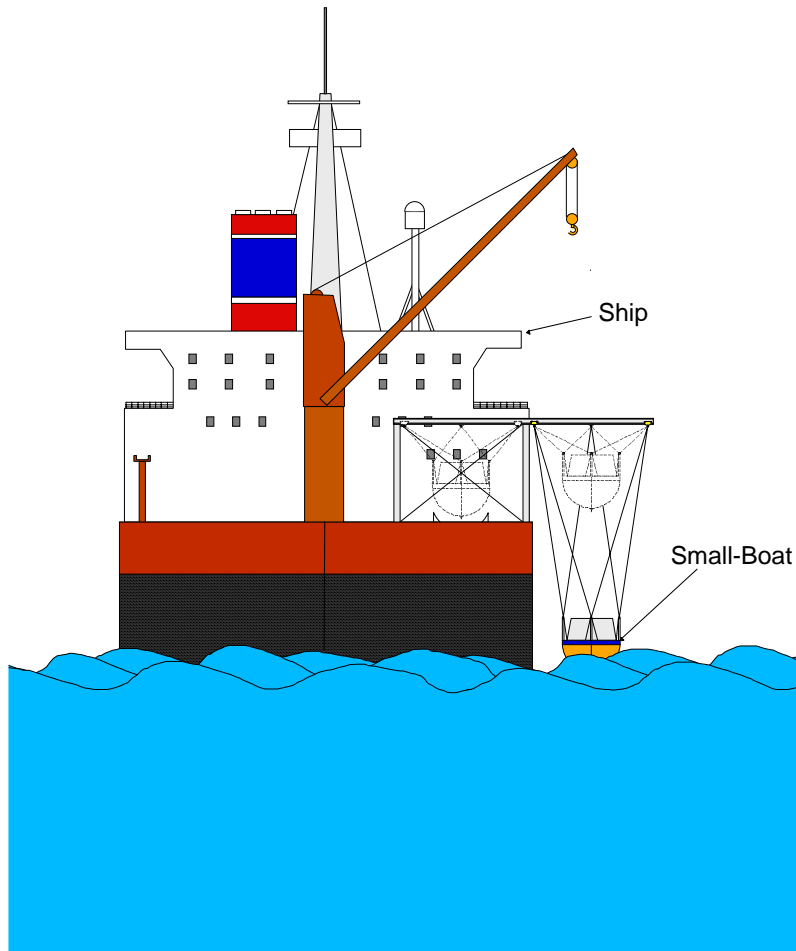


RoboCrane Applications for Ships

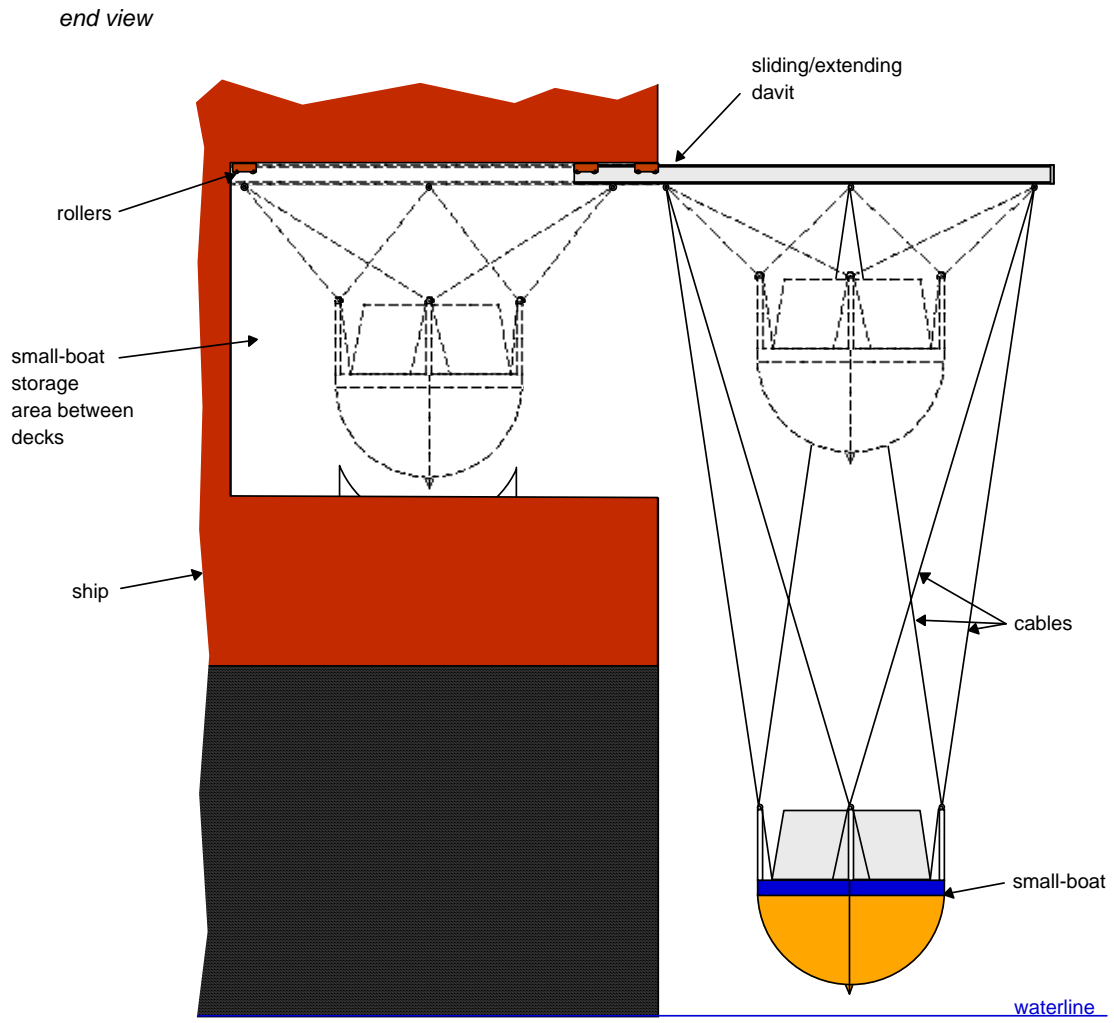
Roger Bostelman, NIST

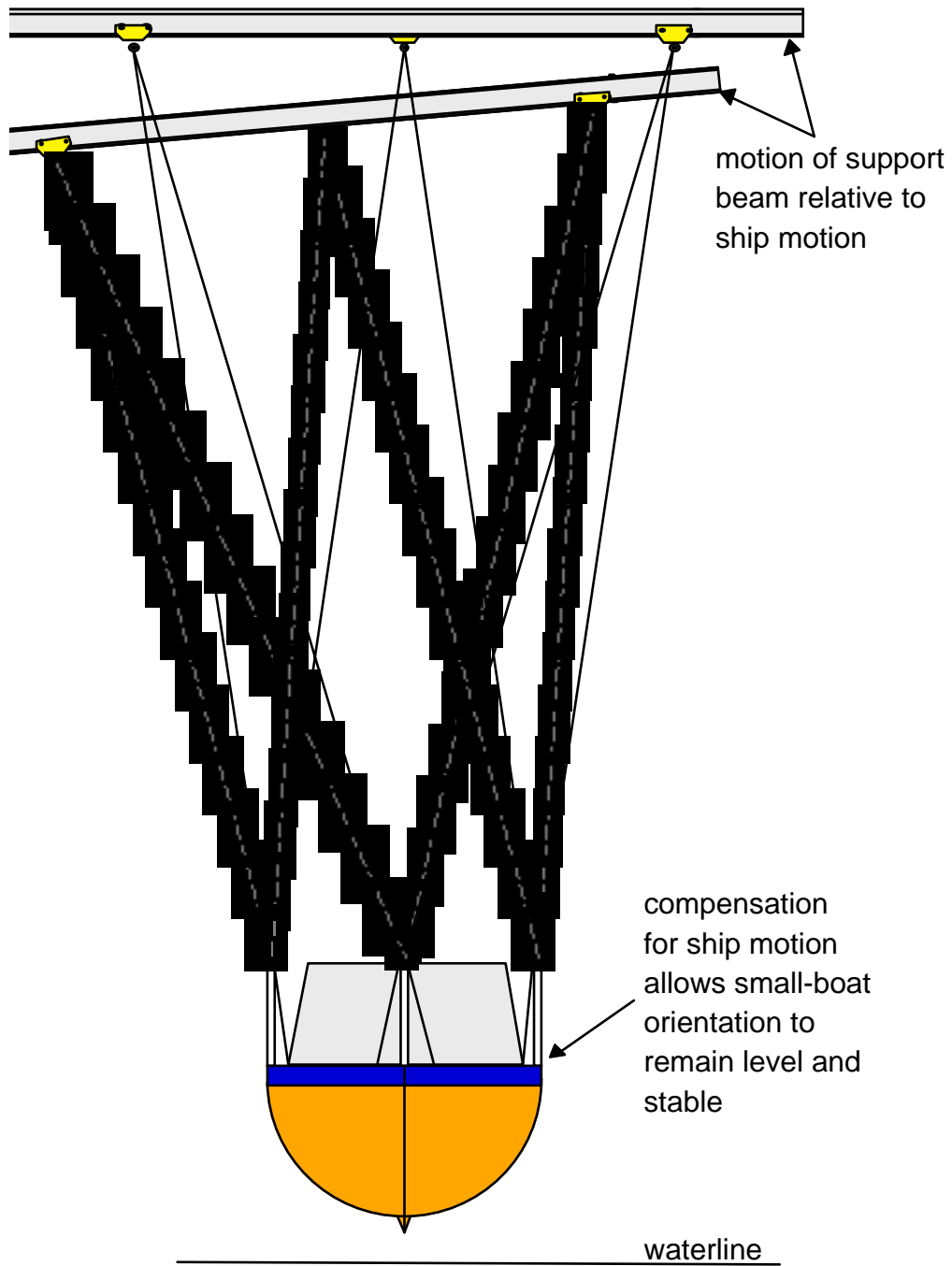
May 28, 2003

Small Boat Launch/Retrieve System

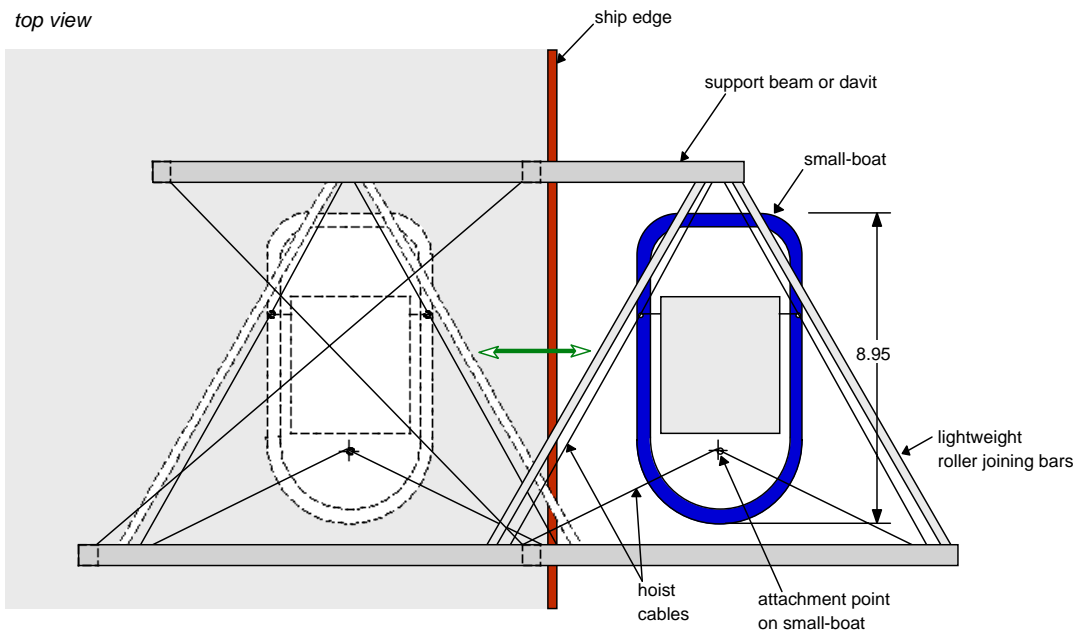
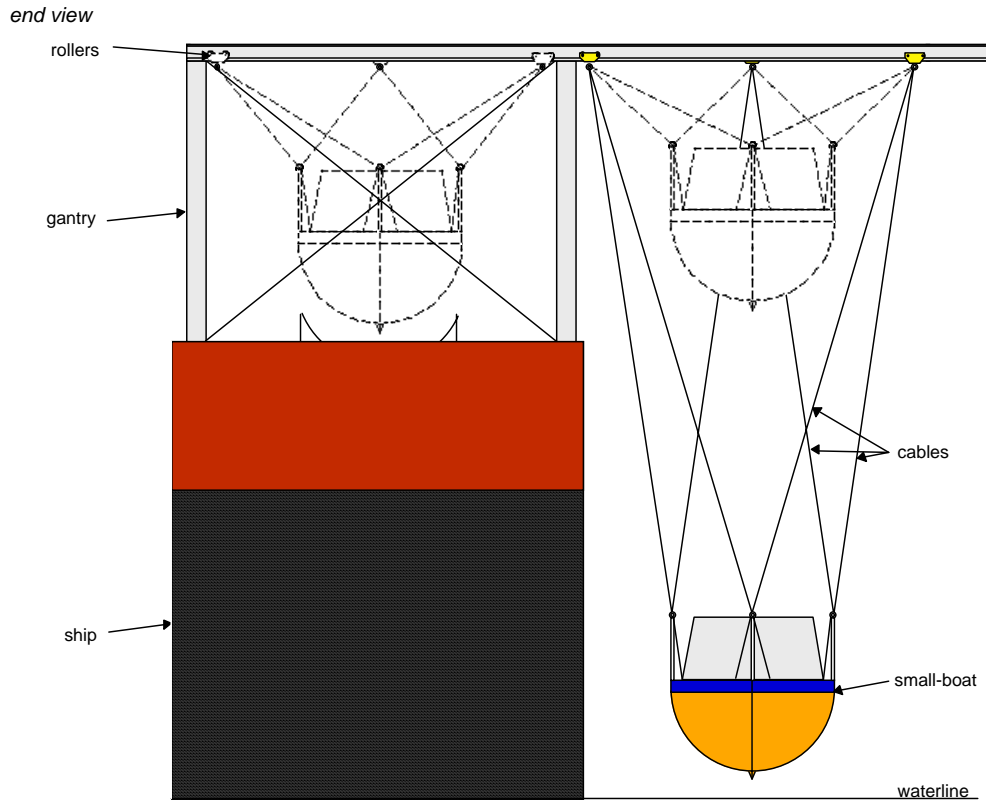


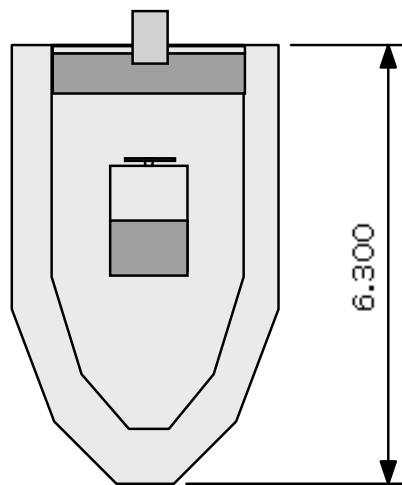
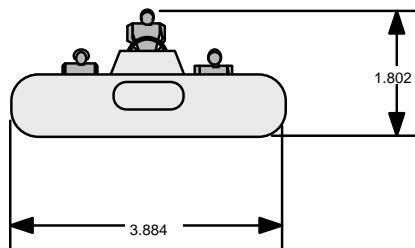
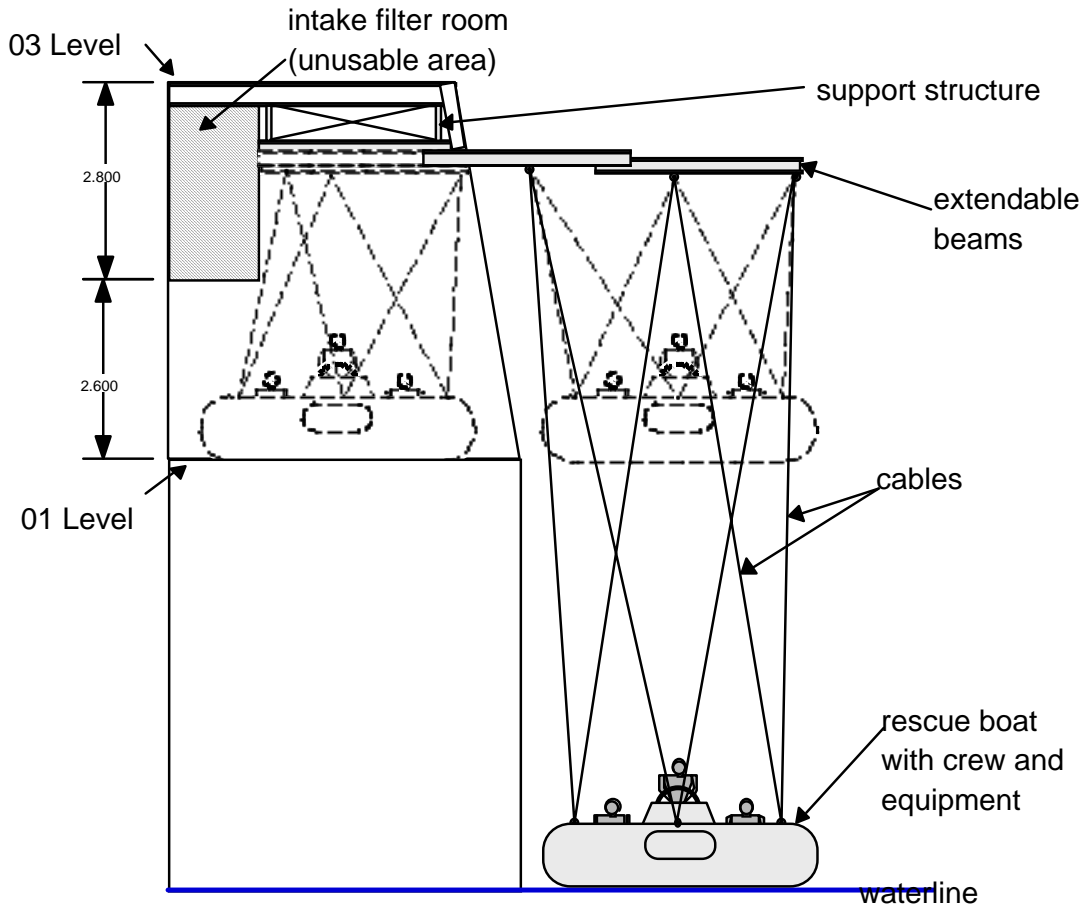
RoboCrane Applications for Ships





RoboCrane Applications for Ships





The Rescue Boat launches from a pocket stbd on the 01 Level extending from FR 62.5 aft to FR 80. The pocket is two decks high, 2.6 meters to the 02 Level

and then 2.8 meters to the 03 Level. On the 01 Level, the pocket extends inbd approx 5 meters from the deck edge. The shell slopes inbd 10 degrees and the transverse bulkhead at FR 80 slopes fwd.

The opening in the shell that the boat launches through is approx 11 meters Long from FR 65 to FR 76 and 4.45 meters in height along the 10 degree slope. There is a 75mm waterway bar above the 01 Level before the opening starts. There is a RCSR closure which covers the opening. At the 02 Level there is a deck which is cut out in way of the opening, 11 meters long and approx 1.3 meters from the inbd bulkhead.

WELL DECK CLEANER

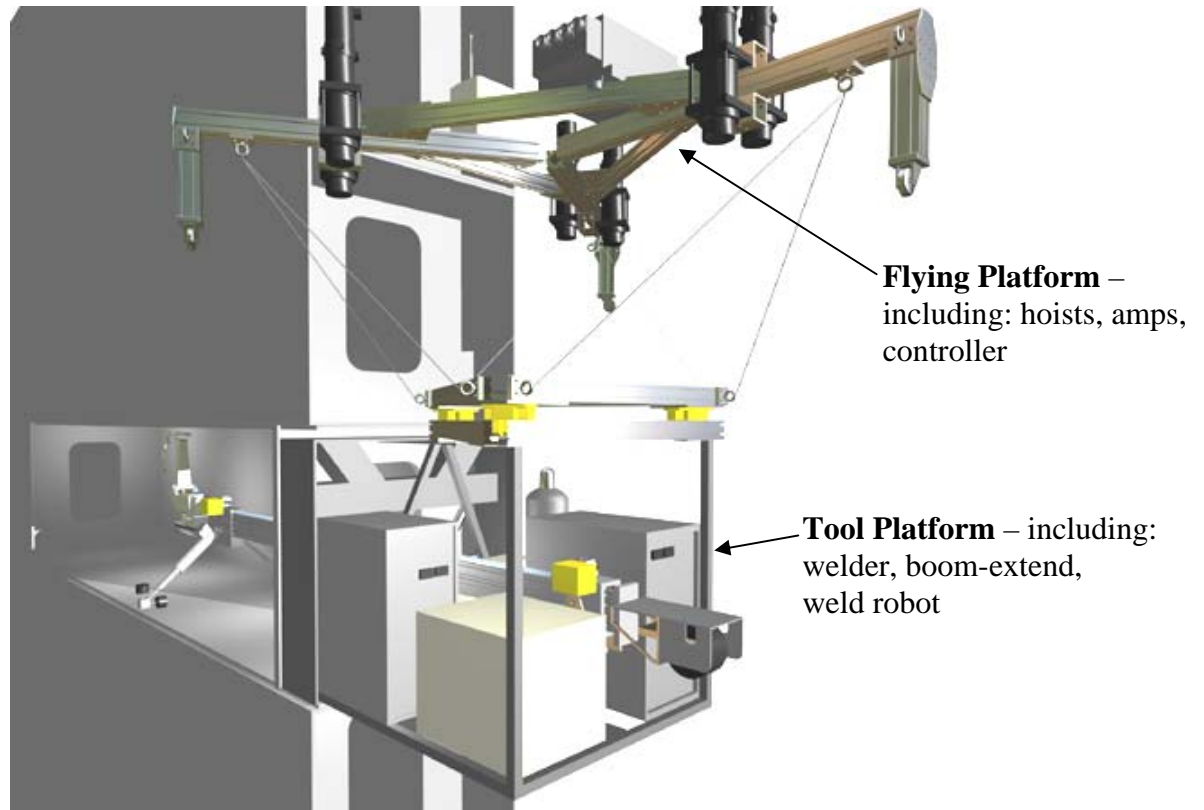
LPD Cargo Bay Corrosion Cleaner

ATR, NIST

May 17, 2000

ATR and NIST jointly developed an Advanced Double-Hull Ship Welding System for the Navy. Partnering with Newport News Shipbuilders and Diahon Robots, managed by Naval Surface Warfare Center, and sponsored by the Office of Naval Research, this project developed useful technology that can be applied to a variety of naval tasks. The basis of the technology was two-fold: a Flying Platform and a Tool Platform as shown in **Figure 1**.

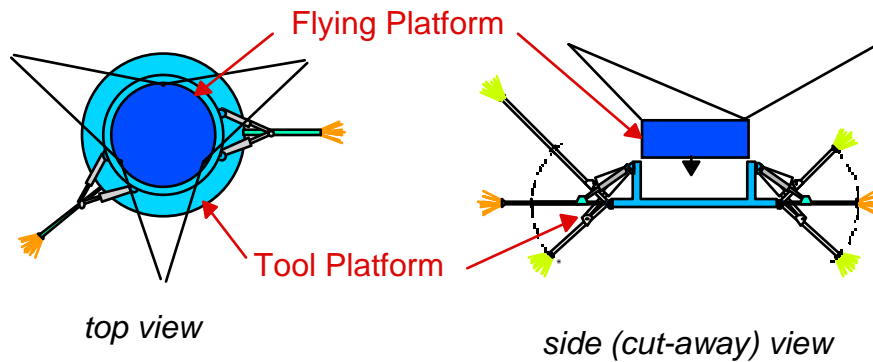
Figure 1 – Advanced Double-Hull Ship Welding System



Similar to the Advanced Double-Hull Ship Welding System, a system of dual platforms is conceptualized for cleaning the LPD Cargo Bay. This system also includes two platforms: a Flying Platform (6' dia.) and a Tool Platform (9' dia.) (see **Figure 2**). The Flying Platform is a remote, 6 DOF controlled manipulator with an additional drive axis (as a roll-platform axis) to drive along support beams. Platform rollers can space between any number of beams, but should reach the ceiling at this separation (16'). Platforms can yaw, pitch and roll $\pm 20^\circ$. Variable length and hinged connector arms between wheel units allow the use of one drive wheel and keep the upper triangle in (nearly) calibrated status. Calibration includes knowing the initial size of the upper triangle (support points locations).

The Tool Platform includes two or more tool arm rotate axes with manual or actuated extend feature on the tool arms that can be joystick controlled. The tool arms are tripod-mounted for stability/rigidity.

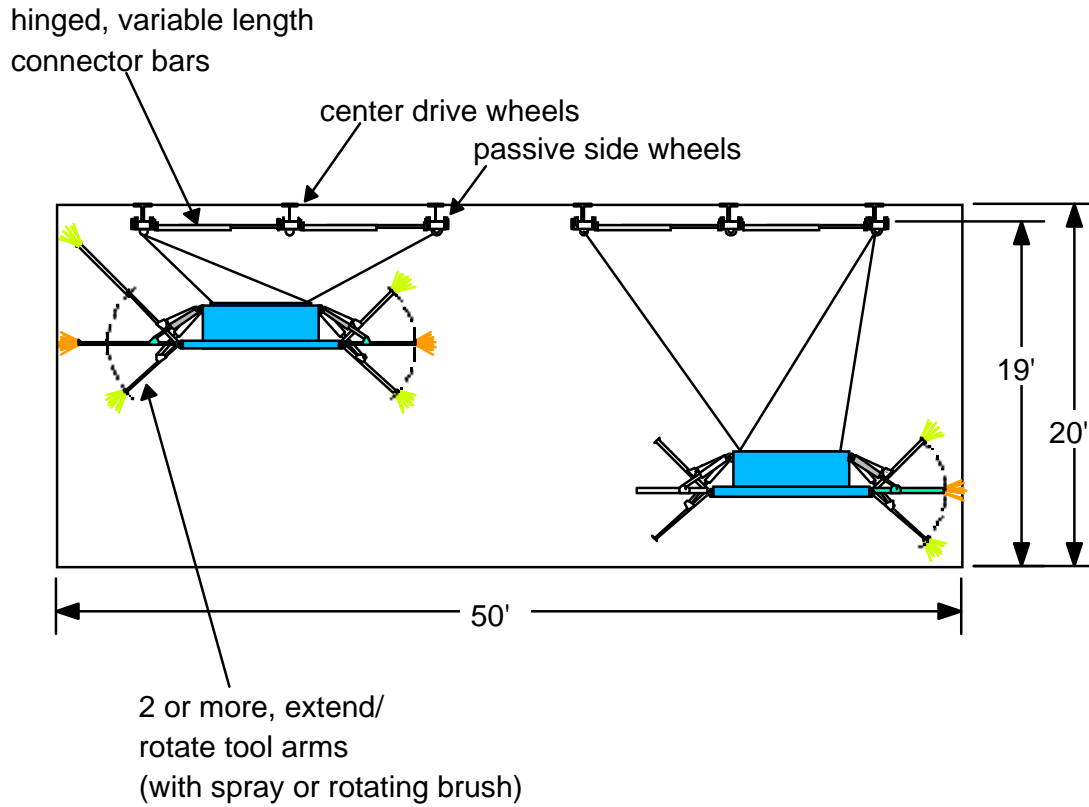
Figure 2 - Platform top and side cut-away views - tool arms have tripod-type mounting for rigidity. Flying platform can be removed from the Tool platform for tool change or other Flying Platform uses (e.g. material handling).



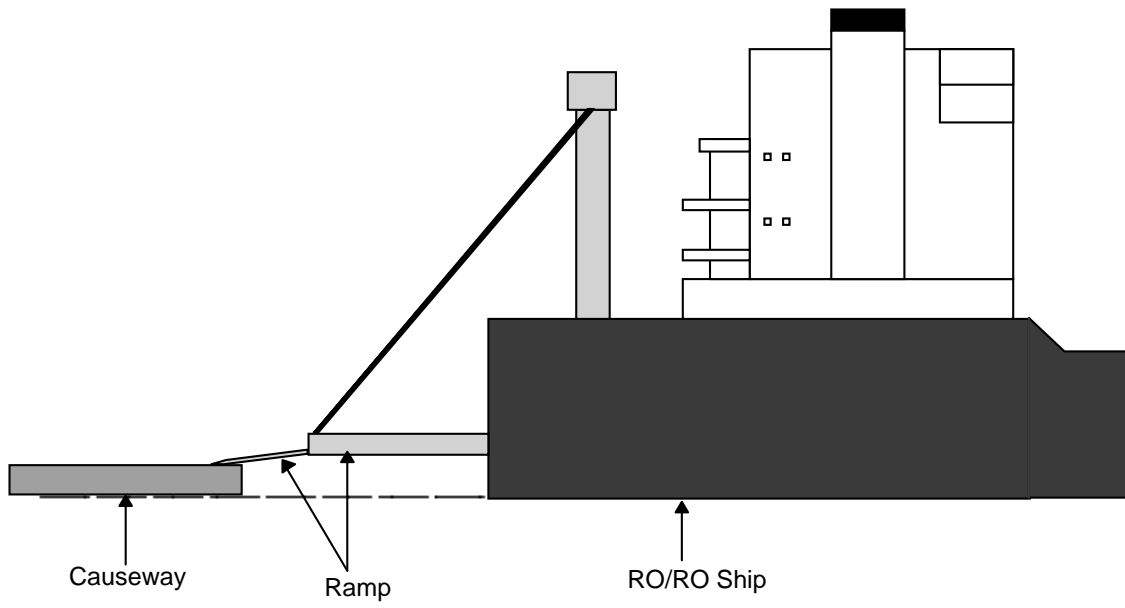
In order to clean the LPD cargo bay, several tools are potentially needed: inspection head, scuff-sand/brush, spray chemical (or other corrosion removal media), vacuum, squeegee, and/or paint tools. This variety lends itself well to the dual platform approach suggested. **Figure 3** shows a cargo bay end view. This approximated size with I-beam support is one approach to deploying the Platforms. Without structural I-beams used for cranes, hard points can be used to attach the Platforms to the ceiling of the cargo bay. Dependent upon what tool is required, the platform can detach and attach tools within its work volume using simple joystick commands. Once attached, the tools are deployed using the Flying Platform throughout a large work volume defined by the structural attachment points. One or more dual Platforms can be deployed and controlled by a remote operator or by semi-autonomous or teach commanded trajectory control.

Figure 3 - Cargo bay end view showing end of ceiling mounted I-beams supporting dual platforms.

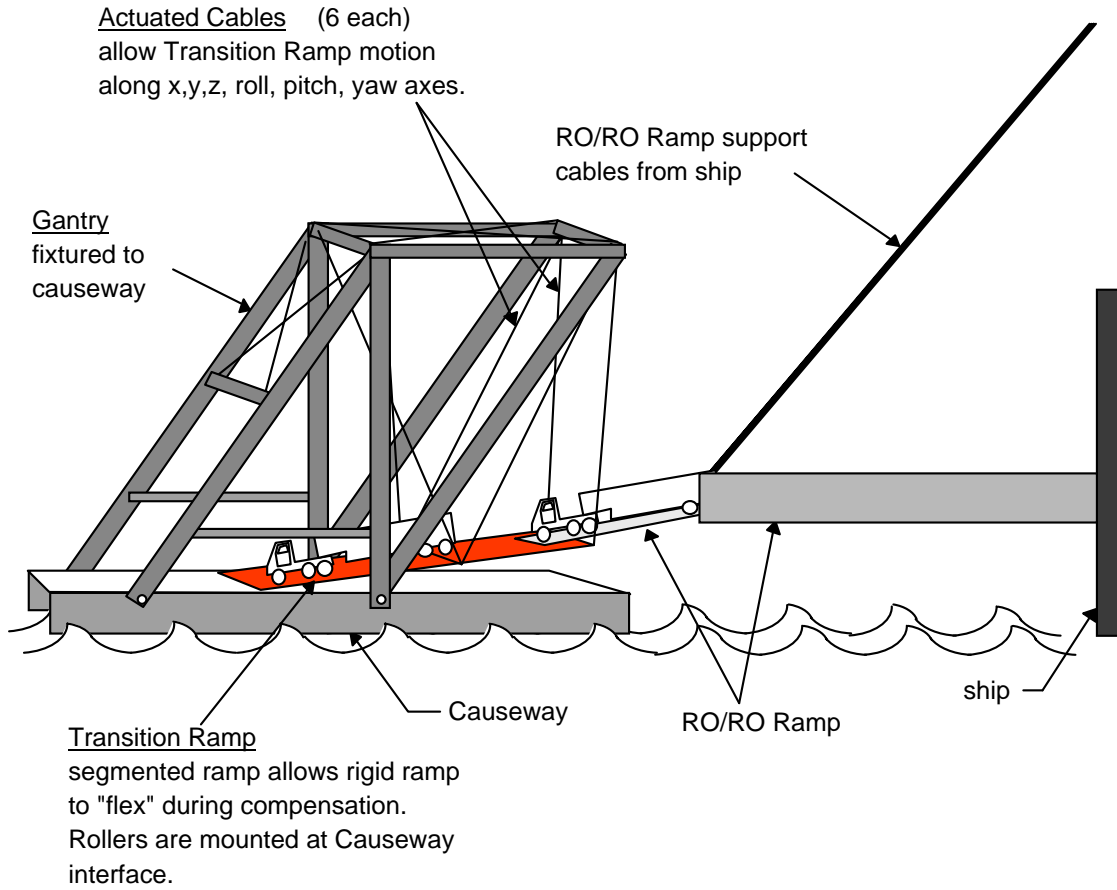
RoboCrane Applications for Ships



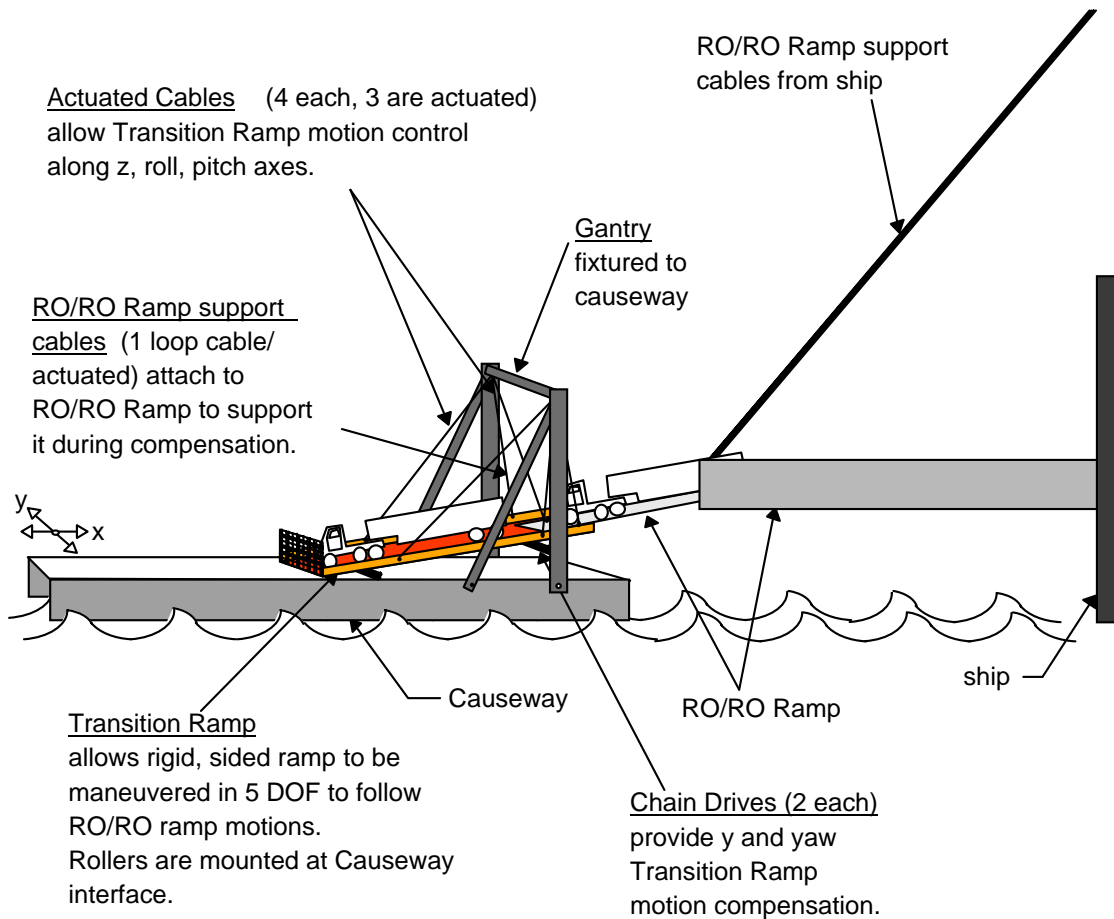
RO/RO Ship with Deployed Ramp to Causeway



CONCEPT 1 RO/RO RAMP COMPENSATION SYSTEM



CONCEPT 1 RO/RO RAMP COMPENSATION SYSTEM

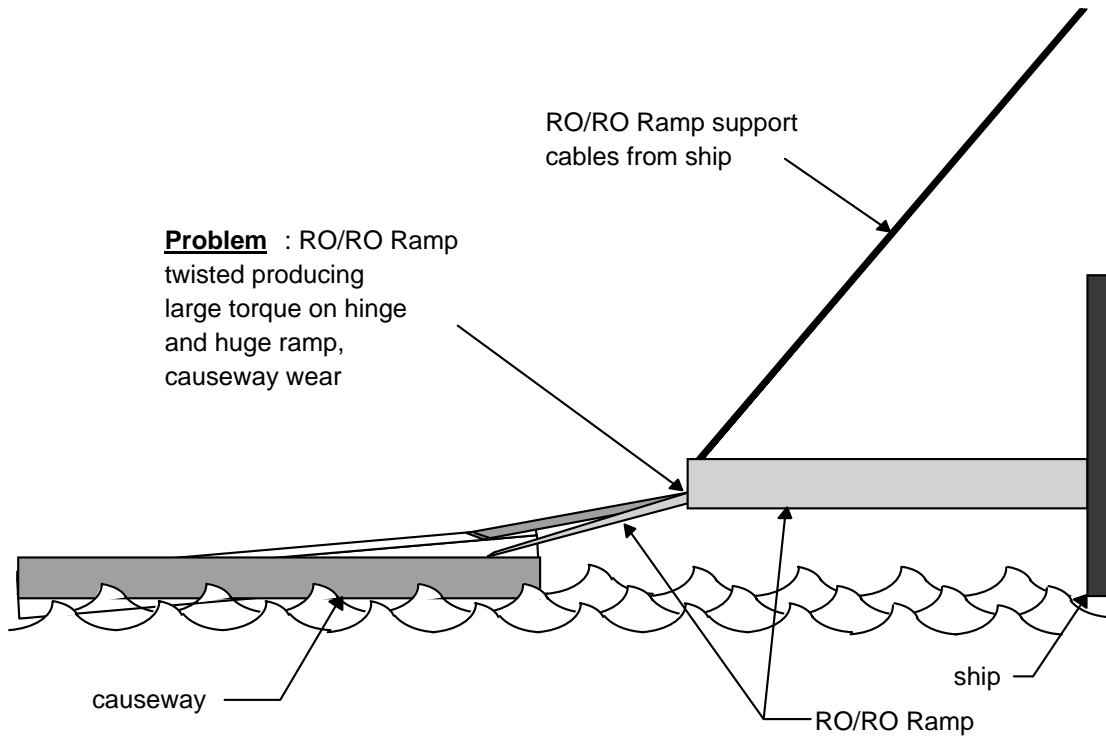


Note: Ramp is long enough to provide sufficient x motion compensation. No additional actuation and control needed for this axis.

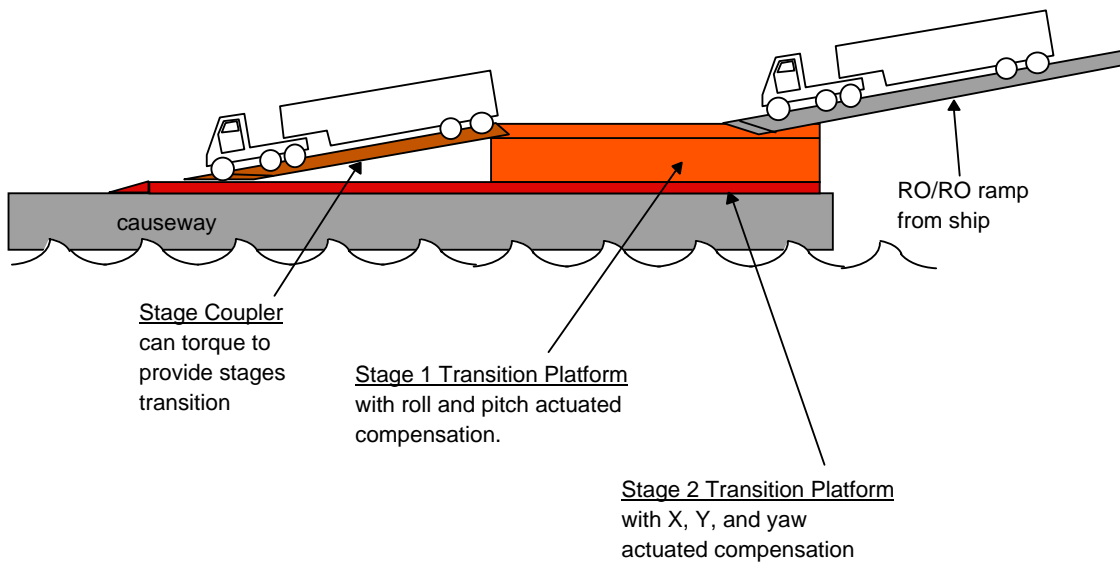
Operating Procedure:

1. RO/RO Ramp cables attach to RO/RO Ramp - allow roll compensation between ship and causeway.
2. Transition Ramp is lifted and servoed to meet RO/RO Ramp - allows smooth transition between RO/RO Ramp and Transition Ramp
3. Cargo moves from RO/RO Ramp to Transition Ramp
4. Transition Ramp is lowered below RO/RO Ramp level - cargo is now moving with respect to causeway ramp only.
5. Front gate is opened to causeway deck and allows cargo to move onto causeway.
6. Repeat...

RO/RO RAMP PROBLEM



CONCEPT 2 RO/RO RAMP COMPENSATION SYSTEM

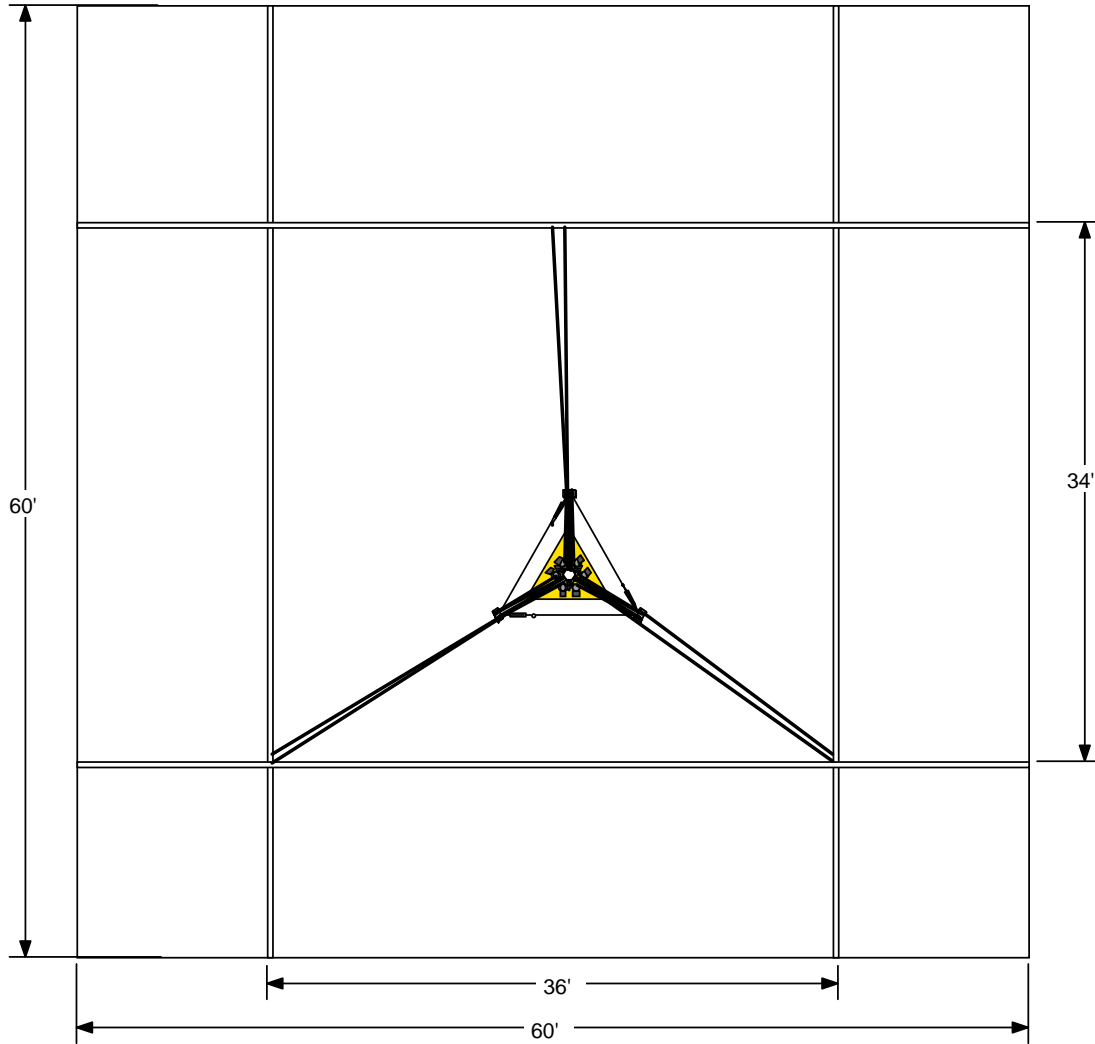


MOTION CONTROL THROUGH:

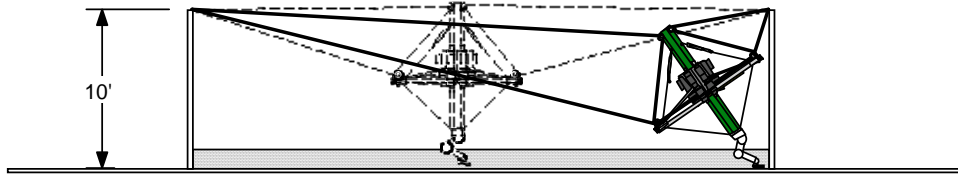
- SENSED RELATIVE MOTION BETWEEN RO/RO RAMP AND CAUSEWAY USING VERTICAL AND RATE GYRO'S COMPARISON
- OR STAGE 1 CONTACT-LOAD SENSING FOR ROLL AND LINEAR POTENTIOMETERS FOR PITCH MOTION FEEDBACK TO CONTROLLER.

SUSPENDED ROBOCRANE WELDING ROBOT for ship section stiffener welding

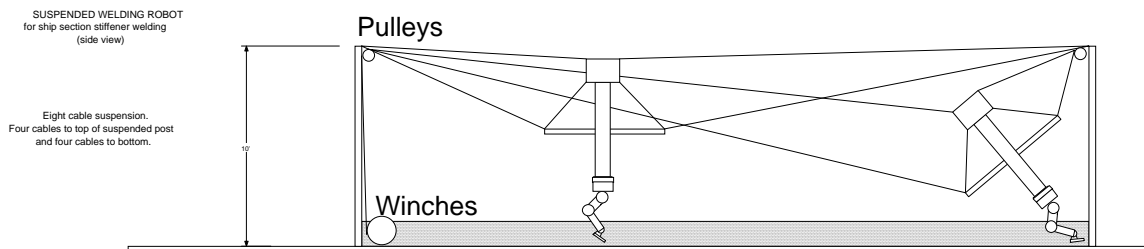
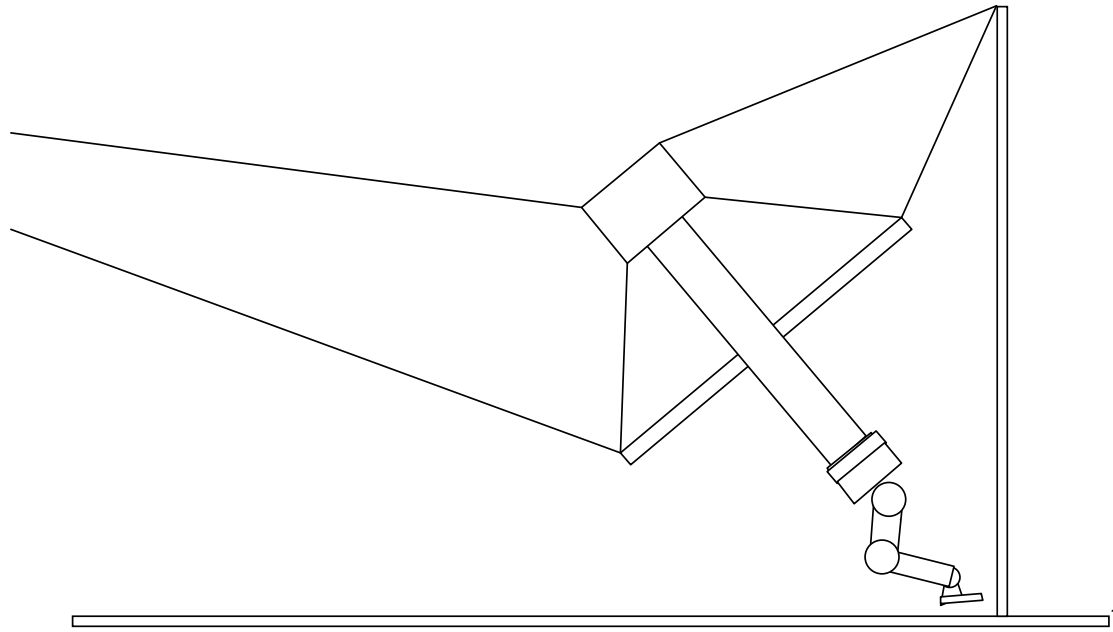
top view



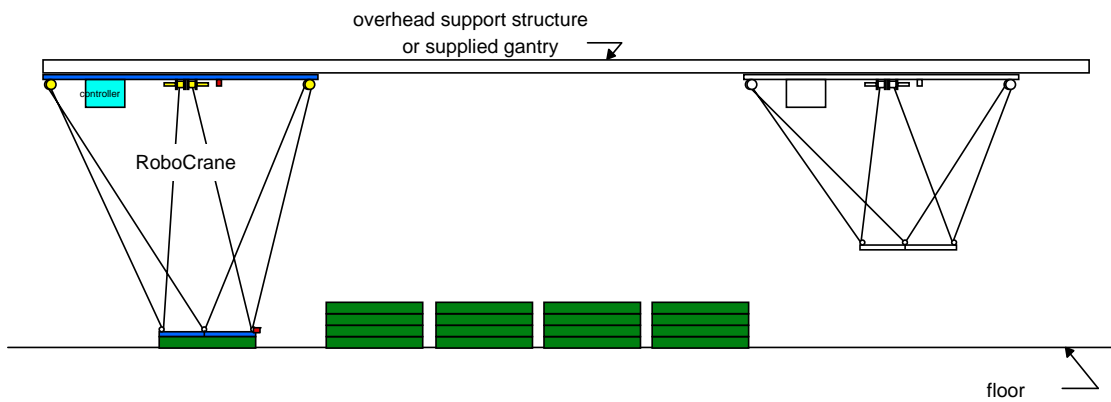
side view



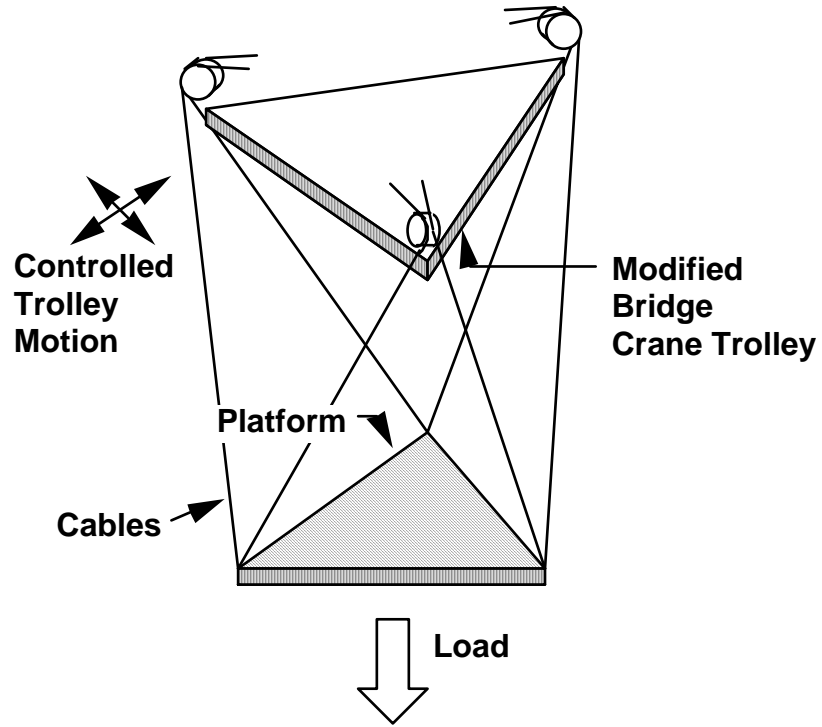
- Nine Cable Suspension:
 - three (tension) cables to top of suspended post
 - six (position/tension) cables to bottom.



Material Handling RoboCrane

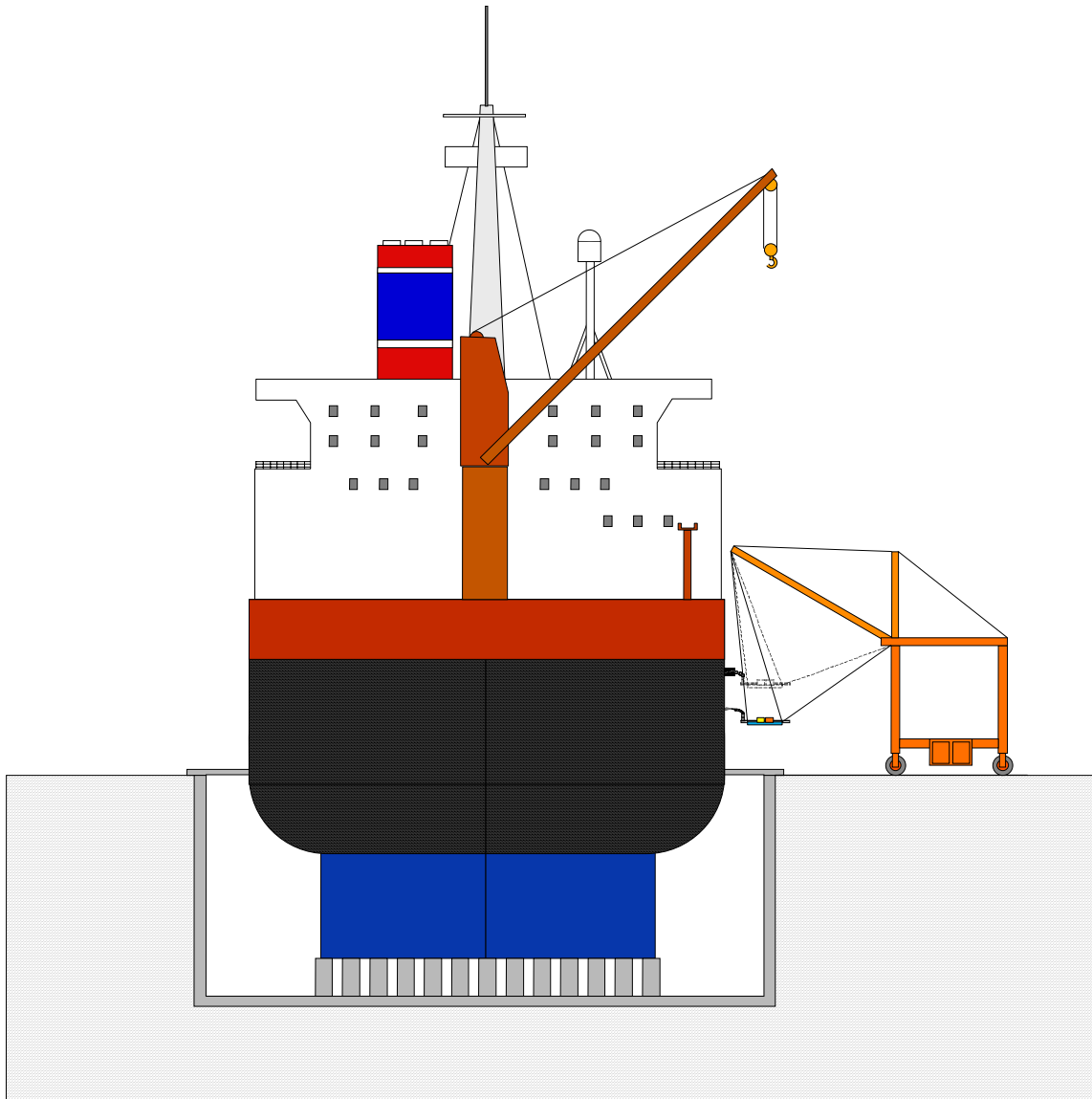


RoboCrane Geometry attached to a bridge gantry crane.



RoboCrane Applications for Ships

Gantry Crane fitted with Robocrane Manipulator for Ship Hull Work



Air Transportable Expeditionary Crane
For Marine Corp.

Includes dual RoboCranes and used for Raised Airstrip Assembly. Air transportable from ships at sea via helicopter but, technology can be applied to ships (e.g., dual RoboCranes, cantilevered boom, cable configuration, etc.).



**Flying Carpet Applied to Ship Repair and Submarine
Repair/Construction**

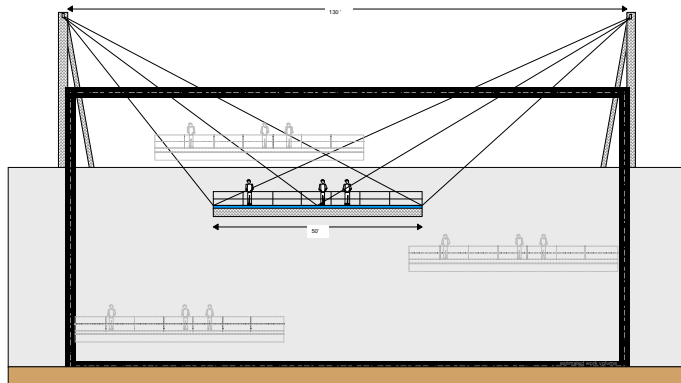
NIST Flying Carpet Concept



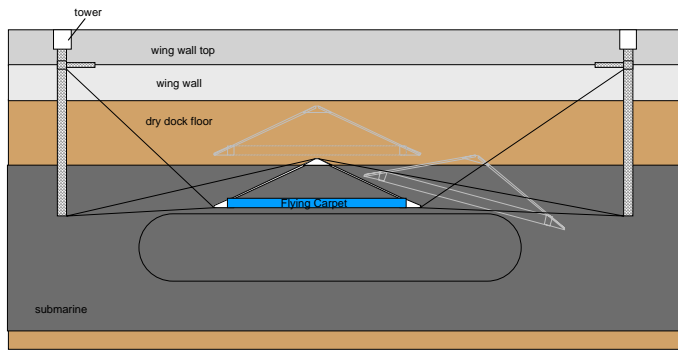
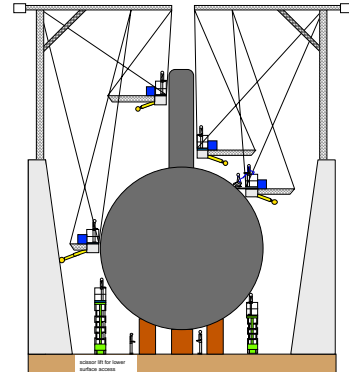
Full Scale (50' long x 22' dp.) Flying Carpet Prototype suspended in the NSIT high bay.



Application - Submarine Access in Dry Dock

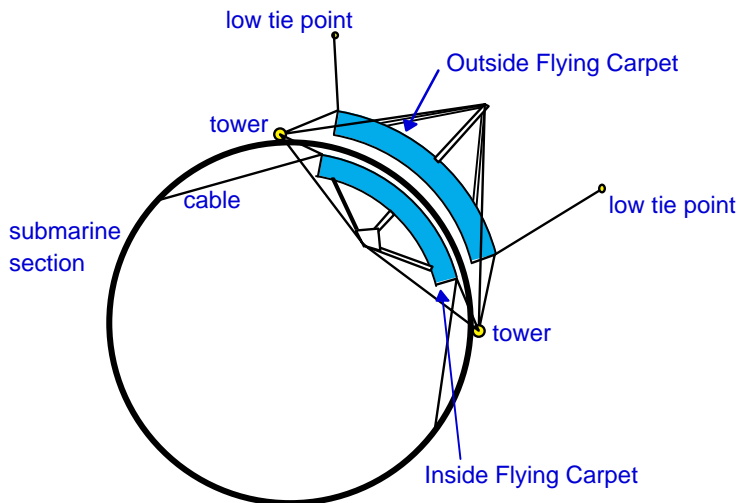


Front View - showing multiple platform positions



Top View - showing multiple platform positions

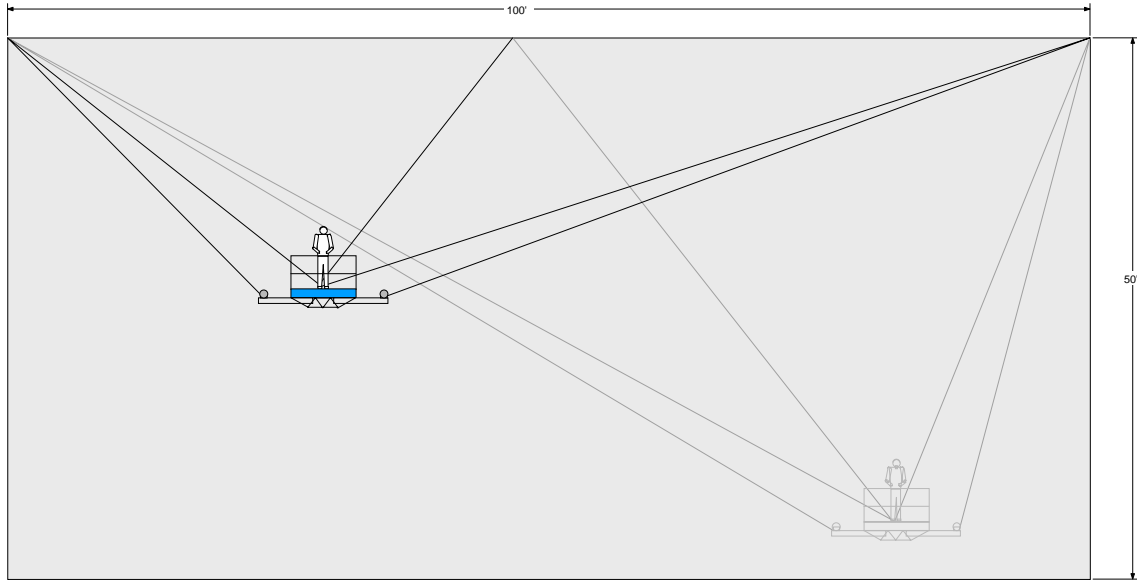
Application- Submarine Manufacturing



Top View of submarine section being accessed by two Flying Carpets - one inside, one outside.

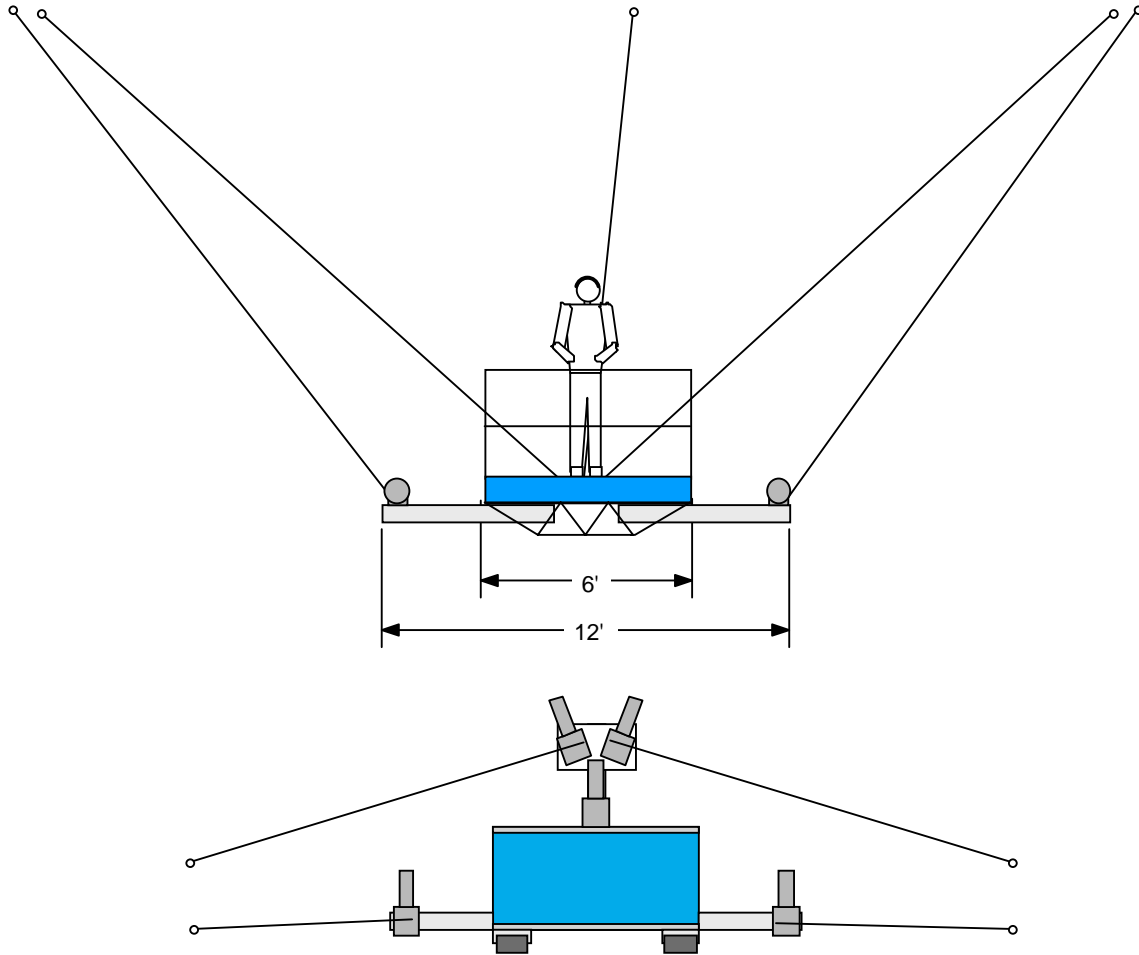
Entire Submarine Section Access

- Larger platforms (i.e., could even be constructed as entire circles)
- *OR* move towers and support points
- *OR* towers and low tie points could be mounted to circular rails



Flying Carpet (Single Operator)
for: Internal Wall Maintenance
e.g., Ship Ballast Tanks
Roger Bostelman
NIST 10/17/02

RoboCrane Applications for Ships



Example of a (nearly) commercial RoboCrane system:

The Air Force Manipulator Platform (AMP) Deployed at Warner Robins Air Logistic Center in Georgia. The RoboCrane system is used to remove paint rapidly from an aircraft while the operator is inside an enclosed cab.

RoboCrane Applications for Ships



