Shipbuilding Experience Outside Of Asia
A Cooperative Global Approach to U.S. Shipbuilding

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Fig. 1 - MT Overseas Houston on Maiden Voyage

Abstract

In 2005, Aker American Shipping, Aker Philadelphia Shipyard, Overseas Shipholding Group, Inc. and Hyundai Mipo Dockyards, Inc. (HMD) embarked on an ambitious project to construct ten medium range Jones Act product tankers in the United States. The vessels are of the same design as those currently under construction at HMD. The success of this program is predicated on the close collaboration of these organizations to address all aspects of the ship construction and operation – design integration and modification, procurement and logistics, construction, quality control and commercial and technical management. This paper describes the project from its inception to the present and offers insight to the aspects of the partnership that have made the project a success and can be applied elsewhere around the world.

Introduction

In February 2004, the U.S. Military Sealift Command released to the American shipping industry a request for product tankers to supplement the Navy's requirement for petroleum product transport. This program, the National Defense Tank Vessel Construction program or NDTVC, required three ships of about 39,000 to 50,000 tons deadweight, and built and operated under the Jones Act - the U.S. cabotage laws that mandate that trading between U.S. ports must be done by ships that are built in the United States and operated under U.S. Flag by U.S. citizen corporations. The NVTDC required that the design of the ships be generally similar to ships being built elsewhere in the world – that is, there were no significant military requirements. This request came at a time when the U.S. deep sea tanker fleet was in general need of replenishment with a significant number of U.S. flag tankers leaving service because of double hull requirements or service life issues.

Numerous U.S. ship owners and shipyards partnered to offer new construction vessels to the U.S. government. Ultimately the Military Sealift Command did not take up the program. What evolved however was a dialogue between owners, shipbuilders and potential commercial charterers that confirmed new U.S. Flag tonnage was required for both technical and commercial reasons, that charter rates could support the vessels in the market and that new ships could be available on a delivery schedule that suited the phase-out of older tonnage. This realization led to the partnership of Aker Philadelphia Shipyard (APSI), Overseas Shipholding Group Inc. (OSG), and Hyundai Mipo Dockyard, Inc. (HMD) and the construction of the Veteran Class tankers, a series of ten product/chemical tankers based on the successful 46,000 ton dwt design developed by and under construction at HMD.

This paper discusses the origins of the project, the partnership between Aker, OSG and HMD, the technical and logistical aspects of the construction program, highlights several areas of the design changed to suit construction and operation of the vessels in the U.S. market and describes challenges unique to undertaking vessel series construction in the Unites States. Moreover, this paper recommends this partnering model as a means for leveraging the experience and purchasing power of Asian shipyards at other shipyards around the word.

Project History

At the time of the NVDTC program, Aker Philadelphia Shipyard had already developed a home grown product tanker design that closely reflected the existing requirements and experience of the Jones Act market. This 48,000 ton dwt design, the Franklin Class, was fully developed and reflected inputs from several Jones Act tanker operators. In addition to this design candidate, Aker Philadelphia also considered a similar design from a sister yard in Germany. Neither design had been constructed.

When considering preparing a proposal for the NDTVC, OSG spoke with several U.S. shipyards and concluded that the most cost effective solution was to partner with a shipyard in Korea or Japan that had a successful existing design and to construct a vessel series based this design in the States. With this conclusion, OSG approached HMD to consider using their well-proven 46,000 ton dwt product/chemical tanker design and then brought this design to APSI. Aker and OSG considered all three candidate designs – the Franklin Class, the Aker Yards Germany design and the HMD design – for the program. Aker assessed each design considering ease of production, material cost, labor effort and design and production risk. Of the three designs, the Franklin Class had the greatest lightship weight, a significant material cost disadvantage. It was, however, specifically designed with block sizes and outfitting arrangements to suit the production facilities at Aker Philadelphia, which could yield potential savings in both time and labor and time. Both the German and Korean designs represented an "international" standard design with levels of outfit and materials consistent with Far East construction. To varying degrees, both Aker Yards Germany and HMD would provide equipment procurement and design and logistics support for APSI during construction.

HMD's design had the distinct advantage of being presently under construction with more than eighty ships on order. This provided several significant benefits. First, the material procurement for the ten-ship series in Philadelphia represented for HMD only a modest increase in procurement effort. The design risk was minimal as more than thirty vessels of this design had been delivered. Finally, the production risk was reduced because the start-up and production issues that might be faced at APSI had already and recently been addressed by HMD. After due consideration of the alternatives, APSI concluded that the HMD design, the HMD project support and the overall reduction in risks would result in the lowest overall project cost. From OSG's standpoint, all three designs had merit and would be suitable for the proposed service. OSG reviewed all three and identified modest changes to each to suit the NDTVC and/or commercial service in U.S. coastal service. OSG had not to that point ordered ships at HMD but had built forty-seven ships at Hyundai Heavy Industries (HHI), had a close relationship with many of the senior managers at HHI and HMD, knew the productions standards and understood the design. OSG also spoke at some length with other owners with ships of this design, was familiar with the makers specified for the vessel and looked at the HMD design as a vessel fit for and proven in service. In consideration of these factors, OSG preferred the HMD design and believed the ships to be suitable for the NDTVC program or as additions to OSG's existing U.S. Flag product carrier fleet.

In early 2005, a formal partnership (Fig. 2) was formed between Aker and OSG and between Aker and HMD to build and charter ten product tankers for the U.S. market. Within this partnership, Aker formed what ultimately became Aker American Shipping ASA (AKASA), the parent company for Aker Philadelphia Shipyard (APSI) and American Shipping Company (ASC). ASC, the ship owning entity, contracted with APSI for ten product tankers and OSG, through specially formed subsidiaries, took these ten vessels on long term bareboat charter with both technical and commercial management. OSG oversees construction of the vessels on behalf of both the owner and charterer. This complicated partnership allows AKASA to retain a position and revenue stream over the life of the ships. AKASA, as a foreign-owned entity, is not permitted to operate ships in the Jones act trade but, with a U.S. operator like OSG, can build and charter vessels for this service. HMD has provided the necessary design documentation and design and production support and material procurement services to support APSI with the construction effort. This construction program will take nearly four and one-half years (Fig. 3) and has a value of approximately USD 850m.

Fig. 2 - AKASA - OSG Partnership Structure

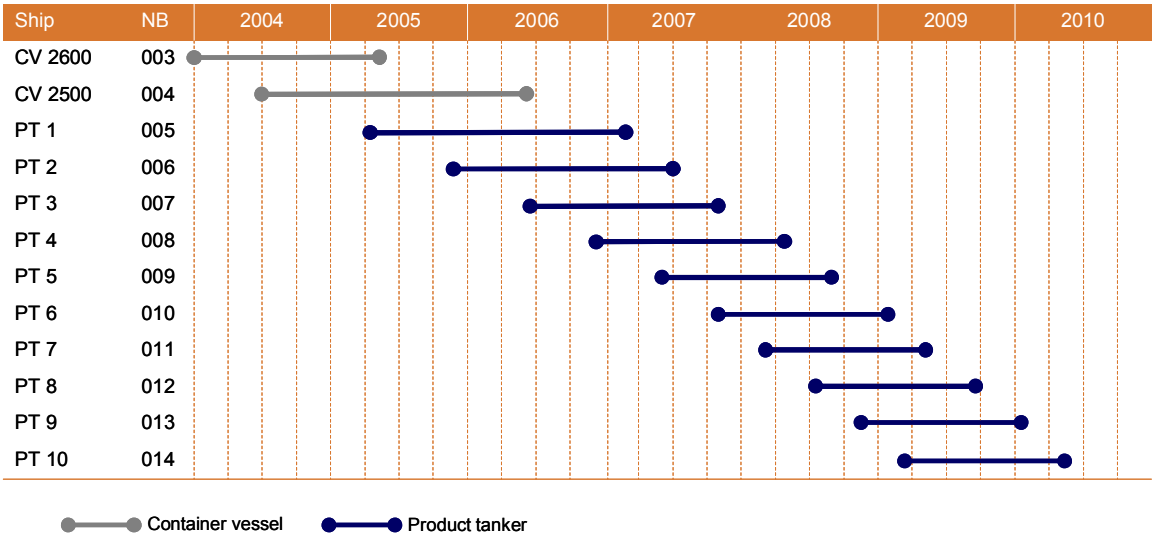


Fig. 3 - APSI Tanker Delivery Schedule

Ship Design and Features

The HMD 46,000 ton dwt product/chemical tanker design is well proven with an excellent track record in service. As noted previously, more than eighty of these ships have been ordered and at the time of this writing more than sixty have been delivered. The principal characteristics and General Arrangement are shown in Fig. 4.

Featuring a single deck with forecastle, the Veteran Class tankers have been designed for carriage of crude and oil products, as well as IMO Type II chemicals by means of a double hull with the cargo space divided into six pairs of tanks by corrugated longitudinal and transverse bulkheads. Structural stiffening is provided within the double hull and on the cambered upper

deck, external to the cargo space resulting in flush internal tank surfaces. Approximately 30 percent of the total steel weight used in construction is high strength steel.

Cargo tank surfaces are protected by phenolic epoxy coating, making it possible to carry more than 250 different commodities. The piping system, constructed of 316L stainless steel, is designed to accommodate six cargo segregations, and each of the twelve tanks is fitted with a Frank Mohn (Framo) submerged, hydraulic pump rated at 600m3/h. A pair of slop tanks is also provided and each is fitted with a 300m3/h pump. Maximum unloading rate is 3,600m3/h and a loading rate of 8,400m3/h is possible through six different connections at the midship manifold. The main engine is a MAN B&W 6S50MC Mark VI design and develops 8,580kW MCR at 127rev/min. Electrical power is supplied by three sets of 730kW Hyundai alternators powered by 6N21L-EV Yanmar diesel engines. Steam is produced by means of an Aalborg oil-fired boiler rated at 18,000kg/h and a 1,000 kg/h exhaust gas economizer.

Accommodation is provided for 10 officers, 13 crew, 4 trainees and 1 spare berthed in 24 single and two double cabins. An additional room for six Suez/repair crew is located in the deckhouse forward. A free-fall lifeboat is fitted for operation over the stern, and a rescue boat and life rafts are also carried.

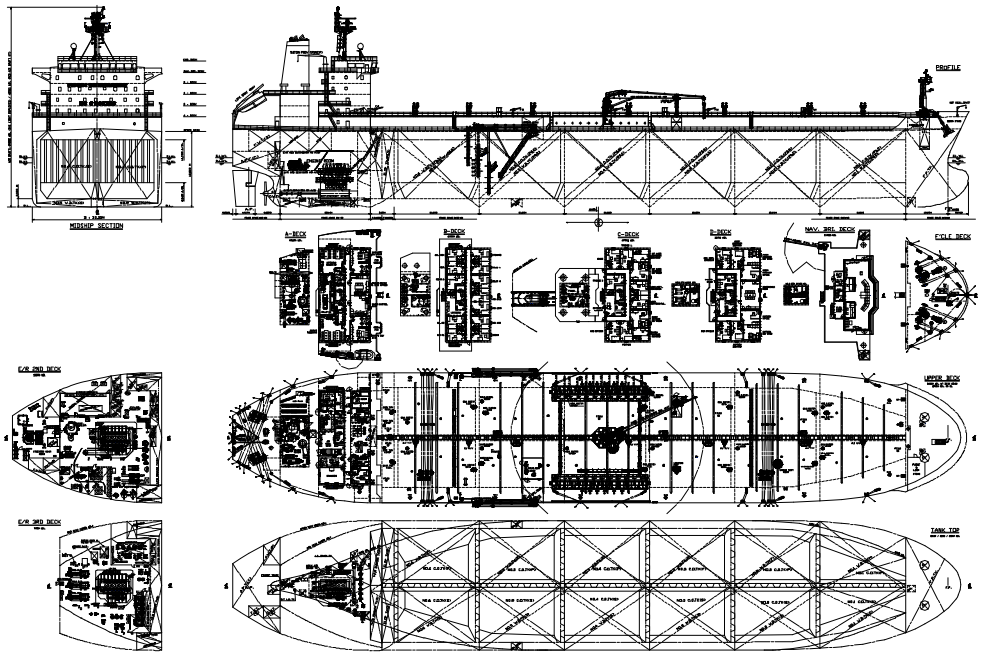
AKASA Group and the Modernization of Philadelphia's Shipyard

Prior to the establishment of the AKASA Group, Aker Philadelphia Shipyard, Inc (APSI), formerly known as Kvaerner Philadelphia Shipyard, Inc, was owned by Kværner's subsidiary Kvaerner, Inc. As part of the establishment of the AKASA Group, the shares in APSI were transferred from Kvaerner, Inc. to Kværner ASA and thereafter to the AKASA Group. During the second quarter of 2005, Aker American Shipping ASA carried out the Private Placement, which was directed towards institutional, industrial and other professional investors. Upon completion of the Private Placement, Kværner's ownership in the Company was reduced to approximately 54.7 %.

On June 30, 2005, Kværner sold its shares in the Company to Aker ASA's subsidiary Aker American Shipping Holding AS. After a further secondary sale, Aker American Shipping Holding AS owns 53.2 % of the shares in AKASA.

Aker Philadelphia Shipyard, Inc (APSI) is located on the site of the former Philadelphia Naval Shipyard in Philadelphia, Pennsylvania, and is the product of a public-private partnership founded in 1996 by the City of Philadelphia, the Commonwealth of Pennsylvania, the United States Government (collectively the "Governmental Parties") and the Kvaerner group of companies.

Shipbuilding has been part of the industrial and commercial economy of Philadelphia for over a century; however the Philadelphia Naval Shipyard was closed in 1995 (Fig. 5). In order to mitigate the impact of the closure, the Governmental Parties formed a quasi-governmental authority, the Philadelphia Shipyard Development Corporation (PSDC) to: (1) convert the ageing naval facility into a world class shipyard; (2) locate a premier international shipbuilding company to construct and operate the new facility; and (3) perform the functions of a local board of directors overseeing shipyard operations and acting as a liaison between the Governmental Parties and APSI. In order to accomplish the transformation of the facility to a world-class commercial shipbuilding organization, the Governmental Parties collectively invested over USD 400m in grants, loans and loan guarantees. These funds were used in the construction of the state-of-the-art facility and in the workforce training.



Length Overall	abt 183 m
Length between Perpendiculars	174.0 m
Beam	32.2 m
Depth	18.8 m
Scantling Draft	12.2 m
Deadweight at Scantling Draft	45,800 t
Design Draft	11.0 m
Deadweight at Design Draft	40,700 t
Cargo Tank Capacity	53,800 m^3
Speed at Design Draft, 85% MCR, 15% Sea Margin	14.6 kts
Range at Design Draft, 15 kts	14,000 nm

Fig. 4 - General Arrangement and Particulars

Fig. 5 – Philadelphia Naval Shipyard circa 1996

APSI's facility and equipment was installed new between 1998 and 2000 (Fig. 6). Based on experience from other state-of-the-art Aker shipyards in Europe, the shipyard was designed with the specific intent of reducing material handling operations. APSI employs highly automated processes that result in annual steel fabrication capacity of 25,000 tons per year (Fig. 8). APSI has developed an effective "just in time" delivery system for its steel plate, eliminating the need to maintain large inventories of steel. Fundamental to APSI's building philosophy is the maximization of subcontracted "turnkey" packages for many outfitting activities, which enables the shipyard to maintain the focus on steel fabrication and to utilize the procurement system developed with HMD.

The shipyard is fully outfitted with modern facilities with the following highlights:

Main Fabrication Shop - The main fabrication shop is fully enclosed and heated, and contains the flat panel lines, curved panel line, double bottom line, section assembly shop, and outfitting shop. It has a total enclosed area of 40,000 m2.

Flat Panel Lines - APSI has three highly automated flat panel lines-large, medium, and small. Work flow proceeds generally in the following order: plate drying, plate edge milling, one-sided seam welding, panel marking and cutting of holes and edges, stiffener mounting, and stiffener welding (with pre-bending to reduce distortion on the large and medium lines). Transportation of panels is by conveyor system.

Double Bottom Line - The double bottom line is located adjacent to the flat panel line and is optimized for construction of double bottom (or double side) construction. Robotic welding gantries are employed.

Fig. 6 – Aker Philadelphia Shipyard circa 2006

Profile Processing - Bulb flat, angle and flat bar profiles can be processed by numerically controlled machines in either of two separate profile lines. Workflow proceeds generally in the following order: vent/drain hole cutting, edge milling, cutting, and marking.
Curved Panel Line - The curved panel line produces shaped panels using cold bending. Panels are cut from plate using an NC plasma machine and bent to shape using a 600 ton portal press and/or 1270 ton roll press. Panel shape is verified by full-size plywood templates, cut with a numerically-controlled router. Curved panels are assembled on pin jig cassettes. A tilting table is employed to allow automatic tractor welding of seams. Stiffeners are bent using a hydraulic press.
Outfitting Shop - The outfitting shop includes some pipe fabrication equipment and is used for the installation of most outfitting components. Complete ship sections may be brought into the outfitting shop through the 30m wide door.
Grand Block Shop - The grand block shop is a separate building near the main fabrication shop. Here sections are joined into grand blocks of up to approximately 600 tons. Final hot outfitting of sections and grand blocks also occurs here.
Heavy-lift Transporters - APSI utilizes two heavy-lift transporters, each with a capacity of 420 tons and a combined capacity of 720 tons
Paint Halls - Two paint halls are located near the grand block shop and used for painting of grand blocks after outfitting. The paint halls are fully enclosed and heated to allow painting regardless of weather, improve paint quality, and reduce environmental impact. Surface preparation is by grit blasting and grit is recycled. All emissions from painting operations in the paint hall are controlled and regulated and meet or exceed the requirements of state and federal agencies.
Building Dock - Ships are erected in a graving dock located on the Delaware River. Its overall dimensions are 333 m long by 45.7 m wide. An intermediate gate and skidding system are fitted to allow tandem production of ships. In tandem mode, ships up to 235 m long can be built. After welding is completed, the ships are floated and shifted to the outfitting dock for

completion. The building and outfitting docks were constructed in 1941 and 1942 respectively as part of the Philadelphia Naval Shipyard.

Goliath Gantry Crane - The goliath crane is used for turning and dock mounting of grand blocks. The crane has three main hoists, each with a capacity of 280 tons. One hoist can move independently of the other two to allow turning of grand blocks. The nominal capacity of the crane is 660 tons, although lifts of up to 750 tons are possible.

Outfitting Dock - After launching, ships are towed to the outfitting dock for final outfitting and commissioning. It is also used for delivery of main engines and other items directly offloaded from ships. The outfitting dock is a graving dock identical to the building dock. It is served by one portal crane with a capacity of 70 tons.

Workforce/Unions - There are now 750 APSI employees, approximately 600 of whom are represented under an umbrella agreement with the Philadelphia Metal Trades Council which represents several different unions operating in the facility. This results in a single bargaining unit and has resulted in a unique partnership between APSI and its workforce that permits APSI to employ subcontracted labor. The workforce is supplemented by subcontracted employees from the United States and Europe on an "as needed" basis. There are presently 500 to 600 subcontractors in the gates as general production labor as well as providing turnkey painting, deckhouse fabrication, deckhouse outfitting, and electrical installation services. The workforce is 90% American and 85% of these individuals are local to the Philadelphia area.

Facility construction was completed in 2000, at which point APSI began construction of its first two container vessels. These vessels, CV 2600 type, were based on a proven CV2900 design that Aker Yards was building in an affiliated shipyard in Germany. The Philadelphia Class CV 2600 was modified by APSI to meet the unique needs of the U.S. domestic markets. In 2002, Matson Navigation Company, Inc. (Matson) agreed to purchase the two container vessels, taking delivery of the M.V. Manukai on September 4, 2003 and the M.V. Maunawilli on July 30, 2004. In 2005, Matson agreed to purchase two additional container vessels (one of the CV 2600 type and another of the CV 2500 type). The first of these two vessels, the M.V. Manulani, was delivered on May 19, 2005, ahead of the contract delivery date of June 15, 2005. The second of these two vessels, the M.V. Manualei, was delivered on July 12, 2006. All four ships are employed in Matson's Hawaii-Guam-China shipping route.

American Shipping Corporation (ASC) was formed in the second quarter of 2005 to own and bareboat charter out Jones Act vessels. The first of these Veteran Class tankers, the Overseas Houston, was delivered on February 7, 2007. The second, Overseas Long Beach, was delivered in June 2007 and the third ship will be delivered in the fourth quarter of 2007. All ten vessels are named after major U.S. oil ports.

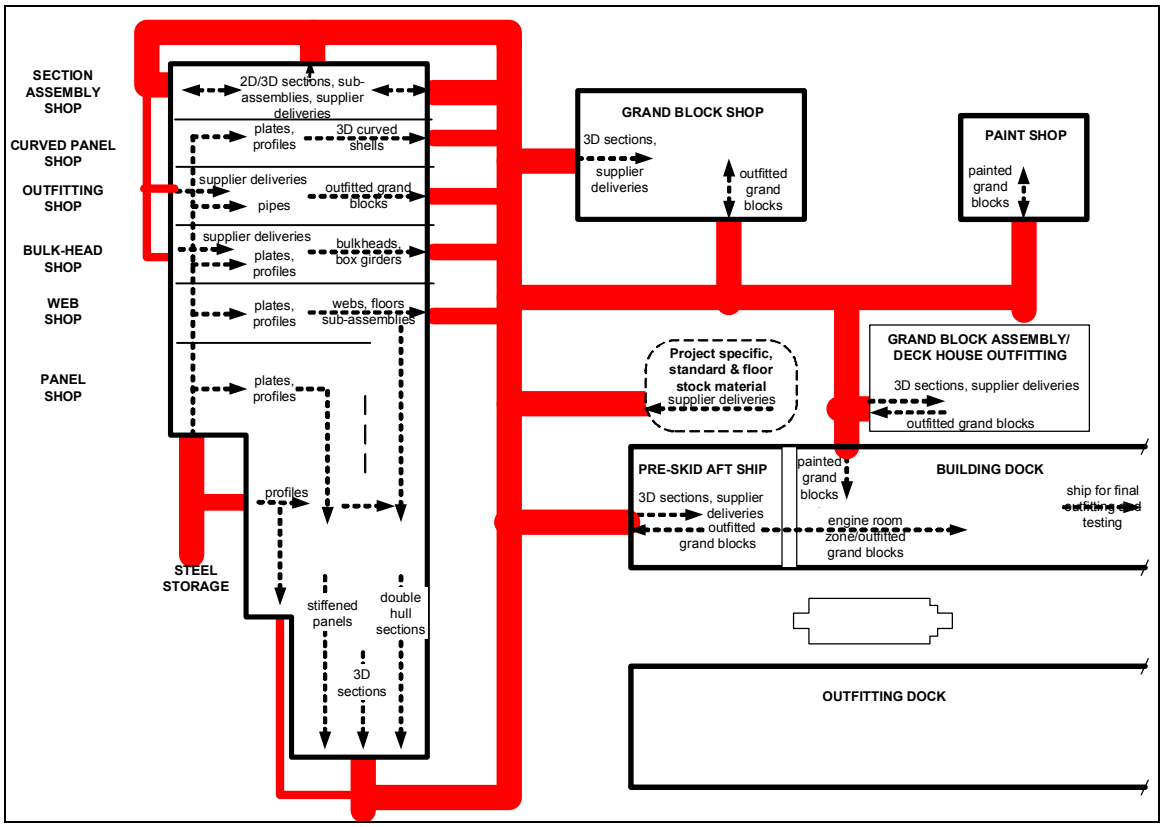


Fig. 7 - APSI Steel Handling Process

Hyundai Mipo Dockyard, Inc.

Hyundai Mipo Dockyard is a world-class shipbuilder in Ulsan, South Korea. They have transitioned successfully from a repair shipyard to a 100% newbuilding facility focusing on containerships, tankers, bulk carriers and specialty ships such as LPG carriers, cable laying vessels and others. HMD focuses on series construction of vessels and delivers more than 60 vessels each year. Their production success is based on just-in-time delivery of materials and equipment and integrated engineering packages that support this philosophy. HMD has built or has on order more than eighty of the 46,000 ton dwt product/chemical tankers.

For the Veteran Class tankers, HMD has licensed the design of the 46,000 ton dwt tanker to Aker Philadelphia with limitations on its use and distribution. HMD is responsible for design support, purchasing and procurement of major equipment and outfitting and provides technical support during construction, testing and commissioning and delivery.

As noted above, a basic precept of the program is that these ten ships at APSI represent, for HMD, a modest addition to the already sizable series of vessels presently under construction. This provides Aker Philadelphia with access to the greater purchasing power of HMD. For example, HMD orders boilers for several ships to its own account and can add one more to the order for APSI. An outside agency manages the logistics of packaging, transporting and delivering the HMD-ordered equipment from Ulsan to Philadelphia.

Overseas Shipholding Group Inc.

Overseas Shipholding Group Inc. is an integrated energy transportation group with fleet of modern crude, LNG and product carriers and articulated tug barge units. OSG presently has more than forty vessels on order or under construction including the ten ships at Aker Philadelphia. Commercial, technical and corporate support services are managed from New

York, Newcastle, Athens and Tampa, Fla. The company has satellite operations Philadelphia, Pa., Houston, Tx., Singapore, London and Quebec.
OSG has entered into a long-term bareboat charter agreement with ASC Leasing for each vessel in the series. Nine of the ten vessels have at the time of this writing been entered into similar long-term charters with oil majors requiring Jones Act transportation services. OSG has contracted with ASC Leasing to provide site supervision services and acts as both the Owner's and Charterer's on-site representative at Aker Philadelphia. OSG is working with SeaTechnology (USA) to provide site supervision services. At present, the site team consists of eight people, overseeing the three ships typically under construction at any given time. Additionally, OSG provides support in Korea and China to perform factory acceptance tests for parts and equipment including main engines, boilers and other machinery and outfitting.

The Jones Act, U.S. Flag and the Alternative Compliance Program

The U.S. coastal shipping market is governed by certain cabotage laws that are broadly known as the Jones Act. Under this law, vessels trading between U.S. ports must be substantially constructed in the United States, operated by a U.S. company and sailed under U.S. Flag by U.S. mariners. These tankers and the containerships built by APSI previously are governed by these requirements.

The Jones Act dictates, to some extent, the source of the content in the vessel. In simple terms, not less than 98.5% of the hull steel must be constructed in the United States. Up to 1.5% of the steel can be constructed overseas and delivered in fabricated form to the U.S. building facility. Equipment and outfitting can be sourced from international suppliers as best suited to the particular project. The great majority of equipment, outfitting and materials for these vessels comes from Korea. The procurement and logistics process is described elsewhere. The bow bulb block forward of the forward perpendicular and the lowest portion of the aft peak tank - the shaped blocks most difficult to construct - are constructed in Korea and shipped to the States. These represent about 0.9% of the total steel weight.

The U.S. Coast Guard (USCG) working as the U.S. Flag Authority has a set of vessel design and operating requirements codified under the U.S. Code of Federal Regulations. These touch on all aspects of ship design and construction, safety, operations and pollution prevention. These requirements were most often developed before the harmonization of many of the international requirements by IMO and IACS. The USCG standards and requirements are sometimes stringent or more often simply different than the internationally accepted standards and, as such, often place the Jones Act shipping community at a disadvantage to the international market. For example, Jones Act vessels operating under the Coast Guard regime are not able to use SOLAS-standard fire hoses but must use specially constructed, tested and certified units. Recognizing this, the USCG reviewed their rules in the early 1990s and developed a harmonization plan intended to unburden U.S. operator and builders from a set of different requirements than those faced by those working in the international markets. The result of this effort was the Alternative Compliance Program or ACP.

The Coast Guard's Alternate Compliance Program (ACP) is one of the most significant regulatory reinvention programs of the 1990s. The ACP is intended to reduce the regulatory burden on the maritime industry while maintaining existing levels of safety and providing increased flexibility in the construction and operation of U.S. flag vessels. In this voluntary program, Classification Society Rules, International Conventions, and an approved U.S. Supplement provide an alternative basis for Flag State certification that is equivalent to the published Coast Guard regulations. Compliance with this equivalent alternative standard is administered through survey and inspection conducted by authorized classification society surveyors. This U.S. Supplement identifies requirements, principally safety related, noted by the USCG that necessitate additional attention above the requirements of Class and IMO or that are not addressed by same. Under this scheme, the fire hoses noted above and onboard an "ACP"

U.S. Flag ship can built fabricated and certified on the same basis as those sourced in Korea without any additional requirements above SOLAS and its supporting documents.

This ACP program is essential to the construction and operation strategy for both OSG and Aker. By allowing OSG to operate its fleet of U.S. Flag tankers to the same standard as its international fleet, OSG's operating costs are reduced. By allowing Aker to take advantage of internationally sourced equipment generally identical to what HMD is providing to the similar ships built in Korea, a purchasing and design economy is achieved.

Modifications to the HMD Tanker Design

The Veteran Class tankers are sister ships the proven 46,000 ton dwt product/chemical tankers delivered between 2004 and 2006 as HMD Hulls 0234-0241. These vessels were built to ABS 2002 Rules and for service under the Marshall Islands Flag. They have been to be modified to meet the following requirements:
U.S. Flag Regulations including USCG Alternative Compliance Program (ACP), requirements for Coastwise Endorsement (Jones Act), and air pollution requirements of the Environmental Protection Agency (EPA)
Changes in ABS/IACS rules from 2002 to 2005 and International Regulations (MARPOL, SOLAS, IBC, etc)
OSG operational requirements and fleet practices
To ensure the ships would comply with above regulatory requirements, APSI engaged ABS Pacific to perform a bottom-to-top technical review and provide comments to HMD. HMD then revised 140 drawings to suit the applicable regulations and submitted these then to ABS Busan for approval. As part of ACP program, ABS Houston performed review of U.S. Flag requirements on behalf of the USCG.

U.S. Flag Changes

U.S. Coast Guard ACP regulations focus principally on safety systems such as local water mist and CO2 fire fighting systems and insulation and structural fire protection materials. Lifesaving equipment and monitoring and detection systems for oily water, cargo, and sanitary discharges must be type-approved by the USCG at a USCG-approved laboratory. Where necessary, equipment models were certified or substituted to ensure compliance with these regulations.
The U.S. Environmental Protection Agency (EPA) has imposed regulations that created the most significant deviation from the original Korean design. Starting with the fifth tanker in the series, new Tier II emissions standards will impact the diesel engines used to power the auxiliary generators, emergency generator and hydraulic power unit. These requirements are generally equivalent to MARPOL Annex VI with additional requirements for particulate matter. The auxiliary engines will be modified by the maker and will no longer be arranged to operate on heavy fuel oil. Prototype testing is presently underway at Yanmar's Osaka factory. A redesign of the corresponding fuel, lubricating oil, cooling water, and ventilation systems has been performed by HMD and is presently being incorporated into the design. The emergency diesel generator and hydraulic power unit engines were changed out completely and replaced with compliant units. The rescue boat maker and model have also been replaced to obtain a unit with an outboard engine that complies with the EPA small engine emissions requirements.

Class and other Regulatory Changes

The impact of 2005 ABS Rules versus the original 2002 design was limited to the design of the forecastle deck hatches and windlass deck stiffening. The Tanker Common Structural Rules are not applicable because the shipbuilding contract was signed prior to the rule implementation date.

As a result of 2007 changes to MARPOL Annex II and the International Bulk Chemical Code (IBC) the fifth and following tankers in the series will receive modified cargo stripping lines to ensure the tanker vessel can comply with reduction in allowable cargo residue from 150 to 75 liters.

OSG Design Changes

To suit the normal operating practices of its fleet and to accommodate certain requirements for American crews, OSG elected to make a number of design changes to the vessels:
Coating Systems - OSG improved the antifouling system from a 3 to a 5 year system and a polyurethane topcoat was added to the topsides and superstructures. The cargo tank coating was upgraded from a pure epoxy to a phenolic epoxy to allow for expanded chemical carrying capability.

Chemical Cargos - OSG with support from HMD modified the vessel from and IBC Type III to Type II/III vessel with expanded chemical carrying capability and to address requirements of the 2007 IBC changes. The HMD tanker's structural arrangement and materials specifications already satisfied the more rigid Type II requirements. Damage stability calculations were performed by HMD to confirm compliance with applicable two compartment damage requirements.
Accommodation Modifications - The most significant change was the re-arrangement of the galley, crew and officer mess rooms on the A-Deck to suit accommodation standards for U.S. crews. Traditionally, American ships have been arranged with separate mess rooms for the officers and crew but with a common self-service window. The HMD arrangement was set for traditional steward's service and was not readily rearranged for a common service line. Rather, service windows were arranged at either end of the galley and the galley equipment was rearranged to provide better visibility and access. Space names were changed throughout the ship to suit U.S. crew titles.
Other minor equipment changes to suite OSG operational preferences included the replacement of the stern tube oil seal with an air seal to prevent oil pollution, modifying the uppermost portion of the radar mast with a hinge to accommodate some U.S. bridge clearances, improved mooring wires for some vessels to suit charterer's requirements, and the addition of an aft deck escort tow bitt and chock to the aft deck. Telephone and computer network connections were expanded to all staterooms and the number of alarm call stations was also increased.

Design for Production

HMD provided APSI with a full set of 220 Basic and 1500 production drawings for the tanker. HMD also provided APSI with a complete Tribon 3D Steel Hull Model and partial Tribon piping model. To supplement HMD drawings and model, a comprehensive set of photo and video documentation was gathered for use in Philadelphia.
APSI's Hull Design Department revised the HMD Tribon model hierarchy and assembly tree to suit the Philadelphia yard's steel fabrication equipment, workstation coding, and build methodology. APSI then was able to generate its own detail steel drawings and implement minor changes to the HMD steel fabrication details as necessary to suit production.
To support all other non-structural fabrication and installation, multi-discipline "Prep Teams" were established to review HMD outfitting design and production information and compile work packages for each tanker section at various production phases. The HMD Tribon piping model is used by APSI Engineering as a reference tool to assist with production installation support and verify system completion.
To better understand the HMD tanker design and production methodology and facilitate communications, APSI established a permanent presence at the Ulsan shipyard with a site office

and project coordinator. Regular training visits are conducted by representatives of all APSI engineering, planning, and production departments. This process continues to this day.
As part of licensing agreement, HMD maintains responsibility for the tanker design approval and maintenance. Design changes instigated by the operator, APSI production process, rule changes and equipment changes are typically defined by APSI engineering and issued to Production in the form of Design Change Notices (DCN's) for modification of vessels currently under construction. Incorporation of these changes into the baseline tanker design and corresponding drawings is performed by HMD at additional cost to APSI. These revised drawings and corresponding bills of material are then used for construction of later vessels in the series.

Production Methodology

Although APSI has modern facilities of generally similar capability to HMD's, differences in production methodology, equipment, and product experience had to be addressed.
Because of its origins as a repair yard, HMD does not have the large dock crane lifting capacity typical of most newbuilding yards. As a result, the 150 block sections that subdivide the tanker can only be combined into 65 dock mounting blocks of less than 300 tons. APSI's facility is based on the European large block philosophy with cranes, shops and paint halls sized for blocks of over 600 tons. Considering this, APSI went about reducing the number of dock mounting lifts to 50 by combining several of the HMD blocks into "grand blocks" whose size are limited not by weight but by the size of the paint halls. For the third tanker, APSI began the process of assembling "super-units" by combining multiple grand blocks after they were painted. This process has allowed the number of dock mounting lifts for the fifth tanker to be further reduced to 45, as shown in Fig. 8.
The first four containerships built by APSI used bulb flats as structural stiffeners whereas HMD's structural design uses angles. APSI's two profile processing lines thus had to be modified to cut both angles and bulbs. Additionally, the change in profile shape also had a significant impact on the coating process in that stripe coating and tank spraying procedures needed to be modified.
HMD's cargo hold design features large corrugated transverse and centerline bulkheads whereas APSI's only previous experience with corrugations was for deckhouse panel stiffening. APSI does not have a press brake to manufacture the corrugations so the yard contracted with metal works in Louisiana and Ohio to fabricate "Z" sections which are shipped to Philadelphia and assembled by a third subcontractor adjacent to the shipyard.

Materials Procurement and Logistics

Per the partnering agreement, HMD provides procurement services for APSI and purchases almost all equipment and materials except for steel plate and paint. For each vessel, approximately 4,100 purchase orders are issued to procure 35,000 individual items. The vast majority of these items are from the same suppliers and to the same specifications as those currently being used on HMD's tankers. APSI purchases steel from Mittal Steel, who supplies the materials from mills in Indiana and Pennsylvania. APSI also procures coatings directly from CMP Coatings, Inc, the U.S. division of Chugoku Marine Paint and Class inspection services from the American Bureau of Shipping (ABS) in Houston.
APSI also partnered with Oriental Shipping Company of Busan, South Korea to manage the tracking, packing, and shipping of all items ordered in Korea. Approximately 500 containers of material are shipped from Busan to Philadelphia for each vessel. A further twenty-five or so bulk shipments are made for large items such as the main engine, propeller, anchors, etc.
These tankers are intended to carry both oil products and chemical cargoes and thus phenolic epoxy cargo tank coatings were specified. Prior to the tanker program, APSI as an organization had no experience with this coating material or the corresponding staging, blasting and painting

process. APSI therefore adopted HMD's cargo coating standards and procedures as well as their tank staging system design and material. A subcontractor was hired to perform tank blasting, painting, inspection, and removal of staging on-site at APSI both before and after launch of the tankers. Experience with the cargo tank coatings continues to be improved. Based on experience with the first ship, modifications have been made to the staging system to improve access and reduce the number of staging pieces. Training and greater worker awareness have led to significantly reduced damages during tank de-staging. These improvements are the result of the combined efforts of the shipyard's production, coatings and quality control departments, the painting subcontractor, the paint supplier CMP, and the owner's site team.

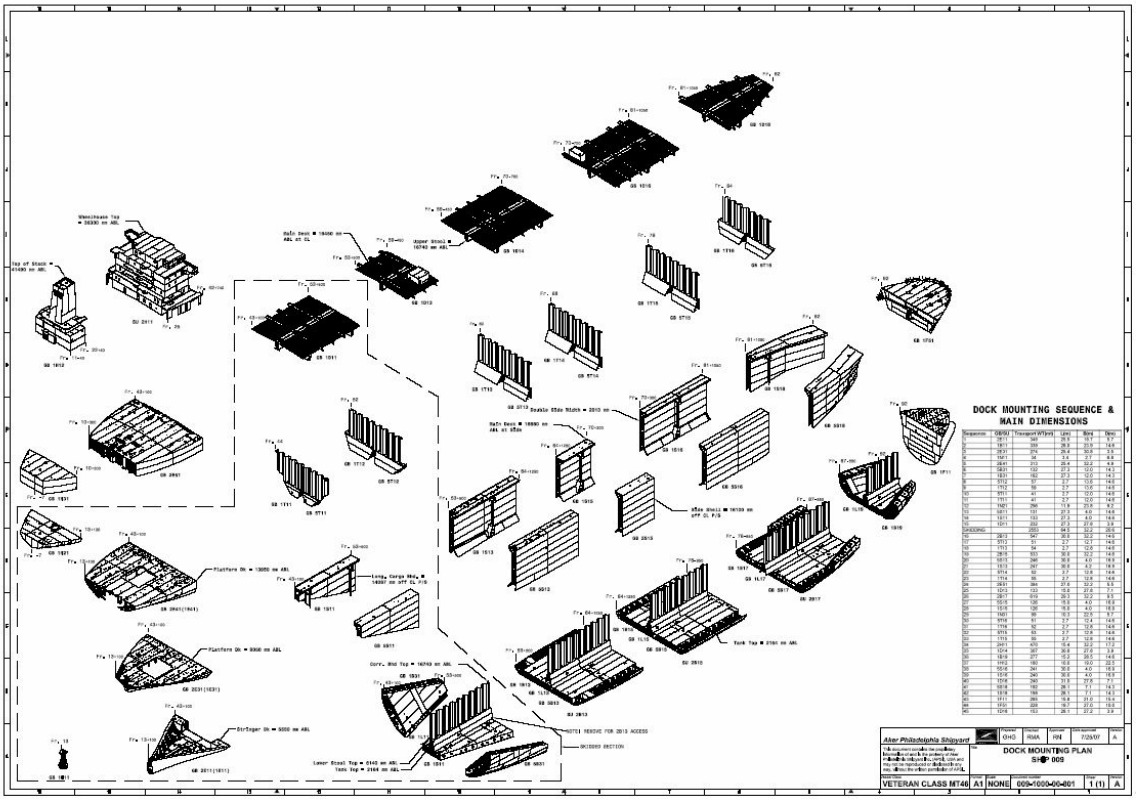


Fig. 8 - APSI Block Breakdown

Ensuring Product Quality

APSI adopted not only HMD's design but also their Korean partner's manufacturing, installation, inspection, and testing standards. APSI also obtained a full set of HMD test procedures and arranged for assistance and support by HMD personnel during the testing and commissioning stages of the first vessels. Considering the adoption en masse of HMD's standards and practices, both OSG and ASC agreed at the outset that international shipbuilding experience was required for the construction supervision team and for the Class surveyors. Similarly, it was agreed that working in an American shipyard presented certain unique challenges and that experience in such a forum would also prove valuable.

This was not the first time that APSI had adopted another shipyard's standards although it was the first time it happened so fully. Recalling that the shipyard was formed less than ten years ago, the first yard standards were a mix of best practices from the sister Kvaerner yards and home-grown documents designed to suit the yard's production and operating philosophies. When the shipyard constructed the fourth containership to a design developed by the Aker shipyards in Germany, additional standards and practices were added to the mix. With the start of the tanker project, many of these were scrapped in order to match the procedures used in

Korea. Although no shipyard wishes to so radically modify established standards, this change was a key step in ensuring to copying the success demonstrated at HMD over and over again. The site supervision staff was assembled and is managed by SeaTechnology (USA) of Stamford, Conn. The team members have newbuilding experience working on newbuilding projects in the States (suezmaxes and a car carrier in the U.S. Gulf, product tankers in Virginia and others) and overseas (cablelayers in Singapore, tankers in Korea, etc.). Further to the supervision efforts in Philadelphia, OSG has used its Korea-based inspection teams to undertake equipment inspections and factory inspection test inspections on behalf of APSI and ASC. This has worked well because the teams in Korea are familiar with the equipment, the testing practices and standards typically found in the Far East. To the same end, ABS has done an excellent job staffing their office in the shipyard with a mix of individuals with considerable experience in Korea (Samsung, Daewoo) and the United States (NASSCO). This mix of experience has served the project well in ensuring that the same standards applied at HMD area applied at APSI. Furthermore, ABS is to be commended for using this project as a training ground for its next generation of newbuilding surveyors.

Process Improvements at APSI

All parties understand that the project's scale of investment and the requirement for success in all phases. APSI has taken this to heart in the adoption of a positive culture of constant improvement. In December 2006, APSI launched the Advancement & Improvement Measures (AIM) 200 program with the objective of improving work processes to achieve a target of building the tenth tanker in one half the production man-hours used on the first tanker in the series. This 200% productivity increase will coincide with the shipyard's increase in throughput from four containerships in four years to three tankers in one year. The AIM 200 program has focused on eight primary action areas, each with its own goal, as shown in Table 1.
Each area is headed up by an Action Team of members from various departments in the organization that targets specific issues and actions to remove obstacles in a workers performance and improve their accountability and their individual productivity. Five coordination teams now focus on steel fabrication, machinery installation, outfitting & cargo, turnkey suppliers, and painting. For example, the Steel Coordination Team is addressing improvements in the flow of design information to Production, with particular emphasis on reducing rework and repetitive material handling, maximizing the re-use of production aids, and optimizing steel construction methods.

Table 1 - AIM 200 Focus Areas

Action Area	**Goal**
Communications	Keep people informed
Welding	Improve equipment, processes, and training
Logistics	Delivery the right material at the right time
Tools	Make available the right tool for the job
Overhead	Commercial awareness / cost efficiency
Human Resources	Skilled and stable workforce
Work Preparation	Improve work planning, execution, and management

The Human Resources team is focused on establishing a skilled and stable workforce at APSI. Attracting skilled workers from other parts of the country is difficult because of the relatively high cost of living in the Philadelphia area compared to most other shipbuilding regions in the States. As is the case in other developed shipbuilding nations like Japan and Korea, shipbuilding and other heavy industries are not considered attractive vocations for young people as they have been in years gone by. In response, APSI has established an apprenticeship program to recruit and train the next generation of shipyard workers and supervisors. Each year,

several classes of thirty recruits enter the four year program and rotate between classroom sessions and fieldwork in various production departments.
The Work Preparation Team has begun implementing lean manufacturing concepts to break down planned and actual production rates for each step of the production process. Daily work plans have been developed to better organize each team and improve their productivity and effective work time. Critical blocks have also been identified and improvements are being closely monitored and coordinated using a project management approach.
To date, APSI has achieved approximately a 25% reduction in man-hours from the first to the third tankers. The time between launch and delivery was reduced from twenty-one weeks on the first tanker to fifteen weeks on the second and to thirteen weeks for the third tanker. This corresponds to an increase in the percentage of work complete at time of launch of more than 10%. Implementation of the detailed work preparation plans mentioned above has resulted in a 20% reduction in dock fitting and welding hours between the second and fourth tankers. A similar reduction in grand block shop fitting and welding hours is now being evidenced between the third and fourth tankers as the process is expanded to earlier phases of construction.

International Partnerships in U.S. Shipbuilding

This partnering of a U.S. shipyard, an owner and a design sourced from overseas is neither new nor groundbreaking. APSI themselves chose a similar path with the construction of their fourth vessel. This containership, a ship of German design, is key to the success of the tanker program in that there are direct parallels between the approached used for both efforts and the lessons learned highlighted areas of requiring attention when the tankers started.

The 460 class containership project was originally intended to encompass two to four vessels; only one was built. The design of these ships was conceived by Aker Germany and the series had been previously constructed there. Aker Germany retained the design rights while providing production, engineering and procurement support. To a significant extent, APSI took on Aker Germany's production and quality standards. Overall, the project was a success but in hindsight some portions of the efforts could be improved. Some areas of design support and control were not included in the scope of work from Aker Germany and this created production difficulties. There was limited coordination on the procurement and logistics programs. The vessels were constructed on specification by the yard and the eventual owner entered the program at a later stage, resulting in some design changes. Lastly, the ships were classed with Germanischer Lloyd, which at the time was not part of the Coast Guard's aforementioned ACP program. As a result, all areas of the design and the equipment and components used all needed to be vetted against the published U.S. Coast Guard requirements and submitted to Coast Guard for approval in addition to the normal Class approval process. Lessons learned here were directly applied at startup of the tanker program and these have led to meaningful improvements in process and quality.

As noted, other U.S. shipyards have used a similar approach but to a much lesser extent of coordination, as follows:

Halter Shipyard 3,000-unit Car Carrier – design and production drawings from Croatian shipyard

Atlantic Marine 16,000 ton dwt Chemical Tankers – basic design from European design agent

The Veteran Class tanker project is the scale of cooperation and partnership between APSI, HMD and OSG. These relationships touch on every aspect of the shipbuilding and ship operating process. The levels of teamwork and integration combined with a mature design currently under production have created efficiencies for all parties that are unprecedented in the U.S. shipbuilding industry.

It should be noted that since the inception of the Veteran tanker program, a second tanker operator U.S. Shipping LLC has contracted with another U.S. shipyard, General Dynamics National Shipbuilding and Steel Co. (NASSCO) to build up to nine product tankers. As APSI has done with HMD, NASSCO has entered into a similar agreement with Daewoo Ship

Engineering Co. (DSEC) for basic, detailed and production design services and material procurement and logistics. DSEC is a wholly-owned subsidiary of Daewoo Shipbuilding & Marine Engineering, (DSME). DSEC's initial activity was the provision of technical and procurement support to Daewoo's Mangalia shipyard, in Romania and has since expanded to provide full service support to owners and shipbuilders alike.

Conclusion

At the time of this writing, with shipyard productivity and quality improving, with two ships is successful service and a third readying for delivery, the Veteran Class tanker program and the partnerships that support are considered a success. Continued reductions in APSI's man-hour expenditures and improvements in OSG's maintenance and operating expenditures will ensure that the project is fruitful on a long term basis.

This project has demonstrated that a joint working agreement between an experienced Far East shipyard and a newbuilding shipyard outside the region can result in a successful shipbuilding program with realized cost savings. Several factors can be identified as directly contributing to the success of the program.

The selection of a well-proven and current design effectively eliminated the design risk for the building shipyard and provided significant economies of scale for purchasing.

A comprehensive logistics program coordinated between the yards and mirroring the build strategy significantly facilitated production. Future improvements for larger building programs could result in true just-in-time delivery of parts and pieces needed for production.

Modern and generally similar facilities at the two shipyards required minimal rework of the design to suit differing build strategies.

APSI's philosophy of constant and meaningful self-assessment helps ensure that delivery performance is improved and that costs are continually reduced for all parties.

The commitment to series construction of a significant number of ships provides a basis for the adoption of new standards and defrays many of the one-time costs such as initial modeling, engineering and familiarization.

Finally, the wholesale adoption of the parent shipyard's standards for workmanship and quality provide a common language for both parties and reduce significantly risks associated with process control.

Of these, the most critical and perhaps the most difficult for other shipyards to undertake is the last – the near complete adoption of another builder's standards and practices. APSI is unique in that the shipyard has a history of design partnership and has now worked to three different sets of standards for three different ship designs. A shipbuilder with a more varied order book, greater throughput or more entrenched processes would likely find it difficult to justify or undertake such a fundamental change for an individual program. If an active shipyard attempts to undertake such a partnership program for a modest vessel series while constructing other vessels, the builder is faced with a significant decision –build to two different standards at the same time or reject the partner's practices and accept any quality or production risk that comes with doing so. This decision can be made easier if the partnership between the two shipyards extends beyond just a single ship series of ship type, or to a more comprehensive agreement including partial or complete ownership. Examples of such extended relationships and partnership include Daewoo Mangalia Heavy Industries, Inc. in Constanza, Romania and Hanjin Heavy Industries develop of its facility in the Philippines' Subic Bay. The authors have no direct knowledge as to whether these shipyards have adopted the practices of their parent shipyards but expect that to a large extent they must in order to recognize the same gains seen by APSI.

Based on the experiences with the Veteran Class tankers, the authors recommend that Far East shipyards looking to expand their markets or increase their capacity and shipyards outside of Asia looking to compete in specialized markets strongly consider suitable partnering

arrangements. With careful forethought and planning and with good cooperation, a model such as this can be highly successful.