2.4 Shipping Plan

The MagAO-X plan envisions accommodating a total of six air-shipments of the instrument from Tucson to LCO and five return air-shipments to Tucson. As explained previously the idea is that improvements and upgrades to the instrument can be made in between commissioning runs. Where it makes sense we will buy/fabricate duplicate hardware such as the table legs and the table lifting fixture to reduce shipping costs.

The table and optical components will be aligned in the lab in Tucson and then packaged in a special wooden handling crate see fig 2.4-1. The only component not shipped in the crate will be the critical BMC DM, which will be hand carried for each run. The crate is equipped with wire rope isolators sized to reduce the shock load of an 18" drop to 15g. The box construction is such that the table is bolted to a steel frame that is attached to the isolators which is in turn bolted to a steel sub-frame that attaches to the bottom of the crate. Additionally we will have impact indicators (e.g. Drop-N-Tell) attached to the crate to record any actual events during shipment. Also, desiccant will be added to the crate to prevent moisture buildup.

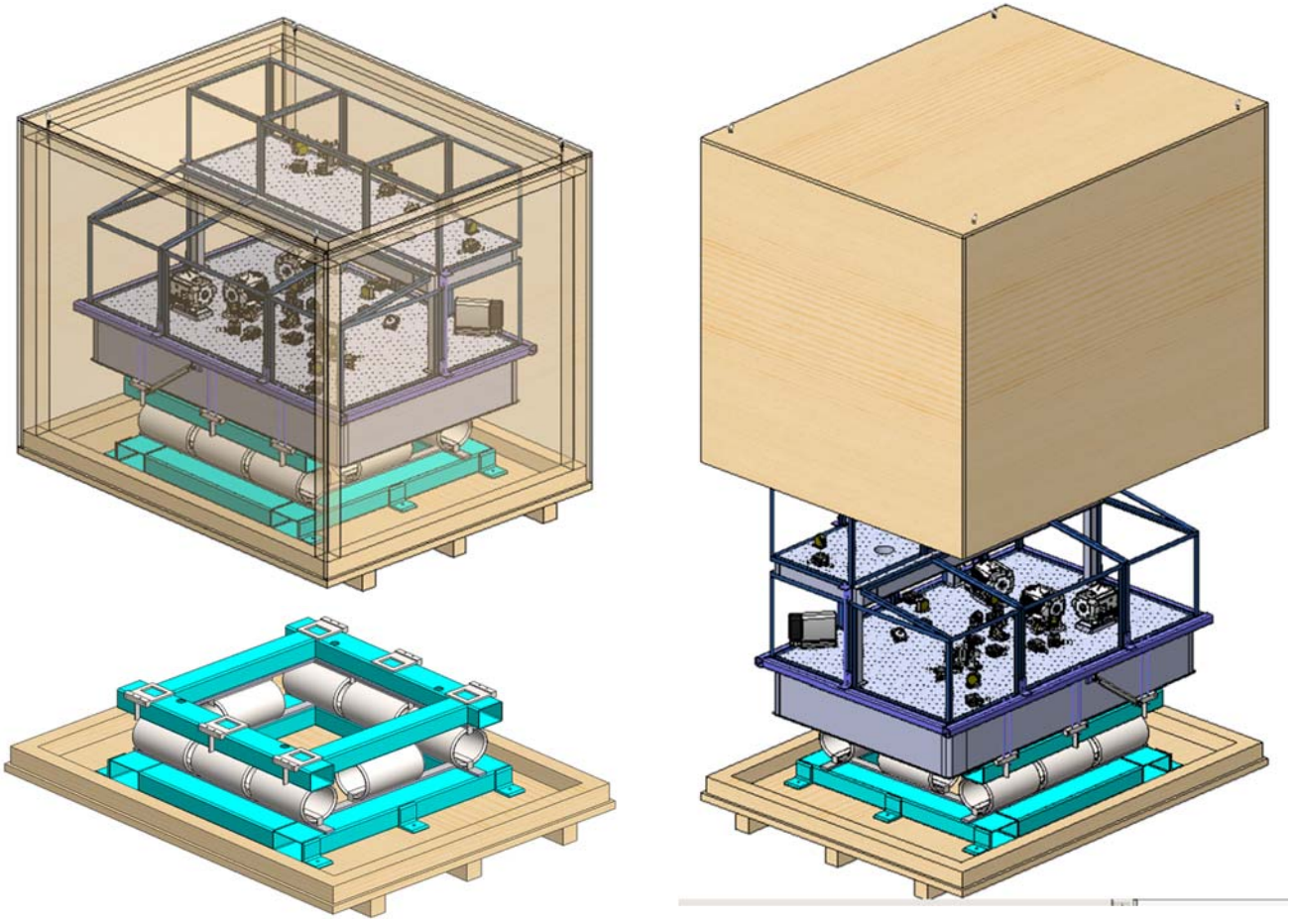

Figure 2.4-1: Special handling crate for the table and components. Top-left view shows the full assembly. Right-hand view shows the removal of the top of the crate to access the table. Bottom-left shows the assembly of the steel frames and wire rope isolator configuration mounted to the bottom of the crate.

The electronics rack, table legs and lifting fixture will be packaged in their own separate wooden crates. The electronics rack will have a crate that will be reusable, similar to the crate for the table. The rack will be bolted to the bottom of the crate and the lid will be lifted off similar to the table crate see fig 2.4-2. The lid and rack will be lifted using the four lifting eyes on the top of the box lid and electronics rack. The electronics rack crate will also have impact indicators and desiccant. The table legs will likely be dropped shipped from the manufacturer to Carnegie in Pasadena for shipment to LCO. The lifting frame will be palletized and shipped to Carnegie from Tucson for shipment, ideally concurrent with the legs, to the site. Table 2.4-1 contains a list of the crate dimensions.

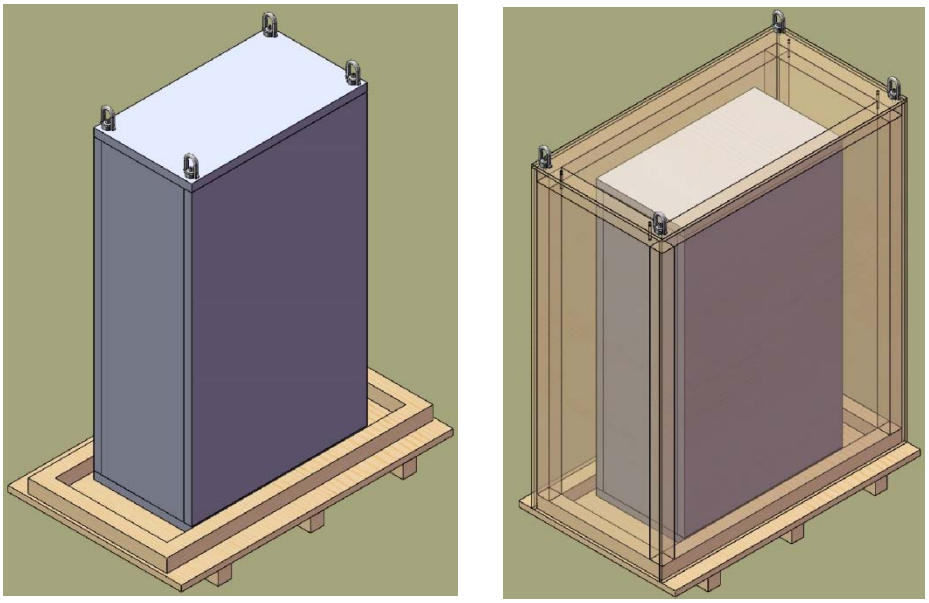

Figure 2.4-2: Electronics rack crate.

Table 2.4-1: MagAO-X Shipping Crates

Crate	Contents	Dims (LxWxH) (Inches)	Weight (Lbs.)
1	TMC Optics Table populated with components	88.5 x 70.5 x 77.2	3250
2	Electronics Rack fully populated	70.5x45x91	1140
3	TMC Optical Table Legs	72 x 62 x 30	800
4	Lifting Fixture	83 x 74 x 16	840
5	Miscellaneous Computers and Equipment	48 x 45 x 34	500

Optics Table Crate Design Details

The optics table crate is designed to handle and 18” drop and reduce the shock the table sees to 15g. We believe this is sufficient attenuation to make the drop survivable for the table and reduce chances for damage to the components. After such an event the optics may need to be realigned. The following is the shipping environment and subsequent deflections (see Table 2.4-2) based on the use of 8ea. John Evans’ Sons HM08875-5 7/8” wire rope isolators and a 2000 lb load (load may be 1500 lbs, but design provides some margin). The table is constrained to the wire rope isolators via the upper shipping frame and lower clamps.

- Ref. Mil-STD-810D Environmental Test Methods and Engineering Guidelines

  - Transit Drop, Method 516.3 Procedure III (Weight > 1000 Lbs)
    - 18" drop on base or skids
    - One edge on 5 to 6" blocks, the other raised 18" above floor and dropped.
- Basic transportation Method 514.3 Category 1 (land, air and sea)
  - Vertical: .015 g^2/Hz from 5 to 50 Hz rolling off to .00015 g^2/Hz at 500 Hz
  - Transverse: less than 0.0007 g^2/Hz from 5 to 500 Hz
  - Fore and aft: less than .007 g^2/Hz from 5 to 500 Hz

Table 2.4-2: Optical table shipping deflections.

Load Case on Shipping Box, 2000 lb breadboard, 8 isloators	Max Deflection (inch)
18" Drop	3.6
Vertical Shipping Vibrations	.57
F&A Shipping Vibrations	.97
Transverse Shipping Vibrations	.18
F&A Shipping Vibrations with Rolled Isolator	1.38

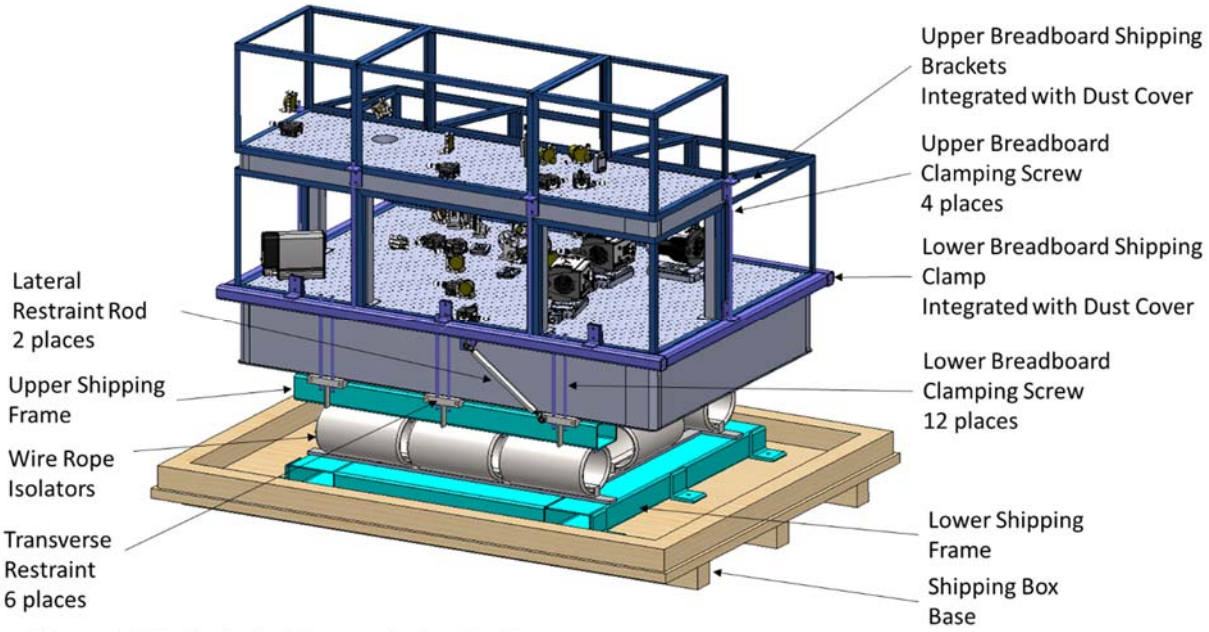

Figure 2.4-3: Optical table crate design details.

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Optical Table Handling

A special lifting fixture has been designed to lift the optical table in and out of the crate and onto the legs both at the telescope and in the lab (see fig 2.4-4). The steel fixture can be disassembled for storage, handling and shipping and then reassembled with the aid of a crane as needed. The overall weight is 540 lbs. The crane lifting point will be nominally set to coincide with the cg of the table and fined tuned with adjustable bumpers.

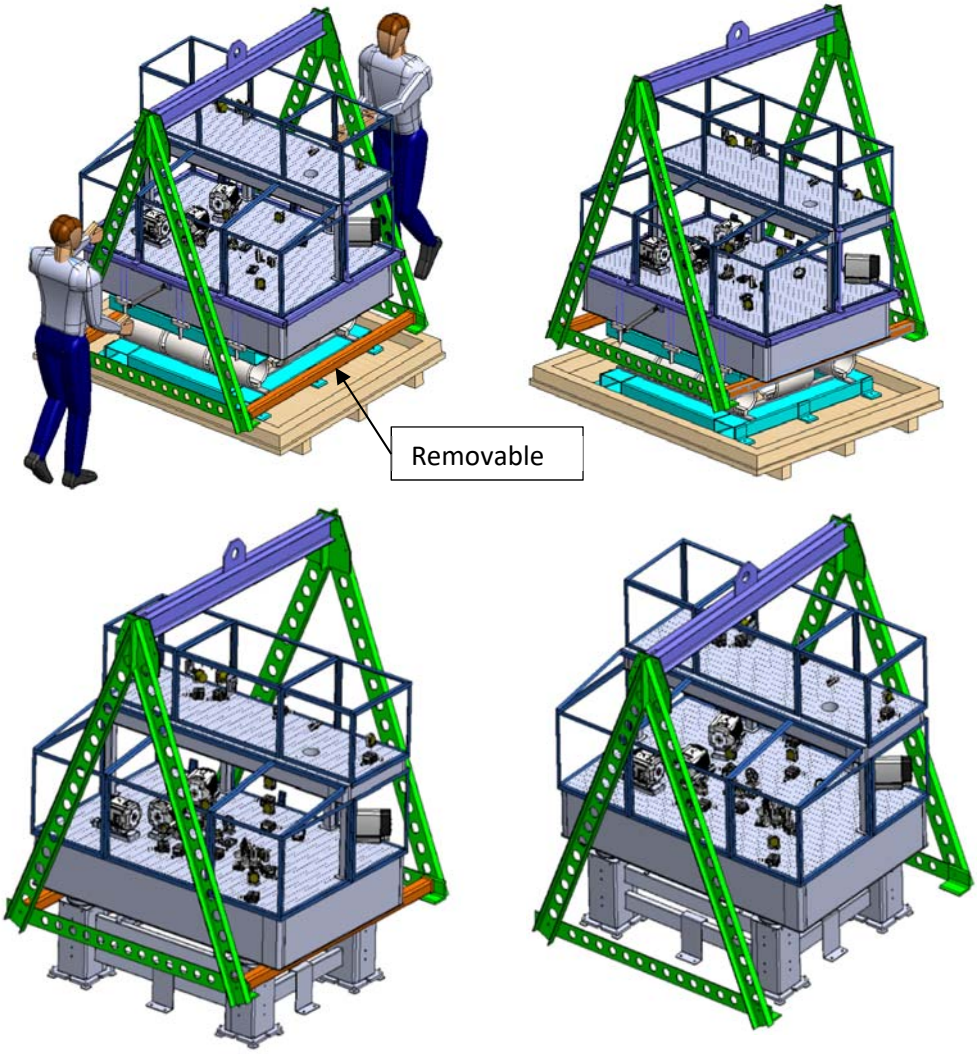

Figure 2.4-4: Optical table lifting frame. Top-left and top-right view shows the configuration when lifting the table out of the crate. Bottom-left and bottom-right views shows the configuration when lowering the table onto the legs. Red bars are removed prior to lowering upper frame onto and off of table.

Handling in Lab

The process to load the optical bench crate will be to:

1) Lift the table off the legs, using the lifting fixture, in the lab with a gantry crane and onto an industrial moving dolly (see fig 2.4-5).
2) The table is then rolled down the hall to the freight elevator and moved to the first floor and out on to the loading dock. (Note: that the dust covers will be installed during the entire operation.)
3) We then employ a industrial moving comany to lift the table onto the shipping frame and lower crate assembly.
4) Lift the lid onto the lower crate and secure.
5) Then when the truck arrives to pick up the shipment the crate will be loaded into the truck.

The opposite steps will be used to unload the crate when returning to the lab.

Figure 2.4-5: Industrial moving dolly. It is three point support that eliminates the possibility of a skate to slip out due to uneven loading when traversing uneven and discontinuous flooring. Wide rollers prevent wheel from getting stuck. Model shown has a 6 ton capacity.

Handling at the Site

The crate will be moved to the summit with the Isuzu truck and unloaded using the lift. Then:

1) Use a hand truck shipping box to telescope observing floor off of the elevator.

2) Independently, position our legs (on their casters) (see figure 2.4-6) to the correct X position of the legs w.r.t. the guider center of the NASE platform. So all that is needed is a straight push (in Y) towards the guider, rotate the casters in the Y direction.

3) Lift up the 5 sided top of the shipping box -- rotate dome and place beside table.

4) Pull table out of shipping box base with overhead jib crane and lifting fixture.

5) Lower the table onto the legs with crane, remove lifting fixture.

(NOTE: the Table/Legs alignment is guaranteed to within +/- 0.1mm with alignment pins (that slide into the tiebars on legs) that are bolted onto in the tapped holes for earthquake brackets -- these pins are already attached when we are shipping the bench)

6) Now slowly push the whole assembly on the casters towards the guider until the air gap is 9.6mm then stop.

7) Carefully engage all 16 leveling pads (disengaging the casters).

8) Remove alignment pins and add the missing 2 upper earthquake brackets.

9) Add the lower earthquake brackets.

10) Cable up the system, etc.

See section 2.1 for details of instrument layout on the NASE platform.

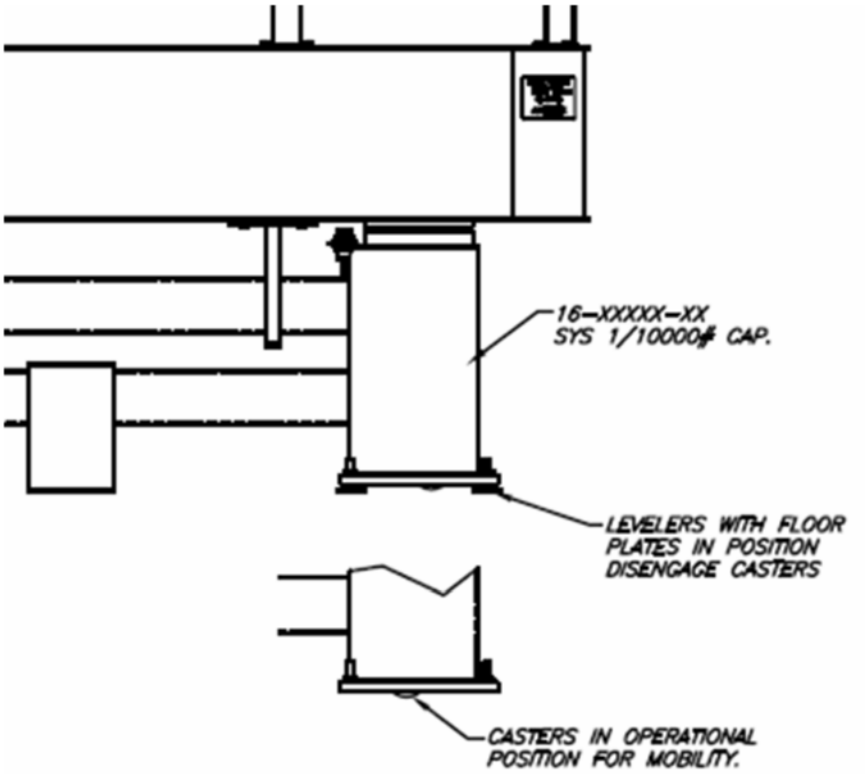

Figure 2.4-6: Table casters allow fine alignment under load.

Export Licenses

The University of Arizona will arrange for the export licenses to Chile for the BMC DM and OCAM-2K camera, since they are both EAR classified equipment, 6A004.a.1 and 6A003.b.4.c respectively. We see no show stoppers and we are already in the process of applying for both of the licenses. We expect to have them well ahead of the first planned shipments.