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TASK PARTITIONING:
AN INNOVATION PROCESS VARIABLE

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ABSTRACT

It has long been reasoned that there is an inherent interdependence between some production tasks, and that this can influence how production should be organized for efficiency. Thus, it has been shown that the close integration of steel-making and steel rolling can reduce the costs of steel production by reducing the need for reheating materials in process.

Specialists in engineering design have shown that there is also an important form of interdependence between elements in engineering design tasks - interdependence with respect to problem-solving. In this paper, I generalize and build upon this observation to point out that problem-solving interdependence is an important but currently unexplored aspect of many or most innovation tasks ranging from the design-build interface to the marketing-R&D interface.

Problem-solving interdependence can vary as a function of how tasks are specified or "partitioned" in a given innovation project. I propose that understanding and managing task partitioning can increase the efficiency and effectiveness of innovation project work. I suggest that potential high task interdependence with respect to problem-solving can be predicted in many projects, and can then be managed (1) by changing the boundaries of affected tasks, and/or (2) by taking steps to improve problem-solving communication among affected tasks. Finally, I note the potential value of the innovation task partitioning concept to a number of areas of innovation process research, and offer some suggestions for further work.

¹ I am indebted to Anne Carter, Professor of Economics, Brandeis University, and to Dietmar Harhoff, PhD Candidate at the MIT Sloan School of Management, for their thoughtful critiques of this paper.

1.0: Dividing An Innovation Project Into Tasks

An innovation project of any magnitude is divided up ("partitioned") into a number of tasks and subtasks that may then be distributed among a number of individuals, and perhaps among a number of firms. When the partitioning process is complete, the component tasks and their interfaces are specified - implicitly or explicitly - so that all will fit and work together to form the total project when combined. Such specifications say in effect: "This is the nature of Task X. These are the inputs it will or can receive from other parts of the project; and these are the outputs it must provide to specified points in the project at specified times." Note that this partitioning process focuses on the innovation work itself, and not on the product or process resulting from that work. For example a new product may physically consist of components A and B. But the innovation project tasks leading to the development of that product may have been partitioned according to different boundaries, and it is the latter we are concerned with here.

Small innovation projects may be partitioned into tens or hundreds of component tasks. Large projects may be divided into thousands or even tens of thousands of such tasks, woven into an intricate network of interrelationships.

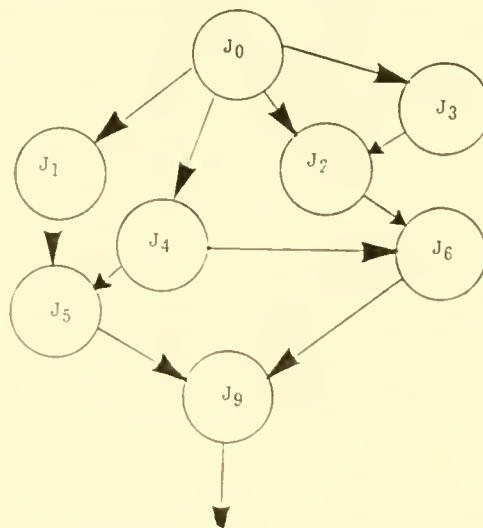


Figure 1: Schematic of Simple Project Task Network

Figure 1 shows a simple project task network in schematic form. Here, tasks (or groups of tasks) are shown as circles or nodes, and interconnecting lines show the nature of task interdependencies - that is, show that the outputs of some tasks are required as the inputs of others.

Task networks can be drawn at a number of levels of aggregation depending on one's purpose. For example, if one is planning to manage the start-up of an entire auto company, "develop car model X" may well be shown as a single activity in a complex task network. But managers responsible for that project only might well devote an entire network to related tasks - perhaps to the level of detail of "develop front left door of car model X". Then, those in charge of door development work might in turn develop a network consisting of tasks at the level of "develop door locking mechanism", and so forth.

There are many different ways to partition a given project. Thus, in the instance of the "develop car model X" activity mentioned above, project participants might decide to specify "develop left front door" as a task, or they might decide to specify "develop left side of car" as a task and then specify subsidiary tasks such as "develop windows"; "develop door locks"; etc., in a way that never isolates development of the door itself as a separate task. The actual partitions chosen in a given project are at the discretion of project managers and participants.

2.0: Task Changes, Problem-Solving Interdependence and Efficiency

Project managers specify tasks and their interrelationships so that they can distribute innovation effort across people and organizations, both in parallel and in series with respect to time. It is the assumption that task boundary (input and output) specifications will be relatively stable as a project proceeds that allows project participants to focus on their own tasks, with some assurance that their

output will properly mesh with the output of others to comprise the total intended project output.

Yet changes to initially-established task specifications and interrelationships are often required during the course of a project because planning errors were made, or because new information is introduced that was not available at that project's start. In the instance of innovation projects, changes for the latter reason are especially likely, because the core function of many innovation project tasks is precisely problem-solving and the generation of new information.

Changes caused by a single new information "event" may be restricted to only one task, or may affect the task network more widely. For example, suppose that a task in an auto development project involves research directed towards developing a very fuel-efficient engine. And suppose that research reveals that the originally-planned approach to that problem will not succeed. Then, one might devise a new approach to achieving that same goal, in which case no other task need be affected by the new information. Or, one might decide that one will change other tasks or their interrelationships to compensate for the shortfall and maintain overall project performance. (For example, one might decide to try and lower friction in the drive train, and/or try to decrease the weight of the car to meet the original goal for fuel efficiency.) In this latter case the response of project participants to the new information clearly involves more extensive changes in the original task network.

With this example in mind, let me define the interdependence between any two innovation project tasks with respect to problem-solving as the likelihood that efforts to perform one of the tasks to specification are likely to spill over and require coordinated problem-solving in the other. The higher this probability in a given instance, the greater the problem-solving interdependence.

Changes introduced to task specifications after project work is underway can be costly because they often make work already done valueless, and/or may degrade the solution ultimately arrived at, as task work groups strive to "save" work already

done by making suboptimal adaptations to change.

I propose that the cost of such changes will be less, other things being equal, if task boundaries are arranged to reduce the problem-solving interdependence among project tasks. (Note that such partitioning changes will not necessarily reduce - or increase - the amount of problem-solving required in a given innovation project. They simply affect how that problem-solving is distributed among tasks.)

The rationale behind this proposal is simply that problem-solving involves communication and coordination among problem-solvers. It seems reasonable that any barriers, such as task boundaries, placed between such problem-solvers will add to the cost of their efforts. Empirical research by Allen offers some preliminary support for this idea. Among the barriers commonly put into place between personnel engaged in different tasks are physical distance and formal organizational barriers (e.g., membership in different groups). Allen has empirically examined the effect of both of these barrier types and has found that members of R&D laboratories separated by either communicate far less frequently than do members not so separated.(1)

Additional support comes from earlier work by researchers studying engineering and architectural design - one type of innovation project task. Some studying in these fields have found it reasonable to argue that the interdependence of elements in a design problem differ, and that elements having a higher interdependence will be harder to "solve". Thus Alexander (2) (who may have been the pioneer in this line of argument) has suggested that incremental adjustments over time to products with a traditional design (for example, a house design that is traditional in a particular society) has, via an unconscious process, resulted in product designs with subsystems that can be adjusted relatively independently. He then argued that modern designers must strive to create such subsystem independence in the projects they are working on, lest the design problems they face become so complex as to be insoluble. With Manheim, Alexander also devised

computer programs intended to help designers assess the interactions among design variables in the form of an "interaction matrix" and to solve for minimally-interacting groups of such variables (3). Lewis, Samuel and Field (4) and Luckman (5) have explored this general type of approach by means of examples.

At this point, I am unaware of any data that can be used to test the proposal that a reduction in problem-solving interdependence among innovation-related tasks will be associated with an increase in innovation project efficiency. However, one may get an intuitive feeling for the plausibility of this idea by considering two very simple and schematic examples. Each specifies an innovation project and then suggests two alternative ways to divide the project into two component tasks. These alternatives differ with respect to problem-solving interdependence between tasks and - as a consequence I suggest - also appear to differ with respect to the efficiency with which they can be carried out.

First, consider how one might partition the project of designing an airplane. In fact, of course, such a project would be partitioned into thousands of tasks. But, for present purposes let us assume that it will be partitioned into only two tasks, each to be undertaken by a different firm. The two alternative partitionings I propose we compare:

- "Firm X is responsible for the design of the aircraft body and firm Y is responsible for the design of the engine,

and:

- "Firm X is responsible for designing the front half of the aircraft body and engine, and firm Y is responsible for the back half of each.

Taken together, each of these proposed partitionings has the same project outcome - a complete aircraft design. But the two differ greatly with respect to the interdependence of the two tasks specified. The second alternative would require a

much higher level of problem-solving between the two tasks. For example, many design decisions affecting the shape of the "front half" of an aircraft body could not be made without forcing related changes on the designers of the back of the body and vice versa: The two halves cannot be considered independently with respect to aerodynamics. In contrast, the detailed design of a complete aircraft engine is much less dependent on the detailed design of a complete aircraft body. As a direct consequence, I suggest, engineers would think the former partitioning far more efficient than the latter. Indeed, faced with the latter proposed division, experts would be likely to throw up their hands and say, "It can't be done that way".

As a second example, consider how one might partition the project of designing the interiors of two rooms between two interior decorators. One might assign each room to each decorator; one might assign one-half of each room to each. Again, the same work is to be accomplished in each instance. Only the way it is divided up has been changed.

In this example, the idea of two interior decorators each designing one-half of a room probably seems absurdly inefficient to the reader. And again, I propose that this is because of the need for between-task problem solving that is inferred. That is, it seems reasonable that a solution devised by one decorator and implemented on one side of a room must cause the second artist to make responsive adaptations on the other side of the room if a satisfactory total design is to result. We can see that it is the need for problem-solving across tasks that makes these partitionings seem inefficient by slightly changing the nature of the task in this second example. Suppose that problem-solving is clearly not involved in the room-design project. For example, suppose that the physical task is the same - two interior decorators are each assigned one-half of a room to design - but suppose that the decorators work for a hotel chain and proceed according to a strict formula. In that case, asking each decorator to design half a room might be a perfectly acceptable, and possibly even efficient, partitioning of the task. For example, one decorator could specialize in

applying the formula to window decorations, and one could specialize in applying it to room furnishings.

3.0: Understanding and Managing Task Partitioning

In order to understand and manage task partitioning we must be able to: (1) predict which tasks are likely to be the source of important new information; (2) predict which other tasks in the network are likely to be affected by that new information; (3) use such predictions to understand and manage the impact of change during the course of an innovation project.

For "very novel" projects, an ability to predict the source and pattern of problem-solving is equivalent to saying that we be able to predict the unexpected - not a very promising prospect. However, it is quite reasonable to expect to be able to predict these things in the instance of less novel innovation projects. And, happily, this more modest capability appears to be all that is needed in most instances - because most innovation projects in most firms do not in fact involve great novelty. Thus, computer companies specialize in repeatedly developing the next new model computer, and auto firms specialize in repeatedly developing the next new auto model. Under such conditions, innovators learn much from prior projects as to areas where change is likely to be needed during the course of a future, similar innovation project. For example, an engineer experienced in auto design work can look at specifications for a new model car and easily predict the areas where the most difficult design problems are likely to be encountered during the course of the project.

The way that changes to a given task are likely to propagate across a task network can also often be predicted by project personnel who have experience with similar projects. Thus, changes in the design of some components of an auto engine can be expected, with a near-certainty, to require changes in other design tasks,

because the tasks are predictably interdependent with respect to problem-solving. For example, problem-solving with respect to the shape of the top of a piston in an auto engine is predictably very interdependent with the task of problem-solving with respect to the shape of a cavity in the cylinder head of an auto engine: The two shapes combine to form the overall shape of an auto engine combustion chamber, and the shape of the combustion chamber is an important variable in engine design. In contrast, the likelihood that changes to either or both of these components will require changes in the tasks of designing many other parts of the auto engine - ranging from alternator to engine mounts - will be seen as predictably very remote by those who understand auto engine design.

Suppose, then, that one can predict the "areas" where new information will be developed during the course of an innovation project. And suppose also that one can predict something about the location of related changes likely to be required or made desirable due to such new information. How can one use this information to improve innovation project management? To this point I have suggested that one might relocate task partitions to minimize the need for problem-solving across task boundaries. Let me now suggest the additional, complementary strategy of reducing the cost of engaging in problem-solving across task boundaries. I will briefly elaborate on each of these possibilities next.

Improve Partitioning

The first approach, minimizing problem-solving across task boundaries by "properly" locating initial task boundaries, requires the ability to predict the likely source and pattern of problem-solving activity in an innovation project discussed above. Ideally, the partitions initially established will be located so that the development of an optimal solution via problem-solving within the boundaries of each task specified will also provide an optimal solution for the overall project.

Currently, I am not aware of any methods that can enhance practitioner insight

with respect to identifying likely areas and patterns of change in an innovation project. Tools do exist, however, that can help managers to record and to think through the implications of their insights. As was mentioned earlier, several authors have developed interaction-matrix approaches to aid in the management of this problem in the instance of engineering design. A version of such models developed and used by practitioners called the House of Quality has also recently been reported on (6). Among other things, this model encourages project participants to list features of a product being developed that are interdependent in engineering terms.

For example, the method encourages project participants to note that: 'The better an auto door is at tightly sealing out noise and dirt (a desirable characteristic), the harder it is to close (an undesirable characteristic) given that conventional sealing technology is applied'. Such information can then be used to improve task partitioning. Thus, if project specifications require improvements in door closing or door sealing, the presence of the interaction with respect to these two matters suggests that arranging task partitions so that both are included in a single "improve door closing and door sealing" task would reduce task problem-solving interdependence in this instance.

Also, task network modeling tools used by innovation project managers such as PERT, GERT and VERT can be useful. They require data regarding project task content and the interactions between project tasks as an input. But, given these, they can then help practitioners think through the implications of their insights and predictions for task network behavior. (7)

Ease Cross-Boundary Problem-Solving

A second approach to managing task problem-solving interdependence involves reducing the cost of engaging in problem-solving across task boundaries. This approach is complementary to the one discussed above: It regards existing task partitions as given, and seeks ways to minimize the costs of any associated

cross-boundary problem-solving. Therefore, both approaches can be applied simultaneously when attempting to manage the effects of task problem-solving interdependence.

There has long been a literature in the field of organizational behavior that explores ways to pass information across group boundaries, or to integrate groups divided by a boundary. Therefore we are currently better provided with tools for lowering the cost of problem-solving across boundaries than we are with tools for improving initial project task partitioning. Naturally-occurring mechanisms to this end such as the "gatekeeper" who takes on the role of passing information between groups have been described.(8) Also, various inventions developed specifically to accomplish boundary spanning such as the "integrating group" (9) have been described by specialists and been applied in the field.

One could address such tools to our present problem by first predicting where high interaction between tasks will be required, and/or monitoring task activities to identify such needs as they arise. Then, special efforts could be made to ease communication across the relevant task boundaries. Thus, in this second approach one might keep the door closing and door sealing activities described earlier as two independent tasks. But, upon noting the problem-solving interdependence between them, one could take steps to facilitate problem-solving interaction across that particular boundary.

There is also a more recent literature reporting on the Japanese industrial experience in this matter. Here, the emphasis appears to be less on specific mechanisms intended to span a particular boundary for a particular end, and more on organizational designs that encourage a general high level of communication and a reduction of barriers to communication and joint problem-solving between all project tasks.

Thus, Imai (10) reports that five very successful product development projects by Japanese firms used multifunctional development teams of 30 or less people to

develop relatively complex products having a significant degree of novelty in their fields. (Honda, the 'City' car; Fuji-Xerox, the FX-3500 copier; Canon, the 'Sure Shot' camera; NEC, the PC 8000 personal computer; Epson, the MP-80 dot matrix computer printer).

Imai points out many ways in which these teams were designed to maximize within-team information flow and minimize task boundaries, and contrasts this with US product development practice. Thus, he points out that project phases such as product concept, feasibility, definition and design - often sharply demarked in US practice with progress reviews and approvals - were much less defined and overlapped more heavily in the practice of the Japanese teams. He notes that:

"The loose coupling of [project] phases also makes the division of labor, in the strict sense of the word, ineffective. Division of labor works well in a [US style] system where the tasks to be accomplished in each phase are clearly delineated and defined. Each project member knows his or her responsibility, seeks depth of knowledge in a specialized area, and is evaluated on an individual basis. But such segmentalism ... works against the grain of a loosely coupled system [such as that observed in the Japanese development projects]. Here, the norm is to reach out across functional boundaries as well as across different phases. Project members are expected to interact with each other extensively, to share everything from risk, responsibility [and] information to decision-making, and to acquire breadth of knowledge and skills. (11)

Under such conditions, barriers between many project tasks may indeed be very low and flexible, thus eliminating the need to make special accommodation for those tasks having high interdependence with respect to problem-solving.

4.0: Practical Importance

Is management of the problem-solving interdependence of tasks a matter of any practical importance to innovators? I think so, and will illustrate the possibility

anecdotally by looking at two areas in the innovation process that are known to be problematic through the lens of task partitioning. The first of these is commonly called the "marketing-R&D" or "marketing research - product design" interface in the innovation process literature. The second is typically referred to as the "product design - process design" or "design-build" interface in that literature. These two interfaces are the boundaries between the three tasks of marketing research, product design and process design. All three tasks are typically carried out (in series or with some time overlap) during the course of an innovation project. In what follows, I will first consider the "design-build" interface in some detail. Then I will more briefly incorporate the marketing-R&D interface into the discussion.

4.1: The Product Design - Process Design Interface

Traditionally, the interface between product design and process design has been a source of difficulty in the progress of an innovation project. Traditionally, also, this difficulty has been framed as the problem of transferring information smoothly and completely from the former to the latter.⁽¹²⁾ More recently, however, the underlying assumption of a one-way flow from product design to process design has begun to be seen as a problem in itself. In essence, researchers and practitioners now better appreciate that the product and process design tasks can interact in a way that requires two-way communication and joint problem-solving between the groups engaged in these. That is, the way you design a product has implications for process design - and vice versa.

For example, a product designer may initially design a component part that is very difficult to manufacture - despite instructions and good intentions - because he does not understand manufacturing processes well. He will typically be able to change his design to resolve the problem - if told of the difficulty in a timely manner. But if product designers only provide information to process designers at the completion of product design, there will obviously be no opportunity for process

designers to provide the needed data during the time when the design work is still underway and changes could be relatively easily accommodated.

Two empirical studies I am aware of have examined the design-build interface, and have shown that an increase in interaction across this boundary is associated with increased project efficiency. Thus, authors of a study of the matter in the commercial, power, light industrial and heavy industrial segments of the construction industry found that:

"... a construction specialist [building constructor], working with the engineering team [building designers] as the project is defined and designed, can cut costs by 10 to 20 times the added cost of extra personnel. On a \$30 million project, an extensive constructability program may cost \$50,000, but can bring savings of \$1 million. Costs and schedules are trimmed by:

- Arranging the optimum preparation of both engineering details and the sequence in which they are prepared so as to avoid delays in construction on the site.
- Taking advantage of the latest construction technology as part of the design.
- Developing work-simplifying methods and minimizing labor-intensive design."(13)

Similarly, Clark et al (14), in a recent comparison of aspects of the European, Japanese, and US auto industries, provide a detailed case study of how information was passed between designers of the sheet-metal parts that make up the surface of an automobile, and the designers of the dies used to produce these parts. In the Japanese firms, they found, the work of parts designers and dies designers had a larger overlap with respect to time than did US and European firms. They also found that Japanese parts designers typically passed preliminary information more frequently to die designers regarding the planned shape of parts as work progressed.(15) As a consequence, they suggest, die designers in the Japanese firms were in a better position to begin the design of dies while some areas of shape were still uncertain,

and to suggest changes to part designers in a timely fashion that would reduce the cost, complexity or number of dies required to make the part.

On the basis of studies such as these, plus anecdotal reports of good results in various firms with "design-build" teams, practitioners and researchers are now moving to the view that closer interaction between product and process design is in general beneficial. However, if we view this problem through the lens developed in this paper - that one wants to partition tasks so as to minimize the need for problem-solving across task boundaries and/or build bridges between tasks anticipated to require high problem-solving interaction - then we can advance the discussion a step further, in my view.

I propose that the level of benefit obtained from bridging or eliminating the task boundary between product design and process design will differ as a function of the particular part and process at issue. This is because, as discussed earlier, the need for problem-solving across such a boundary can vary depending on the particular part and process involved, and depending upon the specifications set for task outcomes.

Thus, in the case study by Clark et al mentioned above, the design of parts and of the dies used to produce them are clearly very interdependent design tasks, and it therefore seems reasonable that the bridging or elimination of the boundary between these two tasks would improve innovation process efficiency and effectiveness.

On the other hand, I would suspect that one would not typically get a similar benefit by bridging or eliminating the task barrier between product design and process design in the instance of "middle-of-the-road" printed circuits. This is because standard printed circuit manufacturing technology is capable of producing any such ordinary circuit without any process adjustments being needed or useful. That is, there will not usually be a need for joint problem-solving - or two-way

communication - between these two tasks. (Those unfamiliar with printed circuit technology can think of book printing as a useful substitute example. Book authors typically do not have to write their books with the needs of the printer in mind, because the ordinary printing process does not have to be adapted to the particular words chosen by an author. In contrast, a graphics designer trying to do something that pushes the limits of existing printing processes might well find joint problem-solving with the printer to be very valuable.)

The need to make choices with respect to where one will eliminate task boundaries and/or increase interaction across them can be illustrated by reference to the practice of some auto manufacturers of sometimes assigning the detailed design work for auto components they will purchase to the supplier firms that will manufacture them.(16)

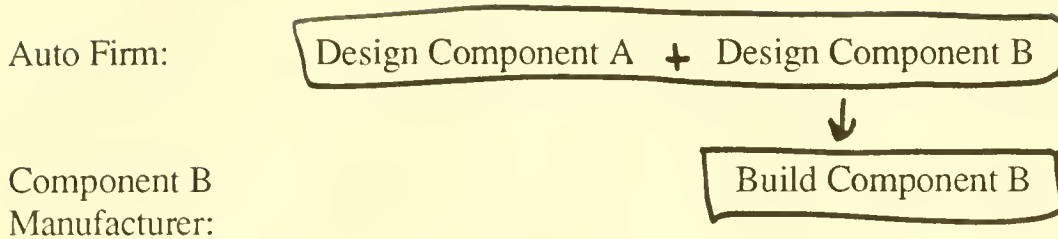
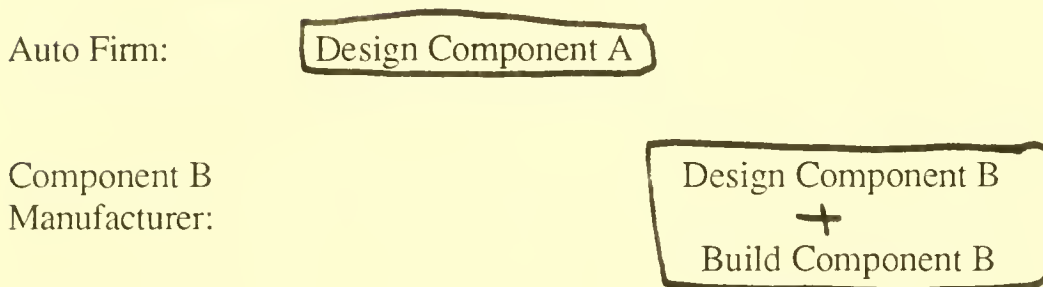
Figure 2AFigure 2B

Figure 2: Shifting the detailed design of one product component (Component B) from the firm designing the product to the firm that will manufacture it improves the design-build linkage for Component B - but weakens the design linkage between Component A and Component B.

As is suggested in Figure 2, a shift of the detailed design of automobile component A from the firm that designs the overall automobile to the firms that builds the component probably increases the barriers between the design of component A and component B, while decreasing the barrier between product design and process design for these components. After all, the shift involves a shift in the physical and organizational location of the component design work from a close(r) proximity with other design tasks, and to a closer proximity with process design tasks. And, as mentioned earlier, Allen (1) has shown that both physical and

organizational distance appear to represent significant barriers to technical communication.

Clark et al have found the assignment of greater amounts of detailed component design work to component suppliers to be strongly associated with a reduction in the time required to develop a new model car. Indeed, they estimate that "...bringing an additional twenty percent of the engineering effort in-house and inside the project [that is, assigning less of the detailed component design work to the component supplier] would add eight months to project lead time."(17).

In line with arguments made earlier, I suggest that further examination will show that the effect of this shift is positive only for those components where there is less benefit obtainable from problem-solving interaction between particular component design tasks than between the tasks of product design and process design. For example, I suspect that shifting the detailed design of an electrical alternator (generator) to be used in a new model car from the auto design firm to the component manufacturer would result in a net improvement in efficiency: there is little design trade-off between generator design and the design of other components.

On the other hand, if the component in question is the plastic ducting used to distribute hot and cold air to a car's interior, I would expect the reverse to be true. Such ducting is bulky, and must be laid out with an intimate knowledge of the location and size of many other auto components if it is to be fitted within the car properly. To carry out this design process efficiently, it seems to me, there would be a need for creative, interactive problem-solving involving the designers of the car as a whole and the designers of the air ducting components. Thus, the gain from reducing the barriers to such interaction by keeping both design tasks within the auto manufacturer seems to me likely to outweigh any advantage to be gained from shifting detailed design to the manufacturer in this instance.

4.2: The Marketing Research - Product Design Interface

The interface or boundary between the marketing-R&D interface has long been judged to be a source of problems with respect to the commercial success of innovation projects because: Most new products developed fail in the marketplace (18); accurate understanding of user need has been shown key to innovation project success (19); engineers and marketers are often unhappy with the quality of the information regarding user need transmitted across the marketing-R&D interface (20).

As was the case with the design-build interface, the "interface problem" has been traditionally seen as one of smooth and accurate transfer of "need" information from marketing to product designers. Today, however, improved two-way communication across this interface is now clearly identified as a likely way to improve performance at this interface.(21) However, as in the case of the design-build interface, I suggest that the benefit realizable from repartitioning tasks to eliminate the boundary between marketing research and product design, or taking steps to ease problem-solving across that boundary, will depend on the amount of joint problem-solving required across the interface in any particular instance.

Thus, a single one-way message from marketing to product design may suffice if the need information is unambiguous, and if the designers can accommodate the request without compromising other product characteristics. E.g., "The customer wants this software to interface with the XYZ printer." On the other hand, joint problem-solving between marketing researchers, customers and product designers will clearly be valuable when, for example, data on new product needs provided by marketing research to engineering have consequences or offer opportunities that are not initially visible to all these parties. E.g. "Are you aware that adding memory to the computer as you request will make it slower?" Or, "Do you realize that if we add extra memory we can also add feature X at no cost?"

5.0: Discussion and Suggestions for Further Research

In this paper I have proposed that the level of problem-solving interdependence between tasks is a function of choices made with respect to task partitioning. I have also suggested that such choices can be managed, and that doing so may have an important impact on innovation process efficiency. It seems to me that these proposals are worth exploring further from the point of view of both innovation process research and innovation practice.

Innovation task partitioning is potentially a very interesting topic in the field of innovation process research because it bears directly on the matter of how innovation can be most efficiently distributed within and among firms. Findings related to partitioning can therefore serve as a useful input to research on topics ranging from specialization to vertical integration to the role of suppliers in the innovation process.

In such research, the conditional nature of improvements to innovation process efficiency as a result of changes in task partitioning will become evident and important. That is, decisions regarding partitioning influence far more than problem-solving efficiency. They also have an impact on matters ranging from the efficient utilization of specialized resources, to the ability of a firm to protect its innovation-related advantages in the marketplace. Sometimes partitioning from the point of view of minimizing problem-solving interdependence among tasks will have positive impacts on these related matters, but sometimes a trade-off of benefits will be required. (E.g., "We would gain efficiency if the manufacturer of component X worked with our designers at an early stage, but this strategy would also increase our risk that news of our new product might leak early and reduce our profits.")

An improved understanding of innovation task partitioning will be important to innovation managers if and as it can have an important impact on innovation project efficiency and effectiveness. The magnitude of this effect needs to be empirically explored. As an initial step, it might be reasonable to attempt to view the

efficiency effects of innovation project task partitioning in isolation. One might be able to do this experimentally by, for example, systematically varying the way a given software development project is divided into modules (tasks) and observing the effect of these variations on project efficiency.

Next, it might be reasonable to explore the possibility of managing innovation task partitioning in practice to achieve efficiency gains in innovation project work. For example, one might select a sample of innovation projects for study, list the major tasks associated with each, and then ask project participants to: (1) rank the degree of problem-solving interaction required among different listed tasks and, (2) rank the ease of accomplishing such problem-solving among these same tasks. A large mismatch between the answers to the two questions might indicate that practically useful task partitioning changes could be made, and would also suggest where these might lie.

If improvements to innovation task partitioning can yield major benefits to firms, we then have much to learn about managing it. Firms I have interviewed to date appear not to think about task problem-solving interdependence as an input to partitioning decisions at all. Instead, some appear to make such decisions primarily on the basis of assumed economies of specialization (e.g.: "All electrical design work will be done by group A"; "All marketing research studies will be done by group M"). Other firms appear to simply follow some traditional pattern of innovation task partitioning without analysis. (E.g.: "We have always designed aircraft bodies by dividing them into a series of cylindrical sections and assigning each section to a different task group. No one now at the company has thought about why we do this or whether it currently makes sense from any point of view. It is just the way we do it.")

Given this situation, it would seem reasonable to start research into the effective management of innovation task partitioning with basic issues such as:

When should one attempt to specify task partitions at the start of a project, and when should one strive for the capability for flexible mid-project changes?; What partitioning decisions will be best made "bottoms-up" by lower-level project personnel (who may currently be making mid-project partitioning adjustments informally and covertly in any case (22)), and which should be made "top-down"?

I look forward to studying innovation task partitioning further, and very much hope that others might also find the area interesting enough to explore.

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