SANTIAGO CALATRAVA

Henry Petroski

The conception and design of most monumental structures involve a collaboration of architect and engineer. However, except in the case of bridges, which are often considered to be pure engineering, it is usually the architect who gets credit for the creative idea. According to the conventional wisdom, it is the architect who first sketches grand plans and facades, and the engineer who calculates what beams and columns are needed to make the artistic concept work. Even for plans never realized, architectural drawings can take on a life of their own and be the subject of art shows, but the blueprints of engineers are seldom seen outside the design office or construction site. Engineers curse architects who conceive buildings that require extraordinary contortions of heavy concrete and steelwork to execute; architects look down on engineers whom they accuse of lacking the structural creativity to solve unusual problems or the willingness to let their imaginations soar.

As with all caricatures of groups of people and professions, this oversimplified view has both its elements of truth and many exceptions. Sydney Harbor provides an excellent juxtaposition of contrary examples. The Sydney Opera House is famous for its graceful shell- and sail-evoking roofs, conceived by the Danish architect Jorn Utzon and entered into a design competition announced in 1955. Utzon's original sketches so captivated the judges of the competition that little consideration appears to have been given to the constructability of the forms. It took the innovative engineer Peter Rice, who would later have so much to do with the exposed structure of the Centre Pompidou in Paris, six years to work out the practical matters of the shells. The opera house was not completed until 1973, seven years after the resignation of Utzon and at a cost 14 times the original estimate. Within about 15 years, the condition of the structure had deteriorated to such an extent that it was evaluated to need repairs costing about as much as the structure itself.

In contrast to the opera house, the neighboring landmark of Sydney Harbor Bridge, like most major bridges, began not with an architect's sketch but with an engineer's concept of the bridge form that would be most appropriate for the site. Rather than simply seeking a unique structure to cross the harbor, John Bradfield, chief engineer of the New South Wales Public Works Department, wanted one that would be buildable and functional as well as distinctive. His first plan was to erect a nondescript and faddish cantilever, but this was changed when he visited America and saw Gustav Lindenthal's design for the Hell Gate Bridge in New York City. The cantilever plan was scrapped, and Bradfield had the Sydney Harbor Bridge designed as a scaled-up version of the Hell Gate, with some improved structural details. The contribution of architects was by and large limited to the stone pylons that frame the bridge proper, which opened in 1932.

Some of the most innovative and effective works of architecture and engineering have been true collaborations, and two of the most striking examples stand in Chicago. Both the John Hancock Building, completed in 1969, and the Sears Tower, finished in 1974, were made possible by the structural engineer Fazlur Khan and the architect Bruce Graham working together in the firm of Skidmore, Owings & Merrill. For such tall buildings to use steel economically and yet stand steady against the winds of Chicago, their structural bones and architectural skin had to evolve and work together, with engineer and architect influencing each other's concepts of form and function. Rather than presenting to the observer mere facades hung from structural skeletons, the Hancock and Sears towers are in fact tall, slender structural tubes that themselves shape the facades. There have been numerous other successful collaborations among engineers and architects, especially in the design of tall buildings, but some of the most talked-about structures today are coming not from teams but from the mind of a single individual who himself is both architect and engineer.

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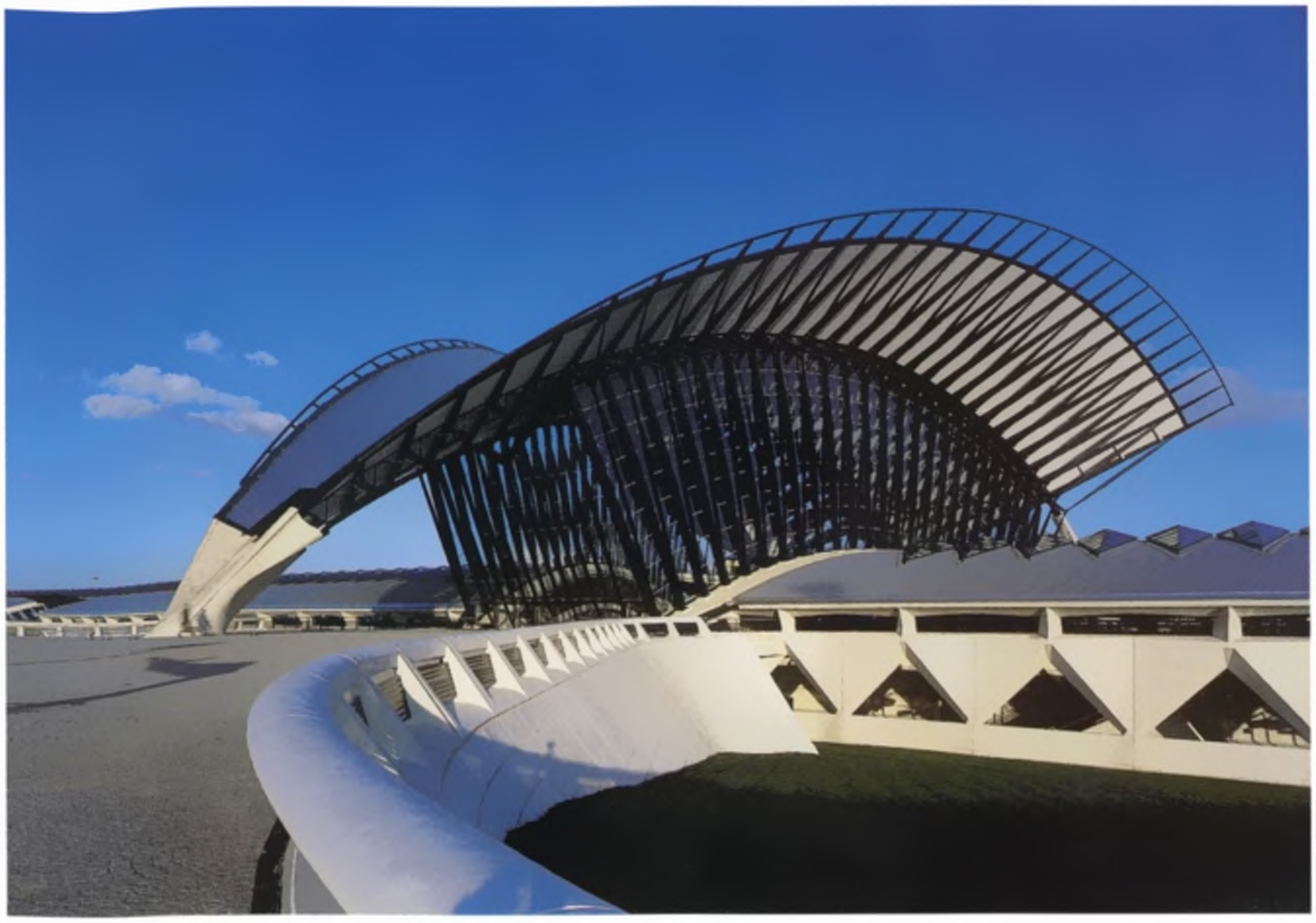


Tim Griffith/Esto

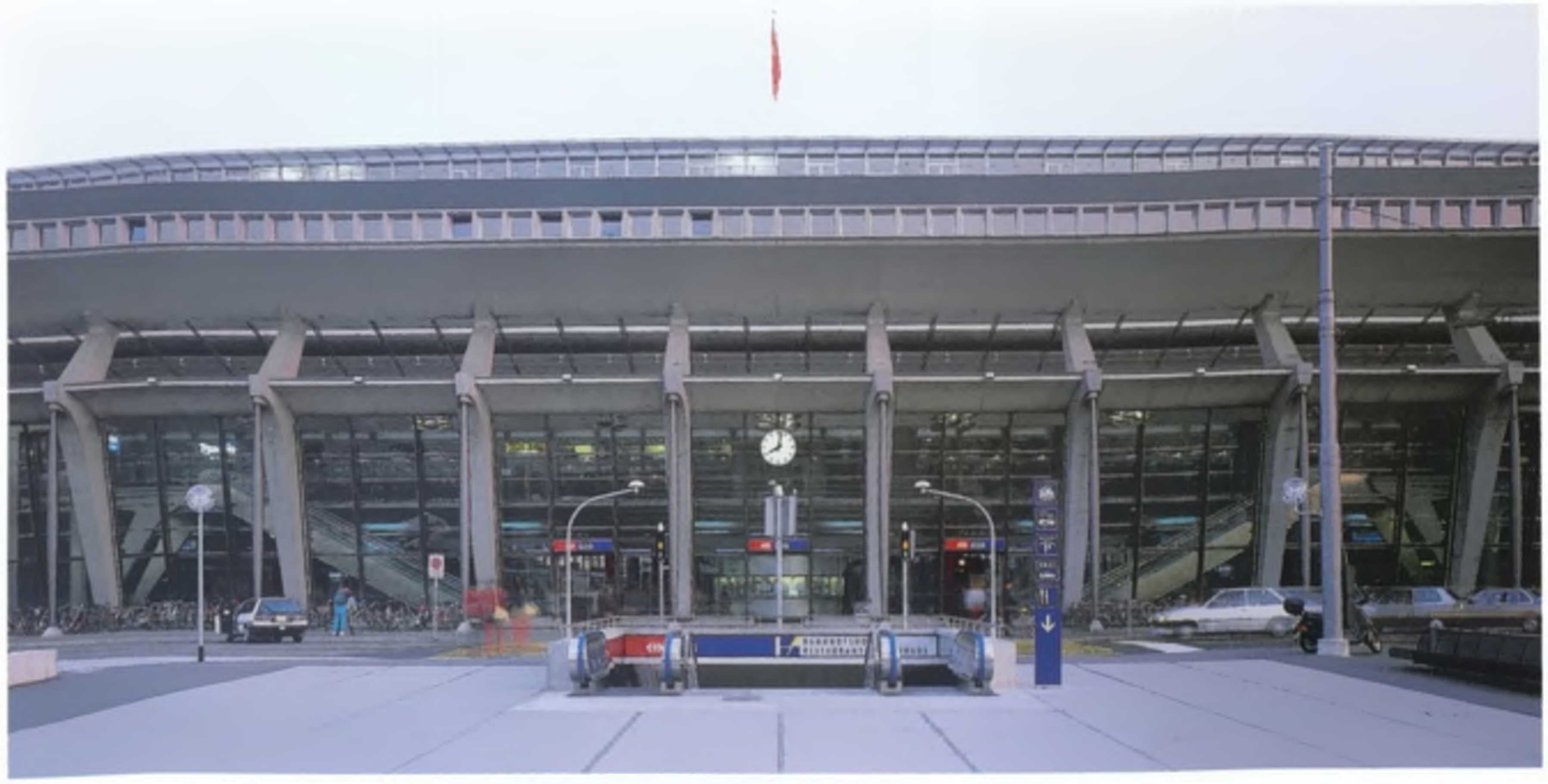
Figure 1. Satolas Airport Railway Station, near Lyons, France, was completed in 1994.

The Renaissance Designer

Santiago Calatrava Valls was born in Valencia, Spain in 1958. He studied art before entering Escuela Technica Superior de Arquitectura de Valencia to become an architect, and he subsequently did graduate work in urban studies. According to Calatrava's own account, during his studies in Valencia he developed a "great admiration for the work of engineers" and recognized the need for "more technical knowledge to do the things I wanted to do." In 1975 Calatrava left his home town for Zurich to study civil engineering at the Eidgenossische Technische Hochschule (the famous ETH, or Swiss Federal Institute of Technology). He saw engineering as "the art of the possible" and ultimately received a doctorate in technical science from ETH, with a thesis on the foldability of spaceframes. He also served as an assistant in the Institute for Building Statics and Construction and for Aerodynamics and Lightweight Constructions before leaving ETH in 1981, at the age of 30, to found his own architectural and civil-engineering practice in Zurich. The firm, which would open an office in Paris in 1989, is formally known as Calatrava Valls S.A. Unlike Ludwig Mies, whose given name tended to be dropped after he added his mother's surname, van der Rohe, Santiago Calatrava has tended to drop the matronymic in all but the most formal of matters.

For a less deliberate person, the apparent flitting between art and architecture and urban studies and civil engineering and technical science might presage an undirected life of frustration and dilettantism. For Calatrava, however, it appears at least in retrospect to have been the carefully planned, if unorthodox, curriculum of an individual determined to be a unique combination of architect and engineer. It must have been daring even for Calatrava to strike out into private practice when he did, for before 1981 he had designed only a single highway bridge and a single exhibition hall, neither of which was built. However, for a confident, if budding, architect/engineer like the young Calatrava, with dreams of designing great structures that were also works of art, Zurich might have seemed to be a city of opportunity with a tradition of structural genius. It was in Zurich, after all, where the great Swiss bridge designer Robert Maillart began his career, and it was to Zurich that a successful Christian Menn, who had been so influenced by Maillart, returned to become professor of structural engineering at ETH—his, Maillart's and Calatrava's alma mater.

Even without any of his early design projects being realized, Calatrava was quickly able to make a name for himself because of the European practice of holding design competitions for proposed civic works. Under this system, designs are advertised for or invited for a specific site and purpose. There are public displays of the designs, and they are judged. Whereas in the United States choices among competing designs are often made on the basis of cost, in Europe choices tend to be more influenced by less quantifiable questions of aesthetics and symbolism. Even if one's design does not win in a European-



Peter Mauss/Esto

Peter Mauss/Esto

Figure 2. Lucerne, Switzerland's Railway Station and Post Office is shown in front *(top)* and profile *(above)* views.

style design competition, the occasion provides a venue for displaying one's talent, vision and promise. Calatrava entered a half-dozen design competitions between 1979 and 1982, for projects ranging from highway bridges and exhibition halls to factories, warehouses and libraries. It was not until 1983 that he received a commission to bring any of his designs to fruition, but then his practice took off, with commissions coming to him even without competitions.

Calatrava's designs, even when they exist only as sketches, drawings or models, are striking works of art. His buildings and stations are rich in sculptural form and detail, and his bridges are dynamic assemblages of arches and cables with dramatic approaches and spaces for people to use and enjoy. By the mid-1980s, exhibitions dealing with Calatrava's work began to appear in Swiss art galleries and museums, and by the end of the decade an exhibition was organized to travel to America. Awards also began to come Calatrava's way, from art, architecture and engineering associations alike, including gold medals from both the French Academy of Architecture and the British Institution of Structural Engineers.

Among his earliest completed designs is the Bach de Roda Bridge, completed in 1987 in Barcelona, in which two outside steel arches supporting walkways lean over pedestrians and against two more conventionally placed vertical arches on either side of the central roadway. The cables from the arches to the bridge deck enclose pedestrians in a broad space that gives an almost shell-like feel to what might in lesser designs have been a narrow path across a busy bridge. Perhaps Calatrava's most famous bridge to date is his Alamillo Bridge, built for the 1992 Expo in Seville. This dramatic cable-stayed structure has a single 142-foot-high pylon angled back from the main span. Between the pylon and the 220-meter-long bridge deck stretch the steel cables in a harp-like arrangement.

None of Calatrava's bridges is particularly long or daring in span, and his first British project that went beyond the drawing board was a 62 meter-long footbridge whose design was unveiled in 1993. Trinity Bridge, which spans the river Irwell between Salford and Manchester, is also supported by a single, inclined pylon (60 meters high), but the cables are in a much more expansive three-dimensional arrangement, and the roadway splits on the Salford side to make the bridge accessible to the handicapped via two gracefully curving ramps. The bridge is designed to be the centerpiece of a riverside redevelopment project.

Peter Mauss/Esto

Peter Mauss/Esto

Peter Mauss/Esto

Figure 3. Stadelhofen Railway Station, in Zurich, Switzerland, was completed in 1990 and was the first of Calatrava's building designs to be realized

From Train Stations to Museums

Although by the early 1990s bridges may have been considered the mainstays of his practice, Calatrava also established his reputation as a designer of spectacular railway stations and other public spaces. His Stadelhofen Railway Station in Zurich, completed in 1990, expanded the capacity of the rail line on a complicated curved urban site from two tracks to three, added an underground transfer gallery lined with shops hidden between massive but graceful "zoomorphic" concrete pillars, and let daylight into it all to brighten what might otherwise have been a dark and heavy space indeed. The Satolas Airport Railway Station, 15 kilometers east of Lyons, France, was completed in 1994 and uses concrete—"the most noble" of construction materials, according to Calatrava—in a much lighter and dynamic way, in keeping with the high-speed French TGV trains that will pull into and out of the station. Above ground, Calatrava's 500 meter-long steel, aluminum and glass building that straddles the railroad tracks gives the traveler the impression of being inside the skeleton of some prehistoric giant.

Calatrava's first work in the United States came in 1991, when he was invited to participate in a design competition for the unfinished Cathedral of St. John the Divine in New York City. His controversial design for a glass-topped, towering transept has yet to be fully accepted or rejected. Most likely the first Calatrava-designed building in the United States will be an addition to the Milwaukee Art Museum, which was originally designed by Eero Saarinen. The Calatrava addition, selected from designs submitted by almost 70 architects from around the world, includes a main pavilion with a louvered roof that in the closed position looks not unlike a giant wigwam. This roof will control sunlight into the space below during the day; at night the roof can be unfolded to rise winglike above the pavilion to serve as a lighted beacon for visitors from downtown that welcomes them to cross the Calatrava footbridge to the new museum wing. Some see the fully unfolded motorized roof as the flukes of a great whale—something unexpected in nearby Lake Michigan.

Not surprisingly, Santiago Calatrava has his detractors as well as his champions. In the latter camp tend to be art and architecture critics, who see him as "the most exciting shaper of public space in Europe today." His bridges and stations, places where commuters and travelers can be so frustrated among rush-hour traffic jams and crowds, come in for especial praise. According to Boyd Tonkin, writing in the *New Statesman & Society* on the occasion of the architect/engineer's visit to England in 1994, "Calatrava redeems the dead space, and dead time, of transit. To get somewhere, we tolerate passing through nowhere. His constructions help to turn those nowheres into somewheres." The dramatic canted columns and the welcoming vibrant open-work spaces in his structures of transit have become trademarks of Calatrava, making his creations immediately recognizable as his. That is not to say that there is a sameness to his work, for each new design adds new surprises to his growing *oeuvre*.

Some engineers have criticized Calatrava's designs because they do not make efficient use of materials. For example, to keep the longest cable in the Alamillo Bridge from having an unsightly sag due to its own great weight, it was stressed by a concrete counterweight under the roadway to a greater degree than structurally necessary. Another criticism of Calatrava's designs is their constructability, or rather their lack of constructability. Most cable-stayed bridges are designed to be self-supporting even when only partially completed, but the unusual design of the Alamillo Bridge did not allow that. Such complications add greatly to the cost of projects, and the final price of the Alamillo Bridge was reportedly twice the initial estimate. It is this aspect of Calatrava's work that may ultimately frustrate him from realizing one of his stated goals: "I want to win back engineering objects like bridges for architecture."

Some of the criticism of Calatrava by engineers may stem from the fact that his broad educational background has frequently been contrasted to the narrow specialized training supposedly received by so many engineers. According to Anthony Webster, writing in *Architectural Review*, the predominantly technical education of engineers "limits their ability to tackle many larger design issues." Furthermore,

> This system encourages engineers to develop only very limited design skills, and has resulted in today's ironic situation in which the professionals entrusted with the creation of a significant portion of our built environment are unprepared to consider its compositional and programmatic aspects. By contrast, Calatrava's unusually broad formal training (as both architect and engineer) fosters a design approach incorporating technology, aesthetics and space-making.

Whatever may be said of or about it, Calatrava's approach to design has captured the attention of architects and engineers and critics alike. In a field where there are so many collaborative relationships between architects and engineers, Calatrava is almost unique as a lone designer who seems to feel comfortable in both professions and who has the talents and self confidence to combine their skills and sensitivities in his striking and effective designs for civic structures. Even though a large portion of the designs he is noted for still exist only on paper, in computer-generated images or in striking table-top models, Calatrava has become the turn-of-the-century architect/engineer to watch.

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