Shuttle Vessel for Crew Changing Offshore

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SYNOPSIS: The S^3 CCV is a special-purpose vessel proposed for transporting personnel to and from offshore sites in the North Sea. Various design alternatives have been studied and model tests have been conducted. The results indicate that the S^3 CCV is a viable candidate to supplement helicopter transport.

INTRODUCTION

Surface transport of personnel to offshore sites in the North Sea, and particularly the Norwegian Continental Shelf, has not previously been a viable supplement to existing helicopter operations. The primary reasons have been:

- The severity of the North Sea environment limits the amount of time that crews will voluntarily ride any form of surface vessel.
- The transfer of crews from a surface vessel to offshore installations has not been safe.
- Surface vessels may not be economically competitive with air transport.

The Semi-Submerged Ship Corporation (SSSCO) of California, British Shipbuilders Offshore of the UK, and Manderstam Technical Services Ltd. (MTS) of the UK proposes a **Special-Purpose Vessel**, the S^3 Crew Change Vessel (CCV) designed by SSSCO to serve in hostile North Sea conditions on a year-round basis, to offer a safe and convenient voyage as a real transportation alternative for the offshore workers. The proposed system is predicted to meet current standards with respect to regularity and economy. Market prospects and logistic questions have been addressed and further studies are in process.

The Group* is presenting the S^3 CCV as a *complement* to offshore helicopter transport, offering a more viable, flexible, and reliable system than any other type of surface vessel. Kongsberg Engineering and MTS are developing the design of a ship-to-platform transfer system that will solve the interface problem in rough seas. Figure 1 shows a photo of a 1/200 scale S^3 CCV display model.

THE SEMI-SUBMERGED SHIP (S^3) CONCEPT

An S^3 is considered to be one of several types of SWATH** designs. Also, an S^3 is considered to be a cousin of the well-known semi-submersibles, some of which may be thought of as SWATH-type designs since they have a small waterplane area and have twin submerged hulls.

Basically, the S^3 consists of two parallel, torpedo-like hulls located beneath the water, attached to which are either two or four (as shown) streamlined struts which pierce the surface and support an above-water platform. Inboard stabilising fins are attached near the after end of each hull, and a pair of smaller fins are located near their forward ends. (See Figure 2.)

The performance features that, in general, set an S^3 apart from a conventional vessel are: greatly reduced motions with sustained speed even in heavy seas, lower hydrodynamic drag and reduced power requirements at moderate to high speeds, and superior course-keeping characteristics at all sea headings. S^3s have excellent manoeuverability at all speeds, when station-keeping, and when operating in confined harbours.

Typical vessel designs include: Crew Change Vessels, Ferries, Intervention Vessels, Multifunction Support Vessels, Diving Support Vessels, etc, in the displacement range up to 10,000 tons, and possibly larger.

The S^3 is proven technology, as demonstrated over the past five years by the *SSP Kaimalino* (see Figure 3). The SSP is a range-support vessel designed and developed by the US Navy which has been operating in the rough seas of the Hawaiian Islands since 1975.

The SSP was invented by Dr. Thomas G. Lang, who introduced the concept into the US Navy in 1968 following private development. He led the Navy's first research work, and initiated and developed the Hydrodynamic design of the SSP, the world's first high-performance, open-ocean semi-submerged ship. The US Navy's present SWATH ship programme incorporates the S^3 concept.

The *Kaimalino*, a unique 217-ton vessel, is 89 ft (27 m) long, 46 ft (14 m) wide at mid-section, and 32 ft (9.7 m) high. Her range is 400 nautical miles at speeds up to 25 knots, while carrying 50 tons of payload and fuel. Kaimalino means *calm water* in Hawaiian.

The SSP has operated under prevailing conditions from near calm to beyond sea state 6 at speeds up to 25 knots. Her motion is small relative to a conventional monohull either when at rest or underway.

The SSP has made smooth transits in 15 ft swells without any impacts; however, in short, steep 12 ft waves, occasional bow

* SSSCO has an exclusive agreement with British Shipbuilders covering the development of the S^3 in the European and Mediterranean areas, and another exclusive agreement with MTS covering marketing and technical assistance.
**SWATH = Small Waterplane Area Twin Hull.

impacts have occurred. No structural damage has ever occurred, even during storm conditions when 15 to 30 ft waves were encountered.

S³ ADVANTAGES OVER MONOHULL VESSELS

The inherent characteristics unique to S³ vessels give them the following technical advantages over conventional monohull designs: (See Curves Nos: 1-5 on Figure 4.)

A. Better high speed performance. An S³ has less wave-making drag, and this saves on propulsion power and fuel at the higher speeds where conventional monohull vessels are greatly degraded.

B. Reduced motion characteristics in waves, both underway and when stationary. The motions of an S³ in operational sea states are small because their small waterplane areas result in longer natural periods and reduced buoyancy force changes. The fins further assist in reducing the motion in waves, when underway, and ensure passenger comfort.

C. Better transit speeds. Being little affected by waves, with the consequent reductions in ship motions, S³s are able to sustain their speed in waves far more effectively than conventional vessels, and are consequently more dependable and economic to operate.

D. Greater deck areas. An S³ provides greater deck space than a monohull vessel of comparable displacement and is especially suitable for transporting passengers and cargoes requiring large deck areas and storage spaces.

E. Better cargo-handling characteristics. S³s have large cargo spaces above the waterline which permit ready access. This improves cargo handling efficiency. Also, centre wells in the deck can provide ideal submersible equipment handling capabilities.

F. Versatility. With excellent motion characteristics, high-speed performance, and modular construction potential, S³ designs are applicable to many types of vessel needs.

S³ CREW CHANGE VESSEL DESCRIPTION

The S³ CCV is designed to operate as a Crew Change Vessel servicing offshore complexes. Her high speed capability (35 knots cruising, 38 knots maximum) would also help the vessel to participate in the emergency evacuation of personnel.

She can carry 400 passengers and a smooth ride is to be expected in 22 ft waves at 30 knots in the North Sea. This vessel has characteristics exceptionally appropriate to simple and safe passenger transfer systems when station-keeping with offshore installations. (See Figure 5.)

Main Characteristics

Length overall	255 ft	77.7 m
Deck Length	239 ft	72.8 m
Overall Beam	93 ft	28.3 m
Deck Beam	80 ft	24.4 m
Draft	21 ft	6.4 m
Cruising Speed		35 knots
Maximum Speed		38 knots
Passengers		400
Range		500 to 1,000 Naut. Mi.
Power (2 x G.T.)		54,000 HP total
Type of Vessel		SWATH S³
Classification		Lloyds/DNV (pending)

Propulsion

Two gas turbines drive the controllable and reversible pitch propellers (CRP). The CRPs provide exceptionally good manoeuvering, DP, and docking capabilities. Also, they eliminate the need for reversing gears, clutches, and clutch brakes, and reduce the stopping time significantly. Maximum engine efficiency can be maintained for varying sea states, wind, load, or other off-design operating conditions by adjusting the CRP propellers for optimum pitch. This also applies to operation of only one engine in an emergency, or for slow speed operation.

The preferred design option is to place the turbines in the lower hulls, in which case they would be designed to be removed via the air intake ducting in the aft struts. Generators would be used for domestic and DP tunnel-thruster electrical supply. Gas turbines situated in each pontoon provide favourable weight distribution together with reduced noise and vibration levels for passengers.

Dynamic Positioning System

During the transfer mode the S³ CCV is dynamically positioned, having full thruster/propeller redundancy and surplus power so the vessel can remain at a close but safe distance from a platform in order to provide safe passenger transfer.

A typical system is a computerised system which enables the ship to be automatically controlled, in both position and heading, and which incorporates a main CRT display to show the ship's position relative to a stationary reference point.

Crew and Passenger Accommodation

The accommodation that would be proposed on the S³ CCV would be planned to suit the requirements of the owner and the particular service for which the vessel was intended.

Typical accommodation is provided for a total complement of 25 in single-berth cabins. The captain and chief engineer both have suites consisting of stateroom, bathroom and dayroom, whilst the remaining officers and petty officers cabins have separate bathrooms consisting of shower, wash basin and wc. The remaining crew have single-berth cabins with shower and wash basins. Adequate messing and recreational facilities are provided as well as laundry and drying rooms. The entire accommodation is melamine-faced for ease of maintenance and is fully air conditioned for comfort in both tropical and arctic conditions.

The one-class passenger accommodation is arranged on the lower deck and is quite separate from the crew's living quarters. The vessel is designed to operate on short haul routes, and consequently no sleeping accommodation is provided; instead, there are a variety of seating compartments. Among other features are: (a) pleasant air-conditioned interiors, (b) spacious compartments, finished in different colours to improve environmental atmosphere and comfort, (c) floors carpeted, and seats large and luxurious – 24 inches (61 cm) wide – aircraft club type, with light and sound control panels, and headset channel selectors, (d) carry-on luggage and parcels may be placed in the 10 inch (25 cm) space under each seat where the usual life jacket is to be found, (e) windows are large, spray-free, and afford excellent visability, (f) individual aircraft-style reading lights and ventilators are provided, (g) low interior noise level, acceptable for easy conversation, (h) passenger entertainment, combined with P.A. and information services using parallel-coupled sound and colour video systems, (i) 49-seat cinema with full equipment, (j) large refreshment lounge, (k) drinking water dispensers conveniently located, (l) automatic motion control system (AMCS) ensures passenger comfort and enhances operating efficiency and (m) airline, club-class type, on-board catering.

Stability, Seakindliness and Automatic Motion Control System (AMCS)

Perhaps the greatest single advantage of a well-designed semi-submerged ship over monohulls is its reduced motion in waves. If the waves are restricted to the strut region, the resulting changes in buoyancy due to passing waves will be small. Also, canards and the stabilising fins perhaps permit the already small motions to be further reduced with automatic control.

What makes the S^3 CCV even more unusual are the control fins which assist her to ride smoothly through the water. Controllable bow fins called *canards* and stabilising fins at the stern are operated collectively or differentially to dampen vessel heave, pitch and roll.

Since the encounter period of waves varies with relative ship/-wave speed, there will always be some speed and heading where resonance can occur in each of the heave, pitch and roll modes. Because of the AMCS, resonance problems are minimised in comparison to monohulls or other types of semi-submerged ships which lack fins.

The cross-structure, bow, and bottom sides are designed to accept and minimise the force of impacts. In the highest sea states, model tests on semi-submerged ship models indicate excellent survivability and seakindliness relative to monohulls.

Signals are supplied to the Central Computer Unit by a gyro-stabilised inertial reference platform, static pressure taps on the lower hull, and manual inputs from the Helmsman Control Unit. The Helmsman Control Unit allows the Captain to select a desired heading, to trim the vessel in pitch and roll, and to engage/disengage the AMCS at will. He can manually override the AMCS at any time. (See Figure 6.)

The AMCS system can be engaged at all speeds and is even partially effective at speeds as low as 8 knots.

Another great advantage of the S^3 design is that the canards and fins are attached between the hull and extending *in board*. This means that there is no necessity for their protection or retraction during harbour manoeuvering.

Safety
The S^3 CCV is an inherently safe vessel. Statistically, surface craft are safer than aircraft primarily because complete or partial loss of power is not per se a life-risk emergency.

The cross structure is designed as a hull with full integrity. It is possible to flood or loose either or both subsea hulls without anything worse than becoming an unpowered barge which will float quite adequately.

Unlike a helicopter, the vessel is equipped with life boats which can be used to abandon ship in the normal manner if necessary.

The S^3 CCV can accommodate a Sikorski S61N on deck, which can be used for passenger transfer to and from offshore structures, or for transport of injured personnel.

The craft is not precluded from operating in poor visibility, or at night.

The S^3 CCV is an ideal emergency vessel and can respond to disasters in weather conditions and at a speed which no other vessel in the North Sea can duplicate, even in rough sea conditions.

TRANSFER SYSTEM

The purpose of a crew transfer system is to provide a safe way of transferring personnel between the vessel and a fixed structure. Any transfer system concept must be able to cope with relative motions between the vessel on station and the receiving balcony on the fixed structure; also, it must provide a safe, totally reliable, and comfortable means of transfer.

Today, there is no such system in operation in the North Sea; however, vessel-based crew transfer might become feasible provided that a number of requirements can be met. Such requirements are related to cost, crew acceptance, operational procedures, seamanship, seasickness, acceptance by regulating authorities, system flexibility (serve various types of platforms), capacities, speed, back-up systems, emergency procedures, material selection, etc.

Taking into consideration the complexity of such a development, Kongsberg Engineering felt that a technical change in the problem-solving approach was required. They are now working on a feasibility study, sponsored by the oil companies in Norway. An outline of the programme is shown in Figure 7.

Many solutions have been proposed by shipbuilders, ship operators and oil companies.

A simple solution was proposed two years ago by GEC Mechanical Handling Ltd based on their *Naval Replenishment-at-Sea-System*; it is a similar system to the one used by navies around the world. Possible extensions of the naval *solid replenishment system* are now being considered for emergency evacuation of personnel from production platforms. This system might also be used for crew transfer onto and from the S^3 CCV, but we do not think that this solution is the most modern approach for the S^3 CCV. (See Figure 8.)

An ideal solution being studied by Kongsberg involves a proprietary telescopic gangway, similar to those in use at modern airports to transfer passengers from a gate to and from an airplane. Such a gangway would be based on the S^3 CCV. This type of solution is only feasible with a semi-submerged ship because of its low motion characteristics at rest with dynamic positioning.

The flexibility of this system enables discharge of passengers from the vessel at more than one point on the platform, thereby allowing the vessel to be located at the best possible position depending upon the weather conditions. (See Figure 9.)

This key problem needs a more thorough study, and when the design is completed, further model tests will be conducted and numerous tests offshore will be required before such systems could be approved.

SEA STATE CONSIDERATIONS AND RIDE QUALITY

As a result of the semi-submerged ship design, speed reductions in rough weather will be modest and the S^3 CCV should therefore operate without significant delays.

The S^3 CCV is designed to offer a relatively smooth ride in the North Sea at 35 knots in waves with a significant height of 20 ft (6 m). This is equivalent to a Beaufort wind force 7, or a sea state between 6 and 7. Annual wave statistics from accepted sources for various critical areas in the North Sea show that the S^3 CCV will be able to operate at least 96 per cent of the time, all the year around. In very high waves, the S^3 may have to reduce speed, in which case the passengers may experience greater motion.

Model tests have shown excellent survival characteristics in simulated 55 ft (16 m) significant wave heights with occasional 100 ft (30 m) waves (Beaufort wind force 11). Other model tests conducted in simulated 20 ft (6 m) significant wave heights, with and without various offloader models, indicate that the S^3 motions are in the range where safe and comfortable offloading can be accomplished.

ECONOMICS

In developing data for an economic evaluation in the Norwegian Sector, it is necessary to first develop an understanding of the potential routes and their traffic levels. The two major bases are Stavanger and Bergen which serve three major field complexes: Ekofisk, Frigg and Statfjord. See Figure 10 which illustrates these routes.

At a speed of 35 knots, crossing times are:

Bergen – Statfjord	3 hours 25 mins.
Bergen – Frigg	3 hours 10 mins.
Stavanger – Frigg	3 hours 45 mins.
Stavanger – Ekofisk	5 hours

It is well known that each of these areas have, or will have, significant numbers of isolated and independent platform facilities. It is possible that the S^3 CCV will transfer onto and from a central platform and small quantities of people would then be transferred from and to the independent satellite facilities by a small helicopter based on the S^3 CCV, during the period when the people are transferred via the gangway.

The longest journey, Stavanger to Ekofisk, will take five hours with a one-hour stop at the central platform. The return trip can be performed during day time (see Figure 11). The transport capacity, with fixed departure and arrival schedules, result in opportunities for co-ordination with onshore transport connections. Individuals will have the possibility of going the entire distance door-to-door on the same day as his or her shift starts or ends. Thus, combined with a high standard of comfort, entertainment, and catering on board, the S^3 CCV could quickly become a very popular mode of transport for offshore workers, a successful business for the ship operator, and provide savings for the oil companies.

Preliminary estimates based on conservative figures show that the cost per passenger per mile should be only a fraction of the cost of going by an S61 helicopter. The comparison also looks very favourable relative to a Boeing Chinook.

CONCLUSION

In view of the severe weather in the North Sea, it is our belief that the S^3 CCV can provide at least 96 per cent regularity and reliability at a comfortable level needed to effectively handle the needs of the oil industry in transporting personnel to and from various offshore platforms.

The S^3 CCV is considered to be a *complement to offshore helicopter transport*, and a key link of a properly-planned surface transportation system which can provide safe, comfortable, and economic transport. It is important to all parties including government authorities, oil industry, unions, workers, and the transportation companies to determine how best to utilise surface transportation in the overall transportation system.

This study indicates that time and money can be saved in the offshore industry where delays in reaching the platform may cost thousands of dollars and where another major helicopter accident would tend to place even more emphasis on developing a surface transport system.

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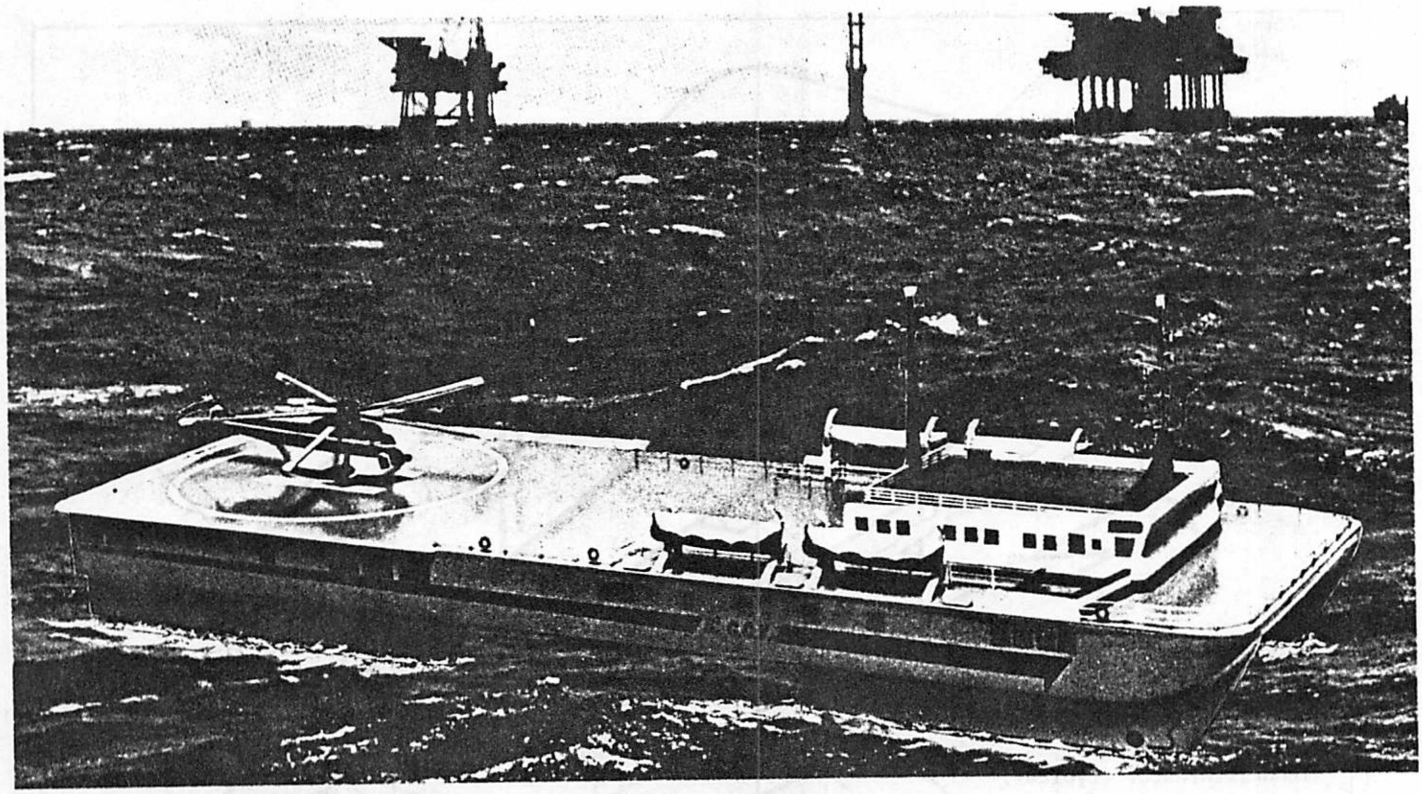

Fig 1. Collage with the picture of the S^3 CCV model (1/200 scale) Modelmaker: D. Smith, Photo: T. Wilks

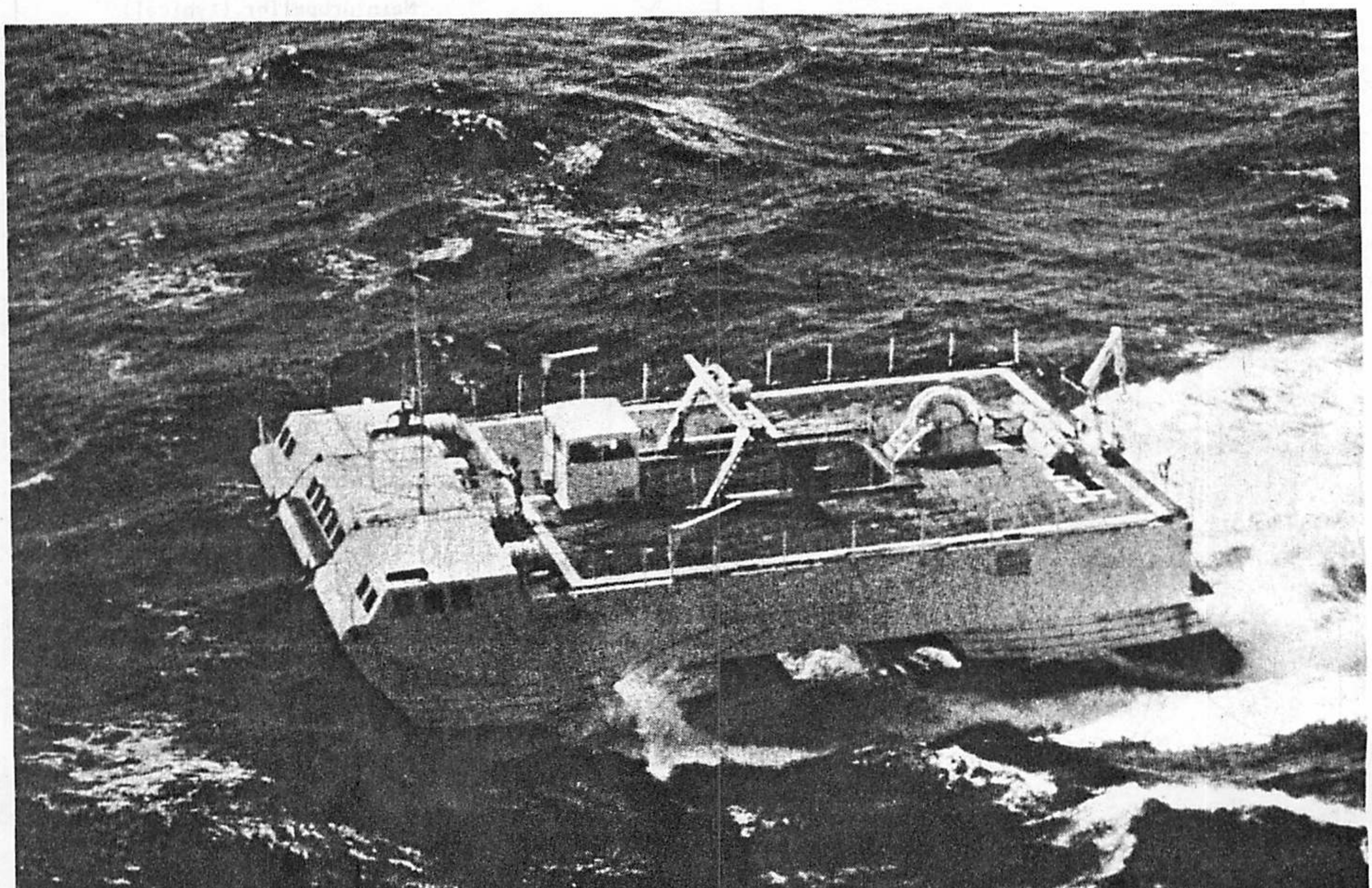

Fig 3. SSP *KAIMALINO* at 25 knots Photo: Official US Navy

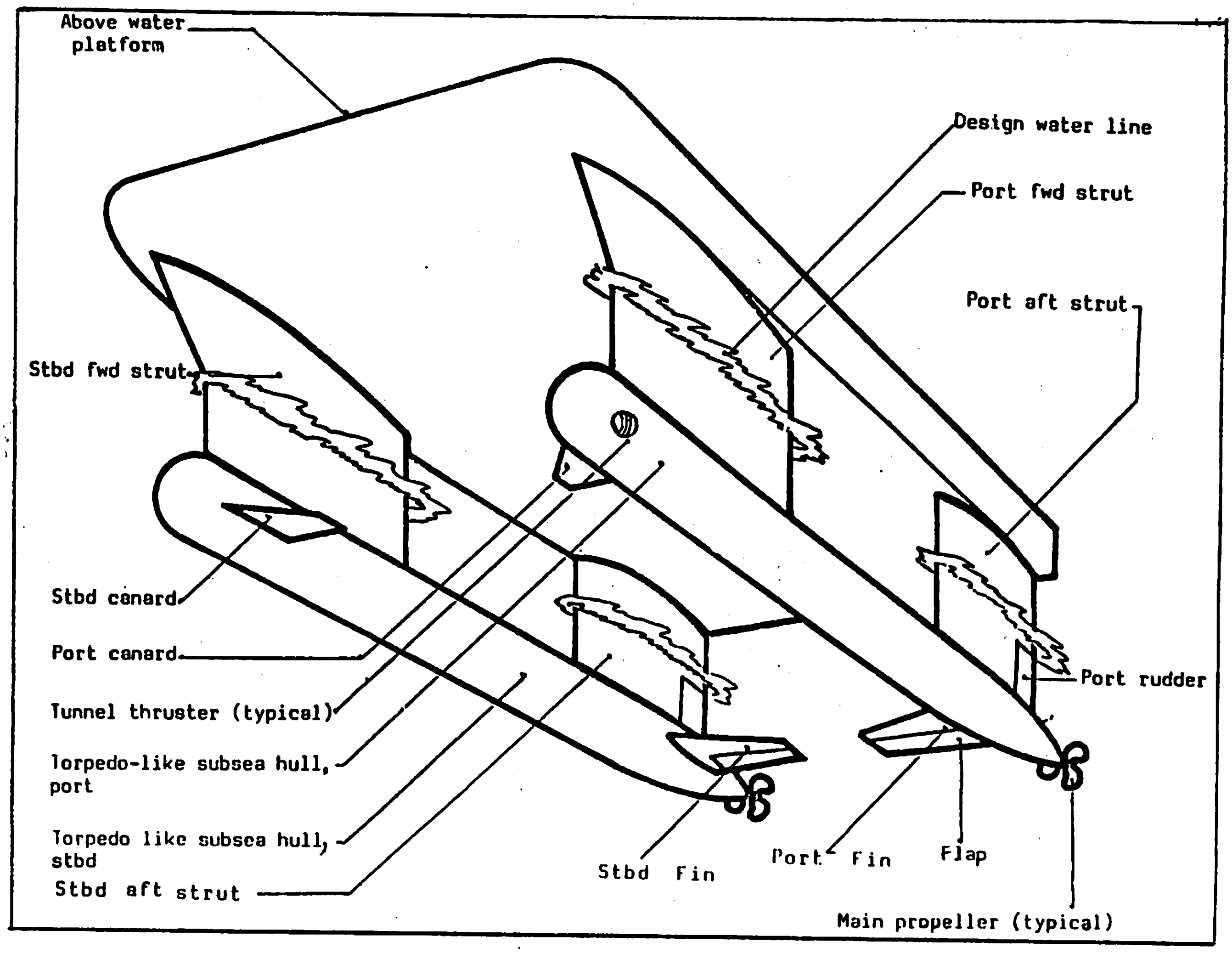

Fig 2. Typical S³ Design

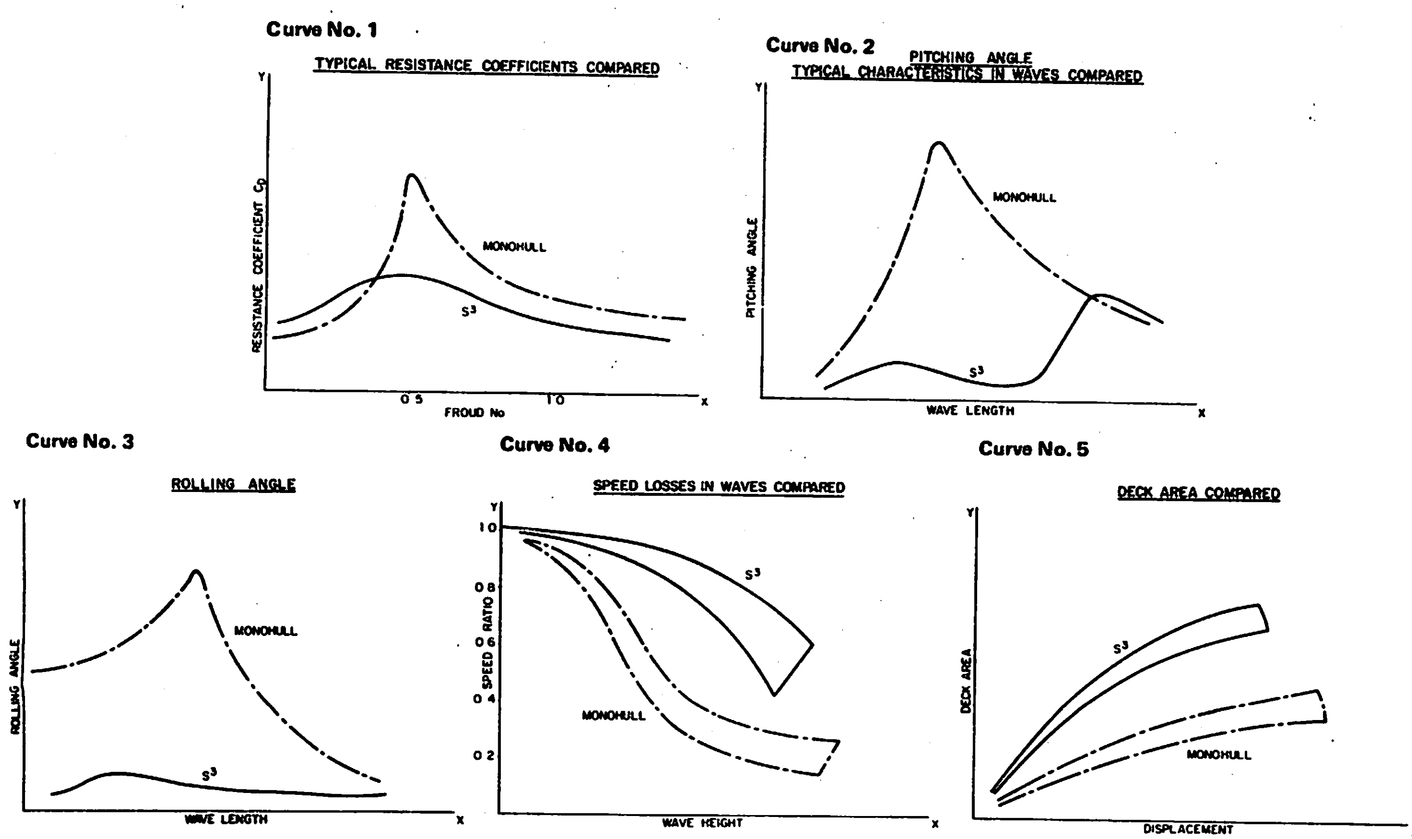

Fig 4. S³ Advantage over Monohull Vessels – Curves

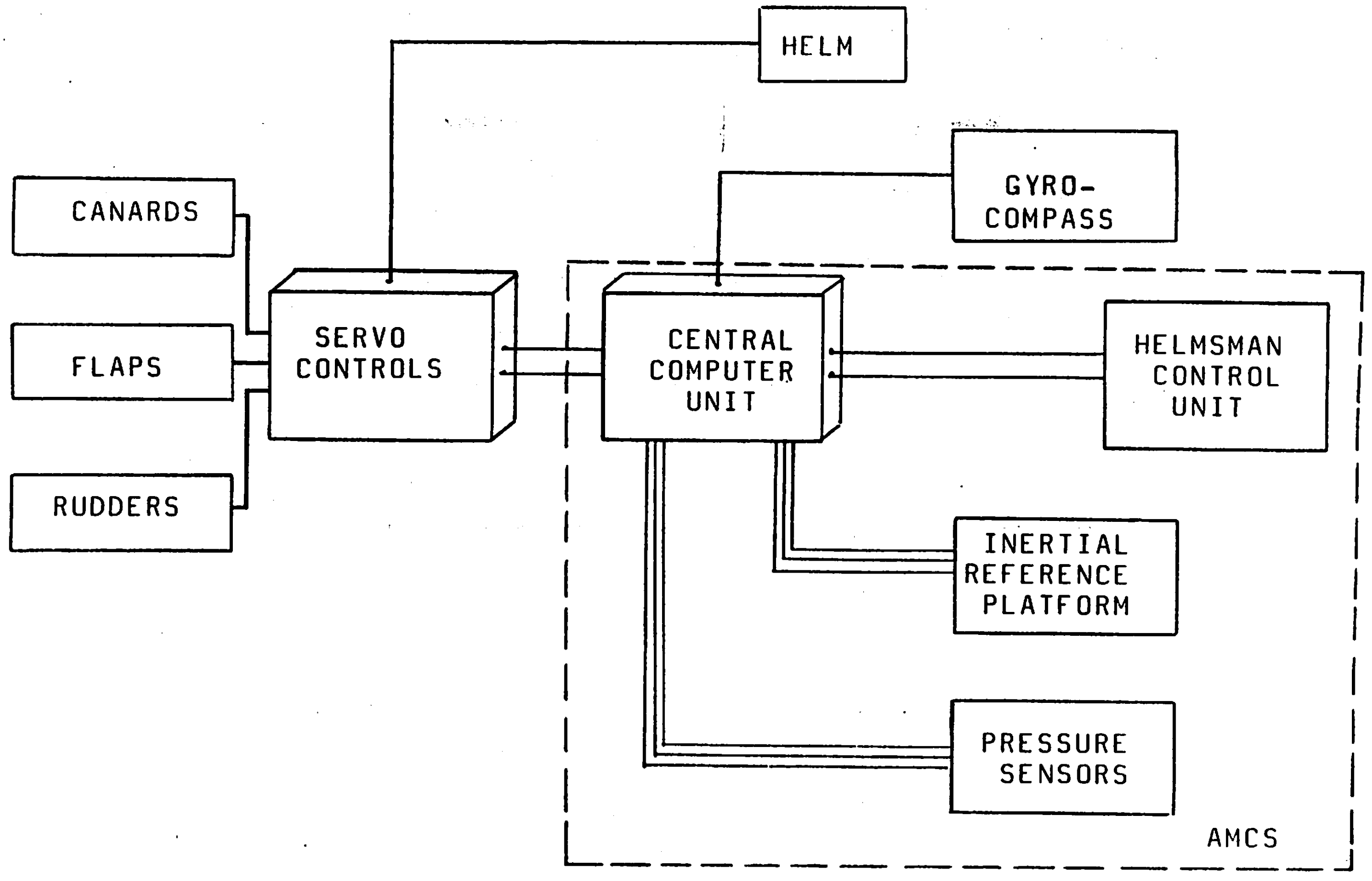

Fig 6. AMCS Block Diagram

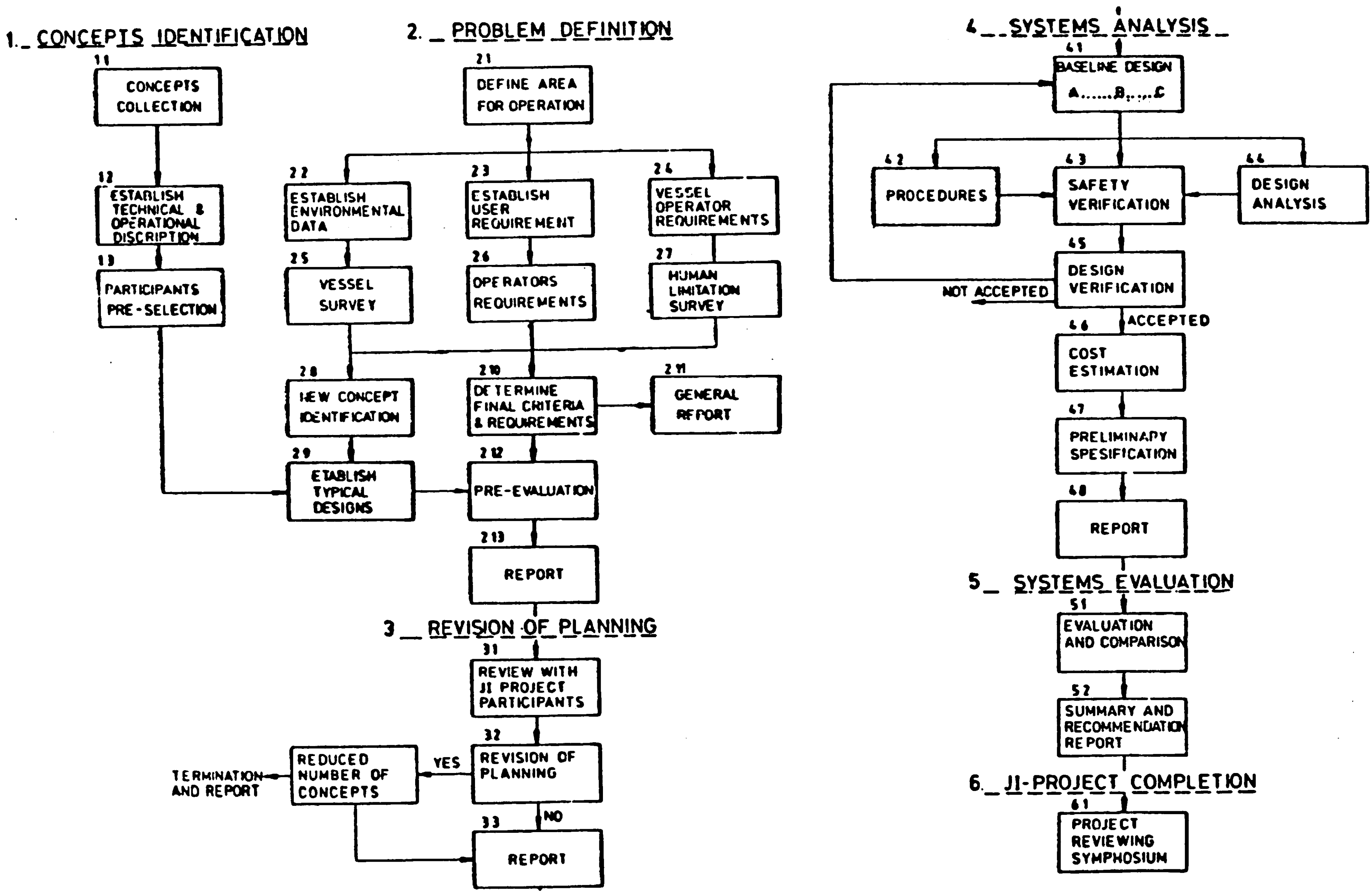

Fig 7. Transfer System Feasability Study – Kongsberg

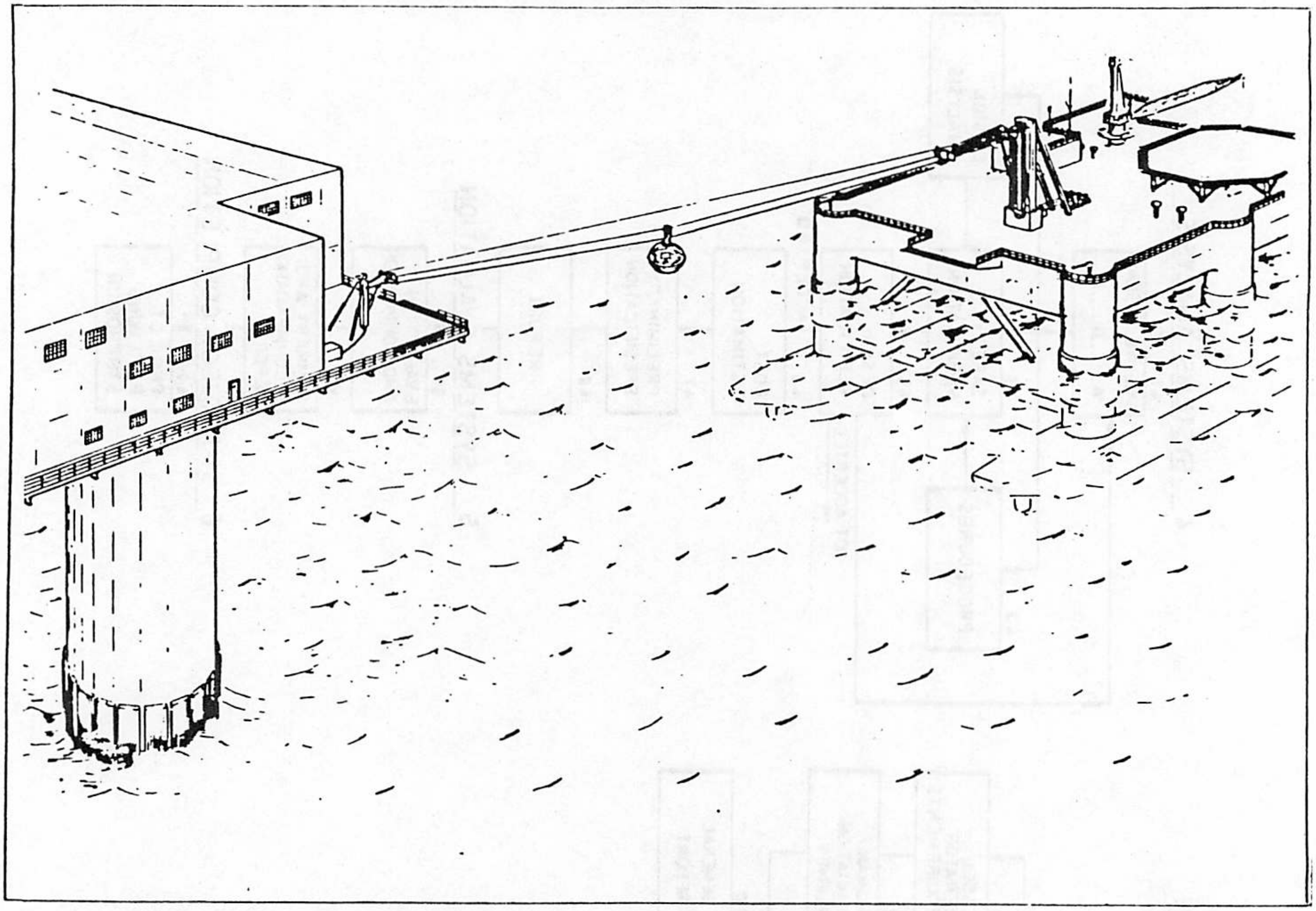

Fig 8. GEC Transfer System Based on the Naval Replenishment at Sea System

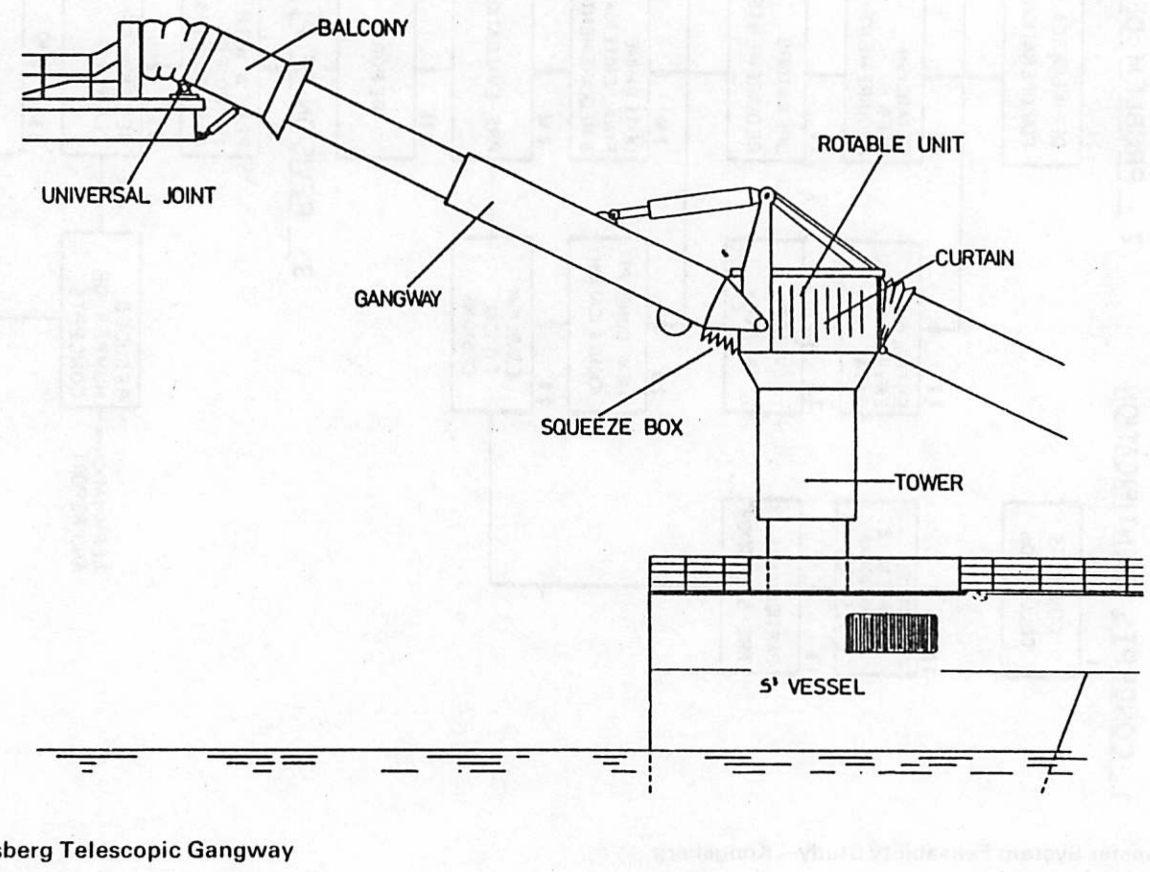

Fig 9. Kongsberg Telescopic Gangway

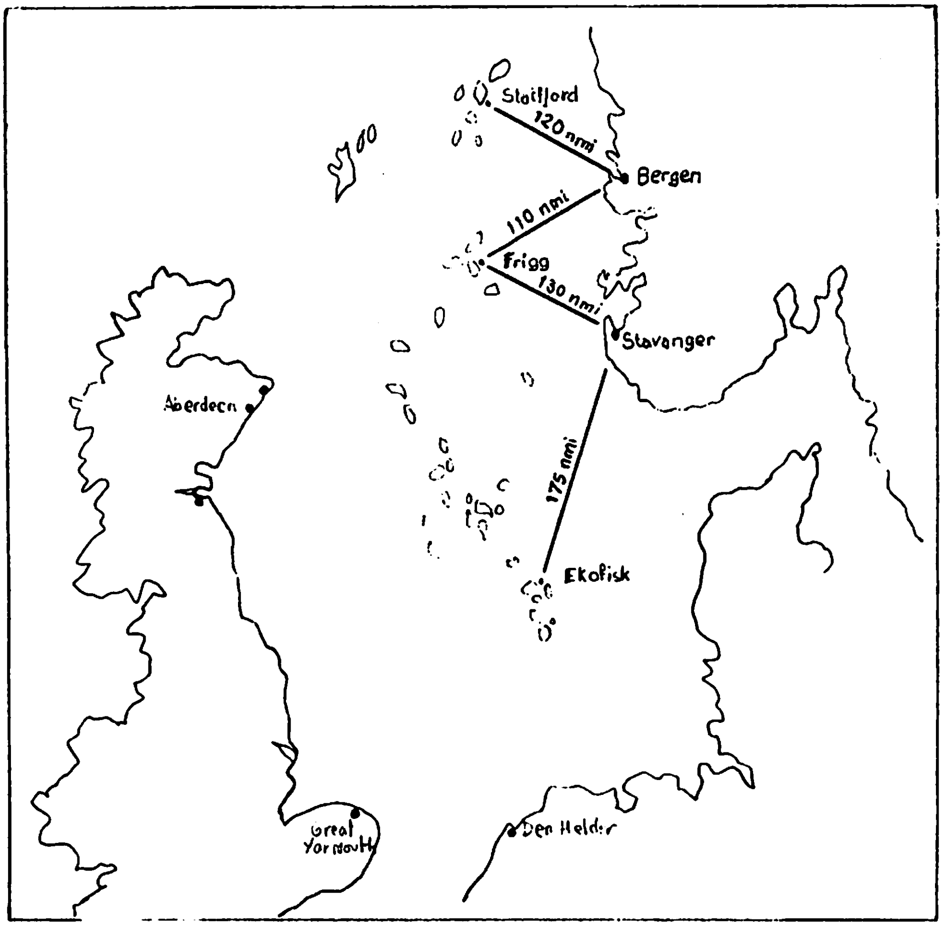

Fig 10. Major routes in Norwegian Sector

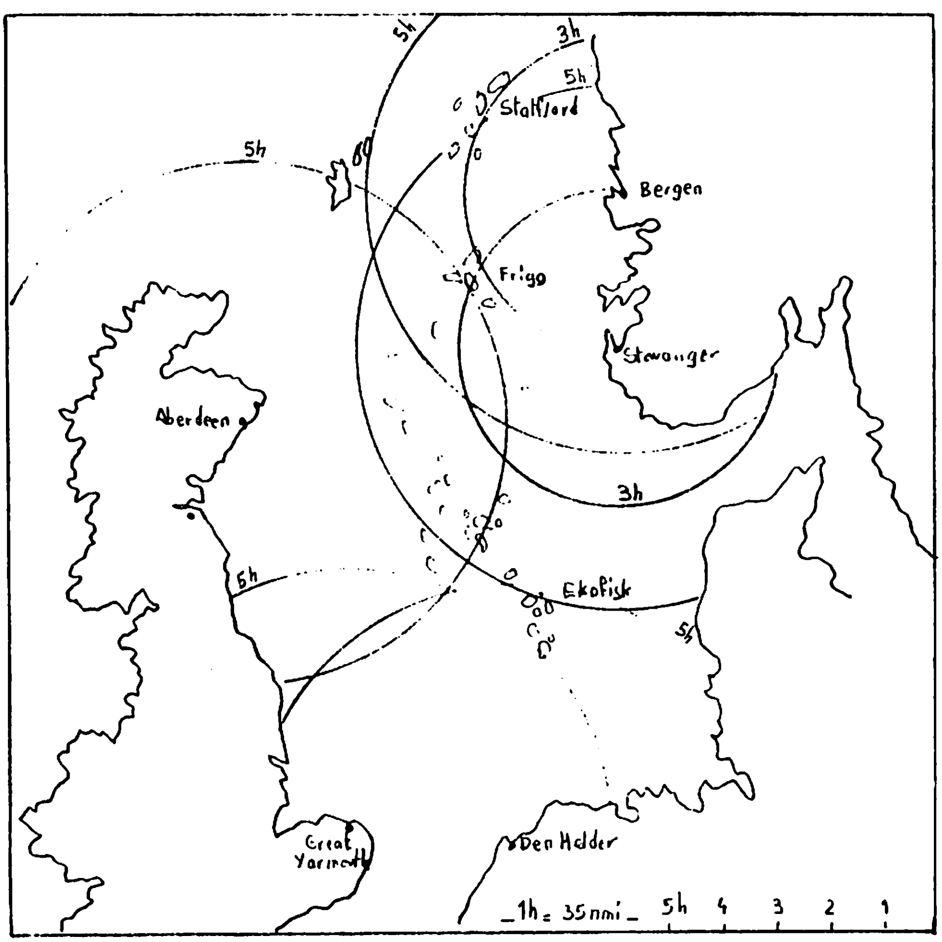

Fig 11. Speed effectiveness of the S³ CCV