COMMISSION OF THE EUROPEAN COMMUNITIES

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Proposal for a

COUNCIL DECISION

on the LORAN-C radionavigation system

(presented by the Commission)

1. Introduction

The enhancement of the standard of maritime safety in general and in Europe in particular is one of the concerns of the Community. While recognising the important role of international organisations, such as the International Maritime Organisation, for the establishment of worldwide safety rules it is nevertheless in the field of operations of the maritime industry that the European Community can best develop specific actions. With the objective of ensuring the safety of navigation in Europe and neighbouring areas, the development and improvement of aids to navigation is one of the actions which we are currently concerned with.

Although the Commission intends to outline its view on maritime safety at a later date, recent developments have made it a necessity to consider the matter of radionavigation aids at this stage.

II. Radionavigation Aids

Under the Safety of life at Sea Convention (SOLAS 1974), as amended, especially regulation 14 of Chapter V "Safety of Navigation", dealing with aids to navigation, each contracting government has the obligation to arrange the establishment and maintenance of such aids to navigation as in their opinion the volume of traffic justifies and the degree of risk requires. In European waters, and especially in coastal areas, radionavigation aids have long been recognised as an important element of the provisions made to meet the above mentioned international obligation to maintain maritime safety.

Radionavigation aids are complemented by the visual aids of lights and buoys, of which a basic system will continue to be necessary to mark hazards and navigable channels and give visual confirmation of a ship's position. With the advance of technology, however, there is a growing wealth of choice of electronic aids to navigation.

The existing radiopositioning systems can be divided into two categories, the space-based systems on the one hand and the terrestrial-based systems on the other. The systems can be further classified on the basis of the extent of their coverage extending from purely local to worldwide coverage.

Two satellite systems offering worldwide cover to an intended accuracy of 100 metres for civil users are expected to be operational in the mid 1990's.These are the U.S. Global Positioning System (GPS) and the USSR Global Navigation Satellite System (GLONASS).

Due to similarities between the two systems it might theoretically be possible for users to have receivers that could work with either system. Unfortunately both systems are military systems. Many organisations within the International Maritime Organisation have expressed reservations about adopting either system as a worldwide civil navigation system. As stated in the U.S. Federal Radionavigation Plan, GPS signals will be available to serve the safety of navigation at all times except during a time of national emergency when only those radionavigation signals that serve the national interest will be available. The recent past has proved that despite the policy detente regional conflict cannot be ruled out. Thus total reliance on any single system would expose users to the risk of having no radionavigation aid. In addition there is uncertainty concerning the possible future introduction of user dues on the satellite systems.

On the European level, GRANAS (Global Radionavigation System) and NAVSAT, developed by the European industries, funded by the European Space Agency, are global civil navigation satellite systems which have similar operational objectives to GPS. These are still in the planning phase.

Technical specifications of these systems are given in annex B 1.

The satellite systems will provide three dimensional position determination. Satellite systems have an achievable accuracy of between 2.4 and 24 metres according to whether the user is stationary or moving but for the civilian user the accuracy offered is in the order of 100 metres.

As terrestrial-based radionavigation systems suitable for general navigational ,purposes the OMEGA, the DECCA Navigator System and the LORAN-C system can be identified.

The OMEGA system provides position fixing of limited accuracy, it is only usable for general navigation on routes followed by ships in the ocean phase and for aircraft. It is likely to be replaced by GPS but may be retained for marine use until the turn of the century.

The technical specifications of the DECCA system are given in annex B 1. Coverage by DECCA is adequate around the British Isles, extensive in western Europe from Norway to the English Channel including part of the Baltic. It is also provided in certain other sea areas around the Iberian Peninsula, Australia, Japan, South Africa, India and the Arabian Gulf. It has been estimated there are about 140.000 users worldwide; most are in Europe. In total about 80.000, rising to 90.000 by the end of 1989, are fitted to vessels which use three UK chains.

The Loran-C system is also a terrestrial-based radio hyperbolic position-fixing system. The system is based upon measurements in the difference in time of arrival of pulses of radio frequency energy radiated by a chain of synchronised transmitters which are separated by hundreds of miles. More technical information is given in annexes B 1 and B 2.
Although initially established to meet US defense requirements LORAN-C is widely available for civil use in the Northern Hemisphere to all using a commercially available receiver. In addition to the fourteen LORAN-C chains managed by the US Coastguard worldwide LORAN-C chains have been established in France, Egypt, Saudi Arabia, China, India and Korea. The Soviet Union operates a similar radionavigation system called Chayka.

III. INTERNATIONAL DEVELOPMENTS

The US Coastguard has stated its intention to cease funding and manning all Loran-C stations outside of the US at the end of 1994. The US Coastguard has also offered to transfer all or part of Loran-C station equipment to interested host nations when these are no longer needed by the U.S.

A working group comprising representatives from Canada, Denmark, the Federal Republic of Germany, France, Iceland, Ireland, Norway the USA and IALA (the International Association of Lighthouse Authorities) started discussions about the future of Loran-C in 1983.

In 1985 France introduced a Loran-C chain at its own expense which is operated with two stations.

From 1 January 1987 the RACAL DECCA Company ceased to be responsible for the management of the DECCA navigator chains around Great Britain and Ireland and the responsibility for them has been assumed by the Lighthouse Authorities.

In March 1987 a special radionavigation Conference of IALA presented seven conclusions on Loran-C. The most important conclusion undoubtedly was that whereby Denmark, France, the Federal Republic of Germany, Ireland, the Netherlands, Norway and the United Kingdom agreed to enter into direct negotiations with each other to consider the possibility of extending Loran-C coverage in N.W. Europe. The conference concluded that in appropriate national and Regional areas terrestrial radionaviagtion systems should be maintained after the introduction of new satellite navigation systems for the foreseeable future.

Another conclusion reached by the conference was that the IALA will continue to pursue the possibility of extending Loran-C coverage along the Iberian Peninsula and in the Mediterranean until such time as the governments concerned are in a position to enter into direct negotiations with each other.

Discussions between the Mediterranean countries started in 1989 in IALA with the participation of the Commission of the European Communities to examine the need to maintain or even extend Loran-C in the Mediterranean area.

In 1989 the USA and the USSR signed an agreement for a joint Loran-C/CHAYKA radionavigation system to facilitate improved marine and air navigation in the North Pacific Ocean and the Bering Sea areas.

In April 1990,the UK decided in principle, on technical and cost grounds, to join the international civil Loran C system currently proposed for N W Europe and the North Atlantic. Implementation of this decision is dependent upon a satisfactory international agreement being achieved by early/mid 1991 with the other interested states, with the new Loran C system in place and operational before the end of 1993.The existing contractual arrangements for the UK Decca Navigation system extend to February 1997.

In May 1990 the French, Portuguese and Spanish governments begun expert level discussions on the establishment of a Loran-C chain for the Atlantic with sufficient coverage to link the Mediterranean and North Atlantic chains.

In September 1990 IALA chaired a first meeting, in Tokyo, between Japan, USSR, China and Republic of Korea with a view to seeking the co-operative operation of the Loran-C in these countries.

IV. ADVANTAGES AND POSSIBILITIES POSED BY THE LORAN-C

Loran-C satisfies the mariners needs for accuracy. It meets the requirements of IMO Resolution A 529 (13) and provides an accuracy level at least equal to, and in many cases better than, the existing DECCA system.

The existence of operational Loran-C stations, and others coming into operation, facilitates the development of a European Network in the short term.

The handover of existing facilities without charge has an obvious cost advantage and Loran-C is considered to be markedly less costly than the existing DECCA system.

Loran-C is capable of being extended to provide coverage of all European and neighbouring waters without major difficulty. Existing projects will offer coverage of blind radionavigation areas which is not possible with existing DECCA (especially in Irish waters, and the Bay of Biscay). Furthermore the co-operation with the USSR Chayka Chains will be possible.

The existing Loran-C charts would continue to apply thus minimising inconvenience and costs to mariners.

The Loran-C system has proved to have an acceptable level of reliability of operation which is vital for the mariner.

Loran-C technology is already developed and transmitters/receivers are commercially available. A large number of receiver types are available without restrictive systems patents. This provides considerable scope for lower unit costs and hence lower selling prices of receivers as the system is extended.

Confidence is lacking in the continuing availability of essentially military satellite systems and Loran-C would be a terrestrial-based alternative civil system under the control of contracting governments.

The chain configuration of Loran-C facilitates phased implementation for programmed growth and utility in the coverage area.

As there is no limit to the number of receivers that can use Loran-C simultaneously future capacity considerations are accommodated.

Applications of Loran-C are not confined to maritime use. It can also be extended for land and air use. There has been a significant increase in the number of users in the US civil aviation community in recent years. The US has established new stations to complete coverage of the entire continental US.

Combined Satellite/Loran-C coverage will offer the highest degree of system verification and continuity of radionavigation coverage for the benefit of maritime safety and environmental protection.

V. State of the discussion on international level

1. North West European chain :

The governmental representatives of Denmark, The Federal republic of Germany, France, Ireland, the United Kingdom, Canada, Iceland and Norway, members of the Loran-C Policy Group, will finalise an agreement based upon the Policy-Group report before the end of this year. Since July 1990 the E.C. Commission has attended the meetings of the Group as an observer.

The governments participating in the Loran-C Policy Group will be invited to establish a Loran- C system for North West Europe and the North Atlantic. An agreement has and already been reached on the configuration (Annex B 2) and on the technical requirements of the System (Annex B 3).

It will be noted that in the current stage of the discussions the Benelux countries are not envisaged to be involved in the foreseen agreement.

The Netherlands initially participated in the policy group but decided not to participate in the agreement. Their reasons are that the two DECCA navigator chains controlled by the Dutch authorities still meet the requirements regarding maritime traffic in their coastal waters.

Despite the opinion of all other Member States involved, the Netherlands considers that putting Loran-C into operation in Dutch coastal waters would be a superfluous interim step in the global changeover from terrestrial navigation systems to satellite based systems.

Denmark has already agreed to maintain the Loran-C stations in Ejde and Angissoq but will not be able to take a final decision regarding its participation in the final agreement before the end of this year. It is the intention of the Policy Group to finalise the agreement before the end of the year even if the Netherlands or Denmark will not participate in an agreement.

Germany supports the NWE chain. That results from the inclusion of the Sylt station in the chain. Germany is prepared to support an enhancement of the Loran-C system in the Baltic with possible new stations in the eastern part of Germany or the Polish area. The International Telecommunications Unions has already been asked to allocate frequencies for an East European Chain. The Soviet Union is prepared to co-operate in this respect.

The United Kingdom, Ireland and Iceland support the agreement with the largest coverage area. The UK emphasised that an acceptable international agreement on Loran-C is a prerequisite for the UK for changing from its DECCA system to the Loran-C.

France is prepared to bring its two stations built on its own account into the system. France is supporting the chain with the largest coverage to ensure the link with the foreseen Atlantic chain. Therefore France is prepared to make signals from its two stations available for hyperbolic use of the system with other stations.

Canada is participating in the chain because of its interest in the Loran-C station at Angissoq which is dualrated as part of the Labrador Sea chain.

It is important to emphasise that the decision of the Netherlands or Denmark not to participate in an agreement will probably not affect the configuration and coverage of the foreseen N.W. European Chain. Although a revision of the costsharing agreement could have an influence on some technical aspects such as the power of the stations.

The agreement will be finalised in the January meeting of the Policy group.

The Mediterranean chain

The IALA took the initiative to bring the interested parties of the Mediterranean area together with the aim of setting up a similar agreement to the NWE agreement. Representatives of Italy, Greece, France, Spain, Portugal, Algeria, Egypt, the US Coast Guard and the Commission of the E.C. have met each other since January 1989.

There is a general consensus in the Mediterranean working group in favour of maintaining the existing Loran-C stations in Italy and Spain and maintaining the existing coverage in the Mediterranean for the benefit of merchant ships, fishing vessels, pleasure craft and hydrographic surveys after the US Coastguard cease to operate the stations in 1994. The latest meeting in Paris confirmed the need for a terrestrial navigation system in the Mediterranean Sea and that the Loran-C was the only feasible system meeting the maximum service requirements of coverage in the most cost-effective way.

A subcommittee, coordinated by Italy, will study the technical and administrative matters concerning the existing Loran-C stations.

To ensure a coverage equivalent to or even better than the actual chain it is vital that a solution for the re-siting of the Turkish Station of Kargaburun be found if the Turkish government maintains its decision not to take over the US Coastguard station on its territory. One solution could be to site a new station on Greek territory. The final objective of the group is to facilitate as soon as possible the setting up of a Mediterranean MOU for the Mediterranean Loran-C with 1994 as the operational target date.

Iberian (Atlantic) chain

The French, Spanish and Portuguese representatives participating in the Mediterranean Loran-C group, confirmed their intention to extend Loran-C coverage into the Atlantic Ocean, including the Azores and the Canary Islands and improve coverage in SW Mediterranean area.

As a result, preliminary discussions started in Madrid in May 1990 between experts of those countries. It is the intention to find an agreement on the configuration and the technical requirements of the chain thus ensuring a link with the NW European and Mediterranean chains.

VI. Community interests in the Loran-C chain

The countries participating in the N.W. European Loran-C Policy group and in the Mediterranean Loran-C group consider it advisable that the goal should be to have a single terrestrial based radionavigation system, stretching from North Europe to the Mediterranean and through the Atlantic.

Without prejudice to the development of satellite navigational systems, the Commission supports the development of a European Loran-C coverage composed of three regional chains. A possible configuration of the European chain is given in annex B 4)

Taking account of the achievements of the discussions on a NW European chain and the intention of the Mediterranean countries regarding the Mediterranean and Iberian chains, the Commission supports the development of regional chains with the largest coverage area.

As safety is an integral part of the Common Transport Policy it is the role of the Community to develop initiatives in the field of maritime safety with special regard to the maintenance of high safety standards. Having regard to the achievement of the objectives of the Treaty it is the role of the Commission to base its proposals to the Council upon a high level of protection.

Radionavigation systems are part of the safety environment of ships. The withdrawal of existing systems without any replacement by another reliable and accurate system will affect the level of safety of ship operations in Community waters. The development of regional Loran-C chains is, for the immediate future only, a suitable alternative for existing terrestrial systems which are being phased out, it will result in an improvement of the actual accuracy of radiopositioning. In the future Loran-C, as an essential and economical verification system for satellite navigational aids will contribute to the enhancement of maritime safety in Europe on a large scale.
Recognising that Loran-C is an accurate radiopositioning system that can be developed on the European level in the very near future, the Commission, with the purpose of maintaining and developing the high standard of safety for ship operations in European waters, proposes to the Council that it supports the achievement of regional Loran-C chains in the European area. This will, through its operation, contribute significantly to the preservation and protection of the marine envirionment.

Considering the need for the compatibility of the aids to navigation systems introduced or foreseen on the regional level in Europe it is important that the Commission acts so as to ensure such compatibility.

It must be noted that the withdrawal of any involved party from the envisaged agreement will seriously jeopardise the development of the European network.

Following an agreement between the USA and the USSR on Loran-C the development of a European Loran-C chain will extend Loran-C coverage to the entire northern hemisphere.

As soon as the European interest in the Loran-C chains is recognised it will be necessary to improve the accuracy of the system and to develop the most suitable receivers, with regard to future developments especialy by satellite.

Taking account of the decision of some Member States to cease operating the DECCA system appropriate measures have to be found to ensure the transition from one radionavigation system to another is achieved at the lowest cost for the users.
The Commission is prepared to start investigation in this field.

For all the above mentioned reasons there now exists a unique opportunity to provide a low-cost radionavigation system to cover European waters thus enhancing maritime safety and protection of the maritime environment. It is vital that this opportunity is seized. The Commission proposes to the Council the adoption, as soon as possible, of a Decision, based upon the proposal in Annex A.

Proposal for a
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THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 84 paragraph 2 thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Parliament,

Having regard to the opinion of the Economic and Social Committee,

Whereas the international Maritime Organisation (IMO) requires the contracting governments to the SOLAS Convention to undertake to arrange for the establishment and maintenance of such aids to navigation as the volume of traffic justifies and the degree of risk requires;

Whereas it is a concern of the Community to ensure the highest degree of safety of navigation and protection of the marine environment;

Whereas the United States Coastguard has decided to terminate its LORAN-C commitments outside the USA before 1994 and has the intention to offer the LORAN-C facilities to the relevant host nations;

Whereas the international Association of Lighthouse Authorities (IALA) supports the need for a terrestrial radionavigation system to meet the needs of maritime navigation;

Whereas certain Member States intend to participate in one or more regional agreements on the establishment of LORAN-C chains covering North West Europe and the North Atlantic, the Mediterranean, the Iberian Peninsula and the Baltic;

Whereas the LORAN-C system satisfies the international requirements and the more general utilisation of the LORAN-C system does not prejudice the development of satellite aids to navigation; whereas, furthermore, combined coverage by satellite and LORAN-C will offer the highest degree of system verification and continuity of radionavigation coverage for the benefit of maritime safety and environmental protection;

Whereas the establishment of regional LORAN-C systems must ensure, a coherent and complete coverage of the European maritime area, avoiding as much as possible the imposition of additional costs upon the users of existing terrestrial radionavigation systems;

HAS ADOPTED THIS DECISION :

Article 1

1. The Member States shall participate in or join regional agreements on LORAN-C as far as necessary to realise the international objectives.

2. With regard to their participation in regional agreements the Member States shall seek to achieve the LORAN-C configurations which cover the widest possible geographical area in Europe and in neighbouring waters.

Article 2

The Commission:

- shall ensure coordination between the Member States participating in regional agreements with a view to ensuring compatability between the LORAN-C chains introduced on the regional level,

- shall encourage the development of LORAN-C receivers, taking account of the ongoing development of satellite systems and the enhancement of the present LORAN-C system,

and shall propose, where necessary, to the Council the necessary measures.

Article 3

In their role as member or observer within the International Association of Lighthouse Authorities the Member States and the Commission shall strive to obtain the participation of the greatest possible number of countries in the European regional LORAN-C chains with the purpose of enlarging the coverage of LORAN-C worldwide in order to improve safety of navigation and protection of the marine environment.

Article 4

This Decision is addressed to the Member States.

Done at Brussels,

For the Council
The President

TECHNICAL SPECIFICATION OF AIDS TO NAVIGATION SYSTEMS

1. GLOBAL POSITIONING SYSTEM (GPS)

GENERAL

The Global Positioning System (GPS) is a space-based, radio positioning, navigation and time-transfer system having free major segments: space, control and user. The GPS space segment, when fully operational, will be composed of 21 satellites, plus three operational spares in six orbital planes. The satellites will operate in circular 20,200 km orbits at an inclination angle of 55° and with a 12-hour period. The spacing of satellites in orbit will be precisely arranged so that a minimum of four satellites will be in view to any user, thereby ensuring world-wide coverage. Each satellite will transmit L1 and L2 signals. L1 will carry a precise (P) signal and a coarse/acquisition (C/A) signal. L2 will carry a P signal only. Superimposed on these signals will be navigation and atmospheric-propagation correction data, and satellite clock-bias information.

The control segment will include a number of monitor stations and ground antennas located throughout the world. The monitor stations will use GPS receivers to track passively all satellites in view, and thereby accumulate ranging data from the satellite signals. The information from the monitor stations will be processed at the master control station (MCS) to determine the satellite orbits, and to update the navigation message of each satellite. This updated information will be transmitted to the satellites via the ground antennas, which will also be used for transmitting and receiving satellite control information.

The user segment will consist of antennas and receiverprocessors that will provide positioning and navigation data to the user.

PURPOSE

GPS is a position-fixing system which will be used for general navigation on land, sea and air. It will also have survey and timing applications.

SIGNAL CHARACTERISTICS

The GPS concept depends upon having accurate and continous knowledge of the spatial position of any satellite in the system, in terms of the time and distance of the satellite from the user. Each satellite transmits its own ephemeris data. This data is periodically updated by the control station, and is based upon information obtained from five widely dispersed monitor stations.

The GPS receiver automatically selects appropriate signals from three or four of the satellites that give the best view as based on the optimum satellite-to-user geometry. It then solves time-of-arrival difference quantities to obtain the distances between the user and the satellites. This information establishes the user's position with respect to the satellite system. A timecorrection factor then relates the satellite system to earth co-ordinates. Each satellite continuously transmits a composite spread-spectrum signal at 12227.6 (L2) and 1575.42(L1) MHz that contains a precise navigational signal, a coarse navigational signal, satellite ephemeris data, atmospheric-propagation correction data and clock-bias information. The user equipment measures four independent pseudo-ranges and range rates, and translates these to a three-dimensional position, a velocity and a system time.

ACCURACY

Reference System. The geodetic reference system selected for use by the Global Positioning System (GPS) is the World Geodetic System (WGS). The GPS currently uses the 1984 version, which is designated as WGS 84. Datum transformation will permit coordinates to be transformed between WGS 84 and most of the major and local datums in the world.

The GPS provides two services for position determination.

The Precise Positioning Service (PPS) will provide predictable positioning accuracy of 17.8 m (2dRMS) horizontally and 27.7 m (2 sigma) vertically, velocity accuracy of 0.2 m/sec (2 sigma) in each of the three dimensions, and timing accuracy. The PPS will be limited to the US and allied military and federal government users. Limited civil use may be authorised to those who can demonstrate a need for the accuracy that cannot be obtained by other means, is in the US national interest and can satisfy US national security requirements.

The Standard Positioning Service (SPS) will provide a lower level of accuracy than the PPS. The SPS will be made available to civil, commercial and other users at the highest level of accuracy that is consistent with the national interests of the USA. The current policy of the American Department of Defense (DOD) is to provide the SPS at an accuracy of 100 m (2 dRMS).

2. GRANAS/NAVSAT

GENERAL

The GRANAS (Global Radio Navigation System) is a planned civil, satellite-based radio navigation system with the capability of additional communication services. NAVSAT is a planned global civil navigation satellite system which has similar operational objectives to the GPS.

GRANAS has been investigated by Standard Elektrik Lorenz, (SEL) funded by the German Ministry of Research and Technology. NAVSAT has been developed by European industries, funded by the European Space Agency (ESA).

Both systems reveal more similarities than differences. In order to enhance the prospect of a future system realization, ESA decided to release a study which aims at the harmonization of the GRANAS and NAVSAT systems. It was the objective of the study to identify the best features of the original concepts and to merge them into a single consolidated system.

For the method of satellite position determination the principles of GRANAS and NAVSAT are taken as two parallel options. One of these will be selected at a later stage, when some realization aspects are considered in more detail, e. g. by means of an experimental validation system.

The new system is characterized by the composition of the following features :

SPACE SEGMENT

The configuration of the space segment is characterized by 6 equally spaced geostationary satellites (GEO) supplied by 12 satellites in 6 inclined highly-elliptic orbits (HEO) with 12-hour periods. These orbits are arranged within 3 orbital planes mutually separated by 120 % in right ascension of ascending nodes and incline by 63.4 with regard to the equator. Each plane includes two orbits, one with its apogee in the Northern, the other with its apogee in the Southern hemisphere. During 5/6 of a HEO period the ground track is concentrated on a relative small area providing good visibility conditions and making this type of orbit comparable to GEO satellites. Only the altitude of a HEO satellite is changing considerably increasing up to 39,000 km. To avoid problems of high Doppler frequencies each HEO satellite becomes operational only above an altitude of about 10,000 km. Nevertheless, this constellation guarantees, that during 96,2 % of the time at least 4 satellites (GEO as well as HEO) are visible.

The communication function (e.g. for the purpose of position reporting in case of SAR) may be realized according to INMARSAT standards.

GROUND SEGMENT

In the case of autonomous satellite position determination 16 ground stations are proposed which are equipped with simple transponders to respond to the interrogation signal. The monitor function is performed simultaneously.

For the ground based position determination 6 Regional Centres are needed, one of which provides the service of the Mission Centre. However, about 10 additional monitor and tracking stations are required. For these the same locations as above can be used.

USER SEGMENT

The harmonized navigation system offers two navigation modes : dual frequency and single frequency. The dual frequency mode permits correction for ionospheric delays to be made and hence provides higher accuracy than the single frequency mode of operation.

PURPOSE

GRANAS/NAVSAT would be a general navigation system for position-fixing by air, land and sea users.

SIGNAL CHARACTERISTICS

The determination of the user position is similar to that of GPS in making pseudorange measurements to at least 4 satellites. However, the new system bases on a time-devision multiplex (TDMA) approach using 15 time slots within a frame length of 2.4 s. Each navigation burst consists of a synchronization preamble (24 ms), 5 data words (100 ms and a postamble 16 ms). The latter is transmitted at another frequency (1228 MHz compared to 1575 MHz) in order to compensate for ionospheric delays.

The data part of the burst includes system time, satellite position coordinates as well as an additional word indicating the health status of the system.

ACCURACY

Due to the chip rate of 4 MHz and the dual-frequency method, the accuracy of user position is comparable to that of the GPS P-code.

According to whether a user is stationary or moving an accuracy of 2.4 or 24 m (2dRMS) respectively is achievable.

3. GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS)

GENERAL

The Global Navigation Satellite System (GLONASS) is a space-based, radio positioning system that is being introduced in the USSR for world-wide use by aircraft, but it could also be used at sea level. The system will start operation with between 10 and 12 satellites, of which 5 or 6 will be positioned in each of two orbital planes having an inclination of 65°. The satellites will operate in nearly circular orbits at an approximate height of 19,100 km, and with a period of 11.25 hours. The system is finally intended to contain 24 satellites, of which 3 will normally serve in a standby mode, three orbit planes 120° apart will each contain seven to eight satellites.

The user will establish his position by receiving signals from three satellites and thereby calculating the distances to the satellites. A signal that will give a very precise fix of position will be provided to users who are allowed the means to decode it, while a different signal that will give a less accurate fix will be generally available. The former signal will be carried by two frequencies in the L band (L1 and L2), while the latter will be carried by only one of these frequencies. This arrangement is similar to the P and C/A signals of the GPS. It might be possible, because of similarities between the GLONASS and GPS, for users to have receivers that could work with either system.

PURPOSE

Glonass is a position-fixing system which will be used for general navigation by aircraft and ships.

SIGNAL CHARACTERISTICS

A master station monitors the satellites in order to keep the ephemeris, or positional, data of each one up to date. The satellites transmit their data over separate channels using a spread-spectrum technique. The L1 and L2 frequencies are respectively 1597-1617 MHz and 1240-1260 MHz.

ACCURACY

100 m horizontal, 150 m vertical and 15 cm/s velocity (all 95 % probability).

4. DECCA

GENERAL

The Decca Navigator System, generally known as Decca, is a hyperbolic radio navigation system, operating in the 70-130 kHz frequency band, using groups of at least three ground transmitter stations, each group making a system unit known as a chain. A Decca chain consists of one Master, and two or three Slave stations, 80-110 km from the Master, designated as Red, Green and Purple. The signals can be received by surface craft and by aircraft at all altitudes down to ground level at distances of several hundred kilometres from the transmitters. The characteristic high accuracy of Decca results from its combination of hyperbolic geometry, and the phase comparison method of time-difference measurement.

PURPOSE

The Decca Navigator System is used for position-fixing principally by maritime and aviation users.

SIGNAL CHARACTERISTICS

Transmitter signals are continuous unmodulated radio waves, the Slave signal is phase-locked to the Master. The frequencies of the unmodulated continuous radio waves transmitted from the Master and Slaves are harmonically related to a fundamental value "f" which is not transmitted but which is roughly 14 kHz, the exact value varying from chain to chain.

Phase synchronisation of Master and Slave transmissions creates a pattern of hyperbolic position lines along which the phase difference between Master and Slave is constant. Position fixing carried out by the Decca receiver consists basically of identifying position lines by phase comparison carried out with a multiple frequency.

In receivers, the transmitted frequencies are multiplied in order to produce comparison frequencies of 24f (Red), 18f (Green) and 30f (Purple).

Taking the Red comparison frequency as an example, 24f equals approximately 340 kHz corresponding to a wavelength of about 880 metres. By travelling 440 metres (half a wavelength) along the Master-to-Slave baseline a phase change of 360° is produced, and this distance is designated as a lane and indicated by a complete revolution of the phasemeter pointer of Deccometer receivers and by counting up or down 100 divisions of one lane, at the displays of receivers with a digital performance.

However, on the latest receivers the position is usually displayed in geographical coordinates.

Off the inter-station baseline, the lane widths expand in accordance with the hyperbolic geometry but the instrinsic accuracy of the system is indicated by the fact that phase is measured to within one or two hundredths of a lane, corresponding to a few metres in distance.

Lanes and zones (groups of 24 Red, 18 Green and 30 Purple lanes) are counted by either a geared pointer on the Deccometer or on a digital display of a modern microprocessor based receiver.

Once every 20 seconds lane identification signals known as multipulse, are transmitted from each station in turn. Their prime purpose is to provide a check on the lane settings, however, because these signals are formed from a 1 f pulse synthesised from all four radiated frequencies, they are much less susceptible to skywave errors at night than those that may be experienced using the normal patterns, it can be shown that variable errors, particularly at longer ranges from the chain, are significantly smaller at night using multipulse - and can be up to 2:1 better. In the current generation of Decca receivers, the multipulse signals can provide the primary fixing information, being rate-aided between transmissions by the normal or continuous patterns.

ACCURACY

The accuracy of Decca is specified in some metres at positions on or near the baselines between two stations, but this accuracy decreases as the distance from the baseline increases. Due to sky-wave interference Decca is susceptible to night effect which generally reduces the accuracy by a factor of 6 to 8.

In daylight at a distance of 240 km the accuracy will be better than 440 metres; this figure deteriorates to approximately 2.4 km at night. Within 80 km of the Master station the accuracy is approximately 25 metres by day and 190 metres at night.

All accuracies quoted are at 2 dRMS.

In areas of fringe cover, a single line is used for homing purposes by mariners. The high order of repeatability of the Decca system is also particularly significant. For example, if the Decca co-ordinates of a particularly good fishing area are known, a vessel can subsequently return to the position by referring solely to the Decca readings. Similarly, any user can be directed to a precise location by using Decca coordinates.

In certain areas the hyperbolic patterns are distorted, mainly owing to the signals passing over ground of low electrical conductivity. These distortions, known as fixed errors, should be taken into consideration when fixing the ship's position. This information is published in the form of Pattern Correction Charts in the Chain Data Sheets.

5. LORAN-C

PURPOSE

LORAN-C is a general navigation system for air, land and sea users. In addition to its position fixing capability it can be used for timing purposes.

SIGNAL CHARACTERISTICS

LORAN-C is a hyperbolic system operating in the 90-110 kHz frequency band. Each station of a chain is separated by several hundred miles with each transmitting a series of eight precisely timed RF pulses.

Chain differentiation is provided by Group Repetition Interval (GRI). Selection of specific GRI may be coordinated with the US Coast Guard to avoid interference.

The system is based on the measurement of the differences in the time of arrival of signals from the stations in a chain. The measurements of the Time Difference (TD) are made in a receiver which achieves high accuracy by comparing a specified cycle zero-crossing within the transmitted pulses of the master and secondary stations of a chain. The comparison is made at the 30 us zero crossing to avoid sky-wave interference. Additionally, the phase of the pulses is alternated in a predetermined pattern over two groups of eight pulses to limit the effects of long delayed sky waves. Precise control over the pulse shape ensures the proper comparison at the 30 us zerocrossing.

ACCURACY

Within the defined coverage area, Loran-C provides the user using an adequate receiver with a predictable accuracy of 0.25 m (2dRMS) or better. The repeatable and relative accuracies range between 18 and 90 m. Accuracy is dependent upon the Geometric Dilution of Precision (GDOP) at the user's location, the measurement error (signal-to-noise ratio) and chart or local area calibration. The Loran-C ground wave is primarily used for navigation; precise time measurement and time interval dissemination are also derived from the Loran-C signal.

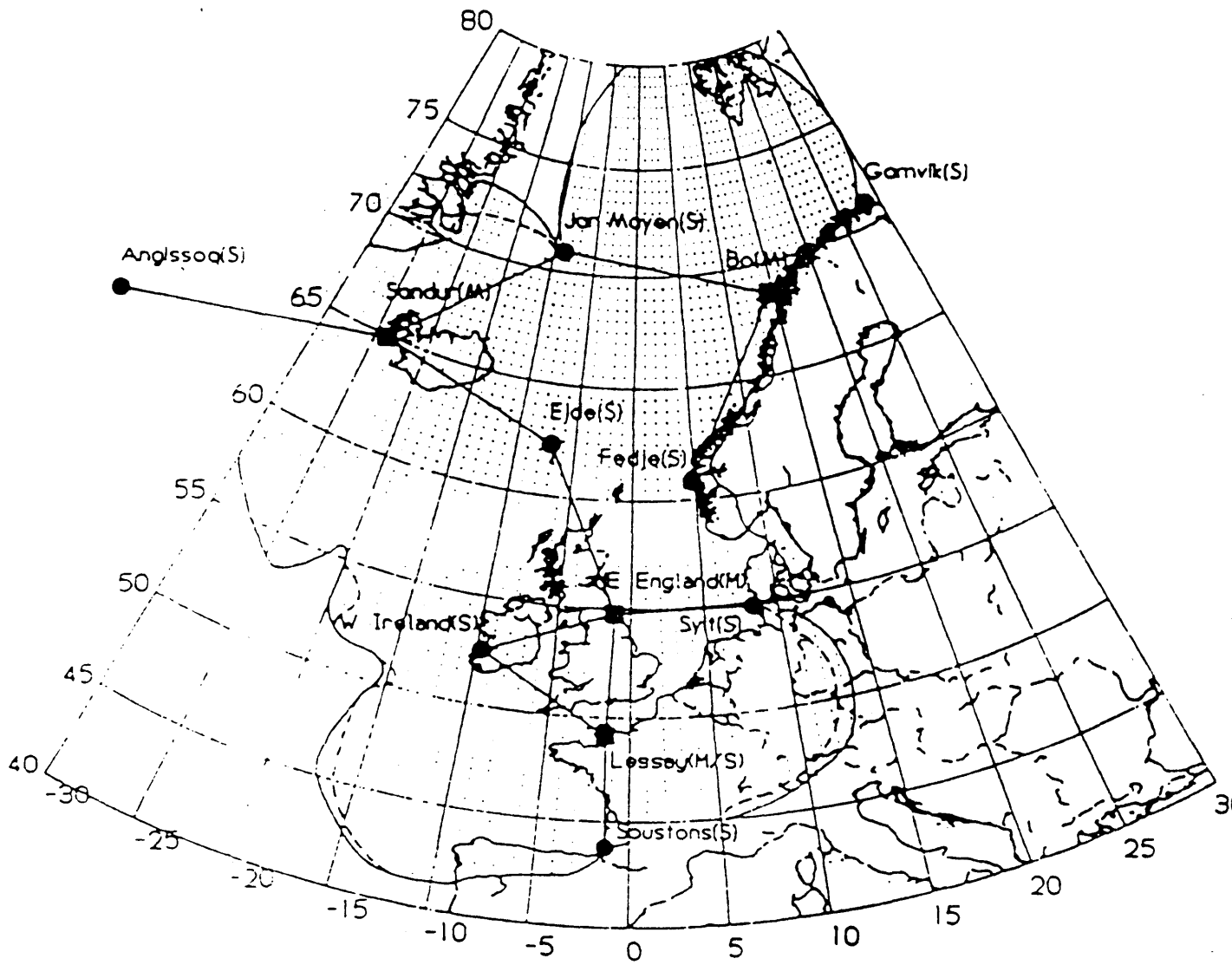
Sky-wave navigation is feasible, but with a significant loss in accuracy. Like ground waves, sky-waves to some extent may also be used for time dissemination. Loran-C was originally designed to be primarily a hyperbolic navigation system. However, with the advent of the highly stable frequency standards, Loran-C can also be used in the range-range (rho-rho) mode of navigation. This is accomplished by a comparison of the received signal phase with a known time reference to determine propagation time and, therefore, range from the stations. It can be used in situations where the user is within reception range of individual stations, but beyond the hyperbolic coverage area. The rho-rho method using Loran-C requires that the user has a very precise and stable time reference. The high cost of equipment limits the use of this mode.

The accuracy of the Loran-C system makes it a suitable candidate for many land radiolocation applications. Loran-C can be received in mountainous areas where VHF and UHF systems are terrain limited. Some distortion of the hyperbolic grid is to be expected since the 100 kHz signal's time of arrival and strength are affected by the soil conductivity and terrain. Propagation anomalies may be encountered in urban areas where the proximity of large man-made structures affect the signal. The existence of these anomalies is predictable and can be compensated for, usually by surveying the area. The long range of the Loran-C system makes it particularly desirable for application to remote areas, or where the user population is too low to justify the cost of a large number of short-range facilities.

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ANNEX B2

Proposed configuration NW-Europe and Atlantic



SYSTEM DESCRIPTION

General

1. The North West European Loran C system shall comprise the eight existing stations of the Icelandic, Norwegian and French chains, with the addition of two new stations in Norway and one each in Ireland and the United Kingdom.

2.The coverage of the new system is shown in annex 2. The area shaded is limited either by accuracy (maximum error .25 n. mile 2drms) or by signal strength (minimum SNR - 10db noise 61dB above 1uV/m).

Transmitted Signal

3. The signal from all the transmitters shall conform to the requirements of the "Specification of the transmitted Loran C signal" (USCG-USDOT COMDTINST M 16562. 4 July 1981).

Transmitting Equipment

4.The transmitters shall be of modular construction and shall consist of a prime power unit, timing and control units, pulse generating assemblies, a coupling network, output cabinets, switch network and antenna fenders.

5.New transmitting equipment shall be required at all sites except those in France. Gamvik, Fedje, South West Ireland and North East England are new sites. The existing stations in Norway (Boe and Jan Mayen) shall be dual-rated in the new system, but the existing transmitting equipment is unsuitable. The present valve transmitters on the other four sites (Angissoq, Sandur, Ejde and Sylt) shall be replaced with solid-state equipment.

6. Power requirements vary depending on the ranges and types of terrain to be covered. Transmitters of different peak radiated power (p.r.p.) can be provided using the same components but increasing the number of pulse generating assemblies.

Antenna

7. The antenna is a top-loaded, guyed, steel lattice tower, fully insulated from the guys and foundation with the exception of the feed from the antenna coupler. The antenna may be 200 m to 400 m high.

ANNEX B3

Monitoring and control

8. Time of transmission (TOT) control will probably be used for the complete system eventually, although existing USCG stations will be controlled via System Area Monitors at least until the proposed handover date (1994).

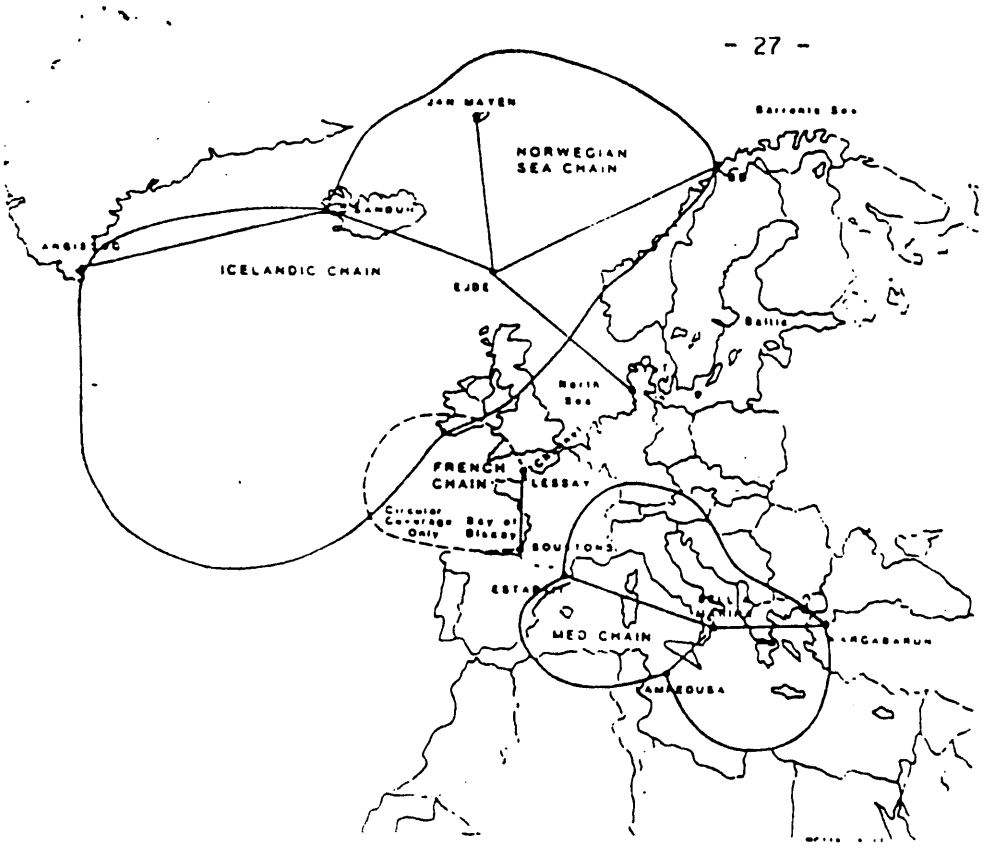
9. Under TOT, times of transmission are fixed relative to an external standard such as Universal Co-ordinated Time (UTC). Propagation time along the baselines is measured by monitor receivers located at or near the transmitter sites. Data from these monitors is automatically sent to a control centre from which commands such as timing adjustments are sent, again by data link.

10. The standard deviation of TOT, with respect to UTC, for each transmitter shall be kept below a pre-determined value, probably 50-100 nanosec. The standard deviation of time differences between masters and secondary shall be less than 30 nanosec.

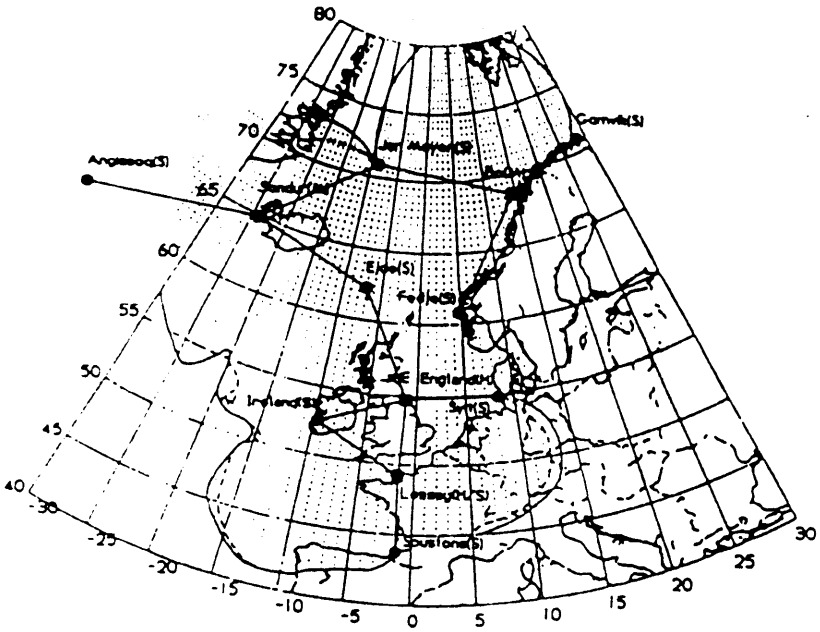
11. The system shall be controlled from two centres : Boe in Norway for the Iceland and Norwegian Sea chains and Brest in France for the North Sea and Biscay chains.

12. The principal maintenance centres and stores shall also be at these control centre locations, together with a maintenance centre at Sandur.

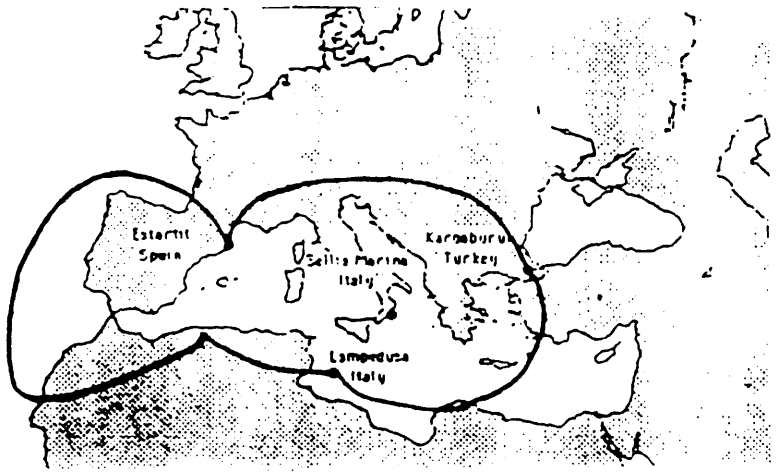
ANNEX B 4



EXISTING LORAN C COVERAGE



PROPOSED COVERAGE
N-W EUROPEAN LORAN C



ENVISAGED LORAN C
COVERAGE IBERIAN PENINSULA
AND MEDITERRANEAN SEA

COMPETITIVENESS AND EMPLOYMENT IMPACT STATEMENT

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1. What is the main reason for introducing the measure ?

The simultaneous withdrawal of the DECCA RACAL company and the US Coastguard from the provision of radionavigation signals in Europe and the on-going development of new radionavigation systems in the Iberian Peninsula and the Mediterranean poses the potential major problem of piecemeal, uncoordinated, and hence uneconomic development of radionavigation signal systems in Europe. The proposal aims to secure the commitment of the Member States and inter alia third countries to the introduction of the LORAN-C radionavigation system as the European standard for the medium term.

2. Features of the business in question

All enterprises which use radionavigation signal systems.

3. What obligations does this measure impose directly on business ?

No additional obligations.

4. What indirect obligations are national, regional or local authorities likely to impose on business ?

Authorities are likely in-due course to require vessel owners to adapt or replace existing receiving equipment to ensure the maintenance of high safety standards.

5. Are there any special provisions in respect of SME's ?

None.

6. What is the likely effect on :

a) The competitiveness of the business

The competitiveness of Community vessel operators will be enhanced through the avoidance of the necessity to equip vessels with multiple receivers to interface with different radionavigation signal systems.

b) Employment

Positive.

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