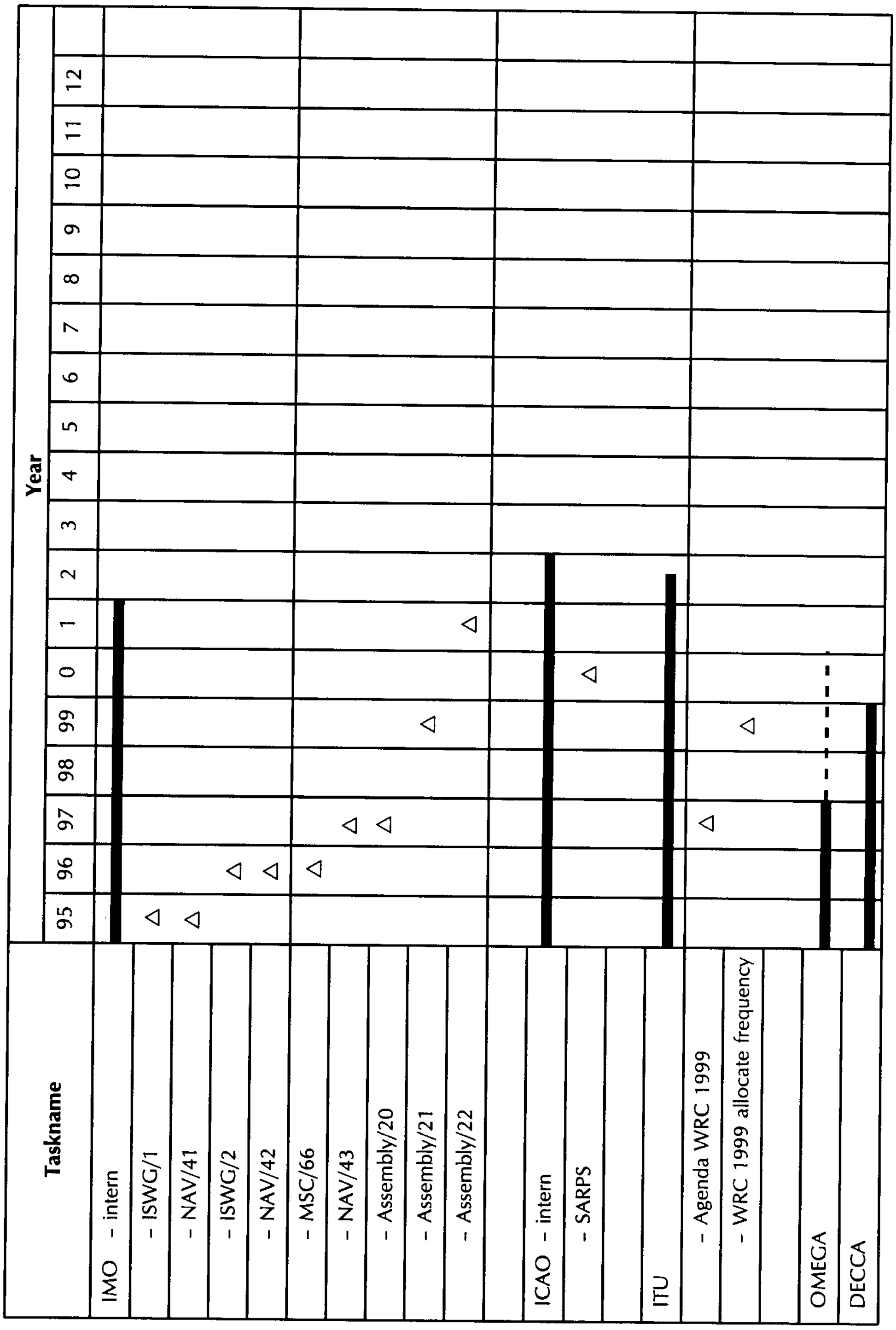
Parameter	Requirement
Accuracy* of the system at the position of the receiving antenna - absolute accuracy - repeatable accuracy	 $\leqslant$10 m (95%) $\leqslant$14 m (95%)
Integrity of the system - time to alarm - threshold value	 $\leqslant$10 s $\leqslant$25 m
Availability of service - threshold value	>99.8% (30 days) Unintended interruptions should not exceed 3 s
Reliability of service	$\geqslant$ 99.97% (1 year)
Coverage of service	world-wide
Fix (update) rate of the system	at least once every 2 s
Service capacity	unlimited

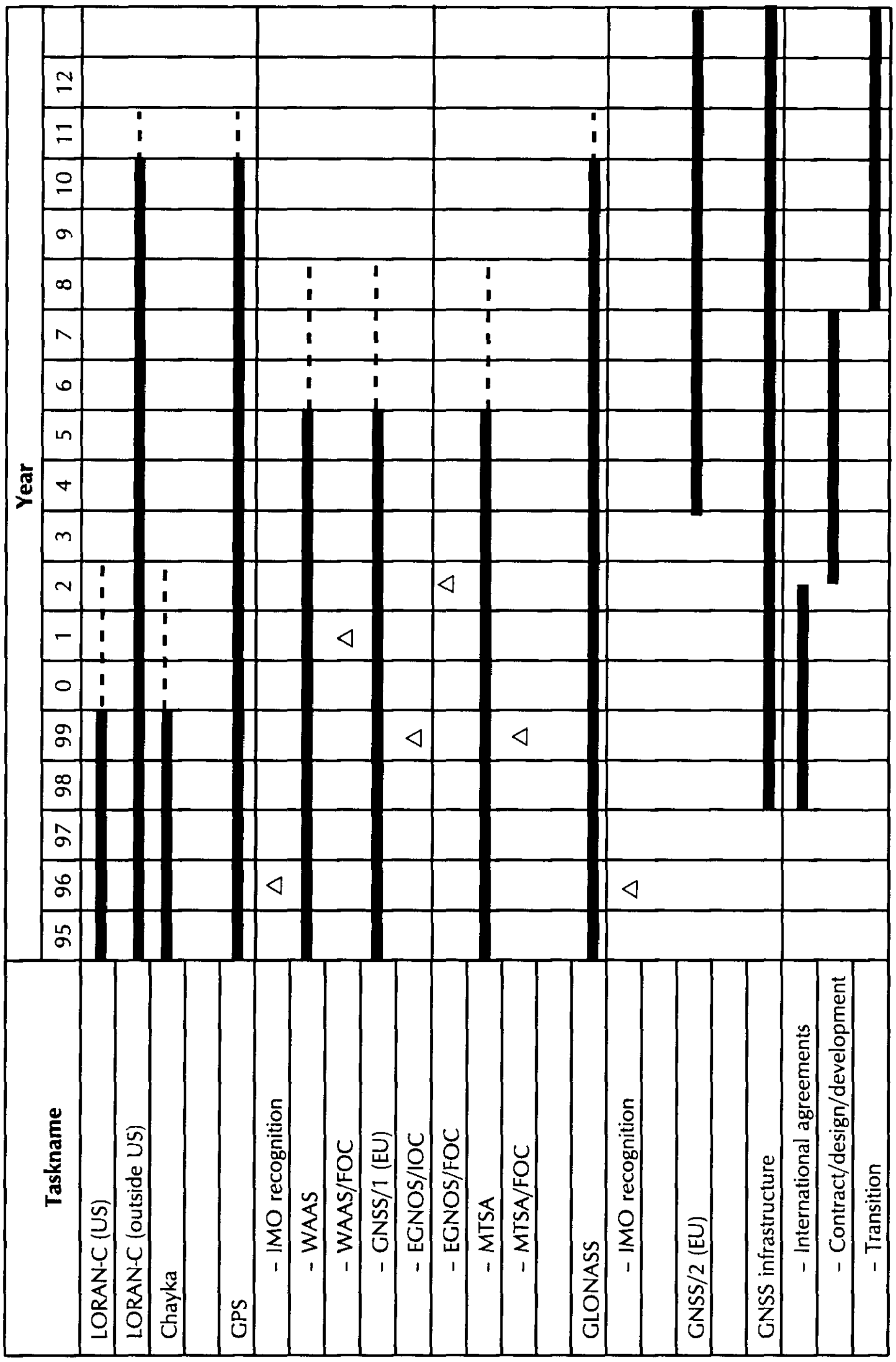
Note: "***system***" includes the service and the shipborne equipment
"***service***" does not include the shipborne equipment.

* Referred to WGS-84.

Appendix 3

Development of future global navigation satellite system/GNSS (indicative)

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LORAN-C (US)
LORAN-C (outside US)
Chayka
GPS
- IMO recognition
- WAAS
- WAAS/FOC
- GNSS/1 (EU)
- EGNOS/IOC
- EGNOS/FOC
- MTSA
- MTSA/FOC
GLONASS
- IMO recognition
GNSS/2 (EU)
GNSS infrastructure
- International agreements
- Contract/design/development
- Transition

Glossary

IMO	International Maritime Organization
ISWG	Intersessional Working Group
NAV	Sub-Committee on Safety of Navigation (of IMO)
MSC	Maritime Safety Committee (of IMO)
ICAO	International Civil Aviation Organization
SARPS	Standards and Recommended Practices developed by ICAO
ITU	International Telecommunication Union
WRC	World Radiocommunication Conference (of ITU)
OMEGA	A very-low-frequency (VLF) hyperbolic radionavigation system based on phase-comparison techniques
DECCA	A low-frequency (LF) hyperbolic radionavigation system based on harmonically related continuous wave transmissions
LORAN-C	A low-frequency (LF) hyperbolic radionavigation system based on measurements of the differences of times of arrival of signals using pulse- and phase-comparison techniques
Chayka	A radionavigation system, similar to LORAN-C, operated by the Government of the Russian Federation
GPS	Global Positioning System operated by the Government of the United States
WAAS	Wide Area Augmentation System, based on GPS, developed by the Government of the United States
FOC	Full Operational Capability
GNSS/1	Global Navigation Satellite System, based on GPS and EGNOS, developed by the European Union
EGNOS	European Geostationary Navigation Overlay System developed by the European Union
IOC	Initial Operational Capability
MTSA	Transport Satellite System, based on GPS, developed by Japan
GLONASS	Global Navigation Satellite System, operated by the Government of the Russian Federation
GNSS/2	Future Global Navigation Satellite System, partially developed by the European Union