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A wiry Spaniard with a thick, black beard and brown tortoise-shell glasses is standing inside a cavernous sphere, at 23.5 degrees below my line of sight, to demonstrate the precise tilt of Earth's axis. He's asking which planet I'd like to visit. "Mars," I tell him.

"Okay, Mars is rising right now," he says. "I can press a button, and it will get bigger and bigger until we land on the soil. Then, we can meet the robots that are already there and talk about what they have found."

It sounds unbelievable. For the moment, gravity is holding our feet firmly on the dusty concrete floor of an unfinished planetarium—which, from the outside, looks like a giant white golf ball in the middle of Museum Park in Downtown Miami. It is just one of four structures within the 250,000-square-foot construction site known officially as the Patricia and Phillip Frost Museum of Science, set to open early next year. As conceived, it is designed to deliver unprecedented programming, curated by leading scientists and educators who encourage participatory learning in playful new ways. Guiding your own journey through the cosmos is just the beginning.

At this stage, without a whiz-bang projector screen to help us, intergalactic travel will require an exceptional imagination, but luckily my guide, Dr. Jorge Perez-Gallego, has one. He's an astrophysicist and former project manager for NASA's Florida Space Grant

Consortium, and is now serving as curator of astronomy for the Frost. Perez-Gallego signed onto this project in 2014, inspired by its potential.

Who wouldn't be? This \$305 million, four-acre facility is connected via a series of open-air walkways and terraces. It is comprised of a cone-shaped aquarium built to hold 500,000 gallons of Biscayne Bay seawater, an innovation center equipped to host inventors-in-residence, an exploration center featuring digitally interactive exhibits, and the signature planetarium—an engineering marvel in and of itself. If all goes to plan, it will house Perez-Gallego's dream classroom: a place where you can not only show conventional stargazing, but "fly through space and time."

"If kids grow up in a world where big leaps in technology are possible, they dream bigger," he says. "That's what we hope will happen when we put a man on Mars, and project it here. Kids will feel again that anything is possible."

His enthusiasm is so genuine it's contagious. A faithful disciple of Carl Sagan, the great American democratizer of science, Perez-Gallego subscribes to the principle that, as he puts it: "Somewhere, something incredible is waiting to be known." At the Frost, his mission is to discover not just one something, but many somethings, and relay them to the next generation. It's a lofty goal, and he pairs it with equally lofty

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statements, like this one he gave to *Metropolis* magazine in 2015: "By the time we open we'll be the most cutting-edge planetarium in the world." This superlative, upon closer inspection, doesn't really pass muster, but it's indicative of the ambition surrounding the project.

The Frost Planetarium will display pixel resolution of 8K UHD, which is currently the highest resolution available. To achieve a 360-degree, immersive experience in 8K—including the option for 3-D visualizations—the Planetarium is using a total of six Christie projectors to fill the dome's screen. But both the Hayden Planetarium at the American Museum of Natural History in New York City, and the Adler Planetarium in Chicago also use the same technology in their respective domes. Suffice it to say, resolution is a big-ticket item in the science museum world, because it can make or break the experience. But when the world's top museums are all using similar technologies—what really separates one from another is the quality of content they project.

"The visual content shown in planetariums has advanced greatly in the past two decades, tracking and benefiting from the advances in computer graphics technology," says Benjamin Barnhardt, senior director of electronic media engineering at the Natural History Museum. "The most valid imagery is based on real data sets, such as those published by space agencies." In other words, projecting reruns of *Mystery Science Theater 3000* doesn't cut it. Directing a competitive planetarium not only requires access to the latest

scientific data, but also the computing power to quickly repurpose it in visually coherent ways.

If there is any race going on here, it is for knowledge. In that, Perez-Gallego sees no limits, intending to push his planetarium beyond the very subject of space: "A cool thing that is happening now is our ability to use real footage of the physical world. I can take a GoPro rig, drop it into the ocean in the middle of a bunch of sharks, and use that footage here. That wasn't even possible a few years ago," he says, effusively. Pausing, he gazes into the upper reaches of his beloved dome and adds, in a Sagan-like moment: "We know that in science, 'no' is not a fixed answer."

THE FUNDING SAGA, ABRIDGED

Despite his prominent role, the ultimate fate of the Frost isn't within Perez-Gallego's purview. That responsibility now rests heavily on the shoulders of Frank Steslow, another earnest educator. I meet Steslow on the first day of July, for a hard hat tour of the premises. In fresh khakis and a baby blue button-down with the sleeves rolled up, he comes off as an approachable straight shooter with people skills. >

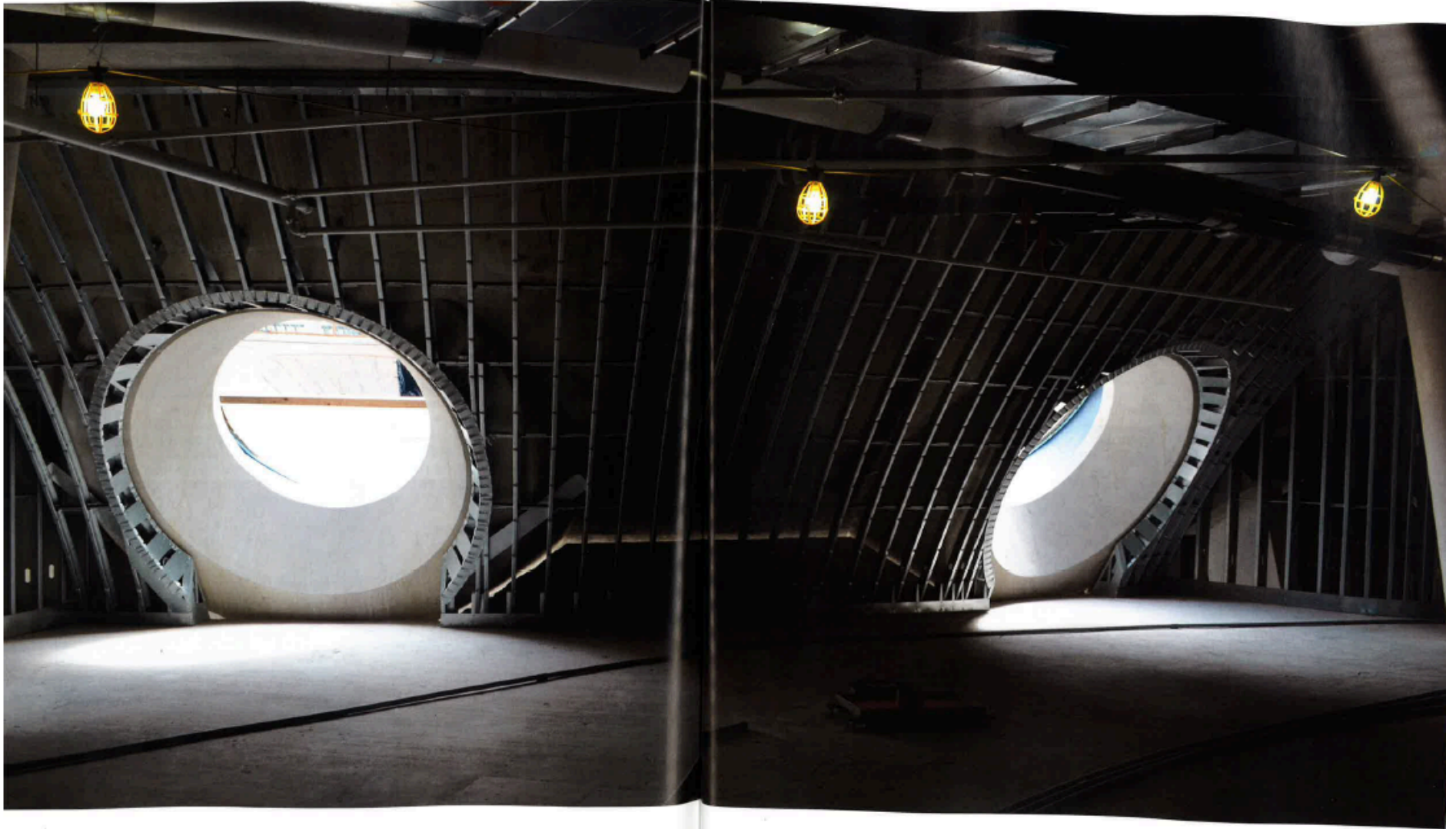
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A rendering of the planetarium interior.

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Viewing portals into the future dive-level of the Frost aquarium.

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It happens to be his first official day as president and CEO of the museum. The day before, the former CEO, Gillian Thomas, 72, announced her retirement after 13 years at the helm of the organization.

Steslow, who served as chief operating officer since 2008, was her second-in-command. The board of trustees took it in stride, unanimously supporting him as Frost's new leader. With more than 30 years of experience as a scientist and executive manager in science-based non-profit organizations, he certainly has street cred. But the announcement still prompted negative media attention from local outfits, whose skepticism is fueled by years of setbacks. After all, the conceptualization of this new museum began 10 years ago, and is only now in the final stages of construction.

The brouhaha centers on the Frost's money problems. Last spring, when the museum fell short of the funds needed to finish construction, Thomas turned to the county, and was met with deep-pocket support. Miami-Dade commissioners approved a \$45 million bailout for the museum, representing a nearly 30 percent increase in tax dollars earmarked for a project that had already secured \$165 million from the county the previous year. Taxpayers weren't happy; government-funded rescues are inherently controversial in today's political climate. But, together with a \$45 million pledge from billionaire benefactors Patricia and Phillip Frost, crisis was averted. It wasn't without a fight. The Frosts lent the money in exchange for control of the board, which entailed the ousting of all 40 members, who have since been replaced.

For his part, Steslow is certain the museum will raise what it needs. "The core building and all main galleries are funded. But we still need another \$25 million in private donations for the planetarium's external projectors, and for our planned exhibits on the outdoor terraces and plaza," he says. "We'll raise it."

His confidence, while comforting, is also legally required. Miami Dade County's government bailout came in the form of revenue bonds, which amounts to a loan payable from money generated by the museum itself.

Much is riding on this museum's success. For starters, it is intended to carry the torch passed on from Miami Museum of Science, a smaller but beloved institution in Coconut Grove that operated for 55 years and shuttered its doors to make way for Frost.

A MASTER PLAN

Designed by Grimshaw Architects, the new museum embodies innovation. Many aspects of it represent groundbreaking advancements in engineering and sustainable energy. And anyone even remotely curious about architecture can find much to learn before ever stepping foot inside.

Back in New York, I meet with managing partner Vincent Chang at Grimshaw's offices to gain a deeper understanding of the design. It began in 2006, with a high-stakes contest between some of the world's most successful firms. The short list read like a who's-who in global architecture, including Steven Holl, Chris Wilkinson, and the late Zaha Hadid. All presented ideas to the ultimate decision-maker, Gillian Thomas.

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In Chang's retelling of it, Grimshaw won largely because of the previous success of its green tech complex the Eden Project, in Cornwall, England, which is located in one of the warmest climates in Europe. The building features advanced solar panel technology, which generates enough electricity to lower air conditioning costs—a clear advantage in Miami. A proven ability to use wind as a coolant was another.

At Frost today, openness between the four main structures serves to capture wind off Biscayne Bay and funnel it using pressurization. "It's all about how you use the environment. The structure encourages wind to move in a certain way," Chang says.

The stark white museum is situated on a diagonal angle facing the Atlantic Ocean. The Frost Planetarium is flanked on both sides by two rectangular-shaped buildings, stretched out like arms opening to the breeze. Embraced by these "arms" is the fourth structure, called "The Living Core," which houses the aquarium and is shaped like the hull of a massive cruise liner, pointing out to the sea. The entire complex is tethered together via translucent glass balconies and bridges.

Seen from above, one might imagine a space-age colony has landed in Miami, right next to the Pérez Art Museum. On the ground, however, the experience of walking through these spaces feels more like a real-life version of *Finding Nemo* than a sci-fi fantasy, as

visitors will be surrounded by native aquatic and terrestrial species at every turn.

This, too, is by design. Establishing a strong connection with that world, rather than the whole world, was the goal from the outset, according to Chang, who collaborated closely with museum management throughout the design process. This relationship is made manifest in the synergetic quality between the architecture and the exhibitions themselves. "We want to highlight the different ecosystems of South Florida for educational purposes. It's not Sea World. We are a part of this environment," says Steslow, who refers to himself not as a scientist or as chief executive, but as an "environmental educator."

With this in mind, Grimshaw architects created a hybrid structure in which visitors could comfortably spend as much time in outdoor exhibits as they do indoors. Landscape architects from Arquitectonica Geo, based in Coconut Grove, also stepped in as a consultant on the project. As a result, lush plant life fills the property, and the open-air plaza space between the Frost and Pérez is covered with sculptural gardens. In almost every aspect, the museum encourages environmental awareness and appreciation.

Even more impressive are the structural engineering feats and countless hours of construction that made this place possible. >



Looking into the under-construction aquarium.

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THE "IMPOSSIBLE" AQUARIUM

In December 2014, construction crews began building a tank large enough to hold 500,000 gallons of seawater. It was their job to create the sloping walls of one contiguous, three-story vessel in the shape of a massive martini glass, designed to create the illusion of a boundaryless body of water. When visitors peer into this aquarium, through a 30-foot acrylic window, they won't actually be able to see the walls of the vessel. At least, that's the concept.

"This was one of the most significant achievements of the project's design and construction, realizing a form that had never been done," says Christian Hoenigschmid, project designer for Grimshaw Architects. To achieve this, the crew conducted what is known as a "monolithic pour," which means that all of the concrete must be poured at the same time. The feat required 200 workers and 120 truckloads of concrete—the equivalent of 1,200 cubic yards. It took 20

hours to set up, and another 25 hours for the actual pour. Further complicating matters: the concrete needed to slide down some walls and not others, requiring different densities. Workers had to continually change the mix mid-flow, making sure they weren't creating holes along the way. In other words, there were no breaks.

"We had one shot at it, and we couldn't mess up. It could all go wrong in a snap," says Eladio Castrodad, vice president of Hill International and a contractor for the Frost project. He shrugged at first, as if it was no big deal, but his smile gave him away. "We got it on the first try," he says. At this moment, we're standing directly beneath the underbelly of the tank, which is held up by six immense columns of staggering strength—each able to bear twice the compression supported by a typical commercial bridge.



The Patricia and Phillip Frost Museum of Science.

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THE NEXT GENERATION

After all the meetings, on-site visits, and phone calls, the real meaning of the Frost seemed to come down to one moment, when a father spoke about his son.

"I have a young child," says Vincent Chang, in an unguarded moment. "It's amazing to see your child genuinely intrigued by something new, eager to learn it. So as a parent, you're always trying to create opportunities for curiosity. That's what we're striving for here. This museum is a meeting place for the curious."

Complex as it is, the simple intent of this institution is to be a place of higher learning. It has taken several years, a considerable fortune, and countless

careers to build it. It follows that the opening of this museum stands to benefit not just its creators, but scores of people, not least of whom are the children who will come to visit. And when they do, the hope is that they will understand more about the universe, the Earth, the nature of our climates, and the outer reaches of galaxies. "If we've created a place that brings people together in pursuit of that understanding," he says, "that's mission accomplished."