RAPID DEPLOYMENT PLATFORM FOR IN-VAULT REACTOR MAINTENANCE

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Abstract:

CANDU nuclear power plants face continual aging effects. A resultant is increased length of outages from the increasing amount of in- vault maintenance work required, coupled with the escalating ambient radiation levels for the workers performing it.

At Bruce Power, most in-vault reactor maintenance and inspection tasks utilize platforms supported on the reactor area bridge to access end fittings, feeder cabinets, bridge drive components and other areas around the reactor face. The various older maintenance platforms typically were purpose-built, to suit specific needs as they arose over the years.

GE Hitachi Nuclear Energy Canada was commissioned by Bruce Power to conceive and develop a better way to deliver the workers to their work sites. The evolving goals of this mandate included maximizing workers' productive working time in the vault, minimizing workers' radiation exposure, maximizing workers' overall safety and eventually crystallized into the generic goal of an adaptable and inherently safe delivery stage for all future reactor maintenance.

As has been attested by all who use the aptly named Rapid Deployment Platform or RDP, the design/build team achieved a resounding overall success. GE Hitachi Nuclear Energy Canada utilized iterative consultations with the Bruce Power team of line and staff users, determined their needs and optimized the RDP's functionality and efficiency.

The RDP is designed to be modular with interchangeable platform sections that can be configured into an array of diverse widths and lengths, combined or separate, functional on all eight (8) Bruce Power reactors. It features a variety of platform configurations, rolling shield canopies and seismic qualification for various configurations. The RDP has demonstrated a dramatic reduction in both deployment time (90%) and number of workers required (90%), as well as reducing reactor face workers' radiation exposure rate by 30 – 80%, according to Bruce Power.

The paper outlines the design and development process used for the RDP and describes the main features and benefits of this new system.

1. Introduction

Candu nuclear power plants face continual aging effects. A resultant is increased length of outages from the increasing amount of in- vault maintenance work required, coupled with the escalating ambient radiation levels for the workers performing it.

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GE Hitachi Canada was commissioned by Bruce Power to conceive and develop a better way to deliver the workers to their work sites. The goals of this mandate were fourfold:

- Maximize workers' productive working time in the vault
- Minimize workers' radiation exposure
- Maximize workers' overall safety
- Provide an adaptable delivery stage for all reactor maintenance tasks, workers & tooling

As has been attested by all who use the aptly named Rapid Deployment Platform or RDP, the design/build team achieved a resounding overall success.

2. Historical Background And Outline Of The Problem

The various older maintenance platforms existing at the stations were typically purpose-built, to suit specific needs over the years. Nearly always, there were similar or identical pieces of equipment in existence at both Bruce A and B.

The seed of the RDP was planted in mid-2003, as Bruce Power planned for a mandated SFCR job. This specific job would require physical improvements to their existing Bruce A MFCR platform, in order to increase its overall efficiency and reduce worker dose. GEH, as the original designer/builder of this platform for OPG, was brought in by the Bruce Power SFCR planning team. Their first idea was to closely follow the design of a later platform that had been designed and built in the 1990's by GEH for OPG Darlington, as a direct improvement upon the design of this Bruce Power MFCR platform.

Due to the projected cost and time frame for the MFCR platform upgrades, the idea of a new replacement platform was raised during several joint Bruce Power-GEH meetings through 2003 and 2004. It became apparent that it would be much easier to formulate a business case for a more universal reactor maintenance platform instead of simply building replacement equipment for the SFCR-specific task.

By October 2004, the GEH design team had developed the universal theme somewhat further, into the first new concept that would utilize interchangeable modular "building blocks". This concept was comprised of a heavy load carrying module on the Carriage, plus 2 to 3 lighter "space frame" modules that would rest on bearing rollers on the Carriage roundway rails. See Figure 1.

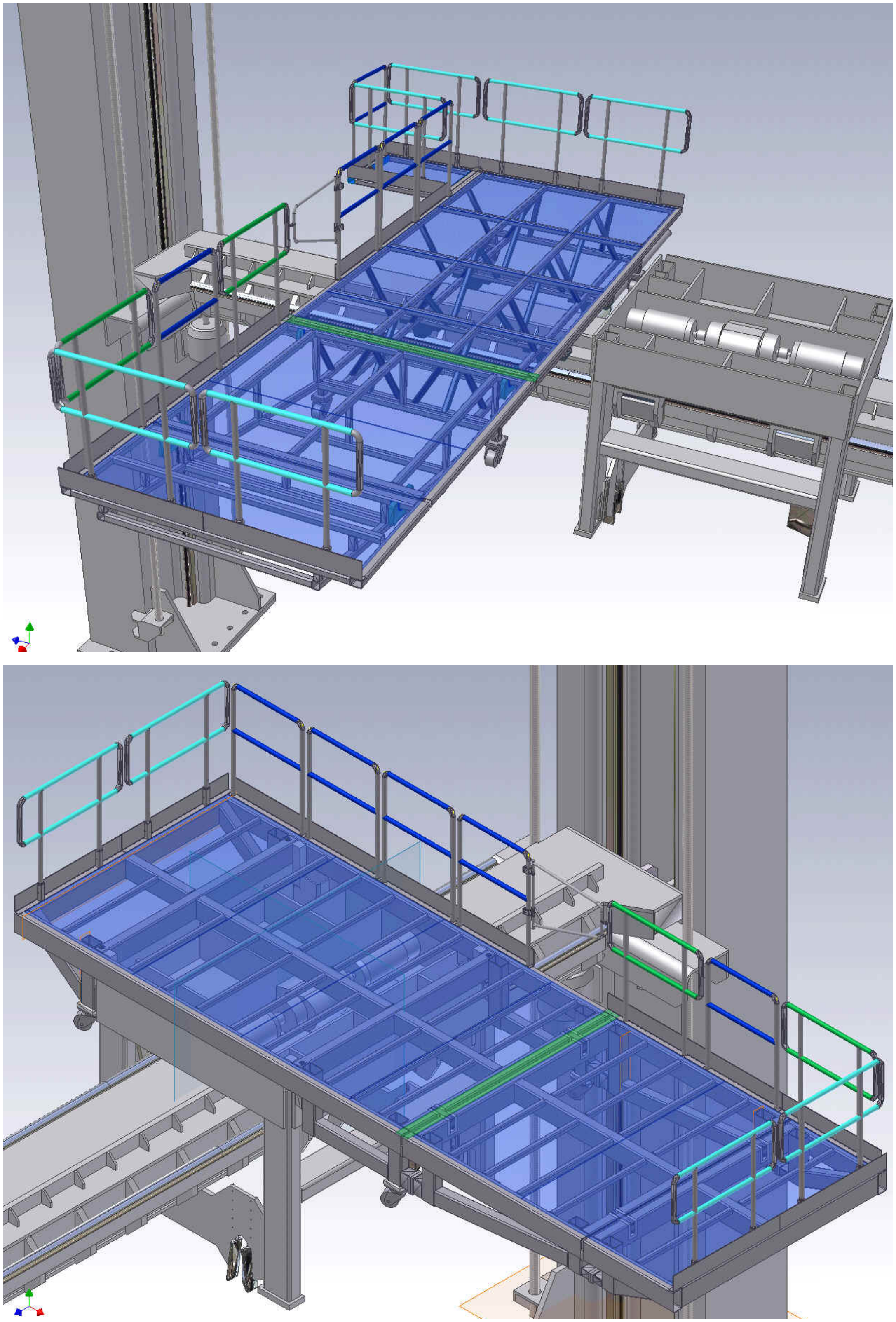

Figure 1 The Original Concept Models, Heavy Carriage Module and Light Space-Frame Module

The modular concept was envisioned to be such a breakthrough that it would address the perceived issues with the existing MFCR platform, plus reduce or even eliminate the need for all of the other reactor face platforms at both Bruce Power stations.

The shortcomings with the existing Bruce Power platforms were perceived to be as follows:

- MFCR Platform: 2 exist at Bruce A, used once at Bruce B. See Figure 2
  - 5 days installation or removal time, requiring 50 workers
  - Scaffolding is required to access platform clamps under the RAB. See Figure 3.
  - Shielding canopy is fixed, with work done through small openings having rolling doors, and has minimal shielding from overhead exposure sources
  - MFCR is built up, in the vault, from many pieces with many transportation carts
  - Difficulty in utilizing anything less than the full width & full length platform
- Mini Platform: 16 in total exist at Bruce A and B, in various states of repair and modification. See Figure 4.
  - Much smaller working area, only 8 feet wide and 14 feet long, minimal shielding
- SFCR Platform: 2 exist at Bruce B, very similar to MFCR but not suitable at Bruce A. See Figure 5.
- In addition, the existing platforms were neither seismically qualified nor acceptable for lifting/lowering workers, nor fully compliant with current safety regulations.

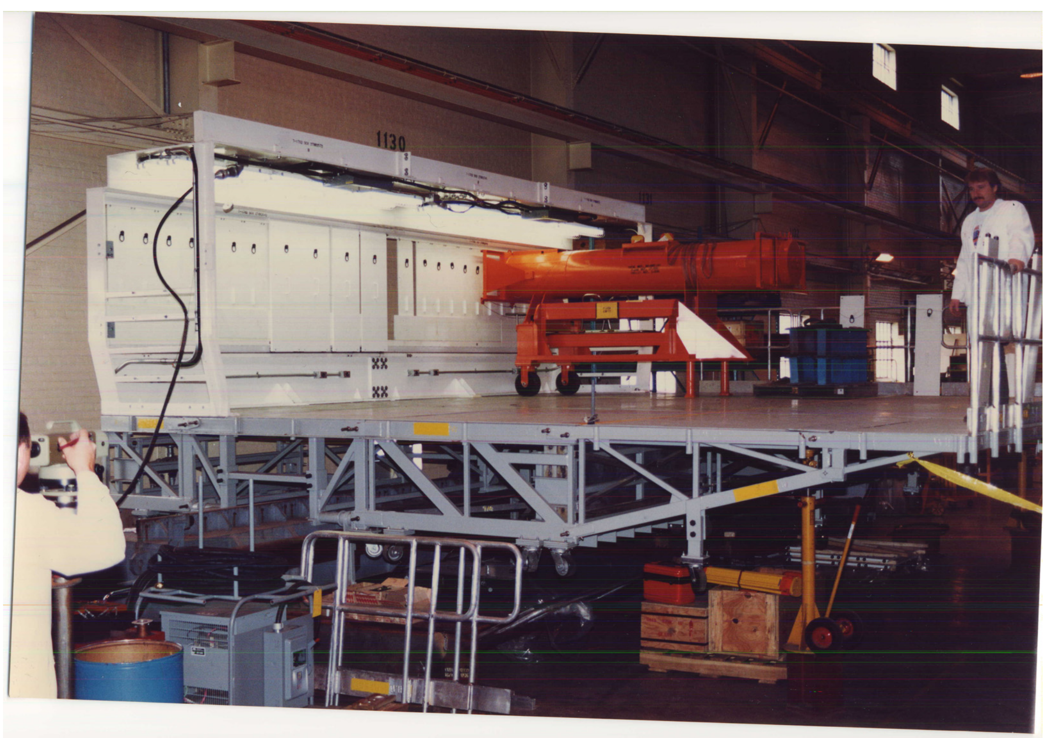

Figure 2 The Existing MFCR Platform and Shielding Canopy

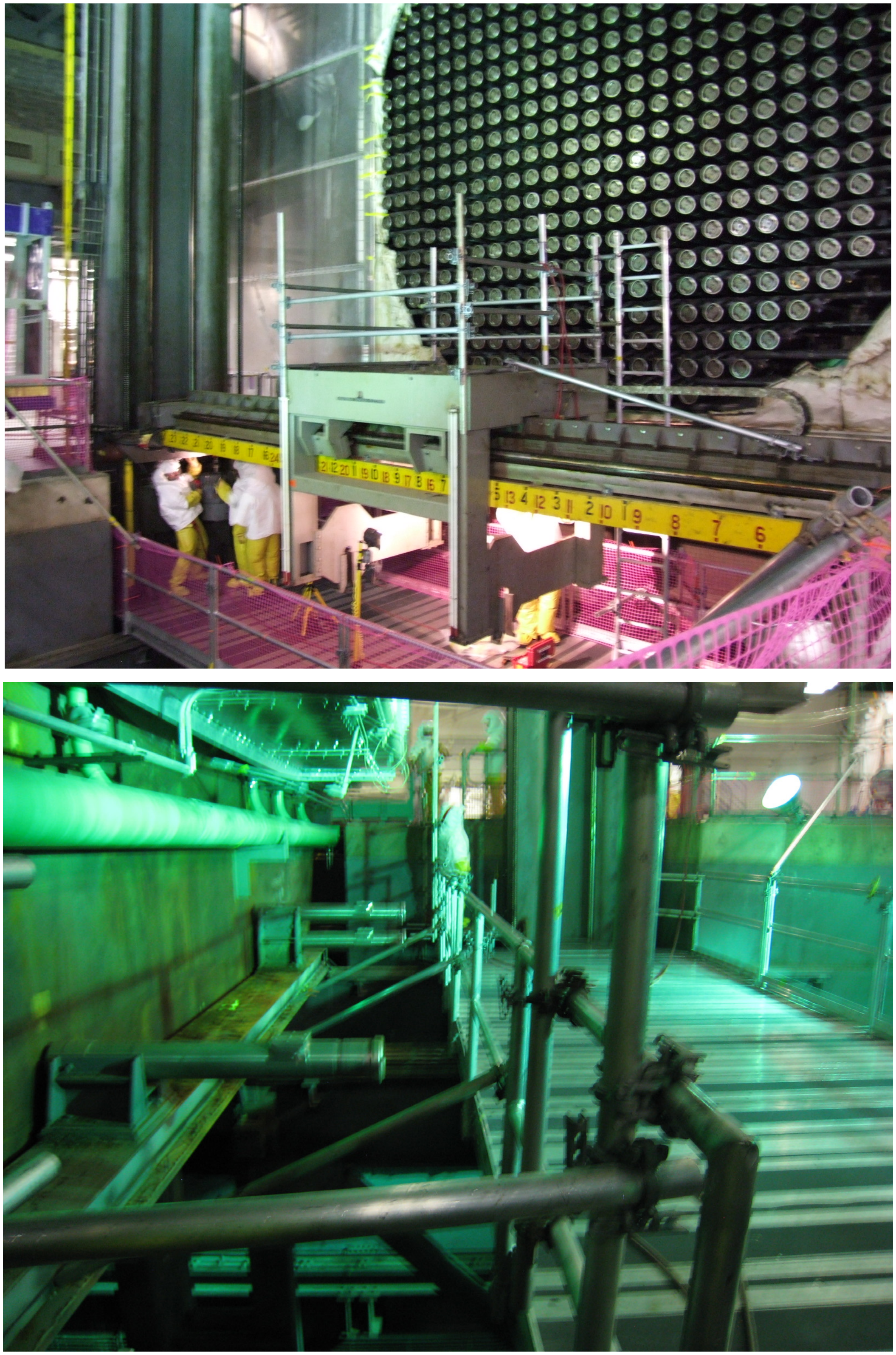

Figure 3 Typical Scaffolding Built Under The RAB

Figure 4 Typical Mini Platform (Bruce B Version)

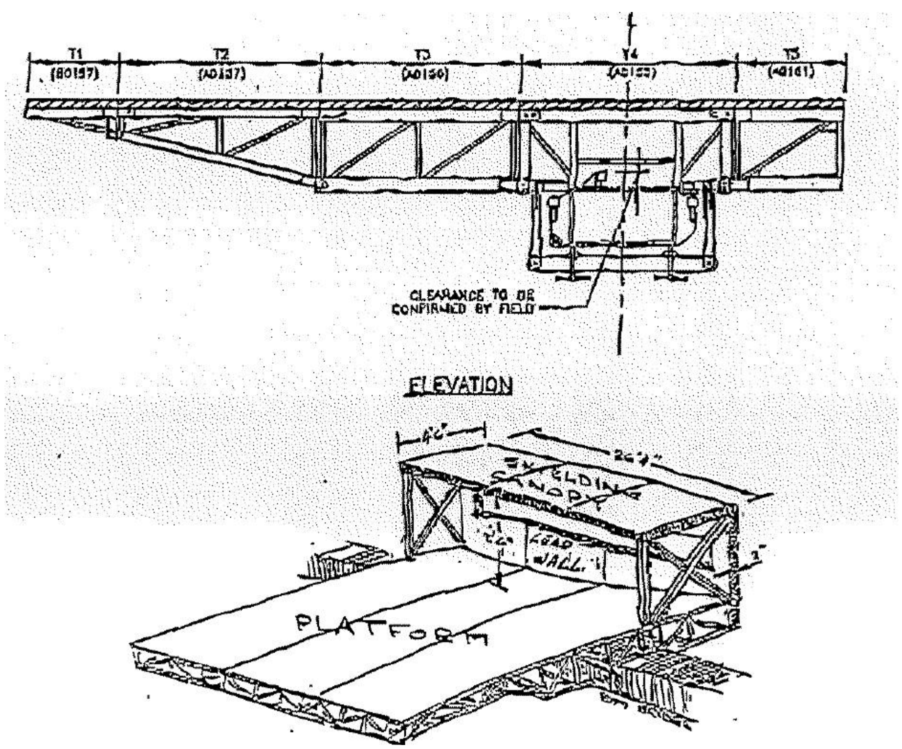

Figure 5 SFCR Platform Sketch

3. Learning From The User Groups

The joint Bruce Power / GE Hitachi Canada development team utilized iterative consultations with groups of line and staff users at the various presentations done by GEH at Bruce site, discussed their needs and optimized the RDP's functionality and efficiency based on the discussions.

The team enlisted feedback from Bruce Power station staff, Design Projects, Fuel Handling Technical, Reactor Maintenance and the Building Trades Union. The feedback from all groups was always positive and constructive, evaluating the concept details from the end user's viewpoint, taking ownership and thereby driving the revisions and simplifications that resulted in the final product.

Because GEH uses state of the art 3D modeling software, starting at the initial layout stage, the CAD concept models enabled the design team to clearly illustrate and often animate the features of the concepts, showing them within the reactor vault environment, to all of the user groups right from the start.

4. Evolution Of The Solution – The Design Process And Description

4.1 Timeframe

GEH received Bruce Power's order in early March, 2006, with the first site reactor deployment beginning May 2, 2007

4.2 Work Programs To Be Supported By The Platform

The RDP is intended for use in the following reactor maintenance programs:

- Single and Multiple Fuel Channel Replacement, including Calandria Tube Replacement. This imposes the highest loading, with flasks weighing from 1 to 10.5 tons, combined with significant axial operating loads, in various combinations and locations.
- Reactor face insulation, installation and removal
- Feeder Inspections.
- Feeder replacement and Grayloc coupling work
- MiniSLAR tooling at 5 tons
- West shift.
- Reconfiguration work.
- End fitting repair/refurbishment work.
- Fuel channel scrape program.
- Ball screw inspection and lubrication.
- Other potential uses as yet unforeseen

4.3 Design Organization

At the end of the concept development, the detail design of the RDP project components was broken down into six phases, with each phase leader coordinating their respective design, drafting, analysis, sourcing and testing needs.

A project leader managed the higher-level coordination between the phase leaders, the customer and manufacturing.

4.4 Platform Modules

Because of the wide variation in requirements, needs and operating loads with these maintenance programs, the joint development team decided that the first concept (Figure 1) should be up-rated such that all of the modules possess heavy load-carrying capacity. This approach sacrificed the lightweight auxiliary modules but enhanced overall interchangeability and permitted the platform system to be split up to service two or more reactors at the same time.

The next modular platform concept was quite similar in appearance to the final RDP. The full-face width platform (later denoted Configuration C. See Figure 8) had by then evolved into four Inboard Modules to span the width of the reactor, with two partially resting on the Carriage (at a choice of three locations) and the other two rolling on the existing Carriage roundway rails, with the whole assembly supporting two Shielding Canopies.

The Inboard Module's size was determined from the maximum envelope the can be transported through both the airlock and the aisles in the vault area. To minimize the number of vault entries required, the larger rolling pieces of equipment were designed to also carry smaller mating pieces through the airlock.

Each Inboard Module has redundant overturning protection safety devices, consisting of a pair of pins to lock it onto the Carriage and a pair of swing-under safety hooks to act as non-contacting restraints under the RAB's bridge beam. In addition, two adjustable load-transfer wedges share the cantilevered Inboard Module's bending loads onto the Carriage structure, plus two adjustable leveling wedges maintain the cantilevered Outboard and Wing/Counterweight Modules level with the Inboard Module. All of these mechanical devices are operated from the deck level, with prominent colour codes and pop-up operators to give a clear visual indication of the devices' status to all vault personnel and to supervisory staff by video. See Figure 10.

One of four Access Wing Modules can be attached to the outboard edge of each Inboard Module and in turn can support a Counterweight to balance the Shielding Canopies' inboard-biased weight. The Access Wings are universal, such that they can also be used individually, without a Counterweight, attaching onto the Inboard Module at either of the inboard corners to access the side feeder cabinets, onto the side edges to access the RAB ballscrews and roundways, or onto the rear of the Outboard Modules during Calandria Tube replacement.

The Counterweight modules have casters that permit the Wing-Counterweight assemblies to be rolled around as needed. The Wing is detached from the Counterweight by simply pulling out four ball-lock pins.

The Outboard Module, as mentioned above, was first intended strictly for SFCR work, supporting the outboard end of 10.5 ton Calandria Tube Flask and utilizing the same Access Wing, mounted on its outboard end to permit personnel access around the rear of this long flask. Two additional and special rolling counterweights are available to be mounted on the inboard area of the deck, one on each Inboard Module, solely to balance the overhung weight of the Calandria Tube Flask.

The combination of two Inboard Modules, two Outboard Modules, two Access Wings and a single Shielding Canopy is denoted Configuration B. See Figure 7. Besides its intended SFCR work, it will also be useful in any other tasks where especially long maintenance tooling or reactor components are being handled or stored.

GEH, as the RDP system's designer, maintains ongoing liaison with the RDP users and advises on the safe use of the equipment, including tooling loading and suggestions for different module configurations that come up from time to time. For instance, it would be physically possible and perhaps desirable to assemble a full width and full-length platform but, unfortunately, the differential loading of that assembly on the RAB elevators would then exceed their design specifications and therefore this is not an approved configuration.

The most useful arrangement (~ 95% of the usage) is denoted Configuration A, combining two Inboard Modules, two Access Wings with Counterweights and a single Shielding Canopy. See Figure 6.

The quickest deployable arrangement, hoisted in a single lift, is denoted Configuration D, combining one Inboard Module and one Access Wing, without any Counterweight or Shielding Canopy. See Figure 9.

The assembled Inboard Modules each weigh 8700 lb., the Outboard Modules are each 4300 lb., The Access Wings are each 800 lb., the outboard Counterweights are each 3700 lb and the special inboard Rolling Counterweights are each 5700 lb.

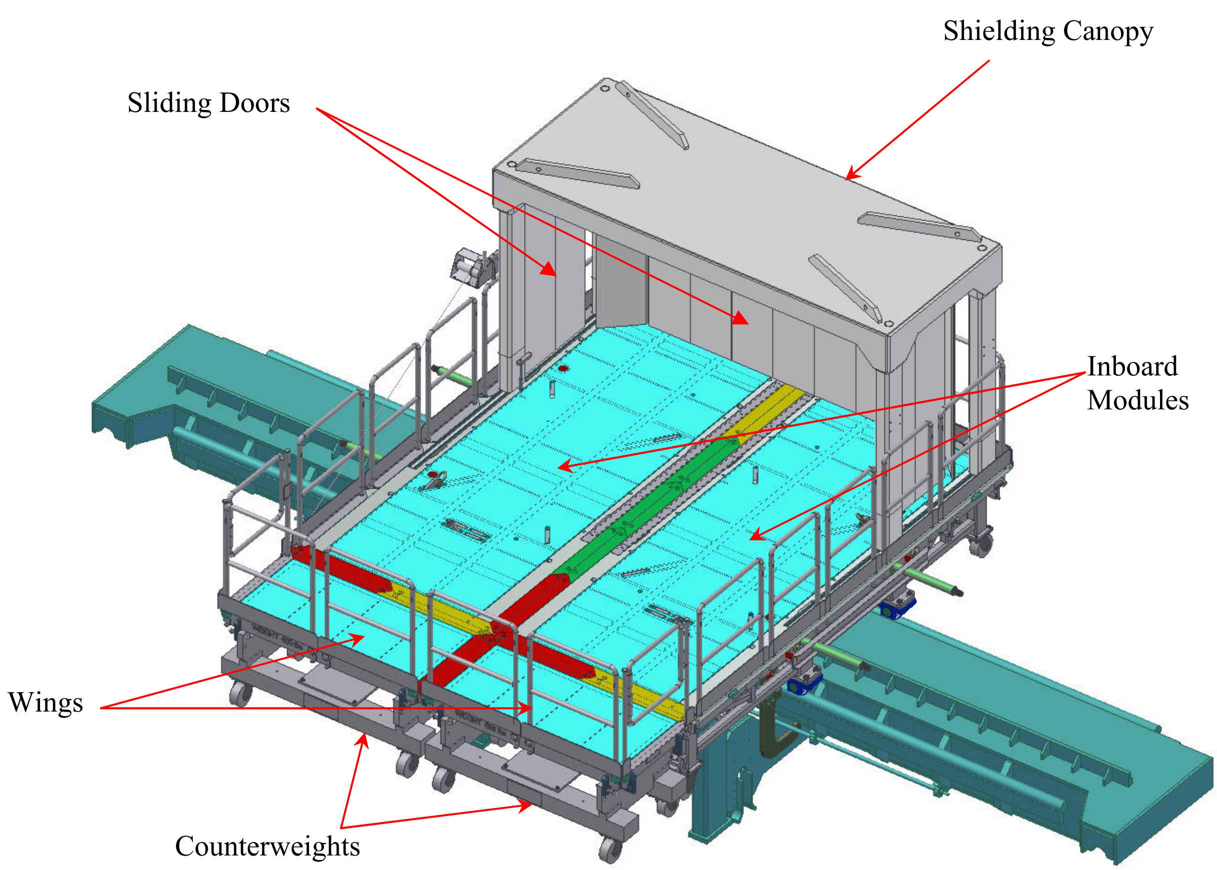

Figure 6 Configuration A, Shown On The RAB Bridge Beam

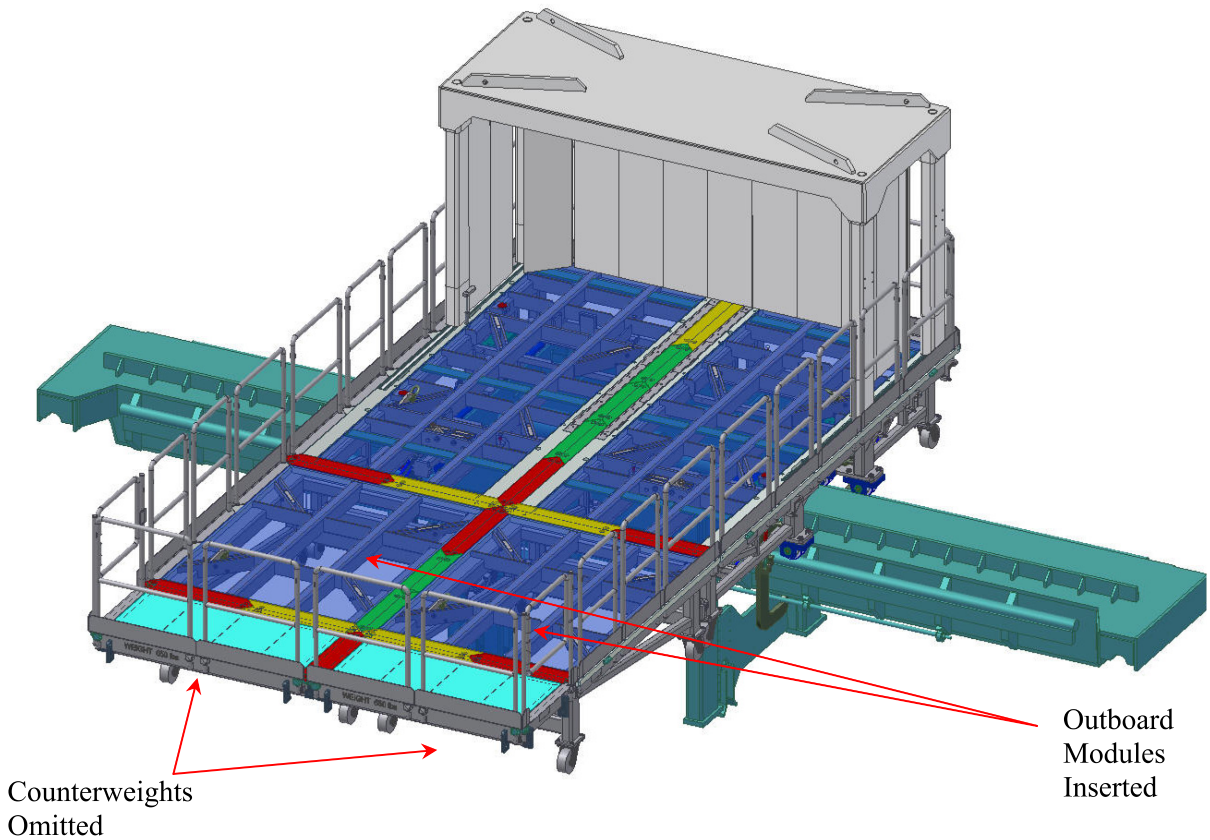

Figure 7 Configuration B, Illustration On The RAB Bridge Beam
And Photographed On The Mock-Up Bridge Beam During Proof Load Testing At GEH

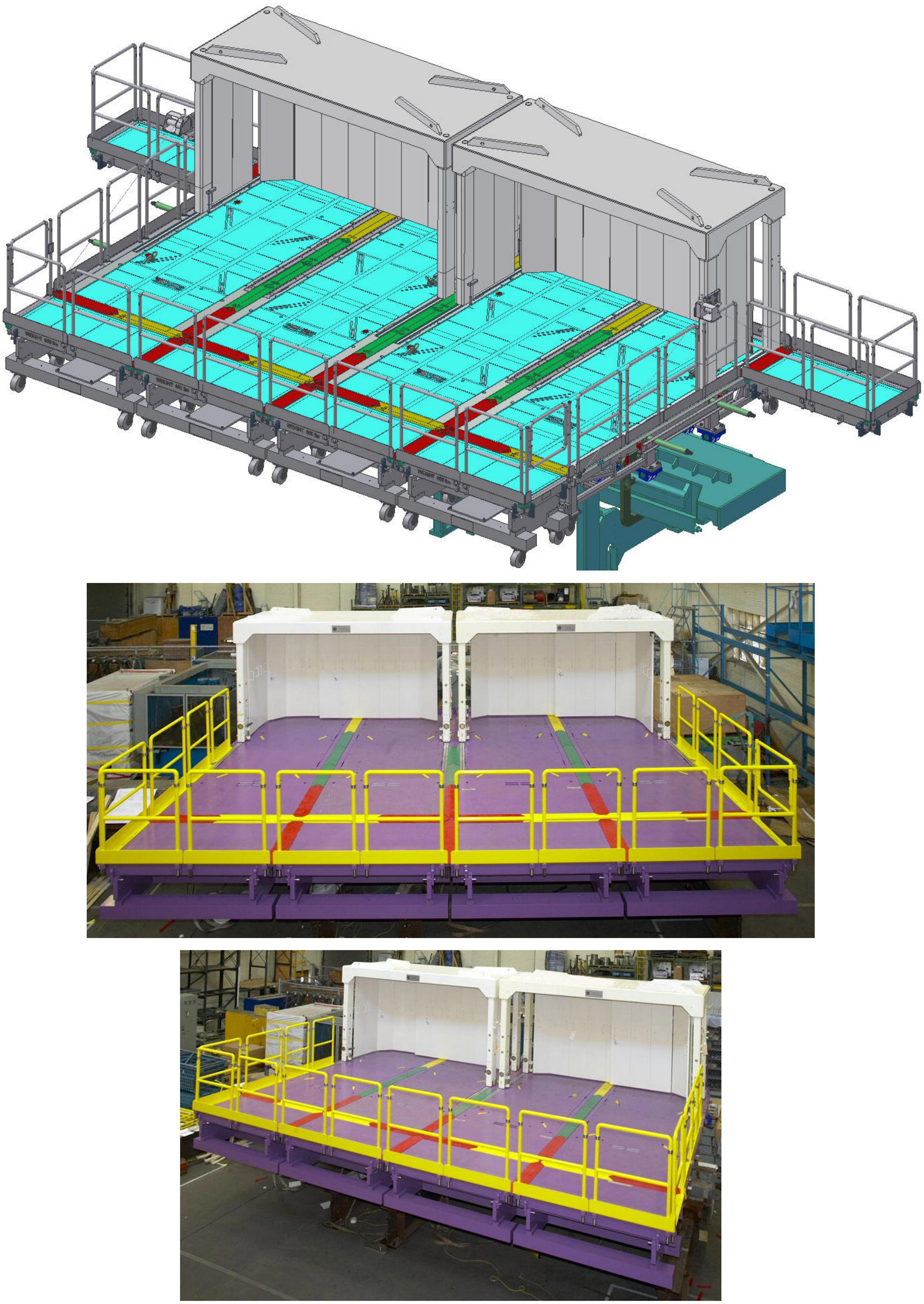

Figure 8 Configuration C

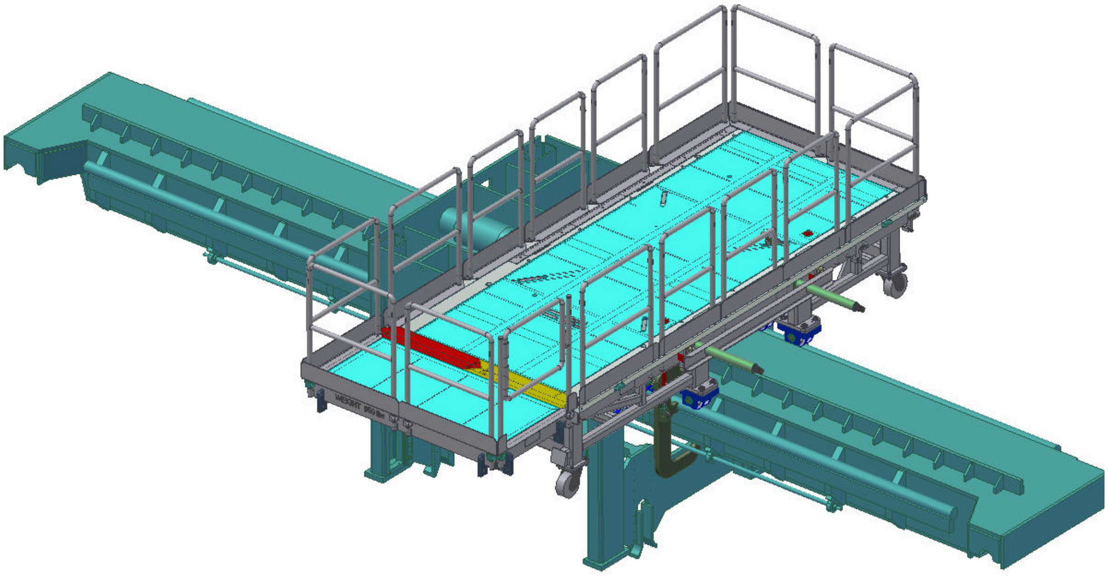

Figure 9 Configuration D, Shown On The RAB Bridge Beam

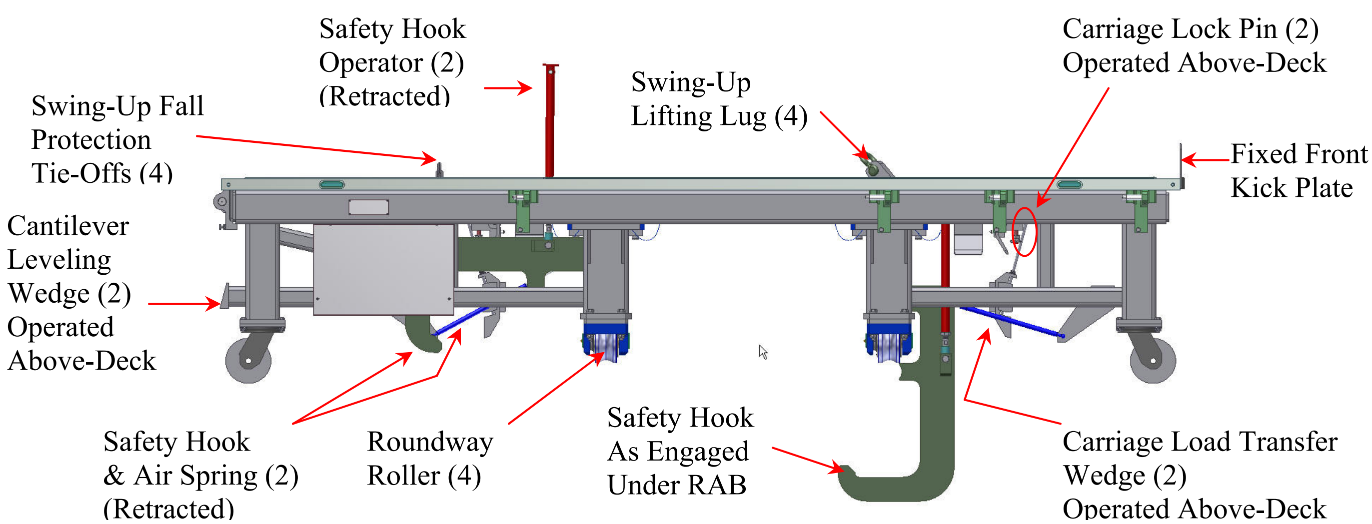

Figure 10 Safety Devices And Deck Level Operators On The Inboard Module

4.5 Safety Handrails and Access Gates

The platform modules and their perimeter guards (Handrails) were designed such that there are only two sizes of handrail and all the ones of each size are fully interchangeable among all Modules and Wings.

Handrails lock in place, into the holes (sockets) in the platform structure, to guard against accidental uplift but also remove easily, with the locking device releases located at the workers' natural grasping points. See Figure 11

Access gates, left or right swing, can be installed at any point where a 'long' handrail location and are mistake-proof, only able to be mounted to swing inwards towards the platform.

Handrails are also designed mistake-proof, able to be attached only in their proper orientation.

The handrails each have an integral kick plate, a formed L-section of plate, for reinforcement that lays flush with the deck plate. The recess for this flush plate and the sockets all around the perimeters of the platform modules are two features that were designed to serve a dual purpose, as will be described in the following section.

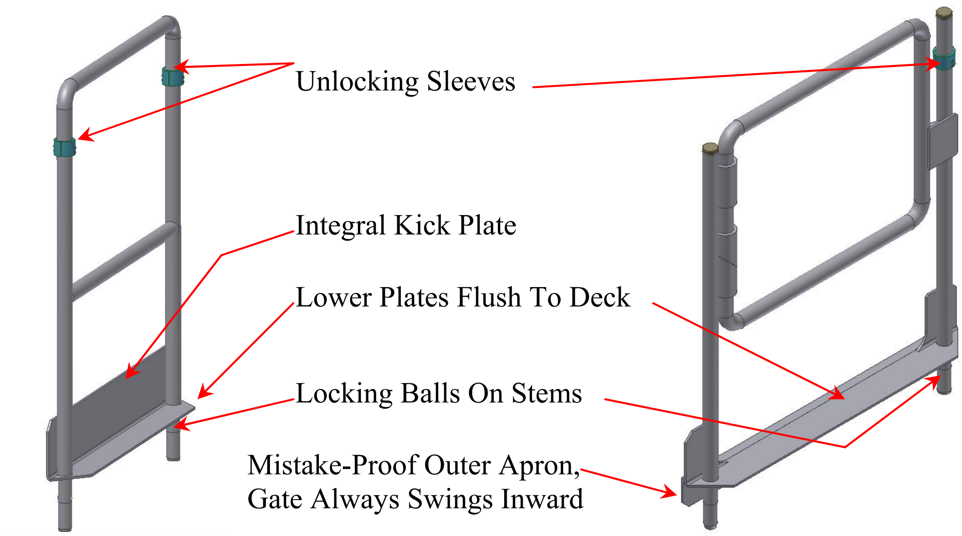

Figure 11 Handrail (Short Shown) And Gate Modules

4.6 Attaching The Platform Modules To One Another

The Modules are attached to one another, when appropriate, with a pin in each of two lugs on one Module mating up with holes in two lugs on the other Module. In all cases, these two pin connections are the sole structural support members that cantilever either an Outboard or a Wing Module onto an Inboard Module.

Beside each pin connection is a passive guiding feature that permits the Modules to be attached using only the vault crane and local visual directions. See Figure 12.

The sliding pin-lug connections are retained by sections of flat plate that each fill the kick plate recess left by one missing handrail on each side of the joint. Each plate lays flush with the mating deck plates and has vertical bars that engage into the handrail sockets on both modules. See Figure 12.

These Connector Plates (Joiner Plates) lock in the same manner as the handrails and are installed or removed from a standing position, using simple T-handle tools. The three different types of Joiner Plates are also colour-coded for ease of installation.

The same Joiner Plates are used in attaching left and right Modules. Here their function is not to retain any pin-lug connection but only to prevent the Modules from rolling apart, plus filling in the gaps in the deck plate.

The result is a continuous flat deck across all of the east-west and north-south connection joints, with no tripping hazards between Modules.

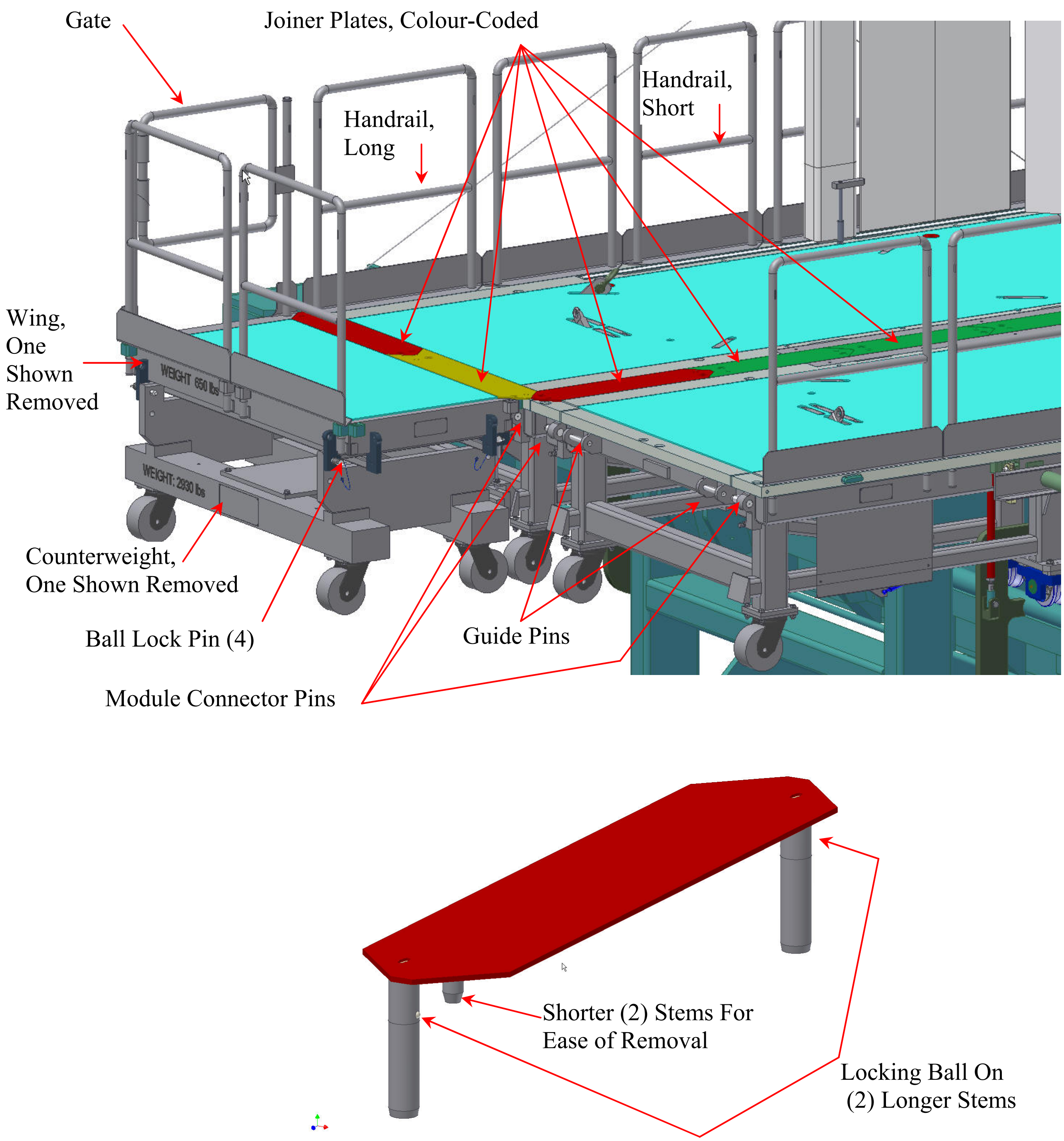

Figure 12 Module Pin & Lug Connections and Joiner Plate Detail

4.7 Shielding Canopies

The Shielding Canopy, in its first concept incarnation, included two levels of removable hinged shielding doors on the reactor side, made of two inch steel plate in a “Dutch door” or “stable door” arrangement, to permit selective shielding of workers. It also used a single horizontal steel plate roof, also two inches thick. See Figure 13.

Because of the previously noted wide variation in requirements between the various maintenance programs’ needs and operating loads, the joint team decided that the Shielding Canopy needed to be more adaptable to the changing jobs at hand, with only minor intervention by the workers.

The next evolution of the concept omitted the Dutch doors and changed the roof to a 2, 1-inch thick horizontal plates separated by a space, to increase the bending stiffness of the roof structure. Further stiffness was achieved with substantial gussets on top of the upper plate, serving double duty as the lifting lugs. See Figure 14.

Roof stiffness had become important after the decision to replace the swinging Dutch doors by sliding doors hanging on roller tracks inset into the roof. It was felt that sliding doors generally would present less potential interference with tools and equipment in the cabinet, as well as being easier to restrain against seismic accelerations. Hanging the doors from the roof enabled the deck area to remain unobstructed all the way to the inboard edge of the platform. Because of the lack of a lower edge door restraint, the roof tracks and roller trucks had to be stiffened to react all of the seismic loading and transmit it into the roof structure. The subsequent load paths are then down through the Shielding Canopy’s legs and into the structure of both Inboard Modules.

The user groups had felt strongly that the Shielding Canopy should be cable of being attached either close to the reactor face or slightly to the rear, in order to permit unimpeded worker access between it and the face for handling long items like feeder pipe sections. In such a position, the Shielding Canopy is available to protect any workers who may be idle at the moment. The vault crane cannot access the inboard 6 feet up to the reactor face, therefore the design team placed the Shielding Canopy on rollers, such that it can be installed by the crane and then rolled forward.

The Shielding Canopy can be rolled manually and locked with lift-pins into holes in the deck, either near its hoisting location, fully forward or at one intermediate position as noted above.

The Shielding Canopy roller tracks are practically flush with the deck plate. A hook-shaped section, on each of the four legs, travels in a slot near the track to provide a restraint against seismic overturning moments. The hook slots are wider at the hoisting location. See Figure 16.

The Shielding Canopy has legs that can be telescoped, using the crane during installation, to increase headroom from 6.7 feet to 7.7 feet. This permits worker access to more fuel channel rows without changing the RAB elevation. See Figure 15.

Each Shielding Canopy weighs 15,000 lb.

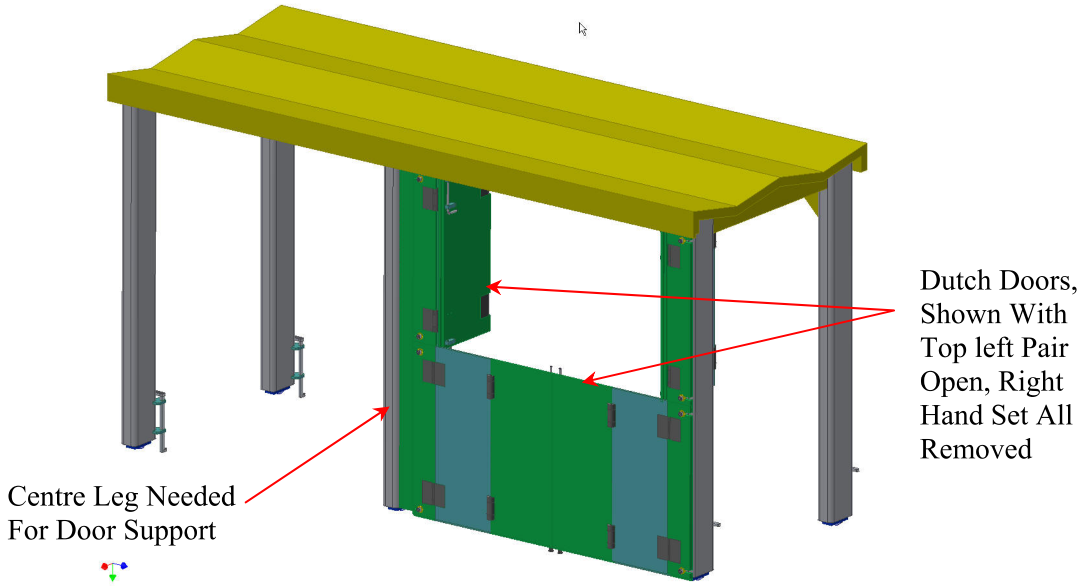

Figure 13 Shielding Canopy Original Concept

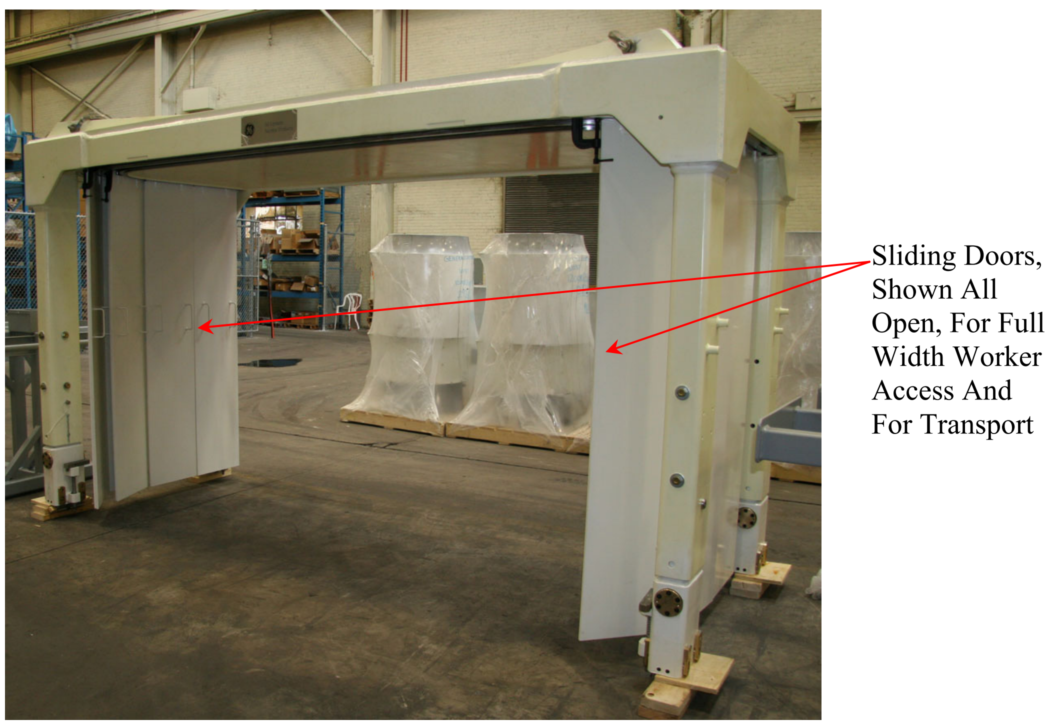

Figure 14 Shielding Canopy As Built

Figure 15 Shielding Canopy, Shown Legs Extended, On Low-Height Transportation Cart

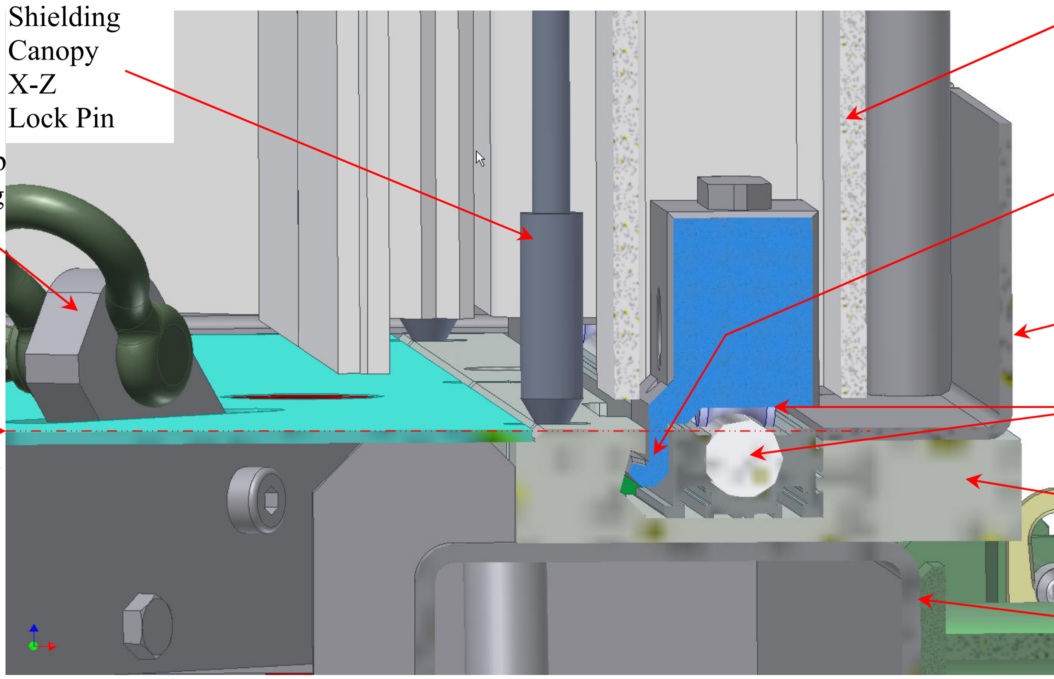

Figure 16 Inboard Module's Flush Roller Track and Seismic Restraints On Shielding Canopy, Plus Other Features (Section View of Right Hand Track)

4.8 Key Contributions of The GEH Stress Analysts

The RDP Modules, the Module assemblies in their various configurations, the Shielding Canopies, the Handrails and the Safety Devices were all rigorously analyzed and optimized by the GEH analysts.

The input of stress analysis was key in properly directing the concept and maintaining the project schedule while also retaining the assemblies' ability to react static loads, as well as seismic and mishap loading, while keeping all of the fast installation/operation capabilities.

The importance of analysis was compounded by the inherent risk of moving the massive RDP structures that are always supported upon and working on parts of the stations' seismically qualified and nuclear safety qualified equipment.

4.9 Codes and Standards

All assemblies have been designed to fully comply with all appropriate federal and provincial regulations, in regard to worker health & safety, nuclear safety, contamination control rules, plus both industrial and construction workplace standards.

4.10 Hoisting And General Order Of Assembly

High levels of design, planning, consultation and rehearsal have been combined into the overall RDP program, in order to ensure that the in-vault work, number of airlock entries, number of crane lifts and number of fall protection tie-offs are all minimized.

All modules are easily rigged, with the Inboard and Outboard Modules having swing-up lifting lugs that are normally flush with the deck. The same sling is used for these modules, while each Shielding Canopy has a dedicated sling permanently attached and accessible without a ladder.

Four similar swing-up lugs, flush with the deck of each Inboard Module, provide qualified fall protection by serving as travel restraint lanyard tie-off points when needed.

The RDP is assembled on the RAB in a general left to right, front to rear and bottom to top order that is summarized as follows:

- Roll in the first Inboard Module (IBM1) with Access Wing-1 and Counterweight-1 (Wing/CWT-1) riding on its deck, a full complement of handrails installed and the slings already attached.
- Hoist Wing/CWT-1 onto the floor.
- Detach Wing-1 from CWT-1, hoist Wing-1 only and attach to IBM1, roll CWT-1 aside.
- Attach sling to crane and hoist the assembly onto the right side of the Carriage (parked near the right concrete floor), guiding it with tag lines from the floor.
- Workers access IBM1 deck via the right side gate, engage the locking pins and hooks, remove the sling from the Module lifting lugs and exit.
- Roll in the second Inboard Module (IBM2) with an Access Wing and Counterweight on its deck and front and rear handrails installed.
- Hoist Wing/CWT-2 onto the floor and roll it aside.
- Attach sling to crane hook and to IBM2, then hoist the assembly onto the left side of the Carriage, in the same manner as before for IBM1.
- Access IBM1 deck, tie off to fall protection restraints, then move all of the left side handrails from IBM1 onto IBM2 to enclose the larger perimeter.

- Engage the locking pins and hooks on IBM2, then remove sling from Module lifting lugs
- Install Joiner Plates between IBM1 and IBM2, then exit.
- Roll in the first Shielding Canopy on its Canopy Cart.
- Attach crane hook to Shielding Canopy sling and hoist it to straddle IBM1 and IBM2.
- Access IBM1/IBM2 deck and guide Shielding Canopy down to final position, lock it in place, detach the crane hook from the sling and exit.
- Roll CWT-1 back to the crane pick up area on the floor.
- Access IBM1/IBM2 deck, tie off to fall protection lugs, attach sling to Wing-1, remove Joiner Plates between IBM1 and Wing-1 and set aside.
- Hoist Wing-1 onto CWT-1 on the floor, engage the four ball lock pins and hoist the Wing/CWT-1 assembly back onto IBM1, reinstall the Joiner Plates.
- Roll the Wing/CWT-2 assembly back out, hoist it onto IBM2, move the rear IBM2 and left side Wing-1 handrails onto Wing-2, install the Joiner Plates around it and detach from the tie-offs.
- This completes Configuration A.
- For Configuration C, repeat all steps except do not disassemble Wing/CWT-3.
- For Configuration B, repeat the same steps but omit the Counterweights and insert the Outboard Modules between the IBMs and the Wings.
- For Configuration D, repeat the same steps but stop after IBM-1/Wing-1 assembly has been locked to the RAB/carriage.

5. Comparison Of The RDP To The Older Purpose-Built Equipment

The following are the points of direct comparison of the RDP versus previous platforms:

The RDP requires 6 workers to install the full Configuration C in 4 to 8 hours and removes is 3 to 4, versus the MFCR platform's 50 workers for 96 hours to install and 60 to remove. The most-used Configurations D & A install and remove in 2 to 4 hours.

Dose during the installation and removal is directly proportional to the time multiplied by the average number of workers in the vault. The RDP requires only slightly more than 1.0 man-rem maximum for installation and removal, versus the MFCR requiring 11.5 man-rem.

Dose during the maintenance work itself is again directly proportional to the time multiplied by the average number of workers and by the average vault fields at the job location. The ambient field outside the Shielding Canopy has been measured at 120 mR, which is attenuated to only 16 mR inside. No data is available for the MFCR Canopy.

The RDP has larger work areas and higher load capacities in all configurations.

All RDP configurations are made up from adaptable modular sections that are arranged to suit the varied jobs, versus the older job-specific platforms.

The Shielding Canopies are compliant with the job at hand, having reactor face access doors infinitely adjustable from fully closed (double thickness) to fully open, versus fixed and partial width cabinets, constricted working windows and some canopies using lead blankets on hooks instead of doors.

Shielding Canopies adjust to the height of the job envelope, versus fixed.

Additional shielding mass provided in the roof, where it is needed for the overhead feeder cabinet, versus little to none on other platforms.

Handrails in only two sizes, fully interchangeable, versus the MFCR's many numbered handrails.

Gates can be mounted at any desired handrail location, versus one or two fixed locations.

Handrails can easily be left in place on the Modules for storage, versus installing and removing all of them in the vault.

The RDP has smooth and glossy surfaces, for easy decontamination, versus others needing the crane for in-vault decontamination handling.

Sealed joints and drain holes mean that active contamination retention is minimal to none, even after an accidental D2O spill.

The RDP provides redundant overturning safety devices, including the rolling modules, such that a worst-case accidental placement of the heaviest flask on the outboard end would not constitute an overturning danger to workers, even though RAB damage might result from such an event.

The RDP modules are self-transportable into the vault and around the station, using a powered puller, except the canopy needs a separate cart due to station height constraints, versus the MFCR's many carts making repeated trips into and out of the vault.

The RDP has large assemblies that are prepared by workers outside the vault, versus inside.

All access to the platform Modules' Joiner Plates and operating devices is from the deck level, versus requiring the building of scaffolds and swing stages for RAB underside access.

All approved RDP configurations are fully qualified, both seismically and for lifting personnel, at both Bruce A and B, versus no qualifications and requiring scissor lift for elevated worker access.

Dedicated and qualified fall protection tie-offs are provided, versus tying-off to handrails.

Each approved RDP configurations has a dedicated and highly detailed instruction manual for its installation, removal and operation. See in the sample page in Figure 17.

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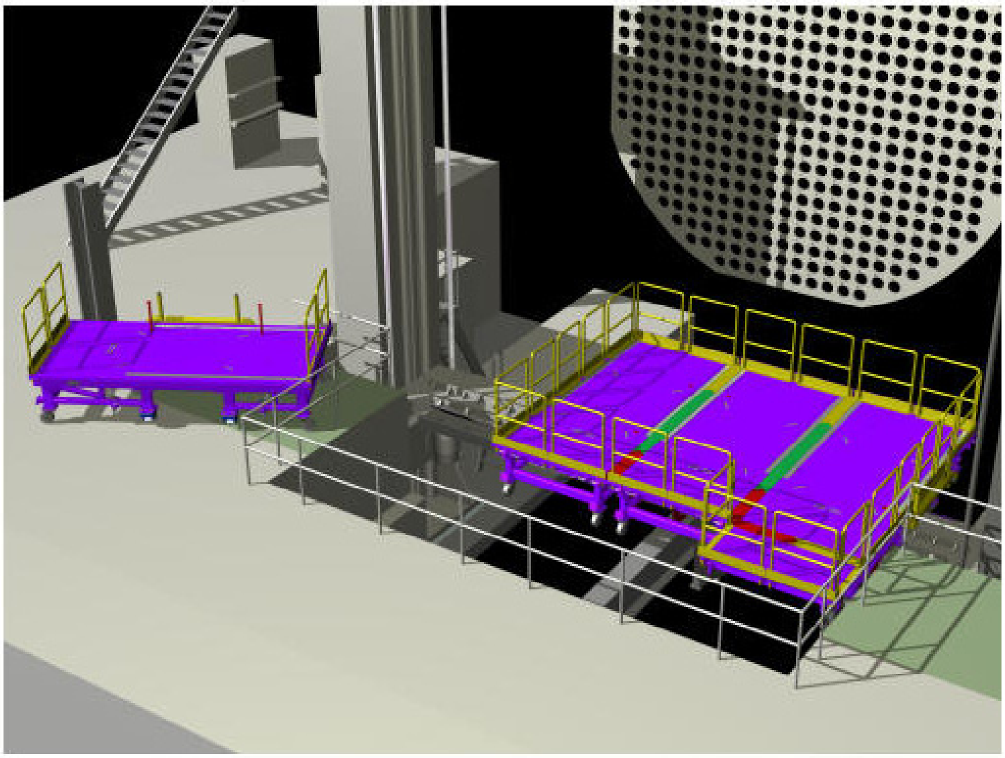
Workers access deck of IBM-4, carrying (4) equal-length web slings

Workers attach (4) equal-length web slings to crane and Wing/CWT-4 lying on deck of IBM-4

Hoist Wing/CWT-4 to the Vault floor, remove slings, and move (truck) to the temporary staging area in the Vault



Workers access deck of IBM-4, carrying (2) Adjust-A-Link Slings

Workers release the X-Mechanical Stop from the vertical position and carefully lower it to the horizontal position

Workers attach Adjust-A-Link sling legs A, B, C, and D to the corresponding lifting lugs on the deck of IBM-4, adjust chain links per recorded settings from test lift outside of vault

Workers attach crane hook to Adjust-A-Link slings

Figure 17 Typical Page from Installation And Operation Manual

6. Special Purpose Ancillary Components

The following ancillary items were designed to enhance the use and safety of the RDP:

- X-Stop spacers assemble to any Inboard Module and prevent damage in the unlikely event that workers accidentally attempt to drive past the end of the Carriage roundways rails if operating outside the RAB software's protective envelope.

- Manual, hand carried Horizontal Alignment Tools (HAT) that engage the Handrail sockets and can easily push or pull platform Modules during assembly and disassembly. See Figure 20.
- Joiner Plate tools that permit installation and removal while workers remain standing.
- Canopy Carts that transport, protect and store the Shielding Canopies. See Figure 15.
- Handrail Carts that that can transport all of the handrails, although current practice is to leave most of them assembled on the Modules as much as practical.
- Special slings that can hoist unbalanced loads, such as an Inboard Module with a front corner Wing attached to it.

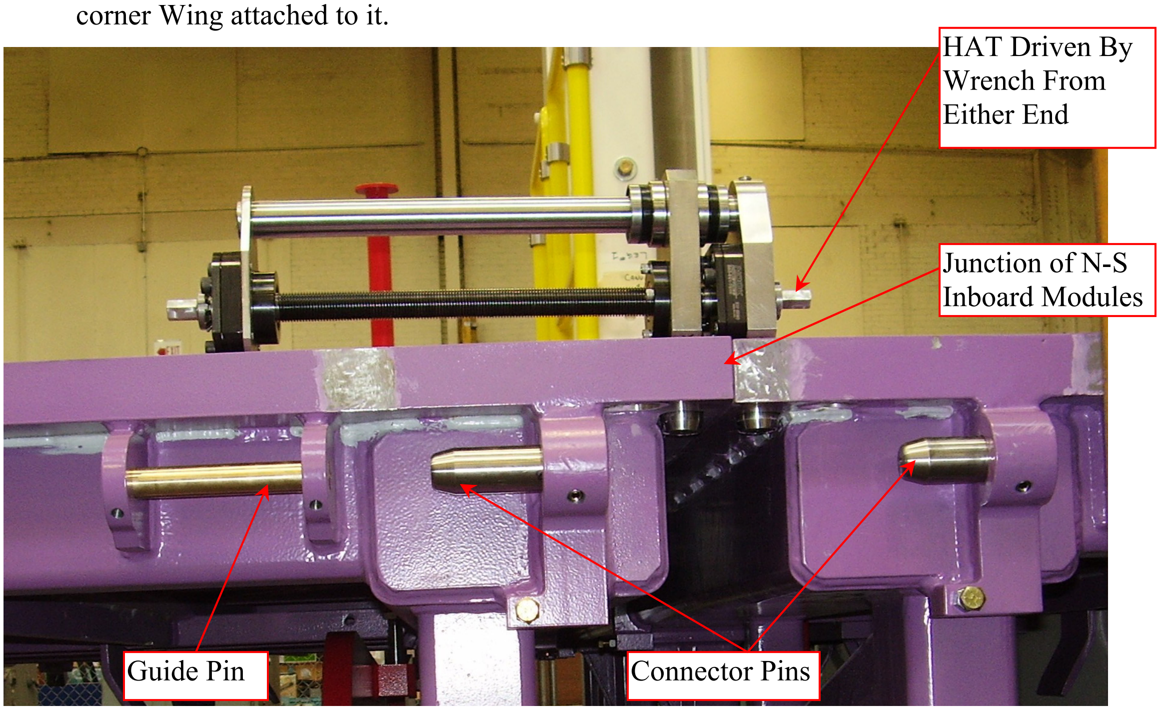


Figure 18 Horizontal Alignment Tool, In Use Near Module Connection And Alignment Pins

7. Lessons Learned During Manufacturing And Testing

GEH manufacturing was carried out with an exceptional combination of teamwork, just in time schedule control and subcontractor coordination.

Multiple fabrication subcontractors worked in parallel on mating assemblies and mating parts (GEH Nuclear Weld Shop, GE Motors Weld Shop and several subcontractors). Engineering, Manufacturing and Project Management's close liaison maintained the full interchangeability.

Bruce Power's Building Trades Union (BTU) shop also assisted the schedule significantly by cutting and coping many large structural steel items, working through their 2006 Christmas break.

8. Commissioning By Test And User Training

Because the RDP system was to be qualified for use on both faces of all eight Bruce Power reactors, commissioning at site would have been time consuming. The commissioning phase was therefore completed on mockups at GEH.

The test and commissioning phase utilized a RAB mockup borrowed from OPG Darlington (originally built at Bruce station), to rehearse the driven equipment motion. Mocked-up building features were used in simulated movements around walls and obstacles of the vault and airlock

Continuing with the beginning strategy of utilizing the experience and needs of the end user groups, many line and staff members of these groups gathered at the GEH Peterborough facility to advise and learn during the final manufacturing and testing phases.

With this experience gained, Bruce Power was able to hit the ground running in the first deployment, and to basically deploy the RDP “right out of the box”.

9. Bruce Power's RDP Operating Experience

In its first 16 months of existence, the RDP system has been deployed, redeployed and reconfigured in the vaults on 10 separate occasions. The user groups and operators on the whole have been very satisfied. See Figure 19.

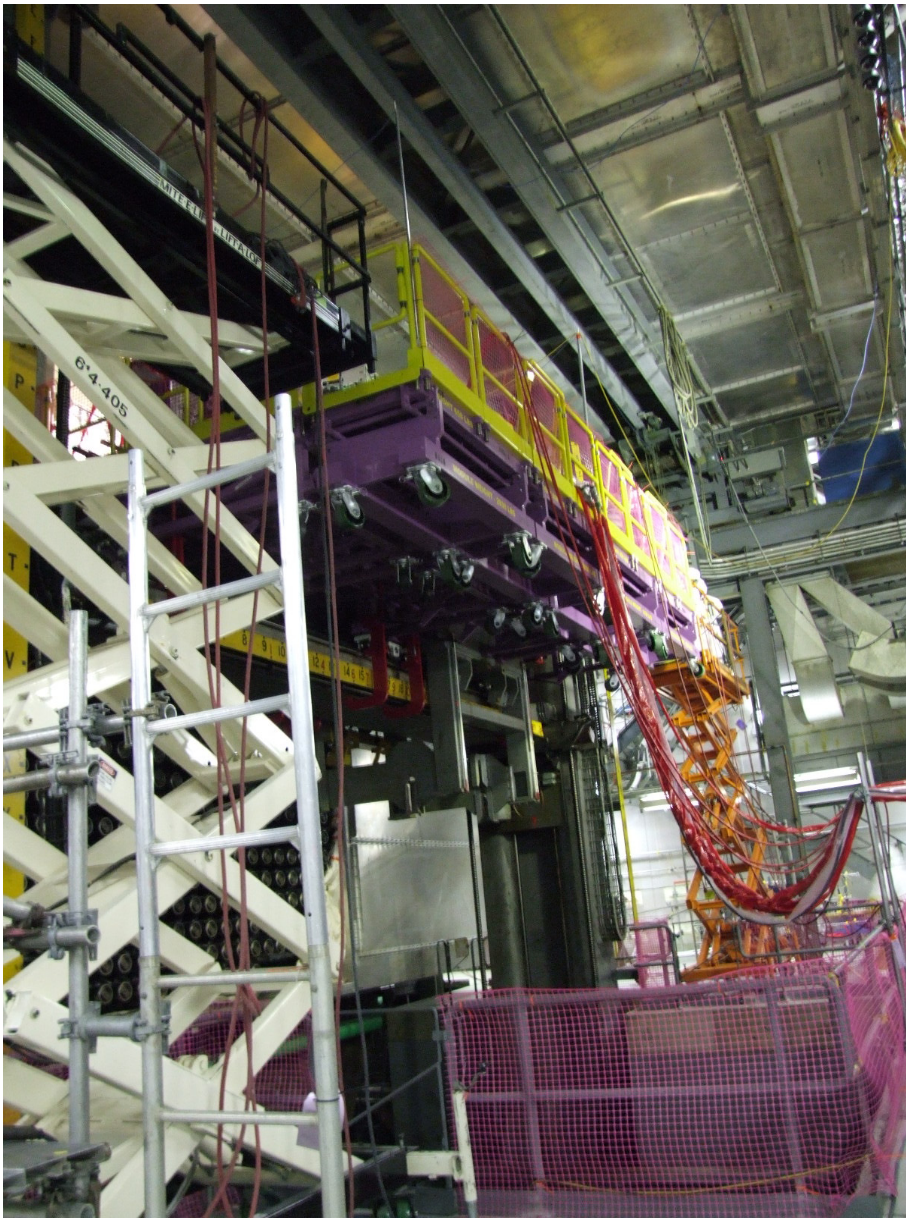
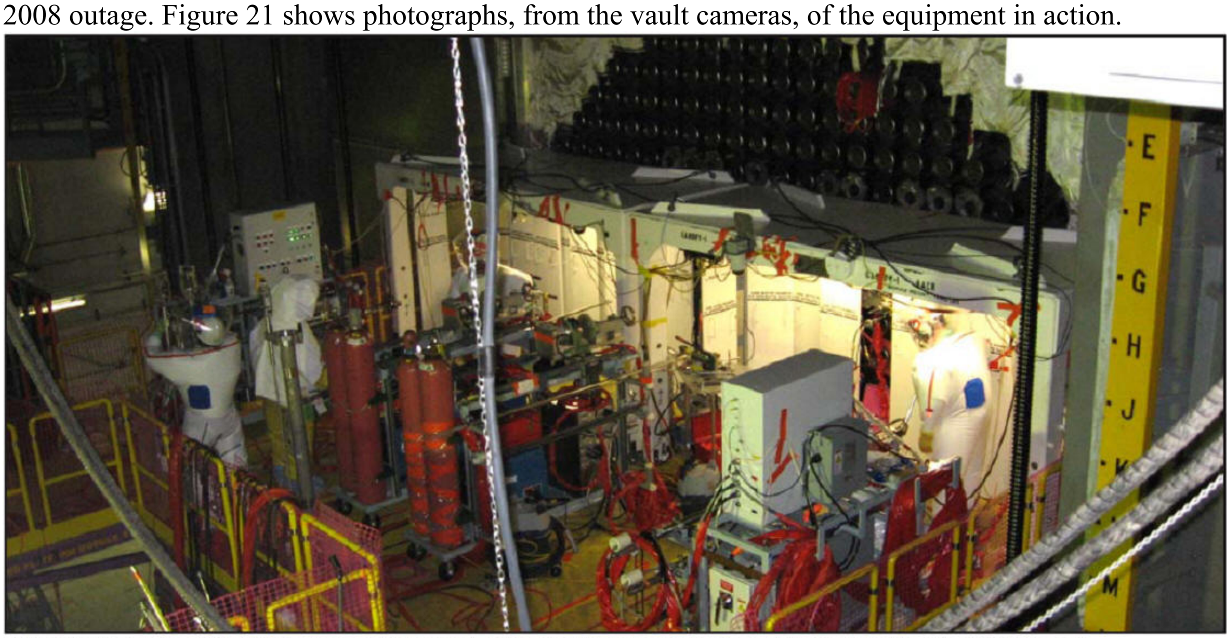


Figure 19 Configuration C Deployed On-Reactor

Because the time required to complete RAB Elevator and Carriage movements has now become a high percentage of the overall outage time with the RDP, Bruce Power has resumed the practice of using a scissors lift to get workers to and from the job elevation without Elevator movements. A further enhancement is currently being instituted that will employ a cantilevering scissor lift that will reduce or eliminate Carriage movements as well. See Figure 20.

Figure 20 Worker Access Time Further Improved By A Cantilevering Scissor-Lift

Bruce Power's Unit 3 West Shift program employed RDP Configuration C throughout the fall 2008 outage. Figure 21 shows photographs, from the vault cameras, of the equipment in action.



During the final stages of the Unit 3 outage, workers stand on the platform in front of the face of the reactor for the West Shift program.

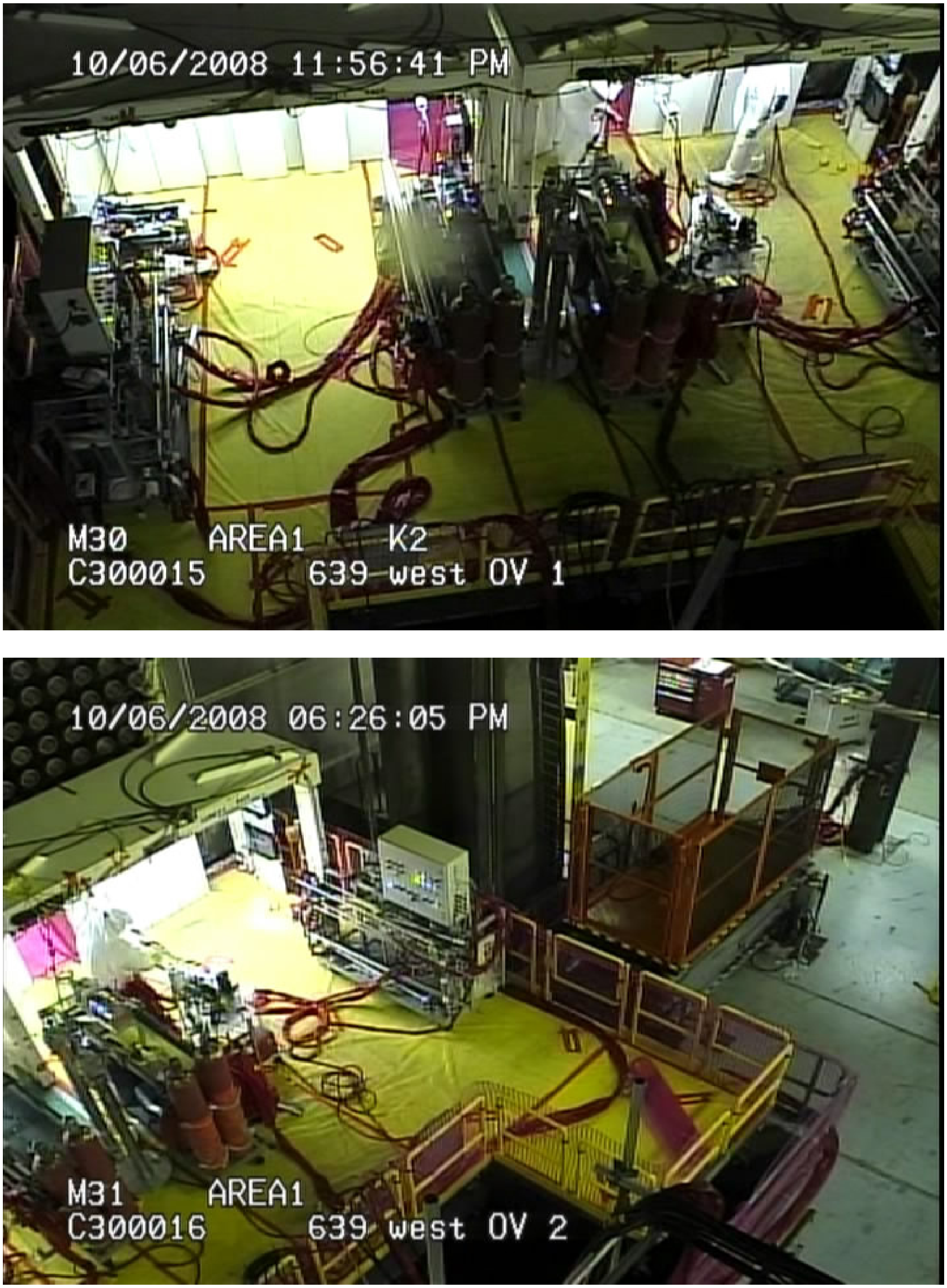


Figure 21 - Configuration C Deployed in Unit 3 West Shift Operations

The west shift project's in-vault work was run as a joint project between Babcock & Wilcox Canada and GE Hitachi Nuclear Energy Canada. The RDP contributed significantly towards the overall 140% productivity, at 80% total dose, compared to the west shift project's work plan.

The user groups' opinions of the RDP can be summed up by the following quote. After the very first deployment of the RDP, in May 2007, a glowing endorsement was quoted from Bruce MacLean, Multi-trade Team Leader at Bruce Power, who said "I've been working on site for 33 years and this is the single biggest improvement to the insulation program ever made. And the more this platform is used, the better we're going to get, and the more benefits we'll see in the long run".

10. Summary

For reactor face maintenance, the RDP is a leap forward in the efficient and safe delivery of the workers and tools to the job site.

This paper outlines the high level of end-user input and cooperation that drove the concept development and has contributed greatly to the overall success and acceptance of the equipment.

It describes the historical background of the problem and the chronology of the development of the solution. The evolving design and the final features of the RDP are chronicled, followed by the continuing story of its manufacture, testing, commissioning and deployment, all of which was consummated over a very short 14-month period.

This paper outlines the underlying RDP philosophies of modularity, adaptability, universality and interchangeability, each of which is key to achieving the goal of one platform system for many jobs at both stations, as opposed to a purpose-built platform for each job at each station. This is illustrated further by comparing the RDP features to the purpose-built equipment it is replacing.

The paper continues with a list of the clockwork steps of the modular RDP installation and then lists the significant benefits that accrue to overall outage time, actual working time and total worker dose, such as:

- Reduce the time to install and remove the RDP by 90%, versus the MFCR platform.
- Reduce the number of workers and total dose to install and remove by 90%.
- Reduce the maintenance workers' dose by 30% to 80%.
- Amortize the overall project cost over 1-2 outages, even without including the significant payback from worker dose reduction.

The RDP project sets a new standard for collaborative development of equipment, between the user, the designer and the builder.

11. Acknowledgements

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Lastly but most important, we owe the overall success to the many people at both GEH and Bruce Power who took ownership of this project from the start and made certain that it all, literally, came together flawlessly in the end.

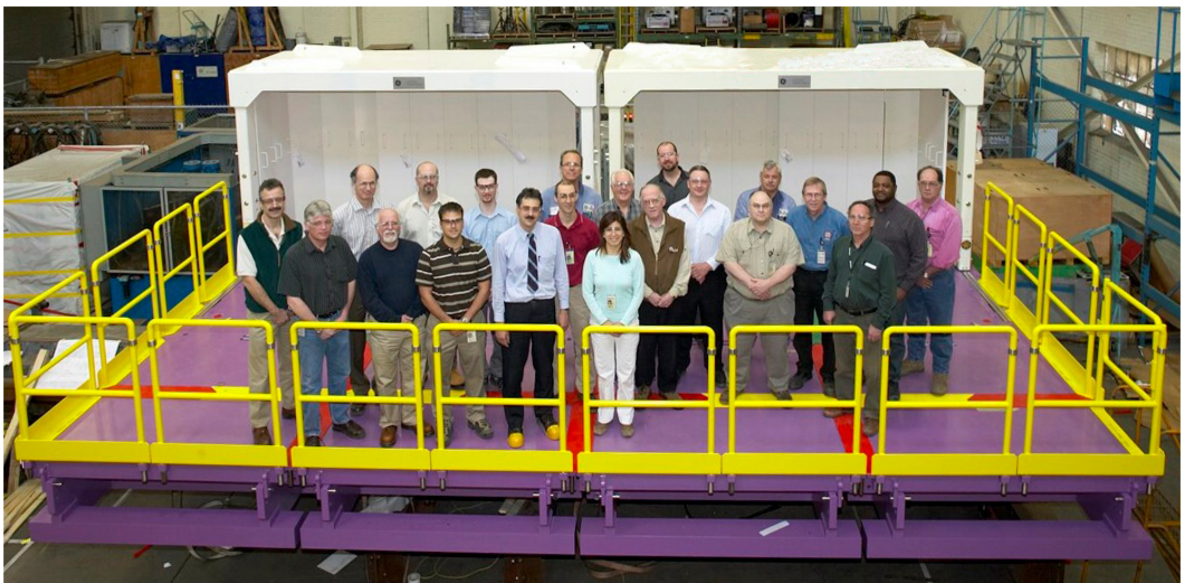

Figure 22 The GEH Design/Build Team Demonstrates The Scale Of Configuration C