

Think Fast

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## Cold Rush

**Long hours. Subfreezing winds. months of absolute darkness. Welcome to the South Pole, where the coolest science outpost on earth is being built atop 9,000 feet of solid ice.**

By Michael Behar

After a grueling 18 hours on the ice, Jerry Marty wanders into the communications center at Amundsen-Scott South Pole Station and collapses on a tattered sofa. It's midnight and the place is quiet. As the National Science Foundation's representative for the station, Marty is, in effect, the mayor of the South Pole. A lanky 55-year-old with fair hair and a broad mustache, he is overseeing construction of a \$153 million research facility that will replace the Pole's current structure - a 27-year-old geodesic dome that is slowly being buried under mounting ice and snow. The sleek new station will have it all: from private rooms outfitted with Ethernet and telephone hookups to modern labs and medical facilities - plus a cozy bar where researchers can host their time-honored Slushy Night in style. By 2006, after 15 years of planning, design, and construction, South Pole scientists and support staff will have a home fit for the 21st century.

But building the new station is a tremendously complex endeavor that demands precision choreography among 85 onsite construction workers, contractors in Denver, architects in Honolulu, administrators in Washington, DC, and a 10,000-mile supply chain that begins aboard a cargo ship in Port Hueneme, California, and culminates at the Pole six weeks later with the daily arrival of up to seven ski-equipped cargo planes. Hence, Marty sleeps by the radio in the "comm center" - if any one of these variables goes awry, he needs to be the first to know.



**Photo by Amundsen-Scott South Pole Station Crew**  
**An Aerial view of Amundsen-Scott South Pole Station; the new Antarctic research facility is scheduled for completion in 2006**

At 5 am, he rouses himself and hikes a quarter mile across the ice to reach his office outside the dome. It's located in a plywood shack called the Cheese Palace (Marty, a Wisconsin native, has a spirited penchant for cheese-themed decor). Just as he enters, the phone rings. It's a conference call patching together four time zones and two continents. Pole engineers have finished crunching data collected over the previous winter, and they've discovered that the half-built South Pole station - at this point a colossal steel and wood frame partially enclosed with siding and insulation - is settling into the snowpack at a rate nearly four times faster than originally predicted. In a single year, the data shows, the station's overall foundation has sunk 5 inches into the 9,000-foot-deep ice. Marty's counterparts on the phone have no choice but to put off plans for connecting the plumbing, electricity, and data conduits between the complex and the adjacent utility tower. Otherwise, the sinking would soon shear them off. Marty hangs up the phone. How do you stay on schedule when your building is slowly going the way of the *Titanic*?

For a small-town mayor, Marty faces some daunting challenges. There are the 185 days of stygian darkness that prevent resupply planes from landing on the unlit runway, and temperatures that plummet past minus 100 degrees Fahrenheit, seizing up heavy equipment. Blinding whiteouts roar in with little warning and can halt construction for days. The ice floor shifts steadily, creeping 30 feet across the underlying continent each year. Heaters, generators, bulldozers, and hot water all vie for portions of a finite fuel supply; showering is limited to a brief twice-weekly spritzing. Patchy telephone service makes outside lines a luxury; occupants are allotted five-minute "morale calls" on Sundays. Internet access isn't much better. Uplinks rely on discarded satellites positioned in eroding orbits, and the local network is a jumble of hastily wired computers and servers.

In spite of these obstacles, Marty and the NSF are pushing ahead with new dormitories, administrative offices, galley, dining room, rec center, research labs, and medical clinic all under one roof. Why? Simple, say those steeped in Antarctic science: With depleted oxygen at its 9,355-foot elevation and so little moisture that metal never rusts, there's no place on earth that matches the environmental purity of the South Pole. This makes the area a benchmark for monitoring the health of the atmosphere and an ideal site for studying astronomy. "Science-wise," declares Patrick Smith, the NSF's polar research technology manager, "it's almost as good as being in space."



Photo by Amundsen-Scott South Pole Station Crew  
Today's central station, rebuilt in 1975; the main quarters are crowded underneath and aluminum done only 50 meters wide.

The Pole's ice is also the best spot on earth to find clues to the origins of the universe. In the past five years, Antarctic-based astrophysics research has mushroomed and is now one of the top endeavors at the Pole. The South Pole's new Antarctic Muon and Neutrino Detector Array (Amanda) - a system that scans the ice cap, looking for the tiny subatomic particles as they pass through the planet - is already the largest anywhere. And a larger one is under construction: the \$250 million IceCube neutrino detector, which will cover a cubic kilometer of ice with an array 100 times the size of Amanda.

This new research is attracting scores of eager scientists, and the southerly migration has triggered the first-ever housing crisis on this mostly uninhabited, 5.4 million-square-mile Popsicle. Marty points out that a facility originally intended for 33 men (literally an all-male crew, with two to a room) now sees more than 150 researchers and staff in the summer and about one-third that many through the eight-month austral winter, which begins in February. During the summer, overflow residents sleep in Korean War surplus tents on the snow.

So why not just expand the current structure? Not an option, explains Marty - the sheer weight of snow piling onto its exterior is gradually crushing the dome. At one point, snow buried enough of the shell that residents could ski off the roof.

And if that doesn't sound threatening enough, consider the fate of the original, 1956 South Pole station, a precursor to the current dome: It has long-since vanished under 30 feet of ice.

Ferraro Choi and Associates, the South Pole station's principal architectural firm, is headquartered in downtown Honolulu. On most days, temperatures here top 80 degrees with light northerly trade winds. Soaring palms shade the building's courtyard, where people eat lunch outside year-round. William Brooks, the project's 51-year-old leader - who is tall and stocky, with a faint resemblance to Brian Dennehy - typifies the mainlander haole: His forehead is sunburned, arms tanned to the elbow; he wears a bright orange T-shirt emblazoned with a logo for Freakin' Hot Sauce.

Brooks got started on the project in the early 1990s, when the NSF, having abandoned hopes of salvaging the old centerpiece of the South Pole, began soliciting ideas for a wholly new compound. The vision that

emerged was of an elevated station, one that would prevent blowing snow from piling onto its exterior. For six months, Brooks studied specs from other Antarctic outposts and consulted Alaska-based engineers and NASA astronauts familiar with working in extreme cold and darkness. His final plan, which won Ferraro Choi its NSF contract, featured a two-story complex with steel pylons fastened to a horizontal foundation - which Brooks compares to a giant raft on an ocean of ice - and nearly 10 feet of ground clearance to let snow freely pass beneath.



Photo by Amundsen-Scott South Pole Station Crew  
The elevated surface station will connect to the underground service area by a fully enclosed vertical tower.

"We used computer modeling to predict wind speed over every square inch of the building," recalls Joseph Ferraro, a founding partner at Ferraro Choi who wears an aloha shirt and shuts his eyes as he talks of the Pole, as if it's impossible to conjure with windsurfers gliding by outside his window. The designers tested mock-ups in wind tunnels and experimented with fluid dynamics. Finally, they built a scale model about the size of a conference table and left it at the Pole for a few years to watch what would happen.

By raising the station high enough so wind could channel above and below it, the Ferraro Choi design solved the snowdrift issue. But there was another problem. "The entire snow plain is crushing under its own weight," explains Brooks. "So the building is like a boat going down with low tide." His plan called for a series of hinges at various joints to absorb any minor shifting. That way, doors and windows will stay centered in their frames as the ice below tweaks the foundation. Brooks also integrated thermal breaks - large neoprene gaskets -

wherever a steel beam penetrates the interior. "This prevents heat transpiration down the pylons and into the snowpack," he says.

But these tactics were intended to handle only slight changes, says Brooks. The latest movement discovered by Marty's team will require a substantial face-lift to the foundation. For that, Brooks presents a more robust solution, one he'd incorporated into the station's design but hadn't expected to implement for at least 10 years. He explains: "At each of the 36 columns, we've placed a mechanism for installing a manual hydraulic system. We put in a jack, and on the word *go* we all lift at once." In 10-inch increments, the entire 65,000-square-foot structure can be raised off the snowpack, a process equivalent to hoisting a Costco warehouse a full story off its foundation. Each day for a month, crews repeat the brutish cycle, sliding new cylindrical segments of steel into the gaps. When they've added enough clearance, workers will bolt new legs into place.

Ferraro Choi's design cleverly dealt with the environmental gremlins that had tormented previous stations. Yet before construction could begin, planners had to figure out how to get nearly 40,000 tons of building materials to a site that might as well be on Mars. They considered constructing the station with prefabricated pods shipped whole to McMurdo Station, the Pole's nearest supply point, where they would be loaded onto a tractor train and hauled across a thousand miles of crevassed glacier to be pieced together at the Pole. At one point, the NSF asked whether it would be feasible to build the station remotely. "They wanted robots to weld the whole thing together," laughs Ferraro, "with scientists sitting in a lab back in the US controlling the machines via joysticks." Eventually, architects, NSF managers, and project contractors at Denver-based Raytheon Polar Services agreed on the present scheme, which delivers building components aboard military transport planes, then requires workers to assemble the parts at the Pole in what the Ferraro Choi team calls a "giant Tinkertoy project." Planners estimate it will take more than 1,500 LC-130 flights over a 10-year timeline to deliver all the materials.

When Raytheon signed on Jeff Thompson, founder of IT Design Build and former counterterrorism expert for the Navy, to implement the computing infrastructure for the new South Pole station, the company couldn't have chosen a more exuberant geek. Thompson, who recently launched a line of ultra-durable nail polish concocted from high tech military enamels, practically leaps from his chair as he details his vision for the new complex. "We're designing a network with 300 percent redundancy," he shouts over a meal of rare filet

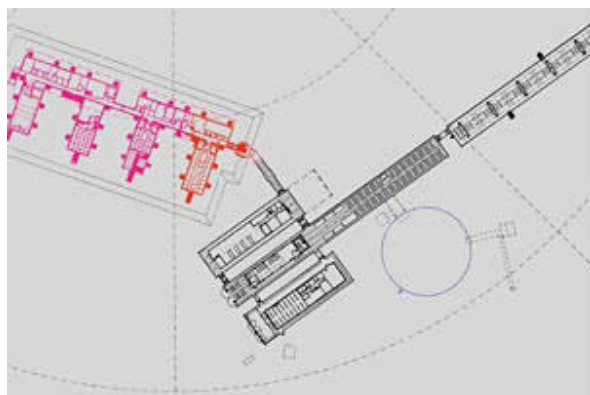
mignon in a noisy Denver steakhouse.

Thompson, 39, is going to tremendous pains to attain this level of reliability. In August, he'll begin assembling the entire network - cables, servers, computers, wiring closets, routers, and hubs in a 2,000-square-foot lab at Raytheon's headquarters. Once everything is functioning properly, he'll dismantle the whole system, box it up, then do it all over again, just to make sure it really works. Only, the second time, it won't be Thompson making the connections but a stand-in with no computer skills, rebuilding the network from instructions spelled out in a step-by-step how-to manual. Should there be a catastrophic system failure at the Pole and an IT person isn't on hand, Thompson wants to guarantee that even the cook can reconfigure the network. He also wants sysadmins to be able to configure the network remotely, without physically touching the servers or routers. "The dry climate means static is very bad," explains Thompson. "There is no humidity and when there's wind, static gets worse. You can blow a monitor just by touching it."

Thompson's brief inventory of new technology planned for the station is staggering. "We are putting a fiber backbone between every facility," he says. "We'll remotely monitor the power plant, water purification, heating, and electrical systems, so if something goes wrong, a tech support person in the States can make adjustments over a virtual private network; we can do tele-medicine, voice-over-IP, video-on-demand, and stream live TV."

At this point, Thompson gets a bit carried away: Video-on-demand and streaming TV are wish-list frills to be added years down the road. More immediately, though, Thompson's team will complete a full-service infirmary stocked with ultrasound and digital microscopes linked over secure networks to hospitals in the States. With the memory still fresh of the Pole doctor who treated her own cancer in 1999, physicians now will work with specialists in real time. And Thompson guarantees plug-and-play connectivity that includes gigabit Ethernet ports spaced every few feet along the walls of the compound and 802.11b Wi-Fi in sectors where wireless transmissions won't interfere with radio astronomy.

All of these services, though, will function only during periods when the station has data access to the outside world, and right now that's just 10 hours a day. The trouble is that geosynchronous communications satellites orbit above the equator, out of the station's range. Over time, these orbits decay and begin to drift into an elliptical pattern that swings far enough south for Earth stations at the Pole to "see" them as they pop up over the horizon. The current system uses three abandoned birds, one formerly operated by Comsat for maritime communications, one previously used for National Oceanic and Atmospheric Administration observations, and another once programmed to monitor orbiting spacecraft for NASA. Still, with all three satellites online, the South Pole gets just a half day of Internet access.



**Photo by Amundsen-Scott South Pole Station Crew**  
**The new site plan includes an underground service area with a 1-megawatt power plant, cargo/fuel storage, plus shop and garage facilities.**

**Pictured in the plans are the new surface facility (under construction; pictured in pink); the completed surface facility (pictured in orange); the new underground facility (pictured in black); and the existing dome, scheduled for demolition (pictured in blue).**

An obvious fix for this spotty connectivity would be a series of dedicated satellites orbiting the Poles, each handing off the signal to the other as it passes over Antarctica. Waxing momentarily pragmatic, Thompson discounts this scheme: "We would need four satellites at a cost of up to \$300 million, plus launch fees," he says. "And there'd be no other users except a few hundred scientists at the South Pole."

Norwegian explorer Roald Amundsen first reached the South Pole on December 14, 1911. He stuck around just long enough to take a few scientific readings, leaving three days later for his base at the Bay of Whales on the Ross Sea. A British team and its leader, naval officer Robert Scott, arrived about a month later, only to find that Amundsen had beat them to the Pole. On the return journey, the weather turned bad and Scott and his men never made it off the ice alive. Three years later, Ernest Henry Shackleton attempted to traverse the continent, with a stop at the Pole. His expedition ship got trapped in frozen seas before it was crushed to splinters. The crew drifted aimlessly on ice floes for months, until reaching the South Shetland Islands in a whale boat. A baldly explicit help-

wanted ad reputedly posted prior to Shackleton's trip says it all: "Men wanted for hazardous journey. Small wages, bitter cold, long months of absolute darkness, constant danger, safe return doubtful. Honor and recognition in case of success."

Only a guy like Carlton Walker would have answered that ad. Walker is the supervising manager for Raytheon Polar Services and directs all aspects of construction for the new station. Trained early on as a pipe fitter and plumber, he first came to the Pole in 1991. "I was shootin' the shit with a guy in a bar in Mississippi, where I was living at the time, and he asked me whether I wanted to work in Antarctica," recalls Walker, now 41. "A few weeks later I stepped off a plane in McMurdo." This fall, he'll make his 13th trip to the Pole, taking up residence in a tent pitched near an overflow area dubbed Altie Meadows, after NSF administrator Altie Metcalf. "The tent's heated," he says, "but I can still freeze a water bottle on my floor."

He's also probably the hardest-working guy in Antarctica. While Jerry Marty acts as the NSF government liaison with design and engineering teams, Walker is the go-to guy - the one person always on the ground who has his hands in every aspect of construction, from opening day of building season until the station closes in February. He gets up at 2 am and often toils past midnight, grabbing catnaps when he can. The long hours let him keep a close eye on outdoor crews that carry on 24 hours a day in overlapping 10-hour shifts. It's his job to ensure that workers meet daily deadlines, completing phases on time and within budget. Before heading home to Denver at the end of each season, Walker inspects building materials and sorts supplies in preparation for the 22-member winter crew, who'll spend eight dark months at work on the station's interior: walls, insulation, electrical wiring, and plumbing.

The particularly dramatic conjunction of outside and inside is what makes this project unique, and it's what Walker, more than anyone else, understands. Here, the difference between backyard and dining room can be more than 110 degrees. The Pole's ambient air is far too frigid to pump directly into the station's heating system. Instead, it's first forced over a coil filled with a heated glycol solution, where it's raised to room temperature before entering a traditional air-handling network. "We are building a walk-in freezer in reverse," he says. "The outside doors are made of 400 pounds of stainless steel." Airlocks at each entrance thwart heat loss, and the interior is pressurized to keep out biting drafts.

If all goes well, he'll be done in 2006, about the time the Amanda and IceCube neutrino detectors become fully operational. The next year, demolition crews will begin tearing down the obsolete aluminum dome. ("It'll end up as beer cans," a manager on the project declares.) They'll haul out construction equipment, empty old storage depots, break down tents, and strip the site of detritus and gear that's collected over three decades.

Ultimately, visitors to the Pole will see nothing but the sleek, elevated station perched above a stark plateau once described by Antarctica explorer Stephen Pyne as a "vision of an immutable nothingness." The complex will embody a sublime aesthetic that Peter Wilkniss, former NSF polar programs director, asked architects to incorporate into the design. "He felt that a pristine environment deserved a pristine station," says Ferraro. The new look might even have compelled Robert Scott to reconsider the first words he spoke when he reached the Pole in 1912: "Great God," he exclaimed, "this is an awful place!"

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Michael Behar ([michael@michaelbehar.com](mailto:michael@michaelbehar.com)) , a Washington, DC-based journalist and a former senior editor at Wired, wrote about military robots in Wired 10.05.

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