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Shipyard Painting Facility Design Considerations

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Construction in a modern shipyard is a complex undertaking, involving multiple trades, uncertain schedule deadlines, supply chain interruptions, and cost estimates in constant flux. One vital trade, often the final step in the workflow prior to final erection, is the painting of components vastly ranging in size and complexity. This paper offers considerations to assist in development of the size, and configuration of blasting and painting facility design.

KEY WORDS: Facilities for painting and blasting; coating; critical path; environmental controls; workflow; booths.

INTRODUCTION

Since coating work is always on the critical path there is often schedule pressure, depending on the work progress prior to reaching the painting stage. Accordingly, the design of the facilities in which the surface preparation [blasting], priming, and final coating are performed is likewise a complex task, as there are many factors to consider. The ultimate goal of optimization of the size, number, and configuration[s] of the buildings in the facility is to maximize productivity of resources including manpower, machinery, and ancillary equipment while maintaining schedule and achieving reasonable commercial goals. This paper is to assist in such design by identifying the many factors to be considered in the design, and how they fit into the overall shipyard work processes.

TOPICS

The Topics to be discussed herein include:

- Contractual Considerations
- Planning & Scheduling
- Facility Design Life
- Facility Location and Orientation
- Facility Sizing & Configuration
- Building Options
- Workflow
- Facility Primary Equipment Systems
- Optional Ancillary Equipment

Definitions

"Facility" refers to the entirety of the blasting, painting, booths, and any supporting structures, including warehouse, dedicated laydown areas, etc.

"Coating" refers to all the activities performed by the contractor within the facility as defined above.

CONTRACTUAL CONSIDERATIONS

The coating contractor may be a direct part of the shipyard organization or may be a separate independent entity working under one of many contractual bases, which could include fixed cost, time & material, unit rate, or a hybrid of these. The primary difference between contractual bases is the assignment of risk, which can become an increasingly important issue as the work progresses and schedule delays and/or cost impacts arise.

As the coating work occurs between the fabrication of modules and the subsequent erection into the ship's structure, any delays that may have occurred prior to delivery to the facility for coating will be essentially passed on to the coating contractor, and acceleration of the coating work may be necessary to get the schedule back on track. Such acceleration regularly comes at the expense of increased cost. Depending on the contractual relationship with the shipbuilder the equitable recovery of such increased costs can become very important. The facility design can complement the means to perform such acceleration, but such capabilities naturally increase the capital cost of the facility. Accordingly, every consideration discussed herein must be mindful of this context.

The use of a sub-contractors versus having shipyard labor to achieve the same scope may drive work to be completed in a different manor.

PLANNING AND SCHEDULING

As the primary focus of this paper involves coating, the most essential factor is having a mutually acceptable plan of execution that addresses schedule and the anticipated flow of work through the facility. This enables planning of resources, both human and equipment. It is well known that when the work area becomes crowded, productivity suffers, leading to increased costs and schedule slowdown. These activities should be well-defined and appropriate durations established, so the overall project schedule can accurately reflect expectations.

For any CPM [Critical Path Method] schedule, the Plan is the **Input**, and the Schedule is the **Output**. Stated otherwise, if the work is performed per the Plan and the activity durations are appropriate, then the work will be completed as the Schedule shows. Sometimes, however the plan development must follow the schedule requirement. Delays and disruptions [e.g., supply chain delays, weather events, labor shortages] will negatively affect the schedule, the magnitude of which will be reflected as the Schedule is updated. If the CPM is resource loaded, contractors can plan accordingly and balance labor with the workload as it progresses.

FACILITY DESIGN LIFE

If the shipyard is new construction, the facility design life becomes a factor, as it should consider the types and sizes of vessels anticipated to be constructed therein over the long term, which obviously affects the overall facility design.

FACILITY LOCATION AND ORIENTATION

If the land space allocated for the facility is limited, consideration for booths that can perform both blasting and painting might be a suitable option. Although these booths cost more due to the inclusion of equipment for both processes, there is a schedule benefit of not having to move the components from the blast booth to the painting booth, which would be a cost benefit to whomever performs such transfers. A cost-benefit analysis would be helpful in this decision.

Additionally, the facility's orientation may influence the design, especially the location and size of the laydown area. This area is crucial because components will be regularly moved there for curing between coats, keeping the painting booth in use. This becomes particularly important if you need to move blasted but unpainted components to the laydown area. Depending on the climate, these components can quickly corrode, requiring rework. Therefore, having the laydown areas close to the booths would be highly beneficial.

Also, the facility should optimally be positioned such that the completed components can be readily and directly transferred to the erection contractors for assembly into the ships structure.

FACILITY SIZING & CONFIGURATION

The decision on the size and number of buildings is obviously the most important consideration in the cost-benefit analysis when making key design decisions. The first factor is the size of the components themselves and the number and frequency of their processing through the coating facility. This ideally will have been discussed in planning meetings so all parties are in agreement of how the work will be executed. If these components are on the scheduled Critical Path [as is typical with coating work], it might be prudent to have multiple-sized buildings so structures of different sizes can be coated simultaneously to maintain the schedule.

Smaller components [e.g., chocks, collars, clips, small foundations, method mounts] typically do not vary significantly for different types of ships [frigate, cutter, tanker, container ship] so having a building dedicated to those components might be a good choice, as that building would be used frequently and more continuously, thereby enabling consistency of resources and improved productivity.

Next in the design planning phase is to understand how the work will be processed though the coating facility with different numbers of booths, and how the schedule would be impacted.

Following are hypothetical examples.

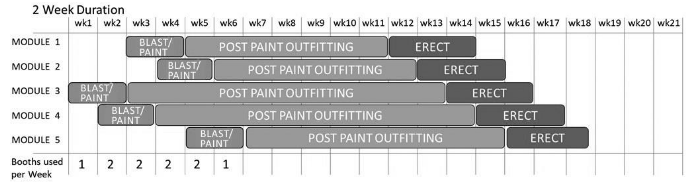

Fig. 1, 2 Week Duration, 2 Booths

In the chart above a total of 5 modules are depicted assuming these modules have a 2-week required duration for the blast and paint scope. They have varying durations for post-paint outfitting, as is common in shipbuilding. Subsequently, there is a 3-week erect window for fitting and stacking the modules in order from 1 to 5, which further assumes there is a single set of cranes capable of lifting the modules. The bottom chart row indicates the number of paint booths in use weekly. The total duration of this example, from the first blast and paint to the last erect, is 18 weeks as shown.

This example is set as a baseline for the other figures to be compared against.

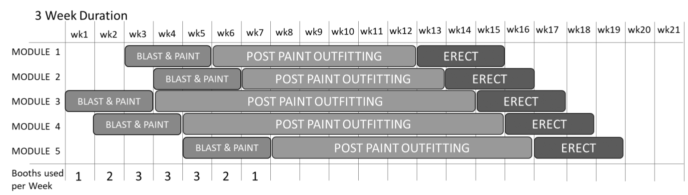

Fig. 2, 3-Week Duration, 3 Booths

In Case 2 a 3-week duration is substituted for the 2-week duration used in Case 1. Maintaining the same erect schedule results in a schedule extension of a week, as would be expected. But this also creates an overlap in the Blast & Paint work, necessitating an additional booth in use in three of the seven weeks. This emphasizes the importance of agreeing to the durations, so the coating contractor/shipyard labor can perform a cost-benefit analysis during the facility design phase.

While extending the blast and paint activity merely a week might seem insignificant, it actually provides significant impact to rhythmic consistency and overall capacity. The main concern in this example is of course the capital cost of the additional booth.

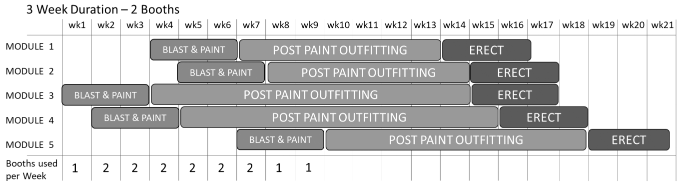

Fig. 3, 3 Week Duration 2 Booths

Case 3 maintains the 3-week blast and paint durations and a total of 2 booths and the same durations for all other shown stages of construction, resulting in an overall schedule extension of 3 weeks. What has happened here is the blast and paint durations must be staggered due to the use of only 2 booths for most of the schedule. The blast and painting of Module 5 cannot begin until Module 1 is completed and its booth becomes available. This causes the delay. Fewer human resources working consistently increases productivity, but the schedule pays the price. If this schedule is acceptable in the overall Plan, this strategy should prove to be equal to the capital cost to Figure 1 while allowing more flexibility should problems arise.

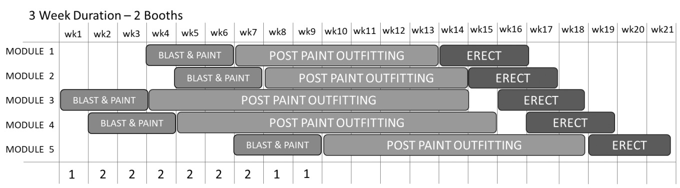

Fig. 4, 3-Week Duration with Erect Sequence

Case 4 maintains the 3-week blast/paint duration and a total of 2 booths. As shown in this example, a gap appears for modules 3 & 4 due to module 5 coating completing late, due to waiting for the booth used for Module 1 to become available. The difference between Example 1 and this sequence is the additional week of blast/ paint while the difference between Example 3 and this sequence is the prioritization of the erection sequence. Module 3 cannot begin simultaneously with Module 2 due to insufficient ability to transfer the multiple modules. The erection crews for modules 3 & 4 would be idle for a week, essentially wasting resources and increased cost. This example further emphasizes the importance of strategic planning and coordination with the erection contractor[s], who would bear the cost burden of the week of lost productivity.

BUILDING OPTIONS

Understanding what types and sizes of modules and components will be processed through the coating facility will inform key design decisions.

If the module is a single inverted deck, there is limited blast and paint scope. If it is a 3-deck tall module that is outfitted between all three decks, then the blast and paint scope will be significantly greater, primarily due to the density of the paint work required.

If the facility is designed primarily for single deck modules this would necessitate the modules to be combined during erection, so the design should consider options to optimize the overall work for the process.

By way of example, if the facility was a 2-cell booth capable of painting a main machinery space and an AMR (Auxiliary Machine Room) sharing a common bulkhead, a door can be included between these work areas that enables the simultaneous use of both cells, thereby gaining a construction advantage by not needing to go down and crawl through the bilge to do it later.

Such a facility could be designed with multiple cells such that the modules could be easily moved from blast to paint.

Another important design factor is the ability of the facility to move components within the facility itself without participation by other contractors. This improves the schedule for the overall benefit of the project. This primarily relates to the inclusion of overhead traveling cranes. This in turn necessitates a stronger supporting structure, which would increase capital cost, the amount of which would be dependent on the weight and size of the components intended to be moved within the facility. Another cost-benefit analysis would inform any decisions in this regard.

Examples of such facilities are depicted in Figs. 4-10.

WORKFLOW

Ideally the combination of all these factors would create a correctly sized facility in accordance with durations, capacity and throughput requirements. This facility would be placed in an area within the shipyard that would not require an out-of-sequence workflow. Preferably, the facility should be placed between the areas in the shipyard where the scope is accomplished. Understanding that land is a premium in most shipyards, this placement can be a challenge and may require relocation of different buildings or maybe the modules need to travel some distance to get to the correctly sized facility erected in an available location.

This concept also applies to a small parts facility, wherein utilizing the most strategic location prevents transportation and logistics from becoming a hinderance to the overall process.

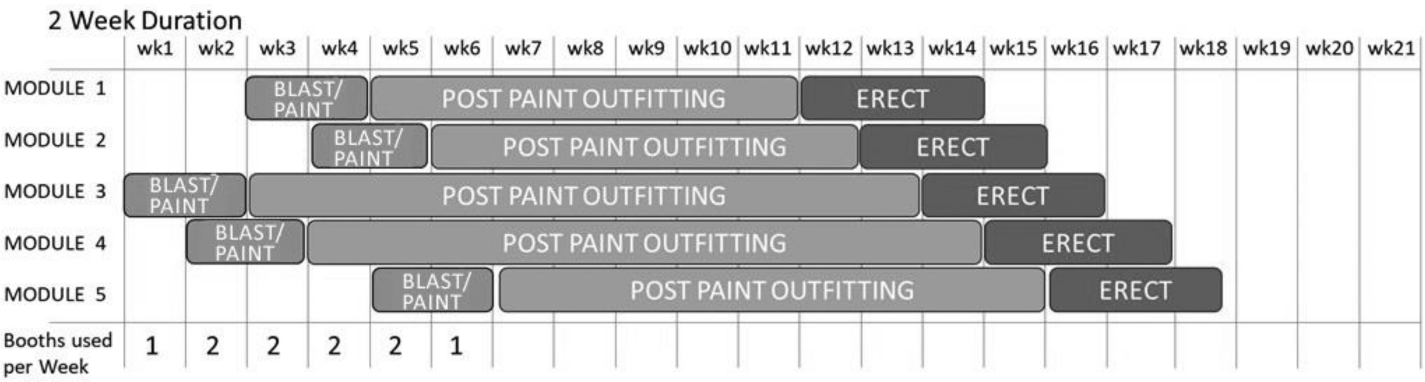

Fig. 1, 2 Week Duration, 2 Booths

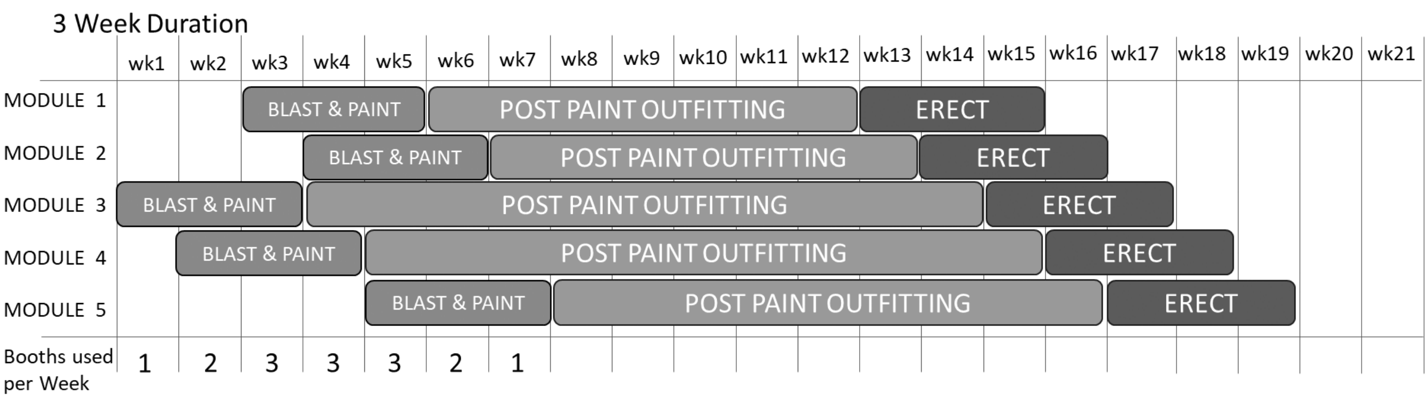

Fig. 2, 3-Week Duration, 3 Booths

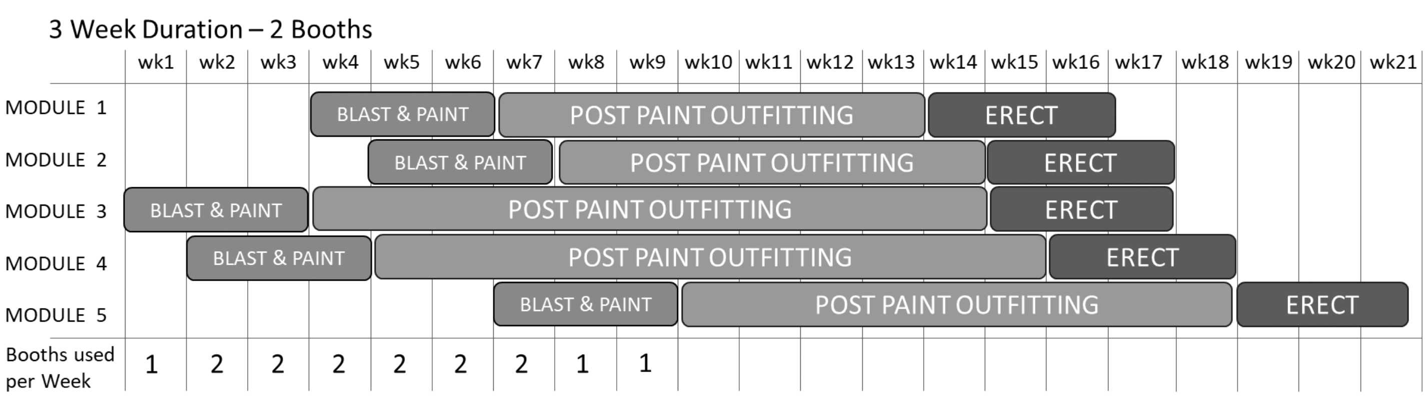

Fig. 3, 3 Week Duration 2 Booths

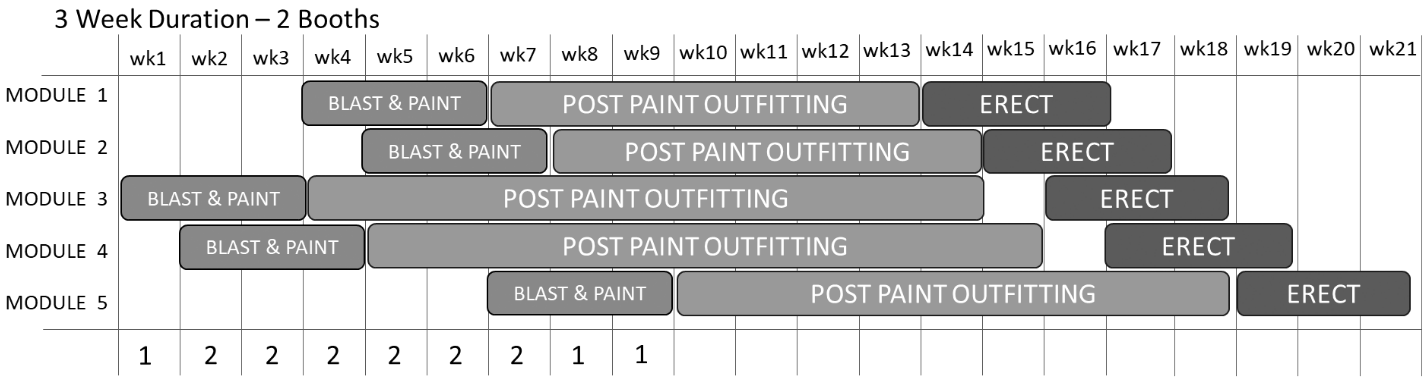

Fig. 4, 3-Week Duration with Erect Sequence

Fig. 5, Blast and Paint Booth with Middle Door View 1

Fig. 6, Blast and Paint Booth with Middle Door View 2

Fig. 7, Blast and Paint Booth with Middle Door, 4 Cell Arrangement

Fig. 8, Blast and Paint Booth with Middle Door and Overhead Crane

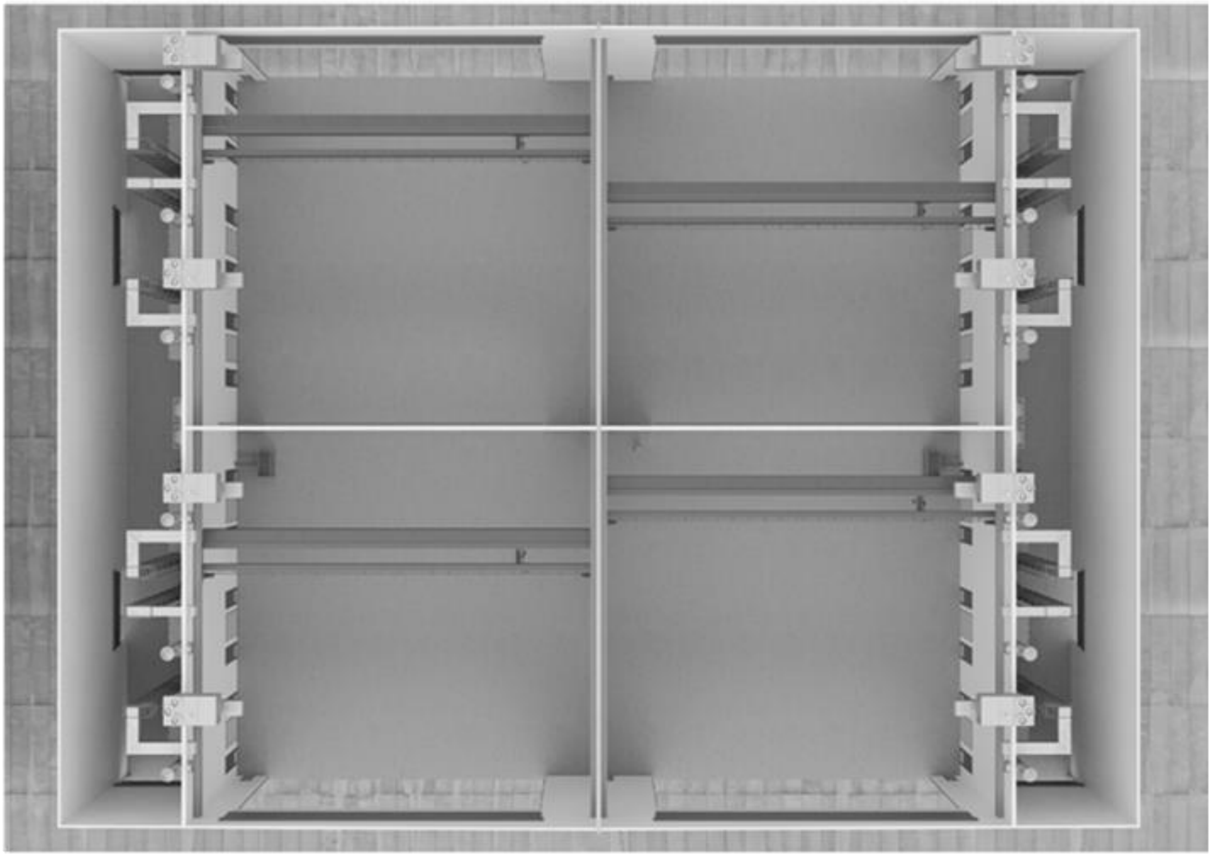

Fig. 9, Blast and Paint Booth with Middle Door and Overhead Crane – Roof Hidden

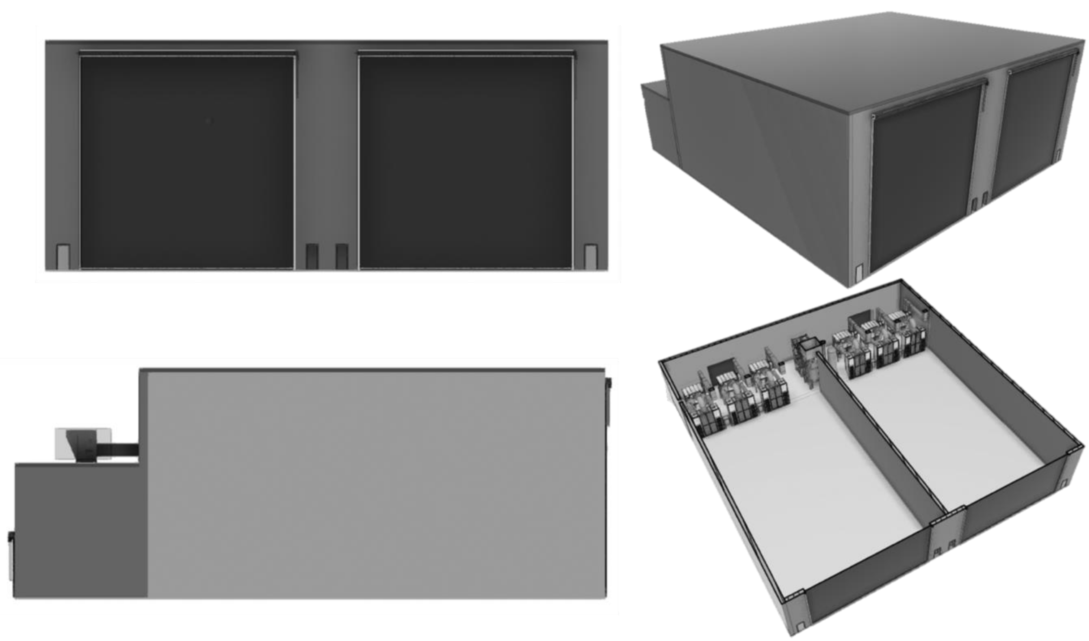

Fig. 10, Blast and Paint Booth with Two Cells, Forward Door Arrangement

FACILITY PRIMARY EQUIPMENT SYSTEMS

Every facility building requires primary equipment systems essential to the design. These include climate control, dust collection, blast media handling, VOC (Volatile Organic Compound) capture and processing and noise abatement. These require different technologies and equipment and collectively are major drivers of capital cost.

First is the issue of climate control. This will be highly dependent on the location of the shipyard. NOAA historical data is available to assist in the design of such systems, although this effort is complicated by climate change, and to what extent it might be attenuated by worldwide efforts. So, the design should anticipate continued worsening of climate-related events over the design life of the facility, with the potential of upgrading such systems as required in the future. Any cost-benefit analysis in this regard should be viewed with an appropriate degree of uncertainty.

HVAC is a major cost factor in facility design and is dependent on the overall size of the facility and the local weather. The cost for ventilation of such facilities can be exponential to the floor space dependent on the height, which is in turn dependent on the height of the modules to be coated therein.

There are newly developed systems that combine technologies that can be considered appropriate for any facility.

These can optimize the air flow of the blasting and painting system via integrated plenums covering everything from air compressors to blast hoses that optimize pressure for noise reduction while simultaneously incorporating dust collection. These systems are complex and when properly designed, sized, and implemented, can be both highly effective as well as cost effective.

Blast media handling is an important and necessary issue in the facility design as well. One consideration is the selection of the best media for the application. While this might vary for different components there are some media types that are often better in terms of recycling. Additionally, there are often local regulations [e.g., proximity to the water] that may drive the media selection decision[s].

Cost of the selected media is another factor in this decision. Some media [e.g. garnet] has an advantage of being capable of multiple recycles while others [e.g. steel grit] have potential explosive factors that necessitate different vent systems for dust collection. These have different initial costs so another cost-benefit analysis would be helpful in the design decisions.

Another design decision is the type of blasting equipment to be employed in the blast booths. There are now available blast systems that are essentially dust-free, with the dual benefit of a lesser requirement for dust collection and a personnel safety benefit.

An example of one such system is shown here.

Fig. 11, Mist Blaster Example

Blast media recovery is another essential facility system that must be considered in the facility design. This is dependent on the media itself as previously discussed as well as the number, overall size and configuration of the blast booth[s].

One example of such system is shown here.

Fig. 12, Blast Recovery System

Scaffolding

One of the most essential items in any blast or paint booth is scaffolding. There is the option of having traditional erected scaffolding, or portable, rolling scaffolds. The primary impact difference is schedule-related, as traditional scaffolding takes a significant amount of time to erect and breakdown, whereas the portable type can be employed very quickly and relocated without delay.

There is also the issue of storage, which may require a significant amount of floor space. In this case, consideration should be made for a separate adjacent building which doesn't require much beyond ventilation, which would be significantly less costly than an equivalent amount of floor space in the coating building.

Fig. 13, Portable Rolling Scaffolding

OPTIONAL ANCILLARY EQUIPMENT

Cranage

Having the ability to potentially manipulate smaller components of steel that need to be rotated to paint the entire piece could be a significant advantage in both cost and schedule. Pre-engineered and engineered metal buildings can typically support a 10-ton crane without additional cost. They also can be locked out and moved to a section of crane rails that can be protected from the blasting or paint process. These advantages can be significant and highly cost effective.

The capability of moving larger components within the facility would likely necessitate a stronger supporting structure, increasing capital cost, but nonetheless still might achieve an overall benefit. Another cost-benefit analysis would help inform design decisions in this regard.

Wheel Machines

The coating process begins with receipt of the components [modules, assemblies, sub-assemblies, etc.] and surface preparation begins as promptly as possible. Depending on the type and number of components received, it might be more cost effective to have wheel machine[s] to blast flat plate significantly more quickly than manual blasting. Obviously, the decision is based on the amount of such steel expected in the scope of work and the associated cost-benefit analysis weighing the cost of the machine[s] vs the savings in manpower and time. Ideally, this has been discussed with the shipbuilder and an estimate of such steel has been developed and mutually agreed. The desired schedule should also be discussed, which is also another important consideration in the facility design.

SUMMARY OF ILLUSTRATIONS C

CONCLUSIONS

Designing a Painting Facility for a shipyard can be a daunting and costly endeavor, as there are many factors to consider. While it would be easy to simply design the facility for the largest vessel anticipated to be built during the lifetime of the facility, it would significantly increase the capital expense of construction without any guarantee of recovering those costs.

If the contractual basis assigns all that risk to the Painting contractor, this would be a risky investment, unless there were guarantee of work sufficient to cover those expenses.

As discussed in the narrative, there are many possible facility configurations, each with their advantages/disadvantages, and varying costs.

The cost-benefit analyses suggested herein are therefore difficult and have significant uncertainty.

It is hoped that the considerations discussed herein, despite these uncertainties, will be helpful to contractors faced with the design of such facilities.