“Flying Carpet” Applied to Ship Repair and Conversion

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Presentation Outline

- Problem Statement/Solution
- NIST Flying Carpet
  - Basis, Set-up Sequence, Ship External Surfaces

    Accessibility, Capabilities, Pros, Scale Models
- Approximated Cost and System Components
  - Testbed and Full-scale versions
- Next Steps/ Maritech Phase 2 Tasks

Problem Statement

- Ship bow and stern are difficult and inefficient to access with conventional stick-built scaffold methods.

- Ship upper sides can also be difficult.

- *Example*: Observed more than 1 shift (8 hrs.) x 8 people to assemble single, fixed 80 foot tower to ship bow on dry dock = *64 person-hours total*.

- ***Solution***: Flying Carpet - takes an estimated 1 hour x 3 people to set-up = ***3 person-hours total***.

    - PLUS: Flying Carpet provides maneuverability of people and heavy loads (steel plate, equipment, ...) with simple joystick control.

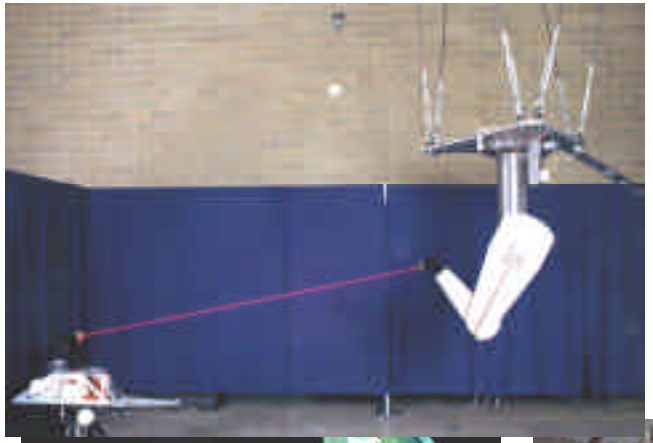
NIST Flying Carpet

Flying Carpet Basis

NIST RoboCrane Technology

Constrained platform motion from rigging

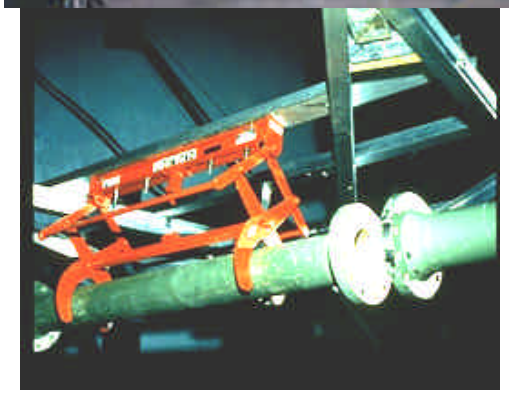
Ref: NIST Tech. Note 1267



... including,

RoboCrane platform control

Precision joystick and programmed control demonstrated



Combined with...

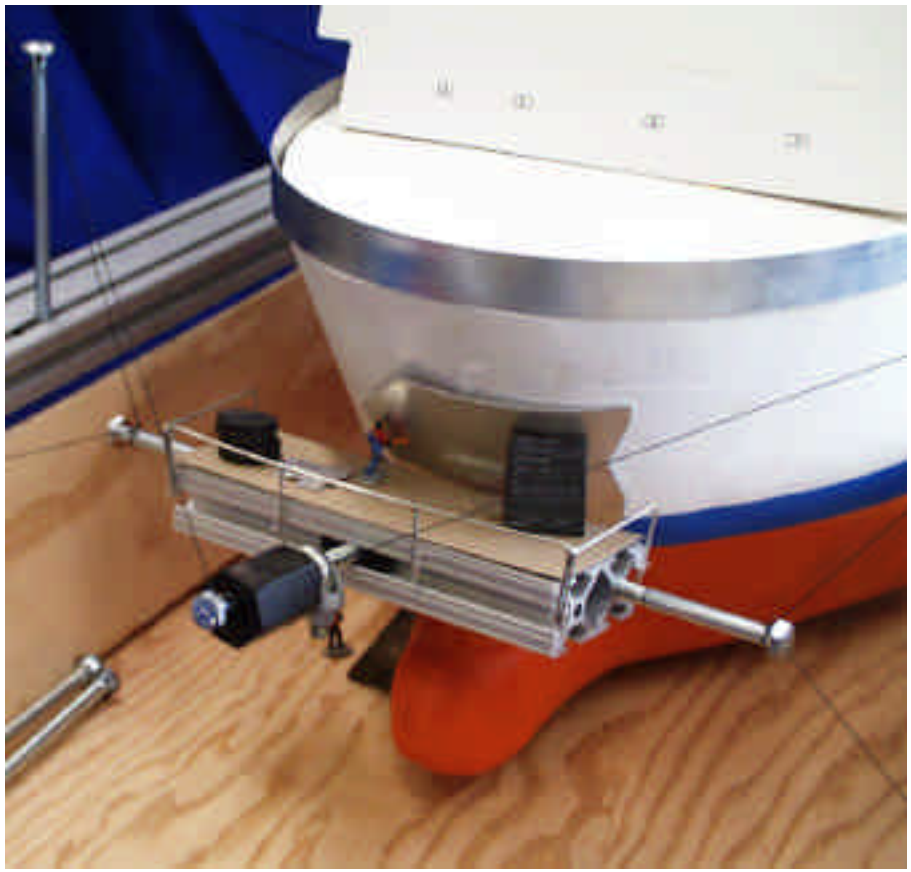
Commercial Scaffold

Photos Courtesy:

Scaffold Service Inc.

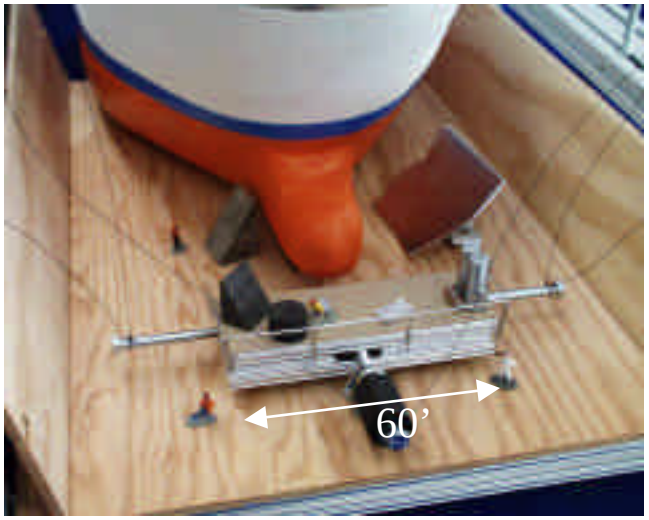
and Courtesy: New York Ladder & Scaffolding Corp.

Flying Carpet Features



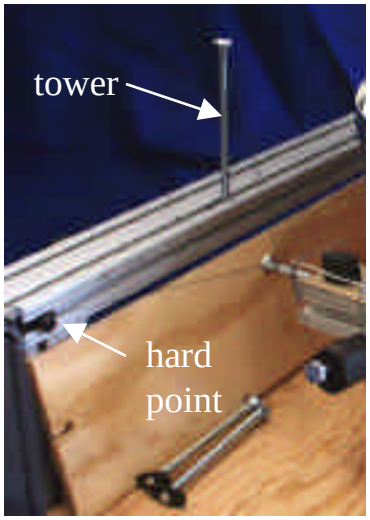
- Joystick controlled
- 60’ x 20’ modular platform
- 5.6 ton max. payload
- 80 feet or more working height (tower ht. depend.)
- ±20° Yaw Rotation
- Dry Dock mount allows some pre-set-up and reconfigurability
- Platform weight: 2.8 tons
- Stable in 6 DOF

Flying Carpet Set-up Sequence



1. Flying Carpet (100’ x 40’ with 60’ x 20’ work-platform) is craned or wheeled to dry-dock; Cables are handed to workers at dry-dock sides.

Note: Some pre-set-up (i.e., tower installation) can occur prior to ship arrival!

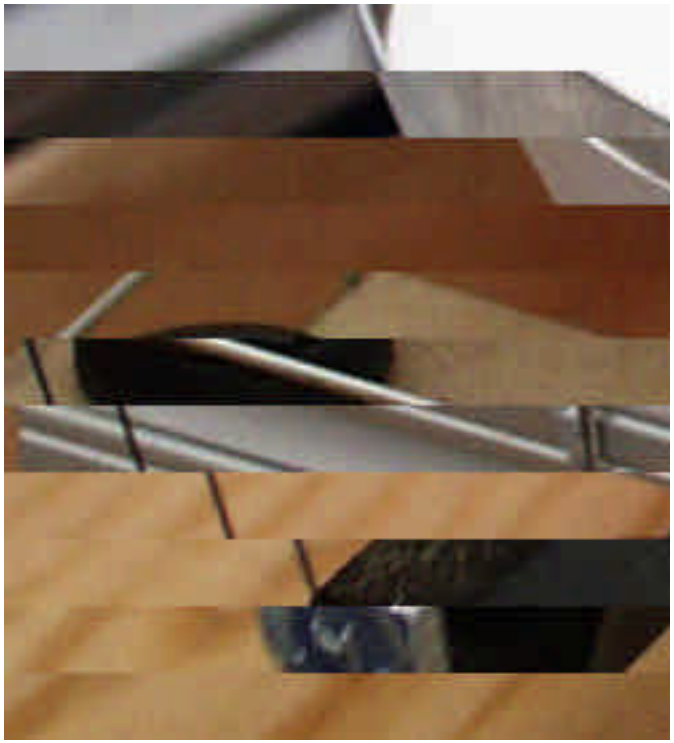


2. Two 40’ tall towers are installed on dry-dock sides; Cables are attached to two towers and two dock hard points.

3. Cables are tightened using controller; Flying Carpet is ready to use with simple joystick control.

Ship Bow/Stern Access

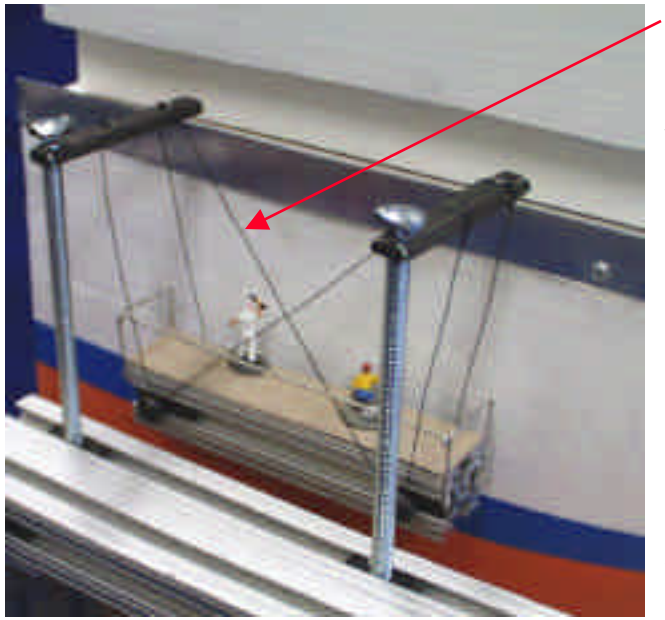
Workers installing and finishing a heavy steel plate with joystick-controlled Flying Carpet



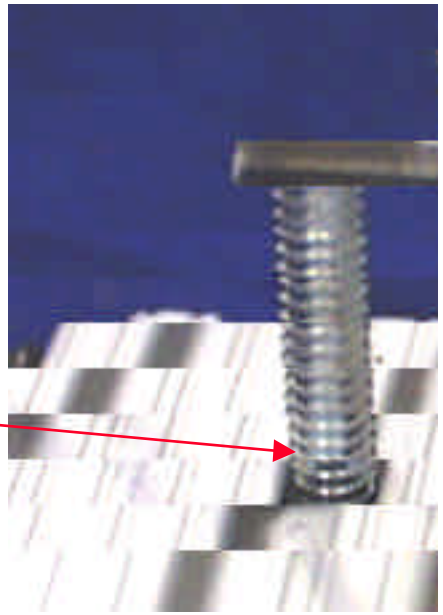
Clearance beneath Flying Carpet for platform maneuverability and/or simultaneous work below platform

Flying Carpet Stern Access

Ship Side Access: Dry Dock-supported



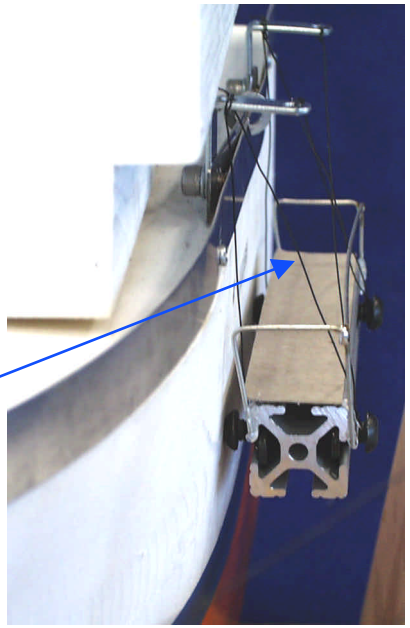
- Cross-cables (atypical) allow stiffer system side-to-side
- Joystick control automatically pays cables in and out
- Angled cables and/or electro-magnets can provide continuous, front platform-edge, ship-touch.



- Dry-Dock-supported system allows pre-set-up prior to ship arrival
- Flexibility of attachment and ship access points
- Minimal ship-touch to allow side plate installation and/or finish work
- Modular Flying Carpet allows reuse/reconfiguration of system components

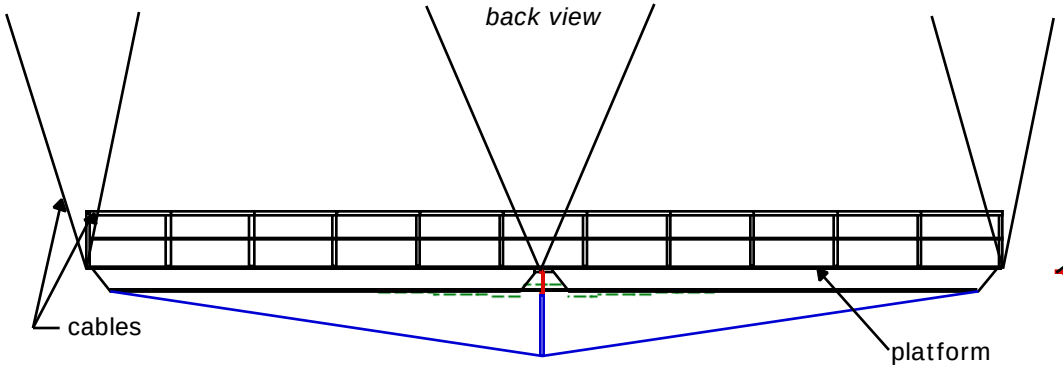
Ship Side Access: ship-supported

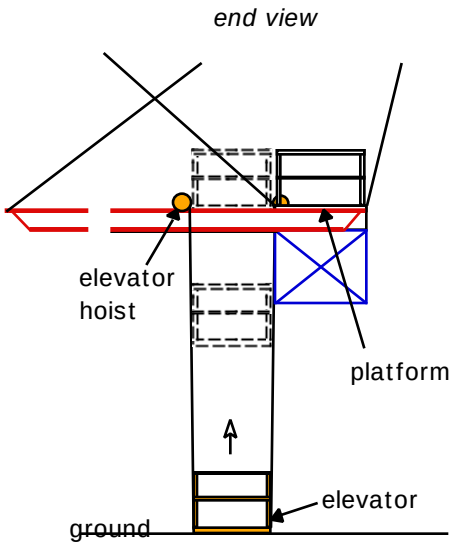
- Cross-cables (atypical) allow stiffer system side-to-side
- Joystick control automatically pays cables in and out
- Angled cables and/or electro-magnets provide continuous, front platform-edge, ship-touch.

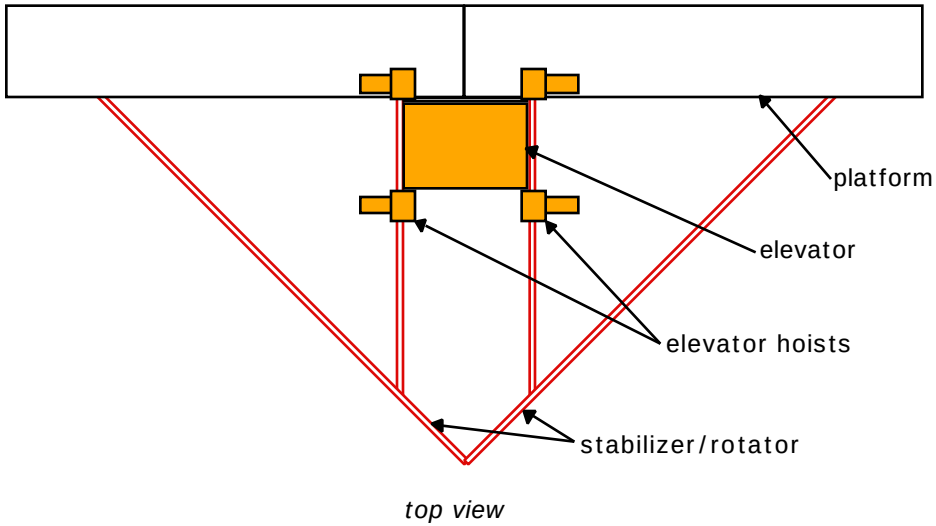


- Ship-supported system allows clear dry-dock sides
- Flexible, but limited, ship attachment and ship access points dependent upon ship and ship owner.
- Modular Flying Carpet allows reuse/reconfiguration of system components

Flying Carpet with Elevator

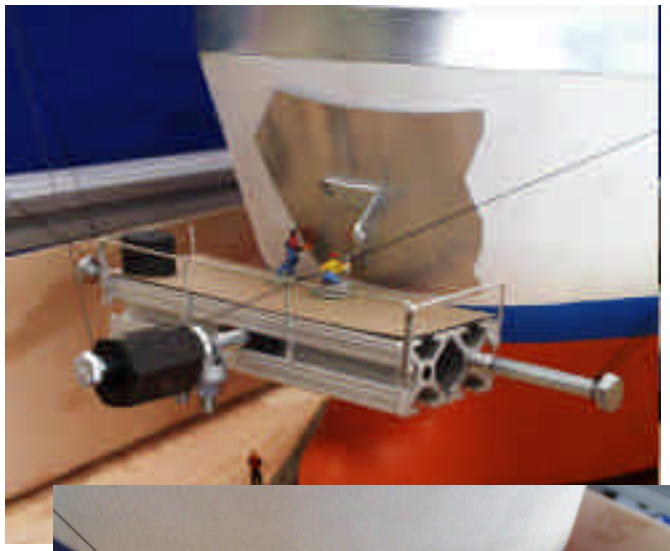


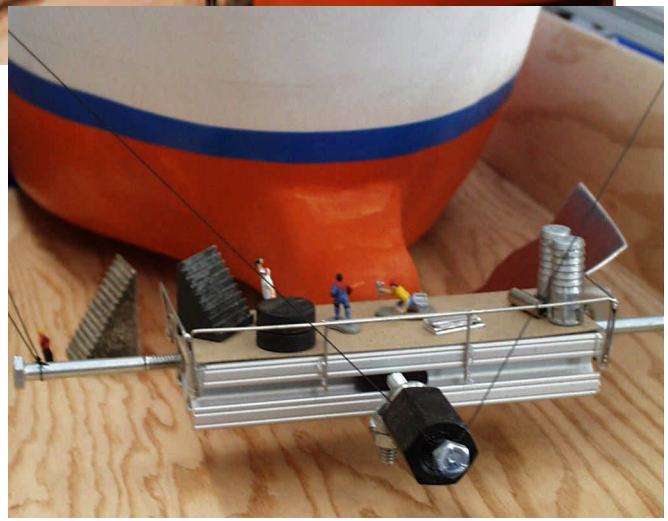




- Elevator allows Carpet to be “parked” while Carpet-access continues (i.e., tools, equipment, personnel).

Flying Carpet Pros





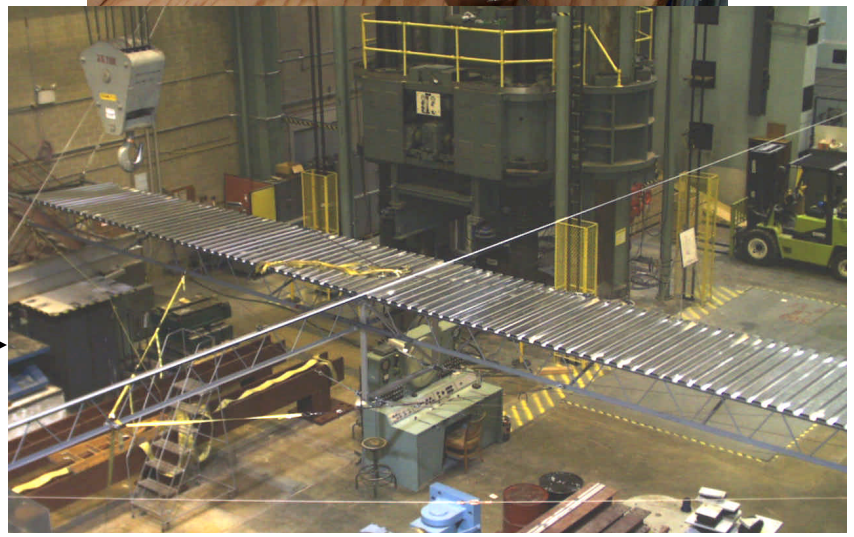
- Rapid set-up and maneuverability around ship bow and stern saves time and costs.
- Installation of heavy steel plate, equipment
- Easy, quick accessibility to external ship surfaces
- Simultaneously carries large amounts of equipment, supplies, tools to work site.
- Using joystick control, operator can maneuver platform, while on- or off-board, around ship bow/stern with no additional set-up (*or* traditional repositioning of fixed scaffold).
- ± 20° yaw rotation about bow/stern by simply twisting joystick; tilt sensors provide level-platform, closed-loop control.
- Modular construction provides multi-use of components for ship bow/stern or ship sides
- Safety rails, oversized cables and hoists on-board.

Flying Carpet Scale Models

- 1/120th scale (table-top) static model built - for feasibility, rigging, and overall concept study

- 1/40th scale moveable model built - for platform work volume limits and rigging study

- Testbed (50’ x 5’) built April 2000 - for stiffness and control study



Flying Carpet Testbed Cost and System Components

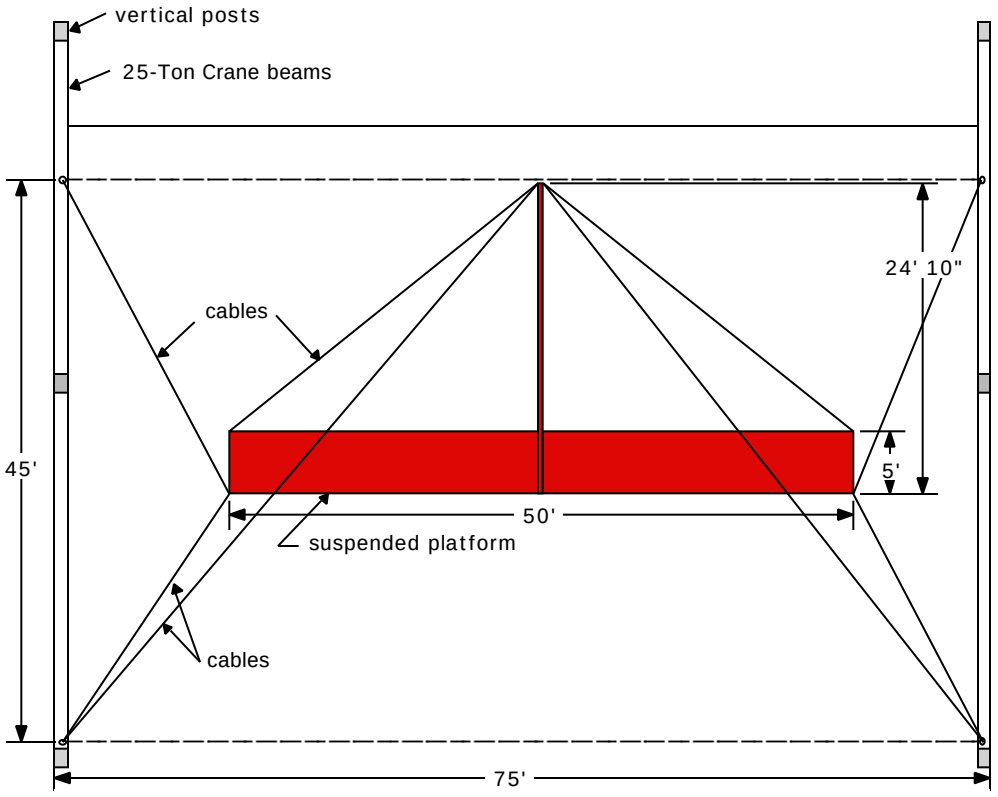
800 Lb. payload system costs est. $7K parts.

System Components:

Component	*number each*	*unit cost*	*total cost*
Winches - 1 ton lift capacity **	6	$ 300	$ -
Platform	1	$ 2,550	$ 2,550
Additional Platform Structure	1	$ 500	$ 500
Mechanical Cables	6	$ 100	$ 600
Railings	1	$ 500	$ 500
Pulleys	6	$ 200	$ 1,200
Support Towers - not needed here	4	$ -	$ -
Support -Hoist Rings	4	$ 200	$ 800
Joystick	1	$ 500	$ 500
Amplifiers **	6	$ 300	$ -
Electronics Cables	1	$ 200	$ 200
Electronics Packaging	1	$ 200	$ 200
		Total	**$ 7,050**

** winches and amplifiers are in-house and are therefore, not included in total cost

Flying Carpet Testbed Features



top view

- Static, then joystick controlled
- 50’ x 5’ platform
- 1.5 max. payload
- 30’ working height
- ±20° Yaw Rotation
- 75’ w x 45’ d support-point separation
- Platform weight: 1/2 ton
- Stable in 6 DOF

Example Load Calc's

Atlantic Marine Dry Dock Application

Typical material loads = Avg. Size plate 12'x12'x5/8"th = 2 tons
Max. Size = 10'x40'x5/8" = 5.4 tons

System Weight Estimate

Component	*Manufacturer/Model*	*No.*	*Unit Wt.*	*Total Wt.*
Scaffold	In-house	1	3500	3500
Wire Rope	Jeamar 1/2", 6x37	6	43	258
Railings	In-house	1	300	300
Pulleys	Jeamar/ SS7000	6	25	150
Electronics	Electronics	1	200	200
			Total Weight (Lbs.):	4408
			Total Weight (tons):	**2.2**
Hoists - 5000 Lb. working load	Jeamar/ NLT5000	6	774	2.3
Support Towers - 40' h (+53'D. Dock)	in-house	2	1000	1

CABLE Calc's:

1/2" - 6x37 EEIPS wire rope nominal strength: 14.6 tons/5 safety **2.92 tons tension/cable**
Vertical load support with cable at 30 degrees with horiz. = **1.46 tons tension/cable**

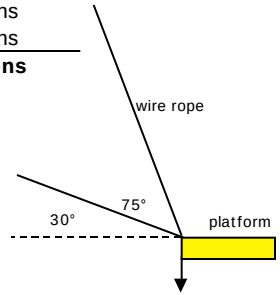
Example hoist: Jeamar 5000 Lb. Capacity hoist:

MINIMUM CABLE ANGLE

Total min. payload = 6 x 2.50*sin(75°) = 14.5 tons
(=75 degrees with horiz. - at bottom) - Platform weight: 2.2 tons
Max. Payload: 12.28 tons

MAXIMUM CABLE ANGLE

Total max. payload = 6 x 2.92 x sin(30°) = 8.76 tons
(= 30 degree angle with horiz. - at top) Platform weight: 2.2 tons
Max. Payload: 6.56 tons



EXAMPLE WORKER/TOOLS ACCESS

3 people x 250 Lbs. = 750 Lbs.
Tools 750 Lbs.
0.75 tons

Available Payload for Materials, etc.

- MINIMUM CABLE ANGLE 11.5 tons spare
- MAXIMUM CABLE ANGLE 5.8 tons spare

Full-Scale Flying Carpet Cost and System Components

5.6 ton max. payload system costs est. $56K parts

System Components*:

Component	*number each*	*Model#*	*unit cost*	*total cost*
Hoists - 2800 Lbs. working ld.-Jeamar	6	Jeamar NLT2800	$ 6,323	$ 37,938
Scaffold	1	NJ Bouras joist,deck	$ 3,500	$ 3,500
Mechanical Cables-Jeamar	6	3/8", 7x19,150'	$ 81	$ 486
Railings	1	estimate	$ 500	$ 500
Pulleys-Jeamar	6	Jeamar SS7000	$ 757	$ 4,542
Support Towers	2	estimate	$ 1,000	$ 2,000
Joystick	1	estimate	$ 1,000	$ 1,000
Amplifiers	6	estimate	$ 800	$ 4,800
Electronics Cables	1	estimate	$ 500	$ 500
Electronics Packaging	1	estimate	$ 1,000	$ 1,000
			Total	**$ 56,266**

* NIST does not endorse products. Names and model numbers are simply used for reference only and do not demonstrate an endorsement of these products. Costs are Feb. 2000 estimates.

Next Steps

- Build a testbed at NIST using procured parts and NIST (Maritech-matching and RoboCrane project) funds.
  - Initial goal: to measure the static constraint of a large-scale platform suspended from 4 points - useful for worker- and/or material-access to large structures (ships, aircraft, buildings, towers).
  - Second goal: to study the platform controllability and dynamics using atypical RoboCrane kinematics.
- Invite shipyards and other industries to system demonstrations
- Collaborate with Shipyard to build and demonstrate full-scale Flying Carpet
- Transfer Technology to Shipyard through Flying Carpet Manufacturer/Maintainer

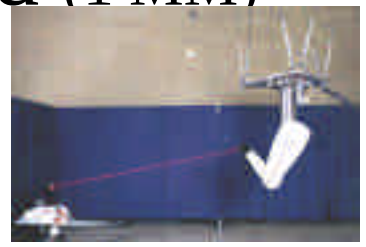
Phase 2 Tasks detailed (1 of 3)

(13 MM x $20K/MM = $160K labor + $15K parts=$175K)

- Measure static testbed (2 MM labor + $5K parts)
  - Improve testbed, Install load cells in testbed cables, apply loads (800 Lbs. max.), and Test platform stiffness
- Computer Model Flying Carpet (2 MM)
  - Build model in Pro/E, Analyze model using ADAMS finite element analysis software, Extrapolate cable/winch needs for 5.6 ton loads using static load results and FEA.

Phase 2 Tasks detailed (2 of 3)

- Actuate testbed (2 MM labor + $7K parts)
  - Design, procure parts, and fabricate actuator package based on computer model results, Test actuation of platform
- Measure dynamics of testbed at NIST (2MM)
  - Measure work volume, cable tensions, stiffness
- Compare Computer model to testbed (1 MM)
  - Relative to testbed dynamic load results, extrapolate results to full-load platform



Phase 2 Tasks detailed (3 of 3)

- Install testbed in A.M. dry dock (3 MM+$3K pts.)
  - Design, fabricate attachment hardware to dry dock, Transport testbed to AM and install in smaller dry dock.
- Transfer technology to industry (1 MM)
  - Patent technology, Work with industry partner(s) (e.g., scaffold company, AM, ...) throughout design and analysis, future: provide measurement services for testbeds/commercial versions.