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SARSAT: A RESCUE SYSTEM FOR SHIPS AND AIRPLANES

ERNO Raumfahrttechnik GMBH

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SARSAT
A Rescue System for Ships and Airplanes

0. INTRODUCTION /1

The search and rescue service is a humane activity for all people in emergency and danger situations. The successful performance of any type of assistance is not only greatly dependent on the emergency equipment of those in distress as well as their helpers, but in a very special way it is also dependent on an effective alarm system that facilitates the rapid transmission of emergency signals and a swift determination of the distress location as well as a quick, powerful and dependable telecommunication system to and among rescue centers and units.

A satellite support system should offer the best guarantee for the creation of a locating system in all emergency and danger situations that functions worldwide, i.e. for sea and air traffic as well as for inhabitant all over the world, independently of the type of terrain and airspace, by the employment of suitable installations and handy emergency beacons and buoys.

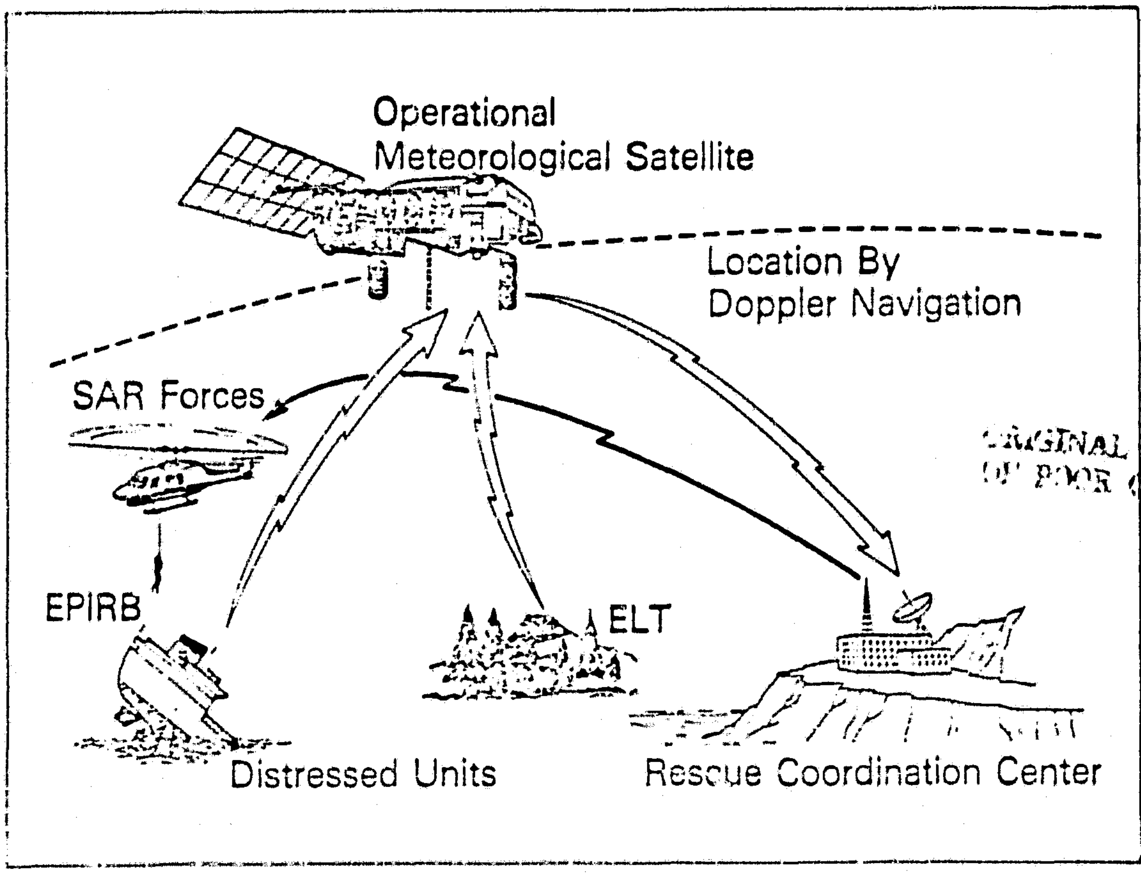
The application of this technology could at long last realize the efforts to develop and introduce an effective alarm system for the fast and rather precise determination of positions and areas all over the world in case of emergencies, threats and accidents of any kind.

1. ACTIVITIES IN OTHER COUNTRIES /2

With SARSAT the USA, Canada and France are presently cooperating on just such a project. "NASA-Goddard Space Flight Center" and the "Canadian Communication Research Center" are pursuing a concept which has the following characteristics (Fig.1):

- Three Weather Satellites of the TIROS-N series (Television Infrared Radiation Observation Satellite), all equipped with a SARSAT (Search and Rescue Satellite) transponder;
- They cross the earth at least twice daily at a height of 834 km in an orbit near the pole;
- The Doppler principle is used to determine the position of the emergeny call beacons (ELT-Emergency Location Transmitter or EPIRB-Emergency Position Indicating Radio Beacon).

Fig.1: SARSAT-Concept [1]



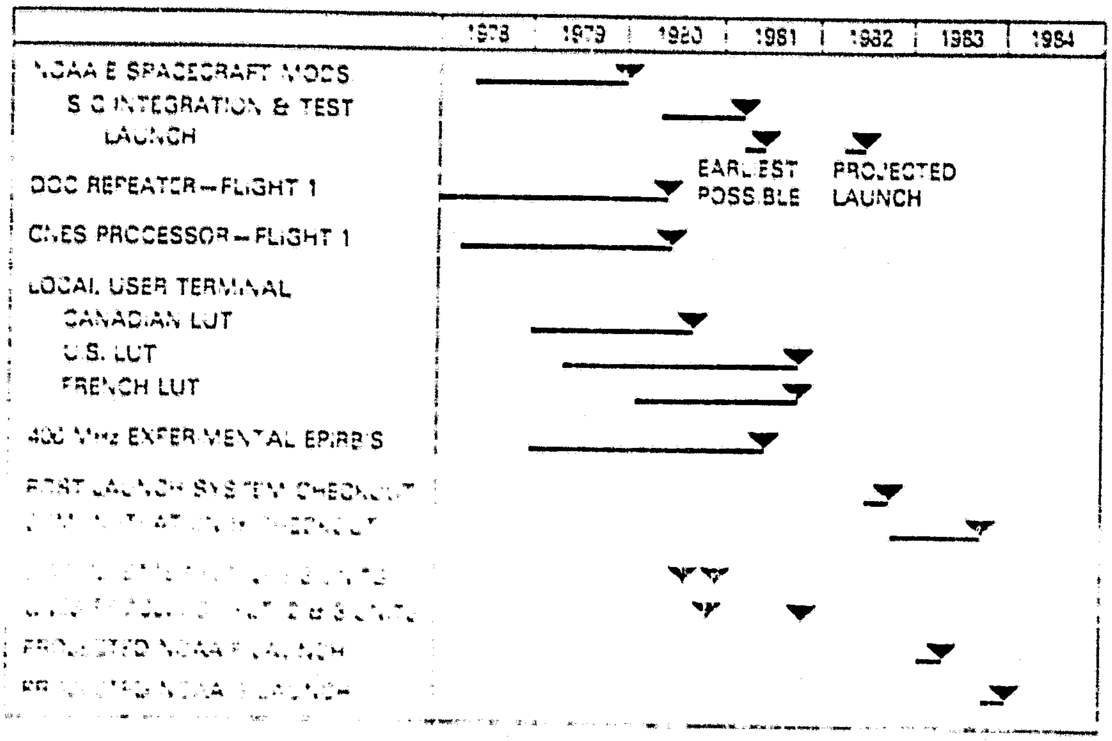
The already existing alarm systems (buoys, beacons, etc.) are working in the range of 121.5/243.0 MHz. With their aid positions can be determined within 10 to 20 km. The beacons which are being developed right now, which will work in the 406 MHz range, can achieve a precision between 2 and 5 km. In addition to the already mentioned SARSAT-transponder there is another signal processor available which stores signals until recall for transmission to the next visible groundstation. /3

Tab.1: SARSAT-Project (USA, Canada, France) [1]
Distribution of Work

	U.S.	CANADA	FRANCE
SPACEBORNE	NOAA SPACECRAFT MODIFICATIONS AND S/C ANTENNAS	COMMUNICATIONS REPEATER	406-MHz SPACEBORNE PROCESSOR
NOAA GROUND SYSTEM	MODIFICATION OF CONTROL CENTER AND DATA PROCESSING FACILITY	———	———
LOCAL USER TERMINALS	PROVIDE U.S. LUT'S	PROVIDE CANADIAN LUT	PROVIDE FRENCH LUT
EXPERIMENTAL 406 MHz EMERGENCY BEACONS	PROVIDE UNITS FOR U.S. USE	PROVIDE UNITS FOR CANADIAN USE	PROVIDE UNITS FOR FRENCH USE
USER DEMONSTRATION	YES	YES	YES

Both the transponder and the signal processor are presently under development--the distribution of work between the USA, Canada and France is shown in Tab.1--. The first flight is intended for 1982. Additional starts are planned for mid-1983 and early 1984. A detailed timetable is shown in Tab.2.

Tab.2: SARSAT-Project [1]
Timetable



2. NECESSITY

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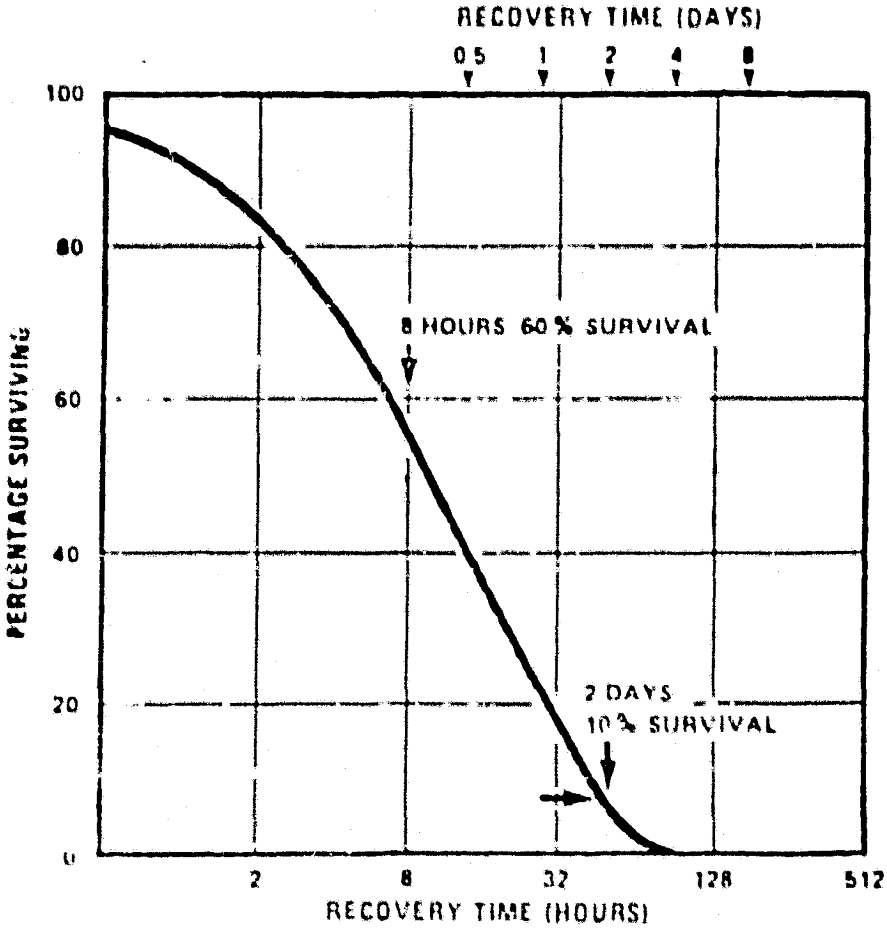
The urgent need for such a satellite system is demonstrated in Fig.2. From the moment the alarm is triggered (in whichever way) the prospects for resue decrease rapidly with the length of the search action. The chances for success are almost always a race against time.

Fig.2: Probability of Success versus Lapse of Time [2]



3. ALTERNATE SYSTEMS

Several realization possibilities are available. After having introduced the SARSAT-concept which is presently being developed Fig.3 shows several system alternatives. Here SARSAT can function either as a independent satellite within an emergency call system or as additional SAR (Search and Rescue) payload of another satellite system. Besides, a differentiation must be made between a general rescue service or an exclusive sea-rescue service. This would allow satellite or track-specific differentiations within these two areas.

Fig.3: Alternate systems

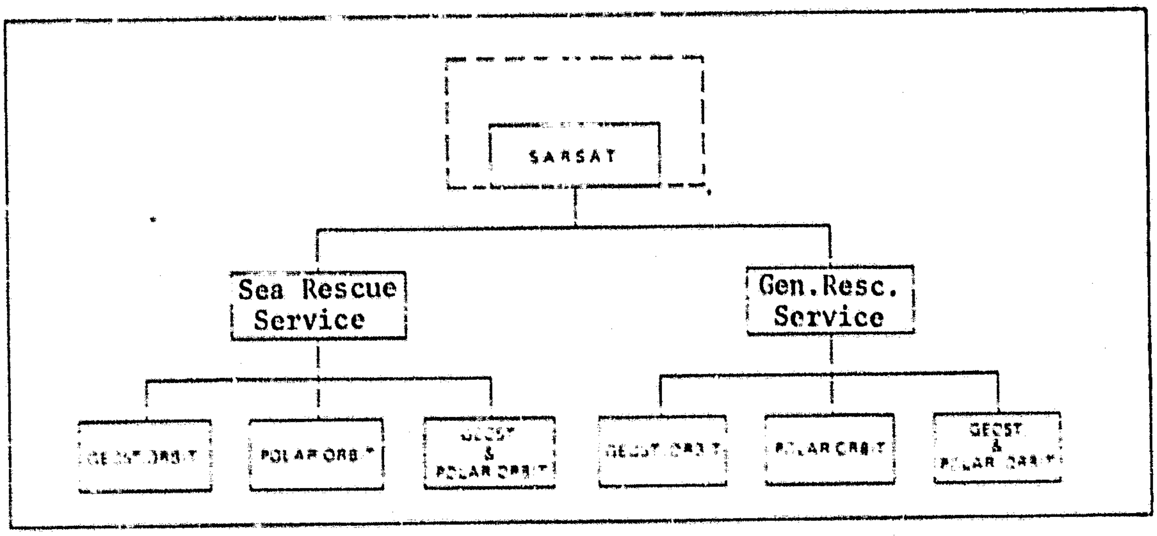


Fig.4 Number of Satellites or System Alternatives

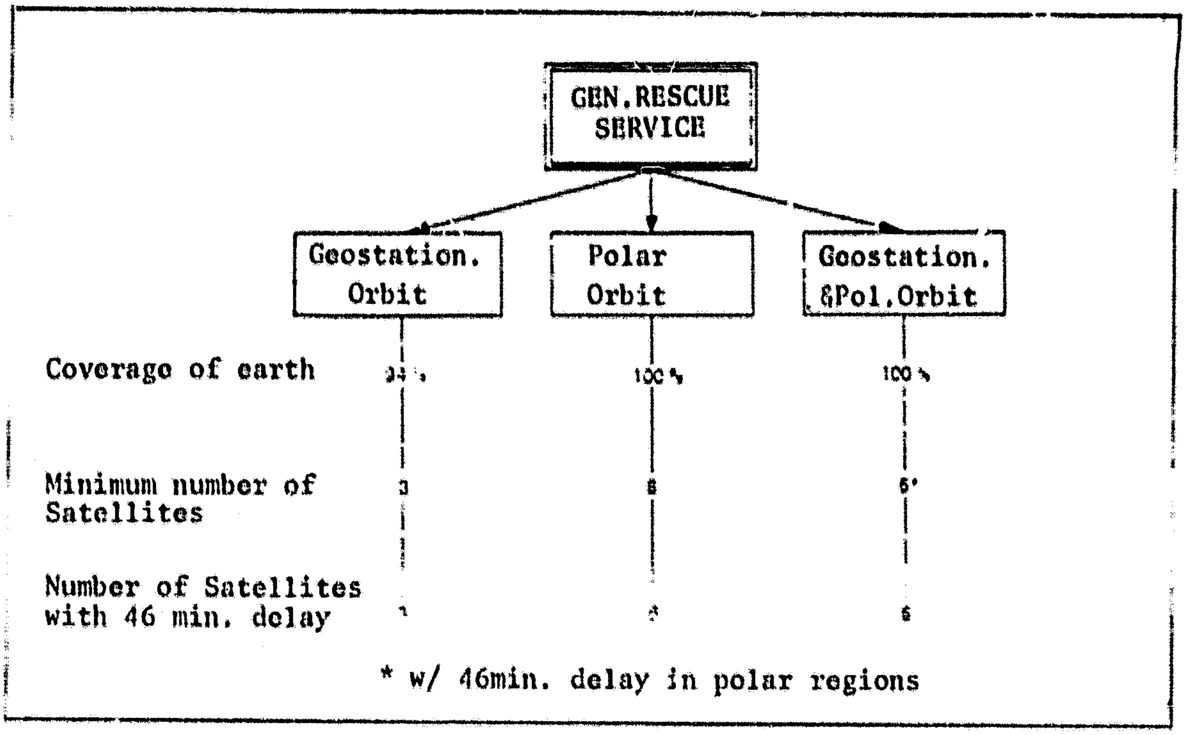


Fig.4 showed the following for general emergency services: /6

- Geostationary orbit:
  Three satellites, positioned above the equator, have a field of view from 70° north to 70° south. The polar areas are not covered. This results in a 94% coverage of the area at all times.

  This system does not permit the use of the Doppler-Principle which makes the use of weak emergency signal-senders questionable.

- Polar orbit:
  Two orbits whose node lines are offset by 45° and who operate at a height of 16,000 km permit a 100% coverage of the earth at all times. This system requires eight satellites. This number can, however, be reduced if a time delay (the time difference between transmission of the signal and localization by the satellite) is permitted.

- Geostationary and polar orbit:
  To cover 100% of the earth's surface by means of geostationary satellites, additional satellites which circle the globe in polar orbits have to be provided. For this possibility 3 geostationary and 3 polar orbits are suggested. To achieve 100% coverage at all times this number would have to be increased to seven (3 geostationary and 4 polar).

4. MARECS IN THE INMARSAT-SYSTEM

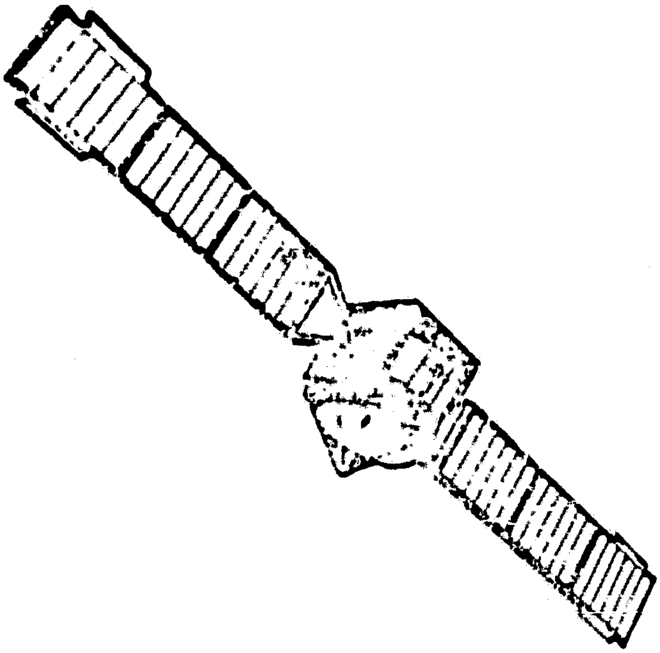
/7

In 1981 the INMARSAT system will take over from the MARISAT system which has been in operation since 1976 and is now at the end of its life. Both systems serve to connect ships to the international public Telephone/Telex/Facsimile network.

Presently the MARISAT system consists of three geostationary satellites (over the Atlantic at 15° West, over the Pacific at 176.5° East, over the Indian Ocean at 73° East). The successor, INMARSAT, will consist of three MARECS and three additional INTELSAT-V satellites with an additional maritime payload. The capacity of the future INMARSAT are summarized in Fig.5.

It is of special interest that here telex and telephone connections can be established with absolute precedence in case of emergencies at sea.

Fig.5: MARECS in the INMARSAT System



PERFORMANCE OF THE INMARSAT-SYSTEM:

* World-wide telephone, Telex, facsimile service (MARECS: Atlantic, Indian Ocean)
* 50 transmission channels
* no wait, constantly good quality independent of distance and weather
* automatic data transmission
* REAL TIME sea distress radio transmission

5. SATELLITE--FOR EMERGENCIES ONLY /8

This Telex/Telephone connection can be augmented by a sea-distress radio-signaler (in the 1.6 GHz range), which was developed in Germany. This device stores regularly (approx. every 30 min.) current position reports. In an emergency the device sends the latest position automatically to the satellite which is in a geostationary orbit.

The American/Canadian/French SARSAT concept was introduced in the first section. Initially this system operates in the 121/243.0 MHz range with satellites of the TIROS-N series, orbiting at a height of 800 km. An extension to include the 406 MHz range and a transition to geostationary orbits is intended.

These solutions seem extravagant. The goal must be an extremely cost conscious system for the user (e.g. the shipping company). Here the retention of the 121.5/243.0 MHz beacon is a case in point. At present approx. 190,000 airplanes and 2000 ships are equipped with this device. Their relatively weak signal has to be located by low-flying satellites (Doppler-Principle). The task is to make specially equipped low-priced satellites available. In the following sections a concept along these lines is being introduced.

5.1 SATELLITE ORBITS, NUMBERS AND TIME DELAYS

For the basic tasks

-- emergency signal transmission

-- localization of the sender

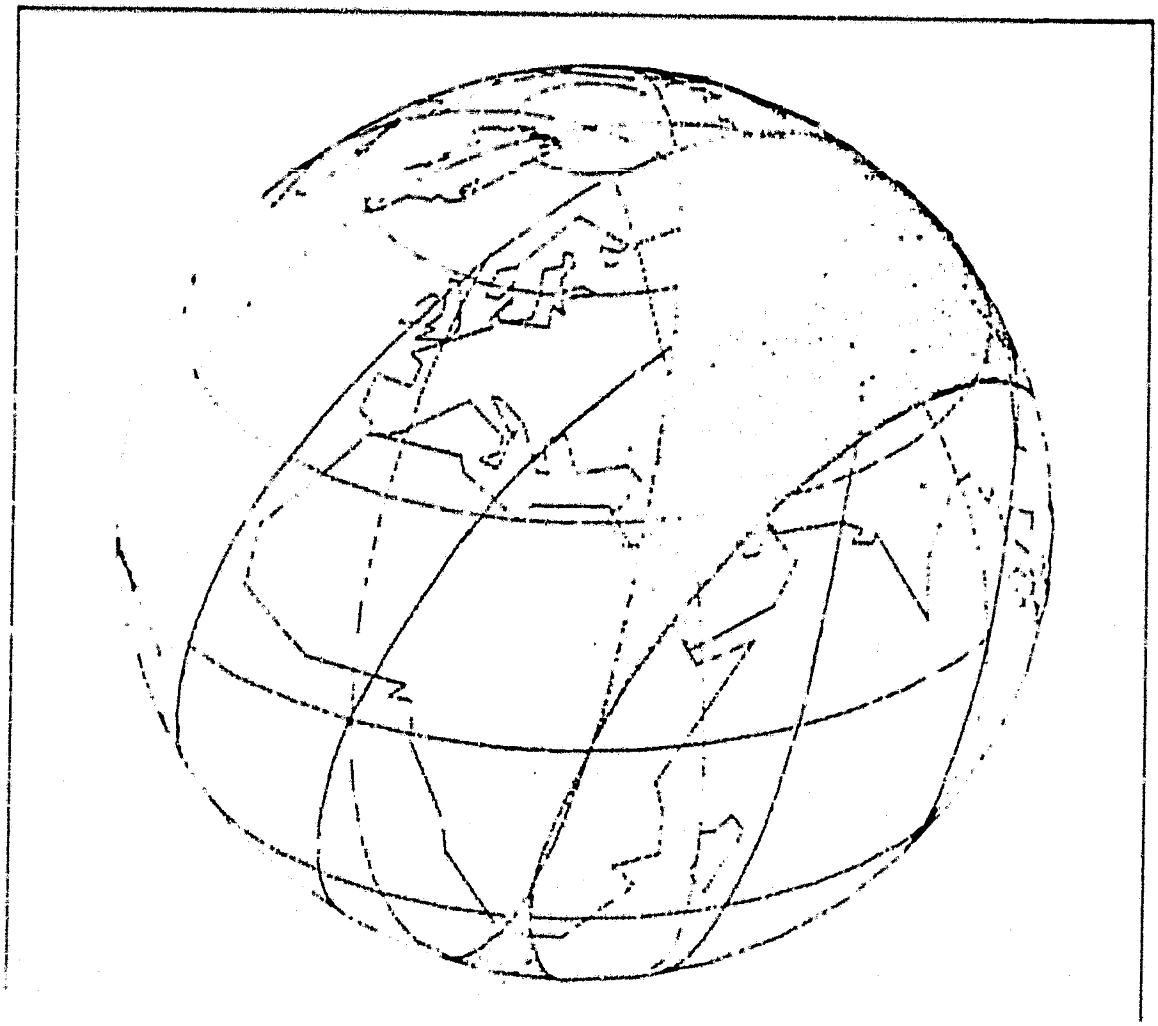
satellites in an orbit at 1000 km in a quasi polar, sun-synchronized orbit are provided for. Four satellites in an orbit at 1070 km, whose node lines (orbit intersections with the equator level) are each offset by 45°, cover the earth completely with a horizontal minimum elevation of 10°. It takes 106.4 minutes to complete such an orbit. That also corresponds with the maximum waiting time (time delay) at the equator if one-each satellite circles on every orbit. Since the covered areas overlap closer to the poles the delay time will be shorter, which favors the heavy traffic on the Atlantic.

Separate starting times are required for the four orbits so that a considerable overcapacity is present if all possible carriers are taken into consideration. This would result in double starts with a weather and an observation satellite. Here, of course, SARSAT would be in the position of a junior partner, hence it would have to make concessions in respect to time of start and type of orbit.

Using an orbit at 57° would offer a way out (Fig.6). /9

Since ETR could establish such an orbit with the SPACE-SHUTTLE the opportunity for piggyback-flights seems to offer itself here sooner and also more frequently. The same height of orbit would in this case exclude the areas beyond 80° latitude from the service area. If the pols were to be included, a height of 2140 km

Fig.6: Orbits and areas of overlap at an inclination of 57° and a nodal offset of 60°



would be required which, among other things, would lead to a strong exposure to radiation from the Van Allen Belt.

It takes only three satellites at a height of 1318 km with an inclination of 57° in orbits that are offset by 60° in the node line to cover the globe. Points on the earth's surface beyond 82° latitude will have, however, an elevation below 10° (e.g. only approx. 2° at the poles).

The node line rotation for the starting orbit at the flight /1
height of the SHUTTLE and the elevated operational orbit differ by 1.7° per day. If the the orbit elevations are performed in 35-day intervals, all three sattelites could be transported with the same SHUTTLE flight. A fourth satellite, started concurrently, could stay in a lower orbit as a reserve. If needed, it could replace any of the three satellites.

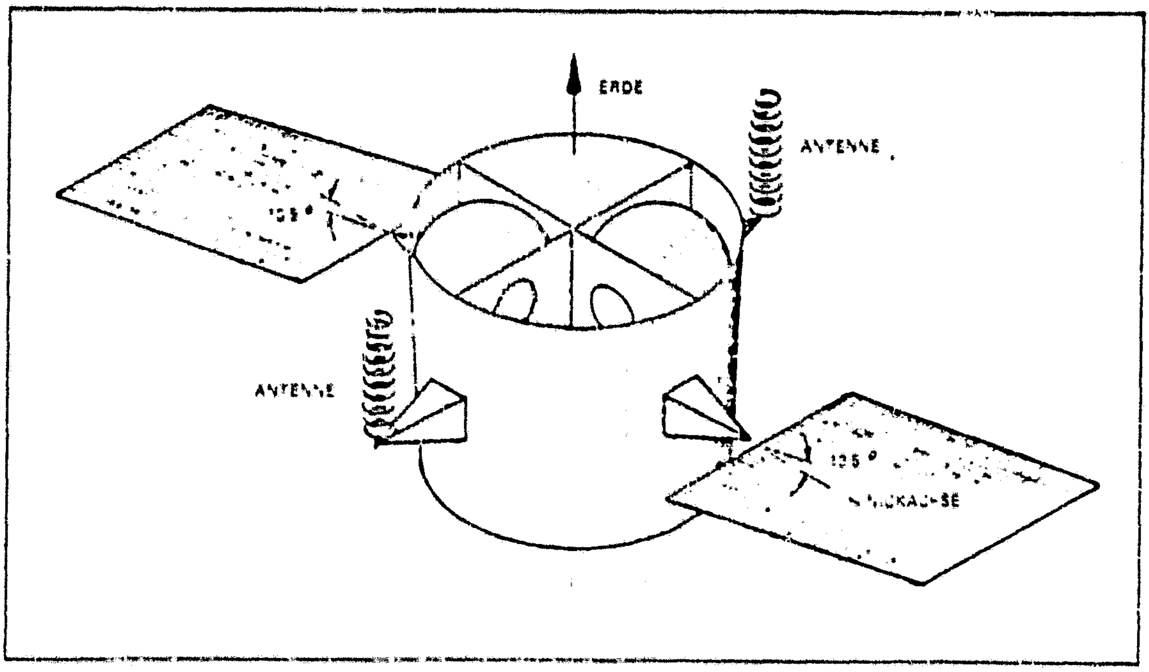
This multiple start of three or four SARSAT units and the simultaneous drifting over the orbit would automatically lead to minimal starting expenses. Required are satellites which can establish the operational course under their own power.

5.2 CONFIGURATION OF THE SATELLITE

By maintaining the usual space utilization, the estimated mass of the satellite (approx.270 kg) will correspond to a space of 1 m^3. Two coil antennas, which are mounted outside, are provided for (Fig.7). The power requirements of the payload of 50 W makes a solar generator performance of 150 W seem necessary, because of the long periods of shadow time and because the solar generator surfaces of about 2 m^2 are not of the follow-type.

If a cuboid of 1.2 x 1.2 x 0.8 m^3 with a strong central tube is chosen, the contemplated triple start can be accommodated.

Fig.7: SARSAT configuration in orbit /10 ctd.



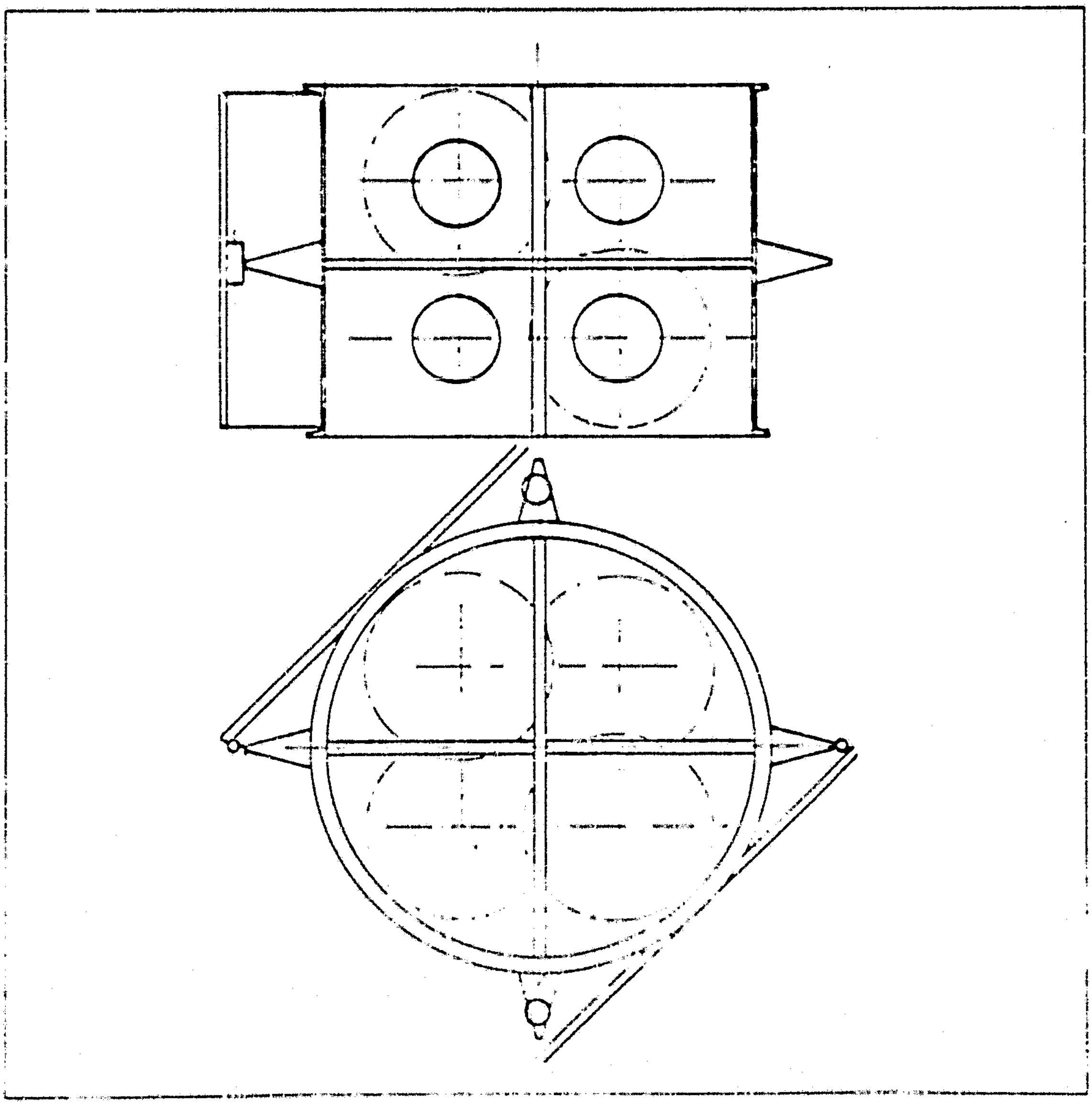
- If Thor Delta is being used, three or four sattelites could be stacked like donuts or the central tube could serve as a connecting adapter for the piggyback load, /11 ctd.

- if ARIANE is being used, the latter method has to be employed,

- if the shuttle is being used, four sattelites could be stowed on a quasi divider wall.

That means that the solar generator installation is then always on the outside walls which have to be folded out at various tilt-angles to accomodate various types of orbit. (see Fig.8)

Fig.8: Structure of SARSAT with installation possibilities for the transport system and (*translators note: 1 line missing)



5.3 TIME PLANNING /12

Since there is no need for weight optimization, the layout of the rather simple structure can be especially concerned with reserves of rigidity and stableness. This layout will be established during study phase A.

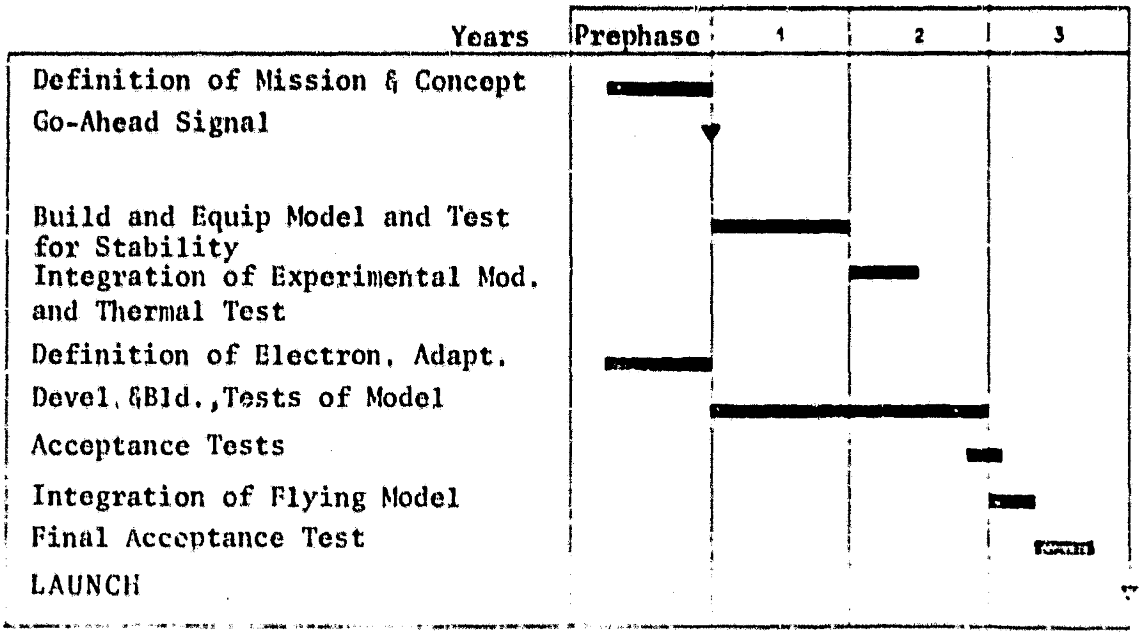
Phase B will see the completion of the engineering drawings which will be immediately followed by the building of a model. It will be equipped and subjected to a shake-up test.

Incompatibilities of frequency and banking factors are to be eliminated by appropriate changes.

The modified model will be tested under qualification load and will serve as the basis for the mathematical model of flight load calculation and for the production of the flight or protoflight model.

It is presumed that this process can be concluded within one year of the go-ahead order. The development of production preparations and flight unit production will require another year. If a time of nine months is projected for integration and final test flight, a launch can be assured three years after the start of the work.

Fig.9: SARSAT time table



It is to be understood that this time table may show some /13
question marks as far as electronics are concerned. On the other hand, the time table permits the deducing of questions which have to be clarified in phase A.

It is important to determine how much extra time would be required if several satellites were to be built simultaneously and if similar sattelites were to be put in readiness for further starts.

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1. --. "Sarsat-Project(-System),"Project update from United States Coast Guard Headquarters, September 1979.

2. Mundo, C., L. Tami and G. Larson, "Final Report Program Plan for Search & Rescue Electronics Alerting & Locating System", DOT-TSC-OST-73-42, February 1974.