NEXT-GEN BIM:

Graphisoft Teamwork 2.0 will revolutionize BIM/IPD workflow and collaboration
By Jerry Laiserin

Collaboration—within building design teams and across multiple project delivery participants—is the most critical success factor for BIM (building information modeling) and IPD (integrated project delivery). Teamwork 2.0, a technological breakthrough in collaboration from Graphisoft (and expected to ship later this year as part of ArchiCAD 13) offers such radical improvement in support for collaboration that any design firm or project team considering or attempting the BIM and/or IPD approaches must now seriously (re-)evaluate their choice of model-authoring tool for BIM/IPD.

What's the problem?
Anyone who has implemented or even evaluated any of the leading BIM model-authoring tools immediately grasps the obvious benefits that follow from having all views and data integrated with each other in a central project model: support for more accurate simulations and analyses; automatic consistency of project documentation; better coordination among disciplines; and so on. But these benefits come at a price. As model data integration goes up, flexibility of workflow and performance in collaboration go down. If multiple project team members work concurrently on a central project model, conflicts among their respective changes will arise unless access to the model is controlled. Each user must, therefore, reserve or check out or be assigned a

workspace or workset (or functionally equivalent subset of the total model) containing portions of the building allocated for work by that user—and thereby restricted or locked out of access for changes by other users. Changes made by each user to his or her local copy of the central project model must be synchronized with or updated to the central project model by merging each user's local copy of the entire project back to the central project model.

As a result of this style of model organization most BIM model-authoring tools—ArchiCAD included—pay penalties in the form of barriers to workflow flexibility and bottlenecks in collaborative performance. Users lose flexibility in how they can access elements they need to work on, through required advance setup and/or ongoing management of worksets or workspaces and the necessity to access elements that may be reserved by or for other users in those users' worksets or workspaces. Performance for individual users and the entire team suffers while waiting for each user to update the entire model with his or her latest changes. Such update operations (or send/receive, save/get or commit) take progressively longer the larger the project and the larger the project team; plus, many such update operations lock all other users out of the central project model while any user is updating. The results are: individual user frustration over inflexible access to elements needed for their work; and team-wide loss of productivity while waiting for updates to complete. This update waiting time can run as long as half an hour per user with some BIM software on larger projects, which also increases the risk of wasted work as team awareness of any user's changes slips ever further from real-time simultaneity. There also are some risks to model security and integrity in the event of a fault at any local machine where model editing is taking place or in the event of disruption/corruption of model data while in transit from any user's local copy back to the central project file.

What are the solutions?
Providers of BIM model-authoring tools have tried diverse approaches to resolving these issues. One approach is to sidestep the "reservation" issue entirely by allowing conflicts to arise among concurrent users' edits to the model. A software vendor adopting this "conflict resolution" approach argues (or hopes) for optimism in that real-world editing conflicts (two or more users working on the same model elements at the same time) may be relatively rare. My view is that the ability of model-authoring tools to make global changes in response to specific edits (a desirable trait) actually increases the likelihood of such conflicts. More importantly, the resolution of any such conflict means that some amount of work and time expended by at least one of the conflicted users will be wasted when the conflict is resolved and only one user's changes are accepted. Plus, the conflict resolution method doesn't directly address the time/performance penalty of full-model updates.

Instead of conflict resolution, many BIM-tool vendors choose a reservation-based or "reservation resolution" approach, but this gives rise to the reservation-related issues already cited. Some vendors favoring reservation resolution approaches have tried to address these issues by increasing the flexibility of workspace/workset configuration and management and/or allowing varying degrees of flexibility in "borrowing" elements from one user's workset or workspace for use in that of another user. Such borrowing of elements can be made more or less transparent to the users on each side of the transaction.

Whether based on conflict resolution or reservation resolution for allocating work, all BIM model-authoring software still must periodically update the central project with edits/changes made at team members' local copies of the model. In the most common arrangement, the entire (edited) model is sent from the local copy to the central project, which tends to be a slow process—and one that grows slower as model- and/or team-size grows larger. These performance issues for updating or synchronizing changes over a LAN can be partially addressed by amending changes to central and local files in ways that limit the necessity of exchanging the entire model file on every update; however, with this method the separate central and local files grow in size rather quickly and require periodic resynchronization and consolidation.

Many such improvements that benefit larger firms and/or larger projects tend to penalize smaller firms and sole practitioners by adding additional levels of model management and workflow management complexity. This issue is especially challenging for mid-size firms large enough to tackle bigger projects but still too small to support a full time CAD/BIM/model manager.

For firms of any size working across the Internet, the underlying bandwidth of WAN (wide-area network) connections is almost always much slower than that of the office LAN (local-area network). Modern, switched LANs typically run at 100Mb/second up to 1Gb/second, while WAN connections typically run at only a fraction of LAN speeds (cable or Telco fiber connections in my part of the world—eastern United States—commonly range from 2–20Mb/second, while a full T1 line is even slower at 1.5Mb/second; plus, many other parts of the world do not offer connections anywhere near as fast as these speeds). This speed differential makes delays in WAN performance for dispersed project teams even more problematic.

In my consulting work with firms comprising many thousands of "seats" of design software I have observed what psychologists call a "threshold of inattention" that sets in after an incremental delay of approximately five seconds. In other words, users will barely notice (or, at least, will tolerate) software performance that is no more than five seconds slower than their perceived baseline performance. However, if performance of a given software operation takes five seconds longer via LAN than on local PCs, users will complain and productivity will suffer. Similarly, if saving/updating over a WAN/internet connection to another office/project location takes five seconds longer than on the users' office LAN and/or local PC, those users will become unhappy. I don't have access to a usability lab or controlled test conditions, so this "five second rule" is truly a rule of thumb, averaged across the subjective judgments of end users in my A/E firm client consulting roster (which is not necessarily a representative sample of all users in all firms).

Whether this is a general phenomenon or whether five seconds is the "right" number, there can be no question that a lagging speed/time differential among local PC versus LAN versus WAN/internet performance is a serious problem for firms and projects of any size. In my experience, simply throwing more bandwidth at the problem (say, increasing from T1 to T3/DS3/OC-1 or beyond) rarely if ever overcomes structural issues in the underlying local/central logic of the design tool in question. Ditto for bandwidth accelerators such as those from Riverbed or Cisco.

One BIM-tool vendor's suggested workaround is to use Windows Remote Desktop Services so that only clicks and pixels are moved to and from PCs acting as dumb terminals over the WAN, with each user's "local" copy of the model kept close to the central project model on a LAN. A further work-around suggested by this same vendor for multi-office firms operating across multiple time zones is for users to update to their geographically closest instance of the "central" project model and then to have the various geographically dispersed instances of the central project model synchronize with each other overnight.

The bottom line on all these attempted solutions and/or workarounds is that no BIM model-authoring system—ArchiCAD included—has provided a truly satisfactory resolution[1] to the workflow and collaboration penalties that have seemed inevitable, negative trade-offs for the data/model integration and other benefits of the BIM approach. That is, none until now, with the introduction of Teamwork 2.0 (TW2) from Graphisoft/ArchiCAD.

How is TW2 different?
Following the historical example of the young hero Alexander the Great who cut through the Gordian Knot that the greatest minds of his era had been unable to untangle, Graphisoft has cut through BIM workflow and collaboration barriers and bottlenecks by fundamentally re-thinking what's central, what's local and how they connect to each other.

The result is that Graphisoft's TW2 technology can perform in as little as 1–2 seconds many update operations (e.g., from a user's local copy to the central project file) that might take 10–20 minutes with other tools. In fact, updating a user's local copy of the model file to the central project in TW2 often can be faster than regenerating a copy of the model on that user's own PC (in other words, LAN/WAN model update performance that imposes little or no time lag penalty compared to working locally—the threshold of inattention never is reached). Furthermore, TW2 offers such flexibility and granularity in allocating model elements to work on—and making those allocations readily and instantly visible to all—that existing schemes for reserving and releasing individual elements (or entire worksets or workspaces) suddenly seem clumsy and counter-productive (to say nothing of the amount of off-screen communication required by most existing methods). Plus, TW2's order-of-magnitude leaps in collaborative performance and workflow flexibility are accompanied by significant advances in security, reliability and robustness of the entire model-authoring system.

For any firm or project team struggling with the frustrations of existing solutions to these problems (even with ArchiCAD itself and its existing, original Teamwork approach) TW2 surely will be seen as disruptive technology that will displace "legacy BIM" approaches just as the legacy BIM tools in their time displaced the legacy CAD methods that preceded them. However, to fully understand the profound and potentially industry-transforming impact of what Graphisoft has achieved with TW2, it may be helpful to zoom out to a broader overview of BIM-method collaboration in both historical and current contexts.

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[1] One or two privileged individuals among the hundreds of thousands of folks employed in AECO in the USA claim to have encountered the "perfect" solution some dozen years ago in an unreleased version of a now defunct product. To those true believers, I can only extend my best wishes on their quest for the holy grail of BIM collaboration. As a consultant and analyst in the real world, I have to limit my scope to the mundane realm of commercially available releases of extant products that my clients and readers can actually purchase and implement.

What's the background?
Since December 2002, when I helped launch the industry conversation about BIM[2] many design firms—of various sizes and on several continents— have sought my advice on choosing BIM model-authoring software and related BIM-automation tools. For this purpose I developed a proprietary methodology for comparing and ranking alternative BIM solutions with a set of desiderata that can be tailored to the workflow and project requirements of specific firms. One key insight that has emerged from this work has been the importance of appropriate file- and model-sharing capabilities in BIM model-authoring software.

Why is this so important? Simply put, design firm productivity demands that multiple people be able to work on a project, whether several people at the same time, different people serially over periods of time, or any mix and match combination of workflow scenarios. Furthermore, in today's internet-connected, global production environment those multiple and/or sequential project workers may be contributing to the project from adjacent cubicles, across town or around the world. Design software that cannot effectively support these types of collaboration in a timely manner is at best a bottleneck and at worst a deal-breaker in any existing or proposed BIM workflow. Other BIM-tool features such as geometric modeling flexibility, automatic change management, third-party support or other software features and benefits are unlikely to overcome a major deficit on this point—at least not under the scoring/weighting factors of my BIM-tool evaluation methodology.

What we now think of as the BIM method or the BIM approach has been gradually superseding drawing/file-based 2D production systems with an integrated 3D/digital model from which any necessary 2D views (or drawings or layouts) are derived. Of AECO design software currently on the market, ArchiCAD from Graphisoft has been using this approach the longest, since many years before the term "BIM" came into popular usage (indeed, since before many of the products that today compete with ArchiCAD even existed; there were, however, pioneering BIM-like tools—such as RUCAPS and its descendants Sonata and Reflex, to name a few— that predated ArchiCAD's ur-BIM approach, none of which have survived commercially into today's marketplace).

As stated earlier, all current BIM model-authoring tools—ArchiCAD included—suffer in varying degrees from workflow and collaboration barriers and bottlenecks that have appeared to be inevitable trade-offs for the other benefits of the BIM approach. AECO firms and project teams have been willing to struggle with and (reluctantly) adapt to the limitations imposed by such "BIM side effects" because the possibility of a better alternative was not known and, indeed, not perceived as feasible. This is a kind of cognitive dissonance in which one can tolerate an existing state until one becomes aware of a better state, at which moment the previously acceptable (albeit grudgingly so) state of affairs suddenly is perceived as intolerable.

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[2] "Comparing Pommes and Naranjas," The LaiserinLetter™ Issue 15, December 16, 2002 — http://www.laiserin.com/features/issue15/feature01.php
"Building Information Modeling," Wikipedia — http://en.wikipedia.org/wiki/Building_Information_Modeling (last accessed July 24, 2009)

How does it work?
Because Graphisoft recently provided me an opportunity to see and experience its TW2 technology (and the future ArchiCAD 13 of which TW2 is such an important part), I think many readers may appreciate a brief look under the hood at some of the technological innovations the Graphisoft folks have pulled together.

It bears repeating that Graphisoft has embodied in TW2 a fundamental re-thinking of what's central, what's local and how they connect to each other. The underpinning for this transformation is a realignment of ArchiCAD's internals—cleaning up its database structure to create relationships among elements without explicit links, effectively a relational database system. In turn, this allows and supports granularity of reserving, editing, updating and releasing parts of a central project model down to the individual element level, enabling any user to now reserve—on the fly— precisely what's needed, and no more, to accomplish his or her immediate tasks.

On this underpinning, the true foundation of TW2 is the new Graphisoft BIM Server, an active server database management system that maintains and updates the central project by passing to and from clients (users' machines) only the "delta" or change-data of user actions and edits, and doing so on an effectively real-time basis. Each user/client still independently reserves/releases any elements as needed for work, and information about the actions of each user/client are automatically communicated by the active server to other clients. While edits by each user are only communicated to the team on user-initiated save/get actions, every user's reservations and releases of elements are displayed by the server to all users/clients immediately.

This ease of selection/reservation applies to any element(s) that can be seen in any model view, with all reservations/releases instantly reflected in all other users' model views via color coding of elements. It is this instant and automatic visual feedback on the actual workspace changes of the rest of the team that provides each user a lively work environment and a unique feeling of connectedness to the project and the team's workflow at all times. Non-modeled data, such as attributes, annotations and even views themselves also can be selected and reserved/released, with these reservations signaled to all other users by a clever on-screen system of what Graphisoft calls "lamps" (I prefer the term "traffic lights," but that may merely be a trans-Atlantic translation issue).

All updates to the central project model occur only at the server (contrasted with many current approaches in which local edits update at the local copy of the project, which then must be transmitted in whole or in part to the server). In TW2, only the delta from each user/client is exchanged with the server, and updates to the central project on the server occur only after a validation step at the server. This has the effect of reducing BIM-based network traffic from tens of megabytes per update to just a few kilobytes. Furthermore, this technology provides the added benefit of protecting the integrity of the central project model—in other words, potential corruption at any client computer and/or in transmission between client(s) and server cannot corrupt the central project because Graphisoft's BIM Server is intelligent enough to filter out any corruption of the incoming data.

On top of ArchiCAD's new model database granularity and the new Graphisoft BIM Server, TW2 also includes a context-based, live messaging system that communicates and displays reservations, changes and releases and also provides structured IM-like capabilities for resolving any remaining reservation conflicts. This BIM-centric action- or task-oriented messaging system supports user-to-user and team-wide communication, including assignments of elements and comments/questions such as requests for review of any part of the project (and, obviously responses to such review requests). All these messages appear directly (and instantly) on the recipients' screens, eliminating the need for additional—and often disruptive—off-screen communication. TW2's messaging system maintains a full history of questions, comments, reviews, replies and so on—including markup sessions as well as actual edits—all in context of the relevant model views.

User-to-user requests for releases of elements (in effect, borrowing) include in the message an action button for the desired response as well as a link to show the specific element(s) subject to the request. This messaging method also applies to requests for review as well as assignments. The message palette on each user's PC screen tracks all message-related actions with icons that sort items among: a To Do List (for me to do, as requested by others); Pending (my unanswered requests to others); and Done (message history). Any user can readily determine which elements other users have reserved by simply observing the model color-coding (and/or attribute "lamp" system) and then mousing over individual elements to reveal an "info box" about each reserved element. Overall, the TW2 messaging system can significantly enhance individual and team performance, while providing non-disruptive insight into project workflow for project leaders and BIM managers overseeing and/or managing the work of any project team.

The active server component can be configured to implement CAD/BIM management controls via access rights that apply profiles to each user/client, whether on a firm-wide basis, by project type, individual project, individual user, specific elements, specific actions or the like. However, recognizing the diverse needs of variously sized firms, TW2 will ship with defaults that allow most teams of five or fewer users to start a project with, effectively, just a single click: no setup routine, no configuration time, and what Graphisoft claims is a five-minute learning curve (which proved to be more than enough learning/training time in my case, and I am not a day-in/day-out head-down user of BIM tools).

The TW2 server also provides for automated backup routines of the entire project as well as the option to "roll back" the project to any previous time or state. Although not discussed by Graphisoft for initial availability of the TW2 technology, I can easily imagine the active server being extended in future by Graphisoft to support further enhancements such as: versioning, with revision management to tag stages of the project by the delta per date at the active server (e.g., a release/issue date); and a complete audit trail, a la Apple TimeMachine, for project control.

Taken together, these innovations in TW2—element-level model granularity, Graphisoft BIM Server, and the TW2 messaging system—not only smash through the barriers and bottlenecks of most existing BIM-tools, but push workflow flexibility, collaboration performance and model reliability/integrity to new levels that collectively exceed the comparable feature set of most existing BIM-tool solutions.

For such a bold and sweeping innovation as TW2 it is difficult to convey in mere words the full scope of the system's operation. Static screenshots (unavailable in any event, due to the pre-release status of this technology) also would fail to do justice to such a dynamic and interactive technology as TW2. In my experience only a live demo can afford a level of product understanding that is sufficiently comprehensive and in-depth (however, such demos may not be publicly available before the actual ArchiCAD 13 product release that includes TW2, but readers who urgently want to proceed right now with their BIM implementation decision might try contacting Graphisoft directly to see if a private demo can be arranged).

Who is it for?
For readers who haven't guessed by now, I believe Graphisoft's TW2 technology will prove beneficial to any individuals, project teams or firms engaged in BIM and/or IDP methods. The benefits can be divided into general benefits versus those applicable to firms of specific sizes—small, medium and large.

TW2's general benefits start with access to elements. Reserving elements to work on in each user's local copy of the project model under TW2 is easy and can be done completely on the fly. Editing is essentially unchanged from current methods in ArchiCAD, but saving and receiving changes under TW2 is radically accelerated because the new, element-level granularity limits data flow between server and client in both directions to just the incremental changes—without any further model clean-up and/or management actions required. Releasing elements is as quick, easy and flexible as reserving them.

Thus, the entire workflow cycle for individual users and for the project team as a whole is totally transformed for the better. Concerns about flexibility of access to appropriate portions of the project model simply melt away. Many current examples of the resolution reservation approach unintentionally encourage user/team behavior that can be dysfunctional at best and mutually destructive at worst. Acting in what each believes to be his or her best interest, users tend to reserve more of the model than they may really need, retain control over those model portions for a longer time than absolutely necessary, and release them only with reluctance. Not only does this negatively impact the entire team, but this behavior can lead to a downward spiral as more members of larger teams adopt this behavior, justifying ever more "model-hoarding" behavior on everyone's part.

Under TW2, no advance setup or ongoing maintenance of workspaces is required (although CAD/BIM management tools remain available for those firms or teams that choose a more structured approach). Each user simply reserves whatever elements are desired by any method of selection available in ArchiCAD. Thus, a workspace reservation can include: as little as a single door, window, column or other element; any grouping of elements; or any area, zone, level or story. Plus, TW2's local/server approach to model updates effectively eliminates the risk of local errors on reserved elements corrupting the central project when edits to those reserved elements are (re-)synchronized to the central project.

Regarding TW2 benefits specific to firms of varying size, Graphisoft chose to respond to what they characterize as the "dynamic workflow" requirements of small-to-mid-sized firms, the "controlled workflow" demands of larger firms (with 50+ staff, often across geographically

dispersed locations), and the so-called "remote workflow" needs of solo practitioners (although I prefer to classify the latter as "asynchronous workflow" as well as remote).

Taking **the largest firms** first, TW2's administration tools support role-based and/or individually tailored access rights capable of managing the most structured or "locked-down" BIM-model production environment. These administrative tools for the Graphisoft BIM Server run separately from the server—even on another PC (local or remote) absent a copy of the server software. Multiple servers can be running in one firm, with each typically supporting up to half a dozen active projects and effectively unlimited users per project.

Thus, scalability issues (by number of users, number of projects, size of projects and so on) often encountered with legacy BIM tools effectively disappear under TW2. Ditto for update delays and LAN/WAN latency issues. Greater ease of user access to working elements creates a virtuous circle: reserving less of the model; holding onto it for shorter periods; and releasing it more readily. The cumulative performance benefits actually increase as projects and teams grow larger (or, stated differently, the performance penalties avoided with TW2 are proportionately greater as the project/team is larger—plus, workflow can be further controlled and optimized by user assignments through the reservation and messaging systems).

In addition to these access, control and scalability issues, larger firms and projects clearly will benefit from TW2's support for distribution of work across multiple locations in a timely manner. TW2 makes it easier to learn and understand a project's internal organization once underway, which therefore makes it easier for users to jump on and off teams as needed and also less costly to stop and start projects. I can readily envision scenarios under which large-firm users of Graphisoft's TW2 technology evolve toward the sort of dynamic allocation of staff resources that has long been a (largely unfulfilled) dream of multi-office practices. To me, the prospect of dynamic resource allocation means the ability to assign any staffer in any office to any project in any (other) office without concern for the learning curve of that project or the latency and delay of working across the WAN/internet.

For **small-to-mid-sized firms**, TW2 promises a slightly different set of benefits, appropriately attuned to their needs. Such firms often lack time and resources for rigorous project setup routines, lengthy training/learning curves and ongoing model management. In my experience, these firms exemplify a collegial rather than hierarchical style of organization, which some observers characterize (in a non-pejorative way) as "controlled chaos."

Contrasted with the controlled workflow approach typically desired by larger firms, small-to-mid-sized firms will benefit from TW2's dynamic workflow capabilities: one-click project start (based on default configurations); a five-minute learning curve (effectively no training time); and element access on the fly for all (without the delays/frustrations of anyone being locked out of the project). What might seem to some as controlled chaos actually is an environment in which each team member can work on any project as easily, seamlessly and uninterruptedly as if he or she were the only person working on that project, yet all team members enjoy the benefits of true, real-time collaboration without a lot of burdensome CAD/BIM/model management and overhead.

Even though TW2 is primarily a BIM collaboration tool, **solo practitioners** should benefit as much as their counterparts in progressively larger firms. Graphisoft calls this bundle of benefits "remote workflow," but as noted above I believe "asynchronous workflow" may be a more fitting description. For true solo practitioners, any software-mediated collaboration almost certainly will happen over the internet. Such collaboration might be with freelancers or part-timers helping bat out a project (inversely, BIM-tool freelancers also will thrive on TW2's support for this kind of out-of-office collaboration). Solo practitioners often team up with others on entries in design competitions and similar one-off work that requires collaboration but doesn't justify setting up a project office.

TW2's "delta-only" method of synchronizing project changes ensures that all updates across such solo-practitioner-based virtual teams move at speeds orders-of-magnitude faster than existing solutions for internet-based BIM-tool model-sharing. Because TW2 workflows can run without advance setup or ongoing management no solo user in a virtual team or freelancer network need be burdened with such non-project chores. Finally, since the Graphisoft BIM Server of TW2 provides automatic backup and supports remote backup, solo practitioners are relieved of another set of concerns about their work.

What does it all mean?
Software design, like most engineering disciplines, is a craft that must balance competing and often mutually exclusive criteria and desiderata. Every successful software program embodies an artful set of trade-offs among these competing demands. For BIM model-authoring tools the principal trade-offs according to my evaluation criteria have been between integration and flexibility or between integration and speed/performance. The accuracy, consistency and coordination benefits that flow from tight integration around a central project model too often come at the price of sluggish speed and performance as well as inflexible operation that can impede or disrupt real-world A/E workflow.

Different vendors have designed their respective products with different approaches to these trade-offs. Product X may achieve the tightest integration, but only at the expense of the least flexibility and the slowest performance. Product Y may have been designed to be faster and more flexible, but only at the price of looser integration. Product Z's designers may have sought a middle path, with moderately tight integration and only a modest hit in performance and flexibility.

There are more such possible combinations of benefits and penalties than there are BIM model-authoring tools currently on the market. However, the important point is that all existing approaches involve fundamentally similar trade-offs. The principal differences among today's competing products boil down to relatively slight shifts in position along the same trade-off curve (whether from integration to flexibility or from integration to speed/performance). In my consulting work, applying my proprietary evaluation methodology, sometimes Product X comes out on top and sometimes it's Product Y or Product Z (or still others). Much depends on the specific circumstances of the design firm to which I'm consulting, their project mix, office/studio structure, network and computing infrastructure, overall firm size and so on.

The inevitable conclusion, however, is that all existing product solutions on the market are surprisingly close along these trade-off continua. To illustrate the point, an acquaintance at Bentley Systems once regaled me with his sly attempt to kill two (competing) birds with one well-aimed bon mot: "Revit is just ArchiCAD with constraints." While that characterization does its (intended) injustice to both products, it also highlights just how tightly bunched all existing BIM model-authoring products are along that same trade-off curve.

Teamwork 2.0, or TW2, from Graphisoft (and expected to ship later this year as part of ArchiCAD 13) is a true breakthrough technology because it achieves significant (i.e., order-of-magnitude) improvement in flexibility and performance without any sacrifice in model integration (if anything, effective model integration is improved by the greater security and fault-tolerance provided by TW2). Compared to the existing trade-off curves on which all current BIM model-authoring tools are positioned, TW2 is literally off the chart. This kind of leap in software product design, staking out a new feature/benefit point that exceeds any dimension of the existing product design trade-off curve, is the very definition of disruptive technology.

As pointed out in classic business strategy texts such as *The Innovator's Dilemma*[3] and *Blown to Bits*[4] the hardest hit victims of disruptive technology often are the market leaders of the prior technology. My professional focus is on software behavior as applied to business practice. In other words, I'm not a "code guy," so I don't know enough about the internal software logic of ArchiCAD or any of its competitors to offer an assessment of the ease or difficulty those competitors may experience in catching up to Graphisoft's breakthrough.

However, it is fair to say that Graphisoft's TW2 meets or exceeds nearly all the requested performance, flexibility and reliability improvements that have been demanded in BIM model-authoring tools by a majority of users in A/E firms of all sizes and types in my direct experience. If one assumes that all software vendors exert good-faith efforts to meet the needs of their customers, then the fact no other major BIM-tool vendor has yet offered a breakthrough comparable to Graphisoft's TW2 may point to some inherent constraints in those other vendors' internal product "architecture." Again, I'm not a code guy, but it's entirely possible that the immediate competitive advantage conferred on users of Graphisoft's TW2 technology may prove to be sustainable for several years while Graphisoft's competitors play catch-up on the flexibility and performance front.

In today's challenging global design and construction environment, no user or firm can afford to ignore any tool that delivers real competitive advantage. The possibility that Graphisoft's TW2 may prove a sustainable competitive advantage for several years makes an even more compelling case for any design firm or project team considering or attempting the BIM and/or IPD approaches to (re-)evaluate their choice of model-authoring tool for BIM/IPD.

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[3] Clayton M. Christianson, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business School Press, 1997

[4] Philip Evans and Thomas S. Wurster, *Blown to Bits: How the New Economics of Information Transforms Strategy*. Harvard Business School Press, 2000

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He also writes and edits the *LaiserinLetter™*, an e-mail/Web service providing analysis, strategy and opinion about computer and communications technologies for senior managers in design, construction, facilities and real estate. In addition to the *LaiserinLetter™*, he has served as contributing editor and monthly columnist for *Architectural Record*, *CADence* and *Cadalyst* magazines, and has written for, or been written about in nearly every other significant design and technology publication. In all, his analyses and opinions have reached a cumulative audience of more than a million readers in 138 countries. Jerry has presented seminars on emerging trends in design, construction and facilities to nearly 100,000 professionals worldwide—including leading professional society conventions, trade show venues, international research conferences and talks at major universities ranging from the Harvard Graduate School of Design and Pratt Institute to Georgia Tech and MIT.

Jerry Laiserin has helped shape the agenda for twenty-first century digital practice in design, construction, facilities and real estate. In 1999 he helped launch and served as Interim Executive Director of the aecXML Project, an industry-wide, vendor-neutral initiative for data exchange via the web that was subsequently merged into the International Alliance for Interoperability (IAI) and the National Institute of Building Sciences (NIBS). His career achievements "leading the profession and the industry in the Information Age" were recognized in 2000 by his election to the College of Fellows of the American Institute of Architects (FAIA). In 2002–2003 he helped achieve industry-wide consensus around both the term and concept of "building information modeling" (BIM) as the future direction for representation, simulation and management of buildings. Jerry extended that trend by co-producing and co-presenting the first industry/academic Conference on BIM at Georgia Tech's College of Architecture (2005) and the first BIM4builders™ Conference at the University of Florida Rinker School of Construction (2008).

Jerry is a Brandeis University alumnus with advanced degrees from Princeton University's School of Architecture (M.Arch) and New York University's Stern School of Business (MBA, *with distinction*, ΒΓΣ). Prior to his present technology consulting practice, Jerry was a project architect responsible for design and construction of more than $500,000,000 of building projects (in current US dollars)—ranging from work on the New Jersey Capitol complex and Governor's Mansion to labs for biochemical research. His service to the industry includes past terms on the steering committee of the Association for Computer-Aided Design in Architecture (ACADIA) the Information Technology Council of the International Facility Management Association (IFMA) and the national board of directors of the American Institute of Architects (AIA). Jerry currently serves on the President's Advisory Board for the School of Architecture at Carnegie-Mellon University and on the Editorial Advisory Board of the *International Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies*.