**A Better Means of Identifying and Quantifying the Impacts of Shipbuilding Disruption**

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*In a perfect world – perfect shipbuilders, perfect ship owners, perfect contracts, and a perfect shipbuilding environment – there would be no issues between builders and owners surrounding the completion of shipbuilding projects. However, in a less-than-perfect world, things do not always go well, and builders and owners sometimes dispute changes in cost, delivery, performance, and other characteristics of the contracts and the vessels. While it may not be possible to create a perfect world, builders, owners, and insurers can take steps to ensure better data are available when it becomes necessary to identify a disruptive event and quantify its impacts.*

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INTRODUCTION

When was the last time you – the ship builder or the ship owner – experienced a program that went off without a hitch?

* The owner’s specification was flawless and reflected everything the owner wanted; there were no changes introduced throughout the project.
* The builder’s work was flawless and everything was done to the owner’s satisfaction and on time.
* Suppliers got everything right, delivered on time, and never changed the price from what was used in the bid.
* There were no storms, floods, or inclement weather that affected the ability to get the work done.

If this describes how your projects go, you are very fortunate, very good, or very lucky, and a member of a rather small group. More often than not, the purchasing and building of a ship is a less-than-perfect experience. Because of this, we believe that the industry needs a better way to deal with change.

In today’s environment, when an unexpected change occurs and it is found to affect the construction of the ship, all the involved parties seek to assess the situation. Because the impact is generally not recognized until sometime after the disruptive event, the assessment requires reconstructing the past.

* Builders seek to identify the problem, the cause, and the impact in terms of cost and delay.
* Owners seek to validate the existence of the problem, identify the cause, and check whether the additional cost being passed to the owner is correct.
* Insurers, if affected, are assessing the situation in ways similar to those being pursued by the owners.

Finding data that enables the past to be accurately represented can be difficult. The types of data generally collected by the builder and owner fail to identify disruptive events and the associated impacts. There is rarely a plan in place to address the unexpected.

If unexpected change is likely to occur, what can shipbuilders and ship owners do to be better prepared for this situation?

SCENARIO

The process of building a ship can be disrupted by a variety of events, including problems created by the shipbuilder, by suppliers, by the owner, and by natural forces. Typical examples include:

**Builder**

The shipyard plans to upgrade a panel line and outfitting area. The upgrade is planned as a multi-phase project. A detailed schedule is laid out to sequence shipbuilding work around each of the planned shutdowns. The upgrade is timed to follow the production flow as the vessel modules under construction travel from the panel line to the blast and paint area to the outfitting areas. However, the upgrade does not go as planned, and work on the yard’s infrastructure gets in the way of building the ship. Work is delayed.

**Owner**

During detailed design and construction of the ship, the owner is unable to staff its engineering and inspection office as planned. Review and approval of drawings is delayed, and owner’s representatives in the yard are not available when needed to inspect completed work, such as compartment closeout. Work is delayed or proceeds absent approval and faces substantial risk of rework.

**Supplier**

A supplier specified by the owner and used by the builder is unable to deliver a major piece of machinery on time. Work is delayed and must be re-sequenced because the window for blue-sky installation has passed.

**Environment**

During construction of the ship, the shipyard experiences a flood. This flood interrupts ship production, as some areas become inaccessible to personnel, cranes, and rolling stock for an extended period. Due to limited real estate there are restrictions on available space to store modules being fabricated in unaffected parts of the yard. While waiting for the flood waters to retreat and during restoration of damaged facilities, work is delayed. An insurance claim is filed.

In all of the scenarios above, the events cause additional direct labor hours for vessels under construction as well as additional time and manpower for level of effort personnel supporting the construction of vessels. The implementation of work-arounds to keep employees productive and reduce delay results in out-of-sequence work and overtime. Other programs in the yard may be impacted. In the case of the flood, the company insuring the yard may have to cover the losses.

RESPONSE

Seemingly straightforward events can be convoluted when various stakeholders - the shipyard, its customers, suppliers, and insurers - experience cumulative impacts with unclear lines of responsibility for the disruption.

Builders scramble to identify the events that affected the planned work and the costs associated with those changes. Owners recount their own losses and failures of the shipbuilder to meet contractual obligations. Insurers work to manage their obligations. Whose analysis is correct? What actually happened? Who was at fault? How much did it cost? What impact did it have on other aspects of the project or on other programs in the yard? How, if at all, was disruption addressed in the ship construction contract?

These questions are generally asked for the first time after a disruptive event has taken place. Both owners and shipbuilders may discover that the answers are not readily available because neither side has been collecting relevant data nor capturing the facts as these events occurred. As a result, a time consuming and costly effort is undertaken to reconstruct the past to determine what really happened.

Today, all the affected parties undertake detailed searches of existing data to enable analysis of the disruption. The research efforts have become more sophisticated, but their effectiveness is limited by the quality and quantity of data. If no one was keeping track of the disruptive event and its impact, there are no data to be found.

If this were a rare event, the limited availability of data, the backward-looking analyses, and the resulting disagreements might be tolerable. But in fact, issues that affect cost and schedule occur regularly. Despite shipbuilders and owners having repeatedly experienced contract disputes and suffered unfavorable outcomes, they continue to enter into projects unprepared to collect the kinds of data that will make resolution of inevitable delays and disruptions fact-based, analytical, and less contentious.

Shipbuilders frequently make decisions to accelerate work by increasing overtime for various reasons, such as a backlog of other work, facility constraints, the availability of skilled labor, customer demands, or other economics and policies. Proper management of the shipyard and vessels under construction must be constantly reassessed to ensure critical tasks are given priority to avoid ongoing extra costs. Since these activities may affect losses it is advisable to evaluate these alternative scenarios and advantages of acceleration. A properly adjusted claim will not exonerate mismanagement and inefficiencies of a shipyard, nor guarantee an owner that a schedule will be accelerated to pardon owner-responsible delays.

IMPACTS

The consequences of an unexpected disruptive event can be many and often significant. While not exhaustive, the following list (Fig. 1) includes many of the problems encountered.

| *Impact* | *Challenge* |
| --- | --- |
| **Less Experienced Work Teams.** Additional man-hours due to unplanned mix of employee skills, seniorities following the event | * The shipyard may not have defined the optimal mix. * Supervisors may not have noted when they reassigned personnel. * Additional man-hours are not tracked relative to the event. |
| **Decrease in Productivity.** Increased man-hours due to changes to less efficient processes and methods caused by event | * Switch to less efficient process may not be recorded. * Additional man-hours are not tracked relative to the event. |
| **Manpower Reassignment.** Additional man-hours resulting from moving manpower from areas of expertise to other areas due to the event | * Supervisors may not have noted when they reassigned personnel. * Additional man-hours are not tracked relative to the event. |
| **Overtime to Maintain Schedule.** Additional man-hours expended in OT or additional shifts in an effort to make up lost time resulting from the event | * The reason for additional hours may not be recorded. * Overtime or additional shifts may fail to get the program back on schedule and so may not benefit the owner. |
| **Shop or Worksite Disruption.** Additional man-hours resulting from shops or work areas being completely/partially out of service during the time to functional recovery of productive capacity | * System fails to capture additional man-hours associated with work-arounds. |
| **Level-of-Effort (LOE).** LOE employees are supportive of vessel construction labor, with many assigned regardless of level of vessel hours charged during a period; ship schedule slippage drives added LOE man-hours | * System fails to identify the additional days attributable to the event, so additional LOE man-hours cannot be isolated. |
| **Infrastructure Impacts.** Extra man-hours caused by yard services/facilities being unavailable during some portion of the time to recovery of productive capacity | * System fails to capture additional man-hours spent waiting for cranes or other support because all equipment is not in service. |
| **Material.** Extra man-hours due to material damage, lateness, etc. | * System fails to capture additional man-hours spent waiting for material to arrive or to be repaired or replaced. |
| **Out-of-Sequence Work.** Additional man-hours resulting from event-caused changes in construction processes and suboptimal working sequences | * System fails to capture when process or work sequence changed, so additional man-hours cannot be linked to change. |
| **Additional Support.** Extra man-hours (over/above LOE personnel) required to support event-caused construction labor/process modifications; may include planning, engineering, material control, service department employees | * System fails to capture additional work duration associated with event so additional man-hours cannot be linked to event-caused delay. |
| **Use of Subcontract Labor.** Additional personnel required to offset other impacts and productivity issues | * Shipyard may regularly use subcontract labor and system fails to link additional use to the event. |
| **Supervision.** Increased direct vessel hours imply a need for additional supervisory man-hours | * System fails to identify additional man-hours resulting from event, so event-caused additional supervisory hours cannot be isolated. |
| **Quality Assurance.** Additional man-hours to ensure delivery of a quality product when following alternate plans due to event | * System fails to identify changed work resulting from event, so event-caused additional QA hours cannot be isolated. |
| **Engineering and Logistics.** Additional engineering and logistics man-hours to support extra labor costs associated with the other factors | * System fails to identify additional man-hours resulting from event, so event-caused additional engineering and logistics hours cannot be isolated. |
| **Cumulative Disruption.** The sum total of all factor impacts drives an additional compounding of lost labor hours | * Given all of the uncertainty listed above, quantification of cumulative disruption is not likely to be accurate. |
| *Fig. 1 – Supporting Data and Critical Elements to Delay and Disruption Quantification* | |

ANALYSIS

**Causal Links to Disruption**

A major difficulty related to most of the items in the table above is that all delay and additional costs experienced in the shipyard may not be due to the disruptive event being investigated. Shipbuilding programs sometimes experience cost overruns and delay even in the absence of a disruptive event. Or, there may be multiple concurrent disruptive events, so only a portion of the impacts experienced are associated with the event being analyzed. Unless the impacts of all events are captured separately and all non-event-related inefficiencies are identified, builders, owners, and insurers are not likely to agree on the magnitude of the impact, the cause, and who is responsible.

It is important that the productivity and schedule impacts can be linked to the unanticipated change. Additional hours may have been expended before the issue was recognized and there may be some ongoing impact at a reduced level once the issue is resolved, but a causal link to the unplanned change must be established.

Shipyards often fail to set up accounts to track the impacts of disruptive events, so tradesmen normally cannot charge disrupted hours to a discrete account. Furthermore, the cumulative impacts of multiple changes cannot be physically observed as they occur in a shipyard, thus introducing unknowns.

**Delay**

Builders and owners need to accurately assess the amount of delay associated with the disruptive event being analyzed. This requires isolating the event-caused delay from any other delay being experienced in the program. A one month delay in the arrival of a part or approval of a drawing does not necessarily equate to a one month slip in schedule. This could be the result of not impacting critical path or the builder taking steps to minimize the impact. The yard should make every effort to keep the program moving forward through re-sequencing and/or reassignment of work. ERP systems and other tools enable shipbuilders to effectively undertake critical path scheduling.

**Lost Labor Productivity**

Labor productivity can be affected by:

* Late delivery of materials
* Challenges of implementing new technology
* Deviations in material and outfitting
* Late drawing approvals and design changes
* Inferior workmanship and poor performance
* Equipment breakdowns
* Destructive or disruptive weather conditions

If any of these things reduce labor productivity and result in financial losses for the shipbuilder, the shipyard has the burden of proof to establish causation, entitlement, and quantification of extra costs. Quantification of event-caused additional labor costs can be the most challenging.

However, the owner is not contributing to resolution of the problem if simply waiting for the claim from the shipbuilder to arrive. The entire process can be made more efficient and less adversarial if the builder and owner (and insurer if involved) work together. There is much room for improvement in how data are collected and analyzed and in the level of professionalism demonstrated by all sides in dealing with shipbuilding disputes.

HAVING THE NECESSARY DATA

Accessing traditional shipyard performance data – work packages or bills opened and completed, man-hours charged, detailed schedules by process lane or work area, achievement of milestones – leaves the builder and the owner with the need to estimate what portion of this is baseline work, what portion is due to the disruptive event being analyzed, and what portion is attributable to other unidentified events. This inevitably leads to disagreements as builder’s, owner’s, and insurer’s interests, and thus estimates, differ.

We believe that today’s sophisticated accounting systems should enable shipyards to collect more granular data – to track the consequences of the disruptive event and remove the need to estimate.

Will this be easy? No. But we believe it can be done and it will make the quantification of impacts and settlement of cost overruns and delays more amicable and less costly.

**Defining the Framework**

When a shipbuilder decides to pursue this pro-active approach, it must first identify the required data and structure its data management system to record and retain the data.

For a disruptive event, it will be necessary to identify, among other things:

* Event
* Start date
* End date
* Beginning of impact
* End of impact
* Location of disruption
* Work packages affected
* Man-hours expended due to the event (not in baseline work or caused by other events or inefficiencies)
* Increase in work duration resulting from the event (not caused by other events or inefficiencies)
* Decisions and/or procedures affecting delay or expenditure of man-hours, such as reassignment of personnel or re-sequencing of work. (Note that these decisions and procedures have impacts of their own that need to be captured.)

Once a shipyard establishes the means of collecting these data, the framework will be reusable with minor modifications required for each contract.

**Capturing the Data**

The real challenge is capturing the necessary data that have been defined in the framework.

This will require training and incentives for supervisory personnel and workers to think differently about measuring and tracking work. When work is not being executed as planned – as identified in the master schedule or as described in the work package or bill – the workers and their supervisors need to identify why it is different. The framework will provide definitions and options for identifying events and their impact on the work. Undertaking this analysis of change on a daily basis will require some time and thought, and there is a good chance it will be somewhat disruptive until it becomes part of the everyday routine.

This process will not involve the shipyard alone. In the current environment, builders and owners often have different views regarding the cause of delay and disruption, and such disagreements would continue to be a problem if shipbuilders unilaterally assigned the cause of each variation in the work. In the interest of having reliable data for use in cooperatively analyzing performance issues, owners must be given visibility and be willing to review the supervisors’ and workers’ reports on a regular basis – frequently enough so that disagreements can be addressed while the disruption is still being experienced or at least still fresh in everyone’s mind. This too will require some time on the part of the owner, but the downstream payback is likely to be substantial.

With this information in place, obtaining the essential data to assess a problem will not require wading through vast information repositories. Both parties will know what specific questions to ask and where to find the answers. Critical issues will already be identified, timeframes will be known, and managerial decisions to address disruption will be part of the record.

This will make access to, and use of, the shipbuilder’s more comprehensive data more straightforward, enabling easier identification of the relatively minuscule number of precise elements buried in hordes of information. This will ultimately improve the promptness and accuracy of a settlement.

Data inconsistencies among various documents frequently provide clues to missing information, variances, and impacts. Interviews with appropriate shipyard personnel can provide additional insight regarding managerial decisions, “tribal knowledge”, and missing facts. Analysts will be most successful if their data requests are meticulously structured, provide clear justification, and consider the everyday burdens of a working shipyard.

The supporting data table (Fig. 2) illustrates which data are critical to delay and disruption analyses. Shipyards use various semantics and proprietary methods, but the data and analyses are fundamentally similar. Critical elements for generating claims are called out and represent a baseline for collecting data, as these are the building blocks for quantifying claims.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Category* | *Supporting Data* | *Disruption Critical* | *Delay Critical* | *Data Volume* |
| *Schedule* | Key Event Schedules |  |  | Low |
| Critical Path Schedules |  |  | Low |
| Planned Durations and Sequencing |  |  | Low |
| Master Schedule and Changes |  |  | High |
| Pre-Erection and Erection Schedules |  |  | High |
| Material In-Yard Schedules |  |  | High |
| Contract Modifications and Advances/Delays |  |  | Medium |
| Test Schedule, Plans, and Trial Sequencing |  |  | Medium |
| Detailed Schedules by Shop, Process Lane, or Area |  |  | Medium |
| Compartment Schedules |  |  | Medium |
| *Manpower* | Manning Supply/Demand Forecast and History |  |  | Medium |
| Level of Effort Hours Summary by Departments/Tasks |  |  | Medium |
| Direct Labor, Overtime, and Rework by work breakdown structure |  |  | Medium |
| *Performance* | Cost/Schedule Performance Reports |  |  | Medium |
| Earned Value Database (EVMS in Government Contracts) |  |  | High |
| Program and Business Management Reports |  |  | Medium |
| Work Package/Bill Database |  |  | High |
| *Shipbuilding*  *Facilities* | Shop Demand and Capacity Including Shutdowns |  |  | Low |
| Outsourcing Statements of Work |  |  | Medium |
| Facilities and Capital Equipment Upgrades |  |  | Low |
| *Accounting* | Historical Returned Cost Data |  |  | Medium |
| Annual Operating Budget, Allocations, and Changes |  |  | Medium |
| Sales and Margins Financial Database |  |  | High |
| Customer/Supplier Requests for Equitable Adjustment |  |  | Low |

*Fig. 2 – Supporting Data and Critical Elements to Delay and Disruption Quantification*

CONDUCTING THE ANALYSIS

Shipbuilders, ship owners, and insurers who have been party to claims and other forms of contract disputes are familiar with the numerous ways that delay, disruption, and additional costs can be computed.

While it is important for all the parties to agree on how data will be analyzed if the quantification is not to result in disputes, we believe that regardless of the method used to analyze the data, having consistent data endorsed by owners, builders, and insurers will go a long way to ensuring that the outcomes are acceptable to everyone.

One of the challenges typically faced in quantifying the effects of a disruptive event is the complication of having other issues not related to that event woven into the work impacts of the situation being analyzed. Better data will eliminate the need to separate causal issues from other events or changes. The identity of non-event related issues will be clear to all and will not lead to additional areas of disagreement.

**Delay Analysis**

A vessel under construction will have a number of critical schedule elements that must be identified during the period of interruption, or timeframe during which the shipyard and its facilities are running at reduced capacity. In performing schedule analyses, comprehensive production plans and schedules for every vessel and the rationale behind every small detail are not required. Alternatively, high-level key event schedules used by management for a variety of reasons are not always sources of hard and fast productivity-driven milestones. Analyzing critical schedule changes tied to physical ship progress is the basis of schedule analysis.

The agreed-upon collection of event-related data described above will ensure that delays not related to the event are not included in the analysis. For example, a change in the vessel launch date may be excluded because it was caused by weather conditions, other scheduled use of the ways, or tidal issues.

Extra costs of schedule delays are quantified by analysis of level of effort (LOE) personnel charging to a vessel. LOE personnel do not engage in the actual construction of vessels, thus the performance of these personnel is not a measure of productivity. Quantification of schedule delays is based on an analysis of only those LOE personnel whose running man-hours are extended with delays. Calculating the extended run rate of schedule delay lies in determining when these extra costs are applied. In some cases LOE extensions are experienced at the end of the program. In other cases LOE extensions must be applied in the aftermath of the delay, as critical impacts must be dealt with immediately to avoid recurring delays. In addition to addressing critical path delays there are often cost benefits to accelerating or partially accelerating a program to stay in synch with the backlog of work. In other cases when there is sufficient schedule float, a drop in backlog, or a change to non-critical tasks an isolated delay may have little to no schedule impact on the overall vessel or program.

By reviewing manpower loading, shop demand and capacity, facility constraints, variances, and actual schedules, critical paths in the production cycles become evident. Applying standard durations and sequencing based on historical planning data determines whether the shipyard has utilized its available resources in an efficient manner and whether schedule delays may have inevitably impacted a critical path event.

**Quantification Methods**

Lost labor productivity claims must be quantified using direct labor hours, as productivity is not based on the economics of wages or cost data. Due to the dispersed interests among shipbuilders, owners, and insurers, lost margins cannot provide proof of entitlement nor linked to causation. It is important to address contractual entitlement to make claims, as misinterpretations and objections between shipyard management and vessel owners can lead to further differences.

In establishing a lost productivity claim there are benefits and shortfalls to each method. Even if using similar methods, two parties may produce different results due to independent interpretations and different sensitivity tests. One quantification methodology rarely equates to another, thus validating a claim by comparing multiple approaches can prove ineffective. This document will not attempt to explain and analyze all the differences, but it is clear that gaining acceptance of a common quantification method through negotiation and mediation or other means is pivotal to establishing a bargaining zone for settlement.

A reliable methodology must establish causal links. Addressing causes up front in the data collection process described above will improve claim facilitation efforts by resolving differences swiftly, preventing further damages, and avoiding drawn out challenges.

*Project Based Model*

While considered more reliable, comprehensive project-based models are challenging for shipyards to develop. For example, a measured mile analysis would require a comparable undisrupted period for a specific vessel and the period must be long enough to produce an accurate pre-event productivity measurement. Shipbuilding programs generally do not exhibit the steady state nature of a manufacturing plant. Shipbuilding productivity between first of class and last of a class vessels may be difficult to reliably compare. As a vessel moves through the various stages of construction, different snapshots in time reveal the impact of unique combinations of manpower, process, and material. They are therefore not reliably comparable to another time period. An earned value method is another project-based approach that can be easily discredited, because comparing earned hours to actual hours relies on the validity of the shipbuilder’s budget. A budget forecast will provide worst case, most likely, and optimistic estimates. Another party can contest that the claimant is using an overly optimistic projection.

*Total Cost Accounting*

While useful for rough order estimates and forecasting, cost methods are unreliable for claims. Because accounting data are used to calculate lost margins, this method introduces the economics of labor rates, wages, overtime, premium allowances, capital costs, and other indices into the calculation. These accounting forecasts are not linearly associated with labor output, thus true productivity is not represented. While the modified total cost method attempts to isolate shipbuilder- and owner-responsible costs, this top down method fails to designate responsibility for unknown inefficiencies. The claimant would not be establishing causal links to these significant unknowns.

*Industry Standard Approach*

Despite efforts to compile descriptive metadata, there are generally gaps and omissions, and the rationale for shipbuilder and owner decision-making is not always captured. A shipyard-specific factors methodology can estimate these missing facts by applying best practice productivity standards. A shipyard-specific factors analysis is based on adjustment elements from various shipbuilding institutions and expert opinion.

Impacts may vary significantly in magnitude and duration. Each factor must be analyzed for vessels in various stages of construction, each vessel having its own unique sequencing and durations of impacts throughout the period of interruption. Illustrated in Fig. 3 are examples of the most pervasive factors for each stage of construction.

|  |  |  | *Minor Impact* | | | | | | | | |  | *Moderate Impact* | | | | | | | | |  | *Severe Impact* | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *Fabricate and Build* | Out-of-Sequence | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Infrastructure |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Less Experienced Work Teams | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Material |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Level of Effort |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Decrease in Productivity | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Supervision |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Reassignment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Shop Disruption | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| *Integrate* | Decrease in Productivity | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Out-of-Sequence | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Material |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Less Experienced Work Teams | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Level of Effort |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Reassignment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Supervision |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Shop Disruption | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Infrastructure |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| *Test and Deliver* | Decrease in Productivity | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Supervision |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Infrastructure |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Material |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Out-of-Sequence | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Level of Effort |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Less Experienced Work Teams | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Reassignment |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |
| Shop Disruption | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |  |

*Fig. 3 – Shipyard Impacts to Vessels at Various Stages of Construction*

**Cumulative Disruption**

Cumulative impacts occur when multiple changes disrupt unchanged work in the same vicinity. The network of impacts drives greater extra expense, over and above the individual estimates. This ripple effect, analogous to the interaction of ripples from throwing stones into a pond, is a physical cost of multiple disruptive events and can be estimated. Extra direct labor hours caused by the cumulative effect of multiple changes in a shipyard is based on a ratio of disrupted hours to baseline hours and a degree of impact.

The “NAVSEA guidelines” for the quantification of change orders hypothesizes that “the disruption which occurs between two or more change orders and basic work and is exclusive of that local disruption that can be ascribed to a specific change. It is the synergistic effect of changes on the unchanged work and on other changes.” [NAVSEA 1982]

The calculation is based on a percentage ratio of impacted hours (changed) to baseline hours (unchanged). For planned changes, applying a low to medium cumulative disruption factor is appropriate based on the degree of disruption, often informed by the nature of rework and level of planning.

**Quantification of Direct Labor Hours**

The major elements that make up the total man-hours logged during a disrupted period are:

* Baseline hours
* Owner and/or builder impacts
* Disruption impacts
* Cumulative impacts

When quantifying lost labor productivity, the impacted hours, captured during the proposed data collection process, can be readily addressed separately from the baseline hours.

In any estimating methodology the process itself is not exact, thus attention to the accurate allocation of collected man-hours is paramount. While the current methods used to calculate lost productivity have been utilized successfully, misapplied approaches and missing facts can degrade lost productivity findings.

Objectivity is critical in collecting data, supporting claims, and validating quantifications. An unbiased viewpoint precludes errors and omissions and thwarts erroneous objectives. Failing to establish causal links and agreement on a calculation method are principal sources for disputes in settling claims.

AGREEING ON THE ANSWER

The fact-based strategies, data design, and analyses described above will require new thinking on the parts of all stakeholders in shipbuilding programs. The ideas presented in this paper are just the starting point in an effort to improve the analysis of shipbuilding disruption.

The goal to achieve results that are accepted by owners, builders, and insurers suggests that the effort may be best administered by impartial claim adjustment teams – working with the parties to agree on the approach, developing the data structure, and using the data to calculate delay and disruption and support each claim element with documented causal links. Scheduling, workforce trends, performance analysis, facility impacts, and financial performance can be assessed and woven into the framework of the claim. The broad perspectives of experienced claim teams collaborating with shipyard management, owners, and insurers increase the likelihood of appropriate settlements. Such an approach frees up shipbuilders to do what they do best – building ships.

CONCLUSIONS

Ideally, data collection, claim methodology, and settlement should be a joint effort. All stakeholders can benefit from collaboration because they have access to different information and can provide input from varying perspectives. The collaboration can be enhanced and applied most effectively if the parties are not hindering the very start of the process by questioning the validity of the data offered by both sides.

Sophisticated shipbuilders and owners must understand contractual obligations and objectivity in planning, scheduling, cost accounting, and management of shipbuilding programs. A strategic framework for approaching data collection associated with a disruptive event can bring order to misguided proceedings. Independent experts can often provide guidance in structuring the new data identification and gathering framework, can play a role in the data collection and discovery process, and can validate claims and methodologies by establishing cause and effect. Leveraging their broad knowledge of the entire process, they can work with stakeholders as potential problems are identified and challenges or rebuttals are considered, thereby dismantling roadblocks to the final settlement.

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This paper has drawn on the experience of the consultants of Maritime Management Consulting (MMC) to describe the types of disruption and challengers that occur, the types of data that are needed to settle disagreements, why such data are lacking, and the attempts builders and owners make to estimate the missing facts. MMC has suggested strategic approaches to claims to ensure owners, builders, and insurers can obtain the required facts.

MMC personnel have worked with ship builders, ship owners, insurers, arbitration boards, and attorneys as these various parties have wrestled with identifying and quantifying the events, changes, and resulting delays and disruption that were not anticipated when shipbuilding contracts were signed.

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