Wolfgang Bohlayer/
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Naval Shipbuilding

Current Developmental Trends with Combatants and Combat Support Ships

Since the end of the Cold War and the constantly changing threat scenarios thereafter, new demands regarding defence materiel as well as organization and training of the armed forces have repeatedly been made on the Bundeswehr and its allies and partners. In contrast to organization and training, the materiel often requires high expenditures and plenty of time to be adapted to the changed requirements. It is therefore all the more important to heed the aspects of possible modification, retrofitting, and flexibility in the procurement of defence materiel. This applies particularly to the ships and boats of the Navy whose service phase of up to forty years is extremely long.

If new ships and boats are going to be designed for the Navy, there are not only the currently prevailing requirements which have to be taken account of as much as possible, but it is also necessary to make respective provisions to be able to react adequately to future requirements. A conversion and retrofitting of existing units becoming necessary at a later point in time should therefore be possible to be realizable with a reasonable effort in time and costs. One of the means necessary for that is, without doubt, the consistent implementation of a modular concept. The principle introduced by the Blohm + Voss Company in the 1970s is therefore still of high relevance for the present. In the past years, the family of the many construction modules developed in the course of time was however complemented by a new module series, the "mission modules". They allow the user to switch over from one mission to another within a short period of time. The new quality of modularization achieved by that guarantees at the same time that the flexibility needed for the adaptation to future requirements is given.

In the following discussion of concrete examples of current development trends in naval shipbuilding particular attention is given to the aspect of modularization. In addition, other developments in marine engineering will also be presented and discussed hereinafter.

Current Developmental Trends in the Field of Platforms

A number of innovative technical solutions in the fields of marine engineering, weapon and sensor systems, and logistics fulfill, on the one hand, the requirements for ship units of sophisticated design mentioned above in summary form, but are to keep the costs for the procurement and employment in check on the other hand.

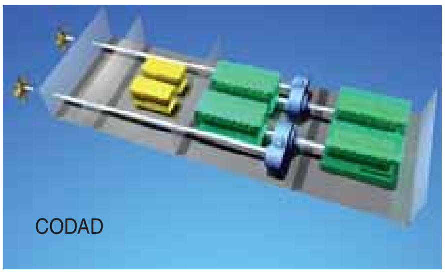
Flexibility

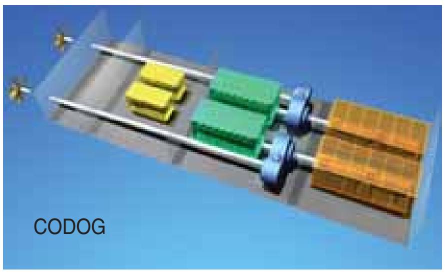
The keyword "flexibility", which indicates one of the possibilities for a cost-effective implementation of the mentioned requirements of the navies, refers not only to a possible flexible use of the ships on missions, but also to the design of such units. Only a respectively open and flexibly designed layout allows the full exploitation of the potential of such a vessel during its subsequent use. Furthermore, such an approach has the considerable advantage that such a developed technical base design can cover a majority of customer requests with only a few modifications, also and especially in fields, which are normally not so much affected by the flexibility in the above mentioned meaning.

The given possibility of selecting a propulsion concept may serve here as an example for the above mentioned flexibility. In the field of high-speed combatants, a number of propulsion concepts have become established which certainly need to be adapted to the current state of the art in some sub-sections, but which, apart from that, will continue to be in service in the years to come. These are the following propulsion models:

- CODAD (Combined Diesel and Diesel)
- CODOG (Combined Diesel or Gas Turbine)
- CODAG (Combined Diesel and Gas Turbine)
- CODAG-WARP (Combined Diesel and Gas Turbine — Waterjet and Refined Propeller)
- CODELAG (Combined Diesel Electric and Gas Turbine)
- AE (All Electric).

The above chosen order also indicates the time sequence of the realization of the individual concepts. In principle, these configurations can be integrated in one and the same base design of the ship (by considering certain parametric conditions) as it was e.g. the case with the successful MEKO™ 200 frigate class


CODAD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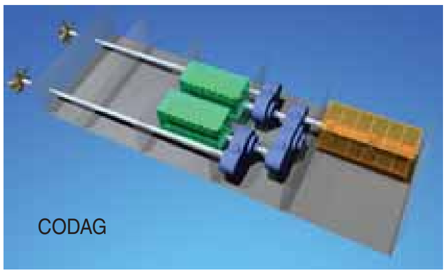
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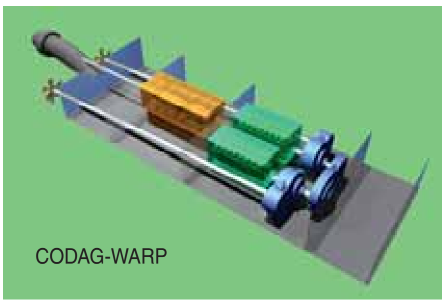
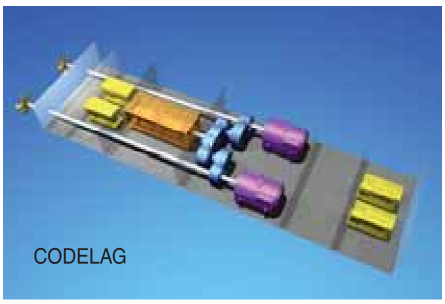
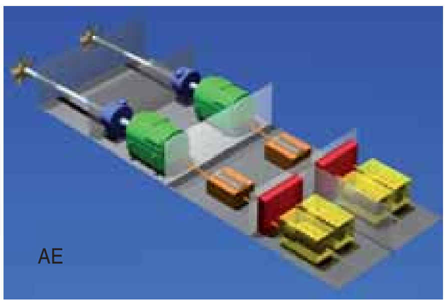

CODAG-WARP


CODELAG


AE

where a number of these propulsion concepts (CODAD, CODOG, CODAG) were applied. Here it was possible to react to the different demands of various customers by a "built-in" flexibility inherent in the base design without having to develop a completely new ship.

All these propulsion types reflect in different ways the efforts made to ensure as cost-efficiently as possible the demanded values and levels regarding speed, ranges, redundancies, and fuel consumption. Interesting with the CODAG WARP variant is the dividing of cruising and boost propulsions up into different power trains, which clearly increases the redundancy of the system as well as the first use of a waterjet in connection with propellers (Figure 1).

Propulsion Concepts

The last-mentioned propulsion concepts CODELAG and AE are based on the basic consideration to operate all power consuming systems aboard ship through one type of energy, here by means of electric energy. On the one hand, this allows a greater flexibility in supplying individual systems, and on the other hand it is possible to achieve a reduction of the number and types of power generators. This has positive effects on elements like stability, maintenance costs, operating costs, etc.

Today's modern propulsion concepts of the merchant fleet like diesel-electric propulsion or propulsion by medium or slow-running diesel motors are being used in the field of combat support ships. Here, there are no high military requirements to be met in respect to speed, stability, redundancy etc., which would lead to more complex and comprehensive propulsion systems.

Propulsion Systems

Another interesting development in the field of the propulsion systems is the deep-submerged waterjet as it is presently being developed by the Voith Turbo Schneider Propulsion Company as "Voith Water Jet (VWJ)". The VWJ consists of the three hydrodynamic elements, the jet, rotor, and stator. In comparison with a conventional waterjet the advantages result from the fact that there is no deflection of the flow and that no difference in height has to be overcome. Figure 2 shows a possible arrangement of a propulsion system with two VWJ at a frigate hull. For reasons of a clear representation, the shaft and inner components of the VWJ are not shown here. Numeric computations of the flow show that with the correct arrangement of the VWJ it is possible the reach a positive effect on the resistance compared to a conventional propeller arrangement.

Figure 3 SWATH under Construction with TKMS for Use with German Customs Police.

In contrast to the past decades one can nowadays notice a clear acceptance of "unconventional" hull forms in international naval shipbuilding. The search for cost and consumption-effective hull form alternatives — also by inclusion of non-metallic construction materials (GFK, CFK, etc.) which are meanwhile available as well as other miscellaneous technical findings — have brought a number of alternative hull forms into focus, as for instance:

- Catamaran
- Trimaran
- SWATH (Small Waterplane Area Twin Hull).

The two first mentioned "new" hull forms have the common aim to reduce the resistance in the water in comparison with the single-hull ship. However, this is only successful if concessions are made in other fields such as deadweight, internal arrangement of important elements like propulsion systems or seakeeping characteristics in higher sea states.

Generally speaking, each ship design is a comprise between the requirements on the one hand and the resulting capabilities of the design on the other hand. When seen from that point of view, the unconventional hull forms may be absolutely justified for special uses, if some other (in the specific cases regarded as less important) capabilities/features must take second place in favor of some important, desired advantages.

A classic example where specific advantages clearly turn the scales for an unconventional hull form is the selection of the SWATH hull form for small and medium-size vessels, which have to feature long seagoing endurance combined with extremely good seakeeping characteristics. To be mentioned here are especially the official vessels for the coast guard, customs or pilot services. There is no high terminal speed of the vehicles required in these fields, but long endurance at sea with good sea performance are indispensable. The customs boats currently under construction at TKMS are an excellent example of another successful realization of the SWATH hull form (Figure 3). The design of these boats is based on the know-how and experiences gathered by the shipyard in the construction of the defence research vessel PLANET, also a SWATH.

Catamarans show, especially at high speeds, lower performance requirements in comparison with single-hull ships. However, the seakeeping characteristics of a catamaran are not optimal compared to single-hull ships of the same size; nowadays this has been improved by special designs of the hulls and the installation of addition systems, though. To be mentioned here is the hull form of the "Wave Piercer" in co-action with an automatically controlled "Ride Control System". On the basis of this development, the catamaran has found worldwide acceptance in the use as a large, fast personnel and roll on/roll off ferry in short and medium haul traffic. This success was more or

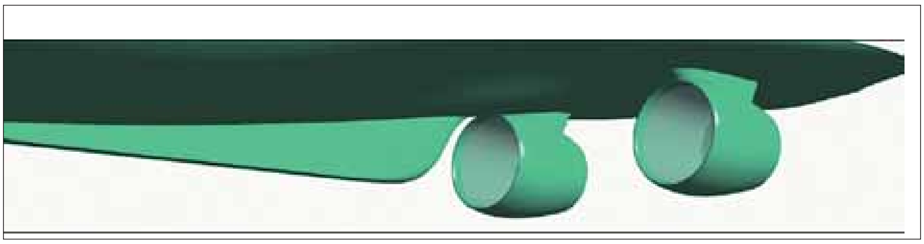


Figure 2 Example of the Integration of Deeply Submerged Waterjets.

Figure 4 Frigate (MEKO™ A-200) with Modern Hull Form.

less denied the catamaran in the field of combatants or combat support ships until today. Only very few navies use the catamaran form in specific fields of employment (e.g. Norway — mine hunters; USA — fast transport ships).

Trimarans are just now beginning to appear at the military stage. They combine propulsion power savings with — in comparison with catamarans — improved seakeeping characteristics and a large useable area on the connecting deck. These positive features are won by a reduced space in the (very narrow) hulls as well as by a generally more sophisticated design of the ship's structure. First comprehensive operating results and experiences were gathered by the British and the US Navy during test runs of a trial ship (HMS TRITON) in the past years which have not led to follow-ups on the British side as yet (e.g. construction of combatants), but with the USN which has chosen this hull form for the construction of one of the two LCS (Littoral Combat Ship) alternatives. Findings from the testing of that ship are still expected to be produced, however.

But in the field of single-hull forms the time did not stand still either. Constant further developments of the hull lines in respect to deadweight capacity, resistance reduction, improvement of the sea behavior, and the stability characteristics have resulted in hull forms which represent a good compromise with all the requirements to be met by them. Not for nothing is it by far the most used ship form. Even (modified) bulbous bow forms can be seen in the field of combatants today (example: K130 Corvette, F125 Frigate, MEKO™ A-200 SAN frigates; Figure 4).

Additional developments of this "omnipotent" single-hull form are apparently under way and/or can be expected. TKMS is presently studying and propagating a hull form with ship sides that are not parallel (delta form). The MEKO™ CSL corvette described later in this article has such a form.

Construction Material

Steel is and continues to be the construction material that is predominantly used for combatants and combat support ships, mainly for reasons of structure design, service life, and the fire safety. For specific cases of use where a steel structure does not represent the optimum solution because of its weight or other characteristics — like magnetism — structures made of fiber compound material in the form of GRP or CFP (carbon fiber reinforced plastics) are preferred, however. To be mentioned here, as an example, is the class of the minesweepers/minehunters that (almost all of them) are built and/or are being constructed with this material.

As one of the first countries Sweden has decided to have a combatant class (the VISBY class, Figure 5) completely built of CFP in sandwich construction. These 650-ton corvettes are particularly designed for service in offshore waters and feature, apart from the special construction material, even more technical "highlights" such as pure water jet propulsion, extreme stealth characteristics, and a (limited) mission modularity.

As for larger combatants like frigates or similar vessels, fiber composites are presently used to a limited extent in the field of add-on elements or mast houses only.

Here, TKMS has made a further step forward, also by capitalizing on the VISBY experiences and findings. The designs of the new MEKO™ CSL corvette class feature a superstructure made completely of CFP. The structure weight saved is thus a benefit for the weapons and sensor systems dead load. Due to the design philosophy of the ship and especially of the superstructure as an area (one could also say: garage) for placing the (mostly) covered mission modules, a construction of this superstructure of CFP is of particular advantage.

A new Generation of Flexible Combatants

As described at the beginning, flexibility offers a possibility to design and built in a cost-effective and future-oriented way. Flexibility in missions is at least just as important and required. The basic strategic and tactical parameters for mission modularity were defined and worked out by major navies in the past years.

These considerations resulted in the definition and description of a new type of ship which allows to additionally install — on the basis of standardized, firmly mounted basic equipment — different modular weapon and sensor systems which are to accomplish special missions such as air-to-air warfare (AAW), antisubmarine warfare (ASW) or antisurface warfare (ASuW). By taking this idea as a basis, TKMS has developed the MEKO™ CSL (combat ship for the littorals) (Figure 6).

The MEKO™ CSL can be equipped for missions, which are precisely geared to the requirements of the navy customers. This concerns also the requirements necessary for a participation in large-scale international operations. The primary requirement to be met by the new corvette is an operational readiness as either an auxiliary flag command ship or as a participating unit in joint and combined missions with armed forces of other countries. The tasks of a naval unit op-

Figure 5 VISBY Corvette with HAMBURG Frigate.

erating within international task forces include also the typical OOTW (Operations Other Than War) tasks such as surveillance, presence (in-place forces), sanctions, enforcement of measures, and blockades up to combat missions including the support of ground forces by fire power and countering of other naval units who want to force access to the coastal waters and/or sea areas.

Accomplishing all these tasks will require a high degree of flexibility and staying power of the ship in order to be capable of adequately reacting to these different tactical requirements, including the unconventional threats. To be able to offer a highly effective and yet economic solution for the requirements of the naval forces of different countries, the vessel possesses a large number of unique and innovative characteristics. Some prominent features are listed hereinafter:

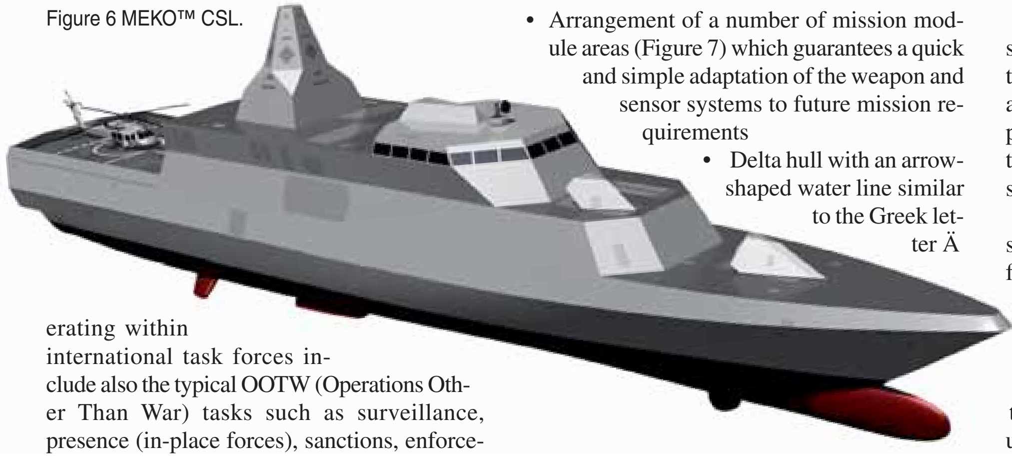


Figure 6 MEKO™ CSL.

- Arrangement of a number of mission module areas (Figure 7) which guarantees a quick and simple adaptation of the weapon and sensor systems to future mission requirements
- Delta hull with an arrow-shaped water line similar to the Greek letter Ä
- Use of a Combined Diesel And Gas Turbine (CODAG) waterjet propulsion system
- Distribution of the power generating system
- Additional significant reduction of signatures.

The MEKO™ CSL is configured with such basis systems and mission modules, which allow the ship to meet all basic on-board functions and the requirements for at least one mission task. A basis system is a system, which belongs to the basic equipment of the ship, i.e. it is independent of the respective mission task and it ensures basic functions such as self-defence, navigation and communication as well as other general functions. The functions can be controlled from the bridge.

The corvette is capable of changing the mission configuration within a very short time. For that purpose, the ship has a number of module areas where the mission modules can be employed by means of predetermined installation methods and connected to the supply systems via standard interfaces.

This principle is the central feature of the design and provides for the combat capability and functionality in specific mission tasks. Mission modules can be manned or unmanned, can encompass sensor systems, vehicles, weapon systems, medical facilities, and storerooms for spare parts or workshops, just to mention some of the possibilities. The module areas on the ship have fixed dimensions, constructions and utility connections.

All mission modules have the size of a typical 20-foot container. This ensures easy land, sea, and air transports. Up to 21 mission modules can be accommodated in the module areas.

Equipped with the respective mission configuration, a large number of missions are possible to be conducted:

- Peace missions (planning and conduct of operations in natural disasters, humanitarian missions, SAR missions, etc.)
- War missions (planning and conduct of operations such as support by fire power, protection of logistic measures, support of combat troops, etc.).

New Concepts for Support Ships

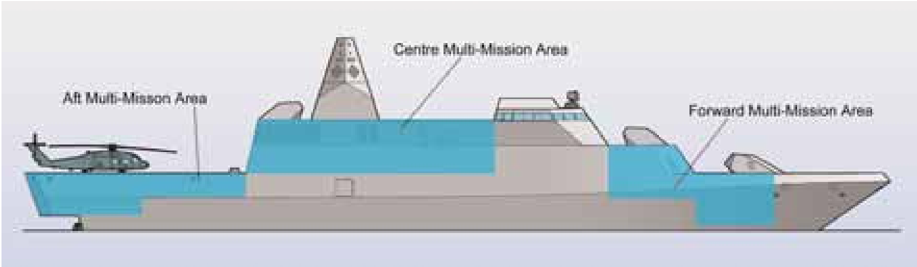


Figure 7 Mission Module Areas on MEKO™ CSL.

The tasks of the support vessels have developed from a historical basis. Whilst the support of the fleet with coal and supplies was in the focus in the initial phase, it is now the task spectrum, which has grown with the new operations concepts. Ship types for amphibious operations developed from the Pacific war of the USA during the Second World War are an example. The mission spectrum of today ranges from replenishment at sea by way of strategic sea transports up to amphibious operations and the new aspect of the "sea basing". In the past, specialized ships tailored for the respective task met this mission spectrum. However, a trend has recently been noticed to have various tasks fulfilled by multi-mission ships. The projects for joint support ships in Canada, The Netherlands, and Great Britain are typical examples.

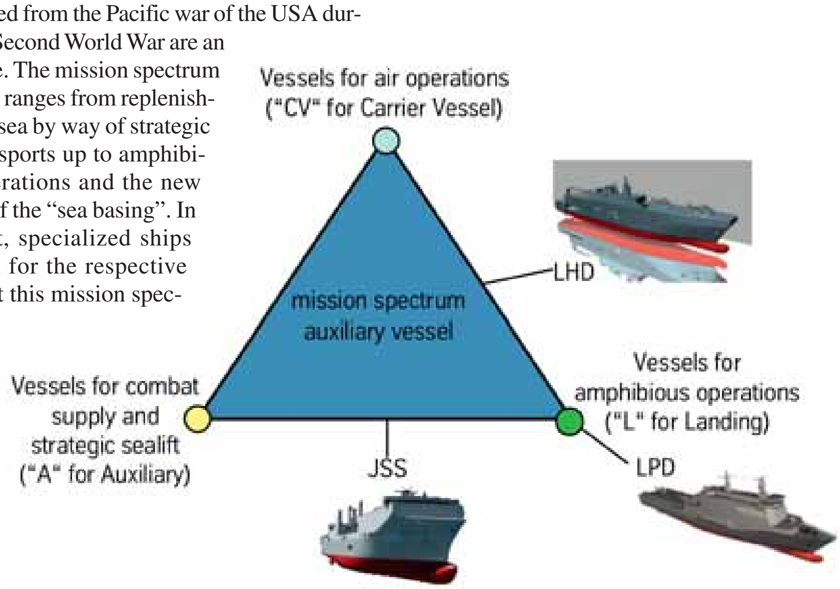


Figure 8 Core Tasks of Combat Support Ships.

When grouping the support ships according to their core tasks, there are three main designs, which can be defined here (Figure 8):

- Ships for replenishment at sea and strategic transports; these are the "classic" support ship tasks; they are marked with the initial "A" for "Auxiliary"
- Ships for amphibious operations developed from the Second World War which are marked with the initial "L" for "Landing"
- Ships for air operations; these include aircraft and helicopter carriers; the initials "CV" stand for "Carrier Vessel".

Today, quickly changeable modules can already realize many of the capability requirements of support ships. It is thus possible to replace e.g. the stowage spaces and tanks of supply vessels just as on-board accommodations for landing troops by containerized solutions. The development of the logistic chain with the armed forces with an increased trend to use ISO 20-foot containers for diverse transport and storage tasks is another development supporting the modular approach.

A modularization for other capabilities is not possible due to the far-reaching changes in ship design or the emerging stress tensions to be expected. Undivided cargo holds/payload bays for a quick landing transfer of vehicles or cranes and winches/hoists for the supply at sea have to be firmly integrated into the basic design. The right combination of these modular/non-modular capabilities shows the way to an innovative concept which will provide the navies a broad, situation-adapted operation spectrum without having to disproportionately increase the fleet size, i.e. the number of the units.

MEKO™ MESHD Approach

The support ship concept of a MEK MESHD (Multi-role Expeditionary Support Helicopter

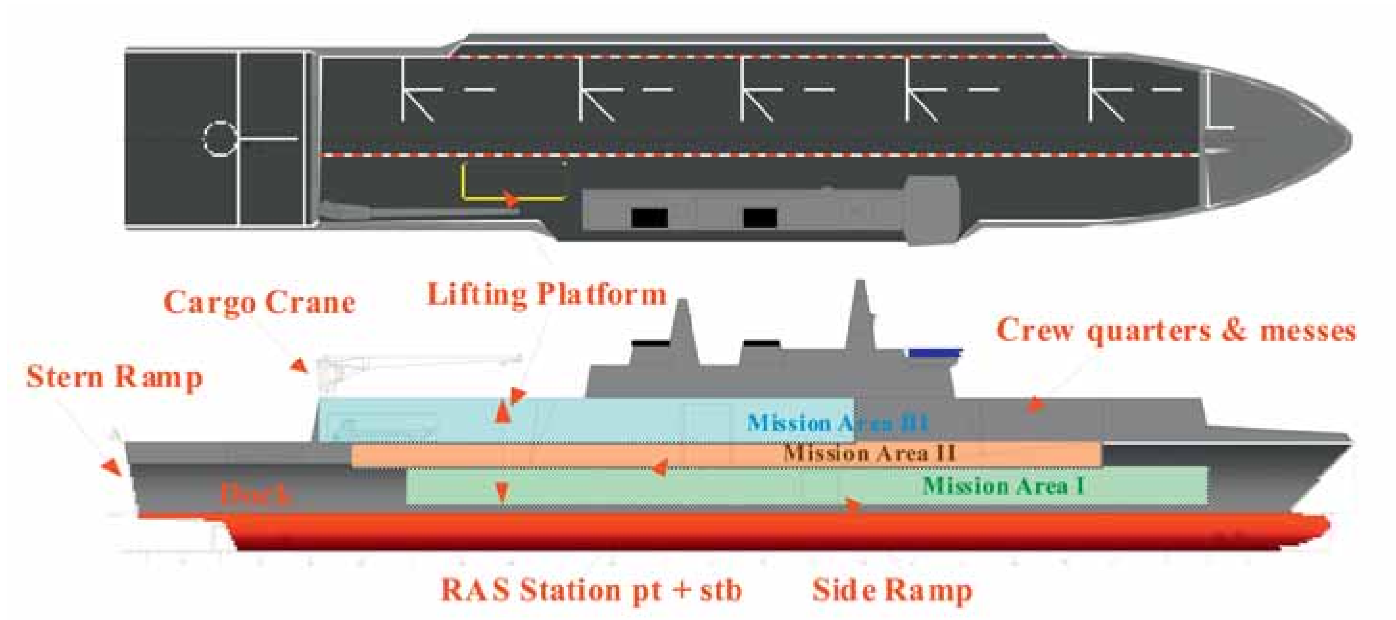


Figure 9 Concept Depiction of MEKO™ MESHD.

Dock) applies the deliberations on mission modules made hitherto for combat ships as a possible solution to support vessels. Here, mission modules are not only understood as containers, but the term is extended to vehicles, aircraft, and boats as well.

The ship is principally equipped with communication and command control facilities to command the task group. Other customary platform-related system considerations on the form of the vessel, the propulsion and ship service systems as well as customer-specified weapons and electronic systems configurations are put aside in this article in order to emphasize the modular approach and its capabilities.

Core element is here the reduction of the items of equipment to the necessary basic capabilities of a ship. For a support vessel these basic capabilities comprise the following:

- Accommodations and utility services for the skeleton crew of the ship
- Non-modularizable capabilities of the individual types of support ships

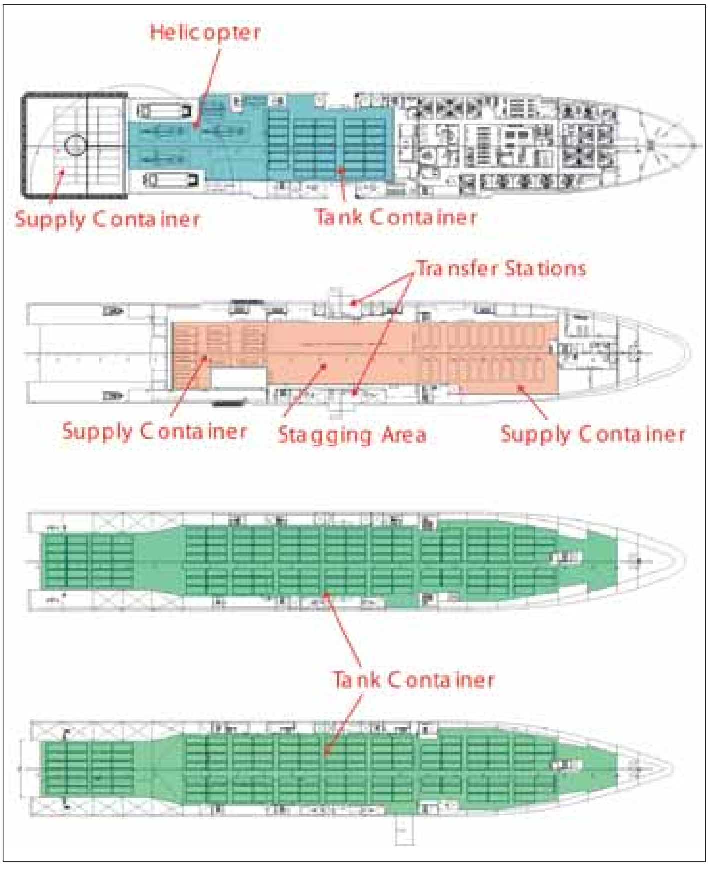


Figure 10 AOR Configuration.

- Flexible multifunction areas for receiving and placing mission modules.

The following non-modularizable capabilities are resultant from the capability requirements:

- Dock: designed for the transport of two LCM-8 class landing crafts (e.g. LCU-MK IX) and dimensioned to allow an interoperability with landing crafts of allied forces
- Flight deck: 2,700 square meters with 5 (+1) launch pads for airborne operations up to company strength and air transport of supplies
- Lift platform: 25-ton lifting load; connects the multifunction areas
- System for replenishment at sea; at the same time abeam replenishment of two ships with solid and liquid fuels
- Crane: 30-ton SWL for lifting mission modules on board even without port infrastructure.
- Stern and side ramp: quick Ro/Ro transfer of mission modules.

The three multifunction areas shown in Figure 9 feature different heights:

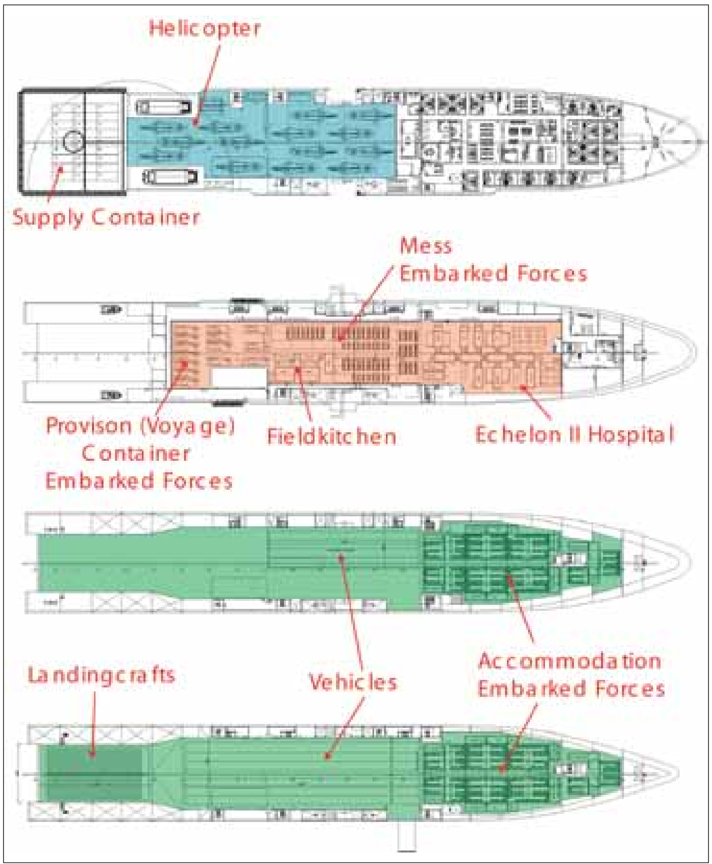


Figure 11 LHD Configuration.

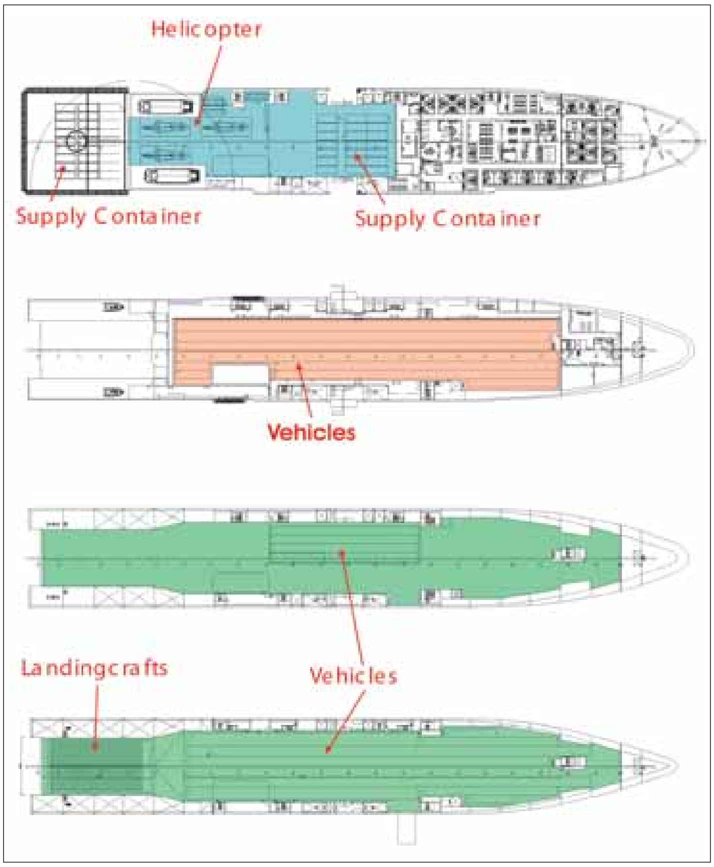


Figure 12 SMSD Configuration.

- Functional area I: 6.2 m
- Functional area II: 2.9 m
- Functional area III: 5.2 m (under crane runway).

This basic equipment is complemented by mission-specific module components. These module components (mission modules) are based on equipment introduced in the armed forces. This fielded equipment is also suitable for transport by the commercial transport chain as a result of the harmonization of the military-civilian logistic chains. In the light of the growing share in global operations it is thus possible to make use of the commercial transport chain for deploying the modules to the periphery of the area of operations. This enables MEKO™ MESHD to adapt itself to changed mission parameters in the area of operations; returning to the home country is thus not necessary. For on-ship container transports there exist lifting systems, which are already introduced with the armed forces. Listed as an example are here the technical data of a system, which is in operation with the Swedish, Belgian, and Italian air forces. This system consists of four wheel sets with hydraulic lifting cylinders and is mounted from the front end or laterally at the container pedals/heel plates. The free space required for the installation is 1 m. The system is capable of lifting loads up to 24 tons and is designed for transport speeds of up to 21 km/h. Based on these data, a complete module change is possible within a maximum of two days.

Examples for the Use of Multifunction Areas

It becomes quickly apparent that the possibilities for combinations are set almost no limits. But to demonstrate the effectiveness of this concept, three of the presently most common support ship roles are described in the following:

Supply Ship

In its role as supply ship, MEKO™ MESHD features the capabilities of a combat support ship for supporting a task force with POL and supplies, spare parts and ammunition. The dead load in the supply (AOR) role comes here to (Figure 10)

- 3 helicopters
- 6,440 tons of fuel
- 320 tons of supplies
- 250 tons of ammunition.

Amphibious Operations

For amphibious operations the MEKO™ MESHD has been configured in the function capabilities of an LHD. Aside from the dock, MEKO™ MESHD is additionally also equipped with two Davit stations for boats and landing vehicles up to deadweight of 35 tons. It is thus possible to carry along two additional landing boats of the LCM-6 class aside from the two LCM-8 transported in the dock. These LCM-6 have a dead load of 30 to 35 tons and a loading platform which allows to transport even medium-size armored vehicles, e.g. a PUMA infantry fighting vehicle (IFV) in Protection State A. In this respect, the MEKO™ MESHD has in this role the standard four landing boats for the transport of medium-size and heavy vehicles.

Here, the dead weight in the LHD role is as follows (Figure 11):

- Accommodations for 750 military personnel (about 1 battalion)
- Containerized field kitchen
- Containerized mess hall with 300 seats
- Containerized “light” rescue center
- Containerized command center for joint operations
- 14 type NH-90 or EH-101 helicopters; 1,960 sqm for 120 vehicles (excl. Dock area)
- 2 LCM-8 in dock
- 240 tons of supplies
- 360 tons of fuel (POL) for motor vehicles
- 290 tons of aviation fuel.

Apart from that it is possible to carry along even additional mission modules that will be “activated” only after disembarkation of troops and vehicles. It is thus possible to extend e.g. the capabilities of the rescue center “light” by additional hospital modules.

Sea Transport/“Sea Base”

In that role, the MEKO™ MESHD ensures the secure military sea deployability (SMSD) and can, when staying longer on station in the area of operations, function as a seaborne logistic base. It will then serve as a transfer station between the secured commercial strategic sea transport (SCSS) and the operating units ashore. The transfer of goods between MEKO™ MESHD and SCSS ships is carried out either by means of landing boats/barges or by way of skin-to-skin transfer using the shipboard crane capacity of MEKO™ MESHD.

A possible dead load for the SMSD role (Figure 12) is:

- 6,600 sqm for 260 vehicles (incl. a tank company)
- 3 helicopters
- 2 LCM-8 or elements of a modular floating pier in the dock
- 700 tons of supplies
- 1,100 tons of fuel (POL) for motor vehicles
  290 tons of aviation fuel.

For the "Sea Base" role there are diverse parametric conditions, which have an influence on the modular equipment. Listed, as examples are here the troop strength to be supplied, the distance between ground unit and "Sea Base", and the branch of the ground units employed. It is thus difficult to describe representative module equipment. For that reason, there are only those essential functions for the "Sea Base" listed in the following, which can be realized with the variant of the MEKO™ MESHD presented here:

- An area of 7,900 sqm for placing supplies
- Flight deck with 5 launch pads of which 3 are suitable for simultaneous operation of CH-53 helicopters
- Shipboard crane (SWL 30 tons) with rope coiling and take-off equipment
- Dock for the secured landing transfer up to sea state 4.

Result

The presented MEKO™ MESHD approach offers the armed forces the following advantages:

- Focused, mission-related capabilities
- Tactical flexibility in the area of operations
- Adaptation to the technological development;
- Parallel procurement channels for ship and modules.

An example for a possible configuration of MEKO™ MESHD is shown in Figure 13.

Figure 13 MEKO™ MESHD — Main Dimensions.

Outlook

The aspect of flexibility will be of considerable importance for the future development of naval ships. This applies to both the modularization in the construction phase for the purpose of cost reduction and creation of a flexible design and for the mission modularity particularly highlighted in this article, which allows a quick adaptation to different requirements in missions and operations. As shown, a combination of shipboard base equipment and mission-dedicated modules adapted to the requirements of the customer allows the employment of a ship for diverse tasks. As demonstrated by the examples of MEKO™ CSL and MEKO™ MESHD, this concept is applicable to both combat and combat support ships. Increased discussions with potential customers will, on the basis shown here, lead further developments to an optimized extent of the mission modularity.

In the field of new platform concepts — especially with frigates and corvettes — partially electric propulsion systems will continue to become more and more accepted in the next years. In addition to the advantages of diesel-electric propulsion (acoustic signature, staying power, operating costs, etc.) in cruising speed sailing, the high peak power demand is possible to be mechanically covered both in space and weight-optimal respects. The step to all-electric combatants will then be essentially determined by the availability of electric high-energy weapons. Whereas special hull forms — SWATH ships in particular — will be used for special types of ships, most of the combatants will be based on advanced single-hull forms partly equipped with new propulsion systems (deeply submerged waterjet). The application of fiber composites will gain in importance with larger combatants as well, even if steel will continue to be an essential material especially in the hull area. The integration of new technologies and components — also at a later point in time in the operation of a ship — will also be simplified by the modularization concept presented here. ■

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