Collapsible Tower Launchers

An R&D Project for NARAM-44

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Why a Collapsible Tower?

The inspiration for my project came from our attendance of NARAM 42 in Colorado. We were living in southern California at the time, so the trip to Canon City was quite an undertaking. All five of us were competing, so the amount of "stuff" multiplied quickly.

Everything that we needed for a two week trip had to fit into the AeroStar and the car-top carrier: the dog and his stuff, clothes, coolers, plus all of our rocket stuff, including the EZ Up, chairs and tables, five sets of rockets, engines, repair and building supplies, and our first, home built tower launcher.

I noted that the some of our largest items (EZ Up and tables) folded neatly and took up little room and indifferent to rough handling. My stove-pipe tower, however, was the most bulky and hard to handle item. Not only was it generally large, but I did not make it to be disassembled in any way, except for being able to remove the base's legs.

Since we needed a 4-guide tower for an upcoming PMC contest, I decided to do that one first, then follow up with at 3-guide version.

I looked at the excellent Medalist tower available from BMS and, though it has a much smaller bulk than our stove-pipe and addressed the storage space issue when disassembled, it didn't fold or collapse for the daily trip back and forth to the NARAM hotel. It also would not accommodate our existing pistons. I wanted a little more.

I drew on a lot of information and ideas about towers that already exist. I knew that I wanted to try parallelogram guides similar to those on the Medalist tower. Also, a tower that fellow AARG member David Bellhorn built using a wood frame convinced me that wood was the perfect rigid, available, easy to work medium for my frame. I was also impressed by Ted Mahler's launch equipment made of easily obtainable materials and use of jigs in construction.

I started my post-military career in manufacturing and have an admiration for things that are made from interchangeable parts that are hard to misalign. As I sketched the 4-guide design I looked for ways to keep the parts or processes common to each other.

I also wanted to make use of simple jigs to make the parts easily reproduced in case I changed the design or wanted to make a future repair.

The tools that I used for this project were:
Table saw
Drill press
Band saw
Propane torch
3/8" drill
Dremel tool
Screwdrivers, wrenches, other common misc. hand tools

Note: I used the band saw for easy cutting of the aluminum for the uprights and guide parts. A hacksaw could be used instead.

I set out some criteria for an "ideal" tower for us.
It would disassemble for storage.
It would collapse for transportation.
It would be inexpensive (<$100).
It would set up quickly.
It would use 4' guides to help get PMCs up to speed.
It would be readily attached to a camera tripod or any other base

Getting it together

Planning the 4-guide tower

The key element at the planning stage was the collapsible frames. Looking at the square shape of the obvious frame for a 4-guide tower, it struck me that a hinge at each corner would allow the entire frame to fold on itself like the sides of a cardboard box. A simple bar held rigidly in place across on corner of the upper and lower frames would "lock" all of the corners at 90 degrees.

I realized that if I offset the point where the guides would meet toward one corner of the frame by at least 5/8" it would allow the uprights to pass each other when the frame was folded. Note: It turned out that the offset would be more effective if it were significantly larger to allow the guide-upright assemblies to pass each other. A future redesign will incorporate this change.

The next planning element was to design an attachment scheme for the uprights. I decided to use two pin-and-hole guides, one of which would accommodate a wing nut for easy attachment and removal. The "pins" are just screws bolted onto the uprights with the nuts facing the frame. A ½" counter-bore in the frame accommodates the nuts while a close-fit through hole accepts the "pins".

The base of the bottom frame has no protrusions and can be directly screwed to a base, or all manner of attachment hardware can be mounted to it from the base or from the side.

Planning the 3-guide tower

The only real difference between the 3-guide tower and the 4-guide tower is the collapsible frame detail. The 3-guide tower again uses hinges at all of the corners, but one side of one hinge on each frame is attached with a hangar bolt and a wing nut. The "collapse" of this tower is visually impressive.

Building

The 4-guide frame:

1. Cut the frame side pieces to 7 7/8" length.
2. Mark the convergence line on each piece 3 5/8" from one end.
3. Mark the 3 5/8" side as "long" and the 4 1/4" side as "short".
4. Mark the registration pin locations two inches apart and the same distance from both edges.
5. Counter bore the nut reliefs .
6. Bore the pin registration holes to pass a #10 screw.

The 3-guide frame:

1. Cut the frame pieces to 12" length
2. Mark the convergence line on each piece at 6".

Follow steps 3-6 of the 4-guide frame instructions above.

The angle lock bars

1. Cut the angle lock bars to length
2. Drill the lock point holes

The uprights

1. Cut the upright pieces to length
2. Drill the pin registration holes
3. Drill the guide arm pivot holes

The guide attachment posts

1. Cut the guide attachment posts to length
2. Drill the guide pivot holes
3. Remove any anodizing

The guides

1. Cut the guides to length
2. Mark the locations for the guide attachment posts
3. Remove any anodizing

The guide assemblies

Hold the guide attachment posts in place with a fixture so that the distance between the holes matches the distance between the guide arm pivot holes in the uprights. Also, the distance from the holes to the face of the guide must be consistent.

Using an aluminum solder such as Alum-alloy, solder the guide attachment posts in place.

The guide arms

1. Cut the guide arms to length
2. Round one corner
3. Drill the arm pivot holes
4. Drill the guide pivot holes

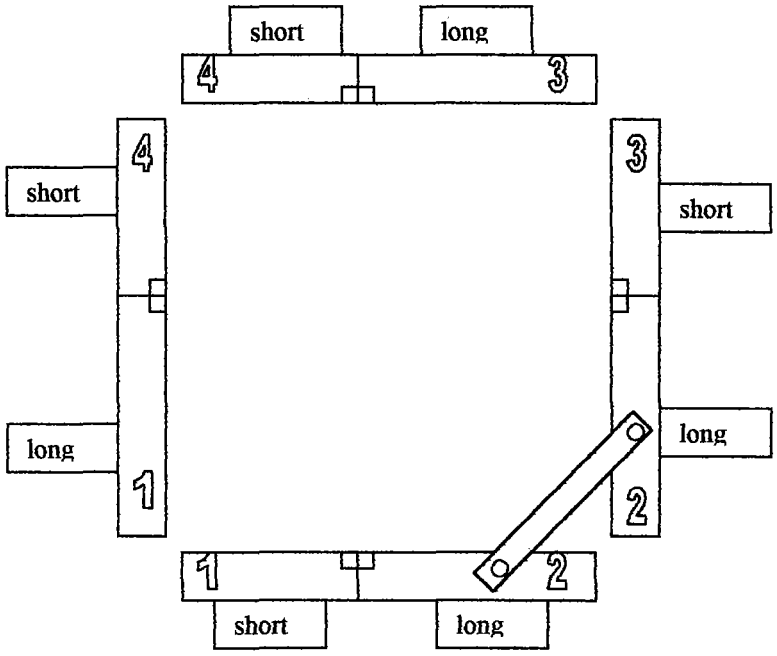
Problems

Only one of the assemblies gave me trouble. In spite of using a fixture to hold the guide attachment posts in place during soldering, three out of seven of them were misaligned after soldering to the point of being unusable.
I had to take them back into the garage and reattach them so that the distance between them was correct – some of them several times.
Note: If the holes in the guide attachment posts are too far apart, the guides will diverge at the top of the tower compared to the bottom, allowing the last part of the rocket's trip through the tower to be inadequately guided. If they are too close together , the guides will converge, pinching the rocket and impeding its trip through the tower.

Assembly

The 4-guide Frame:

Arrange the frame sides with all of the counter-bore facing inward as shown. (il)
Mark the corners as shown. (il)



Place two frame sides together with the counter-bored sides facing each other and with matching corner numbers together.
Attach a hinge to both sides with the screws that came with a hinge.
Repeat for each corner.
Place an angle lock bar across the top of one corner as shown.
Mark the centers of the holes onto the two locations (one on each side piece).
Drill these to fit a #10 tee nut.
Install the tee nuts.
Install the angle lock bar using two #10 thumb screws. The frame is now complete and rigidly held in a square.
Repeat for the other frame.

The 3-guide Frame:

Place two frame sides together with the counter-bored sides facing each other.
Attach a hinge to both sides with the screws that came with the hinge.
Repeat for the next corner.
Attach a hinge to one side of the last corner as before.
Mark one hole location for the other side of the hinge.
Mark this corner of the frame as #1.
Drill a pilot hole at the location for a #10 hangar bolt.
Lock a wing nut and a nut together ¼ " onto the hangar bolt.
Install the hangar bolt into the pilot hole.
Remove the nuts from the hangar bolt.
Install the last hinge onto the hangar bolt with the wing nut. The frame is now complete and rigidly held in a triangle.

The Upright Assemblies:

Attach a guide assembly to two guide arms with ½" #6 screws and nylon-insert lock nuts. Tighten them all the way down then back off the nut lightly to allow the joint to pivot easily.
Attach the other ends of the guide arms to the uprights using ¾" #6 screws, two lock washers, and a wing nut.
Attach a long #10 screw and a short #10 screw to each frame mount location as shown. (pic)

Final assembly:

Align the upper and lower frames horizontally on a table or the floor. The #1 marked corners must line up.
Insert an upright assembly into one face of the bottom frame and attach it with a washer and a wing nut.
Repeat with the upper frame.
Repeat with the rest of the upright assemblies.
Tighten the guide arm wing nuts for firm adjustment of the guide positions.

How did it go?

I intentionally left out the description of some of the frustrations I ran into with getting designs that would be build-able. There were two magic bullets that shot down problems: simplicity and actually starting the build.

Getting the actual building started got me out of the mire of "what if"-ing myself to death on paper. And every problem that I ran into after that was solved with the "KISS" ("Keep It Simple, Stupid") method.

I am pleased at how interchangeable the parts are: many parts are even interchangeable between the 3-guide and 4-guide versions. I was also somewhat surprised at how good the towers look.

Assembly and disassembly are straightforward and pretty quick.

The 3-guide version collapses somewhat dramatically and takes up very little room even without taking it completely apart.

The 4-guide version does collapse pretty well, but needs the design change that I mentioned earlier to be more robust.

Both versions store very nicely when disassembled and take up what I think is very little car space. When the guides are stored in a mailing tube or long box, the whole arrangement is easily tough enough to store in the car-top carrier for long trips.

The cost of materials for either tower version was below $45. Most of that was the cost for the aluminum channel that I used for the uprights and guides. I felt that the cost was justified by the reduced weight of the tower. All of the materials that I used are available at any large hardware store, though some may be cheaper from other sources.

Other things to try are...

I am anxious to try the design revision that allows a better collapse of the 4-guide version of the collapsible tower.
Some other ideas that could be explored are bases that allow easy positive mounting of pistons with the rocket already attached, and using more advanced – lighter or stronger – construction materials.

Reference

Parts List for the 3-Guide Collapsible Tower

1x	1x4x6' pine or fir
2x	3/8"x3/8"x8' aluminum channel
1x	1/2x1/2x6' aluminum channel
6x	1 ¼" hinges with screws
6x	#6-32 x1/2" pan head screws
6x	#6-32 x3/4" pan head screws
6x	#6-32 nylon insert lock nuts
6x	#6-32 wing nuts
12x	#6-32 lock washers
6x	#10-24 x1/2" pan head screws
6x	#10-24 x1 1/2" pan head screws
6x	#10 washers
8x	#10-24 wing nuts
6x	#10-24 nuts
2x	#10-24 hangar bolts

Parts List for the 4-Guide Collapsible Tower

1x	1x4x6' pine or fir
3x	3/8"x3/8"x8' al. ch. (2x for 3.5' guides)
1x	1/2x1/2x8' aluminum channel
1x	1/8"x1"x 8in. aluminum bar
8x	1 ¼" hinges with screws
8x	#6-32 x1/2" pan head screws
8x	#6-32 x3/4" pan head screws
8x	#6-32 nylon insert lock nuts
8x	#6-32 wing nuts
16x	#6-32 lock washers
8x	#10-24 x1/2" pan head screws
8x	#10-24 x1 1/2" pan head screws
8x	#10 washers
8x	#10-24 wing nuts
8x	#10-24 nuts
4x	#10-24 thumb screws
4x	#10-24 tee nuts