Technology-Mediated Process: MIT Stata Center case study

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Abstract

Gehry Partners’ (GP) sculptural approach to tectonic form, with its dramatic curves, complex geometry, and idiosyncratic application of materials, seems to have redefined the limits of architecture. The development of a strong formal vocabulary has been achieved by advanced use of information technologies, including CATIA, which allows translation among various tectonic representations, both in physical and digital forms. In addition, the nature of the office has much to do with other changes in the project delivery system, such as the relationships with associate architect, manufacturers, and subcontractors. This paper discusses how new technology changes the design and fabrication process, which has evolved from GP’s milestone project, Guggenheim Museum Bilbao, and how organizational efforts to involve the industry in the design process facilitate the project. Unlike at Bilbao, in the newly-completed Stata Center GP produced all the construction documents. This shift coincided with a gradual change in which GP was becoming involved in the technical aspects of their projects much earlier in the design process. Therefore they had to invest in new working relationships with the construction team,
including fabricators, manufacturers, and contractors. The approach of Gehry and his team suggests that architectural practice can be liberated from its conventional arrangements. Although it is still evolving, Gehry has achieved a holistically integrated organizational system where the architect has far more direct interaction with all aspects of design and fabrication.

Introduction

Frank O. Gehry, one of the most inventive and pioneering architects working today, has displayed formal freedoms enabled by the use of digital technology. His exploration of technology-mediated design and fabrication possibilities was pushed into new territory with the MIT Stata Center. Prefabricated elements, both physical and electronic, were more extensively used here than in his previous projects. Unlike the automotive industry or product manufacturing, architectural fabricated elements have to be assembled and installed on-site, and a disconnection between fabrication and installation may inhibit accurate translation of the design into building systems. GP devised a seamless design/fabrication/assembly process deploying digitally mediated systems and implementing new models of collaboration.

1. Project outline

Pritzker Prize laureate architect Frank Gehry and Boston-based associate architect Cannon Design devised a 430,000-square-foot (above grade) academic complex in the northeast quadrant of the MIT campus. This complex features flexible research facilities and offices, an interior “student street,” an auditorium, state-of-the-art classrooms, fitness facilities adjoining the existing Alumni Pool, a childcare center, and underground parking. Inaugurated in spring 2004, the Ray and Maria Stata Center encompasses the William H. Gates Building, housing the Laboratory for Computer Science (LCS), and the Alexander Dreyfoos Building, housing the Artificial Intelligence Laboratory, the Laboratory for Information Decision System (LIDS), and the Department of Linguistics and Philosophy. The 2.8-acre complex was made possible in part by gifts from Ray Stata and Maria Stata, William H. Gates, and Alexander W. Dreyfoos, Jr. (Figure 1).

![Stata Center: view from north](image)

![Project delivery system](image)
On January 28, 1998, MIT selected Frank O. Gehry and Associates (currently named Gehry Partners, LLP) through the qualification process. The temporary status and warehouse-like spaces of the existing building on the site—the historic Building 20, where radar was developed during World War II—had permitted its occupants free reign in adapting the spaces to their needs, and in designing the new complex, Gehry sought to recapture this spirit of flexibility and accommodation. This is his first new structure in the Boston area; his lone Boston landmark had been a redesign project in which he collaborated with a local firm, Schwartz/Silver, on what is now the Virgin Megastore Building (360 Newbury Street) at the corner of Newbury Street and Massachusetts Avenue in Boston.

For this project MIT felt a responsibility to conceive of a more ambitious construction project—not just as the rational allocation of resources to achieve quantifiable management goals, but also as an inventive, critical contribution to our evolving culture (Mitchell 2004). “The building itself is an experiment. The people brought together to build and design it are all pioneers” (Glymph 2004).

2. Project team organization—associate architect model

In previous projects, GP had been accustomed to associating with a local architect who would do the construction documents for them. However, for this project they decided to produce essentially all the construction documents by themselves. A milestone in this process change was the Guggenheim Museum Bilbao, where they produced 80% of the construction documents. Because the design process and the documentation had come to rely so much on the computer using CATIA 3-dimensional (3D) models, they realized that the only way they could deliver the project at the level of quality they wanted was to develop the construction documents themselves. This shift coincided with a gradual change in which the Gehry office was starting to be involved in the technical aspects of their projects much earlier. Therefore, they were blurring the conventional boundaries between the design phases. So the conventional associate architect model, where someone else would take over the preparing of construction documents, no longer made sense for them.
In addition, since Gehry’s design was coming to rely heavily on computers, they were afraid of something being lost in translation when they handed over the design information to somebody else. The more complex the project and the more heavily it would be documented in three dimensions, the more information might be lost in the process of translation. Therefore, while they needed a local partner who would provide local knowledge and work as on-site representative, they had to invest in a new working relationship with the associate architect. In this case Cannon Design worked as part of Gehry’s design team. This change also affected the whole organization of the construction team, including fabricator, manufacturer, and contractors (Figure 2 for project delivery system).

In Bilbao, even though the project employed the design architect/local architect-of-record project delivery system that is typical of important international projects, the relationship was not a conventional one. Designing in a 3D computer model and producing construction documents had an impact on the entire process of the project. Comprehensive services provided by the executive architect IDOM, which also served as project manager and construction manager, ensured this idiosyncratic approach. CATIA data were seamlessly used by the structural engineer SOM for analysis and by the fabricators for CAM (Fig. 3).

Gehry moved his process further in the MIT project, holding the role of architect-of-record where as the local associate architect played a supplemental role that included inputting local knowledge and assessing the project as an on-site representative. To help the associate architect learn about what they call their ‘idiosyncratic’ design process, two people from the associate architect’s office, Edward Duffy and Christine Clements, worked at Gehry’s office in Santa Monica for one-and-a-half years, from design development to the end of construction documents.

3. Builder—CM-at-risk

Once GP was selected as architect for the Stata Center, MIT assembled a team to support the design of this facility. Gehry’s nontraditional approach to design and construction and the location of his firm’s headquarters in Los Angeles led MIT to bring in a construction company early in the process. MIT wanted a construction company proficient in technology usage, able to support experimental design proposals, and possessing the intellectual depth to actively participate in potentially esoteric discussions early in the design process. All of these criteria, it turned out, were met by Beacon Skanska (currently named Skanska USA Building, Inc.) (Joyce, 2004). Beacon Skanska was engaged in the project through a CM-at-risk contract.

**Design process**

While advanced design technology is highly integrated into GP’s design process, Gehry’s own work consists of iterating tactile processes. The Gehry team works under his guidance to create the nuts-and-bolts block models that account for the functional relationship between pieces. “Once I understand scale, context, and everything else visually,” he says, “I just absorb that stuff into new sketches.” It is in this phase that the architect and his team can make the leap from block model to skin models, which account for a building’s interior
and exterior look and feel (Guzmán 2001). Then the model is transferred into a 3D digital model (Fig. 4).

GP works on its designs in two directions at once: from inside out and from outside in. On the Stata Center project, their design started with programming the building (Fig. 5). They also carried out an urban-scale study on how the building would sit in the context of the campus (Fig. 6). “The design process they go through is very long. I mean, the schematic design lasted for more than a year, which is unheard of on a conventional project. And they spent a lot of time with these little boxes. And also they make many, many, many models. And whenever they have an idea, they make a model of it. And they do many iterations of it,” Edward Duffy of Cannon Design recalled. In Gehry’s process, functional models come first, before his sketches. They spent a lot of time trying to understand the program: how much there was and how the parts needed to relate to each other. Therefore, they spent a lot of time designing from the inside out. At the same time, they were thinking about the site and the sculptural possibilities. But they were not yet designing them. “They were sort of arranging a building that they can then sculpt. So once they’ve got more or less the massing that they want and the program makes sense, the client has bought into it,” said Duffy. When they first looked at the model, the clients were somewhat embarrassed. Gehry always said that the model was only a programmatic diagram to determine what masses would be needed for the program, not an architectural model. “Frank kept saying, ‘no, no, no, this is just a diagram and it’ll get better.’ Then at a certain point, usually fairly late in the process, they started shaping it.”

The following process was more complicated, as they spent a lot of time shaping the building using physical models. Once that had settled down, they brought in a structural engineer. They had a preconception about how they would hold up the building. However, for the first year there were essentially never any columns in the plans, while they had done a preliminary study of structural feasibility placing columns early in the process.

Because GP did not have an in-house structural engineer, they worked with Ron Lee of John Martin Associates. Early in the design process the engineers...
talked about conceptual structure with GP, and the
decision was made that the structure of the building
would be concrete. Beacon Skanska also participated
in this decision-making process from the point of view
of constructability. At some point they decided that
certain particular shapes would become steel. They
had these basic ideas in mind and then they shaped
the geometry of the building.

1. Shaping and digitizing
The shaping process was still one of tactile ma-
nipulation of physical objects. The process went back
and forth between the models and Gehry's sketches
(Fig. 7).

Once they had sculpted shapes, scale models
were produced by Gehry's assistants, based on the
sculpted shapes, and were scanned into 3D computer
models using a digitizer (a medical plotter originally
designed to record the shape of the human head
for brain surgery). The digitized forms were then
manipulated using CATIA, providing the ability to
model and engineer every spline and node point
accurately (Gann 2000; Fig. 8). In addition, more physi-
cal models were then created for design verification,
sometimes using rapid prototyping machines. Once
the final design had been agreed upon, electronic
design data could be transferred digitally to various
specialists.

2. Structure and service systems
They went back to the structural engineer to
start developing the structure after the shapes were
already set. It was developed mostly in CATIA, espe-
cially the steel shapes. Concrete was also an impor-
tant element for this building. They set up a rule for
how far the column was to be from the wall; it had
to follow the geometry of the wall (Fig. 8). Besides
the structural system, the other significant difference
from Bilbao was programmatic. "Bilbao is a big building,
but museums are fairly simple in terms of program: big
rooms that display things and they have to have good
light and all other things. But this has a huge program,
pretty complicated," said Duffy. The study of service and
mechanical systems followed this process.

Figure 8. Digitizing the model and structural study

Figure 9. Interior models
3. Interior space
The interior design was also studied using physical models, again starting from the blocks, and then scale models were produced for the clients to confirm the design (Fig. 9).

4. Constructability—associate architect and construction manager
Cannon Design, Edward Duffy and Christine Clements in particular, provided local knowledge while working at Gehry’s office. In addition, since many of Gehry’s staff were very young (about 80% of them were in their 20s) and Duffy and Clements turned out to be among the most experienced members of the team, they supported the younger ones by supplying professional knowledge.

Beacon Skanska’s commitment to the design process facilitated the project. The owner and the architects needed a ‘builder’ up front. Dr. James Becker, president and CEO of Beacon Skanska, commented on the difference between builder and construction manager (CM): “[a] CM has a sense of passivity in this country, which means that I’m very professional, I sit back and bring all these different people in to collaborate. The word builder means [something] much more proactive, like people who know how to build out there directing people more proactively.” Beacon Skanska came to a lot of the design meetings. Part of what they did was the cost estimation from the beginning, as the designers also wanted to understand the market in Boston in terms of issues such as how the unions work. Also, the architects asked them for some advice about the most cost-effective way to build things. Although GP took the lead, Beacon Skanska provided practical information. Their collective effort led to the choice of a concrete structure. Because they were interested in maximizing available space and they had to link into the existing Building 36, which is a concrete building and which already determined the floor heights, concrete was the obvious choice on that score. In addition, it would be much easier to build with the usual concrete formwork than using steel. Dimensional control issues in steel were assumed to be difficult, and also they found that how to determine the edges of each floor would really matter for the building of these complex shapes. The most difficult problem was building the sloped masonry wall. “It’s a difficult one because that
means you put in different loads on the backup system as opposed to the backup just stabilizing the brick. Now it carries the brick,” said Becker. “Normally in this country you would use either steel stud backup or masonry block, but you can’t use masonry block backup because you can’t set the block on the slope without something behind it. Then you come to either a backup that has to be cast-in-place concrete or … precast.” The choice fell on the cast-in-place concrete.

5. Constructability—request for proposals to fabricators

To ensure the quality of a design and its constructability, GP needs to work with companies that are able to use the 3-dimensional methodology. They also have to develop a protocol from project to project, negotiating the contract with the company. A. Zahner, the metal cladding subcontractor that had collaborated with Gehry’s office for the Experience Music Project, is a good example. The ultimate output GP wanted to provide them for the Stata Center was the exterior geometry with its pattern, and then the interior geometry, and then they would be filling in between the two. However, it was not as simple as that, because in the process of hiring and getting the offers and cost estimates, and so on, and of developing the architect’s own dimensional control, GP had to work out the design at a certain level of detail. GP prepared a fairly extensive request-for-proposal (RFP) package during the first part of the construction documents phase. Because they had already developed the concepts at the schematic design level or the design development level, the package contained a complete description of the exterior metal and glass geometry and pattern, if not all the way down to details such as bolts, as well as full performance specifications. It also contained the details of a very specific wall system, developed on certain building elements, to show the bidders at least one way of meeting the performance and visual requirements. The bidders were asked to make a proposal based on these requirements for either the system described by GP or some other, or both. The two candidate bidders each chose to propose a prefabricated system instead of a ‘stick-built’ system as developed by GP. This ‘stick-built’ method, which consists of the metal studs and layers of metal, waterproofing, and thermal insulation, was similar to the cladding system applied to the Guggenheim Museum Bilbao. Zahner

John A. Martin
Structural consultant

Gehry Partners

Cannon Design

Beacon Skanska
Construction manager

SDS/2

2D documents

SDS/2

2D documents from SDS/2

Capco Steel
Primary structure

S&F Concrete

Zahner/Karas&Karas JV

A. Zahner
Metal work

Karas&Karas
Glass

Figure 12. Information technology flow

Figure 13. Metal skin modeling; all the panels were modeled. Left: framing; middle: skin pattern; right: endpoints (small dots) connected with coordinate system that also interfaced with slab for placing clips for the metal panels. All shop drawings were in 3 dimensions. Dennis Shelden, chief technology officer of Gehry Technologies, LLC, and a Ph.D. from MIT, made a program to rationalize the curvature of the panels. Source: Beacon Skanska and Cannon Design
instead proposed a prefabricated hybrid metal panel system that would assemble all the necessary components in their factory. This system eliminated the secondary structure and thus reduced the site work. All they needed were the clips to anchor the panels to the concrete slabs. Zahner’s proposal streamlined the exterior metal skin construction.

Although GP’s specifications were not adopted, the fabricator was able to propose their scheme because they could see something at the start, and the original idea was able to give them a sense of the elements they would be building. It was a very collaborative process, and it devised a way of interfacing with trade specialists before the construction documents were completed.

6. Construction documents

At a certain point, some of this information was then pulled out into 2D drawings in AutoCAD. However, that was not an automatic process, because it was cumbersome to move things back and forth. It was impossible to draw only a plan of this building. Once it was developed three dimensionally, they had to do precise cuts or slice the building at a given elevation, and that became the basis of the plan. Then they had a 2D map and that was imported into AutoCAD, which traced it to produce an orthographic representation (Fig. 11).

Interfacing with construction people: fabrication and on-site assembly

In handing the information of the building to the construction side, the questions asked included how to describe the complex object, and what information needed to be provided to convey design intent so that the construction people could develop it into construction information such as shop drawings. The most difficult obstacle in this process was the norms of the industry, which were essentially two dimensional and paper-based. While some of the construction people were familiar with digital imagery, others were not and initially resisted. Beacon Skanska had two CATIA machines and they had spent much of time becoming comfortable with looking at the CATIA model. They were looking at it all the time just to visualize what they were trying to accomplish. Moreover, they went further and took a lot of coordinates directly from the model. For some aspects, digital data
created by GP and interfaced by Beacon Skanska were effectively used for fabrication in a somewhat seamless manner (Fig. 12).

1. Skin metal and glass
A couple of the subcontractors such as A. Zahner and Karas & Karas JV, the skin metal and glass fabricators respectively, used the digital model extensively (Fig. 13). Because Zahner had had a long history with GP, the firm was accustomed to the issues. All the metal pieces were cut directly from CATIA data using a computer numeric control (CNC) machine, assembled by hand in Zahner’s factory in Kansas, and transported to the site (Fig. 14). As opposed to the metal sheets of Bilbao, onto which multiple layers including insulation and waterproofing were constructed on site, at the Stata Center, each zinc steel panel had thermal insulation and waterproofing applied at the factory. After being touched up on site if necessary, each panel was fixed to the clips anchored to the concrete structure. This also eliminated secondary frames for most of the areas (Fig. 15).

Zahner and Karas & Karas JV also developed all the framing dimensions using CATIA data. All the skin areas were modeled in three dimensions; material information and coordinates appeared when one clicked on any part of the skin (Fig. 16).

2. Steel frame
For the steel work, another key element, Capco Steel of Providence, Rhode Island, was able to handle digital data. They could work with Gehry’s office early on because they were one of the top three users of 3-dimensional models in the country. They use an SDS/2 platform, industry-standard fabrication software (Fig. 17). Dennis Shelden wrote the program for translation from CATIA to SDS/2. However, it did not work in the other direction. From SDS/2, data have to be exported in DXF format, then translated into Initial Graphics Exchange Specification (IGES) format in AutoCAD, and then read by CATIA (Fig. 18).

Because of the tradition of having the steel fabricator define the detailed connections, the architect did not draw them at a very detailed level. It was always understood that the fabricator would draw all the connections. In producing the shop drawings, the
data went back and forth between GP and the fabricator, so the shop drawing of the framing was essentially a 3D and paperless process. Even a review was done in digital form (Fig. 19).

3. Concrete

Conversely, the concrete work was completely documented using 2D drawings because the subcontractor, S&F, was not capable of using 3D data. As part of Gehry’s team, Christine Clements developed a 3D CATIA model and then interfaced with the concrete subcontractor (Fig. 20). However, 3D information was used to calculate concrete volume quantities and to define coordinates for carpenters’ formwork (Fig. 21, 22). Each concrete structural drawing showed coordinate points plotted every foot to couple of feet, which were predefined by Gehry’s office or figured out by Beacon Skanska. Every point was plotted on site using Tripod Data Systems (TDS—see construction management discussion for detail).

4. Interior

Interior work was carried out in a more conventional manner, except for special elements (Figure 23).

Construction management: plotting digital data

On-site assembly of complex, digitally fabricated parts can be a greater challenge than placement of standardized elements. Because Beacon Skanska was willing to be exposed to new technology and assigned people to the project who would be amenable to innovation, construction management actively involved new technologies for aspects including scheduling, material takeoff, and coordination between various elements.

1. Digitally controlled on-site assembly

Fieldwork for Beacon Skanska also involved advanced information technology. For surveying, in particular, CATIA data were transferred to AutoCAD and then imported to a field CAD system, Eagle Point. Then the data were interfaced by Survey Link software with Total Station’s robotics laser survey system and Tripod Data System’s (TDS’s) handheld computer that was used for data collection (Fig. 24). This system involved a local positioning system that used coordinate points defined by surveys using several benchmarks, and later by using a radio station placed on the parking garage in the below-grade after it was built.
In addition, coordinate points were extracted from CATIA data, sorted by MS-Excel, and then put on the website using MS Active Sink. In the field, people interactively referred collected surveyed data to the data put on the website, which was a powerful method for this complex project, providing accurate measurement and achieving a range of accurate leveling, grading, alignment, and positioning (Fig. 25).

This system was also used for various aspects of the construction, such as giving coordinate points to carpenters for the formwork. Gehry’s office essentially defined the coordinate points of all the elements. However, in case some of them were missing or construction people needed them, field people could extract the points from the CATIA model and reflect to the construction information.

2. Schedule—4D CAD

For scheduling GP employed 4D CAD, developed by the Center for Integrated Facility Engineering (CIFE) of Stanford University. Gehry’s office had integrated CATIA into the system working with Walt Disney Imagineering for the Disney Concert Hall in Los Angeles. This software enables the construction management to schedule construction sequentially: how things would go up, what the relations would be between the tasks, and what temporary work would be happening (Fig. 26). Another advantage is material takeoff. Each element comes with attributes and is used for various tasks, including cost modeling and skin pattern arrangement (Fig. 27, 28).

Information management protocol

In order to make the most of a digitally-mediated process, coordination of the project was also mediated by information technology, though they did not use a single tool (Fig. 29). The design website was basically the Frank Gehry website, and there was a file transfer protocol (FTP) site that was separate from the design website. In this design website they posted information ess for the client. However, the other members of the design team, including Cannon and Vanderweil, also looked at it. On the design website there were program documents, and every month they updated the plans and photographs of the models. Most of the heavy transfer of data, including drawings between offices and so forth, used the FTP site. For example,
Cannon was in Boston developing all the drawings for the underground work; when GP needed to get this printed, it got posted on the FTP site and then GP had a complete set of documents. MIT had its own website mainly for public relations purposes. Beacon Skanska had its own Stata Center FTP site to communicate with its subcontractors.

1. Citadon

In the construction administration phase (Fig. 30), the commercial extranet software Citadon replaced the design website. MIT hosted Citadon, whose server was in San Francisco. During construction this became a central clearinghouse for questions, memos, and issuing of new documents. It gained a fairly good reputation among users, including architects. "Tremendously useful. People like to complain about it, … but we couldn’t live without it because everybody can instantly see everything and everything you can get to easily," said Duffy. While the extranet won a good reputation during construction, it did not during the design mode. Becker comments, "I think the whole area of a collaboration website turned out to be somewhat of a disappointment. We tended to drift to more administratively rich websites like ‘ProjectTalk’ (www.projecttalk.com/) that have stronger administrative packages. … But the problem with all these things is they require a real commitment to use them. And if the team doesn’t have the commitment (and often the worst people are architects), these things fit better into construction administration mode."

Merging design and fabrication

I. Design, representation, and fabrication

Frank Gehry not only changed the design of architectural objects but also changed the way things are designed and built, which is process. Figure 31 shows a comprehensive diagram of the translation among representations in the sixth decade, originally proposed by William Mitchell (the 2000s is the sixth decade since Dr. Ivan Sutherland invented Sketchpad at MIT). In Gehry’s case, all three ellipses in the diagram are important. While conventional design evolves mostly in the domains of ellipses 1 and 2, his design also involves the third ellipse domain. In particular, his design goes back and forth constantly between the physical model and the digital model. In many respects, his design starts with physical models, then is brought into CATIA and refined, then brought back to physical
models. The designers then play with the model some more and go back and forth. Finally, the information is developed into construction documents in both 2 and 3 dimensions.

2. Limitations

In actual practice, however, the process was really challenging because the architect has to have three databases (physical model, digital model, and drawings) that are completely disconnected. The problem is that the moment the digital model is sliced and sent to the 2D world, they are in two different worlds, says Marc Salette, GP’s project architect. “The difference is not so much the format as the method. So ideally you would have one database and you can spread it out in 3D, in 4D, in 2D, and it doesn’t matter. You just do it for what you need it for. If it’s simpler to convey the information for somebody’s building in 2 dimensions, you would do it in 2 dimensions even in our process.” Working on the organization of the plan to meet the code requirements for handicapped access, for instance, need not be done in 3 dimensions. As long as the various layers are kept, working in 2 dimensions is better in certain situations. “The problem that we are trying to resolve is that we still have two different databases, not because we need these two different types of outputs but because in our office we still don’t have the resources or the knowledge globally to conduct all of our work in 3D,” says Salette.

“You can only create the bridges between the two universes so often. You could do it on a daily basis, but that would be completely impractical because that means that you will have one person who is working in 3D spending all his time doing 2D cuts, and that would mean the person working on 2D would be on very shifty ground because they would be developing something and [then] I will send them a new version,” Salette continues. It is particularly impractical during the phases of the project when the geometry changes a lot. Therefore, they are aiming to have a single database, working in a way that would allow the architects in our office to concentrate on solving problems and spend as little time as possible organizing documentation. There is also a higher potential for errors resulting from lack of synchronization between the two databases. However, Salette points out that even in the traditional 2D world, a lot of time is spent just managing information: “discrepancies between two drawings...”
The way GP sees it in their process, it would be the single database in 3 dimensions that could contain all the information. “For example, as you work on this room you can assign this door a number. And then all the information is there, which is used in different ways of outputting. But it’s all linked. You don’t have to verify between one platform and the other,” says Salette. Currently they are working with the V5 version of CATIA, which has an enhanced function to produce 2D information, led by Dennis Shelden. It is one step in the right direction because it can create 2D slices much more easily than the previous version, which means that the objects can be better linked. However, they are still importing the slices into AutoCAD drawings, which means that the objects are on different platforms and no longer linked. “I just hope the day comes when we just have one platform and it’s CATIA or something else, something better that will allow you as an architect to work at 3 dimensions most of the time, because that’s how we can better solve the problems,” he says.

Conclusion

A design and fabrication method that heavily involves computer technology changes the way not only the design team, but also the construction sectors, work. People involved in the process are required to have literacy in, and willingness to adapt themselves to, the new system. The organization of the project has to be structured by reimagining the relation of design and construction in a way that blurs their traditional divisions, which means not only process integration, such as vertical integration, but also the integration of expertises. Such integration, however, sometimes creates siloed situations where vertically integrated processes are less well connected horizontally. This situation may be exacerbated when parts of the project are competitively bid in conventional manner or when someone takes over a task at a certain point. GP’s approach displays particular aspects of a holistic design process for which the office has been shaping its organizational culture over time. One of the major forces in this change has been the increasing dependence of their design process on the computer. In addition, they have
been examining the technical issues, which used to be studied in the later phases, early on in the process, so the distinctions between schematic design, design development, and construction documents have become somewhat meaningless for GP. On top of that, as they have switched from working with an associate architect who produced construction documents to producing construction documents themselves, they have been required to take on all the risks and liabilities that other participants in the project, such as local architect of record, construction manager; and fabricators, used to be responsible for. GP has developed a method to hedge these risks by involving industry up front, devising a project delivery system in which the construction manager ensures overall constructability and fabricators develop design detail for some elements, while GP maintains its own design management tasks (Fig. 32).

In the context of a digitally mediated building process, the critical issue for GP is to collaborate with construction sectors that have the skills and fabrication facilities needed to develop and implement their ideas. Unlike mass-market production, buildings are mostly done one at a time, and construction calls for very few off-the-shelf parts (Joyce 2004). Devising a way to involve the industry in the design process in order to translate their design ideas accurately into building systems is crucial for GP in order to deliver buildings at the level of quality they want.
ACADIA: Architectural Practice

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Literature


Notes
This research paper is based on and developed from the case study on the Stata Center conducted for the author’s doctoral dissertation entitled “Collaboration in Architectural Design: an IT Perspective,” submitted in June 2003 to Harvard Design School, Cambridge, Massachusetts. Thanks are due to thesis committee members Professor Spiro Pollalis and Professor Jeffrey Huang of Harvard Design School and Professor William Mitchell of Massachusetts Institute of Technology for their guidance of the dissertation. Thanks especially to Professor Mitchell, architectural advisor to the president of MIT, who helped the author gain access to the project team of this building and enabled intensive interviews with the team members. Interviews were carried out at mid- to end-construction period, so the people interviewed had diverse knowledge and reflections about this innovative project, which provided concrete information on which this paper has relied. I thank all the interviewees for their kind cooperation. I also thank Matthew Abbate of MIT Press for his editing my English and input about structuring this paper.

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