Instrument Development Group
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MACS Translation Stage Phase A Design Study Report

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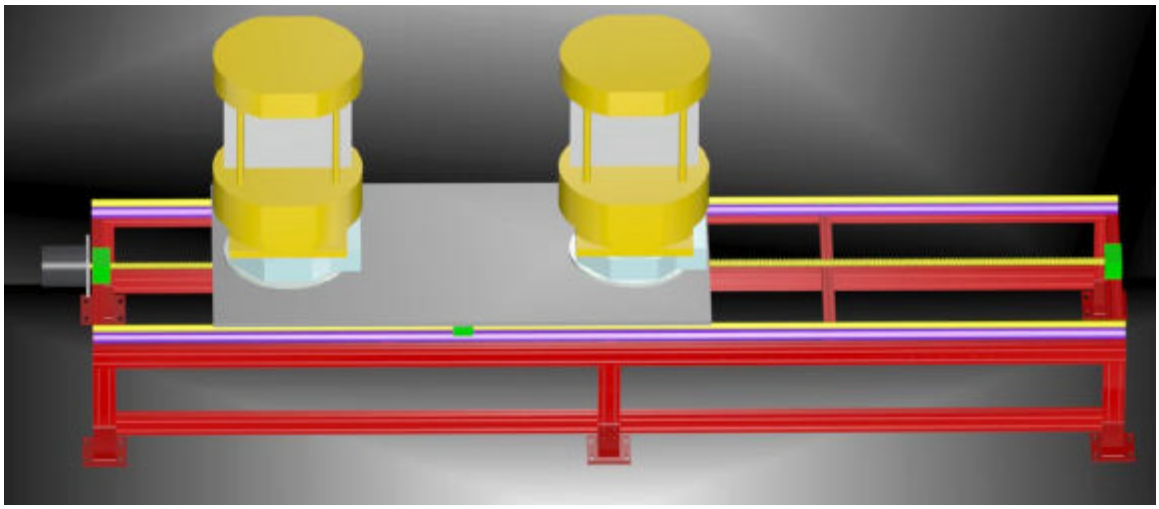


Requirements:

1) Support two Doubly Focusing Monochromators (~250lbs x 2 =~500lbs).
2) Provide linear translation over full range of motion with a repeatability of 0.010in.
3) Beam-line to floor distance = 42in. (1.07m).
4) Reposition from one energy level to the next in less than 5 seconds.
5) Range of translation for single monochromator is 63in. (1.6 m).
6) Additional range to accommodate second monochromator is 2*displacement = 47.2in. (1.2 m).
7) Total translation range = 110.2in. (2.8 m).
8) Max vertical displacement over full range 0.03".
9) Max horizontal displacement over full range 0.03".
10) Max rotation of trolley over full range about vertical or horizontal axis 0.05 degree.

Description of the Design

Mechanical Design:

The proposed design will consist of a support frame, translation & carriage assembly, cable take-up system, supporting electronics and software development. The frame and cable take-up system will be constructed of aluminum extrusions manufactured by 80/20 Inc. Hardened steel guide rails and rail supports will be attached atop the frame. A supporting carriage will carry one to two monochromators along the rails. The carriage will be driven by a ball screw and stepper motor system. Open linear bearings, attached beneath the carriage, will provide for smooth travel along the guide rails. The support frame will be firmly attached to the cement floor with adjustable brackets, also provided by 80/20 inc.

Electrical Design:

A stepper motor and gearhead assembly will be used to drive the ball screw. A resolver will be incorporated to provide position feedback. After further design study it will be determined if a motor brake system is needed as well. In addition, a Hall-effect sensor and limits switches will be used for home position and limits of motion detection. If feasible, the control electronics will be integrated into the already existing MACS monochromator electronics rack.

Software Development:

As with the electrical system, if feasible, the software control of the linear translation stage will be integrated with the existing MACS monochromator control software. The stage will be treated as just another axis of motion.

Assembly:

The complete electrical and mechanical system will be assembled here at JHU. A calibration procedure will be used to set rail-to-rail parallelism. A leveling procedure will be performed to ensure that the system is level and plumb.

Testing and Calibration:

Metrological measurements will be used to determine carriage position accuracy as well as calibrate accumulated error in the ball screw. This will entail using theodolites set up along the side of the stage.

Performance testing will also be needed to determine acceleration/deceleration, velocity and motor current parameters. Machine health and safety issues will be tested as will as failure mode prevention.

Task List

1. Design Support Frame – 3 weeks ($5,175)
2. Design cable take-up system – 3 weeks ($5,175)
3. Design carriage assembly – 1 week ($1,725)
4. Drawing creation, documentation and authoring test procedures – 3 weeks ($5,175)
5. Specify stepper motor and electronics system – 2 weeks ($3,450)
6. Specify ball screw, mounts and rail assembly – 1 week ($1,725)
7. Design overall electrical system – 2 weeks ($3,450)
8. Obtain quotes and purchase parts – 2 weeks ($3,450)

9. Integrate electronics into DFM electronics rack – 3 weeks ($5,175)
10. Modify DFM software to include translation stage – 2 weeks ($3,450)
11. Assemble all mechanical components – 2 weeks ($3,450)
12. Construct electrical harness and wire up assembly – 1 week ($1,725)
13. Performance testing and calibration – 5 weeks ($8,625)
14. Deliver and Integrate at NIST – 1.5 weeks ($2,588)

Total time needed for completion = 31.5 FTE – weeks ($54,337)

Purchased Parts

1. 80/20 hardware.
    a. Extrusions - $2,500
    b. Fastening hardware - $1,000
    c. Leg Brackets - $203
    d. Misc. hardware - $500
2. Stepper-motor assembly.
    a. Rad-hard stepper-motor – $2,400
    b. Gearhead - $2,300
    c. Resolver - $2,000
    d. Limit switches - $100
    e. Home sensor - $75
3. Motor Indexer - $1,000
4. Translation stage parts.
    a. Ball-screw
        i. Cut length - $330
        ii. Machine ends $160 x 2 - $320
    b. Guide rails
        i. Support rails - $1002
        ii. Hardened Precision Shafts - $792
    c. Linear bearing blocks - $103.53 x 6 = $950
    d. Mounting blocks - $332.61 x 2 = $665
    e. Ball nut - $250
5. Cable and Connectors
    a. Cable harness and wire (Kapton insulated) - $500
    b. Connectors - $200
6. Cable Take-up system.

a. Cable conduits and guide ways - $1,000

Total Purchased Parts Cost - $18,123

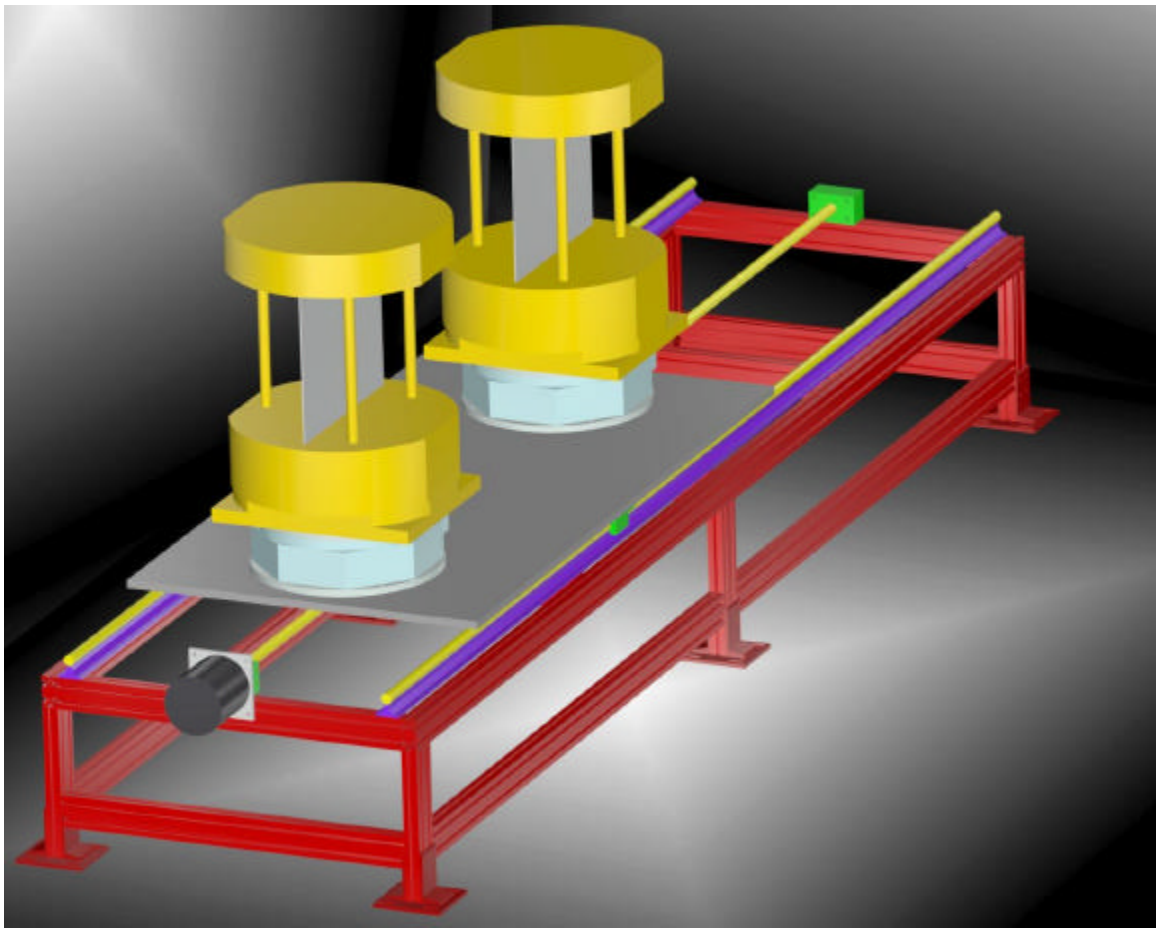
Parts to be manufactured

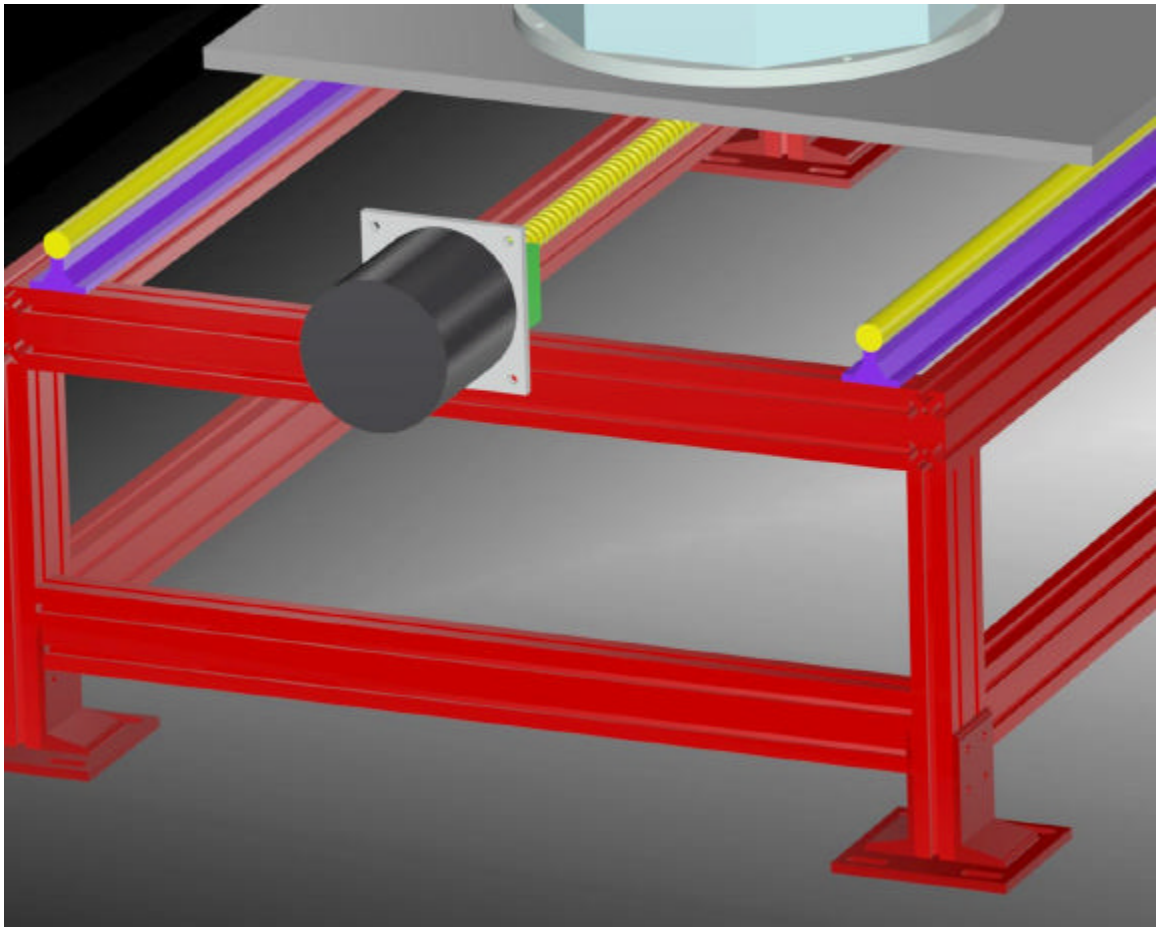
1. Carriage Assembly
    a. Base-plate - $1,500
    b. Fixtures - $1,500
2. Frame.
    a. Cut frame supports to size - $500
3. Cable take up system - $2,000
4. Miscellaneous machined parts - $1,000

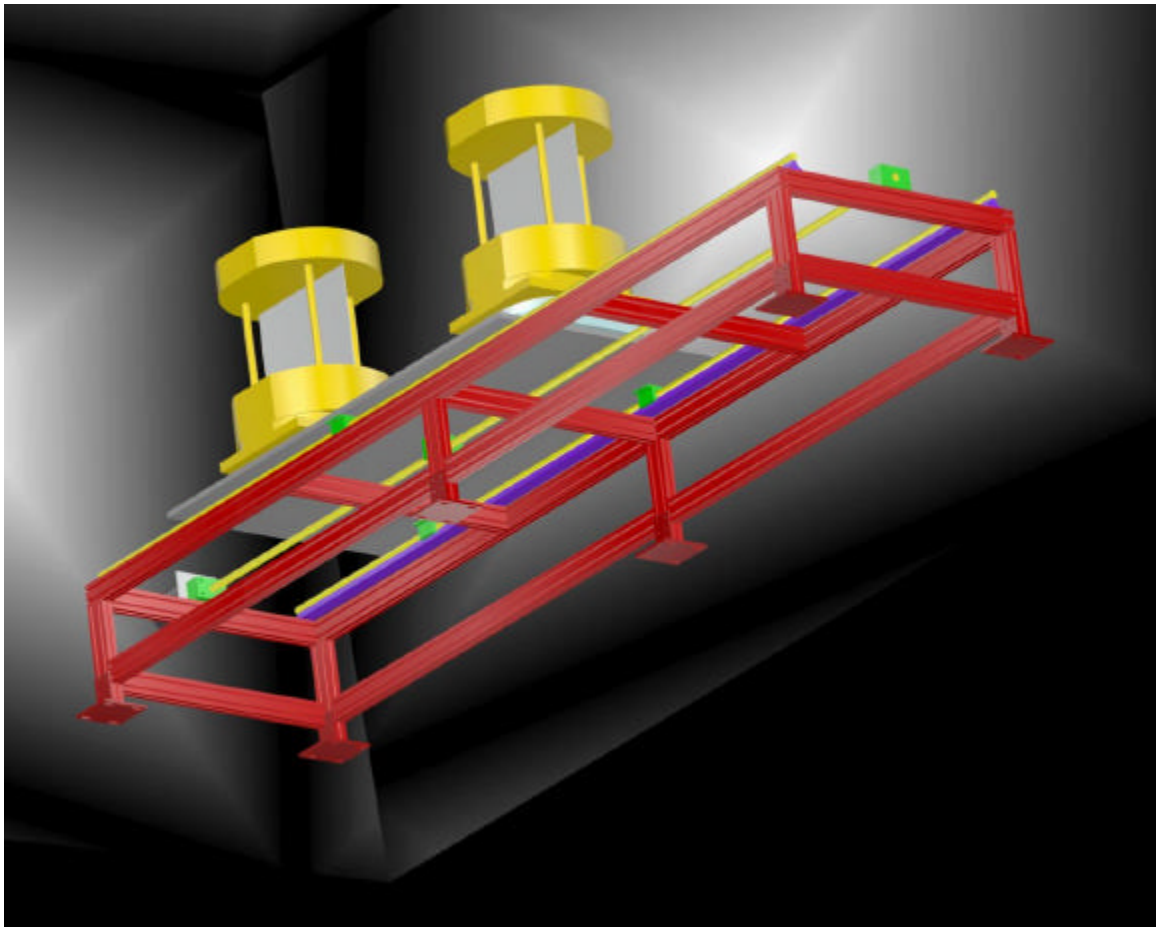
Total Manufacturing Costs – $6,500

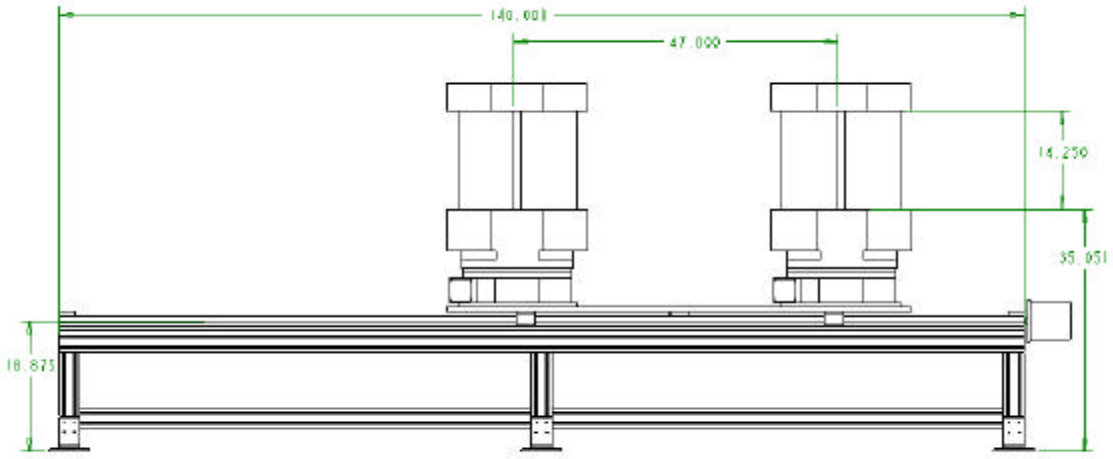
Grand Total - $78,960

Conceptual Design (does not include cable take-up system)









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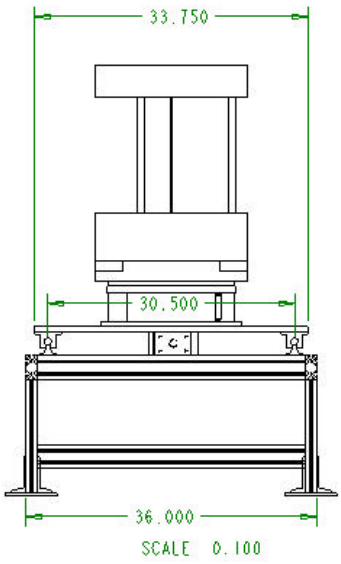
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