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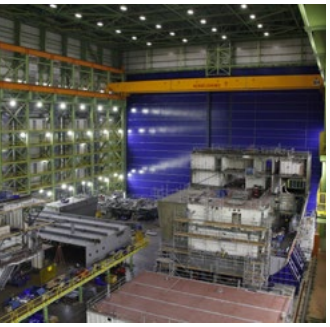
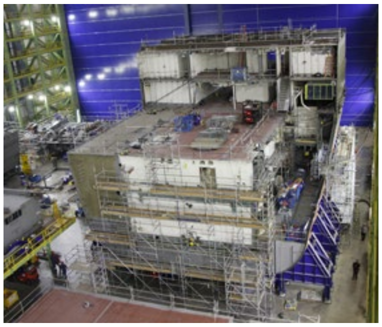
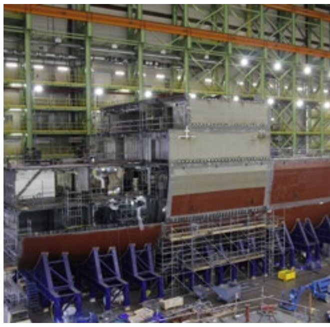
2017 ACEC-CCE AWARD SUBMISSION

Halifax Shipyard Modernization Program







OWNER: IRVING
Irving Shipbuilding Inc.

DESIGN: HATCH

1. Project Description

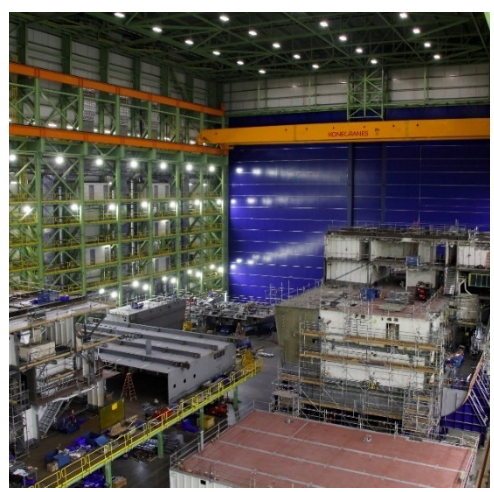
The Halifax Shipyard Modernization Project was the redevelopment of Irving Shipbuilding Inc. (ISI)'s shipyard facility to accommodate the fabrication, assembly and launching of the new Arctic and Offshore Patrol Ships and later the Canadian Surface Combatants Ships as part of the National Shipbuilding Strategy. Using a modular 'mega block' approach, ISI commissioned the design and construction of a massive new assembly building with an integral blast/paint shop, and final assembly and launch pier. With a capital cost of over $350 million, this was one of the largest construction projects in Atlantic Canada. Located centrally on the Halifax harbour front, the new shipyard facility now stands as an awe inspiring representation of the achievements of the engineering profession. The impressive structure is 150 feet high and can be seen from many vantage points in the city, providing a visual representation of Halifax's unique shipbuilding past, present, and future.

Hatch was retained by ISI to be the lead design engineer and construction consultant. Working closely with ISI, the project team overcame numerous technical and schedule challenges to deliver North America's most modern shipbuilding facility. Hatch was responsible for design and construction quality for the entirety of the new facility including:

ASSEMBLY HALL

- 265m long structural steel production hall, including an adjoining office building which includes:
    - A panel line.
    - 75 welding stations.
    - Six looped gas lines.
    - specialized welding fume filtration.
    - 10 overhead cranes with up to 130 tonne capacity.
- Constructed from 4,700 tonnes of structural steel and 12,000 cu.m. of concrete.
- Contains a paint hall with two sealed, fully independent ventilated paint booths.

ULTRA HALL



- 100m long and 46m high production hall with five overhead cranes with up to 200 tonne capacity.
- Houses 25 welding stations.
- Six looped gas lines.
- Specialized welding fume filtration.
- Three 40m high specialized rolling doors.
- Constructed from 4,320 tonnes of structural steel and 10,000 cu.m. of concrete.

NEW PIER 6

- 5,000 cu.m of dredging.
- Construction of a 220 metre long, 16 metre high combination pipe/sheet pile bulkhead.
- Anchor system included pipes, strand anchors and pipe pile anchor pins.
- Finished facility includes a wharf / vessel launching interface.

NEW PIER 8

- Dredging of 40,000 cu metres with 200,000 tonnes of rock fill for land reclamation.
- Caisson rock mattress and slip-form construction and placement of seven 14.6 metre deep concrete caissons.
- Service trench behind cope wall (air/water/welding gases/sewer/460v electrical).
- 1.2 metre thick ship erection platform structural concrete slab and wharf / vessel launching interface.

NEW SITE SERVICES

- 25kv electrical service with looped site system.
- Looped watermain system.
- New stormwater and contaminated water collection system.
- Compressor building with two 1,000 cfm compressors and buried compressed air piping system; fire pump station.
- site gas tank farm and piping for welding gasses.

500 VEHICLE PARKNG GARAGE

- Pre-cast concrete superstructure and decks; foundations on rock fill.

SECURITY BUILDING

- Pre-cast concrete facility entrance building.

DARTMOUTH MARINE FABRICATORS

- Steel fabrication facility located on the opposite side of the harbour in Dartmouth.
- The $28 million facility has almost 9,300 sq. m. of production space.
- This is the facility where suppliers will deliver the raw steel. The steel will then be marked, cut, formed, kitted and delivered daily by truck to the Halifax Shipyard.

Refer to the following page for a high level overview of the site.

$350 million
construction cost

9,000 tonnes
of structural steel

22,000 m³
of concrete

6,000 m
of industrial piping

Completed in
36 months

100% LED lighting
uses 75% less energy than traditional lighting

Halifax Shipyard Modernization Program

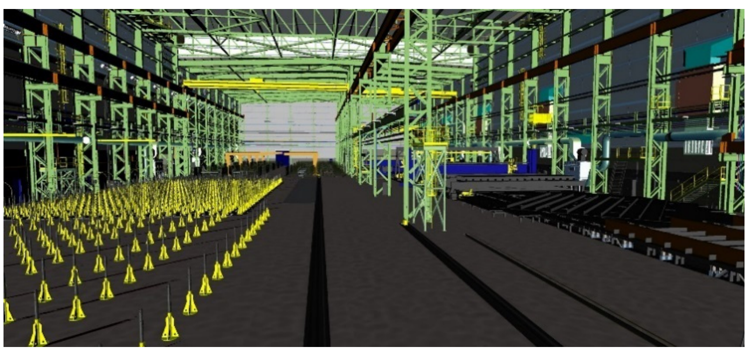
OWNER: IRVING Irving Shipbuilding Inc. | DESIGN: HATCH

2. Innovation

The ISI Halifax Shipyard Modernization Project has many examples of innovative application of engineering principles and techniques. First and foremost, the facility in its entirety is a modernization of the shipbuilding process, and has innovation at the core of the design concept. The layout of the facility is centered around constructing ships in a mega block assembly line, whereby individual sheets of steel are fed into one end of the building, and are gradually assembled into larger pieces (units) as they move through the production area. At the Ultra Hall end of the facility, the units are constructed into blocks that make up approximately one third of a ship hull. Every component of the facility is designed to be state of the art, allowing the modernization of a historic process, and bringing Halifax to the forefront of world shipbuilding. Specific design innovations were numerous, and several examples are provided below.

2.1 Building Information Modelling (BIM)

The ISI Halifax Shipyard Modernization Project utilized the latest tools in BIM technology. Modelling and 3D design were at the core of the design process, in which the entire facility was collaboratively designed, reviewed, analyzed and shared exclusively in Revit with ISI, sub-consultants and stakeholders. The implementation of 3D modelling allowed a level design detail and clash detection that was critical to the successful design of this complex facility. This level of detail would have been impossible to achieve using a conventional 2D approach. In addition to facilitating excellence in design, our BIM approach greatly improved efficiencies and communication during design, tender, procurement, fabrication and construction phases. The BIM capabilities and processes immediately added value to ISI by working more efficiently, reducing costs and risks and producing more valuable information in shorter timeframe. During construction, live BIM models were updated as construction occurred and as-built and asset information was produced in near real-time. The benefits of the modelling approach continue to be realized post-construction, as ISI relies heavily on the model for asset tagging and operations.



2.2 Integrated annexes

The Assembly Hall and Ultra Hall both have annex structures, which are complex buildings in their own right. The annexes offer over 144,000 square feet of multipurpose space, ranging from industrial workshops to executive boardrooms with the latest in video conferencing technology. Additionally, the annexes house washrooms, lunchrooms and other staff facilities, as well as offices, conference rooms, labs and training areas to support the shipbuilding operation in the adjoining production halls. Hatch was able to efficiently combine the commercial and industrial design elements into a single building structure to maximize usage of the available site, which required careful consideration with respect to building occupancy classification and fire protection measures. The annexes have adjoining Operation Support Platforms at all levels, such that personnel are able to access the production hall at all elevations, resulting in a seamless transition between an industrial and office environment.

2.3 New Piers

The new fabrication facilities are located immediately adjacent to two new piers that we constructed as part of the project. Each of these structures are unique in terms of design, and were optimized specifically for the site. Pier 6 involved rock anchor installation to support a sheet pile wall structure. Pier 8 involved a major concrete caisson slip forming operation which allowed for a mass amount of infilling at the North end of the site. The concrete caissons employed an innovative slip forming technique, whereby the caisson forming is started on a semi-submersible barge, after which the caisson is placed in the water, and completed in single pour using slip forming. Extensive amounts of dredging and the construction of a rock caisson mattress was required. Pier 6 will be used largely for vessel maintenance while Pier 8 is the base for the post-launch shipbuilding and final fit out.

2.4 Operation Support Tower

Adjacent to Pier 8 is the Ship Erection Platform – a 1.2 metre thick concrete pad design to support the vessel as the mega blocks are assembled into the final ship. Immediately next to the ship erection is a six storey structural steel Operation Support Tower (OST) to support a final assembly workforce of 200 people with washrooms, lunchrooms and office facilities. The OST design is innovative in that it is 100% mobile; it can be relocated along the ship erection platform to suit the assembly needs of different models of navy ship. The tower is bolted to steel plates and embedded in concrete foundations. The tower and offices are modular in construction and are designed to be dismantled and moved.

2.5 Welding Fume Extraction

A significant portion of the planning and design revolved around proper ventilation for all of the fabrication equipment. The ventilation system was designed to achieve the highly stringent new manganese standards that were implemented as the new recommended provincial practice during the design phase. This shipyard is designed to more stringent air quality standards than the vast majority of facilities in North America, and innovation played a large part in achieving this.

Design considerations included implementation of welding fume control in the Production Hall which had major challenges and limitations, primarily owing to the unprecedented nature and scale of the project. The facility has an extremely large floor area of over 310,000 sq.ft, and the height ranges from approximately 26 m in the Assembly Hall to 47m in the Ultra Hall. Welding for shipbuilding occurs concurrently at multiple levels in multiple areas; this presented a real challenge for fume extraction. Work processes frequently change and require the welding and handling of extremely large pieces, especially in the Ultra Hall. Furthermore, the relatively cold climate does not allow for high building ventilation rates and the facility is located within the city limits of Halifax, so minimization of environmental emissions was an important consideration.

A unique and modern system was required to address the challenging work environment and ensure that it was safe for occupancy. The engineered system selected consisted of three parallel sub-systems, which are as follows:

1. Fume extraction guns or arms used at all manual welding stations.
2. A dedicated parallel arrangement Push-Pull system installed along both outer walls of the Production Hall.
3. Production Hall ventilation system sized to meet ASHRAE standards (approximately 35 m^3/h per square meter of workspace) and provide the required final dilution.

Direct fired make-up air units provide the general heating and ventilation for the building. The HVAC system is designed to operate normally with 1 or 2 units down for maintenance in both the Assembly and Ultra Halls. The Push-Pull system consists of 26 cartridge-type filter units, each equipped with dedicated fans and distribution/collection ductwork spanning the length of the Production Hall. The arrangement of the distribution headers is designed to introduce (i.e. 'push') cleaned air from one side of the Production Hall, allow it to sweep air across the width of the hall, and collect it through return air (i.e. 'pull') headers at the opposite side. The collected fumes are cleaned using filter units equipped with nanofiber polyester-blend cartridges. The use of re-circulated air offers an estimated operational savings of US$430,000 per annum in comparison to conventional design employing only two of the three methods indicated above.

2.6 Industrial Gasses

The new facility houses 6,000m of industrial piping to ensure that all of the fabrication equipment has the necessary industrial gasses for the work. These gasses included compressed air, oxygen, natural gas, Blueshield shielding gasses, and Flamal, which is the main gas used for steel cutting operations across the facilities. Flamal was chosen by ISI as the main cutting gas in part because it removed the requirement for mixing boxes. The use of Flamal on this scale was unprecedented in Nova Scotia, and Hatch worked hand-in-hand with local authorities to ensure that the correct regulations were being exceeded, leading to the successful installation of the system.

2.7 Crane Bearing

From a structural perspective, the facility is at its core a crane bearing structure. The assembly hall houses 10 overhead cranes with up to 130 tonne capacity, and the Ultra Hall houses an additional five overhead cranes with up to 200 tonne capacity. In addition the overhead cranes, there are four semi-gantry cranes and 10 jib cranes. By industry standards, the overhead cranes are very long spans, imposed by the wide production halls. The combination of a high aspect ratio, necessitated in order to minimize the approach distance between adjacent cranes on the same runway, high lifting capacities (up to 200 t) and long runways meant that the crane runways needed to be unusually stiff to prevent skewing of the cranes as they traverse the building. Our structural engineers designed a stable and efficient structural steel building frame to achieve this. Also, the sheer number of cranes in simultaneous operation required careful attention to detail to avoid interferences and conflicts both with the other cranes as well as the installed equipment and the structure itself. The resulting design is efficient and there are minimal operational constraints that impact the shipbuilding procedures.

2.8 Dynamic Compaction

The existing soils were found to have unacceptably low bearing capacities that were incapable of supporting the extremely large loading from the superstructure and proposed shipbuilding activities. Due to schedule restrictions it was not feasible to excavate and replace the existing material. To overcome this problem, an innovative approach to ground improvement was taken in the form of dynamic compaction. The basic principle of this technique is the transmission of high energy impacts to loose and soft granular soils, which initially have low bearing capacity and high compressibility potentials, in order to significantly improve the soil's characteristics at depth. This impact energy is delivered to the foundation soils by dropping a heavy weight from a significant height using a crawler crane. Dynamic compaction at the shipyard was implemented in phases. The first phase improved the deepest soil layers by dropping a 20 tonne tamper from a height of 20 metres (the 'High Energy Phase'). The second and final phase improved the upper soil layers initially sheared by the previous phases in a grid pattern by utilizing a smaller tamper ('Low Energy Phase').

2.9 Fire Protection System

Further innovation was required in the design of the fire protection system for the facility because the facility falls outside the practical reaches of the National Building Code specifications, owed in large part to the sheer size of the production areas. In order to meet fire safety requirements while maintaining practicality Hatch worked closely with code consultants to create an 'alternative solution', whereby an entire customized fire safety design was completed for the facility. This involved interpreting the code and designing with appropriate fire rated materials to ensure that the high-hazard areas of the facility were safe for the end-users. Once all authorities having jurisdiction were satisfied with the design, the buildings were constructed and the relevant emergency response personnel were invited to the sites to walk through the buildings and become familiar with the safety measures in place.

3. Complexity

The ISI Halifax Shipyard Modernization Project required creative engineering and problem solving from project inception through to completion. One of the primary complexities of the project came in the form of an extremely aggressive schedule, coupled with limited physical space. The aggressive schedule, set by contractual mandates with the Federal Government, required the project to move from preliminary design to the commencement of shipbuilding in a mere 36 months.

One of the first major challenges to overcome was the phased demolition of the existing shipyard facilities while shipbuilding was still in progress. Demolition of the existing shipyard buildings required careful coordination and the implementation of hazardous material mitigation measures. The previous fabrication facilities were removed in stages to allow for successful completion of the final coastguard vessel without disrupting their construction schedule. The staged demolition also permitted foundation construction activities for the new building to begin at the end of the existing building that had been demolished, while the final vessel was completed in the still standing part of the existing facility at the other end. The presence of hazardous materials, contaminated soils, and unexploded ordnance only added to the existing complexities involved with the demolition.

Driven by schedule, structural steel and equipment was procured earlier in the design process than is typical. As such, there was a great deal of design and detailing that had to occur during construction, while maintaining schedule and budget. Hatch employed a team of site staff to work closely with the construction manager to answer over 1,000 requests-for-information. Most issues were resolved quickly and efficiently, in large part due to the highly detailed 3D model of the entire facility and the presence of knowledgeable field staff.

The demanding schedule required a vast design team to be established. The sheer number of design hours meant that the designs could not be completed entirely locally. A large multidisciplinary design team was compiled from multiple offices across the country. Using the latest communications technology, we were able complete the design seamlessly such that the geographical diversity did not have an adverse effect on the design or schedule.

The multidisciplinary nature of the project provided additional complexity. Combining designs for structural steel, concrete, marine, HVAC, piping, electrical, plumbing, architectural, water, sewer, industrial gasses, and overhead cranes into a single design and construction phasing plan presented real challenges. These challenges were exacerbated by the physical constraints imposed by the site. Bound by the harbour on one side, and main city thoroughfare on the other, space was extremely confined, which required careful consideration from both a design and construction perspective. Nowhere were the physical constraints felt more than in the Assembly and Ultra Halls, where floor space needed to be maximized to provide optimal shipbuilding conditions. Because of this, and the presence of the overhead cranes carrying large loads, all ventilation, filtration, heating, lighting, walkways, and industrial gas services were required to be placed within the confines of the column enclosures. Yet again the employment of BIM was critical in preventing service clashes.

4. Social and Economic Benefits

Not only has this project had a tremendous impact on the local economy of Nova Scotia, but it's had a great financial impact on Canada's economy. Construction has contributed a capital value of over $350 million, of which 63% was distributed within the province of Nova Scotia. As operations increase at the shipyard, employment at ISI and with associated subcontractors is expected to reach 2,400. And, with employment rising in the region, so will revenue to the City of Halifax and the province through taxes and consumer spending. The economic impact of the shipyard has also been recognized by the Conference Board of Canada, declaring Halifax as one the top three cities in Canada for economic growth in 2015.

Other economic benefits include the generation of stable employment, reduction of the outward migration of young people, stability for small businesses, and increased confidence in the community. The new shipyard facility has and will continue to provide economic benefit to Nova Scotia for decades to come, as workers proudly construct the next fleet of Canada's navy vessels.

Furthermore, ISI has recently donated $4.52 million to the Centre for Ocean Ventures and Entrepreneurship for the construction of an ocean research centre on Halifax's waterfront, comprising 1,500 square metres of office space, 930 square metres of incubation space, and 1,500 square metres of shop and lab spaces. This will serve as a centre for local and global ocean technology, as well as research, and will greatly improve the region's prospects in the industry.

5. Environmental Benefits

In the design and construction of the Assembly Hall and Ultra Hall, upgrades were made to the lighting, air exchange, fuel and building management systems to make the facility more energy efficient going forward and was switched to natural gas, a cleaner burning fuel with a lower carbon footprint.

A comprehensive Fume Exhaust System was installed to purify the air in the facility through the installation of push/pull air exchange units throughout the building. These units capture all welding fumes and filter out particles and dust so that clean air can be pumped back into the facility. By purifying the existing air, it limits the need to introduce outside air into the facility, saving significant energy and heating costs.

The facility features 100% LED lighting which is shown to use 75% less energy, and last 25 times longer, than incandescent bulbs. The lighting control system is automated to turn lights on and off depending on the time of day so that energy is not wasted in areas that are only active during peak business hours.

When installing these upgraded systems, we introduced a complex Building Management System (BMS) that allows ISI to centralize, monitor and regulate the building temperature and lighting while also allowing ISI to monitor all of the operational equipment in use at the facility. This shows ISI what operations use the most energy, so they can understand why, and explore future opportunities for further energy conservation.

Atlantic Reef Ball Program: In 2013, while in the midst of expanding operations along Halifax Harbour and constructing this shipbuilding facility, ISI partnered with Clean Foundation (formerly Clean Nova Scotia) on the inaugural installation of artificial reef structures, known as Reef Balls, as part of Clean Foundation's Atlantic Reef Ball Program. The Atlantic Reef Ball Program builds, installs, and monitors artificial reefs in Atlantic Canada in an effort to improve and/or restore coastal marine habitat. The artificial reef structures are designed to establish quality habitat that will draw a variety of marine species into coastal zones and contribute to the growth of coastal ecosystems. ISI supported Clean Foundation as a way to offset any impact the expansion of the Halifax Shipyard would have on marine habitat in the Halifax Harbour.

Clean Foundation installed 100 Reef Balls in two locations in Halifax Harbour – one just off Point Pleasant Park and one off the coast of McNab's Island – resulting in the creation of 16,700 square meters of marine habitat.

Clean Foundation has maintained and monitored the habitats since their installation and has seen great success with the locations to date. Regular monitoring has shown a variety of marine life in and around the structures. In addition to providing shelter and protection for marine species, the artificial reefs have also supported the growth of algae which is a foundational piece in the marine ecosystem. In some areas, the original structures are no longer visible under the growth of algae and seaweed, demonstrating the successful intent of the installations.

6. Meeting Client's Needs

ISI had several key objectives they wanted to accomplish over the course of this project. Each objective and an explanation of our team meeting each one is included below:

- Budgetary control and management of scope and the facility built on time to accommodate the National Shipbuilding Strategy and Mid-Shore Patrol Vessel completion schedule.
  - Using the latest tools in BIM technology, the combined assembly hall, paint shop and ultra hall facility were collaboratively designed, reviewed, analyzed and shared. BIM models were shared with ISI and amongst disciplines, sub-consultants and external contractors – greatly improving efficiencies and communication between the design, tender, procurement, fabrication and construction phases as well as feeding into ISI's CMMS maintenance system for operations. During construction, live BIM models were updated as construction occurred, as-built and asset information were produced in near real-time and provided valuable information to contractors, engineers, sub-consultants and ISI more efficiently and more robustly than by any traditional means of project delivery.
  - The use of Hatch's financial tracking system to monitor and report labor and expenses allowed our project manager to review all project charges by task in real time and evaluate if the project team was on track to produce deliverables within the agreed upon timeframe and budget. This in conjunction with our dynamic project scheduling software program afforded our project manager and technical leads an excellent tool for tracking and controlling the project budget and schedule. As a result, the project was successfully completed within scope and budget and the team was able to accommodate late design changes by ISI during construction of the building.
- Protection of ISI's existing Halifax Shipyard operation.
  - Demolition of the existing shipyard buildings required careful coordination and the implementation of hazardous material mitigation measures. The previous fabrication facilities were removed in stages to allow for successful completion of the final coastguard vessel without disrupting their construction schedule. The staged demolition also permitted foundation construction activities for the new building to begin at the end of the existing building that had been demolished, while the final vessel was completed in the still standing part of the existing facility at the other end.
- Quality control, testing, commissioning and efficient turnover program to operations.
  - Quality was a driving force throughout the design and construction of the project. The design process was controlled through Hatch's Information Management System (established to satisfy ISO 9001 certification), included thorough checking and review. Hatch provided highly experienced full time site staff to monitor the works, and executed a robust Quality Assurance program. Contractor shop drawings were thoroughly reviewed, and all relevant materials underwent testing. Commissioning and turnover became a top priority toward the end of the project. Early turnover of critical areas of the building to the shipbuilding crew was achieved, and major pieces of equipment such as the ventilation system underwent a full commissioning stage. Hatch remains involved in the shipyard to tend to ISI's needs during the day to day operation of the facility.

Hatch is an employee-owned, multidisciplinary professional services firm that delivers a comprehensive array of technical and strategic services, including consulting, information technology, engineering, process development, and project and construction management to the Mining, Metallurgical, Energy, and Infrastructure sectors.

Hatch has served clients for over six decades with corporate roots extending over 100 years and has project experience in more than 150 countries around the world.

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