by Don Lancaster

The Mount Graham Aerial Tramway

Once upon a time (June of 1923 to be exact), there seemed to be a crying need for sawn lumber in the farming communities of the Gila Valley. There was lots of large Ponderosa Pine and Douglas Fir high up on nearby Mount Graham. Along with an existing steam sawmill. But that was there and this was here.

So close, and yet so far away.

Two earlier attempts at logging flumes lay in shattered ruins. Unworkable because of extreme topography, little water and really bad engineering. A tortuous and deadly wagon toll road priced the boards out of their seemingly nearby markets. Including several "Are we having fun yet?" pleasure spots such as *The Dugway*, *Slick Rock* and *Dead Horse Turn*. Through wild country which *to this day* remains accessible *only* by foot or mule.

So, the decision was made to simply sail the boards up through the air. Frisbee style. An *aerial lumber tramway* was built. Which turned into one of the most astounding engineering feats in all of Southern Arizona.

The Route

The aerial tram began at the Old Columbine mill site at an elevation of 8685 feet. It then headed out straight as an arrow one degree east of true north. First traveling a half mile *up* across a 9045 foot ridge and then dropping to the Shingle Mill Canyon transfer station at 4480 feet and a distance of 4.2 miles.

At the transfer station, the path shifted some 36 degrees easterly. Then traveling another straight-arrow 3.3 miles to the Pima terminal at an elevation of 3241 feet.

A total length of 7.5 miles and an elevation delta of 5804 feet. *Which is well over one vertical mile!*

Wooden Towers

Much of the tram was fairly low tech, cobbed up out of wood and a few key pieces of recycled low grade cast iron. Everything had to be packed in or drug in by mule over wildly inhospitable terrain.

Around ninety towers (the precise number is arguable) were used over the route. The typical tower spacing was around 300 feet. With a maximum single hop span of 1800 feet and an end-to-end drop of 800 feet.

A few of the towers were rather spindly and reached a startling 40 feet in height. But the average tower was just high enough to safely clear the lumber loads.

The typical all-wood tower was a fairly sturdy buttressed A-frame affair which stood a tad under fifteen feet tall. Its sole reinforcement was a pair of iron tie rods. Machine bolts or lag screws and fat washers for the larger timbers; plain old nails for the braces. Most towers rested on small concrete footers which ultimately proved to be too small and way too shallow. A pair of fixed cast iron *track saddles* sat on each end of the tower's top beam.

At shoulder height, one pair of cross-track braces. On these, a pair of along-track wooden rails on each side. The rails supported an off-center sixteen inch *tow wheel idler* spinning inside a cast iron carrier frame. Whose bearings were plain old axle iron on casting iron, helped along with a little grease. Each tower thus had only *two* moving parts.

Fixed "M" shaped guide rods acted as simple pilots for the wheels. A heavier one on the downside; a lighter and longer version on the upside.

You'd see what at first seemed to be five cables at any tower site. One was a simple iron telegraph line that went from tower top center to tower top center along the entire route. And doubling as a broken tower detector.

Track cables went from tower top to tower top, sitting in greased groves in the track saddles. As the name implies, these are more or less stationary cables whose task is to support the hanging tram cars.

Since the heavy traffic all went downhill, the l-1/4 inch "down" track cable on the eastern side was thicker than the western 1-1/8 inch "up" track. A special tram-optimized flat *lock coil* cable weave was used.

What first appears like a pair of *tow cables* went from tower to tower at eye height. In absence of a car, the tow cable sat on and spun the idler wheels. This was thinner wire rope as its only role was to tow the cars along.

In actuality, the tow cable was continuous on either tram leg. This wound around a horizontal drum at the terminal, went down the route on the east tower sides, wound around a second horizontal drum and a tensioner at the transfer station, and then went back up the same route on the west tower sides. This tow cable was field spliced.

As a car or a pair of cars approached a tower, the tow cable would get hoisted up out of the grooved tow wheel idler. After the cars passed, the cable guide rods would realign the tow cable back down into the idler groove.

The Cars

The cars themselves seemed fairly sophisticated. These were recycled from ore bucket mining duty. Each car was basically a four foot diamond shaped iron frame that had a pair of 10 inch track rolling wheels on the top, a swivel mounted and roller-backed automatic gripper in the middle, and a chain sling at the bottom.

Unloaded, each car weighed around 240 pounds.

The cars would roll underslung along the track cables and, when the gripper was closed, got towed by the tow cable. On the down trip, the cars would get used in pairs. One near each end of one dozen boards or half a dozen timbers. The cars would thus typically be six to ten feet apart. Iron guides and channels "squared up" the chain slings to match the load. There was a hidden quick release under each bottom support channel.

On the up trip, the cars usually returned singly. Mostly empty, but sometimes carrying a sack of grain, mail, a bale of hay, or whatever.

The gripper mechanism showed some creative design. There was a rolling ball the size and shape of a trailer hitch which activated an overcenter two-state toggle mechanism. Sort of a mechanical set-reset flip flop. Ball up and the gripper was open; ball down and the gripper grabbed the tow cable. Deflection plates mounted on the stations would automatically release or grab as needed.

These plates would be placed *after* the ends of the track cables but *before* the loop of the tow cable. At activate time, the car would be riding on a set of high rails similar to those in a large meat locker.

The gripper casting seemed to include an obvious bell. Presumably it dinged once on each grab or release.

Tension Stations

Rather than trying to manhandle (and mulehandle) some fifteen miles of cable through country that would make a marine drill sergeant blanch, the track cables were broken up into mile long segments. One end of each cable was secured to a giant eye set in a solid concrete foundation. The cable would then route up and over the top saddles of a dozen or more towers and end at a *tension station*.

Besides allowing shorter cables, the tension stations kept the track lines from sagging under load.

At the tension station, the track cables would go over large pulleys and hang on *floating* concrete weights.

These humongous blocks weighed in from 8000 to 30,000 pounds. Made from iron-reinforced cement poured around groups of locally gathered large rocks. Gneiss, mostly. The weights would ride up and down in massive wood guides reminiscent of a double hung window.

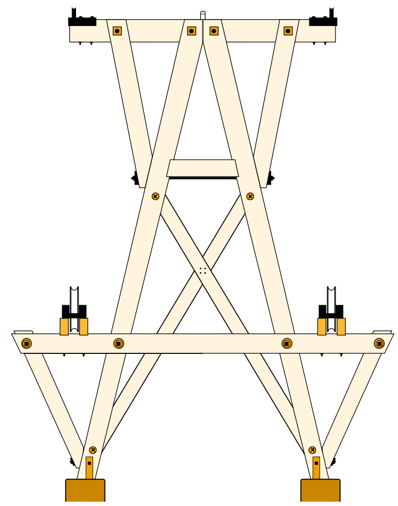
At a tension station, the cars would leave their entry track cable, traverse a short *transition sheave* to a fixed horizontal rail, traverse a second transition sheave, and end up on the exiting track cable. The moving tow cable was oblivious to the bait-and-switch, and simply dragged the cars along. The fixed rail was supported by cast iron "J" skyhooks bolted to upper support timbers.

Three "double" tension stations held two weights and two anchors each. Two "quad" tension stations supported four weights but no anchors. The remaining eight anchors were paired at the upper terminal, the lower terminal, or at either end of the transfer station.

Down track weights were always heavier.

Much of the aerial tram was built from parts recycled from earlier tram and mining ventures. The tension pulleys form a curious mix. Obviously gleaned from a variety of strange sources. In several cases, a rod hoop got welded

A TYPICAL TRAM TOWER



onto a mine car wheel to form a cable guide pulley.

As you might guess, 30,000 pound concrete blocks are somewhat vandal resistant. Many survive intact to this day. Even so, at least one of them has gotten hauled off as a tourist memento. In operation, these tension stations must have been extremely impressive.

It is still a stunning adventure to come upon a station unexpectedly in heavy brush. I'm trying to reconstruct their engineering drawings. But exact details of their upper reaches still remains elusive.

The transfer station and the Pima terminal also were long and rather elaborate wooden structures which allowed for intermediate storage and routing of the loaded cars. At the transfer station, the uncoupled cars would get slid along skyhook rails and recoupled to the second leg of the tram route. Human intervention was apparently required. A few tantalizing photos show how big and how complex these stations really were. But they don't reveal much in the way of precise technical details.

Little remains of most of these sites today.

Gravity Powered?

Local lore has the tram running entirely by gravity. And having enough energy left to run the sawmill as well. There was in fact a steam boiler at the sawmill and an engine at the nearby tram terminal. Motive power apparently was coupled to the lower tram leg at the transfer station by a vertical axle and pair of gripper wheels.

Let's see. Take 400 pounds or so of wood and drop them 5000 feet. That is around 2 million foot pounds of work.

Make the trip in, say, 40 minutes.

This gives you something like *three* horsepower's worth of effort. Per load. Because of loading times, I'd think it unlikely that the average loads could be closer than seven minutes apart. Guessing six loads active at any one time yields you something around 18 horsepower derived from gravity. But two of those loads would cancel each other out going over the ridge.

Leaving you with a net 12 horsepower.

Those 12 horses had to overcome wind resistance, flex a lot of stiff cable, and spin hundreds of idler wheels.

So we can give some credence to historical statements that the tram "pretty much ran by itself." But *no way* did it saw up any boards in its spare time.

Success and Failure

Judging by the few surviving photos, great heaping loads of lumber got delivered on down to Pima Terminal. Sadly, the aerial tram got shut down and was partially dismantled *one year* after it started operation.

Part of the reason might have been underlying economic problems with the sawmill. Or new Forest Service regs.

But the tram apparently needed continuous repairs and seemed to have had woefully excessive downtime. At least, that's what today's on-ground evidence suggests to me. My guess is that the delivered cost-per-board was too high to make much economic sense.

The system design and construction was all done using local help, because an experienced real tram engineering firm was "too expensive".

There were several gruesome fatalities and a number of other gory accidents. The transfer terminal literally ate an operator for lunch one day. At least one track cable failed spectacularly. Giving a profound new depth of meaning to the term *sprooiinnggg….*

In those days, of course, OSHA inspectors were dealt with simply by hooking them onto the next tram car.

One series of repeated tower failures required at least five rebuilds. Done without any attempt at improving the design or fixing the problem. Other towers were hastily rebuilt or added without proper footings.

Scattered piles of fire bricks in strange places suggest impromptu blacksmithing. Collisions between cars and towers apparently occurred. To the obvious detriment of both. Lost loads and shattered towers still litter some of the more remote canyon bottoms along the route.

I guess the final analysis was that the Mt. Graham aerial tram delivered the boards but not the bucks.

Back to the Future

What does this failed and largely forgotten tech venture have to do with any of today's Midnight Engineering?

I see several key points here…

To work hard, you gotta play hard– No matter whether it's hiking, caving, hang gliding, bike, ski, or scuba, you flat out have to get down and dirty.

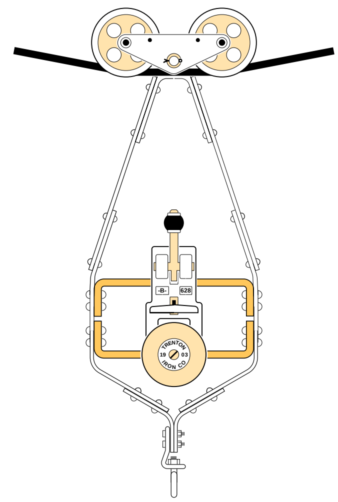
Study the classics– That's where all the fundamentals of appropriate technology, elegant simplicity, and workable real world results first come down.

It ain't creative unless it sells– No matter how wonderful your design, iffen it don't pay for itself in one manner or another, you have a failure.

Cheapest is rarely the most cost effective– Solid footers, steel, and real bearings outperform wood, rocks, and low grade iron. Every time. Guaranteed.

Budget for maintenance– Design your product from the ground up to be fixable and improvable. Always aim for minimum total life cycle costs.

THE TRAM CAR OR "CARRIER"



Much more on these concepts in my *Incredible Secret Money Machine II* and my *Blatant Opportunist* reprints.

For More Info

Your usual starting point on tram research is *Pioneer Town*, the Pima Centennial book published by the *Graham County Historical Society*. Limited but highly useful photo collections exist in the Pima museum or the Safford Ranger District of the Coronado National Forest.

Written family clan histories are a big deal in this area, so there are a lot of private sources. These often can end up a curious mixture of fact and fiction. One or two tramway employees remain in the area and are very much alive.

I could use a little help in relocating two "lost" tension stations. But you'll have to be the type of hiker who brings along your own catclaw. Just in case there is not enough along the route. Naturally, the word *"trail"* is not in your vocabulary. Your 4WD vehicle will, of course, receive a 100% authentic Arizona pinstriping job.

I have uploaded several artsy-craftsy tram sketches as TRAMCAR.PDF and TRAMTOWR.PDF to *www.tinaja.com* Suitable for framing. Along with custom drawing utilities. I'm working on translating the original tram photos to CD ROM. More on this whenever. ◆

Microcomputer pioneer and guru Don Lancaster is the author of 33 books and countless articles. Don maintains a US technical helpline you'll find at (520) 428-4073, besides offering all his own books, reprints and various services.

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