RESOLUTION A.666(16)

Revoked by A.815(19)

Adopted on 19 October 1989
Agenda item 10

WORLD-WIDE RADIONAVIGATION SYSTEM

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,

RECOGNIZING the need for a world-wide radionavigation system to provide ships with navigational position-fixing throughout the world,

HAVING CONSIDERED the report of the Maritime Safety Committee at its fifty-seventh session,

1. ADOPTS the Report on the Study of a World-Wide Radionavigation System, the text of which is set out in the Annex to the present resolution, as the IMO policy for the recognition and acceptance of suitable radionavigation systems intended for international use;

2. INVITES Member Governments to keep the Organization informed of the operational development of suitable radionavigation systems conforming to this policy which might be considered by the Organization for use by ships world-wide;

3. REQUESTS the Maritime Safety Committee to keep the aforesaid Report under review for adjustment as necessary.

ANNEX

REPORT ON THE STUDY OF A WORLD-WIDE RADIONAVIGATION SYSTEM

1 INTRODUCTION

1.1 A study on a world-wide radionavigation system has been taking place since 1983 with the objective of providing a basis on which regulation V/12 of the 1974 SOLAS Convention might be amended to include a requirement that ships shall carry means of receiving transmissions from a suitable radionavigation system throughout their intended voyages.

1.2 The terms of reference of the study, as approved by the Maritime Safety Committee were as follows:

.1 *Satellite navigation systems*

The study should determine:

.1.1 the operational requirements of such systems, which must be reliable, of low user cost and meet the needs for general navigation as well as the requirements of the GMDSS;

.1.2 the organizational structure and arrangements which would be needed for such a system, whether provided by an organization or one or more Governments, for it to be recognized or accepted by IMO as being suitable for use by ships;

.1.3 the arrangements, if any, by which a national or multinational satellite navigation system might be accepted mutually by other Administrations for use by their ships.

.2 *Terrestrial navigation systems*

The study should determine the extent to which existing or planned terrestrial navigation systems might satisfy the operational requirements for general navigation, as well as the requirements of the GMDSS.

1.3 The operational requirements for satellite navigation systems are given in appendix 1.

1.4 It is not considered to be feasible for IMO to fund a world-wide radionavigation system. Existing and planned systems being provided and operated by Governments or organizations have therefore been studied to ascertain the conditions under which such systems might be recognized or accepted by IMO.

2 RADIONAVIGATION SYSTEMS CURRENTLY IN USE OR UNDER DEVELOPMENT

2.1 The GPS (United States) and GLONASS (USSR) satellite radionavigation systems which will each provide world-wide coverage are well advanced in their development and are both expected to be operational in the early 1990s. These systems will be suitable for world-wide navigation and will be available to international shipping. Details of both systems are given in table 1, appendix 2.

2.2 In addition to these world-wide radionavigation systems, there are some other satellite and terrestrial systems currently in use providing a service for shipping which operates within the coverage area of such systems. Details of these systems are also given in table 1.

2.3 Some other satellite systems are planned which may be suitable for the navigation of ships when they have been further developed and trials carried out. Details of these systems are given in table 2, appendix 2.

3 PROCEDURES AND RESPONSIBILITIES CONCERNING THE ADOPTION OF SYSTEMS

3.1 Procedures and functions of IMO

3.1.1 The adoption by IMO of a radionavigation system would mean that the Organization recognized that the system is capable of providing adequate position information within its coverage area and that the carriage of receiving equipment for use with the system would satisfy the relevant requirements of the 1974 SOLAS Convention, as it may be amended.

3.1.2 IMO should not adopt a radionavigation system without the consent of the Government or organization which has provided and is operating the system.

3.1.3 In deciding whether or not to adopt a radionavigation system, IMO should consider whether:

- its continued provision is assured;
- it is fully validated;
- adequate arrangements have been made for publication of the characteristics and parameters of the system and of its status, including amendments as necessary;
- adequate arrangements have been made to protect the safety of navigation should it be necessary to introduce changes in the characteristics or parameters of the system which could adversely affect the performance of shipborne receiving equipment;
- adequate arrangements have been made to monitor the availability of the system and the accuracy of the position information obtained;
- the appropriate responsibilities of Governments or organizations have been met, in accordance with paragraph 3.2.

3.1.4 In deciding, in the light of proposed changes in an adopted system, whether the system should continue to be adopted, the criteria given in paragraph 3.1.3 will be applied.

3.2 Responsibilities of Governments or organizations

3.2.1 The provision and operation of a radionavigation system is the responsibility of the Governments or organizations concerned;

3.2.2 Governments or organizations proposing a radionavigation system for adoption by IMO should ensure that:

- it is reliable;
- it is of low user cost;
- it meets the needs for general navigation;
- it is capable of providing position information within its coverage area with an accuracy not less than that given in resolution A.529(13), taking into account the maximum time interval between updates;
- it has an availability which would enable the position information to be obtained in its coverage area for 99.9% of the time, calculated over a 30-day period.

3.2.3 Governments or organizations which have a system adopted by IMO should not make changes to any characteristics or parameters of the system which could adversely affect the performance of shipborne receiving equipment without first notifying IMO in adequate time before the proposed change is made (see resolution A.577(14)).

3.2.4 Governments or organizations which have a system adopted by IMO should assist in the preparation of performance standards for receiving equipment for the system.

4 SHIPBORNE RECEIVING EQUIPMENT

4.1 To avoid the necessity of carrying more than one receiving equipment on a ship, the shipborne receiving equipment should be suitable for operating either with a world-wide radionavigation system, or with one of the radionavigation systems which cover the area in which the ship trades.

4.2 Shipborne receiving equipment should conform to the general requirements for navigational equipment in resolution A.574(14) and be designed to satisfy the detailed requirements of the particular system. The detailed requirements for receivers for the Loran 'C', Tchaika, Decca Navigator, Omega and differential Omega systems are currently available to manufacturers to enable them to construct the equipment.

4.3 Radionavigation systems should make it possible for shipborne receiving equipment automatically to select the appropriate stations for determining the ship's position with the required accuracy and update rate.

4.4 Shipborne receiving equipment should be provided with at least one output from which position information can be supplied in a standard form to other equipment.

5 INTRODUCTION INTO CHAPTER V OF THE 1974 SOLAS CONVENTION OF A CARRIAGE REQUIREMENT FOR SHIPBORNE RADIONAVIGATION RECEIVING EQUIPMENT

5.1 Any necessary amendments to regulation V/12 of the 1974 SOLAS Convention, to introduce a requirement for ships to carry receiving equipment for an appropriate satellite or terrestrial radionavigation system accepted by IMO, should not be considered until world-wide coverage has been achieved by a radionavigation satellite system to an accuracy standard* suitable for general marine navigation.

5.2 To avoid any delay in implementing a carriage requirement after a world-wide radionavigation satellite system has been adopted by IMO, performance standards for the systems described in table 1 should be prepared in advance by the Maritime Safety Committee.

APPENDIX 1

OPERATIONAL REQUIREMENTS

1 INTRODUCTION

The operational requirements for world-wide navigation systems should be general in nature and be capable of being met by a number of systems.

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* Reference is made to resolution A.529(13).

2 COVERAGE

Given that merchant fleets operate world-wide, it is necessary for the information provided by a radionavigation system to be suitable for general* navigation by ships engaged on international voyages anywhere in the world.

3 ACCURACY OF POSITION DETERMINATION

Systems should be capable of providing position information with an accuracy not less than that given in resolution A.529(13). This degree of accuracy is suitable for the purpose of general navigation and for the provision of position information in the GMDSS.

4 UPDATE RATE OF POSITION DATA

The maximum time interval between updates of position information depends upon the accuracy of the particular system and the accuracy required for navigation. Guidance on the update rate is given in resolution A.529(13).

5 AVAILABILITY

Systems should enable a position fix, adequate to meet the accuracy and update rate requirements, to be obtained for 99.9% of the time calculated over a 30-day period.

6 SHIPBORNE RECEIVING EQUIPMENT

6.1 To avoid the necessity for ships to carry more than one receiving equipment for world-wide navigation, the shipborne receiving equipment should be suitable for operating with one of the world-wide navigation systems capable of meeting the operational requirements set out in paragraphs 1.1 to 1.4 or with any other navigation system or systems conforming to the standards of resolution A.529(13) and covering the area in which the ship trades.

6.2 Shipborne receiving equipment should conform to the general requirements for navigational equipment in resolution A.574(14) and be designed to satisfy the detailed requirements of the particular system.

6.3 Systems should make it possible for shipborne receiving equipment automatically to select the appropriate stations for determination of the ship's position with the required accuracy and update rate.

6.4 Shipborne receiving equipment should be provided with at least one output from which position information can be supplied in a standard form to other equipment.

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* Further study is necessary to determine operational requirements for harbour entrances and approaches, and waters in which the freedom to manoeuvre is limited.

APPENDIX 2

TABLE 1

INFORMATION ABOUT OPERATIONAL SATELLITE AND TERRESTRIAL BASED SYSTEMS

Technical and operational aspects

INFORMATION ITEMS	GPS-NAVSTAR* (DOD/ (United States)	TRANSIT (United States)	GLONASS** (USSR)	DIFFERENTIAL OMEGA	DECCA-NAVIGATOR	LORAN-C	TCHAIKA
Principle and system description	Satellite based system. Atomic clock on board the satellites. Position determination of satellites by mathematical model, updated by ground segment. Position determination of user equipment by one-way ranging to four satellites	Satellite based system. Position determination of user equipment by measurement of apparent frequency shifts of signals (Doppler) as the satellite approaches and passes the user	Similar to GPS-NAVSTAR	Transmission of corrections by a local transmitter for each Omega station received locally, in accordance with resolution A.425(XI)	CW, hyperbolic phase comparison system arranged in chains normally comprising one master and three slave transmitters. Each station radiates four harmonically related frequencies in the band 70 kHz to 130 kHz. Each slave is phase locked to master transmitter	High-powered wideband 100 kHz pulsed hyperbolic system arranged in chains comprising 3, 4 or 5 transmitting stations. Stable time source provided by cesium standards	Similar to LORAN-C

* Details of the GPS system may be obtained from:
Space Division CWN-DOT, P.O. Box 92960 WPC, Los Angeles, CA. 90009-2960, United States; or
Commandant (G-NRN), US Coast Guard Headquarters, 2100 2nd St. SW, Washington DC, 20593-0001, United States.

** Details of the GLONASS system may be obtained from:
GLAVCOSMOS USSR, 9, Krasnopresnenskaya, 103 030, Moscow, USSR.

INFORMATION ITEMS	GPS-NAVSTAR* (DOD/ (United States)	TRANSIT (United States)	GLONASS** (USSR)	DIFFERENTIAL OMEGA	DECCA-NAVIGATOR	LORAN-C	TCHAIKA
Status of system	Test with reduced number of satellites	In full operation	Tests with reduced number of satellites	Some stations in operation.	42 fully operational chains around the world comprising 42 master stations and 119 slave stations	16 chains comprising 67 stations	2 chains consisting of 8 stations
Estimated date of introduction	1992		1990 (12 satellites) 1995 (24 satellites)	In operation in selected areas 2000	In operation	In operation	In operation
Phase out		Anticipated 1994					
Operational control	United States Department of Defense	United States Department of Defense	USSR	By the country in which the correction transmitter is	National	United States Department of Transport chains in continental United States at least until the year 2000. Operation of United States Department of Defense chains overseas beyond year 1994 subject to discussions with host and other Administrations. Other chains: not specified	USSR
Key elements			Satellite shore-based stations	1 station can cover an area up to 500 nm depending on transmitter power	–		Shore-based stations

INFORMATION ITEMS	GPS-NAVSTAR* (DOD/ (United States)	TRANSIT (United States)	GLONASS** (USSR)	DIFFERENTIAL OMEGA	DECCA-NAVIGATOR	LORAN-C	TCHAIKA
Number of satellites	24	4	24 (3 spares)		–	–	
Orbit	6 orbits 20,000 km	Polar	6 orbits, 19,000 km		–	–	
Signal	CDMA, different codes for military and civil application	Continuous on 150 MHz and 400 MHz	Published		–	–	
Ground segment	Centralized system. One main station, 4 monitor stations	4 monitor stations	Will be published later	–	–	–	
User segment	Different equipment according to the required accuracy	Accuracy depends on the accuracy of data on ship's speed and course and on date and time	Different equipment at production stage	Different equipment according to manufacturer	Wide range of equipment	Wide range of equipment	Different serial of equipment
Availability (system availability) (coverage)	Continuously all over the world	99% when satellite is in view. Fix rate varies with latitude. Approx. 110 min at equator, 30 min at 80°	Continuously all over the world	Local coverage continuous. Potential for complete coastal coverage	Very high, in excess of 99.95%	Very high, in excess of 99.9%	Local coverage continuous
Reliability	High	99%	High	3 stations joint signal availability of 97%	In excess of 99.95%	95% level of probability	95% level of probability

INFORMATION ITEMS	GPS-NAVSTAR* (DOD/ (United States)	TRANSIT (United States)	GLONASS** (USSR)	DIFFERENTIAL OMEGA	DECCA-NAVIGATOR	LORAN-C	TCHAIKA
Accuracy	General users: 100 m. Differential GPS: below 5 m	Dual frequency: 25 m. Single frequency: 500 m	100 m (2 dmrs)	1 nm to 3 nm up to 300 nm	Typical coastal accuracy: 50 m day 200 m night	Typical coastal accuracy: 50 m to 200 m	50 nm to 200 m
Estimated lifetime	7.5 years each generation (satellite lifetime)	–	At least until year 2000	At least until year 2000	Not specified	United States Department of Transport chains in continental United States will operate into the next century. Operation of United States Department of Defense chains overseas beyond year 1992 subject to discussions with host and other Administrations	Until year 2000
General limitations	System is operated by military authority. User input limited	System is operated by military authority. User input limited	No limitations	No limitations	No limitations	No limitations	No limitations
User limitations	Degree of accuracy of civil code is adjustable by ground segment	User, speed, course and date and time must be known	No limitations	–	–	–	–

INFORMATION ITEMS	GPS-NAVSTAR* (DOD/ (United States)	TRANSIT (United States)	GLONASS** (USSR)	DIFFERENTIAL OMEGA	DECCA-NAVIGATOR	LORAN-C	TCHAIKA
Redundancy	High, because of redundant satellites	High, because of redundancy	High	Same as OMEGA	High, due to high level of redundancy designed into transmitter station equipment and provision for reserve antenna systems	High	High
Additional service			Borne by USSR				Borne by USSR
Installation costs (incl. non-recurrent development costs)	Operating costs borne by the United States Government	Unknown. Costs borne by the United States Government	Borne by USSR	$US 100,000 per station if the supporting radio beacon exists $US 140,000 if not	Variable according to country sites, services and configuration	Variable according to country, site, transmitter size, service and configuration	Borne by USSR
Operating costs per year	No user fee planned	Unknown. Cost borne by the United States Government. No user fee	No user fee	Less than $US 1,500 per station	Some user fees	None	No user fee
Property rights and patents	–	–	–	–	–	–	–
Number of world users	–	–	–	–	Approx. 100,000	Approx. 76,500. Other estimates higher	Approx 1,000

INFORMATION ITEMS	GPS-NAVSTAR* (DOD/ (United States)	TRANSIT (United States)	GLONASS** (USSR)	DIFFERENTIAL OMEGA	DECCA-NAVIGATOR	LORAN-C	TCHAIKA
Growth of users	–	–	–	–	At least 20% per annum	At least 20% per annum	At least 10% per annum
Development	–	–	–	–	Ground station equipment: continuing. Receivers: continuous, to provide maximum facilities at lowest cost	Ground station equipment: continuing. Receivers: continuous, to provide maximum facilities at lowest cost	Ground station and equipment receivers: continuous

TABLE 2

INFORMATION ABOUT PLANNED SATELLITE AND TERRESTRIAL BASED SYSTEMS

Technical and operational aspects

INFORMATION ITEMS	NAVSAT (ESA)	GRANAS (Federal Republic of Germany)	INMARSAT	RDSS United States corporation
Principle and system description	Satellite based system. No atomic clock on board the satellite. Position determination of satellites by corresponding ground segment. Position determination of user equipment by one-way ranging to 3 satellites or by Doppler effect. Notice of satellite malfunction to user within 3 to 9 seconds.	Satellite based system. No atomic clock on board. Satellites determine their own position continuously by two-way ranging to three ground stations. Position determination of user equipment by one-way ranging to four satellites.	Geostationary augmentation of GPS/GLONASS through overlay of similar spread spectrum navigation signals and transmission of GPS/GLONASS integrity information. Satellite position and augmentation signal generation by ground stations. No onboard atomic clock. Position determination by one-way ranging of 4 satellites (INMARSAT overlay and GPS and/or GLONASS). Satellite malfunction notification to users within 10 seconds	Satellite based. No atomic clock on board. Position determination of satellites by ground segment consisting of benchmark transceivers and control centres. Position determination of user equipment by measure of communication path time delays between the user and the RDSS control centre
Status of system	System concept development	System development simulated	System concept development; simulation through a PN test bed on existing INMARSAT satellites (1989). Navigation payload proposed for incorporation on INMARSAT-3 satellites	Coverage of continental United States under development
Estimated date of introduction	1991	Not yet determined	From 1994 in a phased manner	CONUS 1988 world-wide 1989-1991
Phase in Phase out	—			Undetermined

INFORMATION ITEMS	NAVSAT (ESA)	GRANAS (Federal Republic of Germany)	INMARSAT	RDSS United States corporation
Operational control	Not yet determined. International implementation and control envisaged	Not yet determined. International control envisaged	INMARSAT, an international intergovernmental co-operative	Presently by GEOSTAR Corporation. International control possible.
Key elements			Future satellites (INMARSAT-3 and beyond) with navigation payloads, associated satellite position determination facilities and ground stations for generation of navigation signals; integrity monitoring network	
Number of satellites	12 + 6	20	3 + 3 geostationary	2 or 3 for CONUS 6 for coverage between 75°N and 75°S and 8 for world-wide coverage
Orbit	12 highly eccentric Molnya type. 6 geostationary payloads	5 orbits, 20,000 km	Geostationary	Geostationary
Signal	TDMA PN sequence and Doppler	TDMA, PN sequence	Signal structure being defined for maximum possible compatibility and inter-operability with GPS, GLONASS, NAVSAT; presently, CDMA (1.023 Mbps pseudo-noise gold codes) preferred	TDM binary phase shift key carrier
Ground	5 or 6 ground stations and one mission control centre	Decentralized, 15 unmanned stations, one manned	Decentralized employing INMARSAT coast and ground earth stations and TT&C stations world-wide	3 control stations

INFORMATION ITEMS	NAVSAT (ESA)	GRANAS (Federal Republic of Germany)	INMARSAT	RDSS United States corporation
User segment	Different equipment according to the required accuracy	Simple. No code-finding	Different equipment depending on whether working with GPS or GLONASS or GPS + GLONASS, the required accuracy, and whether a combined communications and navigation use	Simple
System availability and coverage	Continuously all over the world	Continuously all over the world	Continuous, world-wide except for high latitude/polar coverage until such time as an orbiting satellite component is added	Continuously all over the world
Reliability	High, graceful degradation of system	High	High	High
Accuracy	Doppler mode: 100 m. Pseudo-range: 5 m to 30 m. Better than 1 m with co-operative transponder	15 m CEP	Pseudo-range: 30 m can be better with differential corrections	Several metres
Estimated lifetime	10 years each generation (satellite lifetime)	10 years each generation (satellite lifetime)	A continuing system. Individual satellites: 10+ years	10 years each generation (satellite lifetime)
General limitations	No limitations	No limitations	Initial phase is in augmentation of GPS and GLONASS; can evolve gracefully to an independent civil CNS system	No limitations
User limitations	—	No limitations	No limitations. A passive system open to all international civil users	No limitations

INFORMATION ITEMS	NAVSAT (ESA)	GRANAS (Federal Republic of Germany)	INMARSAT	RDSS United States corporation
Redundancy	High (redundant satellites)	High (redundant satellites)	High (redundant satellites); both in terms of in-orbit backup for satellites carrying navigation payload but also as a complement to GPS/ GLONASS constellations	Unknown
Additional service	Addition of communications and search and rescue function under study	Communication service: low speed data transmission without additional primary power (space in the timeframe)	A full array of world-wide mobile satellite (maritime, aeronautical and land mobile communications) services – data as well as voice, messaging, data/position reporting, monitoring and control, etc. Integration of functions allows for greater intergrity than provided by separate systems	Distress location. Message transmission. EPIRB capabilities. Homing capabilities. False alarm interrogation capabilities. Secondary radio system capabilities.
Installation costs (inc. $US 150 million non-recurrent development costs)	$US 950 million	$US 600 million	Under review. Navigation package estimated to add about 5% to mass of INMARSAT-3 satellites. Support ground-segment costs also marginal because existing infrastructure can be employed	Unknown
Operating costs per year	$US 150 million	$US 100 million	Under review	Unknown. $US 20 per month user fee and $US 450 transceiver cost
Property rights and patents	None	–	–	
Number of world users	–	–	–	
Growth of users	–	–	–	
Development				