BUILDING A GROUND-LEVEL AZ/EL MOUNT: Volume IV

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CONTENTS

lift tripod DESIGN

The next stage of construction of the AZ/EL mount will be to build tripod lifting structures on opposing sides of the rotating structure, oriented perpendicularly to the truncated square sides. The photograph below shows an adjustable height gantry moved into approximate position to be able to aid in lifting beams into position while assembling a tripod.

Figure 1.   A portable gantry with electric steel-cable hoist is shown in approximate position to aid in assembling beams to form a lift tripod on the rotating structure (19APR2023).

The gantry shown above is in its lowest (collapsed) height. It will be cranked up to about 12’ when being used to lift beams into position when assembling a tripod.

The diagram below shows the basic structural members for the tripods and dish vertical-lift guide posts.

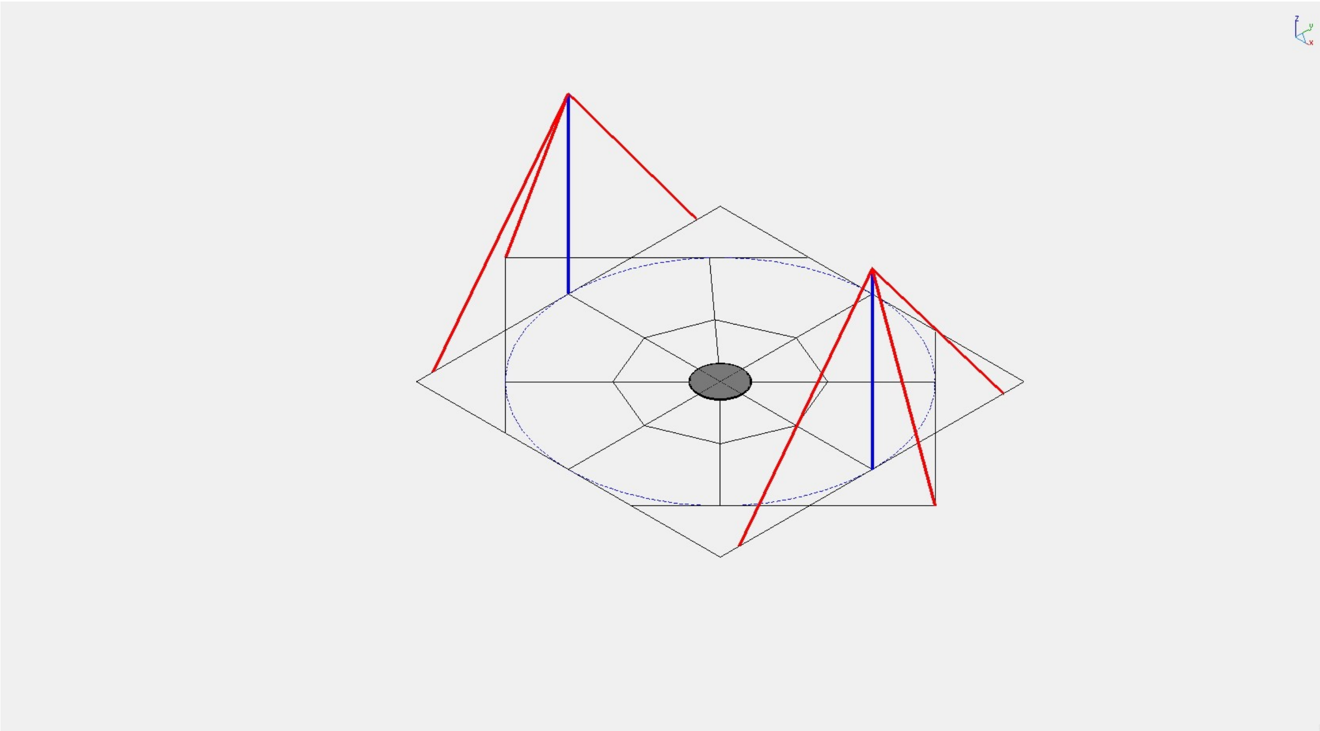


Figure 2. Tripod members (in red) and vertical-lift guide posts (in blue) atop the AZ rotating base structure (thin black lines).

A necessary beginning step toward realizing dish elevation control structures is to select materials from which the tripod members, vertical-lift guide posts, and vertical-lift attachments will be built. There are many choices of materials and sub-assemblies available that might be satisfactory for this part of the project, of course. The particular selections made for this project are:

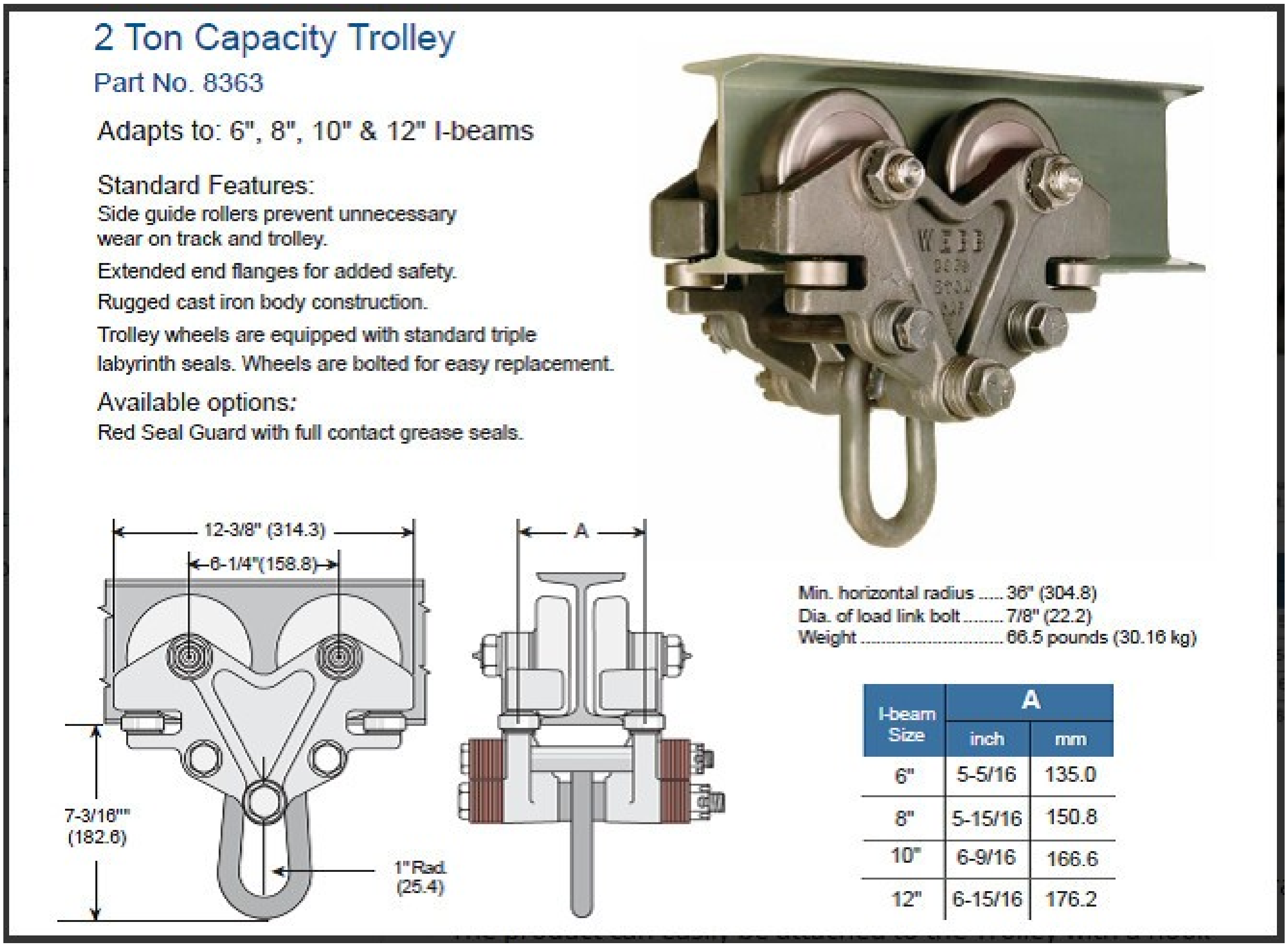
Tripod members: 4”x4”x1/4” thick angle steel

Vertical-lift guide posts: standard 6” steel I-beams

Vertical-lift attachments: I-beam trolleys that are attached to the dish to be pulled up the vertically oriented I-beams via steel cables.

Particular attention has been paid toward selecting suitable vertical-lift guide posts and the associated trolleys. The purpose of the vertical-lift guide posts is to keep the dish from swaying from the tripods as the dish is primarily suspended from steel cables using multiple-sheaved pulleys.

It is expected that using I-beams as guide posts will prove adequately sturdy; more so perhaps than other possibilities such as round pipe or square tubing. Additionally, I-beams offer a ready solution to a compatible lifting attachment via common trolleys that are designed to work with I-beams. The trolleys will be slightly modified to attach to both the lifting cable and a dish attachment member. A few of the details of the trolleys to be used are described and shown in the image below.



I-beam Size	A	
	inch	mm
6"	5-5/16	135.0
8"	5-15/16	150.8
10"	6-9/16	166.6
12"	6-15/16	176.2

Figure 3. Trolley selected for the vertical-lift I-beams to couple the dish lift points to the I-beams.

The load link bolt, to which the lift cables will attach with a shackle or hook, will be rotated 90 degrees from the position that is shown in the above image as the I-beam will be vertical. Note that with the I-beam oriented vertically and with weight applied to the trolleys at the load link bolts that connect to the lift cables, and with the dish attachment members also connected there, there will be a torque moment produced on the trolleys that tends to keep the upper trolley wheels tight against the inward facing rails of the I-beams as the dish is raised or lowered.

Examination of the design of the trolley when used vertically suggests that the rotational torque mentioned above may or may not tend to move the lower trolley wheels away from the inward facing rail of the I-beam. If such motion does occur the motion cannot move to much of an extent due to the construction of the trolley and the I-beam web dimensions. Should the lower wheel motion be large enough to allow the lower trolley wheels to contact the outward facing rail no particular harm will result as the lower trolley wheels would simply rotate in the opposite direction from the upper wheels. As upper and lower trolley wheel rotations are not coupled such anti-rotations will not be a problem should they happen to occur.

Note that the tripod structures will not come to a point at the upper ends of the tripods as shown in the simple line diagram. Instead there will be one or more horizontal angle pieces atop each tripod to which the multiple-sheaved pulley assemblies will hang via shackle attachments and to which the I-beam guide posts will attach. These details will be evident in photographs later when the tripods are actually built.

After studying the requirements for the lift tripods it has become clear that significant advantages can be obtained by increasing the lift height of the tripods to greater than the radius of the dish. The lift tripod design that will be constructed is illustrated in the photograph below.

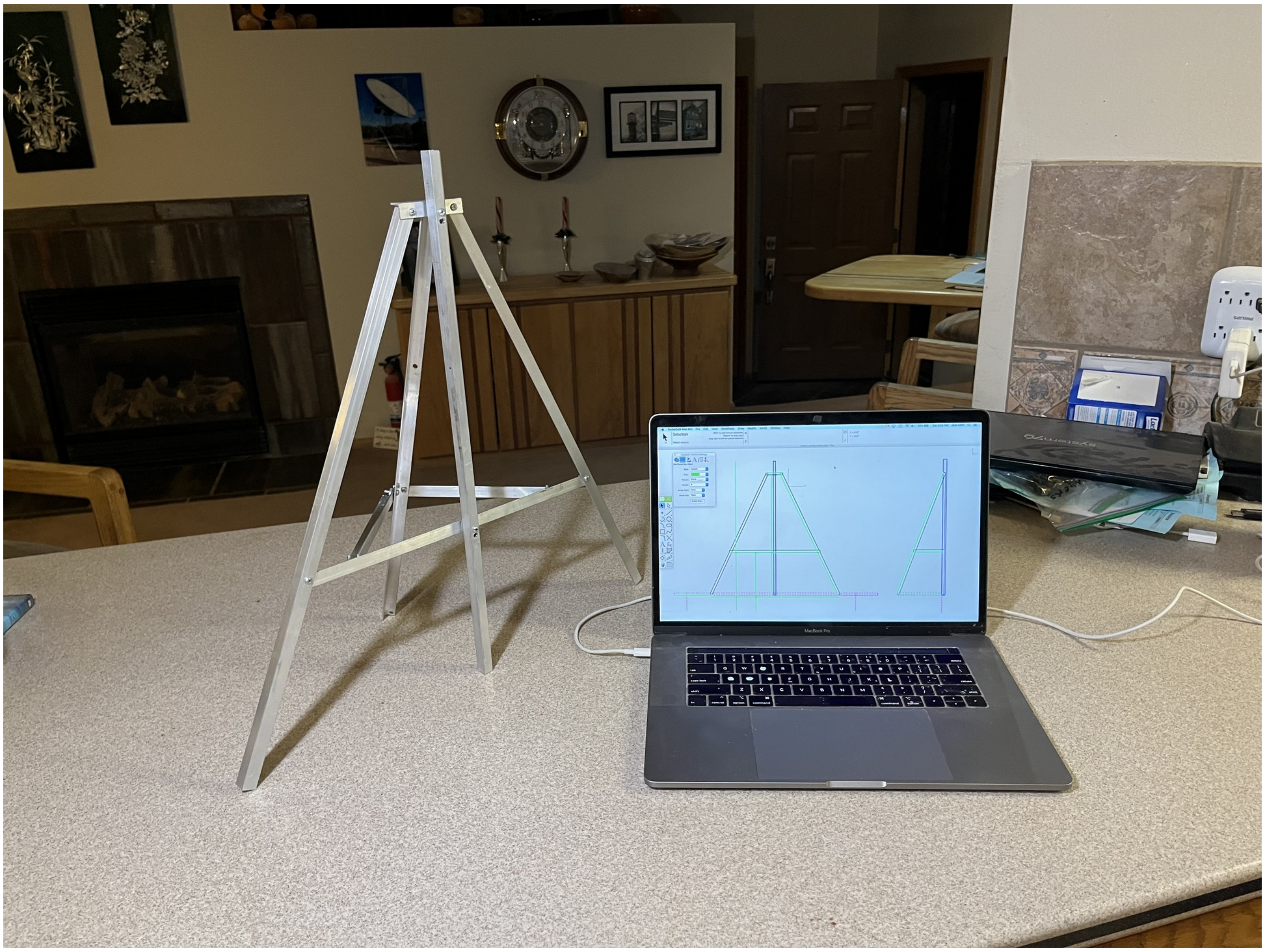


Figure 4. A 1:12 scale model of a lift tripod is shown. The longest elements in the full scale tripod will be 20'.

The resulting lift height for the tripods will be in excess of 18' (the dish radius is 14'). This amount of lift height for the center horizontal cross member of the dish allows for three major advantages:

i) The dish is to be assembled petal by petal in a face down orientation atop the AZ rotation structure and the steel back frame will be fabricated in place on the assembled dish petals to couple the dish to the lift tripods then lifted sufficiently high to ‘flip’ the dish from the face-down orientation to bird bath orientation using the lift tripods.

ii) The dish elevation angle range will extend from -90 degrees (face down) to +90 degrees (bird bath) with no feed system installed and to a negative elevation angle sufficient to place the feed horn and feed system at ground level after the feed system is installed. Being able to work on or replace the feed system at ground level eliminates the previous requirement for stairs or other means to place a person at the feed position when maintenance of the feed system requires it.

iii) There will be ample room available vertically to accommodate the lift hardware including the trolleys shown above and the four sets of double sheaved pulley snatch blocks that will be used to lift the dish.

As the dish edges are about 5’ displaced from the axis of elevation motion rotation at the back of the dish (i.e., the “thickness” of the dish is about 5’) and as extra vertical distance is needed to accommodate the lifting hardware, the lift height to accomplish the above advantages needs to be significantly more than the 14’ dish radius.

The photograph below shows the type of double sheaved pulley snatch blocks that will be used for lifting the dish.

Figure 5. Double sheaved pulley snatch block that has been selected to be used on the lift tripods (22APR2023).

The double sheaved pulley snatch block assemblies are rated for 4 tons of weight (8,000 lbs) each. The pulley sheaves are 4-1/2” diameter and will be using 3/8” steel cable. Two such assemblies will be used on each lift tripod, one at the top of the I-beam and one at the lift point of the dish, yielding a 4:1 mechanical advantage for each tripod on each side. As there are two lift tripods, one on each side of the dish, the total lift mechanical advantage for the lift system is 8:1. This amount of mechanical advantage significantly reduces the amount of torque that will be required from the two cable hoists that will be used with the pulley assemblies to lift the dish. The mechanical advantage is important because it permits the use of commonly available, and less expensive, stepper motors of moderate torque to be used to drive the two lifting hoists for dish elevation motion.

The steel angle and I-beam materials needed to fabricate the two tripod structures have been obtained and assembly of the first lift tripod is underway. The tripods will be assembled in a ‘laying down’ orientation for safety and convenience. Further, assembly of each tripod will be done near the previously used tower (the tower is visible in some of the earlier photographs) with a height extension beam clamped to it to allow safely raising the tripod into a standing orientation after assembly. The tower extension beam will include a pulley at the top so that an electric cable hoist can be used from the ground to lift the tripod upright to stand on its three legs. After standing upright, the tripod will be moved from the old tower location using a tractor with forks that are clamped to the lower horizontal members to position the tripod into a position onto the AZ rotating structure where it will be bolted to the AZ rotating structure. The lifting trolleys and pulley snatch blocks will arrive shortly. They will be added to the lift tripod structures as soon as they arrive.

INSTALLATION OF A UTILITY LIFTING BEAM

As it will be useful and safer when fabricating and raising the lift tripod structures a temporary utility lifting capability is being fabricated. Such a capability can be realized straightforwardly by using the existing 15' tower structure near the AZ rotating structure as a support for a lifting beam. A 20' long beam of 4"x4"x1/4" thick angle steel is used as a lift beam. The photograph below shows how the angle beam has been fitted with several shackle attachments.

Figure 6. A 20' long angle steel beam is rigged with shackle attachments and a cable pulley to be used as a temporary utility lift beam.

One of the shackle attachments at the end of the lift beam has a pulley rigged with steel cable for lifting loads as needed. Note that also shown in the photograph, to the right of the temporary lift beam, is the 6" I-beam that will be used as the vertical guide post for the lift tripod.

The photograph below shows how two tractors were used to raise the temporary lift beam into position on the existing tower.

Figure 7. Positioning the pre-rigged temporary lift beam using two tractors.

The base of the utility lift beam is wedged into the corner of the front bucket of the smaller tractor. The beam is lifted part way up the tower leg and re-chained repeatedly to the tower leg midway up and at the bottom as the beam becomes more vertical and approaches the tower leg base.

The photograph below shows the utility lift beam chained into position on the tower.

Figure 8. The temporary lift beam is chained into position against one of the tower legs (23APR2023).

The utility lift beam is chained to the tower leg at three places; top, midway, and bottom. The fact that the lift beam geometry is angle aids in providing lateral stability to the lift structure by chaining the tower leg into the angle of the steel beam.

To strengthen the lift beam during lifts two support chains are added from the top of the lift beam to the other two tower legs, as shown in the photograph below.

Figure 9. Two support chains are added from the the top of the lift beam to the other two tower legs to increase strength of the lift structure (24APR2023).

FABRICATION OF A LIFT TRIPOD

Each lift tripod will include three full-size (i.e., 20' long) beams, two sloping side beams consisting of 4"x4"x1/4" angle steel and one 6" standard I-beam. Some of the components that attach to the I-beam will be welded into position. Most of the welds that are done in this project are performed using a simple welding technique that most amateur and enthusiast welders utilize. That is, to join two steel pieces the two pieces are clamped together then a simple bead is welded at the junction of the two pieces. That type of weld is normally sufficient for most of our applications and is, indeed, the case for most welds needed in this project. However, there are two welds in particular in this project that need to be performed using a high-strength welding technique because these two pieces will be under high stress during normal operation of the ground-level AZ/EL mount. The two pieces referred to are the two shackle brackets that are used at the tops of the two I-beam vertical guide posts. These are principal lift points for raising the dish. The two brackets are fabricated from ¾" thick steel bar with a 1" diameter hole to accommodate a 1" shackle. Two tabs that will become these brackets are shown in the photograph below placed on the ends of the two vertical guide post I-beams.

Figure 10. Two steel tabs that will become lifting brackets are shown above.

As the welding technique for these two tabs differs from the technique normally used by us for typical welds a brief description and demonstration of how a high-strength weld may be accomplished follows.

ANATOMY OF A HIGH-STRENGTH WELD

A high-strength weld can be accomplished by welding using two different welding materials, one atop the other. In our case, one welding material consists of a steel alloy that is stronger than mild steel, but rather more brittle than mild steel, and one material of a mild steel alloy. In our particular case we will be using an industrial grade welder (Miller Synchro Wave 200) in "stick welding" mode due to the thick steel being welded. A light duty MIG wire welder would not be up to this task.

The initial weld will create a "root" weld using a high-strength welding rod (3/32" diameter E6011 rod in our case) then a "cap" weld will be applied over the root weld using a mild steel rod (1/8" diameter E7018 rod in our case). But before the root weld is done the tab materials need to be prepared in a particular manner for joining to the I-beams. Specifically, the joining ends of the tabs need to be ground into a shape similar to that shown in the photograph below.

Figure 11. The two tabs are shown clamped in a vise with the joining ends protruding. One has been ground in preparation for a high-strength weld and the other is not yet ground.

The joining ends of the tabs need to be ground as illustrated above, with the end ground to about 1/8" wide with sloping sides.   Then, after grinding the I-beam to expose clean steel where the tab will be attached, the tab is placed onto two welding rods to space the tab above the surface of the I-beam.   We use two welding magnets to hold the tab in position atop the welding-rod spacers temporarily. The configuration is shown in the photograph below.

Figure 12. A lifting tab is temporarily spaced above the I-beam surface using two 3/32" diameter welding rods and held between two welding magnets.

Once positioned, the tab is "spot welded" at each end to hold the tab in position while the root weld is performed between the tab and the I-beam surface. The spot welded tab is shown in the photograph below.

Figure 13. Lifting tab is spot welded in position with a 3/32" gap between the tab and the I-beam.

The gap is then filled using high-strength welding rod to form a root weld for the attachment. A photograph showing the completed root weld is shown below.

Figure 14. Root weld for the lifting tab is shown above (27APR2023).

The root weld is welded, ground down, and re-welded and ground repeatedly until it is certain that no welding slag or porosity exists in the weld. It is the root weld that provides the high-strength character of the final connection. After the root weld is in place it is covered with as many "cap" weld layers as desired using mild steel rod in the usual welding fashion.

The photograph below shows the completed lifting tabs welded onto the two I-beams.

Figure 15. Attachment of the lifting tabs is completed. Upper lifting pulleys are shown in place.

Also shown in the photograph above are the two dual-sheaved pulley snatch blocks connected to the lifting tabs using 1” shackle attachments. The vertical guide post I-beams are now ready to be used to assemble the lift tripods.

FABRICATION OF A lift tripod (continued)

The photograph below shows that an electric cable winch has been chained to the base of the tower. The lifting cable is attached to the top shackle of the I-beam to assist in leveling, squaring, and fitting the various beams while fabricating the tripod and will be used to lift the structure into an upright position after it is assembled.

Figure 16. An electric cable winch is shown chained to the base of the tower for use during leveling, squaring, and assembling the various tripod components.

The photograph below shows the principal side of the tripod under construction with members being fitted, cut, squared, bolted, and/or welded during fabrication.

Figure 17. Principal side of the first lift tripod under construction (29APR2023).

The horizontal beam shown (unattached to the structure) across the base is temporarily placed during fitting only and is not part of the principal side of the tripod. The member resting atop the sloping sides will be cut to fit and bolted onto the sloping sides.

The photograph below shows how holes were bored for bolts to connect most of the tripod components together; some components will be welded together.

Figure 18. Preparing to bore a hole for a bolt to connect a horizontal tripod member to a sloping side member.

The photograph below shows the two members bolted together.

Figure 19. A horizontal tripod member is bolted to a sloping side member.

The horizontal tripod member is bolted to the sloping side member using a ¾” diameter bolt, washers, and nut.

The photograph below shows how the upper end of the tripod principal side is bolted together.

Figure 20. Upper end of the principal side of a lift tripod bolted together (29APR2023).

A 5/8” shackle is affixed to the 3/8” thick horizontal cross piece to connect to the upper end of the lifting cable that will run through the multiple-sheaved pulleys used to lift the dish. The I-beam and top horizontal member are clamped and ready to be welded together.

The principal side of the tripod structure has now been welded and bolted together. The photograph below shows use of a gantry to lift the third leg of the tripod into position for fitting of the remaining two horizontal beam members and for connection at the top.

Figure 21. Third leg of the tripod is lifted into position using a chain hoist and gantry (30APR2023).

At last the structure is beginning to resemble an actual tripod. The photograph below shows how the two remaining cross members were attached to the three tripod legs.

Figure 22. All three cross members are now installed on the tripod structure (1MAY2023).

The photograph below shows how the upper end beams are attached.

Figure 23. Upper end beam attachment configurations.

The photograph below shows the completed lift tripod structure prior to setting it upright.

Figure 24. First tripod structure fabrication is shown completed (1MAY2023).

Before raising the tripod structure into an upright orientation and moving to the AZ rotating base structure two dual-sheaved pulleys will be added and rigged with 3/8” diameter steel cable to be ready to lift the I-beam trolley when it arrives and is installed.

The photograph below shows how the multiple sheaved pulleys were rigged prior to standing the tripod upright.

Figure 25. The tripod is lifted partially to allow installation and rigging of the multiple sheaved pulleys.

The photograph below shows the tripod structure being raised using the electric cable winch and utility lift beam.

Figure 26. Using an electric cable winch and the utility lift beam to raise the tripod partially.

The tripod structure rigged as shown weighs approximately 900 lbs and is 20’ in height. The photograph below shows the use of a tractor to pull the tripod into an upright position.

Figure 27. Using a chain and tractor to pull the tripod into a standing position (2MAY2023)

Note the safety line attachment at the top of the tripod to limit how far the tripod can tilt toward the tractor during this lift.

After standing the tripod upright the tractor is moved in close to firmly chain the tripod to the tractor fork cross piece. This stabilizes the structure additionally to safely permit an extension ladder to be placed against the tripod so that the upper utility beam cable connection hardware can be removed from the I-beam. The photograph below shows a ladder setup for the removal of the utility lift cable connection chain.

Figure 28. Using an extension ladder to remove the utility lift beam chain and hardware.

INSTALLING A LIFT TRIPOD

The photograph below shows the lift tripod assembled, rigged, and roughly positioned onto the AZ rotating base structure for fitting and installation.

Figure 29. An assembled and rigged lift tripod is positioned onto the AZ rotating base ready for fitting and installation onto the rotating base structure (2MAY2023).

Extensions for the forks are clamped onto the tractor forks as the forks do not reach entirely through the structure at the horizontal beam height unless fork extensions are added. During initial positioning the tripod is clamped onto the fork extensions and forks of the tractor for added safety and stability.

The photograph below shows the first tripod installed on the AZ mount rotating base structure.

Figure 30. First lift tripod is shown installed on the AZ mount rotating base structure (3MAY2023).

The photograph below shows the upper end of the pulley lift assembly.

Figure 31. Upper end of the pulley lift (5MAY2023).

The photograph below shows the I-beam trolley end of the lift system.

Figure 32. I-beam trolley end of the tripod lift system (5MAY2023).

One side of the horizontal center cross beam of the dish mounting frame will attach to the trolley to form a side connection for the dish elevation motion.

The photograph below shows the second lift tripod nearly completed.

Figure 33. Fabrication of the second lift tripod is nearly completed (6MAY2023).

As before, a gantry and chain hoist are used to hold the third (auxiliary) leg of the tripod in place while the members are bolted or welded together. The top connections of the third leg have yet to be installed in this photograph.

The photograph below shows the second lift tripod fabricated, and painted, with the lift pulley snatch blocks rigged.

Figure 34. Second lift tripod is fabricated and rigged, ready to be installed on the AZ mount base structure (7MAY2023).

The second lift tripod is now ready to install onto the AZ mount rotating base structure on the next cool, still morning. Note that the AZ rotation base structure has been rotated putting the previously installed lift tripod to the back of the AZ base structure with the position for the second lift positioned closest to the lift tripod that is to be installed.   The second lift trolley will be installed after the second lift tripod is in place.

The photograph below illustrates how a magnetic drill is being used to bore a bolt hole through the auxiliary leg and AZ mount rotating base structure during installation of the second lift tripod.

Figure 35. Boring a bolt hole through the auxiliary leg and base frame while installing the second lift tripod (8MAY2023).

Note that a tine of the tractor forks is being used to support the auxiliary leg from the bottom during bolt hole boring using a magnetic drill press and annular cutter. Also note the bubble level magnetically attached to the vertical I-beam in the background of the photograph to monitor the angle of the beam during this process.

The photograph below shows the second lift tripod installed onto the AZ mount rotation base structure.

Figure 36. Second lift tripod is installed on the AZ mount rotation base structure (8MAY2023).

With installation of the lift trolley on the second lift tripod this stage of the work will complete another milestone for the project.

This report concludes Volume IV of the real-time progress report document series. The next progress report will appear in Volume V and will begin describing the assembly of the Kennedy 8.6m dish atop the AZ rotating base structure.