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Cable-Based Reconfigurable Machines for Large Scale Manufacturing

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Department of Commerce

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Intelligent Systems Division
National Institute of Standards and Technology

NIST

Manufacturing Engineering Laboratory
MEL Mission

To satisfy the <u>measurements and standards needs</u> of the US discrete-parts <u>manufacturers</u> in mechanical and dimensional metrology and in advanced manufacturing technology <u>by conducting research & development</u>, <u>providing services</u> and <u>participating in standards activities</u>.

Intelligent Systems Division
ISD Mission

To <u>develop</u> the <u>measurements and standards infrastructure</u> needed for the <u>application of intelligent systems</u> by manufacturing industries and Government agencies.

MEL Intelligent Systems Div. Programs

Research and Engineering of Intelligent Control Systems

Enhanced Machine Control

Knowledge Engineering Program

Reference Model Architecture for Manufacturing

Intelligent Open Architecture Control of Manufacturing Systems

Hexapod

NGIS

Welding

RoboCrane

Reconfigurable Machine Tool combines these

Intelligent Control of Mobility Systems

- *Military:* Demo III Project (Army)
- *Transportation:* Department of Transportation Project
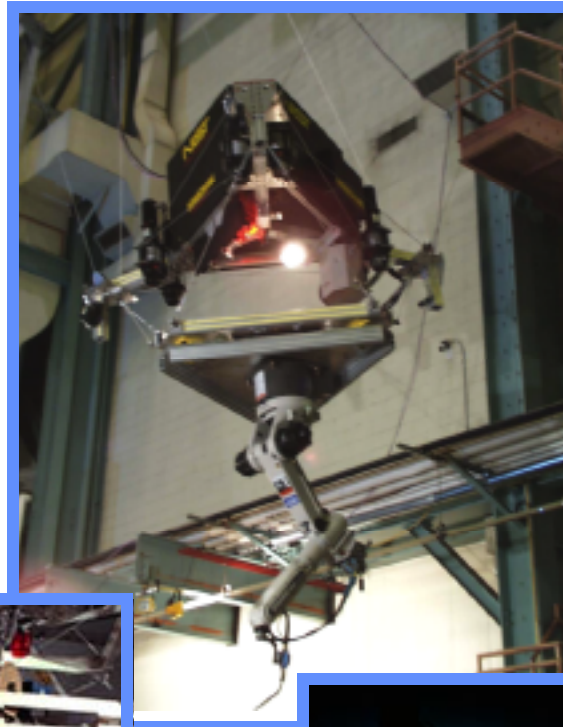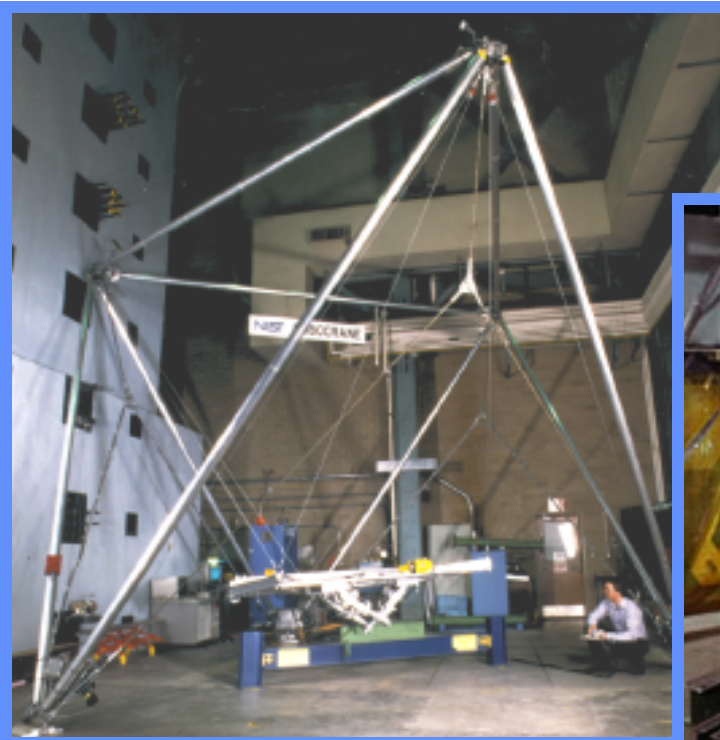- *Manufacturing:* Industrial Autonomous Vehicles Project

Hexapod Machine Tool

Our goal is to develop methods to characterize and extend the limits of performance of a new class of Stewart platform based machine tools in terms of accuracy, productivity, and versatility...
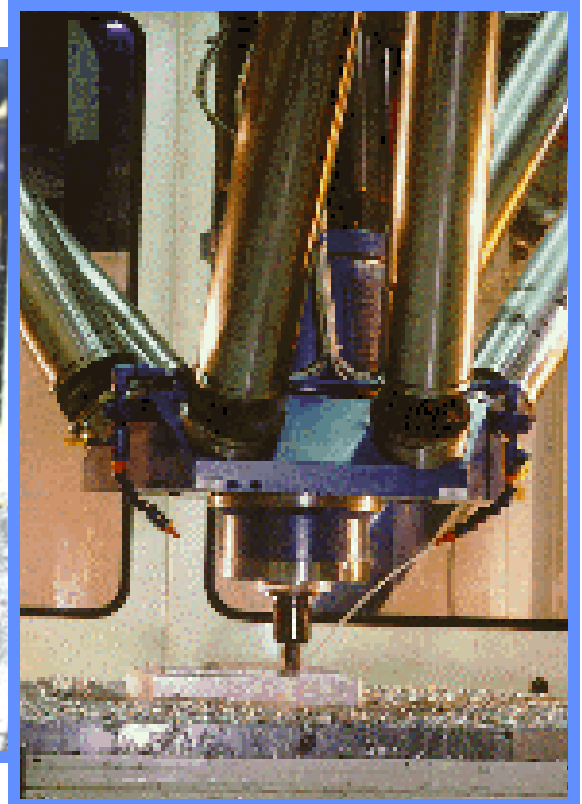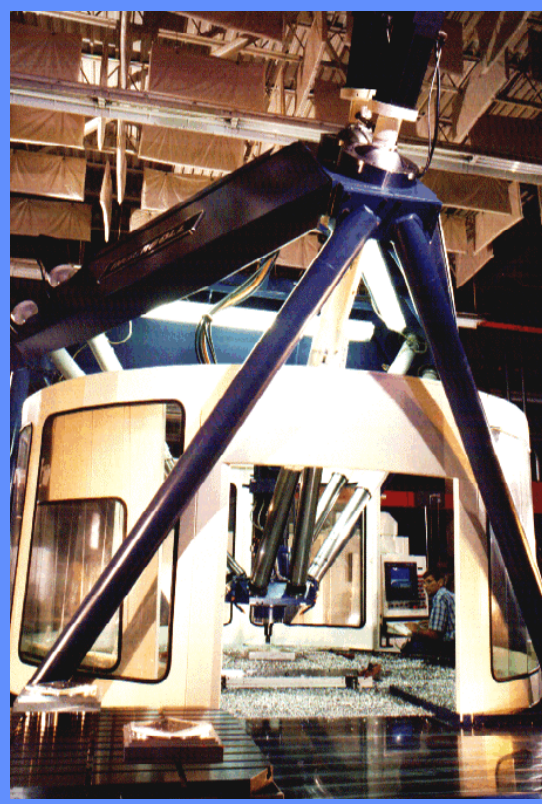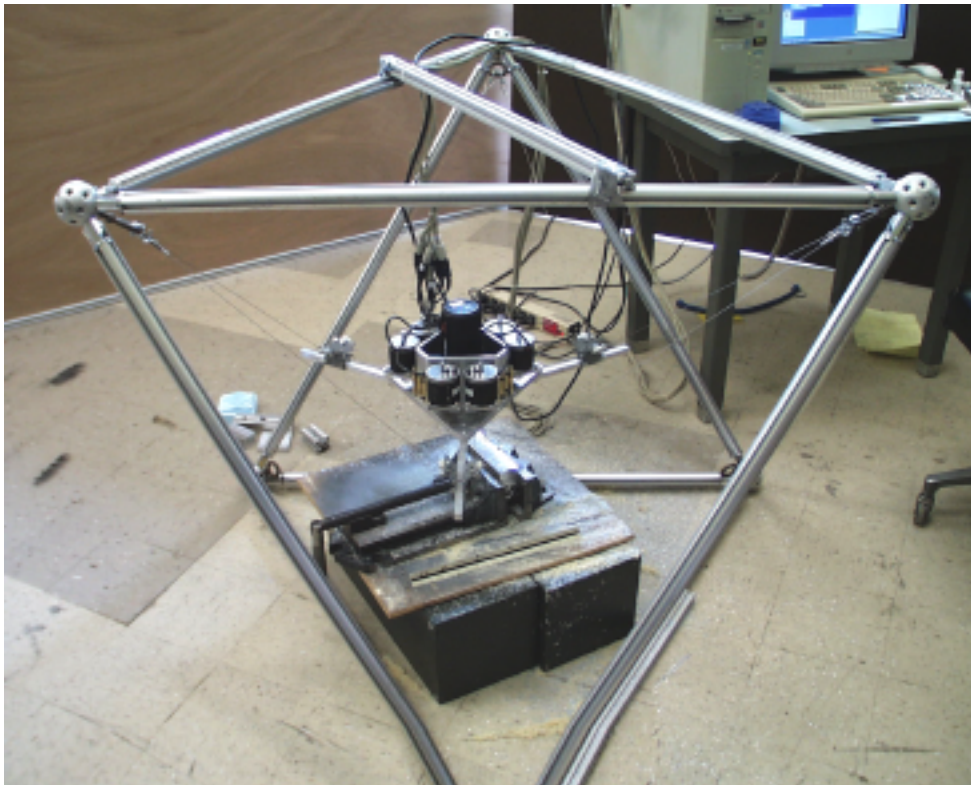
RoboCrane

Gantry or Facility Supported
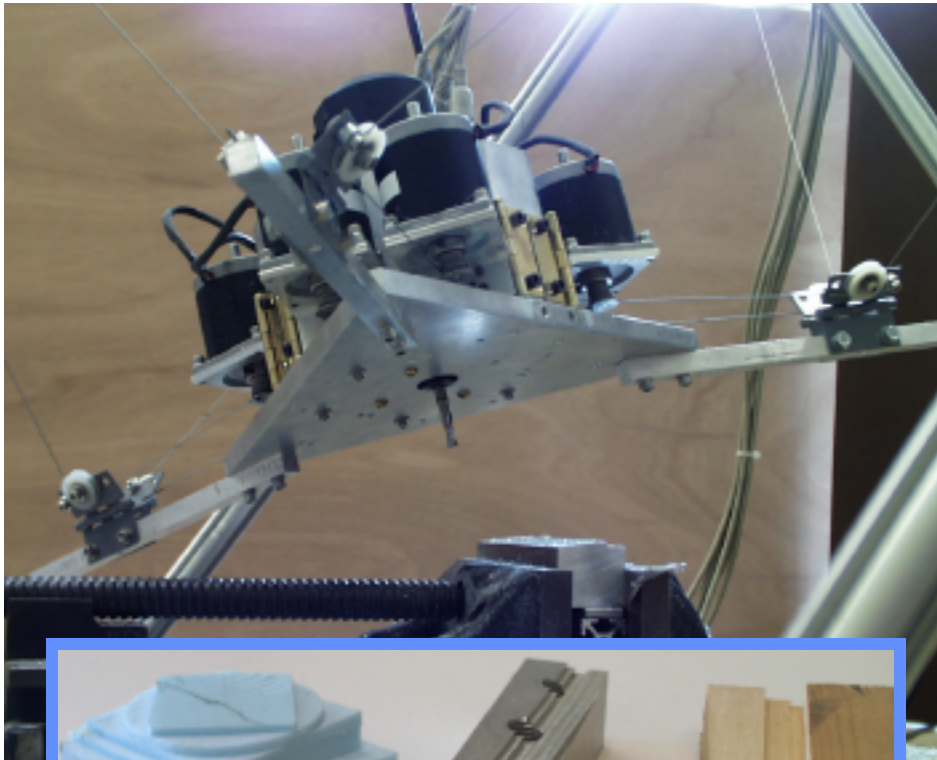
- constrained platform motions

Cable-Based Reconfigurable Machine Tool

Mini-TETRA

- Applies RoboCrane to Machining

- Constrained, computer controlled motions (using RS274 - G/M codes, others)

- 6 DOF, large work-volume applications
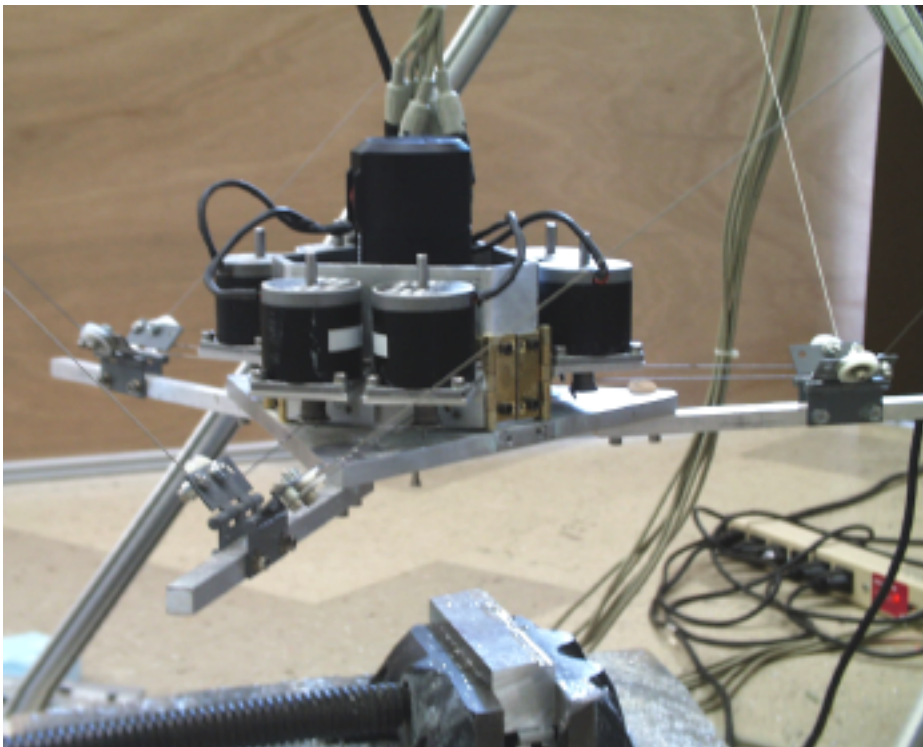
Cable-Based Reconfigurable Machine Tool

Advantages

– Low relative cost for a given range of motion

– Short time to change machine configurations to meet application demands

– Lightweight/easy to handle/ reconfigure relative to ballscrews and slideways

– Large work volume/cable travel

Cable-Based Reconfigurable Machine Tool

Disadvantages

– Lower stiffness and accuracy caused by cable twist, droop, stretch; pulleys, pivots

– Complex work volume

– Relatively limited range of orientational motion

  ($\pm$ 30° yaw, $\pm$ 15° roll/pitch)

– Must be preloaded to keep cable tension (upon preload, can apply same force in all directions)

Machine Calibration
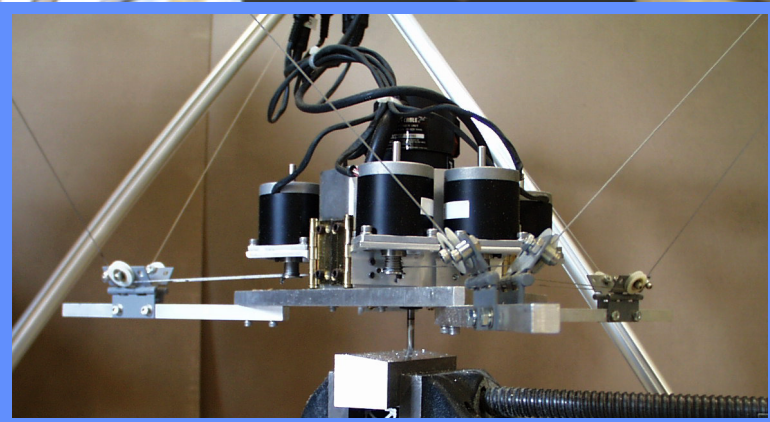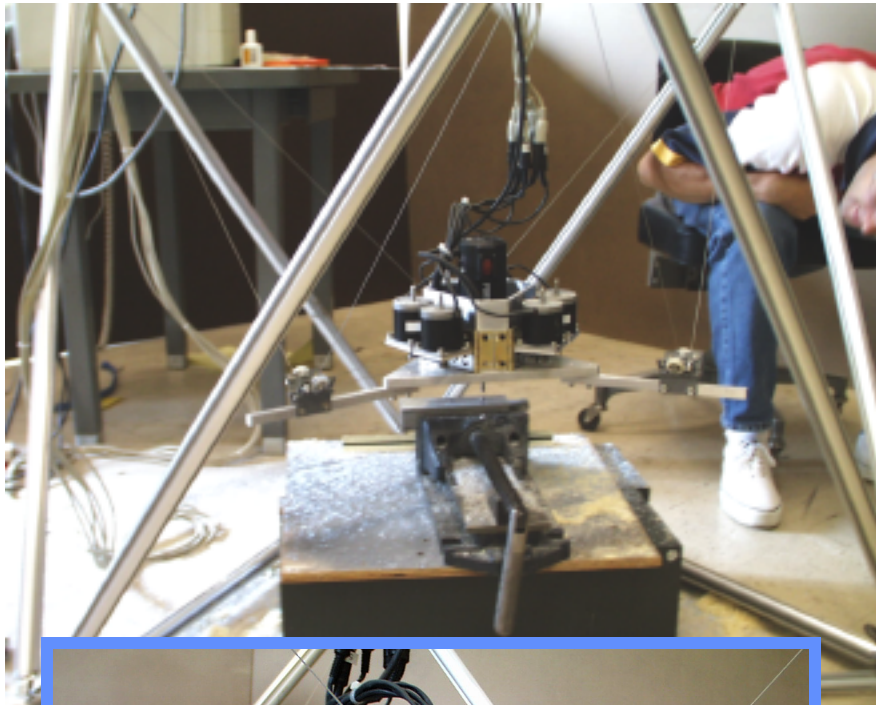
- Must know:
  - Stationary cable attachment point locations
  - Platform dimensions
  - Apply kinematics
  - Measure initial position (home)

    Or compute position using kinematics upon moving there

- Reconfiguring requires these to be updated

CAD/CAM/CNC

- Requires CNC to generate complex cable motions for Cartesian platform motions
- Interpreter program used allowing common industrial prog. languages to output platform motion commands
- Programs generated by CAD/CAM software or robotic off-line programming systems
- Joystick/pendant control simplifies motions

Conclusions

Typical Milled Surface
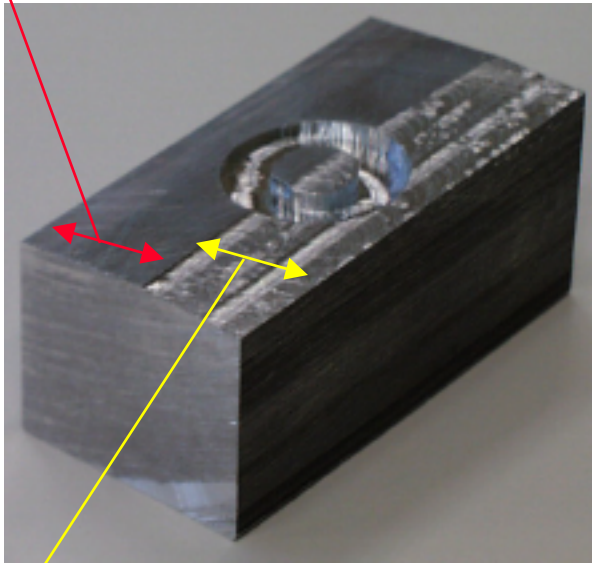
Mini-TETRA Milled Surface and circle feature: 1/4" dia. 2-flute cutter (cut using imprecise table set-up)

- Large scale manufacturing applications (ship, aircraft manufacturing, construction)

- Inherently low cost, easy to reconfigure

- Stiffness and accuracy not as good as fixed-geometry machines

- Calibration is an issue, solutions tested

- Easily integrated into current businesses without large design changes

- Further experiments needed to verify performance in industry settings.

- So far, appears to be a good, large work-volume, rough-cutting machine tool

For More Information

http://isd.mel.nist.gov/projects/

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and

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