

Integrating the Shipbuilding Business Model

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ABSTRACT

The shipbuilding business has traditionally focused heavily on the technical aspects of the products, from education through customer service. Correspondingly less emphasis is placed on the business of shipbuilding, to the detriment of shipyards and shipowners around the world. Based on their experience, the authors present some alternatives for better integrating the shipbuilding business model, all with a view to ensuring satisfied and profitable shipyards and shipowners.

SEPARATE THREADS TO WHOLE CLOTH

Since man first began creating maritime vessels, they have been among the most technically complex items produced by a given civilization. One need only consider the Norse long-boat, the 44-gun Revolutionary War frigate or the WW II battleship to recognize their technical content, relative to other goods and services produced at that time. From this history, a strong emphasis on the technical “thread” is found to this day in modern shipyards. From concept design through post-delivery support, decision-making is driven by an (often) overriding emphasis on technical issues.

Also present is a business “thread”, one that concerns itself with customers, commercial relationships, finances, profit/loss and other mundane issues of enterprise survival. This relationship between the two threads is depicted in Exhibit 1, below. It is the authors’ conviction, after some years of experience both within the industry and consulting to it, that this business thread is often only

loosely bound to the technical thread, and is seemingly viewed in a casual, after-the-fact manner. Even some very senior shipbuilding managers treat business concerns as less important than technical matters during the course of a design/construction program. But is this common in other businesses, industries, or fields of endeavor?

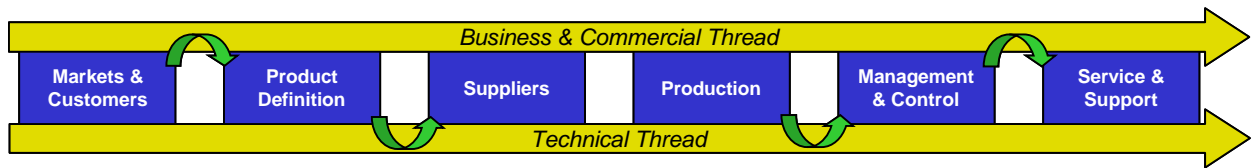


Exhibit 1 – Business/Technical Parallelism, Typical in the Marine Industry

In today’s economy, there are many examples of products and/or systems that rival the technical complexity of a modern vessel: pharmaceutical manufacturing facilities, automotive supply chains or high-tech manufacturing plants, to name a few. In these other industries, key players in the supply chain have figured out how to tightly integrate both technical and business considerations into an integrated approach to serving customers. They have done this by coordinating four drivers of high performance:

- Business strategy

AN IMPERFECT PATTERN OF INFORMATION DISTRIBUTION

Many shipbuilding projects are initiated by a series of discussions between technical parties from both sides; i.e., a sales engineer from a shipyard starts talking to owner engineers, or an owner’s technical department begins exploratory discussions with a design agent or shipyard engineering group. By and large, these talks begin with, and stay largely focused on, the technical aspects of the vessel, whether inherent characteristics, relevant cargo systems or production considerations. At this stage in the typical sales cycle, a considerable portion of the vessel’s cost is being committed.

At some point, and parallel to these technical discussions, assorted representatives from various functional business areas will be involved but usually sequential to technical milestones (as information is considered ready to “throw over the wall”). Finance personnel will begin structuring the terms of the deal, based on the best information available from the technical discussions at the time. Contract administrators and legal counsel will develop the terms of the commercial arrangement between the parties, again after some level of notional or contract design is reached. Business considerations lag the technical, and in a way that full and frank disclosure seldom happens.

Once the contract is in place and work has begun, the parallelism continues. The majority of manpower is

- People
- Process
- Information management and other technology

In the remainder of this paper, the authors will examine the way in which technical-business parallelism is impacting modern shipbuilding, and then suggest some steps and examples to create a more integrated model.

focused on detail design and construction, driven by a series of key technical decisions and milestones. Business concerns, at the customer-facing, strategic and financial levels, occur “on the sidelines”, usually between customer and yard reps who are less than fully aware of the myriad technical decisions being made around them. Design and production managers make decisions every day without the full fact base, both technical and business, needed to ensure their correctness for all concerned.

It begins to be clear that this parallelism is fostering an information management model that is sub-optimal. Almost none of the key stakeholders have, at any given time, a complete, accurate and organized body of information to allow them to be fully effective within their area of responsibility. Engineers throw “over the wall” what they think planning and production will need, absent any of the substantive background discussions and trade-offs that have occurred. Financial planners and analysts seldom provide the production departments with targeted cost information, job standards or other information to guide the program. Similarly, financial and contracts types are seldom included in planning and production meetings where crucial, performance-impacting alternatives are examined.

This imperfect pattern of communication manifests itself throughout the design and construction process:

- Designs which somehow never seem to get finished

- Material which is never on time to support construction
- Adversarial relationships with customers
- An inability on the part of management to get a handle on where a vessel or program is, and where it might be heading
- Poor schedule and budget performance, whether at a work center, department or enterprise level

Those of us who have been around the shipbuilding industry for more than a few years can all recite tale after tale of programs that have exhibited some or all of these characteristics. In fact, those instances where these symptoms have not occurred are almost legendary. But many other industries routinely design and build complex products where horror stories are the exception rather than the rule. Following are our observations on how others have avoided business-technical parallelism and some points that we think US shipbuilders should consider.

- 1. Create a business-centric, not product-centric, strategy**
- 2. Understand fully both your own economics and those of your customers**
- 3. Make your supply chain work for you in as many ways as possible**
- 4. Enable your strategy with processes that are disciplined, flexible and measurable**
- 5. Create an explicit information management strategy that recognizes and supports the need for technical and business integration**
- 6. Enable a “big-picture” workforce**

Exhibit 2 – Avoiding Business/Technical Parallelism

1. CREATE A BUSINESS-CENTRIC, NOT PRODUCT-CENTRIC, STRATEGY

The design and manufacture of heavily engineered-to-order products (ships, planes, buildings, etc.) often entail a considerable investment in specialized resources, whether facilities or people. As these resources are successfully employed to satisfy customers, a mentality sets in among many management teams that the continued pathway to success relies on “more of the same”. This is particularly true where (currently scarce) series contracts have allowed the benefits of the learning curve to be realized at the bottom line. Before long, it

becomes difficult to conceive of a strategy that is beyond “sticking to the knitting”; in the case of shipyards, the company’s strategic direction is defined by trying to sell more of the same type of vessel to other owners. Maximum attention is paid to all of the ways in which the product or processes can be improved to reduce cost and cycle time. Any use of resources that is tangential to this product focus is deemed low priority.

We can all think of shipyards that have followed this product-centric thinking to such a degree that they have been unable to remain in business when the market for their particular products dried up. Or, consider the

singular lack of success attained when shipbuilders have attempted to build rail cars or other large industrial equipment. While they are to be commended for attempting to move outside the box, their emphasis on a product-centric strategy prevented them from addressing the right issues to be successful in a new marketplace.

Similar issues have been faced until recently by American automobile manufacturers, whose assembly plants are often so difficult and expensive to change over that it is easier to close the old and open a new one when market tastes and preferences shift.

A business-centric approach to strategy (Exhibit 3) begins with a desire to understand markets and customers, moves to an objective understanding of the capital (financial, intellectual and human) that a firm can bring to bear, and then attempts to create one or more business models which best utilize capital to serve customers. Put simply, this approach:

- Starts broadly and works down through a series of alternatives to arrive at a strategy; it also

- Begins by surveying externally and then makes decisions about optimizing internal choices

Consider the case of GE Capital, the hugely successful financial arm of General Electric. When originally formed, its mission was simple – supply financial capital to customers of GE’s manufacturing business. However, by taking a business-focused view of their strategy, they have grown the business into a powerful source for everything from containers to mobile office trailers, while ensuring handsome returns to their shareholders. GEC managers would argue that their business is “leveraging assets to generate superior returns”, as opposed to lending money to GE customers. Such a broad, externally-focused vision, when combined with the financial discipline and managerial accountability for which the GE system is legend, ensure a never-ending stream of new business opportunities and a high likelihood of success when they are entered. The organization supports this growth machine by ensuring a broad development path for its managers, moving them around to prevent them from becoming too product-focused and narrow in their perspectives.

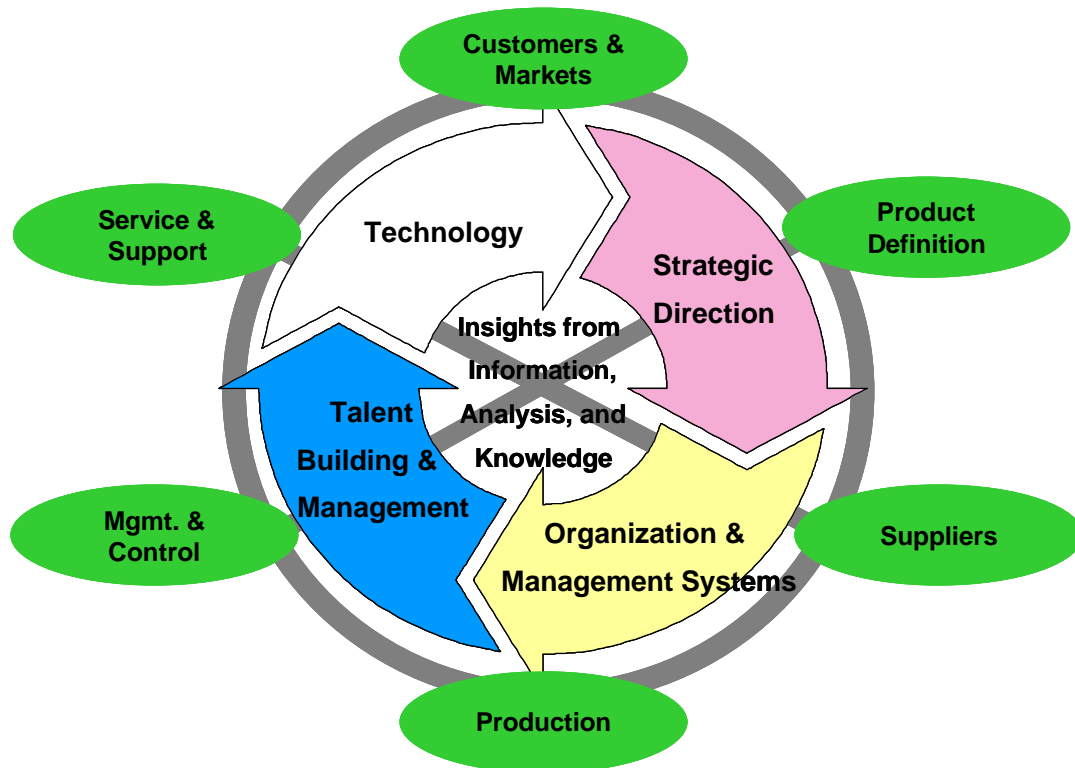


Exhibit 3 – A Business-Centric Model

2. UNDERSTAND FULLY BOTH YOUR OWN ECONOMICS AND THOSE OF YOUR CUSTOMERS

In our work with a variety of shipbuilders, as well as other manufacturers, it is always fascinating to see how little understanding the average middle-manager has of the economics of the business, even in the operation for which he is responsible. Yes, he may understand man-hour targets (if supplied), and maybe he even has an operating expense budget to which to answer. But few US shipbuilding managers have a grasp of the actual dollars involved, how they add up, and how they can be controlled. In our view, there are two fundamental reasons for this failure to create “dollar-aware” management teams:

- An inability of the shipyard “systems” (be they manual or computer-based) to provide relevant, timely and accurate information; and,
- A belief that “we don’t want those [supervisors; engineers; you name it!] to be concerned with cost; we just want them to do their job”

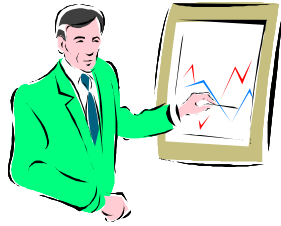
In the case of systems, most shipbuilders utilize tools that are, regardless of how modern, more adapted to an after-the-fact perspective on work performed. Almost all are driven principally by man-hours as reported in a timekeeping module, and then tied closely to a payroll system. Often, a separate system (sometimes tied to the product definition, sometimes not) is used to drive procurement, with a third system being used to create and maintain the schedule. Finally, even in cases where the actual systems are integrated, the time and effort necessary to determine report content that is reflective and supportive of a build strategy are seldom spent. Thus, managers are left to fend for themselves in picking out and enhancing the information critical to the success of their operation. With the usual demands for schedule performance, it is little wonder that most throw up their hands in frustration.

More serious is the pervasive cultural perspective that we just need shipyard managers to “do their job”; i.e., achieve a particular target or milestone by applying the right people with the right skills, according to the

schedule. [This may come from a mis-reading of the intent of the Japanese shipbuilders who advocate providing only the information, materials and tools needed at a particular work center for efficient production. However, we tend to forget that the supervisors of that work center are degreed engineers trained in the use of facts and data to solve problems.] In our view, this has created a chain of command that discourages big-picture or out-of-the-box thinking, populated by managers who are unable to evaluate reasonable alternatives from the perspective of the overall good of the business. Symptoms range from production meetings that devolve into finger pointing and name calling sessions, through to major programs that run months and years off course before someone tries to get them back on track

Failure to understand the economics of the ship buyer also tends to create problems for American shipyards, one of the more glaring examples being the recent demise of AMCV and the attendant loss of major contracts at two US yards. One has to wonder to what extent anyone examined the economics behind AMCV’s business, or whether any attempt was made to quantify the financial risk to AMCV’s partners. In a more proactive sense, understanding the economic drivers of the customer’s business makes it easier to develop your own business model and products to uniquely suit him; in effect, your own “stickiness” to your customers increases. At a tactical level, this appreciation for customer economics makes everything easier, from initial contract negotiations through to daily inspections, change order processing, etc.

The answer to this dilemma is four-fold (Exhibit 4). First, senior management must make and implement a decision to create managers who are fully trained in all aspects of the shipbuilding business, including the management of financials. Second, the time and effort must be put into creating an integrated information management system that can help those managers do a better job of running the business. Third, the enterprise needs to devote time and attention to understanding the economic realities of their customers, both to allow for more relevant partnering and to avoid unpleasant surprises. Fourth and most important, senior management must encourage business-based decision making, with the implicit recognition that managers must receive (within reason) the freedom to fail.



Provide managers with training in financial management

Create effective business information systems



Learn your customer's business and its economics

Encourage business decision-making



Exhibit 4 – Improved Understanding of Economics

One of the authors was engaged for some time by a supplier of critical products to the semiconductor fabrication industry. Their total customer list would fit on half of one side of a piece of paper; salesmen were technically proficient and spent the majority of their time helping their customers use their products in more efficient and cost-effective ways. In other words, the sales force was intimately familiar with their customer's value chain from both the technical and business perspective.

The next step for this firm was to use this knowledge to create a collaborative information management system that would leverage this knowledge to ensure faster, on-time deliveries, higher quality products and a more satisfying customer service experience for their clients. At no time were they interested in enabling the "sales process" – to this day, a sale is made via fax of a handwritten order ticket to customer service central. Rather, they focused on capturing all of the critical production and usage data for their products and making it available to their customers and sales engineers, whether technical or financial. Once the system was up and running, their customers were able to gain real-time access to order status; product engineers; cost comparisons; operating tips/techniques; and a variety of other data that allowed them to make easier, faster and more cost-effective business decisions. By understanding their customers'

business, they increased their real and perceived value to those customers; the purchase decision became that much easier!

3. MAKE YOUR SUPPLY CHAIN WORK FOR YOU IN AS MANY WAYS AS POSSIBLE

Supply chains for most American shipyards today still tend to be product-buy oriented. Engineers and designers on the shipyard payroll decide on a set of specifications for a component, and then turn the Purchasing Department loose to acquire it. A variety of factors enter into the decision, including TCO and other current buzz-words, but look closely and we'll bet that price is still a driver of the decision in more than 50% of the cases. More importantly, the components are generally acquired in isolation, leaving the issue of system integration to the cognizant shipyard departments or sub-contractors. Consider a typical cargo-oil pumping system, for example (Exhibit 5). With rare exception, the pumps, piping, valves, alarms, etc. for these systems are specified, purchased, received and then assembled as components, with the pipe shop and test departments ultimately responsible for whether they perform or not. Not only has this increased the likelihood of sub-optimal process cycle time and cost, but it has also failed to take advantage of the expertise and knowledge contained in each of the supplier organizations.

Contrast this with the path taken in the auto industry over the past two decades. Companies like Johnson Controls and Lear are increasingly asked, from the very beginning of a new design, to assume responsibility for entire sub-assemblies of the vehicle. They leverage their knowledge and experience in a particular area to design the sub-assembly to performance and cost targets, then manufacture the sub-assembly and deliver it to Ford or GM according to the lean assembly principles and production schedules provided. Finally, all of the relevant information exchange that is inherent to these processes is occurring largely without paper and hand-offs, to a schedule jointly developed by all parties. Even more to the point, Tier 1 suppliers like JC or Lear then use the same principles to leverage the capabilities of

their suppliers, a process which is increasingly penetrating to Tier 2, 3 and lower suppliers.

The automotive companies have also utilized outsourcing to improve the efficiency of certain parts of their supply chains. Rather than receive, kit and deliver parts or sub-assemblies to their own assembly lines, they are increasingly using third-party logistics providers to handle these “ancillary”, but critical, chores. Behind this move is recognition that the business of Ford and GM is maintaining the customer relationship and using that knowledge to design and assemble products to satisfy those customers. Anything not germane to that mission can be safely, and usually profitably, outsourced.

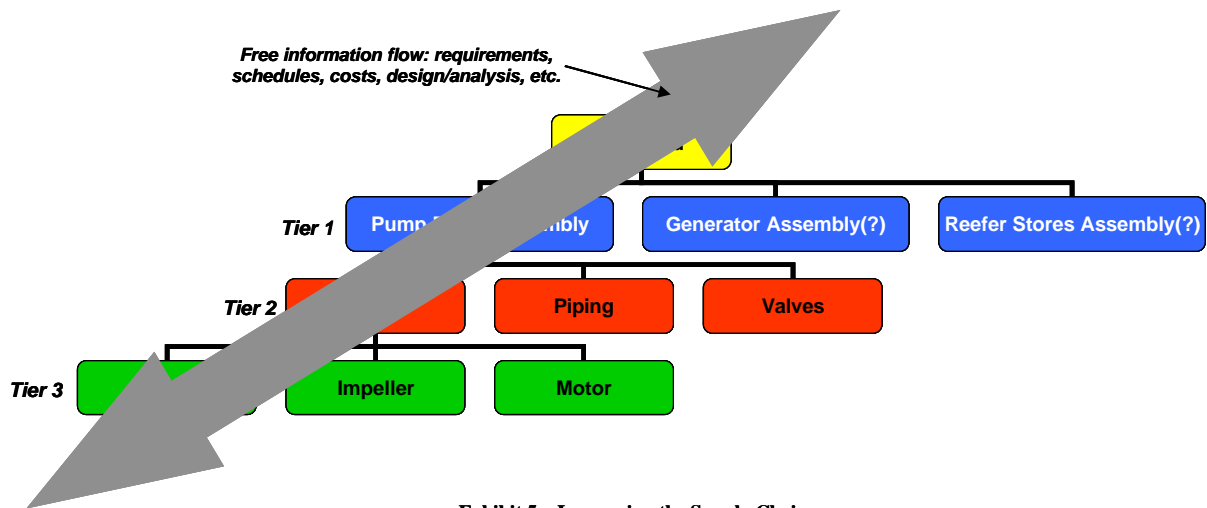


Exhibit 5 – Leveraging the Supply Chain

Entire books have been written on supply-chain improvement, so what’s the lesson for American shipbuilders? First, as noted in the discussion above, be sure that your strategy is business-centric, not product-centric. This will give management the freedom to dispassionately understand core competencies and make wise decisions about supply-chain alternatives.

Second, be creative when thinking about your supplier community and what they can offer. It is true that the marine supplier base in North America is small, but this doesn’t mean that a) they don’t have skills and services that can be used to advantage; or b) they can’t be encouraged to create their own alliances so as to offer the shipyard something bigger than the whole. And what about “non-traditional” sources of supply, i.e., those companies with relevant skills and products but who have traditionally served other industries? Ducting and

electrical work always spring to mind, but steel fabrication and assembly and accommodation spaces are other areas where non-marine firms have shown ability from time to time. And what they bring to bear may be in areas like design, logistics or aftermarket support. (The ultimate supply-chain alliance may be enlisting a traditional competitor to utilize their unique expertise to help on a particular contract; the manufacturing world is filled with examples of companies who compete and align as the business dictates)

Organizationally, continual focus on the issues of strategic procurement and supply chain management is called for, and from the same senior management vantage point (one person or a very small team). Hire an experienced and knowledgeable supply-chain professional, one who is perhaps less familiar with the shipbuilding business but more familiar with lean

manufacturing, 3PLs, etc. Give this individual a mandate to reduce cost and cycle time, a budget to carry it out and a mutually-agreed series of goals and milestones.

The greatest barrier to success in building broad and empowered supply chains is an issue already mentioned – the cultural bias to hold information close to the vest. Achieving lower cost and cycle time through strategic partnering requires the free flow of information – not about your labor agreements or estimating parameters, certainly, but everything about products, schedules, and man-hours. It is true that the mechanics of extracting and distributing this information throughout the supply chain will prove vexing in the extreme (see discussion following), but failure to gain consensus around intent will stop any supply-chain initiative dead in its tracks.

4. ENABLE YOUR STRATEGY WITH PROCESSES THAT ARE DISCIPLINED, FLEXIBLE AND MEASURABLE

We all understand the usual drivers behind robust and disciplined processes – they save money and time. But from a more strategic viewpoint, they also help focus attention on the customer, thereby helping the organization concentrate on, and make rational decisions about, the business (see Exhibit 6).

Discipline comes first from the mere act of describing/defining processes and their accompanying

metrics. Absent specific definition, it is far easier for “free thinkers” at all levels of management to make decisions that optimize their role/performance but sub-optimize the delivery of ships. One of the authors ran a fabricating department for a large shipbuilder; when he first became the manager, the only metric was tons of throughput per week, against a broad-based schedule of sub-assembly and erection. No processes existed, nor were any other metrics tied to the overall needs of the business in place. Needless to say, the fab department management team had figured out multiple ways to “game” the system. Not only were manhours expended in sub-optimal ways, but the flow of material to the yard was seldom what was needed at a particular time. Certain piece-parts and tools were always late, while other (heavier!) parts often were completed early and then sat for months until the rest of the unit caught up. It wasn’t until more specific, strategy-driven scheduling was developed, along with specific shop processes and metrics, that these symptoms were cured.

Flexibility comes about through thoroughly understanding the varied customer and business requirements for a given process and then making explicit decisions about process alternatives and the ways they impact the process and overall business. Flexibility does NOT mean leaving things strictly to either random chance or management decision. Rather, it extends from rational thinking about fact-based decision alternatives.

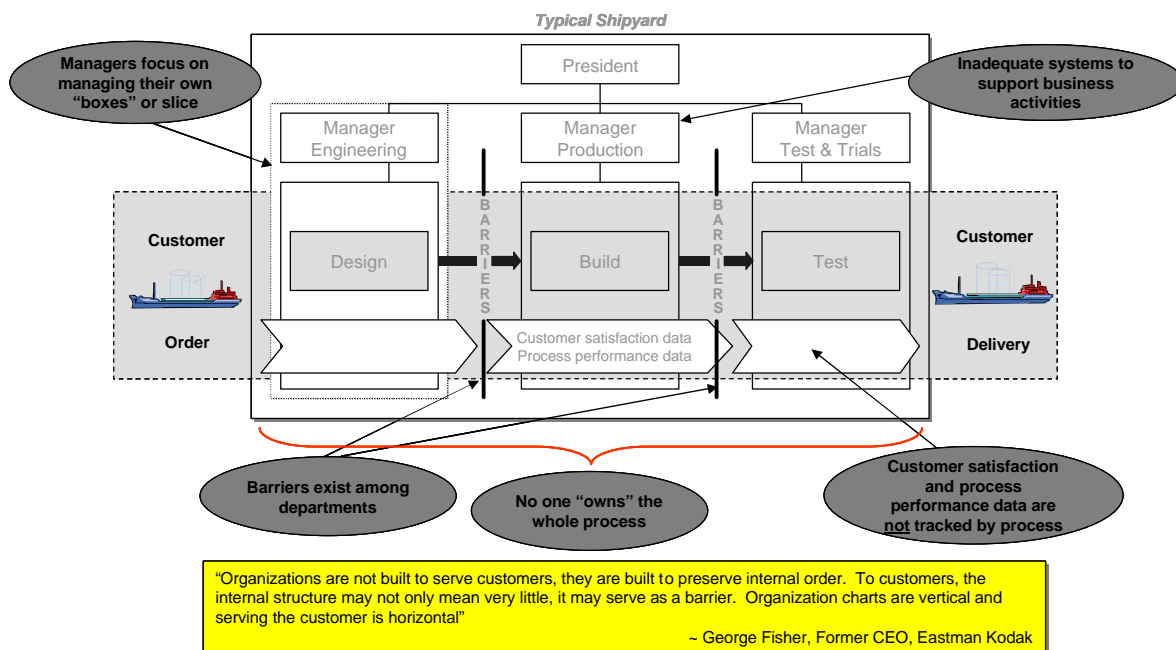


Exhibit 6 – Why Processes don’t Work

A process by itself is not sufficient – there must be measurements associated with it that allow for assessment and re-assessment of the process’ ability to satisfy the customer and support the needs of the business. This requirement for measurement, assessment and adjustment is what distinguishes customer-focused processes from “procedures”, “instruction sets” and other attempts to bring order to the complex endeavor of building a ship. A related pitfall with regard to measurement occurs when the “wrong stuff” is measured; clearly, this was the case in the aforementioned fab shop. Metrics must be tied to overall goals of the business, which means they should include components of schedule delivery, cost, asset utilization and manpower development. In our experience, most metrics currently associated with processes in most shipyards are heavily weighted to only one or two of these elements.

Pharmaceutical companies, in general, have done an above-average job of creating processes tightly integrated with their overall business strategies, then using them to drive improved performance and faster change. While initially driven by a need for faster time to market (gated by Federal regulation), drug companies have also found that disciplined processes remove cost, enhance employee productivity and provide a framework for improved, earlier decision-making about where to commit the large pools of resources required to bring a drug to market. In addition, by having well-defined processes with understood metrics, the pharmaceutical industry has found ways to more highly leverage the suppliers in their value chain, thereby further reducing costs and opening themselves to additional new thinking.

5. CREATE AN EXPLICIT INFORMATION MANAGEMENT STRATEGY THAT RECOGNIZES AND SUPPORTS THE NEED FOR TECHNICAL AND BUSINESS INTEGRATION

A look at the information management system(s) of a reasonably advanced shipyard likely reveals some or all of the following:

- One or two CAD systems used for naval architecture and conceptual design
- A separate drafting system for producing production information
- A purchase order system which may or may not be tied to ...

- ... an accounting package, which may or may not be tied to ...
- ... a time/attendance system
- A payroll system
- A warehouse/material management system

Admittedly, this situation is largely the result of a series of legacy decisions made over many years, often in the days when integration was strictly an EEOC issue. And, it must be said, many yards have successfully used middle-ware tools (either developed in-house or COTS) to force integration of these systems. However, we would argue that few of these efforts are being guided by an integrated information strategy closely coupled to the business strategy, as opposed to addressing specific tactical/technical issues. As an example, consider the integration of CAD system bill of material modules with purchase order systems. The impetus for these was largely to reduce cost, cycle time and potential for error in getting material orders out to vendors. While worthwhile goals all, it is likely that such solutions ignore the greater benefit to be achieved from building closer relationships with the supplier community, through shared planning and forecasting capabilities.

One of the authors was privileged to work for a period of time with the IT department of one of America’s largest homebuilders. Their business strategy was quite clear - provide a pleasant, all-encompassing experience for anyone looking to become established as a homeowner within the geographies they serve. Already, they have a focus beyond a specific product! This strategy allowed them to become involved in all parts of the home ownership process, either through their own divisions or via partnerships; one-stop-shopping was part of their culture.

In the IT department, this message was put into action via a series of programs designed to serve all segments of the value chain. Initially, it began with a series of integrated manufacturing systems that ensured each home produced met quality, cost and schedule targets. These systems were then tied to the point of sale, so that a field office could know when to promise delivery, what the correct price points were for options, etc. Next, links were forged to the mortgage origination and approval divisions, so that potential financing customers could be “hooked” right on the spot.

Note that we are not claiming that all of this was accomplished easily or without mis-steps. This was a multi-year effort that cost millions of dollars and involved considerable changes in direction, adaptations to market conditions, etc. Regardless of these tactical

issues, however, the fact is that all of the IT decisions were ultimately driven from the offices of the CEO and CFO, and ultimately all mapped to the overall business strategy which was clearly communicated to all levels of management.

6. ENABLE A “BIG-PICTURE” WORKFORCE

Regardless of the strides made in automation in other industries, we strongly suspect that ships will continue to be produced with a larger than normal share of manpower. Today, in most American shipyards, this labor is applied and then nurtured on a strictly product basis. Welders stay welders; their pay is based strictly on comparables for other welders, with some bonus based on welding metrics. Pipefitters, carpenters, machinists, warehousemen are a similar story. And to some extent, this is reflective of the unique skills that each trade must possess in order to complete the complex shipbuilding process.

But to what extent has this created such limitations in today’s workforce? And why can’t modern training/development approaches be brought to bear to create greater knowledge and awareness of:

- The customer requirements of those upstream and downstream in the process?
- The overall goals of the business, its drivers and the role of particular crafts in driving or hindering high performance?
- The way in which problems can be identified and solved in a cooperative way?

We are not suggesting that a class of “master shipbuilder” be created, able to perform all functions equally. Clearly, certain people will always be more skilled at certain trades than others. But there must be ways for the extreme specialization inherent in today’s yards to be turned in more flexible directions. However, the workloads in America’s yards for the foreseeable future do not augur well for this model. We see the results whenever a layoff is announced for one craft, when at the same time help-wanted ads are placed for

crafts that are “next in line”. While we would not want to see designers welding pressure vessels, we see no reason that they could not be material expeditors, planners or marketing support personnel. Shipfitters may not be pipefitters, but basic mechanical ability argues that much of what they each know can be shared.

Clearly, this notion has many hurdles, not the least of which is the already-tenuous relationships with organized labor at most of America’s large yards. Also, it would require a commitment of funds for training, development and manpower planning/scheduling that goes beyond that currently made by any yard with which we are familiar. Still, to the extent that worker capabilities can be brought to bear on a wider variety of shipbuilding tasks, the workers will feel greater satisfaction, loyalty and understanding of the overall goals, leading to an enterprise which is overall more focused on the business strategy.

One of the best examples of this notion of “flexible specialization” can be found in the operation of any modern large restaurant. Back of the house, a large contingent of “cooks” can be found, each with a specific function in the “ideal process” of producing satisfied diners. In practice, while the processes remain fixed, manpower shifts back and forth as the demands of that night’s service require. Similarly with the front of the house – workers move to cover tasks as the needs of the evening demand, but always with a focus on the overall strategy – creating delighted customers. [Upward mobility is another noteworthy feature of the restaurant operation – chef/owners who are successful long-term foster development of their personnel via formal and informal training. It is quite common to see someone who started as a dishwasher become a line cook in a matter of a few years.]

A SHIPYARD CASE EXAMPLE

One of the authors has experienced the trials and tribulations of implementing some of the above ideas in a U.S. shipyard. As shown in the below table, the yard took on a series of improvements over a period of a decade that covered all of the key processes and impacted all of the key stages of the ship design and construction. These changes were difficult and

challenged the management of the yard, but in the end they contributed to the continuing positive performance of the yard and their resultant improved competitive position in the U.S. market. One wonders if all the U.S. yards were to catch up with this one through the ideas suggested in this paper, perhaps the domestic bar would be raised sufficiently to allow U.S. yards to actually compete on the international front.

Stage of Work	People	Plant	Processes	Technology	Supply Chain
Planning	<ul style="list-style-type: none"> Manpower allocation charts Overhead allocation across projects 	<ul style="list-style-type: none"> Integrated schedules Capital investment needs defined 			Key supplier partnerships established
Design	<ul style="list-style-type: none"> Production input to Production Information 		<ul style="list-style-type: none"> Integrating production planning with design Process Improvement Teams Build strategy definition Design freeze at the right time Block break down and block standardization 	<ul style="list-style-type: none"> Integrated Product Modeling software 3D model review and approvals On-line access to information Electronic approvals 	<ul style="list-style-type: none"> Outsourced: <ul style="list-style-type: none"> Model testing Finite Element Functional design Propulsion system integration and design Accommodations Specialty skills Input to MRP
Construction	<ul style="list-style-type: none"> Cross training Do it right the first time 	<ul style="list-style-type: none"> Work Stations Work Centers Process Lanes Strategic investments in plant and equipment 	<ul style="list-style-type: none"> Interim products strategy Product hierarchy Minimize transportation Block erection sequence 	<ul style="list-style-type: none"> JIT material delivery MRP II Offsite sub-assemblies 	Teaming with subs, vendors and the customer

Table 1: Key Improvements Implemented at a U.S. Shipyard to Integrate the Technical and Business Threads

CONCLUSION

The ideas presented herein are, for the most part, evolutionary (although certainly some shipbuilding management teams of our acquaintance will regard them as revolutionary!). Regardless, it is our intention to foster thinking and discussion about the ways American shipbuilders can begin to create a more holistic sense of mission for their enterprises. In some cases, the changes required to more tightly integrate business and technical threads will be modest; in other cases, they will require much time, serious deliberation and considerable capital. And, in some cases, a sober consideration of the business thread might lead to a decision to pursue some other application of capital. But by beginning to create a more-integrated business model, there is a greater likelihood that those of us who have earned our bread and butter in the American maritime industry might actually encourage our children to follow in our footsteps.

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