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Technical Report

Naval Applications of Spar Technology in a Seabasing Environment

by

Robin Oldfield

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14. ABSTRACT
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The first part of this study shows the practicality of reduction of the spar length by; changes to spar geometry, reduction of platform mass, and reductions in freeboard.

The study then explores a range of potential applications for spar technology and in a particular three concept designs are detailed; a helo 'lily pad', boat support platform and weapons platforms.

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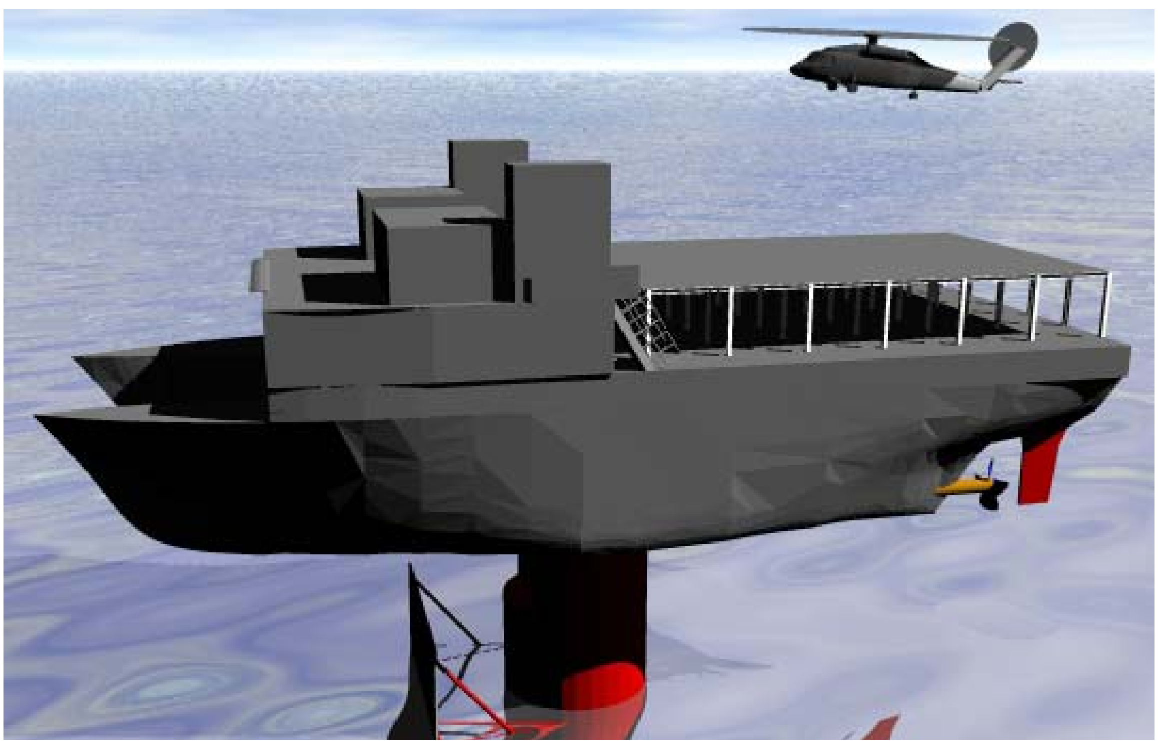

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Nomenclature

AVCAT	Military grade aviation fuel
CISD	Center for Innovation in Ship Design
CIWS	Close in Weapon System
ConOps	Concept of Operations
DESG	Defence Engineering & Science Group
DWSC	Deep Water Stabilized Craneship
Helo	Helicopter
MOD	Ministry of Defence
NSWCCD	Naval Surface Warfare Center, Carderock Division
ONR	Office of Naval Research
SAR	Search And Rescue
SL-AMRAAM	Surface Launched Advanced Medium Range Air to Air Missile
SURC	Small Unit Riverine Craft
UAV	Un-manned Air Vehicle
USCG	United States Coast Guard
USMC	United States Marine Corps
USN	United States Navy
USV	Unmanned Surface Vehicle

1 INTRODUCTION

The offshore industry routinely uses the class of long cylindrical buoyant, vertically aligned, structures commonly referred to as Spars. Common types of spar include cylindrical spars, truss spars and cell spars, all with length to diameter ratios in the range 5-9 typically. The highly attractive seakeeping properties provided by such platforms due to the small waterplane and low centre of gravity have been exploited by the offshore industry for requirements for platforms that require exceptional seakeeping at low or zero forward speeds, but are not anchored.

By contrast, naval use of spar technology is in its infancy due to the limited scope for platforms with lower mobility but higher seakeeping performance in most naval operational concepts. CISD's interest in spars has primarily been in utilizing the technology in the near term naval environment. This environment is expected to comprise of three elements; Sea Base (logistic, maintenance, and reconstitution support), Sea Shield (defensive capabilities) and Sea Strike (offensive capabilities) platforms[1]. It is considered that many aspects of the Sea Base concept are likely to require exceptional seakeeping and some of these will be amenable to a spar based solution.

An earlier CISD concept, the Deep Water Stable Craneship[2] (Figure 1) has produced interest n the design, leading to further ONR funded work for Florida Atlantic University, and other partners including CISD. The Deep Water Stable Craneship (DWSC) consists of two entities, a catamaran craneship and a detachable spar, which when connected form a self-deploying, open ocean capable Trimaran. The spar can be rotated through 90 degrees, from a horizontal oceangoing transit mode to a vertical operating mode, using seawater ballast. The ability to undertake unassisted passage provides a notable benefit for naval requirements in comparison with current offshore industry spars.

When in the vertical mode, partial de-ballasting 'lifts' the catamaran clear of the water surface allowing the system to operate as a spar and take advantage of the superior seakeeping afforded by the small waterplane area.

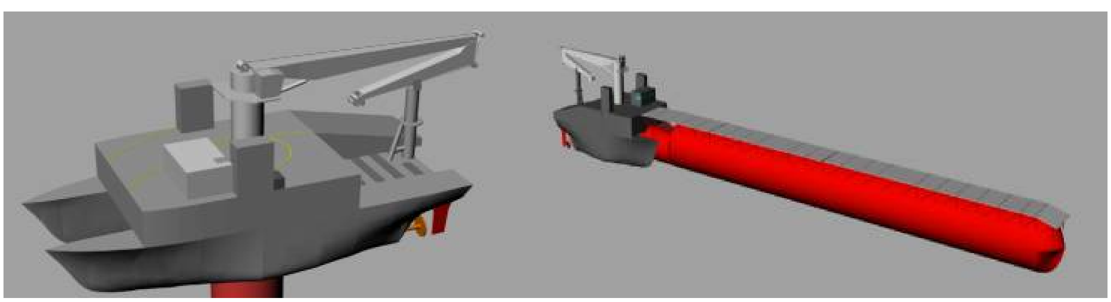

Figure 1 - Deep Water Stable Craneship

The DWSC study produced a concept design tool in spreadsheet form based on a simple geometry model. Whilst the tool and the resulting concept were deemed successful it was believed that significant reductions in spar length could be attained by tuning the geometry from the simple parallel body form originally considered. The first part of this paper examines the impact of spar geometry and payload mass on spar length, with the original aim of reducing the length of a spar concept similar to DWSC from 120m to below 100m, or better. Such a depth reduction is required to allow the spar to operate in shallower waters, closer to land, increasing its utility to the Sea Base.

The second part of the paper explores future spar applications in support of the Sea Base, Sea Shield and Sea Strike concepts. Numerous potential applications of spar technology are postulated. Three of the applications are developed further as concept designs, from the parent DWSC design. The purpose of this study is to improve understanding of what benefits might be achieved with such a platform, rather than to propose specific solutions for detailed design.

2 SPAR LENGTH REDUCTION

Previous DWSC spar development had been undertaken using a simple spreadsheet design tool to identify spar geometry, driven by spar diameter and length, to achieve the required Metacentric height and displacement characteristics for the given payload and catamaran. The spreadsheet's inherent geometry model was based on single spar diameter and hemispherical keel with a reduced diameter "step" for the upper segment to minimize waterplane area and to allow connection to the catamaran between the catamaran hulls.

For the study detailed here, the design tool received a number of refinements; for example, the structural weight estimate algorithm was changed from an enclosed volume approach based to a surface area based algorithm. This was based on the fact that the structural weight of the spar is in reality driven by hydrostatic pressure loading directly on the surface area of the spar.

The most significant change was the introduction of a multi-stage geometry model. A shorter spar still requires sufficient volume to provide buoyancy, but with the structural and ballast weight concentrated closer to the bottom of the spar. It was envisioned that the 'ideal' spar would have an infinitely small diameter at the waterline with an infinitely large diameter below, containing the buoyancy, ballast and structural weight. Multi-section geometry spars were considered a potential solution to excessive depth by distorting the distribution of buoyancy and weight towards the keel. It was considered that as differences between section diameters increased, tending towards the ideal spar, the reduction in spar length would become greater.

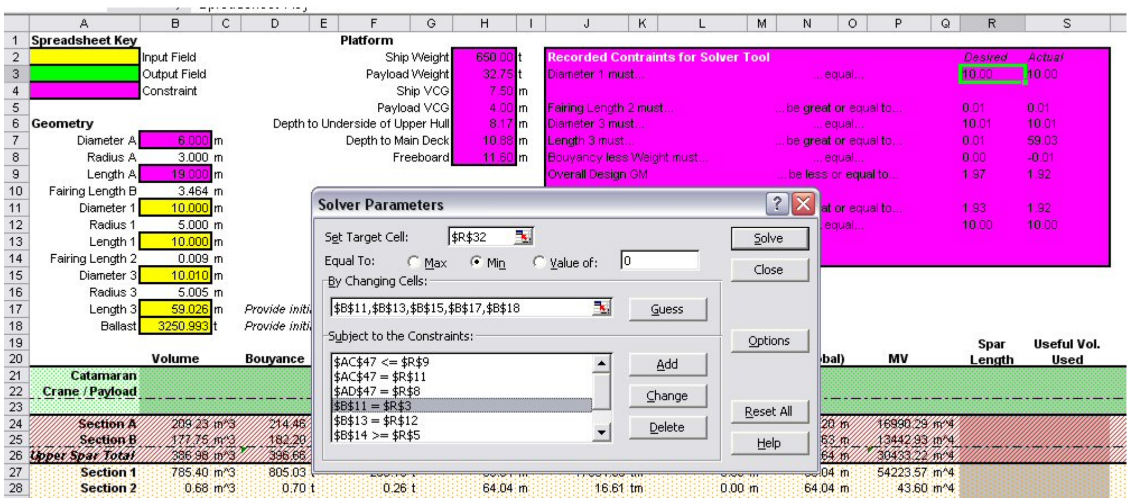

Figure 2 - Spar Design Tool

The design tool (see Figure 2) was configured to identify spar geometry that achieved the minimum spar length.

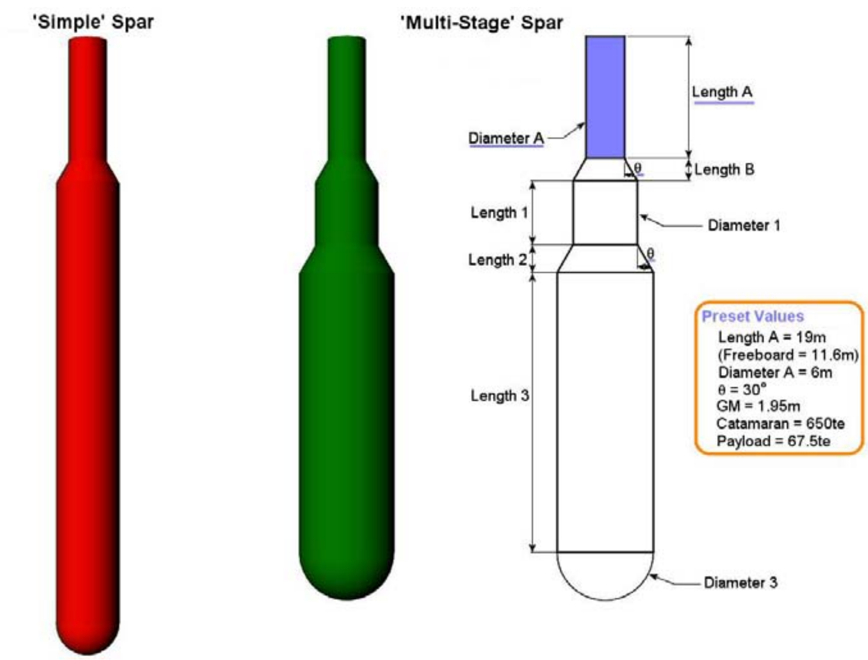

Figure 3 - Spar Geometry Models

To ensure a reasonable comparison with earlier CISD work a number of the spar parameters have been kept constant (Length A, Diameter A and θ), fixing the interface with the Catamaran. The previous spar design for the DWSC study[2] had a GM of 1.95m for a 650mt catamaran mounting a 67.5mt crane and a spar freeboard of 11.6m. An improved design would be constrained to achieve this GM, with the same payload and freeboard.

2.1 MULTI-STAGE GEOMETRIES

The first area of investigation would be the impact multi-stage geometry had on spar length. For given Diameter 1 and Length 1 values a range of $Diameter_3$ values would be investigated, beginning with a simple spar geometry (a single diameter main spar with Diameter 1 = Diameter 3), and transitioning to a multi-diameter spar with a bulbous end. For simplicity, Length 2 would be driven by a fixed transition angle, θ. Length 3 would be unconstrained, varying to achieve the necessary displacement-weight balance at an appropriate metacentric height. For this level of design definition, it was assumed that a constant metacentric height design space with fixed waterplane area would lead to a range of spars with similar seakeeping performance to that demonstrated by the DWSC at Reference 2. In reality the different levels of damping afforded by the differing geometries would change seakeeping performance to a degree.

A range of diameters were tested, from 6m up to 25m. Figure 4 shows two graphs of the impact geometry had on the draft of the spar. Both graphs clearly show that a multi-stage geometry can result in some significant decreases in spar length.

This is particularly evident at small diameters; a Diameter 1 = 6m, Diameter 3 = 12m spar has a length approximately 50% of a simple 6m diameter spar. However as Diameter 1 approaches 12.5m the benefits of a multi-stage geometry diminish and any reduction in spar length due to a multi-stage geometry is negligible. Beyond Diameter 3 = 15m, there is minimal reduction in spar length with increasing diameters.

Whilst there are significant reductions in spar length obtainable with low diameter, multi-stage spars, Figure 5 shows that this is at the expense of an adverse affect on structural weight and overall displacement.

An increase in structural weight is considered to directly increase the cost of the spar due to the additional material and fabrication requirements which are without a corresponding reduction in complexity. An increase in structural weight also leads to less efficient operation in the transit mode.

An exception to the trend of increasing structural weight with diameter is found at very small diameters. In this region increasing diameter results in a decrease in both structural weight and length. This decrease in structural weight is due the large reduction in spar length; which more than counters the additional weight due to the slight increase in Diameter 3. For the given constraints, Figure 5 suggests that the optimum diameter for structural weight purposes would be around 10m. The graphs in Figure 4 show that this diameter would also result in one of the shorter spar lengths.

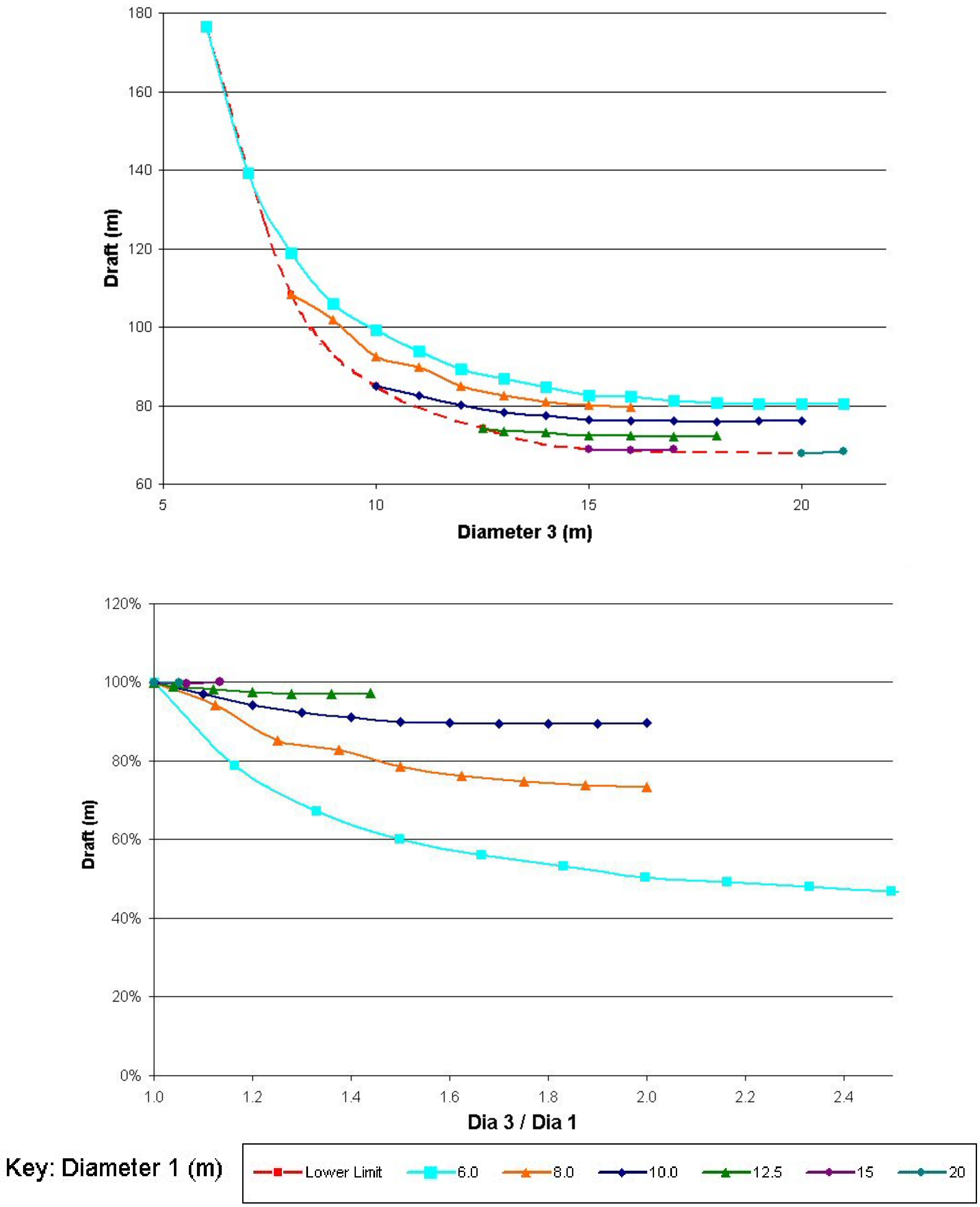

Figure 4 - Spar Diameter vs. Draft Results

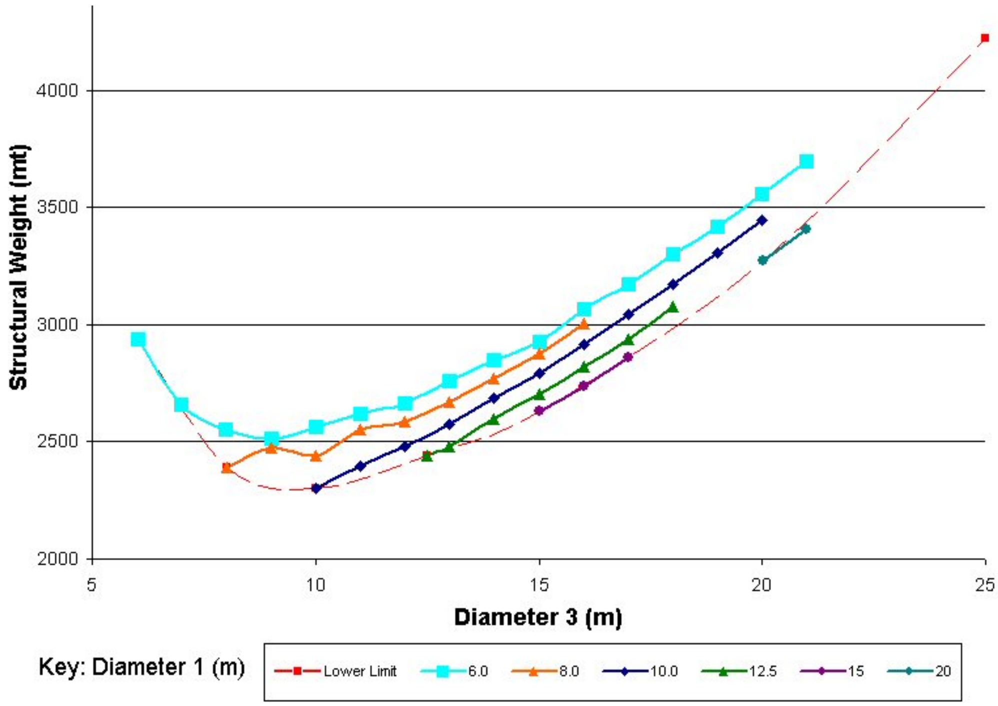

Figure 5 - Spar Geometry vs Structural Weight

2.2 IMPACT OF SPAR DIAMETER ON SEAKEEPING PERFORMANCE

A comparative seakeeping analysis using the WAMIT tool was undertaken to identify the key differences in Roll, Pitch and Heave behavior between the 10m and 15m diameter spar designs. Initial results indicate a notable reduction in the magnitude of non dimensional Roll and Pitch moments for the larger diameter spar with a slight increase in non dimensional Heave forces. Due to time constraints these results will be reported in a subsequent report.

2.2.1 PLATFORM MASS CHANGES

The results above are based on a single Crane payload and Catamaran platform and while indicative of spar design trends, do not provide guidance of the impact of changes in platform mass. Platform mass refers to the mass of the catamaran and all the systems contained within or positioned onboard it.

It is considered that different spar payloads will lead to dramatically differing platform masses as the role of the platform is to support the payload with systems and structure as required. Thus a small change in payload can result in a large change in the capacity required to be carried by the spar.

An area of interest was the impact variations of platform mass had on the required length of spar. Only simple spar geometries were considered, to reduce the number of possible geometric permutations. It was anticipated that a small reduction in mass could produce a sizable reduction in spar length due to the reduced vertical moment. As the graphs in Figure 6 show, this supposition was generally correct for the larger platforms.

The results are particularly interesting for lower platform masses. Spar length reduction appears to be almost negligible as the platform mass decreases below 100 mt. In this design region proportionately more of the spar is required solely to support itself in a, buoyant and stable manner, and proportionately less is effectively required to support the platform.

The sensitivity to payload mass decreases with increased spar diameter because of the greater cross-sectional area of the spar, leading to a greater structural mass and more buoyancy required. A greater cross-section area also requires smaller changes in draft to accommodate the required buoyancy and ballast.

Figure 7 illustrates how the sensitivity to changes in platform mass varies depending on diameter of the simple spar. Again the rate of reduction in spar length is more significant for the smaller diameter spars. At diameters less than 10 m, notable changes in spar length occur due to small changes in platform mass. As the diameter of the spar approaches 15m there appears to no real benefit by increasing diameter further to allow greater payloads for a fixed length. These findings appear to reinforce the benefits of 10m-15m diameter spars.

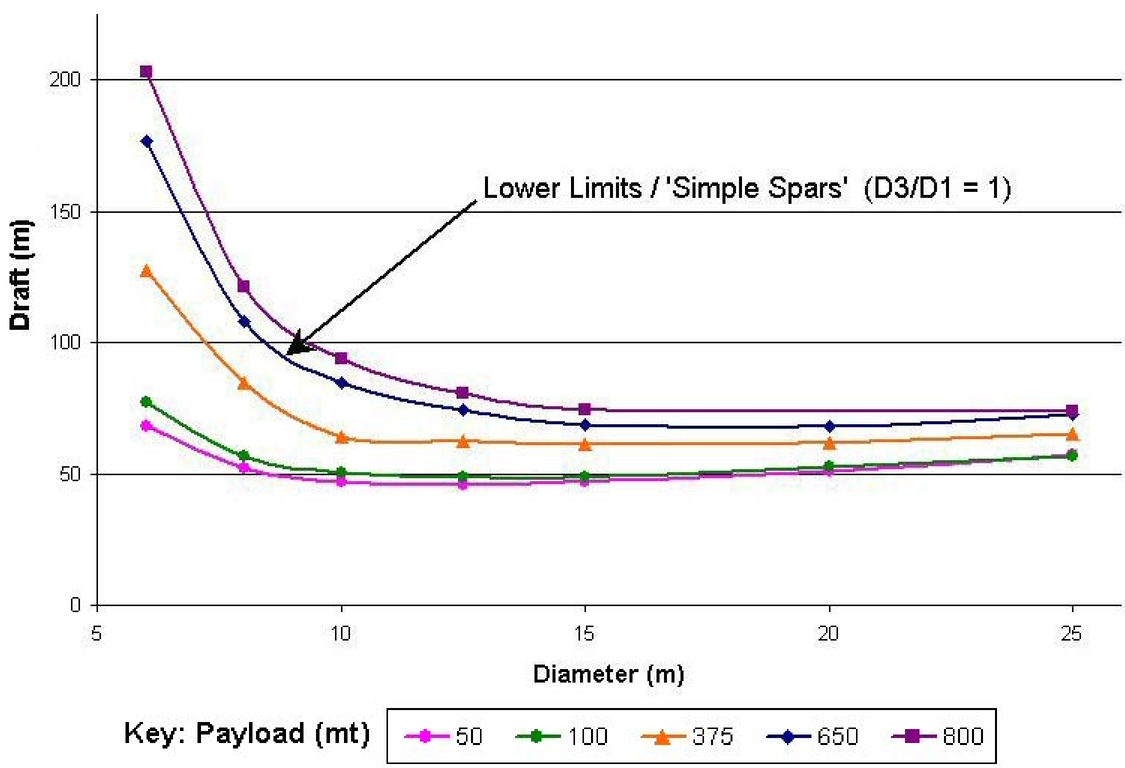

Figure 6 – Platform Mass Reduction

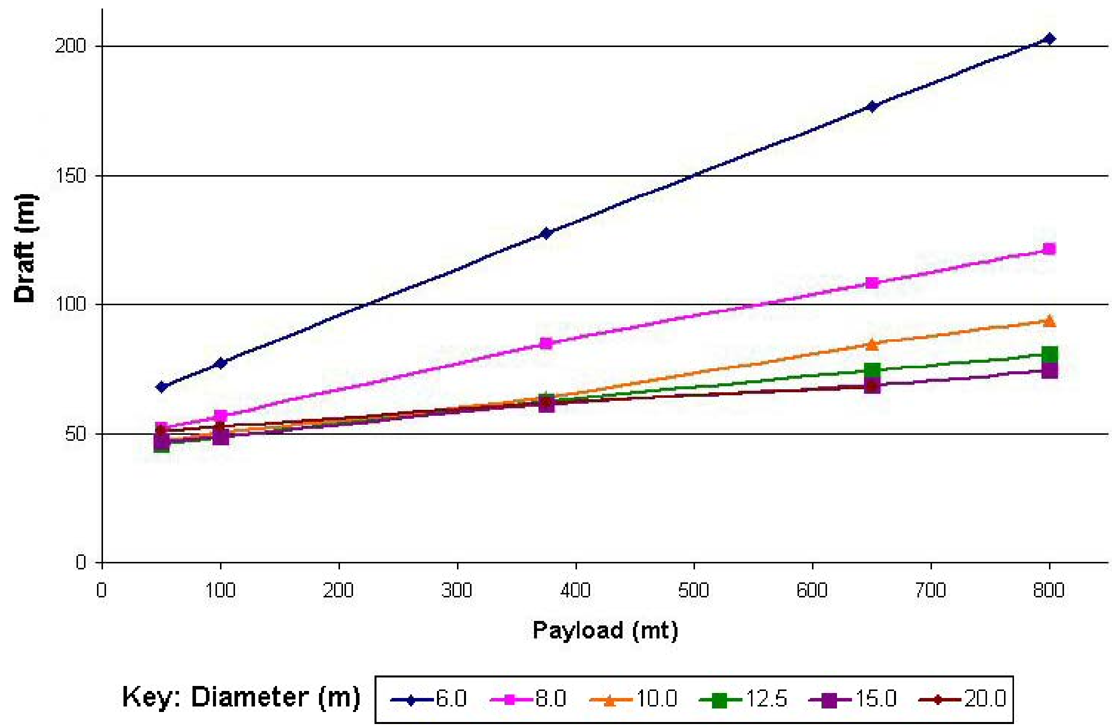

Figure 7 - Spar Platform Mass – Spar Draught Sensitivity

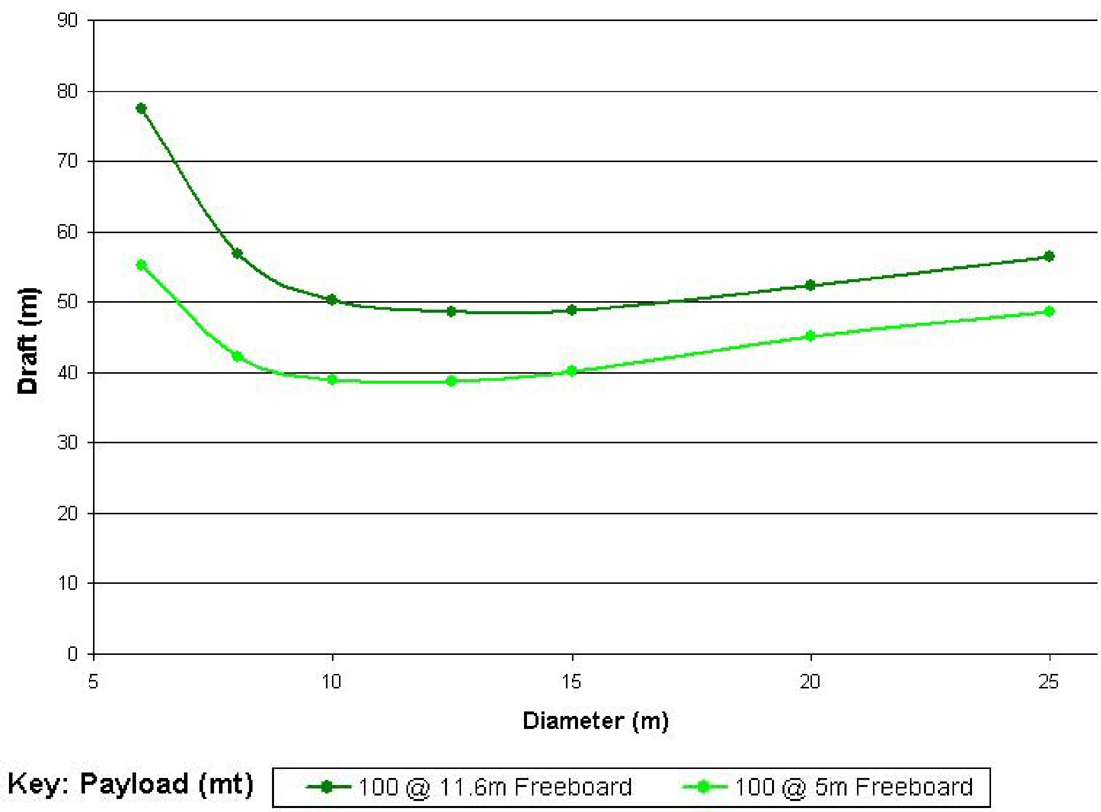

Figure 8 - Spar Freeboard Reduction

2.2.2 FREEBOARD CHANGES

An important driver of the spar length is the platform's freeboard, previously fixed to allow similar seakeeping performance to the reference DWSC. Hence a study was undertaken to investigate the design penalty of mandating such a wet deck clearance. In addition it has been shown that a reduced platform mass and hence vertical moment, leads to a decrease in spar length. Figure 8 notes the impact on spar draught for a spar concept of 100mt platform mass of a freeboard reduction from 11.6m to 5m showing significant reductions in spar length can be obtained. As a result for roles in sheltered waters, with less water depth and less extreme operating conditions, a lower freeboard design should be sought.

The seakeeping performance of a spar platform, with reduced freeboard, situated in littoral waters merits further work, to identify design guidance for ideal wet deck clearances for common sea state.

	Simple Spar (Baseline)	Multi-Stage Spar	Simple Spar Reduced Freeboard	Simple Spar Reduced Platform Mass
Platform Mass (mt)	650.00	650.00	650.00	325.00 (50% Decrease)
Freeboard (m)	11.60	11.60	5.80 (50% Decrease)	11.60
$Diameter_1$ (m)	10.00	10.00	10.00	10.00
$Diameter_3$ (m)	10.00	12.00 (20% Increase)	10.00	10.00
Structural Weight (mt)	2248.63	2422.26	2079.18	1735.10
Structural Weight Change (%)	NA	+7.8	-7.54	-22.8
Draft (m)	83.02	78.14	82.28	63.21
Draft Change (%)	NA	-5.9	-0.01	-23.9

Table 1 - Spar Length Reduction Method Summary

2.3 SPAR LENGTH REDUCTION CONCLUSIONS

In summary it has been found that reduction in spar length is achievable through a variety of means; multi-stage spars, simple spars with large diameters, reducing platform mass and reducing freeboard. However these methods all have areas of the design space in which they have little effect, and often have a significant trade-off to make in terms of performance or cost. Table 1 presents indicative results for these reduction methods. The magnitude of the draught reduction depends on how significant a change has been made to the shaded cells.

As expected for a given spar platform, there is a region of compromise designs to be identified, based on spar diameter and platform freeboard that reduces the overall size of the spar without excessively increasing structural weight (and hence cost) or compromising seakeeping performance by introducing unacceptable slamming loads due to reduced freeboard.

Designing a spar based solution for a particular operational concept will need to identify the location of this region noting the particular operational constraints.

3 SPAR APPLICATIONS

Previous work [2] had explored the potential for a crane equipped naval spar platform, and briefly explored alternative applications such as the use of a spar for a causeway, breakwater or bottom-sitting offload facility.

It is further considered that spar platforms have the potential to be used in a wide range of other naval applications. The second part of this study was to conduct an initial exploration of some of these alternatives; alternatives which featured one or more of the following attributes associated with spar platforms.

- *Seakeeping* – The primary attribute of spar platforms is the excellent seakeeping when upright. Relatively small motions are experienced with long natural periods.
- *Dual mode* – A spar platform with the ability to hinge the spar can transit into theatre much like a conventional ship, and then become a stable platform in its upright position. This provides much needed flexibility for naval missions where reliance on other vessels is not acceptable. A speed of 20 knots in surface mode and 4 knots in spar mode anticipated [2].
- *Controllable freeboard* – Control of the spar ballast and buoyancy provides the ability to control the desired freeboard when in the upright position.
- *Cost* – It would be incorrect to say that spar platforms are low cost. However compared to a multi-mission, highly capable, warship and the associated development and design costs, they can appear relatively inexpensive. If the provision of a dedicated spar can free the warship for other duties, value for money can ensue.
- *Simplicity* – The principals behind the spar are relatively simple. Furthermore unlike warships with multitudes of systems, most spar concepts focus on performing a single role.
- *Potential for automation* – Unmanned technology is developing fast. It can eliminate the need to place personnel in high-risk areas, and utilize them in more appropriate roles and locations.
- *Low Military Value*- Modern naval ships are few in number and in great operational demand. There are circumstances where the limited numbers of hulls, large crew numbers and high military value make it impractical to justify the military risk inherent in their use for some missions. An unmanned or sparsely manned spar system could fulfill individual roles with greater military risk as the military value is less, particularly if significant quantities are available within the seabase.

3.1 POTENTIAL APPLICATIONS

Brainstorming identified a range of applications that spanned military, homeland defense, and civilian uses (see Figure 9).

It is stressed that the naval use of spar platforms complements and does not negate the requirement for conventional naval ships. Naval ships are increasingly designed as multi-role platforms. A dedicated single-role spar design can excel in a particular niche capability with material, manpower and operating costs much less than a warship solution.

The overarching concept is for relatively inexpensive spar platforms to take suitable hazardous or mundane duties that would otherwise require an overly expensive, excessively capable, and more manpower intensive asset.

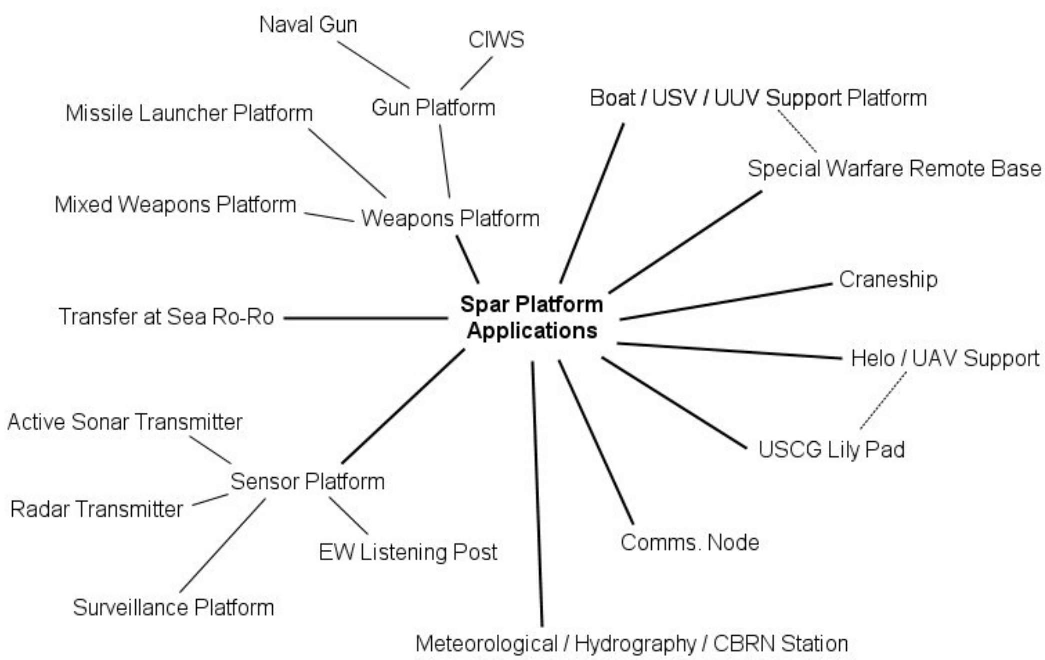

Figure 9 - Spar Applications Brainstorm

3.1.1 CONCEPT DESIGN PROCESS

Three of the possible applications in Figure 9 have been taken to the concept design stage:-

- Helicopter ‘Lily’ Pad: A Landing platform and refueling facilities for SH 60 sized helicopters.
- Boat Support: Sea based mooring platform for small boats and embarked military forces,
- Weapon platforms: Remotely controlled launch platforms for weapons.

For the first two applications the DWSC (including spar design and catamaran platform) was used as a baseline design as the size and seakeeping properties of the design were well suited to the payload being embarked.

Previous work on the DWSC concept had explored the spar design and seakeeping performance in more detail than would be possible within this study. For the level of detail considered, it was assumed that for a constant weight and centre of gravity, all concepts would retain similar seakeeping characteristics, stability and powering requirements as the DWSC (Figure 10).

Motion	Heave	Roll	Pitch
Period (S)	30.5	148.8	148.8

Figure 10 - DWSC Natural Periods (From Reference 2)

The operating envelope of all similar spar designs in heave, pitch and roll would exceed the performance of current naval vessels.

3.2 HELICOPTER 'LILY PAD' CONCEPT

Modern helicopters are an integral part of naval warfare. Landing and refueling facilities are in great demand, often influencing the mission of warships and restricting the employment of the warships in other roles.

Provision of additional landing facilities, in particular landing facilities free from the sea state related operating limitations of traditional monohull escort vessels would be operationally desirable. Comparing the heave, roll and pitch periods of the DWSC at Figure 10 with the (classified) performance of escort vessels indicates the relative ease of landing on a spar based landing pad in a high sea state.

While not the proposed prime mode of operation, it is also expected that the Lily Pad in surface mode will also be able to operate the landing pad during transit, but with greater sea state limitations than in the vertical operating mode.

The Lily Pad is envisioned as a concept to provide a high sea state capability landing and refueling platform for helicopters operating from locations away from other naval vessels. Thus either extended range or more flexibility in helo operations can be provided. The Lily Pad could be also be sited to link an offshore sea base with ground based assets ashore (see ConOps1 in Figure 12). This would permit the sea base to remain detached from higher threat littoral regions or provide alternate facilities in case of emergency or air traffic congestion.

The concept also has potential for civilian applications, allowing law enforcement, homeland security agencies or emergency services to extend mission endurance and range for Search and Rescue or maritime border patrols (see Figure 12). The helicopter could remain within the operating or search region for longer periods, without the need to return to its land base for refueling.

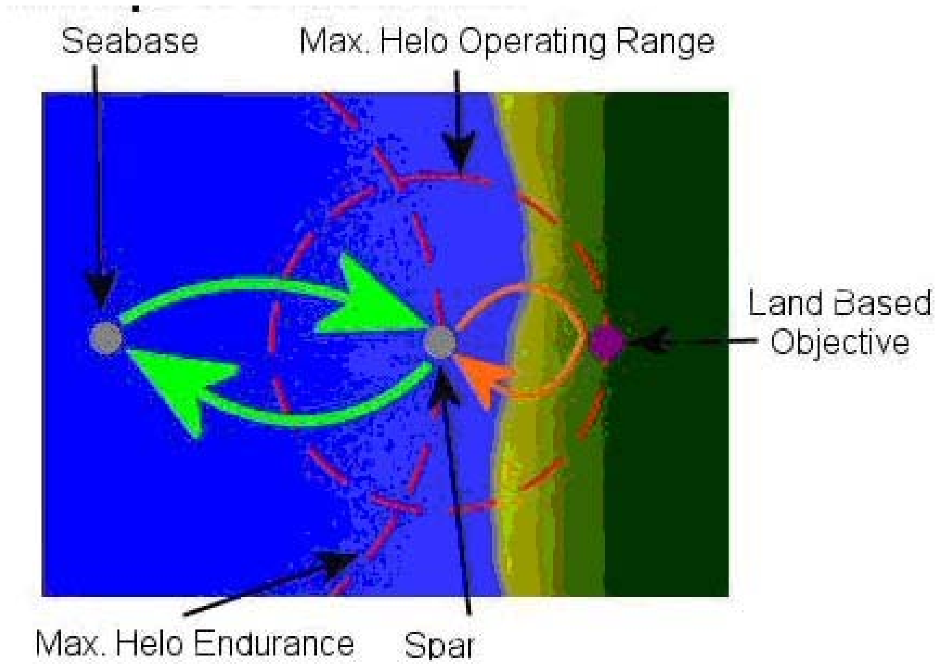

Figure 11 - Helo Lily Pad ConOps 1

In all scenarios helicopter servicing is not specifically considered or allowed for but some first line servicing capabilities could be offered at little additional impact.

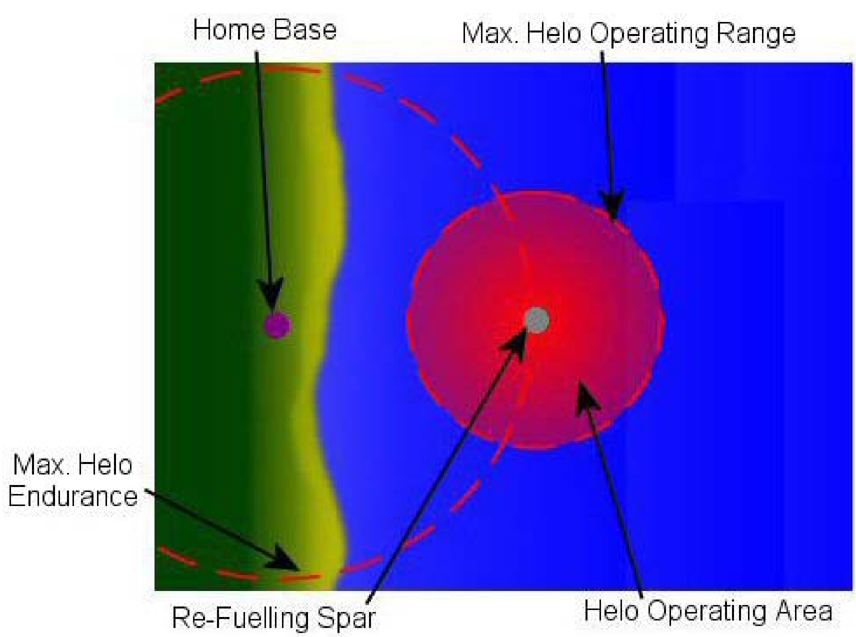

Figure 12 - Helo Lily Pad ConOps 2

The conceptual design of the Lily Pad platform is a variant of the DWSC design, with structural weight, system arrangements and general arrangement being altered to suit the amended role. The size and weight of the original DWSC based spar imposed restrictions on the helicopter types that might be operated from the helo pad.

For the deck space available it is considered unlikely that any naval helicopter larger than a SH-60 Seahawk could land on deck, without a fundamental redesign of catamaran and hence the spar. As a result the SH-60 helicopter was set as the upper limit of capability, in terms of flight deck area and weight, for the helo platform. Operating the multi-role SH-60 Seahawk or similar helicopters could exploit the capabilities of both platforms to their fullness. The selection of this helicopter yields further benefits as the USCG operates its own variant, the HH-60 Jayhawk. Lighter and smaller helicopters or future rotary-wing UAVs, such as the Fire Scout, could also be operated from the platform.

Flight Deck Design: With the requirement to support a SH-60 Seahawk (at approximately 10 tonnes all up mass), Lloyd’s Register Rules for Naval Ships, was used for the platform’s flight deck design. The worse case situation assumed that half the landing force of a fully loaded Seahawk loads the centre of a single flight deck panel. A required panel thickness was so identified. Simple bending and buckling calculations sized the supporting I-beam structure.

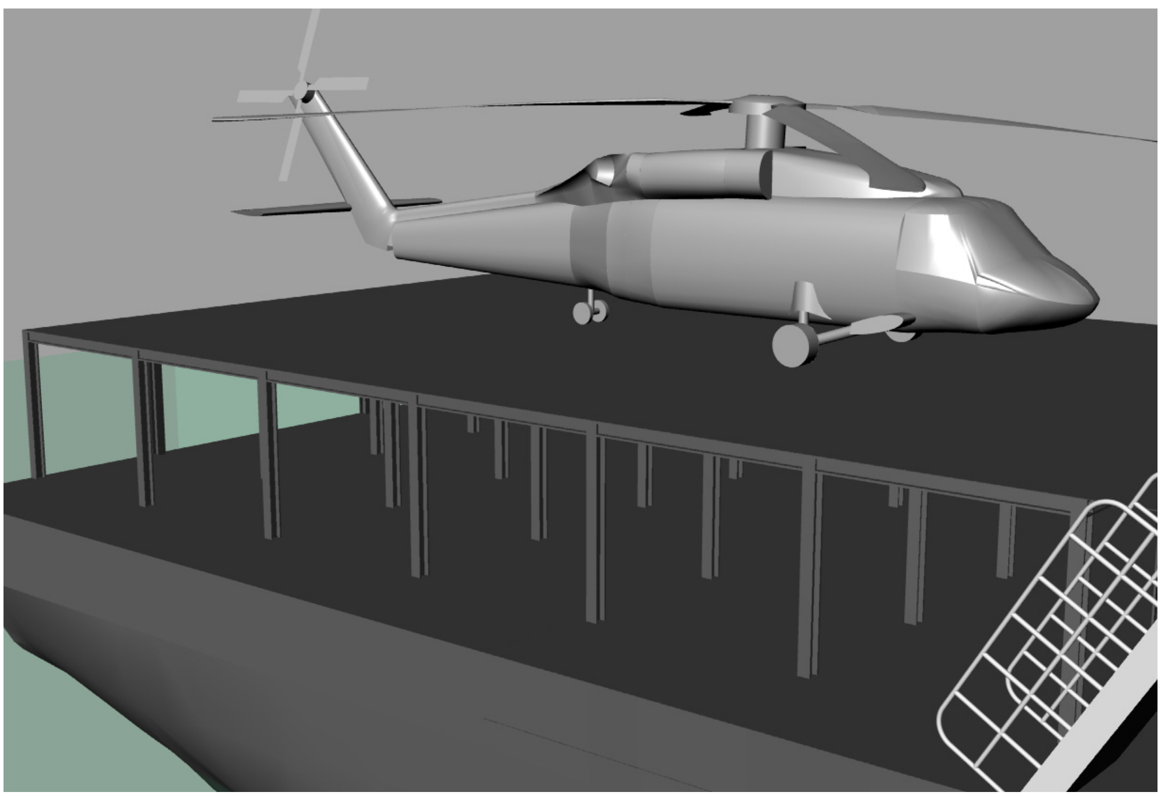

Figure 13 – SH 60 based Helo Lily Pad Flight Deck

	Required Area (m^2)	Weight (mt)
Officer Class III Cabin	11.00	0.90
NCO Cabin	3.32	(Included in Mess)
JR Bunk Space	5.80	(Included in Mess)
Combined Head & Bathroom	2.29	0.30
Combined Mess & Dining Hall	9.96	25.58
Laundry & Drying Room	2.31	0.15
Galley	1.52	0.32
Cold & Cool Rooms (Inc. Required Machinery)	0.15	0.26
Baggage Store	0.48	0.03
Provision Rooms & Victualling Gear	0.42	0.39
Life Saving Gear	NA	0.09
Personnel	NA	1.14
Recreational Space (Estimated)	(Void filled)	0.50
Totals	**37.25**	**29.66**

Note: Deckhead height of 2.5m

Table 2 - Helo Lily Pad Personnel Requirements

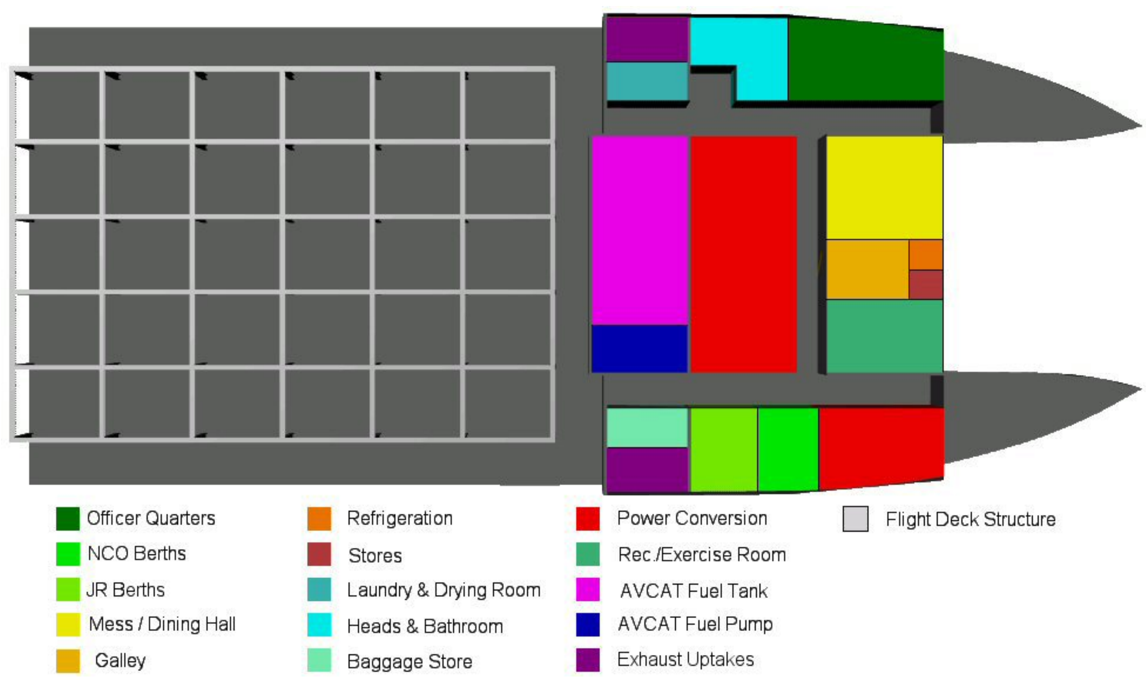

Figure 14 – Helo Lily Pad Arrangement

Personnel Requirements: The catamaran weight and space requirements were re-evaluated from the previous DWSC catamaran. Calculations for the crew of eight persons, with an endurance of fourteen days, resulted in a modest increase in weight but a decrease in required volume, facilitating the removal of upper-deck structure. No provision was made for the helo crew or passengers as the ConOps did not recognize the need for the helo pad to support an organic aviation asset; the platform would purely act as a short duration reception point for refueling and parking purposes.

Helo Support: With the ConOps focused on re-fuelling operations to extend effective range and mission tempo it was essential that the Helo Lily Pad had a supply of AVCAT. 45 tonnes of AVCAT, corresponding to fifteen helicopter sorties of maximum duration, was accommodated within the design. More fuel may be desired to facilitate high-tempo unsupported operations, but this concept is restricted by the assumed spar characteristics.

Helo Lily Pad Summary: The concept design is capable of supporting a versatile, and widely used, helicopter type for a reasonable number of sorties. It is believed that the concept would adequately perform the types of operations detailed in the proposed ConOps. The Helo Lily Pad design meets the displacement limit, and there has been no significant change in the platform centre of gravity, based on estimates for mass and centers of gravity.

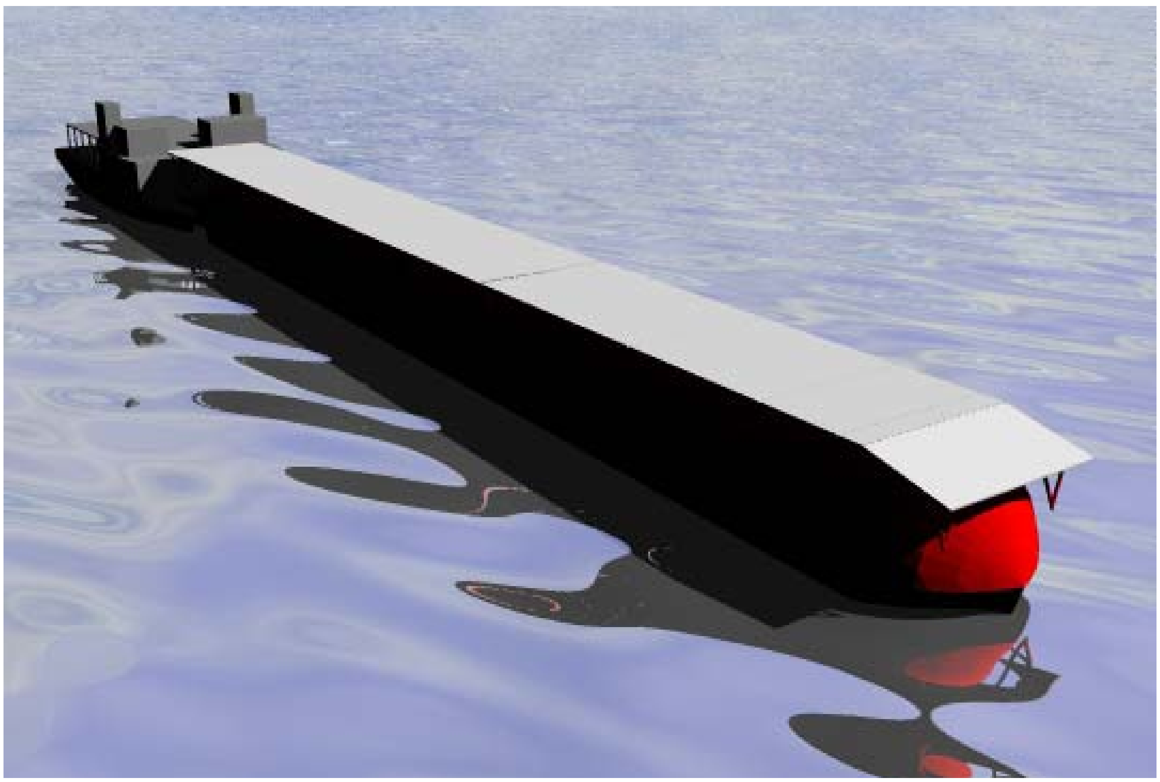

Figure 15 - Helo Lily Pad Concept (in surface transit mode)

While the Lily Pad is primarily designed for landing and refueling operations of medium size helicopters in a seaway, it is anticipated that relatively small design modifications to the spar and platform could allow the incorporation of the following additional capabilities:-

- Limited re-arming capability
- Limited first line servicing
- Larger, heavier helos

- Limited cargo stowage
- Helo crew accommodation
- Limited flight support facilities (for example simple mission planning, communications with other assets)

Action	Object	Mass (kg)	Volume (m^3)		Supported Helo Sorties:	15	
Removed	Crane & Pedestal	-65500.00	-140.00		**Total Mass Change:**	4.87	Mt
Added	Flight Deck	14040.00	0.00		**Total Volume Change:**	-774.89	M^3
Added	FltDeck Structure	23605.14	-469.60		**X Moment Change:**	-468.89	mt.m
Added	Jayhawk	9926.42	0.00		**Y Moment Change:**	29.62	mt.m
Removed	50% Diesel	-25000.00	-29.76		**Z Moment Change:**	-187.18	mt.m
Added	AVCAT	45000.00	50.00				
Added	AVCAT Pumps	2000.00	5.63		Original KG:	7.50	m
Removed	Old Pers. Weights	-21422.00	0.00		KG Change (removing):	3.24	m
Added	New Pers. Weights	29661.61	0.00		KG Change (adding):	1.33	m
Removed	Structure	-7445.88	-191.15		New KG:	5.59	m

Table 3 - Helo Lily Pad Weight Changes

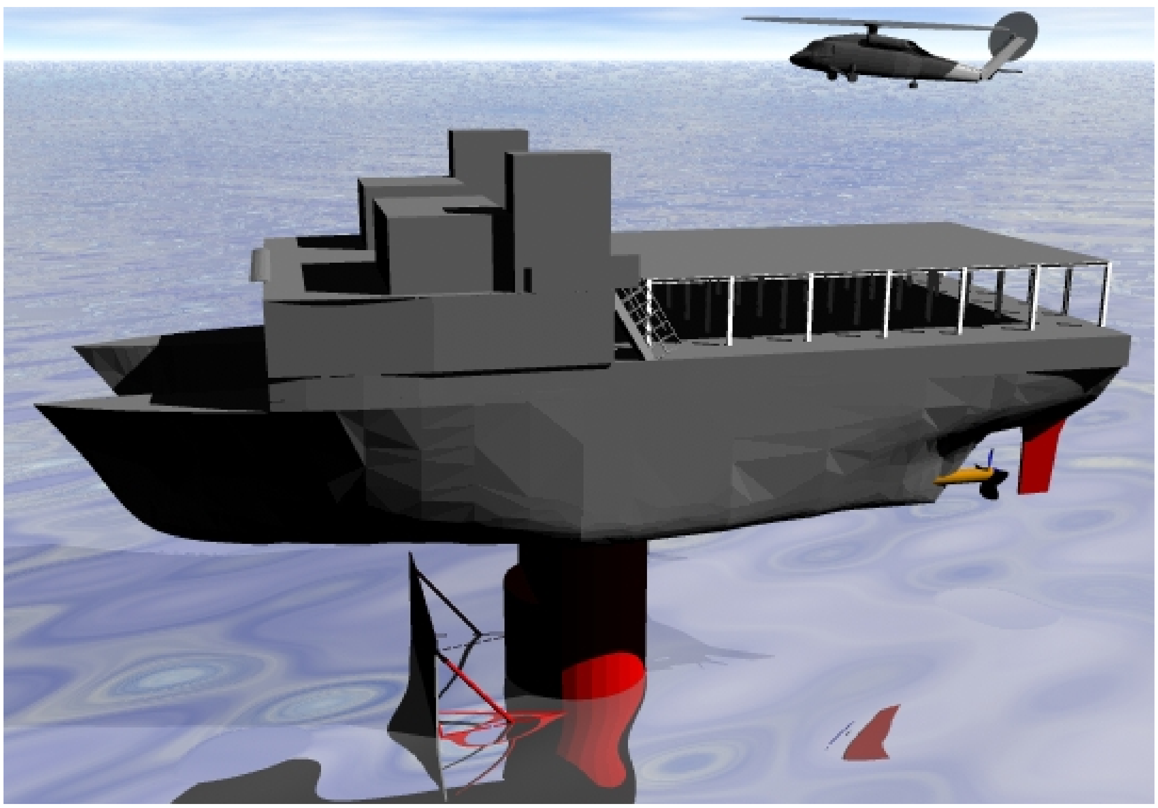

Figure 16 - Helo Lily Pad Concept (in spar mode)

3.3 SMALL BOAT SUPPORT PLATFORM

The second proposed use was the Small Boat Support Platform for either naval, or coastguard forces. A variant of this platform could also easily fulfill the role of a Special Forces hub, providing a remote operating base for Special Forces patrols.

Often small boats carrying boarding parties, infantry or Special Forces are limited in their operational effectiveness by the sea environment and the availability of naval vessels to provide a safe haven. This most often leads to a reduction in the radius of effective operation. By protecting the boats by storage and support on one or more spars, strategically located, increases in operability are expected.

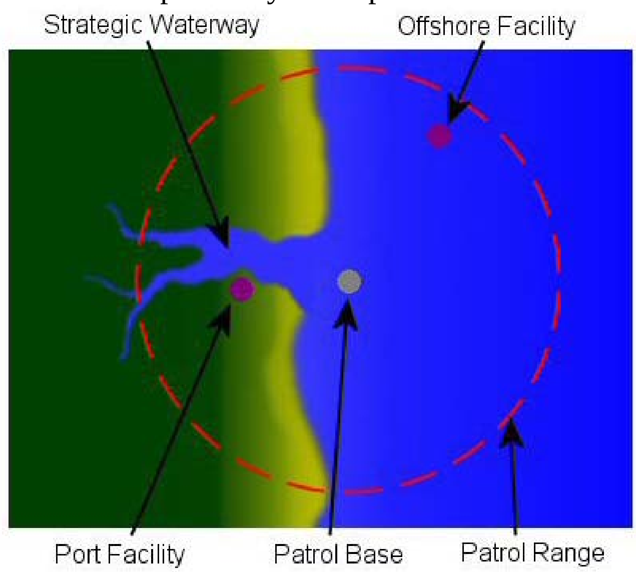

Figure 17 - Small Boat Support Platform ConOps1

The stability of a spar platform makes the technology attractive for a remote base concept. A small number of personnel would be stationed on the catamaran and would operate a number of boats which would be stored on-board during rough weather, or berthed alongside. The platform could be sited centrally in an operating area, negating the need for the patrol boats to have a footprint ashore or being transferred into position by ship. In simplistic terms the boat support platform concept is a 'mini-seabase' for small boats, too small to be unsupplied in open seas for more than a short period. Figure 17 and Figure 18 graphically represents these ConOps.

As with the Helo Lily pad the design work for the small boat support platform concept was based on the DWSC spar and catamaran. Features unique to the DWSC were removed, prior to adding design features required for the boat support platform.

The platform was designed to primarily cater for the Small Unit Riverine Craft, a recent US Marine Corps boat acquisition program, and the boats with the largest personnel lift capability and weight. Other boats that might be supported include the US Marine Corps Rapid Assault Craft, US Navy 11m Rigid Inflatable Boat and Special Operations Craft-Riverine.

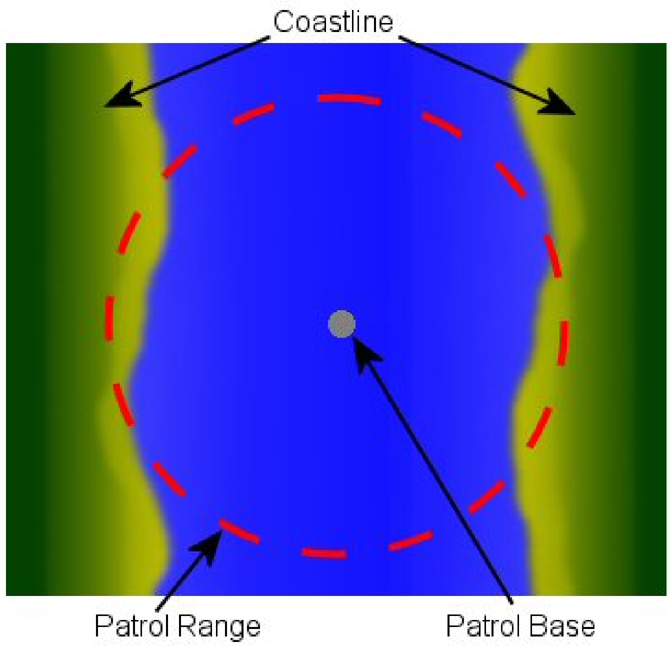

Figure 18 – Small Boat Support Platform ConOps 2

A crew of eight was embarked to man the spar, with the added capability to accommodate thirty-six members of the embarked military force (and their field equipment) sufficient to man two SURC. In the absence of any firm data a very conservative estimate of 10mt was made for the SURC weight.

	Spar Crew	**Embarked Military Force**	**Total**
Officers	2	0	2
Senior Rates	2	4	6
Junior Rates	4	32	36
Total	**8**	**36**	**44**

Table 4 – Small Boat Support Platform Personnel Breakdown

Boat Facilities: An immediate area of interest was the support of the boats in periods of rough weather and high seas. The decision was between berthing alongside the spar or stowage on the platform. Berthing at the waterline of the spar seemed undesirable as the fully equipped EMF would have to climb to reach the boats, which would simultaneously be subjected to sea motions.

It was considered far safer and operationally effective to raise the boats clear of the water and stow them on the stationary platform deck. This would require crane(s) or davits but would have the added benefit of increasing the operable sea state and allowing a more orderly boat embarkation.

Davits were ultimately not used as they lacked sufficient outboard reach. Reach is important as it would be highly undesirable to have a boat swing into, or even beneath, the hull of the boat support platform when excited by the seaway.

The freeboard of the spar could be tuned for the sea state to decrease the hoist distance, and therefore time, a boat would be suspended for. This could reduce the probability of such undesirable events, but any controlled change of the spar ballast would be a slow evolution.

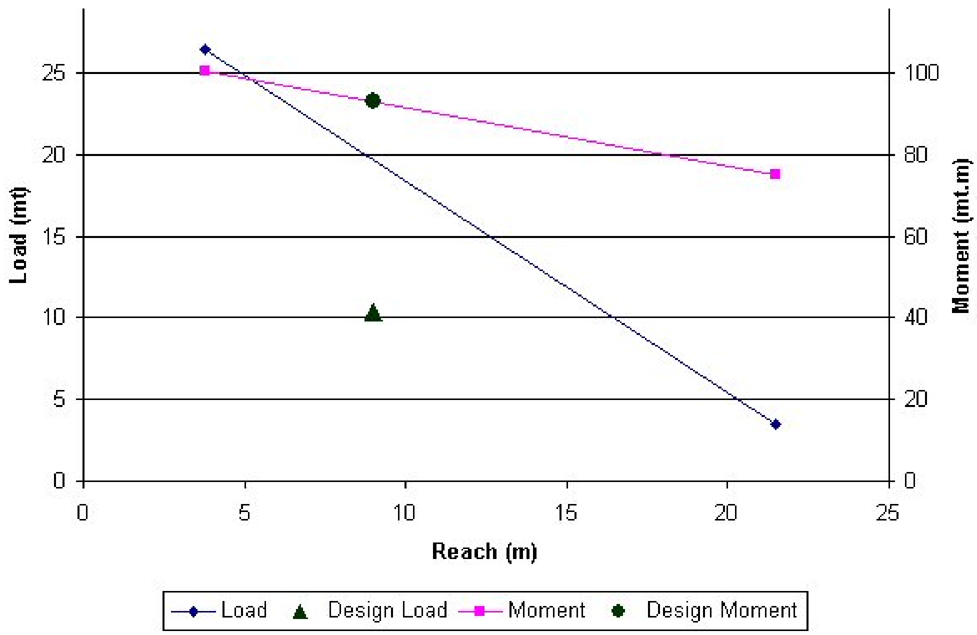

Figure 19 - Knuckle Crane Performance

The selected alternative was a knuckle boom crane, which provides reach with boat and stores lifting flexibility. Having selected a representative knuckle boom, a maximum lift of approximately 10mt with reach of up to 9m (see
Figure 19), a sufficient distance to keep the loaded boat clear of the platform. The beam of the spar platform catamaran indicates that two cranes are required, one for each of the boats stowed onboard. A single centrally positioned crane would have been preferable, but would have likely resulted in a sizable weight increase due to the additional moment on the crane jib.

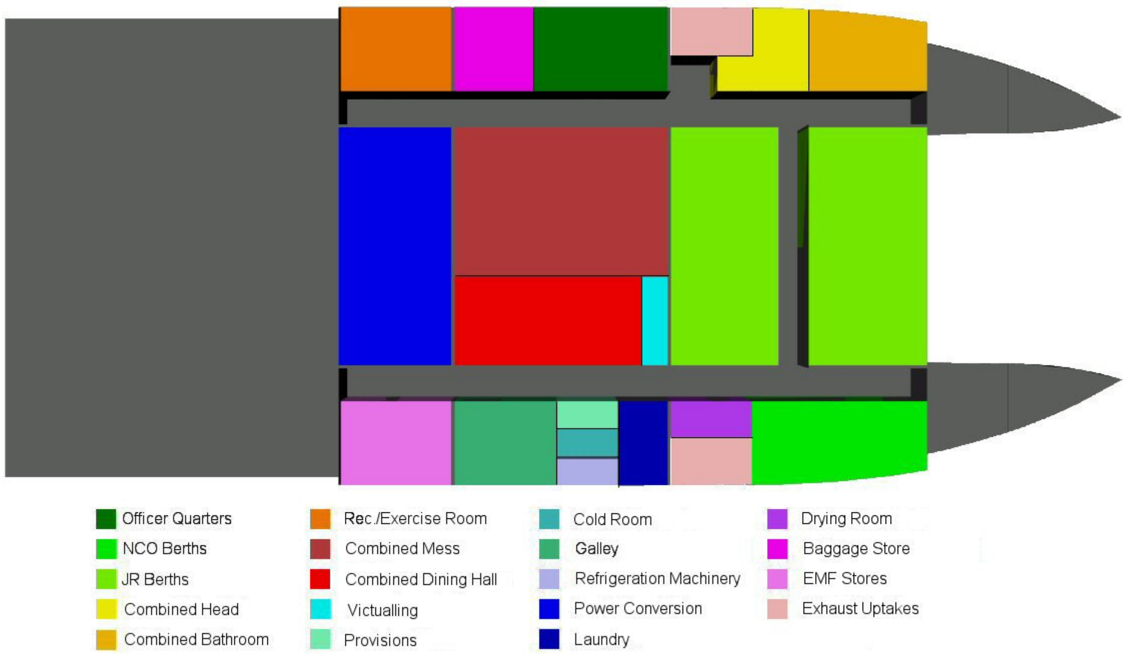

Figure 20 – Small Boat Support Platform Arrangement

	Required Area (m^2)	Weight (mt)
Officer Class III Cabin	11.00	0.90
NCO Cabin	9.96	(Included in Mess)
JR Bunk Space	52.20	(Included in Mess)
Combined Head	5.94	0.36
Combined Bathroom	3.13	0.68
Combined Dining Hall	16.10	12.90
Combined Mess	27.86	20.59
Laundry	4.40	0.70
Drying Room	2.20	0.05
Galley	8.36	1.76
Cold & Cool Rooms	0.85	2.06
Refrigeration Machinery	0.37	0.07
Baggage Store	1.12	0.19
Provision Rooms	0.81	1.13
Victualling Gear	0.76	1.36
Life Saving Gear	NA	0.48
Personnel	NA	6.29
EMF Stores (Estimated)	(Void filled)	1.50
Recreational Space (Estimated)	(Void filled)	0.50
Totals	**146.06**	**51.53**

Note: Deckhead height of 2.5m

Table 5 - Boat Support Platform Personnel Requirements

Action	Object	Mass (kg)	X CoG (m)	Y CoG (m)	Z CoG (m)	Vol (m^3)
Removed	Crane & Pedestal	-65500.00	-0.86	0.00	6.50	-140.00
Added	Boats (2x f'ward)	20000.00	-0.42	0.00	3.00	0.00
Added	2 x Knuckle Crane	15180.00	-7.50	0.00	1.30	0.00
Removed	Exhaust Stacks *	-1.00	1.57	0.00	-7.50	10.48
Added	Exhaust Stacks *	1.00	4.37	0.00	-7.50	10.48
Added	Personnel Weights	30109.99	-4.00	0.00	0.52	0.00

Total Weight Changes:	-0.21	t
Total Volume Changes:	-119.04	m^3
X Moment Change:	-186.36	tm
Y Moment Change:	0.00	tm
Z Moment Change:	-330.36	tm
Original KG:	7.50	m
KG Change (removing):	6.50	m
KG Change (adding):	1.46	m
New KG:	2.46	m

Table 6 - Boat Support Platform Weight Changes

Personnel Requirements: The boat support platform ConOps required the platform to support more personnel than its DWSC basis. The spar platform's crew remains at eight, but there is also a need to accommodate up to thirty-six members of the EMF (see Table 4 for breakdown) in conditions at least as good as in the field.

The EMF accommodation could be reduced to an even lower standard, accepting the impact on morale and deployment duration. This would likely reduce volume and weight, and the savings in volume would further decrease the overall weight because of the reduction in superstructure. The freed weight from such savings could be utilized to store extra operational payload, such as an additional boat or stores, on the large free area aft of the superstructure.

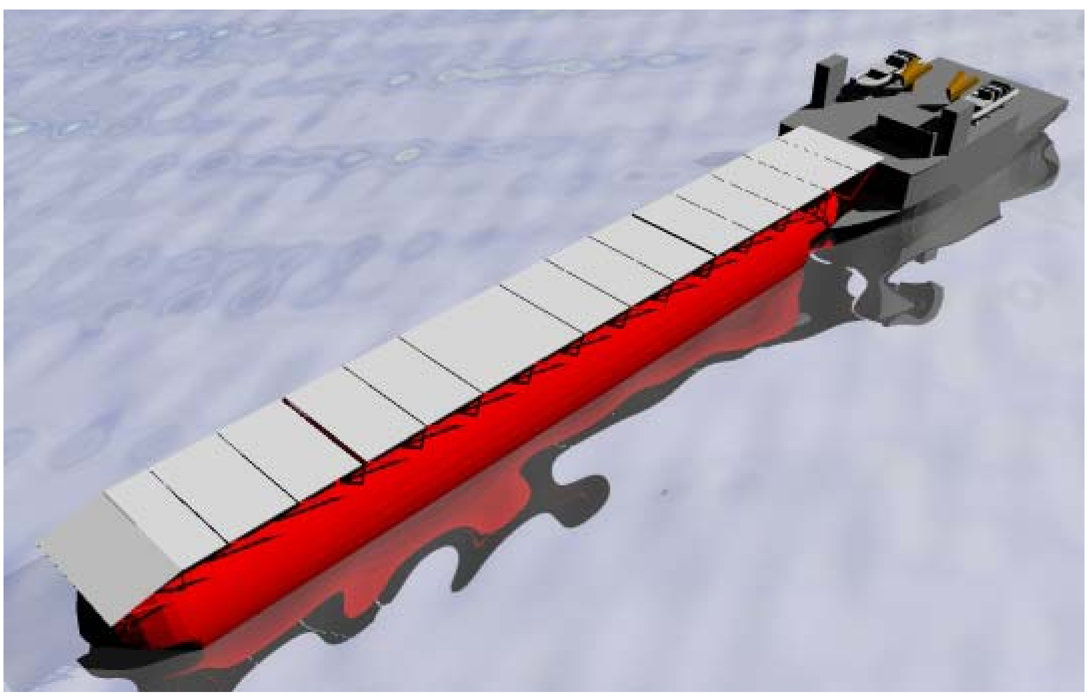

Figure 21 - Small Boat Support Platform (in Surface mode)

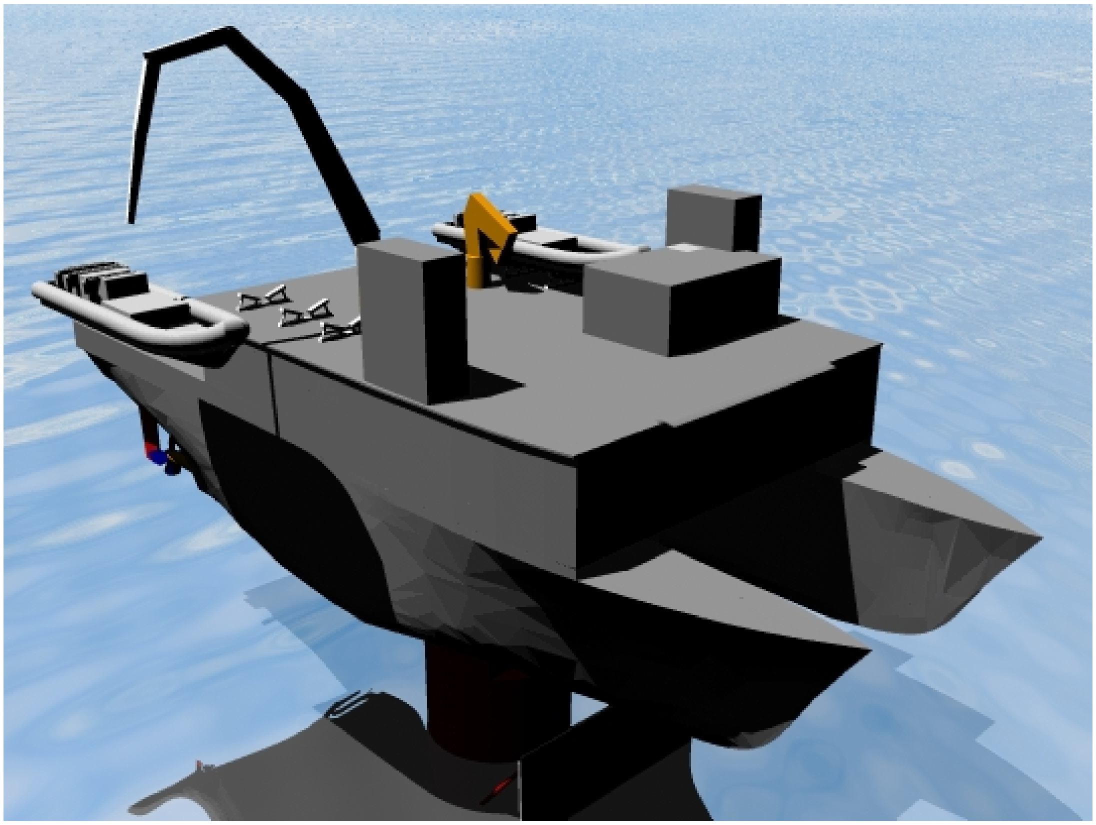

Figure 22 – Small Boat Support Platform Concept (in Spar mode)

Small Boat Support Platform Summary: The concept design is capable of supporting a notable military force for a reasonable duration mission.

The main concern with the platform is the vulnerability to enemy action when in the spar mode. However if operating just inside the defensive perimeter offered by Sea Shield, this issue is less pressing and the ability for the embarked military force to reside within the perimeter and undertake missions outside of the perimeter is useful.

3.4 WEAPON PLATFORMS

The characteristics of a stabilized spar are considered favorable for a range of small weapon platforms. It is envisioned that such weapon platforms might be primarily deployed as remote or autonomous pickets to protect a region of water containing a sea base (see ConOps 1 in Figure 24). The primary defensive screen would be provided as at present by escorting warships, with the weapon platforms augmenting these defenses by being deployed as an outer screen.

An alternative application might be to deploy these platforms in high-threat littoral zones where the high value naval vessels that might otherwise be used, would be at risk (see ConOps 2 in Figure 24). Weapon systems considered for such an application included SAMs (such as SL-AMRAAM), and CIWS (such as Phalanx) or naval guns (e.g. 5" Mk45 lightweight gun).

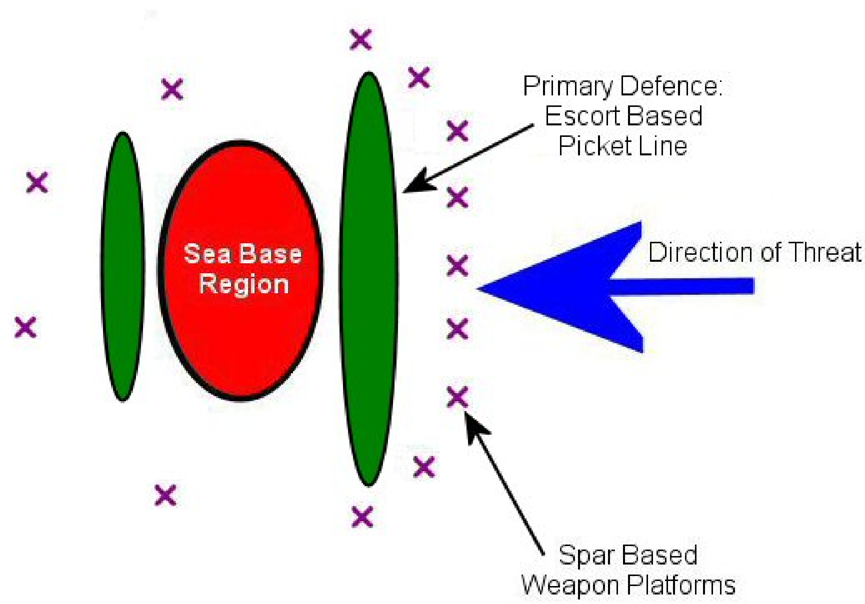

Figure 23 - Spar based Defensive Platform ConOps 1

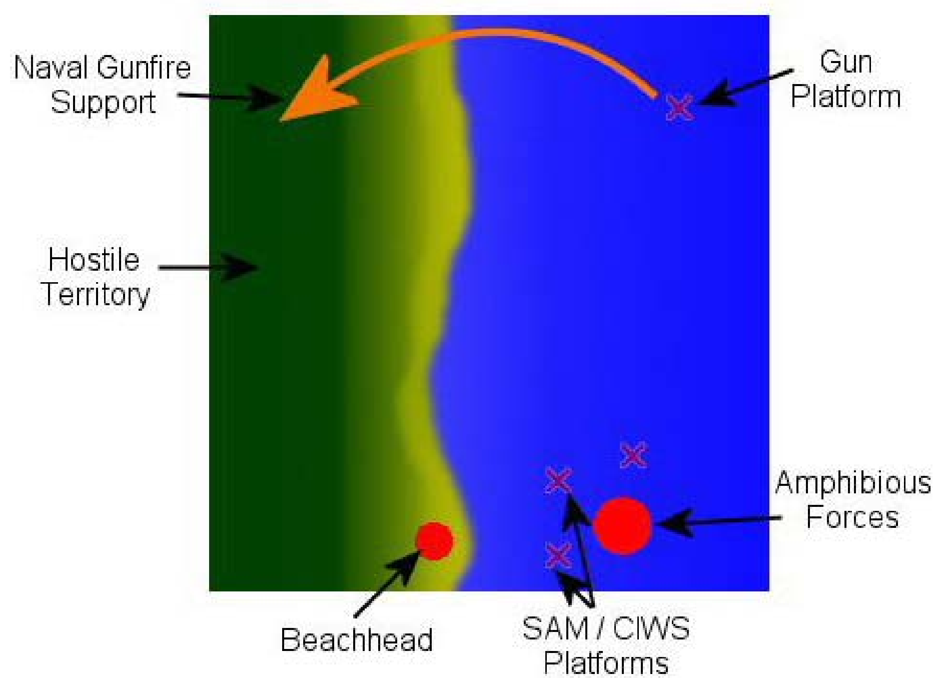

Figure 24 – Spar based Offensive ConOps 2

Design work on spar based weapon platforms have been kept very conceptual, as unclassified details on the weapon systems are limited. The systems weight of the weapon systems considered are typically low. Coupling this with the ConOps requirements for relatively numerous and to some extent 'expendable' picket platforms it was decided to keep the concept as basic as possible. For this reason the DWSC baseline wasn't used in the design process. The concept platforms were limited in scope to those aspects directly supporting the weapon system, thus a generator, some fuel, control and other ancillary systems were provided. The spars are intended to operate in unmanned mode and to be maintained as required by visiting specialist staff.

A major draw-back of this minimalist approach is that the platforms were not able to self-deploy.

Following the work performed in the first part of the study it was hoped that the result of these minimalist design concepts would be very short and lightweight spar platforms, which might be deployed by crane having been carried into position by sealift vessels.

Assumptions for the weights and centre of gravity of the weapon systems, associated systems and fuel allowed crude spars to be designed. Unfortunately even the minimal weight of the platform seemed incapable of reducing the spar length much below 50m. The fairly lengthy spars produced resulted in seemingly disproportioned designs (see Figure 25); for the small weapon system a much larger (than expected) spar was required irrespective of spar diameter. This compromises the viability of ConOps2, which would likely require the spars to be deployed in very shallow water. It also means that transporting the platforms into theatre onboard another vessel would be unattractive.

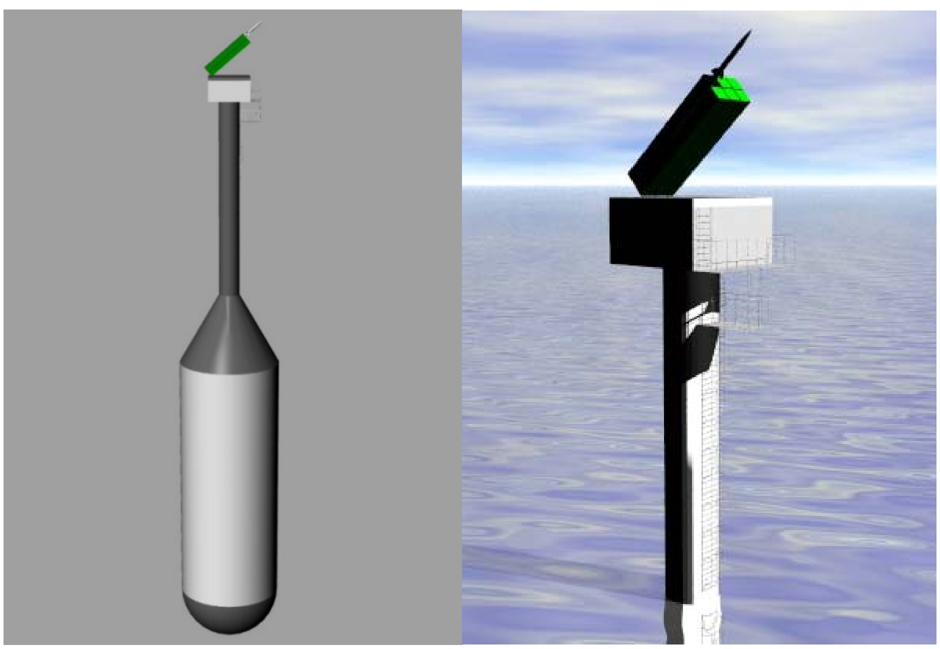

Figure 25 – Surface to Air Missile Spar Platform

While viable conceptual designs, it is not considered that the capability provided by these spar based weapon platforms is truly ‘game-breaking’. An alternative of using the DWSC design as a baseline could have provided a ready-made self-propelled platform on which the weapon systems could have been mounted. However the size of the DWSC catamaran would be excessive for a single SL-AMRAAM launcher.

Instead multiple weapon systems could be mounted to produce an area denial platform, but this would seem inappropriate for the ConOps which asks for many, simple and inexpensive picket platforms. Pursuing the idea of a spar with multiple weapon systems on a catamaran may run the risk of taking the concept too close to the role and sophistication of a warship, but with the inherent vulnerability of the spar when in vertical mode.

4 CONCLUSIONS

The paper has detailed the findings from two studies, concerning the design of spar based naval platforms.

The first study identified that for self deployable spars, significant draught reductions can be obtained in the spar based mode by adopting a multi-diameter spar geometry. However as diameter increases, the structural weight of the spar increases, along with expected cost leading to a smaller draught but less cost effective solution.

As the payload being supported by the spar is decreased a decrease in spar size occurs. However for small payloads, the spar size required becomes excessive in relation to the benefits provided by the platform.

The second study has noted the many possible uses of the benefits of spar technology in the sea base and had concentrated on three missions and the development of spar based solutions to these.

Both the Helo ‘Lily Pad’ and Small Boat Support Platform appear to benefit from the unique capabilities of the spa and catamaran solution. They both provide the ability to stage military forces away from the centre of naval operations and to either extend range of mission duration as a result. The ability to operate or provide a refuge in high sea states particularly adds military capability.

The disproportionate size of spar required to support small weapons platforms seems unlikely to provide benefits in proportion to the cost.

5 RECOMMENDATIONS

It is recommended that the multi stage geometry is adopted for all future spar developments. However care must be taken to identify the area of compromise in spar depth, diameter and weight for each payload.

Further seakeeping analysis should be undertaken.

It is recommended that the benefits of the Helo Lily Pad and Small Boat Support Platform are further considered by expanding the detail of the concept designs and undertaking a detailed review of the benefits of the operational capability. It is recommended that spar based weapons platforms are rethought as at present there seems to be little value for money in these solutions.

6 REFERENCES

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[2] SELFRIDGE, M. 'Spar Technology as a Seabasing Enabler', ASNE Joint Seabasing Conference, 2005