Foreign Shipyard Coatings Benchmarking Study

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1. Introduction

Over the last 20–25 years, coatings have increasingly become a bottleneck in the ship production process. During this time the production capacity of the steel work and outfit departments has increased dramatically, whereas the development of the coating process has remained relatively unchanged (Kattan 2007).

The development of the ship production process can be best represented by Fig. 1. This shows how over the last 80 years the time taken to build a ship has been reduced and the overlap of activities has increased resulting in considerable conflict between the coating process and other activities in the yard that have generated a bottleneck in coating activities (Kattan et al. 1994).

To achieve these reductions in build times, shipyards have invested heavily in automation of the steelwork/outfitting facilities and vessels have been designed to suit the facilities of a particular shipyard. Against the background of this reduction in overall build time, the drying time of the coatings and time allocation to related coating activities have not reduced or improved in terms of productivity to any great extent. This has resulted in increased time pressures on the coating process.

That the technology being used is mature is emphasized by the dates of introduction of the predominant technologies in use.

• The abrasive blasting process was patented by Benjamin Chew Tilghman in 1870 (Plaster 1993);
• An “airless spray” paint unit was introduced by the Gray Company in 1958 (Pederson 2005); and
• The first centrifugal-driven blasting machine, often referred to by the brand name “wheelabrator,” entered service at the Burmister and Wain yard in 1960 (Baldwin 1995).

Against this background it is prudent to take stock of the state of the art of coating technology/practices and management to identify any solutions that can be implemented quickly and relatively cheaply to ensure that the current coating activities in any U.S. yard are making the best use of the available technologies. In the medium and longer term such analysis and study should help direct research and development activities to those areas identified through benchmarking as lagging behind in development when compared with the best commercial builders in Europe or Japan.

2. Broad aims

The broad aims of the benchmarking study were to (Surface Reparation Panel 2013):

• Identify suitable candidate shipyards to benchmark against in Europe and the Far East;
• To conduct visits to those yards and view the production process and hold discussions/interviews with relevant parties to better understand coatings issues;
• To assess the feedback and present the results in a meaningful manner;
To determine what short- and medium-term projects could be undertaken by U.S. yards to improve their productivity/performance in relation to coating activities;

To determine what lessons could be learned from commercial shipbuilders; and

To determine what lessons could be learned from other naval shipbuilders.

3. Participants

Of the 13 shipyards involved in the National Shipbuilding Research Program (NSRP), the following took part in the study from the SPC panel:

- BAE Systems;
- Marinette Marine Corp.;
- GD Bath Iron Works;
- GD Nassco;
- HII Newport News Shipbuilding; and
- Vigor Shipyards.

In addition, the SPC panel invited its key customer, NAVSEA, in the study. The yards were supported by the project manager, Elzly Corp of the United States and coating consultants Safinah Ltd. from the United Kingdom. Some of these yards carry out only new construction, whereas others carry out a combination of new construction and repair work (commercial and naval).

4. Project overview

The visit team was paired up with each pair of observers given a set of key areas to focus on. Each team member had an audit system provided by Safinah Ltd. to guide the process and ensure that all required aspects were covered. The yards had received advanced copies of this so that they could also prepare to make...
the best use of the limited time available at each yard. Each visit was 1 day long split into three sections:

- Opening discussions and presentations/review of the coating process;
- Physical walk through the facility; and
- Final review and outstanding question and answer session.

At the end of the day, the visit team had a wash-up meeting to collate the results from that particular visit and at the end of each trip (Europe/Japan), a 1-day workshop was held to collate all the results and discuss areas of ambiguity or the need for further information and to make assessments.

For a site visit the coating issues were broadly classified under the following headings:

- Preproduction: this covered, tendering, estimating, and planning activities;
- Ship design: the design process in the yard and how much it took ease of coating into account;
- Facilities and production technology: this covered a physical inspection of the facilities and equipment in the yard related to all aspects of coatings (including for example material handling/transport);
- Coating activities: the physical process was viewed as far as practical including the primer line, secondary surface preparation, application, touch-up, and repair;
- Coating materials: understanding of the supply contract and services provided and products used and the decision processes involved;
- Specifications and product selection: how coatings were specified, the role of the customer and supplier, and how lessons learned were applied;
- Management systems (including quality assurance/quality control and planning): review of the procedures and processes of the yard and how they compared with U.S. practices;
- Environmental: discussion with regard to regulations and practical application of the regulations;
- Human factors: aspects such as retention/turnover of personnel, training, etc.; and
- Miscellaneous: any other aspects that were relevant to the yard, e.g., relations with class and suppliers.

To ensure all aspects were covered, a survey questionnaire was prepared before the visits and team individuals assigned to assure that topics were addressed. They were also sent out in advance to the yards to ensure adequate time for translation and any clarifications so as to maximize the use of time during visits.

The first key step was to determine which foreign yards should be visited and would be amenable to an exchange of information with the project. All yards that took part were provided with the final benchmark report in a suitably redacted version.

In the end it was decided to concentrate on northern Europe, because of their size and volume of output, benefit from a number of factors that influence how they paint. They have real purchasing power and hence can dictate to suppliers and their clients in terms of designs and specifications, whereas the demand for their slots/capacity by owners often allowed them leeway in negotiations that are not available to other yards. The priority for the project was to find short-term benefits and gains. Without doubt there would be merit in a subsequent benchmarking study with Korean yards once the short-term fixes have been implemented.

An agenda was developed that would fit with an allowance of a 1-day visit to each yard and the visit team members were allocated specific topic areas to focus on. Broadly the visit was split 60:40 between discussions/questions and answer sessions and a physical tour of the facilities. The people hosting in the yards were all directly responsible for the coating activities and were able to provide both high-level overviews as well as detail on the processes adopted.

5. Yards visited

Four yards were selected in northern Europe; three of the yards were visited while the fourth yard (a warship builder) met with the team at a convenient location and provided a half-day overview of their processes and procedures followed by a half-day discussion. The yards will be referred to as:

- Europe 1—warship builder;
- Europe 2—builder of small complex vessels for offshore and dredging;
- Europe 3—cruise ship builder; and
- Europe 4—cruise ship builder.

The visit to Japan included four visits but the first visit was not to a yard. Instead a visit was organized with Class NK who often act as a hub for major collaborative research and development projects and had recently funded a number of coating-related projects within the shipbuilding industry in Japan. They invited a number of paint suppliers, equipment suppliers, and paint contractors as well as inviting their own in-house coatings experts. The yards visited were:

- Japan 1—builder of commercial and naval vessels;
- Japan 2—builder of commercial vessels; and
- Japan 3—repairer of naval vessels.

The commercial yards visited are among the most efficient in the world with the ability to deliver nine commercial vessels from a semitandem dock in 1 year.

6. Coating activities

Before considering the benchmark study results, there is merit in summarizing the key differences between the coating activities as carried out on a commercial ship as opposed to naval vessels. These observations are based on information gleaned during the visits.

Keeping in mind that the U.S. yards are primarily driven by U.S. Navy-based customers and the yards visited were primarily/
exclusively commercial builders, one of the key areas of interest for the benchmark team was to understand any differences that arose in quality assurance/quality control systems, in particular against subsequent claims/failures.

In this respect, perhaps one of the most salient observations can be summarized as follows:

“The commercial owner inspects the ship before he takes delivery. The Naval owner inspects the paperwork long after the ship has gone.”—Shipyard manager from one of the Japanese yards visited building both naval and commercial vessels

Whereas this may not be a true reflection of the physical process, it perhaps does reflect the perception that naval vessels in general generate more documentation than their commercial equivalents to arrive at a similar outcome. It may also reflect that the commercial owner has less power over the shipyard and therefore uses physical inspection to mitigate risk while work is in process, whereas the naval owner focuses on the document review.

Coating activities are generally undertaken in four locations at a new building:

- Primer line;
- On block;
- Posterection; and
- Postlaunch.

For the purposes of this study, the preconstruction primer line has been ignored because it is an automated process with little differentiation from one yard to another.

The remaining three locations are simply split into two:

- At assembly (on block); and
- Posterection.

Based on the Japanese yard data, for a typical commercial ship, the breakdown of man-hours expended on surface preparation and coating work would fall into the following ratio:

- At assembly—40–45%; and
- Posterection—55–60%.

Whereas for a naval ship, the figures would be:

- At assembly—10–15%; and
- Posterection—85–90%.

Whereas the exact figures of man-hours used are not relevant and would generally be commercially confidential, it is clear that for both commercial and naval vessels, the greater surface areas treated are usually at assembly, the smaller areas posterection, and the resultant hot-work damages and repair can consume significantly more man-hours.

Based on European yard data, the cost ratio of carrying out work at assembly when compared with posterection is a 12-fold increase in the price per square foot, i.e., if it costs $1 at assembly, it will cost $12 postlaunch per square foot.

A study carried out by Safinah Ltd. in the mid-1990s showed that in a commercial yard, carrying out first-time coating activities at assembly was typically 2.5 times cheaper than carrying them out posterection.

A benchmark study carried out by Safinah of the U.S. yards under a previous NSRP study gave the following values as shown in Table 1:

<table>
<thead>
<tr>
<th>Unit of Measure</th>
<th>United States</th>
<th>Asia</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man-hours per GT for coating activities (primer line, assembly, and posterection)</td>
<td>100</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Cost per GT for coating activities (primer line, assembly, and posterection)</td>
<td>100</td>
<td>11</td>
<td>81</td>
</tr>
</tbody>
</table>

On the face of it one could wrongly conclude that the U.S. yards lag considerably behind their international rivals. However, this would not be entirely true. The reasons are that naval vessels tend to be relatively smaller and more consistently complex vessels. A paper published in 2007 (Noel-Johnson & Kattan 2007) considered a measure of complexity as a relationship between the total enclosed volume of the hull and superstructure against the lightship mass. On that basis, naval ships were on average significantly more complex than even quite complex commercial vessels such as RoPax ferries. Other studies carried out by Kattan at Newcastle University in the early 1990s (unpublished data) confirmed this by assessing CGT relationships for naval and commercial vessels.

In general naval vessels incur a far greater number of design and engineering changes through their construction period when compared with commercial ships because many commercial ships are built to a shipyard’s standard design and commercial owners discouraged by increasing costs to any deviation from the standard. The increased changes found in naval vessels can be a function of many factors including:

- Relatively low level of design maturity at start of build and the resulting:
  - Required upgrades and design changes resulting from the relatively long build period;
  - A difference in the coating strategy adopted with a greater acceptance of posterection coating work by naval yards (accepting that there will be hot-work damage resulting from design and engineering changes); and
  - The relative inability to close off spaces and not needing to be re-entered once completed, resulting in damage to coated surfaces.

The painting specification is generally more onerous than commercial ships in the following key areas:

- Documentation requirements (as also evidenced by a previous NSRP SPC Project–Paperless QA) (Boyd 2013);
- Surface preparation requirements;
- Total coats of paint applied in the chosen schemes;
- Increased inspection burden; and
- Generally a greater amount of paint is specified for many benign areas.

In addition it should be noted that within the United States, the behavior of navy yards and commercial yards can vary significantly. For these reasons it should come as no surprise that the U.S. yards direct productivity measures are likely to appear worse. In fact, from the trip and in discussions with Japan 1, which builds both naval and commercial vessels, the productivity achieved for commercial ships was approximately three times better in square
meters per man-hour than their own productivity on naval ships. If this factor is used on the data in the previous table, this shows that U.S. yards building naval ships do lag significantly behind their Far East counterparts.

All these factors reinforce the need for finding better engineering solutions to the coating of naval vessels and the removal of any extra work and effort (in particular documentation and audit oversight) to allow increased focus on the practical process that really matters. It would be wrong to conclude that commercial shipyards have solved the problems of coating ships. They have not. However, they have better optimized their processes and aligned them with their build strategy.

One of the common themes that came to light in the discussions with the yards visited is that all the yards are pretty much using the same technologies for surface preparation and coating application (no one had some magic tool or equipment that others had not considered or seen equivalent of). However, the availability of some small tools (e.g., Perago wheel for mechanical surface preparation) may offer some benefits to some of the U.S. yards. The main differences would seem to have stemmed from:

- Integration of coating work with other activities;
- Improved design to assist coating work; and
- Allocation of man-hours for hot-work damage and repair to the departments who cause them to be incurred (let the extra work be reflected in the man-hours/cost of other trades).

7. Commercial process

The commercial quality assurance/quality control process of inspection for coatings is generally much simpler than for a naval yard process. One new feature that has emerged for commercial ships is the need to create an “as-built” record of how ballast tanks are coated (The Coating Technical File as required by the IMO Performance Standard for Protective Coatings). This has resulted in a number of the yards developing some form of computerized record-keeping system (Prime ship by Class NK and Europe 2 internal system). These have a similar target to the Paperless QA project that NSRP SPC is already undertaking.

The general view is that the commercial process is far simpler than the current naval yard process and presents a less bureaucratic burden on yard while achieving the required quality. There may be merit to simply flow chart the current U.S. shipyard required procedures to understand where they deviate from a commercial shipyard flow chart and to determine the reasons/background to any deviations and to collate the justification for those deviations and reassess the rationale of all of them with a view to streamlining the current process.

8. Weightings and assessments

Given the breadth of the work undertaken and the experience of the various team members, a simple assessment method was developed. The approach took into account two key factors:

- Other benchmarking work already carried out by NSRP and the way the data was presented; and
- Other work done on benchmarking the U.S. yards coating process as carried out by the SPC panel in the early 2000s.

Based on these, then the following approach was adopted:

For each category (as outlined earlier in this article):

A scoring system of 1 to 5 was devised, whereby 5 meant state-of-the-art technology when a particular activity was being adopted and a score of 1 meant a basic level of technology was being used.

For example, at the design stage, a score of 1 would imply that no design for coating is undertaken and no particular standards are applied (e.g., ISO12944), whereas a score of 5 would imply the yard has evidence of a concerted effort to design out known corrosion issues, e.g., taking out mixed metals, reducing edges, increasing access/ventilation.

In all such activities it does not mean that a yard with level 5 across the board is more efficient or productive. The key is for a yard to be at a balanced level of technology across all the aspects and to pick the level of technology that best suits the particular yards cost structure (i.e., do not overspend on technology but do not underinvest).

8.1. Scoring

At the end of the European visit, the U.S. yards were asked to consider the weightings they would give their own yards across the elements. These results were collated and averaged across the United States.

The scoring range 1 to 5 relates to the audit system adopted and as each element was assessed by each individual involved in the visit. The values entered are therefore an average of the findings of the individual team members.

In Table 2 there are two columns for Japanese yards, one including Japan 3 (the naval ship builder) and one including Japan 3. Thus, the first column reflects the technology used in commercial shipbuilding only. The detailed method and approach as well as more comprehensive results and conclusions can be found in the project final report (see references at the end).

The collective results of the project report can be summarized as follows in Table 2.

Thus, it can be seen that coating vessels uses quite mature technology with the results across the yards visited very similar on average. This can be considered both positively and negatively.

The positive aspects are:

- All yards building warships are almost identical in the abilities (Japan, e.g., Japan 3, and the U.S. yards);
- It is likely that the U.S. yards are on a level footing with other yards in terms of technology; and
- The negative aspect is that despite the use of mature technology, the U.S. cost base seems to result in a higher delivered cost per square meter when compared with their Far East rivals. This is interesting in that Japanese yards do not show the employment of a consistently higher level of technology (see Fig. 2) nor do the show a significant difference in the facilities available when compared with the U.S. yards; where they do seem to outperform the U.S. are in the areas of management of the coating process.
In simple terms:

- The U.S. yards lag behind the European builders of complex ships, indicating that there are opportunities for productivity improvements;
- There are opportunities for reducing in-service operational costs;
- It is unlikely that there is a miracle panacea that would solve all the coating issues being faced by U.S. yards; instead, there is a need for a methodical and systematic approach to ensure that the best solutions available are adopted;
- The current technology used is quite mature and hence there is little opportunity at present to make a step change in productivity based on technology improvement without significant investment in research to drive future technology development. This may present a key role for academia in the United States and elsewhere; and
- There would appear to be opportunities to improve the management and control of the coating process.

9. Results

The results from the analysis are presented graphically in Fig. 2. On the vertical axis is the assessed score from 1 to 5 and along the horizontal axis are the different aspects that were assessed, e.g.:

- Ship design;
- Facilities/production technology;
- Etc.

<table>
<thead>
<tr>
<th>Items</th>
<th>Score 1 to 5 U.S.</th>
<th>Score 1 to 5 Europe</th>
<th>Score 1 to 5 Japan Including Japan 3</th>
<th>Score 1 to 5 Japan Excluding Japan 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship design</td>
<td>3.75</td>
<td>4.00</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Facilities and production technology</td>
<td>3.50</td>
<td>4.00</td>
<td>3.2</td>
<td>3.9</td>
</tr>
<tr>
<td>Coating activities</td>
<td>3.30</td>
<td>3.50</td>
<td>3.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Coating specification and product selection</td>
<td>3.30</td>
<td>4.00</td>
<td>3.4</td>
<td>3.5</td>
</tr>
<tr>
<td>Planning and scheduling</td>
<td>3.25</td>
<td>3.60</td>
<td>3.7</td>
<td>3.95</td>
</tr>
<tr>
<td>Quality assurance/quality control management systems</td>
<td>3.25</td>
<td>3.80</td>
<td>3.7</td>
<td>3.75</td>
</tr>
<tr>
<td>Coating materials</td>
<td>3.40</td>
<td>3.60</td>
<td>3.2</td>
<td>3.25</td>
</tr>
<tr>
<td>Environmental</td>
<td>3.75</td>
<td>3.60</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Human factors</td>
<td>3.50</td>
<td>3.50</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Other</td>
<td>3.25</td>
<td>3.40</td>
<td>2.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Overall average</td>
<td>3.43</td>
<td>3.70</td>
<td>3.3</td>
<td>3.46</td>
</tr>
</tbody>
</table>

Fig. 2 Overall results presented graphically
The graph demonstrates a “sawtooth” effect, indicating that all yards are good at some things and not so good at others. Keeping in mind two things:

- The ideal yard would have a horizontal line across all disciplines; and
- Each yard would have a different optimal level (i.e., level 5 may be better than level 3, but level 3 may better fit the yard’s present cost base and capabilities, thus matching investment to capability at any given time).

The limited spread between level 3 and 4 for all the yards across the board confirms that the yards are operating with mature technologies and that although in individual areas there are opportunities for improvement, only the European yards appear to show a consistently higher level of performance.

Some activities show a relatively wide spread of competence, e.g., planning/scheduling, whereas others show a relatively narrow range of capabilities, e.g., planning/scheduling. Key elements relevant to the U.S. yards are singled out as follows:

- Cruise ship builders in Europe had developed innovative design approaches, facilities, and production technology;
- U.S. yards would seem to have opportunities to improve planning and scheduling of coating work, perhaps leading to reduced rework hours and better integration with the build strategy. In addition, better specifications and product selection would enhance productivity and throughput;
- The U.S. yards seem to have opportunities to innovate in the areas of quality control/quality assurance management systems; and
- U.S. yards are ahead of the game in terms of environmental compliance and human factors.

The results indicate that the U.S. yards could improve their coating activities by investing further in the following key areas:

- Facilities and production technologies;
- Coating specifications/product selection;
- Planning/scheduling; and
- Quality assurance/quality control systems.

Based on the scoring, the priority areas would be those where the largest gap exists as shown in Table 3.

These should provide a focus for the medium-/long-term development of U.S. yards.

### 9.1. Short-term benefits

From both Europe and Japan, the U.S. yards were able to take away short-term, small investment opportunities that could have an impact on their immediate performance by merely being exposed to foreign yards that carried out work in a different manner or used different tools/processes. Some examples of these opportunities are:

- Cost savings: temporary protection to reduce rework/touch up by 15–30%;
- Use of paint suppliers to handle logistics of paint supply;
- Undertake some design and build for coating studies (detail design);
- Minimization of paper work/documentation and use of “smart paper”;
- Alternative systems for paint removal (mechanical and laser-based);
- Level of surface preparation in different areas;
- Minimize coating specifications in noncritical areas;
- Standard specifications;
- Volatile organic compound reporting by paint suppliers;
- Testing schedule optimization;
- Use of computer-aided design (CAD) for early area definition; and
- Use of bulk supply paints to minimize waste and standardize processes.

Improved service life:

- Use of polysiloxane topcoats to reduce maintenance and repair (M&R) costs;
- Life cycle plan offered by builders;
- No-liquid paint stores on board (use of adhesive films);
- Alternatives for galvanizing; and
- Use of zinc-rich primers in key areas.

Research and development opportunities:

- Use of robots for tank inspections;
- Use of lasers for coating removal;
- Use of adhesives;
- Training of CAD operators/designers to improve design for coating;
- Use of corrosion-resistant steels; and
- Use of “Konki-jet” abrasive blasting system.

### 9.2. Common themes

Despite the different product types and locations and facilities, all yards did seem to face similar challenges:

- The technology used by all yards is comparable;
- There is a real focus on efficiency and integration in commercial yards;
- The commercial yards seem to work closer with classification societies and regulators to develop win–win solutions, e.g., in allowing painting before tank testing in some instances); and
- Complexity of design (e.g., of naval ships) results in increased man-hours per square foot;
- All yards seek to minimize surface preparation;
- All yards seek to minimize the number of products needed to coat a whole ship;
- The shipyard, paint supplier, and contractor need to work together on planning/scheduling and to minimize quality assurance/quality control documentation;

### Table 3 Target areas for improvement

<table>
<thead>
<tr>
<th>Item</th>
<th>U.S. Yards Average</th>
<th>Other Yards Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities and production technology</td>
<td>3.50</td>
<td>3.95</td>
</tr>
<tr>
<td>Coating specification and product selection</td>
<td>3.30</td>
<td>3.75</td>
</tr>
<tr>
<td>Planning and scheduling</td>
<td>3.25</td>
<td>3.80</td>
</tr>
<tr>
<td>Quality assurance/quality control management systems</td>
<td>3.25</td>
<td>3.80</td>
</tr>
<tr>
<td>Overall average</td>
<td>3.33</td>
<td>3.85</td>
</tr>
</tbody>
</table>
• Selecting coatings to support the build process; and
• Every yard has developed a different strategy to reach the same goal, based on facilities and local circumstances and the product being built.

9.3. Proposed areas of development for U.S. yards

The following projects have been prioritized and are now being fed back into the NSRP program to determine their suitability for implementation.

9.3.1. Short term

The benchmarking team is considering the following key projects to make short-term gains:

• Review of the overall coating process/build strategy to identify opportunities for whole process improvement;
• Improve coating specifications and product selection to get a better fit with build strategy, yard facilities, and capabilities as well as standardize systems;
• Improve planning and scheduling to minimize rework; and
• Improve quality assurance/quality control systems to reduce the documentation burden.

9.3.2. Medium-term projects

The following key elements should be considered for further examination and development:

• Improve ship design for coatings (Broderick 2013); this should reduce the total area to be coated and simplify the structure for fabrication and welding; and
• Review current production technologies and facilities.

10. Summary and conclusions

10.1. The overall experience

Overall the general view of the benchmarking team has been that the experience was very positive on a number of levels:

• Increased awareness and sharing of experiences between U.S. shipyards themselves;
• Increased awareness and sharing of experience with commercial shipyards; and
• Increased awareness and sharing of experience with other naval new build yards.

The process lead to considerable insight has being gained by the U.S. yards into shared problems and challenges and how these have been addressed in different parts of the world and the different approaches adopted to resolving them. It became evident that all yards face the same challenges but that as a result of local conditions/pressure and management commitment, different aspects of the coating process have been addressed to find suitable local solutions from which others could draw if not always emulate.

10.2. Opportunities for cost savings

The opportunities to reduce costs at U.S. yards fall into four categories:

• The immediate take-away projects each U.S. yard may adopt from those identified;
• The opportunities to develop a number of short-term projects that could move U.S. yards toward the better performing yards that were benchmarked as identified;
• The opportunity to develop a number of medium term projects that would allow U.S. yards to focus on those areas where they lag behind some of the yards visited as identified; and
• The opportunity to develop a longer term strategy to coordinate the development of coating technologies to properly integrate them into the complete cycle from design through build to operation.

The exact cost savings that can be made would need to be evaluated to enable the projects to be properly prioritized to ensure that the projects that offer the largest benefits are handled first. This would require NSRP to make a suitable assessment of the benefits of each project and prioritize.

For the medium-term projects, it would be appropriate for some ground work to be undertaken to determine, which have the best chance of success and what options may exist for funding them and if there are opportunities to collaborate with any of the yards visited.

Acknowledgments

We thank the NSRP Executive Board for their support of this project.

References


