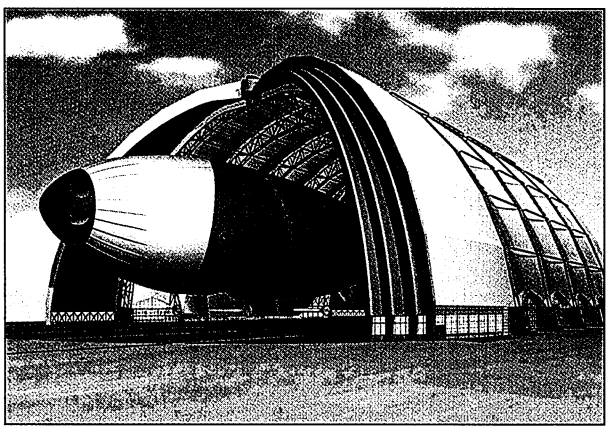
granddaughter, Elisabeth Veil, baptized the modern prototype "Friedrichshafen."

The project Zeppelin NT ("New Technology") has exploited a host of recent advances in materials science to make the modern zeppelin a better airship than its ancestors. The craft's skin is Tedlar foil and polyester textile, weatherproof fabrics that give the company the option of not having to keep the zeppelins in a hangar. Modern materials give the new breed a big advantage over last century's zeppelins, the cotton-based skin of which would suck up a lot of water, making the dirigibles heavier and sometimes rupturing during flight—forcing daring midflight repairs.



Thinking big. CargoLifter has plans for a huge dirigible that could carry heavy objects to remote locations.

The new ship's aluminum and carbon fiber–strengthened plastic frame has a triangular geometry, making the helium-filled dirigible more compact and lighter by volume than its progenitors. Dirigibles also have a big advantage over blimps, famous for hovering over U.S. football games. If a blimp were to lose gas, the skeletonless airship could crumple and become unsteerable. A dirigible's frame allows it to be steered even when deflated.

The prototype Zeppelin NT has completed more than 800 hours of test flights in Germany. Initially, it and a twin to roll out this spring will be confined to German airspace; indeed, dirigible tours will not stray far from Lake Constanze. But the company hopes to launch flights to other countries after getting regulatory approval.

The dirigibles will be used for advertising, and Zeppelin Luftschifftechnik is exploring other markets, including measuring airborne pollutants. The airships could also provide a vibration-free and steerable platform for scientists. "A plane is too quick for some instruments," says Markus Quante of the Institute for Atmospheric Physics in Geesthacht. He studies how greenhouse gases move through the atmosphere. "Our particle detectors work much better at low speed, and they are very complex instruments, so you need an operator at their side," he says. "You can't do this in a balloon."

Taking a different tack is CargoLifter, a Berlin-based company that hopes to revive dirigibles as titanic airborne mules. "We're really creating a new industry," says Charles H. W. Edwards, president of CargoLifter's U.S. holding company. Edwards predicts his firm will have more demand than it can handle for the 50 airships it hopes to build over the next 15 years. Major customers could include the heavy machine and construction industries, oil-exploration firms, and humanitarian missions. Gigantic machines, such as turbines or air liquefiers, are usually moved from factory to customer by truck for shipment out of a port or an airport. "A ship has to end [its journey] at the wharf," says Edwards, and not every airport can handle a cargo jet. So a truck often must complete the journey. "We can go point to point," he says. Like a flying crane, CargoLifter's CL 160—still on the drawing board—would be able to grab its freight—up to 160 tons, equal to 27 full-grown African elephants—while hovering and without disassembling it.

But CargoLifter still must obtain regulatory clearances from air traffic authorities. The cumbersome airships might be excluded from airspace near airports, and regulators have not yet decided whether to treat the CL 160 as a plane or as a container ship, which would affect the number of hours that crews would be allowed to work and thus the duration of CL 160 flights. The uncertainty hasn't stopped CargoLifter from building a hangar at a former Russian military airport 60 kilometers south of Berlin for a prototype it hopes to fly in 2003. Potential competitors are popping up: The U.K.'s Advanced Technologies Group has recently tested a model of a jumbo dirigible designed to carry 1000 tons.

Experts are thrilled that these anachronisms may find a place in the modern world. Within 5 years, predicts Schäfer, German skies will be filled with dirigibles.

–OLAF FRITSCHE

Olaf Fritsche is a freelance writer in Sandhausen, Germany.

MILLIMETER ASTRONOMY

U.S.–Mexican Telescope Gains Firmer Footing

After a shaky start, the Large Millimeter Telescope is taking shape in the mountains of central Mexico. It's Mexico's biggest splash in global research

AMHERST, MASSACHUSETTS—A narrow sand-and-gravel road studded with hairpin turns is the only way to reach the future site of the Large Millimeter Telescope (LMT), atop a 5000-meter mountain in eastern central Mexico. The road is too treacherous to transport the 1000-ton, 35-meter-long pieces of steel, now being manufactured in the lowlands below, that will form the telescope's 50-meter dish and supporting structure. But work on a wider, safer, and long-overdue road has stopped because of lack of money. That problem is just one of several obstacles in the way of a 12-year quest by U.S. and Mexican scientists to construct Mexico's most expensive scientific facility and its largest cooperative R&D effort with its northern neighbor.

Operating at wavelengths as short as 1 millimeter, the $80 million telescope is designed to generate important new data on the nature of early galaxy formation and many other objects in the universe. But despite the road and a host of other challenges—ranging from design headaches to an uphill battle for scientific respect—the project's future suddenly seems bright. The new Mexican government appears favorably disposed to the project, and the U.S. National Science Foundation (NSF) is poised to provide the first chunk of U.S. government support obtained through accepted scientific channels.

A lot is riding on a successful outcome. The telescope would vault Mexico into the elite ranks of countries with world-class observatories. "This is very, very important for us," says Alfonse Serrano, director of the National Institute of Astrophysics, Optics, and Electronics and the Mexican midwife of the effort. For its U.S. partner, the University of Massachusetts (U Mass), the new telescope means a chance to remain in the top ranks of U.S. astronomy departments. And for the community at large, LMT represents a new and valuable tool. "We're happy to have it," says Martha Haynes, a Cornell astronomer who chaired last year's radio astronomy panel that fed into the National Research Council's (NRC's) influential decadal report on the future of U.S. astronomy.

Work on its foundation began last month

CREDIT: CARGOLIFTER AG

and is expected to be completed this year, with "first light" in 2004—2 years behind schedule. Once finished, it will be the largest millimeter-wavelength telescope in the world, soaring more than 15 stories above a desolate mountaintop. "Our killer app" will be data on early galactic development, says U Mass project scientist Peter Schloerb. Highly redshifted galaxies are particularly visible at the millimeter wavelength. With its wide bandwidth, the large dish will be able to collect massive amounts of data on these ancient structures for astrophysicists to plug into their evolutionary models. But researchers also expect to gather more accurate information, and at a faster rate, on distant galaxies, the velocities of galaxy clusters, and molecular gas clouds in our own galaxy. Peering closer to home, the telescope should be able to plot the shape of comets beneath their obscuring comae.

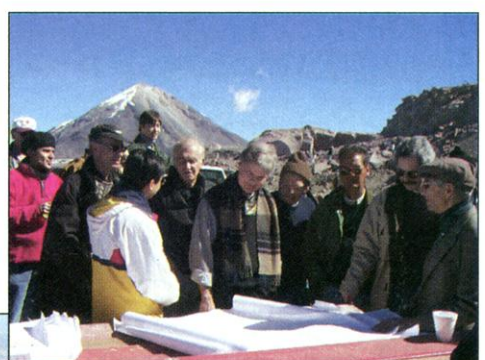
Such results will be vindication for supporters, who have fought hard for scientific respectability. The original idea was conceived in the late 1980s by U Mass scientists who currently operate a 14-meter telescope near the campus, but it was rejected by NSF. The 1991 NRC decadal survey highlighted the need for a millimeter array, but that suggestion grew into the $400 million Atacama Large Millimeter Array (ALMA) being planned jointly by the United States and Europe for a mountain site in Chile's Atacama desert.

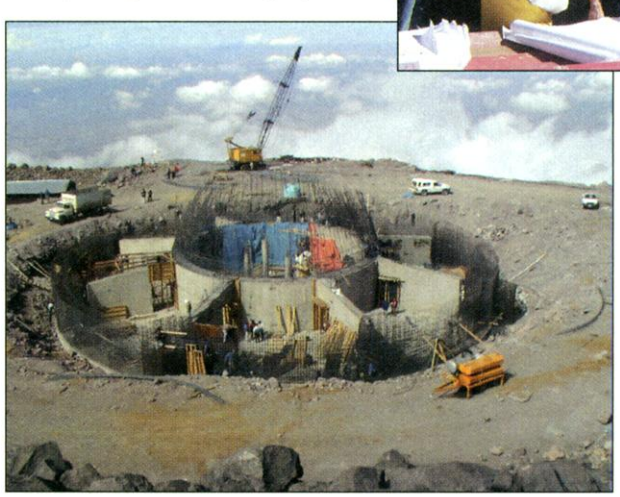
Refusing to give up, U Mass officials struck a deal with their Mexican counterparts, who agreed to host the facility and pay half the cost of construction. And they convinced Congress to put $21.4 million for the LMT into the budget of the Defense Advanced Research Projects Agency (DARPA), circumventing peer review and NSF altogether. The move earned a "tongue-lashing" from one upset House Science Committee staffer, recalls one scientist involved in the effort. They also reaped $5 million from the state of Massachusetts as well as $4 million from the university (*Science*, 17 January 1997, p. 300).

The ill feelings from that pork-barrel strategy have faded, however, in part because the funding earmarked for the LMT did not threaten other radio astronomy projects like ALMA. The LMT will form one part of a suite of new ground-based instruments now being designed or built to cover millimeter and submillimeter wavelengths, each with its own particular technical strengths. LMT, for example, will be capable of imaging celestial regions an order of magnitude more rapidly than the 40-dish ALMA can, Schloerb says. "When you put all these together, you have what you need," Haynes adds.

Mexico's support for the project has been unflagging, surviving the peso crisis of the mid-1990s and numerous strains on the country's research budget. Nevertheless, the project has encountered a host of difficulties. Disputes with the German company hired to design the LMT slowed progress, and a 1997 decision not to build a protective radome around the telescope led to a major redesign midstream. In addition, the site's features—including high winds, extreme temperatures, and crumbly soil—proved a greater challenge than expected for both design and initial construction, says Allen Langord, U Mass program manager.

An August 2000 review by an outside advisory panel appointed by the project noted "substantial progress," although it cited "serious concerns" about antenna design, contract delays, schedule uncertainties, and budget shortfalls. Cornell astronomer Paul Goldsmith, panel chair, says that he and his team were encouraged during a visit last month to the site, but says major challenges remain.





Mountain men. Advisory panel chair Paul Goldsmith *(inset, second from right)* and other researchers at the site of the Large Millimeter Telescope being built on Mount La Negra in central Mexico.

CREDITS: UNIVERSITY OF MASSACHUSETTS

A temporary road to the site has long been complete, for example, but work on the promised permanent route has halted. The state of Puebla had promised to build the road, but funding was halted last year after floods swept the region and a new governor was elected. The state has asked for federal funding to complete it, Serrano says, "but we don't know the result yet." One alternative would be to improve the temporary road so that it could carry the heavy equipment necessary to complete the telescope.

The balance of funding between the partners is another source of tension. Serrano says that Mexico has already spent its $40 million and that it needs an estimated $3 million more. Last week Serrano was named second-in-command at Mexico's research ministry, an appointment that seems likely to bolster government support. "This is good news," says Langord. But Serrano worries about the U.S. contribution, about $30 million so far: "We're in a more difficult position if the U.S. can't raise the additional $10 million" to match Mexico's contribution.

Langord takes a different view of what constitutes a fair share by each side. Not all the Mexican money has gone directly to telescope design and construction, he notes. In addition, he says that it may be possible to finish the U.S. part of the work for less than $40 million. Other project officials say that a 50–50 split was never formalized. Still, they say they are confident that Congress later this year will provide DARPA with the necessary funds, up to $10 million, to finish construction.

In the meantime, he and Schloerb are waiting for final word from NSF on the university's request for support. U Mass currently receives $1.1 million from NSF to operate its current dish, which will be shut down when the LMT goes on line. The goal is to ramp up the funding to $2.5 million annually by 2004, an amount that would cover the U.S. share of operating costs of the LMT. In the meantime, money not needed to operate the existing facility would finance instrumentation.

Outside researchers expect NSF to approve additional funding for at least the next 2 years and then review the overall project. "The fact that NSF is willing to support us is a strong indication that the scientific community considers the LMT to be a worthwhile project," says Schloerb. And Goldsmith is confident of finding operating funds. "The science is so overwhelmingly exciting," he says. "The money will be found, even if no one is quite sure how."

–ANDREW LAWLER