DESIGN YOUR PROJECT ORGANIZATION AS ENGINEERS DESIGN BRIDGES

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Faced with ever-shorter product lifecycles and intensifying global competition, companies producing semiconductors, computers, software, pharmaceuticals, aerospace systems, automobiles, consumer products, financial services and media are striving to shrink their product development cycles. "Rapid Development" or "Concurrent Engineering" approaches in which companies aggressively overlap product design, prototyping, consumer testing and manufacturing, seems like an obvious way to take time out of the product development cycle. Yet, many companies have found that the savings in time that they actually achieve are far less than they expected, and that products developed in this way frequently have serious quality flaws. Witness the long delays in product introduction, and embarrassing "quality meltdowns"—often requiring costly recalls—that have struck companies in aerospace, semiconductors, telecommunications and software over the past decade.

Why the problem? People work as hard as they can. But, by overlapping highly interdependent tasks, projects generate huge—and largely unanticipated—volumes of coordination and rework overhead that overwhelm even the most dedicated product development organizations. This coordination and rework is *hidden effort*: it is not planned, tracked, managed or even acknowledged except by the overworked staff. Managers, extrapolating from their past experience with more sequential product delivery approaches, tend to sorely underestimate the scope and scale of the coordination overhead. As projects fall further and further behind their unrealistic schedules, employees work long hours in heroic attempts to meet impossible deadlines. Product quality inevitably suffers. All the while, traditional project management approaches and tools focus only on direct work, reinforcing managers' overly optimistic estimates, and allowing the inevitable and necessary coordination and rework effort to remain hidden.

Some highly visible examples of "fast-track" project failure to began to show up during the 1970s and 1980s on complex capital projects to develop new facilities rapidly for energy production and semiconductor manufacturing. In both of these sectors, firms were under severe pressure to get products to market faster—to address the energy crisis precipitated by the oil embargo of the 1970s for oil and gas companies, and to avoid rapid technological obsolescence in the case of semiconductors. The companies executing these projects were long-time, sophisticated users of the most advanced project management methodologies and tools. Yet, when they attempted to shrink the durations of their projects by 50 percent or more through aggressively fast-tracking previously sequential development tasks, semiconductor fabrication facilities and new oil production

platforms were coming online months or years late, forfeiting early market revenues worth millions of dollars per day.

Similar problems began to show up in aerospace, software, semiconductors, defense, telecommunications, and other sectors during the 1990s. Commercial satellite launch vehicles in the U.S., France, China and Russia were launched months behind schedule and all too frequently "departed controlled flight," resulting in deliberate detonation of the vehicles and their payloads. Software products from Microsoft, Apple and numerous other vendors were released many months late, often containing bugs effecting security and/or functionality. A minor flaw in the arithmetic computational logic of an early Pentium microprocessor forced Intel to recall and upgrade millions of PCs at enormous cost. And Motorola was forced to recall faulty telecommunications equipment worth over half a billion dollars. These are just a few of the most visible examples of delays and quality meltdowns from some recent, complex product development efforts. Our research indicates that thousands of strategically important, albeit less visible, product development projects worldwide have experienced similar delays, quality meltdowns and cost overruns in the past two decades.

The reason for this is really quite simple. Today, managers plan and assign resources only to direct work tasks. Standard theory and practice ignore the resources that must be spent by the organization in planning and coordinating direct work. But as projects overlap interdependent activities ever more aggressively in an attempt to shorten schedules, the required amount of planning and coordination rises exponentially. Managers' ability to execute the required planning and coordination workload to support direct work then becomes the limiting factor in successfully executing the project. Yet no approaches or tools have been available to managers to help them estimate the "total effort"—that is, the direct work, plus a realistic assessment of the hidden coordination work.

Engineers design their products virtually, in a computer, with quantitative performance predictions based on theory and successful past practice. Managers have no comparable approaches or tools to help them "design" their project organizations in the same way as engineers design their products. Since the late 1980s, our research group has been developing and validating a methodology and software tools to help managers design organizations to successfully execute complex projects. This approach builds on the insight that most product development work is knowledge work. Knowledge work and coordination are both information processing and communication activities. Together, they represent the "total effort" for each position in the organization. Our approach simulates the capacity of each individual or subteam in the project organization to perform its total effort to complete the project, and predicts where information processing bottlenecks will arise, causing delays and quality risks for the project.

The methods, case studies and results of this paper all apply to kinds of complex projects that the organization has performed in the past. We do not try to claim direct implications for novel research projects, project with significant conflict in goals, culture or values, "service and maintenance" activities in which early diagnosis tasks trigger any of a range of follow-on activity, or significant dependence on Internet collaboration among actors who are not part of the project team.

Your company can apply the Project Design methodology and tools we describe here to any complex product/service development project for which the tasks and organization are relatively well understood—even if the work process to implement it has never been previously executed as rapidly—and whose participants' goals, cultures and behavioral norms are reasonably well aligned. This encompasses most capital facility projects, new product development projects, software development projects, and business process/system implementation efforts.

Because it is straightforward, any company can learn to execute this "Project Design" methodology, following four easy steps. First, model the tasks and team—that is, define the total effort associated with the project, and define the information processing capacity of the proposed project organization. Second, simulate the proposed organization executing the work process to identify any backlogs and resulting schedule and process quality risks for the planned or "baseline" project configuration. Third, "flight simulate" multiple alternative management interventions to the baseline case to design a work process and organization that will yield the best tradeoff among product scope, delivery resources and development time. Fourth, revise the model as needed to reflect additional lessons learned from executing the real project, and archive the model of the optimized work process and organization to be reused as a "best practice template" for future projects.

Before that, however, a company must confront and change the "heroic management" culture that pervades many firms in industries with short product lifecycles. Impossible stretch targets, and workplace norms that require employees to work enormous amounts of overtime, and to become "heroes on demand," inevitably lead to employee burnout and loss of product quality. Realistic development targets and a "post heroic" management culture, in which work processes and organizations are explicitly designed for both short-term and long-term strategic advantage, must replace impossible targets and unsustainable cultural norms.

Our research and our personal experiences in bringing this technology into multiple real world project teams, some of which we describe below, show that deploying an aggressive but realistic Project Design approach can achieve both more speed and better quality than setting impossible stretch targets and imposing a heroic management culture on your employees, either deliberately or by default.

Predicting Quality Meltdown on an Aerospace Project

The US military has encouraged commercialization of many of its aerospace technologies and systems. In the mid-1990s, a large defense contractor won the rights to commercialize the design of a missile launch vehicle it had initially developed for the Navy. The company found a commercial customer that agreed to use the adapted missile launch vehicle to carry a telecommunications satellite payload on the first flight test. Thus, one goal was to develop a new, commercial version of the military product that would work perfectly the first time. In addition, the company needed to reduce development and production costs substantially to counter Russian, Chinese and French competitors in the commercial satellite launch vehicle marketplace. Finally, again in response to competitive pressures, the company had the objective to shorten the design and development period radically in comparison with previous practice: The Navy had

given the company *five to seven years* to deliver each new version of the missile launch system; customers for commercial satellite launch vehicles were demanding delivery in *one year!*

Three months into this project, our research group modeled and simulated the organizations and work processes being used by the Structures and Avionics teams, the largest two of the five product development teams involved in this project. The Structures team model predicted no problems. The Avionics team model predicted significant backlogs for the engineering subteam that was to support a new outsourced vendor of cable harnesses.

When discussing the predictions of the model with the project manager, we asked why the company was outsourcing the cable harness subsystem. His answer was, "To save a lot of money." We explained that our Project Design approach indicated that the company would have to devote very large amounts of coordination time during the second half of the project to support the outsourced cable harness vendor on this aggressive schedule—about ten times the level of effort that had been required to support its traditional in-house cable harness subteam in the prior, five-year work process. Our prediction was that resulting backlog for the cable coordination subteam would significantly delay its work and the work of other subteams, delaying the launch date by about four months. Worse, the severity of the cable subteam's predicted backlog—exceeding 50 working days at times—would result in a very high rate of communication failures for this group, creating a severe product quality risk for the cable harness subsystem. "What-if" analyses from the Avionics Team model showed that increasing the size of the cable harness subteam from three to five engineers, and raising the skill level of the engineers assigned to this subteam, could both reduce delay and mitigate quality risks for the entire project at minimal extra cost.

This was an early, experimental test of our Project Design approach, so the company's project team leaders understandably declined to make mid-course changes in the project organization or outsourcing strategy in response to these predictions and recommendations. The vehicle was finally launched four months late—within a few days of the completion date our Project Design method had predicted a year earlier. It rapidly "departed controlled flight" and had to be detonated by the mission safety officer, destroying both the vehicle and its commercial payload. The company's published analysis of telemetry data from this failed launch vehicle identified the most likely cause of the failure to be a cable harness that had been misrouted too close to a high temperature source, causing its insulation to melt and the wires to short-circuit—a literal "quality meltdown"!

In retrospect, our Project Design approach had predicted the cause and extent of completion delay and had correctly identified the most likely coordination risk at the outset of this one-year project. The senior project manager for this project acknowledged the accuracy of the Project Design predictions in a post-mortem debriefing meeting. Managers on a subsequent project of this company attended to organizational risk

warnings and followed several recommendations emerging from a similar Project Design exercise[1].

The Hidden Overhead of Rapid Product Development

Experienced managers in your organization may believe that they can accurately predict the resources and time required for rapid product development. But the fact is, most managers almost always significantly underestimate the extra managerial effort required to radically accelerate a project. Witness manager's dismal success record in achieving aggressive cost and schedule targets for projects ranging from fast-track IT infrastructure projects like e-commerce platforms or ERP system implementations to civil works infrastructure projects like the Trans Alaskan Oil Pipeline or the Channel Tunnel.

Although managers often complain about coordination and meeting time, they do not adequately plan for it. That's because, when people rely on their intuition, they tend to extrapolate linearly from their past experience. But intuition fails managers when they attempt to extrapolate their experience to projects for which many interdependent tasks must be both shortened by unprecedented amounts and executed much more concurrently. Even with relevant implementation experience and today's tools, managers simply do not foresee the tidal waves of coordination and rework that go with any complicated project conducted much more concurrently. What manager, for example, would have predicted that accelerating the schedule for the launch vehicle described above would cause extreme information processing overloads for the subteam managing a relatively small outside contractor developing cable harnesses?

By assuming that a project can be radically accelerated simply through assigning enough additional workers to project tasks, your company is ignoring the critical role of midlevel managers in dealing with the extra coordination required for complex projects. The pressure on middle management is exacerbated by repeated efficiency drives that have almost rendered middle managers extinct in many organizations. When scarce and over-worked mid-level project and program managers become bottlenecked, they take so long to answer technical questions and resolve coordination issues that the issues eventually "time out" and workers assume "delegation by default"—that is, they make their own best judgments about how to proceed. Meanwhile, senior managers in the organization are left with a false sense of security that technical questions are being answered and interdependent tasks are being coordinated.

As your project proceeds in this "default-decentralized" mode, problems start to build up. First, unanswered technical questions result in a higher risk of quality problems for particular components or subsystems. Second, uncoordinated interfaces between subsystems lead to a higher risk of system-level incompatibilities or failures. These coordination failures trigger new issues and questions, which further backlog managers; and so on. In this way, default delegation not only delays project completion, but also triggers a progressive "quality meltdown," both for specific subsystems like the cable

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[1] This early test of our Project Design approach is more fully documented in Kunz et al, "The Virtual Design Team: A Computational Simulation Model of Project Organizations," Communications of the Association for Computing Machinery, November 1998, pp. 84-92.

system in our aerospace example above and for the overall product or service being developed.

To compound these problems, project organizations tend to be "learning-disabled" by nature. Team members generally scatter at the end of a project, so that any tacit learning about how to organize and execute the project better the next time disperses with them. Lacking either documented past experience or analysis tools to predict the real schedule and resource requirements for their projects, managers resort to setting aggressive targets that they may suspect are somewhat unrealistic, and they explicitly or implicitly demand brutally long work hours and other kinds of heroic behavior by team members to achieve these targets. This, we argue, is the basis for the culture of heroic management in many companies whose core technologies and products evolve rapidly, and whose strategic and management approaches for getting products out faster have been chronicled by several previous HBR authors[2].

Compare the haphazard trial-and-error approach for developing and evolving project organizations to the way engineers design their products, ranging from software, biopharmaceuticals and semiconductors to bridges and airplanes. One-off clients or internal marketing groups define the business goals for a product or service to be developed. Engineers then follow a well traveled path in which they: derive the loads or functions that the system must support from the specified business requirements; define and model the components of an initial candidate solution to address these goals; and use a variety of analysis tools to predict the behavior of the candidate solution. If the predicted behavior of the candidate solution does not meet desired goals, engineers attempt to change elements of the system and re-analyze the revised solution. They may iterate through this process dozens or hundreds of times until they find an acceptable tradeoff among performance objectives, resources and time. In effect, the engineers are defining, and then virtually manufacturing and testing, multiple "virtual solutions" as they iterate through a typical design process. Their companies can then proceed to manufacture the actual products or deliver the actual services with a relatively high level of confidence that they will meet their real world performance requirements.

Spurred by companies like Intel, which was striving to accelerate the development of semiconductor fabrication and automated assembly/test facilities in which to produce its fast changing microprocessors and related products, we began in the late 1980s to develop an organizational analysis approach and software tools that project and program managers could use to design their project organizations in the same way as engineers design buildings or semiconductors. In its first real world test, our Project Design approach accurately predicted both the four-month schedule delay and the specific cable harness system that was most likely to experience quality meltdown for the aerospace project described above. Following this successful test of our research approach and software in 1995, our "Virtual Design Team" (VDT) methodology and software have been used commercially to design the work processes and organizations on more than

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[2] Wheelwright and Clark suggest that a portfolio approach can support faster product development in: Steven C. Wheelwright and Kim B. Clark, "Creating Project Plans to Focus Product Development," *Harvard Business Review,* March 01, 1992. See also: Kathleen M. Eisenhardt and Shona L. Brown, "Time Pacing: Competing in Markets That Won't Stand Still," *Harvard Business Review,* March 01, 1998.

100 highly concurrent projects and programs across a spectrum of industries ranging from semiconductors and consumer products to pharmaceuticals and offshore oil fields, and including the multilateral organization set up to build a permanent containment for the failed Chernobyl nuclear reactor.

Theoretical framework

In the 1970s, Jay Galbraith[3] described how managers of complex, fast-paced projects could become overloaded by large numbers of "exceptions"—non-routine situations in which workers lacked sufficient information to proceed with a task, and so needed to ask their managers for advice. Galbraith qualitatively described four generic strategies that organizations could adopt when managers became overloaded with exceptions. To reduce the demand for exception handling, managers could create self-contained tasks and/or decentralize decision-making. To increase the organization's capacity for exception handling, they could invest in enhancing vertical and/or lateral information processing systems. Galbraith's "information processing" view of organizations has been influential in advancing the theory underpinning organization design. But its prescriptions are neither quantitative nor specific. While they provide broad and general insights to scholars of organizations, they cannot provide specific prescriptions to managers.

Existing macro theories such as Galbraith's relate gross features of the process and the organization to aggregate project performance outcomes. We built the Galbraith information processing view of organizations as a micro-theory in the computer. Our micro theory models the effects of task and organizational variables on low-level behaviors of individual team members and then simulates behaviors and interactions among team members to generate aggregate project outcome predictions from the bottom-up.

We model actors (groups of 1 or more workers) working on tasks (one at a time), coordinating and doing rework as needed.

> ➤ Simulated tasks have the normal "sequential" dependency in which one task must precede another. The simulation sends work to the actor responsible for the first task in a project. When the task completes (in the computer simulation), the simulator initiates work on its successor tasks, and so on until the simulator simulates completion of each planned task by its responsible actors.

> ➤ Pairs of simulated tasks can also have coordination-dependency: i.e., the simulator sends responsible actors for coordination-dependent tasks (probabilistically) coordination work packets to process while these tasks are active.

> ➤ Pairs of simulated tasks can also have "rework dependency": The simulator sends the actor responsible for dependent tasks rework to do when the independent task (probabilistically) fails.

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[3] Jay Galbraith, "Organization design: an information processing view" *Interfaces 4:3,* May 1974, pp: 28-36.

➢ When a responsible actor (probabilistically) encounters an exception, it asks its supervisor for guidance on how to proceed, giving supervision workload to its supervisor. As supervisory actors become backlogged, primary actors wait for answers—another source of hidden effort. Excessive supervisor delays in responding to exceptions trigger delegation by default and increase error rates for downstream work.

➢ Our micro model also includes the effects of the organization's decision-making policies, and other task and team characteristics of the specific project. For example, actor behaviors are influenced by: decision-making policies such as centralization and formalization, the match between available vs. required skills, prior team experience working together, and the availability of different coordination technologies.

Based on our conceptualization and implementation of the Galbraith theory, our Project Design approach simulates the direct work and the hidden work, i.e., the coordination, supervision, rework and waiting for all the actors in a project as they perform all of the project tasks (as shown in Figure 1). The simulator sends work to an actor when it is scheduled, and the actor then processes the work, one item at a time. When direct work items, plus coordination, supervision, rework and/or waiting work items, arrive faster than the actor can process them, backlogs start to build up. As explained above, these backlogs not only delay the completion of that actor's own work, but also propagate to other actors through waiting time, missed communications, etc. The simulator reports the predicted total effort (Figure 2), task durations, and other cost and quality metrics (e.g., Figure 3) for actors, tasks and the project as a whole[4].

How to Design Project Organizations

We next describe the application of our VDT Project Design methodology, and illustrate it with a case study of rapid development of a custom chip for a personal digital assistant (PDA).

In January of 1998, a newly formed PDA company—let's call it "Somersault"—was developing a new handheld personal organizer to compete with existing products in the marketplace. To meet its business plan, Somersault needed to have about a dozen working prototypes of its initial product completed and ready to show at the next Comdex trade show in November of 1998. To meet this extremely aggressive development schedule, Adele Davidsen, Somersault's Senior VP of Product Development, determined that her project team needed to have the custom microprocessor for its new PDA completed by the third week in May. A typical development schedule for an application-specific integrated circuit (ASIC) of this complexity was over eight months at that time. Michael Levoy, the ASIC team project leader, and his key technical staff members were confident that they could get the ASIC developed by the end of May—i.e., in about 60% of the typical time for a chip of this complexity. However, this project was so critical to

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[4] A more complete description of our Project Design simulator can be found in Yan Jin and Raymond E. Levitt, "The Virtual Design Team: A Computational Model of Project Organizations," *Journal of Computational and Mathematical Organization Theory 2 (3)*, Fall, 1996, pp. 171-195.

implementing Somersault's strategy that Adele was not willing to bet the company on their intuitions. She wanted to carry out an independent analysis, to reassure herself and her managers that Michael's team could feasibly execute this aggressive development schedule before going ahead.

We will step through the process that Michael's project team followed in designing the Somersault 1 project work process and organization to: (1) provide Adele with the executive-level sanity check of the team's estimate that she wanted; and, (2) redesign the work process and organization as needed to increase the odds they could deliver a high-quality product on this aggressive schedule.

Step 1
Define Baseline Work Process and Organization

Michael's project team, working with a Project Design consultant, first defined and documented their baseline assumptions about the work process and organization for developing this custom chip. The first step was to identify critical business milestones for this project, beginning with the final completion milestone. In this case, the completion milestone was *Fabricate, Test and Deliver.* Two intermediate milestones were *Logic Release* and *Layout Release.* Once the team had defined these three milestones, they defined five to ten activities that would enable each milestone and estimated the direct work volume and the type of skill required to perform each task. The team had no trouble developing this high-level plan. They next defined the sequences of these tasks and milestones, to understand which tasks they were planning to perform in parallel, versus in sequence.

The team's workflow model is shown in the lower part of Figure 1 (blue hexagons show the milestones, yellow boxes show the tasks, and black arrows show the task precedence links). Up to this point, the workflow model is similar to that used by traditional project scheduling tools. However, to capture the coordination work load that would arise from this extremely concurrent schedule, Michael's team augmented its task precedence model with two additional kinds of relationships between tasks: *Communication Links* and *Rework Links.* Communication Links (green two-way arrows) show that two tasks have tight technical interdependency, and will need to be tightly coordinated if they are executed in parallel.[5] Rework Links between two tasks (one-way red arrows) indicate that any exception—an unexpected change or error—significant enough to require rework in the first task will trigger compensating rework in the second, "rework-dependent" task.

This complete Project Design workflow model captures the "total project effort"—that is, all of the information that needs to be processed to execute the project. This includes the *direct work,* plus all of the required *communication work* to coordinate interdependent tasks, the *supervision work* to answer workers' questions, and an allowance for the *rework* that will propagate between parallel tasks as changes or errors

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[5] The type of interdependency shown by the green arrows is what James Thompson termed "reciprocal interdependency" in his classic organization design text, *Organizations in Action,* McGraw-Hill, 1967.

occur. This intuitive, graphical task and organization model, drawn on a whiteboard or the computer, helps each individual identify the work that must be performed, and it helps the team understand how different groups and tasks share precedence, coordination, supervision, and rework interdependence throughout the project.
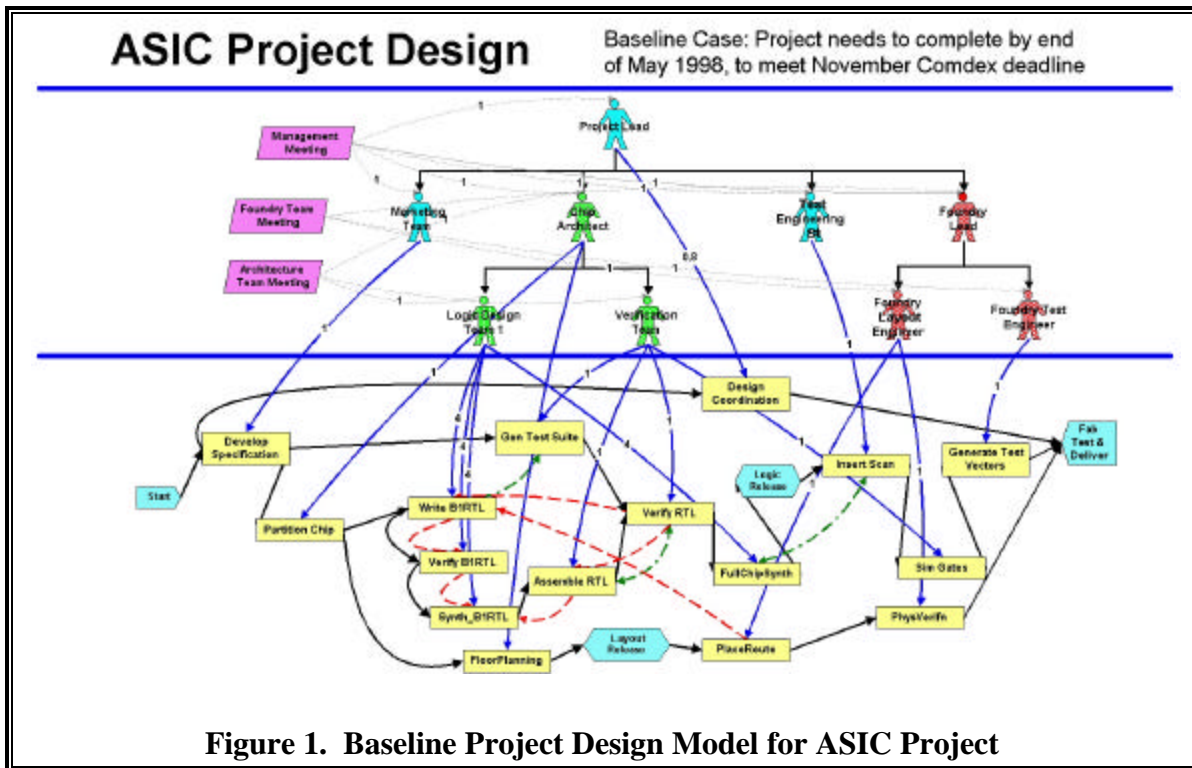
Figure 1. Baseline Project Design Model for ASIC Project

Having modeled the "total effort" for the project, Michael's team now modeled the project organization's information processing capacity to execute the total effort for his project. First Michael and the consultant modeled the participants in the project team. For each *Position* in the organization (staffed by an individual or a subteam of several persons with similar skills), Michael described the total number of full-time equivalent persons, and listed the set of project-relevant skills and skill levels that each person or subteam possessed (at a *high, medium* or *low* level). For example, the Chip Architect position was allocated one full time equivalent person (1 FTE), who had high *Logic Design* skill, medium *Floorplanning* skill and medium *Design Coordination* skill. Michael then described the team's reporting structure. The *Chip Architect*, the *Foundry Lead*, the *Marketing Team* and the *Test Engineering Team* reported to Michael, who filled the position of Project Lead. The Chip Architect and Foundry Lead each had two subteams reporting to them. Meetings also take time and need to be factored into a total effort analysis. Michael identified all regularly scheduled project meetings that he would expect to hold (purple boxes at the upper left) and the team members who needed to

attend these meetings (gray dashed arrows). The Project Design organization model is shown in the upper half of Figure 1 (above the blue line) in which person icons represent the positions and the black lines describe the project reporting hierarchy.

The team then linked the workflow model to the organization model. They assigned each task to one, and only one, responsible position. The blue arrows in Figure 1 show these assignments of responsible positions to tasks.

Finally, Michael described his company's decision-making policies for projects. He assigned *a medium* value to *Centralization* (how high up in the organization decisions get made); a *low* value to *Formalization* (to what extent team members would wait for meetings to coordinate, versus initiate ad-hoc queries to one another); a *high* value for *Matrix Strength* (the degree to which different disciplines on this project would be collocated versus located in separate functional groups); and a *medium* value for *Team Experience* (the extent to which members of this team had previously worked together). The consultant explained that each of these parameters affected the micro-decision-making behavior of workers, subteam leaders and project managers, and so would have an impact on which parts of his project team, if any, would become backlogged while executing this ASIC project.

The baseline project model was now complete. Adele and Michael could now simulate Michael's team executing the project, and assess the realistic delay and process quality risks associated with the proposed work plan and organization for the project.

Step 2
Simulate Project to Assess Risks for Baseline Case

Simulating the baseline plan for the PDA ASIC team produced a nasty surprise for Michael and Adele. When the total effort to accomplish this ASIC project was taken into account, the completion date would likely be in mid-September, even though a traditional "direct work-only" analysis had predicted it could be done by the end of May, as required. Figure 2 showed that overlapping logic design, layout and fabrication tasks as planned would trigger large amounts of coordination and rework for many activities— comparable to, or exceeding, the amount of direct work for some tasks like *Synth_B1RTL* (= Synthesize Block 1 Register Transfer Logic) and *Verify RTL*.
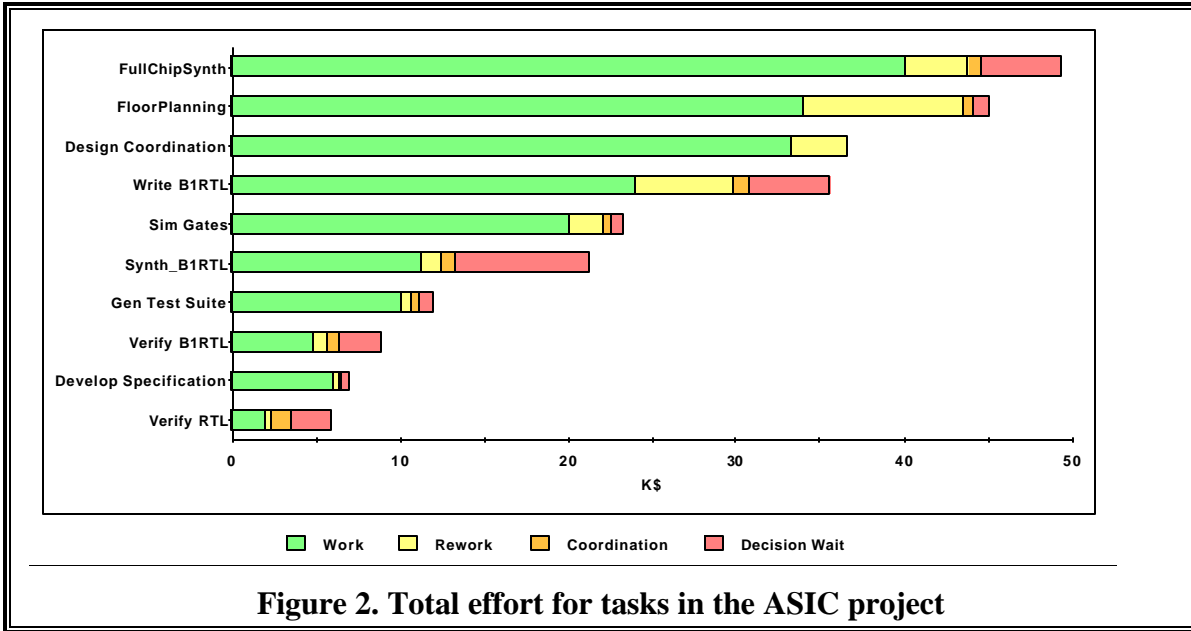
*** Insert Figure 2 about here***

Figure 2. Total effort for tasks in the ASIC project

The VDT simulation predicted that the Chip Architect would become the worst bottleneck in this project team, falling behind by as much as eighteen working days during the middle of the project from a combination of doing his own work, coordinating with team members responsible for interdependent tasks, answering questions from his subordinates when they needed assistance, and attending project meetings. Worse, the simulation indicated that several tasks were likely to have severe Process Quality Risks, as backlogged team participants focused on catching up their own work and missed coordinating with interdependent colleagues or attending meetings. Figure 3 shows that, for the *Generate Test Suite* task performed by the *Verification Team* and the *Write B1RTL* task performed by the *Logic Design Team,* there was risk that more than 50 percent of work-related communications would be missed! The consultant informed the team that communication quality risks above 50 percent had been correlated with serious failures in the past (including the cable harness system for the launch vehicle described above), and would thus become issues to be addressed in a project redesign.

*** Insert Figure 3 about here ***

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Figure 3. Predicted Communication Risk for ASIC Project Tasks

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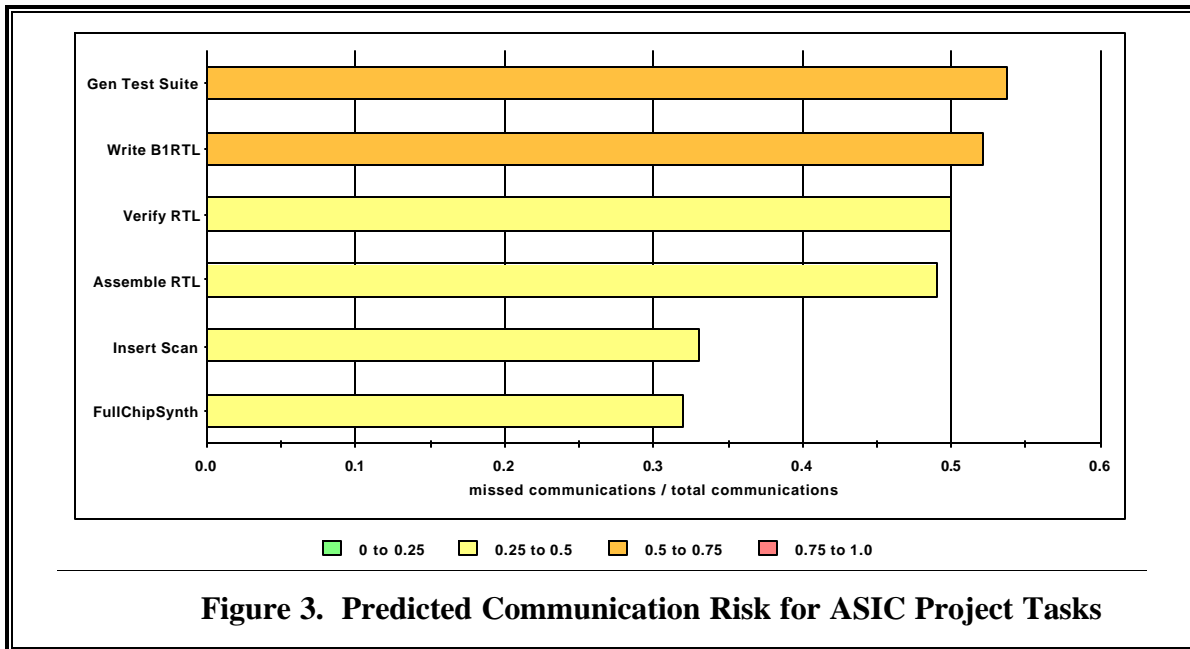
Step 3
Flight Simulate Alternative Management Interventions

Faced with convincing evidence that their initial project schedule was unrealistic, Michael and his team began to think hard about the kinds of proactive interventions that they could make to mitigate these organizational risks and increase the project's likelihood of success.

Michael and his direct reports proceeded to iterate through a number of possible interventions by having the consultant model each intervention and "flight simulate" it (i.e. model and simulate the results of each intervention in just a few minutes) to predict its effect on project performance. They found that adding additional capacity to the *Chip Architect* position would shorten the project schedule by about three weeks. The *Verification Team* and *Logic Design Team* became the worst predicted bottlenecks in the project. Adding additional capacity to these two positions could further reduce the schedule, but the predicted project completion was still early August, nowhere close to its May deadline.

In *The Mythical Man-Month,* a classic study of the project to develop the operating system for an early IBM mainframe computer, Brooks explains why "throwing more bodies" at a delayed knowledge work project can be a futile way to try and accelerate it. Some tasks are simply not divisible, and new team members consume the time of existing team members in being brought up to speed, so that adding further staffing can sometimes actually further delay the project. Michael's team found that three additional full-time equivalent staff was all that the team could productively absorb, yielding an early August completion, still more than two months behind the target date.

Michael's team next explored the possibility of reassigning some tasks from the most backlogged positions to other team members who had the appropriate skills for those tasks, but who were less backlogged. Reassigning three such tasks took only one more week out of the project duration.

The team now began to look at other kinds of interventions. They modeled and simulated the effect of changing skill levels for particular positions. In particular, the skill level of the Verification Team was lower than they would have liked, so they considered outsourcing the verification activities to a consulting firm that could provide high skilled ASIC verification engineers. They learned that this could save another three weeks on the project and improve the Communication Risk significantly, at only nominal additional cost.

Changing decision making policies did not help much in this case. Changing the level of Centralization from *Medium* to *Low* would accelerate the project by a few days, but would also increase Communication Risk unacceptably for some key tasks.

So the team had exhausted the organization and work process changes that its leaders felt were feasible to implement, and was still looking at a mid-July completion vs. the target date of late May. The consultant had seen this situation in numerous previous Project Design sessions. She proceeded to ask Michael and his subteam leaders whether there was any way to simplify the technical design of the ASIC, without compromising its ability to meet critical business requirements. After a painful round of discussions among the team leaders, they concluded that they could reduce the clock speed of the chip. The speed of the chip that they were planning to use significantly exceeded its usage demands in this device. A slower—but still technically adequate—clock speed would greatly shorten and simplify chip layout and floorplanning tasks.

With this technical change, and assuming that three additional full-time equivalent staff were added to the team, and verification tasks were outsourced, the simulation indicated that the team could meet its completion milestone in the third week of May with acceptably low process quality risks.

Through this systematic and repeatable Project Design process, Michael's team identified a feasible plan to meet the aggressive delivery milestone for its project, with a slight rescoping of its technical requirements, a minimum of additional staffing, and a small amount of focused outsourcing. The project actually completed in the second week of May 1998, and the prototype for the product was subsequently presented at the November 1998 Comdex trade show.

Step 4
Refine and Archive Model to Capture Lessons Learned

Once an optimal Project Design has been developed and validated through experience, it becomes a valuable means of capturing and reusing the otherwise tacit work process knowledge the team has gained, both through the Project Design process and through subsequent real world experience. Validated project models then serve as "best practice templates" that managers around the world can localize to fit the unique circumstances of their own similar projects.

A best practice project template reflects the ideal work process and the ideal team structure and staffing for a given type of project. The managers of a subsequent project can customize the template in two ways: They can add or delete tasks to better reflect local requirements, such as getting special permits that are required in a given country. And they can adjust the numbers and skill sets of the ideal positions to reflect the backgrounds of the people who are actually available for the project. In this way, they can quickly localize the template and assess the impact of any locally required tasks or skill deficiencies of locally available team members.

A US-based global computer company used our Project Design approach to optimize the design of its organization and work process for starting up new domestic factories. The company was planning its first factory start up in Ireland to serve the European market. Since this was the company's first European factory, local team members understandably had lower levels of skill and experience than the "best practice" U.S. team. Most of their prior experience was limited to managing the logistics of European distribution for computers and peripherals assembled in the U.S. and Asia.

The project manager for the Ireland factory start-up reviewed the company's best practice factory start-up template and adjusted the task and organization model to fit local assembly practices, which were different than those of the US. He also lowered the assumed skill levels for many positions in the template to reflect the fact that the European group had not yet developed the skill level of the experienced home team. He simulated the localized model to predict the project outcomes. The predictions of the localized best practice template convinced the manager that the schedule and quality risks of carrying out the factory start-up with only local staff were acceptable but not desirable. Because the manager could reuse the company's best practice template with only modest changes, the modeling and simulation process to do this organizational risk assessment for the project was carried out in one morning.

During the afternoon, the manager simulated about 15 different configurations of the Ireland start-up project with higher skills assigned to specific positions, and was able to determine that bringing out four experienced factory start up engineers from the U.S. to fill particularly critical roles in the 43-person Ireland start-up team could give him a performance level almost equivalent to U.S. best practice, at a fraction of the cost of relocating an entire U.S. start-up team. He executed the initial factory start-up with the hybrid, Irish-US organization he had designed, with excellent results. The global team members reported that they understood the basis and the performance implications of variations in local practices for the first time, and each local manager learned valuable methods from the others.

Social Benefits of Project Design

We have shown how Project Design, carried out with the managers of your company's critical strategic projects, allows them to predict risks of schedule delays and quality meltdowns early on, so they can proactively intervene to mitigate these risks. We have also shown the ability to predict the quantitative benefits and costs of specific proposed management interventions. And we have described how Project Design allows your company to capture and archive knowledge gained about its most successful work processes and organizations, and then retrieve and localize these "best practice project

templates" for reuse on subsequent projects. We next discuss some valuable additional benefits that accrue to a project team when the entire management team engages in Project Design collectively, as a social process.

Develop shared mental models

A computer component manufacturer built an organization and work process model at the launch of a major new product development initiative. In one day, the major stakeholders—including the VP, who was the project sponsor, the project manager, and key functional leaders—specified the project business milestones, the major tasks to meet those milestones and the staffing. By the end of the day, simulation results showed a major staff imbalance: some tasks were overstaffed; others understaffed. One engineer showed visible relief when her management observed that she was going to be a bottleneck and that she would need to be freed of some ongoing responsibilities.

The project team fixed most problems quickly. The VP committed to resolve a few others. At the end of a day and a half, all of the team stakeholders reported that they understood the business drivers of the project, the milestones, the plan, and the structure of the team. They felt that they understood the project better after the 1-1/2 day modeling and analysis exercise than they normally did after a month or two of work on a new project. They said that they believed that they could work successfully to meet the scope-schedule-budget objectives, and they publicly committed to doing so. The presence and shared understanding of the risk-owning VP project sponsor motivated the team to complete the project successfully.

Garner strong commitment to realistic project goals

A biopharmaceutical company planned a major new facility to support growing business demand. When the corporate sponsor restarted the project, after stopping work on the project for the second time to reevaluate the effect of changing market conditions, he asked the project team to meet the revised objectives within the initial design and construction schedule. Simulating the project and organization model quickly showed the project manager that the design team was understaffed to do this. The predicted backlogs and high schedule and quality risks for specific individuals and teams convinced the design team's sponsor of the legitimacy and urgency of its request to increase staffing, even at the expense of other ongoing projects. The model analysis enabled the sponsoring manager to convince senior management in three collaborating companies to act quickly to increase staff.

As the design phase proceeded, the process model showed all stakeholders the amount and impact of specific predicted coordination demand as new tasks were initiated week-by-week. The integrated design team held team members publicly accountable for starting and finishing tasks according to the jointly agreed schedule. Every one to two weeks during the design process, teams explicitly identified their current and upcoming dependence on coordination support from both the client and peer subteams, and they were also publicly accountable for providing this coordination support in a timely fashion.

When this Project Design process was started, the percentage of timely initiation and completion of tasks was 20-30%. Within a few weeks, team members stated to make reasoned and proactive requests in status meetings for coordination support, and they soon consistently reported 70-85% timely task initiation and completion. The overall design completed within the revised, but still aggressive, schedule allowed by management, and construction proceeded ahead of schedule.

Another computer manufacturer had a highly aggressive plan to launch an innovative new product family. The team developed a project and organization model, carefully calibrated its performance to meet a "believability" test of management, and then repeatedly intervened in the Project Design to improve workflow and reduce schedule and quality risks. In spite of a number of successful interventions during the first phase of the design project, the simulation model predicted that the schedule objective would not be met. Backed by careful analysis of project constraints and extensive graphs showing projected risks, project management recommended to top management that they reduce the project's scope requirements, while simultaneously starting development of a high-performance follow-on to the initial product. The company successfully launched the product on time with less aggressive performance than originally specified. It quickly followed the original version with a follow-on product that met the more aggressive functional goals and thereby established a major new line of business.

Transform ego-based conflicts into fact-based discussions

In the late 1990s, a global consumer products company was developing an innovative new consumer product that involved aspects of its paper goods technology used in making products like paper towels and diapers, together with its chemicals technology used in making products like toothpaste and shampoo. The expertise for these two areas came from different parts of the company with quite different cultures about the need for meticulous and lengthy consumer testing to discover all possible safety concerns (on the "wet" chemicals side), vs. the need to get innovative products to market rapidly to scoop competitors and gain early market share, and then fix any product bugs in follow-on products (on the "dry" paper goods side).

Working with members of the two groups separately failed to reconcile the two work process sub-models. The team leader finally decided that the only way to reconcile these differences was to convene a joint Project Design session involving sixteen senior managers drawn from the two teams in a conference room equipped with a computer projector to display the project model and charts of its predictions. When we assembled the team in this room, a heated debate erupted. Two of the paper goods managers argued passionately that the team should freeze product specifications based on the results of early, small-scale consumer tests, and immediately place orders for the custom, "unit operations" manufacturing equipment (which required almost eighteen-months lead time) in parallel with ongoing consumer testing. The chemical group managers argued equally emphatically that the product involved unproven technology and might cause unanticipated injuries to customers, and so should be more extensively consumer-tested before committing to specifications and ordering equipment.

The consultants called for a truce, and then proceeded to display and simulate the cautious vs. fast-track approaches advocated by the two groups with the entire team watching and participating. To our surprise, this "project flight simulation" process was transformational. Conducting this exercise as a social process in real time gave all team members present the ability to view graphical representations of two different project models so they could collectively understand the assumptions inherent in each. And their ability to get virtually instantaneous graphical feedback on the implications of each approach immediately changed the tone of the meeting from confrontational and argumentative to constructive and problem-focused.

In about two hours, the project team was able to present and discuss the assumptions, costs and risks, vs. the revenue, ROI and market share benefits of the two approaches: The fast-track approach yielded an earlier product release date, at the cost of increased coordination effort for the team, and increased risk of costly late-cycle changes to the manufacturing equipment. The more cautious, sequential approach yielded significantly lower expected costs for the manufacturing equipment through reduced risk of rework, and lower coordination costs from less aggressive fast-tracking of tasks, but delayed the product release date by four months. The group discussed the value of four months of early market revenue, and the long-term increase in market share that they would enjoy from being first to market with this product. The "wet-side" team members became convinced that the risks of additional coordination effort and cost for possible late changes to the manufacturing equipment were a small price to pay for the gains in time to market from using the fast-track approach. Moreover, their review of the assumptions in the fast-track work process convinced them that any needed changes to the product to address safety concerns could still be addressed through late cycle rework—albeit it costly—to the manufacturing equipment.

Michael Schrage's recent HBS book, *Serious Play,* describes and illustrates exactly these kinds of benefits for a wide range of business modeling and simulation approaches and tools. So, it is perhaps not surprising that the same benefits would show up for simulations of project teams executing fast-track work processes.

The successful results of a formal approach to plan and execute complex projects speak for themselves. The ability of a project manager or entire project team to model and simulate the performance of an organization executing a complex project has multiple benefits. Aside from proactively identifying and mitigating schedule and quality risks, team involvement in collectively modeling and simulating alternative approaches for executing a project builds shared understanding, increases commitment of team members to achieving targets, and can help to channel ego conflicts about preferred approaches into productive problem-solving to discover even better approaches. In all of these ways, the Project Design methodology we have described transforms the traditional trial-and-error process of planning and implementing strategic projects into a manageable, repeatable design discipline.