Design, Advanced Planning and Product Development

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structured planning; product development; concept development; design methods; design planning; product planning; strategic planning; design technology

ABSTRACT
Economic change brings opportunity as well as failure. In today's volatile world economy, traditional ways of doing business are becoming disastrously obsolete. Companies must offer *better* products now—and introduce them frequently to stay in business. Growing populations in developed *and* developing nations have greater expectations for themselves and their environment, and citizens everywhere are demanding more of private business, government and non-governmental organizations. Fundamental to success in this fast-changing, market-driven world are better ways to find, organize and use the information critical to advanced planning and design—of artifacts, systems, services and institutions.

Structured Planning is a computer-supported set of tools for information-age design planning. For the development of new products, it helps planning teams to deal effectively with complexity and ambiguity and to explore projects in both breadth and depth at the time when insight has the greatest impact. Its tools and procedures help planning teams to uncover user-centered needs, recognize insightful relationships, capture ideas as they develop, organize large amounts of information optimally for concept development, and develop solutions appropriate to the real (and natural) complexity of problems.

INTRODUCTION

Design is no longer an exotic pursuit. Tough times, new opportunities and world competition have opened the doors. Overseas competition has done what decades of reasoning could not; design is now recognized as a major strategy for competitive success. Businesses and business schools are making genuine efforts to learn more about design and to incorporate sophisticated design thinking in their operations. With less fanfare, but potentially greater impact, governmental organizations, institutions and NGO's (non-governmental/non-commercial organizations) are also discovering the value of design thinking.

In universities around the world, design educators and design researchers now find themselves with new audiences and new opportunities for leadership. The challenge for all is to nurture development of the new means—the design and planning theories, processes and organizational models—so that they can permanently infuse design values and benefits throughout society.

A DESIGN STRATEGY

To see the multiple values of design most clearly, design should be viewed through the lens of *quality*, now the universally-recognized requisite for success in business. Quality for products (and artifacts generally), is almost always associated with *craftsmanship*—how well the product is made. But there are more dimensions to quality, and they can be best appreciated through a consideration of how things are designed and what benefits are accrued.

The relationships between design and quality are expressed in the Quality Pyramid model (Figure 1). The pyramid has a multilayered design core, with craftsmanship as the first of three progressively sophisticated layers. From the design perspective, quality as craftsmanship is achieved through attention to issues of engineering design and design for manufacturing. Well-designed products at this level are easier to make well.

Detail design is at the second layer of the design core. Here the role of design is to contribute to performance, human factors and appearance. Design specialists (engineering designers, product designers, industrial designers, communication designers and others) invent and refine features or details at this level to make the product work better functionally, work better for people physiologically and psychologically, and work better symbolically within social and cultural niches.

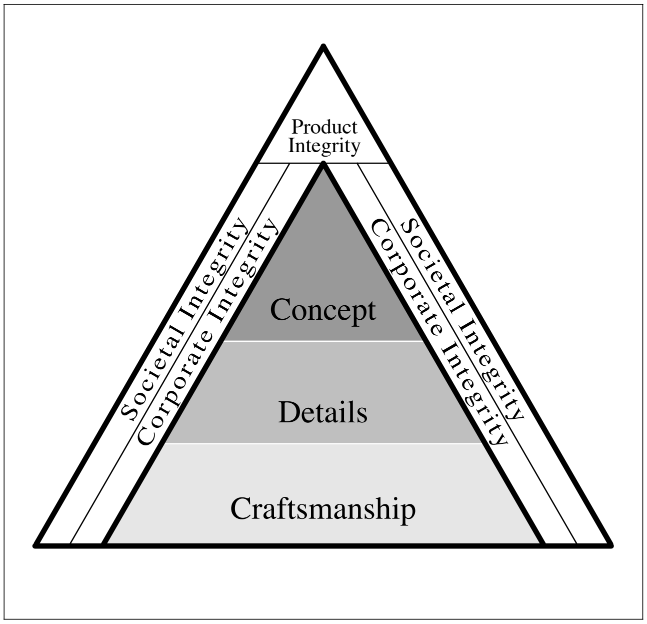


Figure 1. The Quality Pyramid.

At the third layer, *concept*, design contributes most to competitiveness (for all products—including systems, institutions and services). Concepts that are holistic and thoroughly thought through present themselves to buyers and users as qualitatively better (and worth more). Products designed well as concepts typically distribute innovations among their features so systemically that they are exceedingly difficult to copy by competitors.

Capping the Quality Pyramid is *product integrity*; under it, quality extends outward to corporate and societal recipients. Products that are conceived, designed and produced with high quality bring praise to the companies or organizations that produce them. Product integrity confers corporate integrity; the company with high-quality products is itself perceived to be of high quality. And corporate integrity, in turn, adds luster to the society in which the company operates. Following this model, postwar Japan, *as a nation*, became identified with quality in less than a generation.

PROBLEMS OF PLANNING

To reap the benefits of the Quality Pyramid model, we must fundamentally rethink the process of new product development. In today's very volatile business environment, revolutionary changes may be more frequently appropriate than evolutionary changes—a prospect for which the conventional development process is ill-prepared. Competition is the provocateur. Whether the local economy is growing dramatically or shrinking dramatically, global competition places great pressure on the organization unable to produce.

Against the aspirations of the Quality Pyramid, conventional planning for new product development fails in two critical ways. In depth, it fails to find and understand the needs of the many real users of the potential product. The focus too often is on the *customer* and/or "*end user*". This ignores the many other users who also have much to gain or lose from the product's design—those who sell, transport, maintain, repair and retire the product—to name just a few. Listening solely to buyers and operators leads to shallow understanding. Shallow understanding produces little insight and is unlikely to fuel the holistic, thorough thinking necessary for systemically conceived, break-through products.

In breadth, conventional planning routinely fails to conceive the most potent product. Development effort typically lingers little more than momentarily on the issue of *what* the product should be. The concept to be developed, far too frequently, is already determined *before development begins!* To use an outdoor metaphor, the expert development team is off at sound of the gun to climb the mountain—but the mountain may be the wrong one! Just any mountain won't do. If the purpose of climbing the mountain is to get to the highest ground, then it is important to locate the highest mountain before beginning the climb. In today's world, it is as important to know *what to make* as it is to know *how to make it*. And, as technological know-how proliferates, knowing *what to make* becomes more important every year!

REFORMING THE DEVELOPMENT PROCESS

Overcoming these planning deficiencies is critical. A reformation of the development process is necessary, and in that reformation the processes for planning must be improved. How that should be done requires a look at the development process in terms of design and its impact on a product's life span.

The Impact of Design

The business model is instructive. The costs a company incurs in developing a product can be nicely related to the product's profitability by plotting investment and return over time. The form of an investment/return curve is loosely sinusoidal, as suggested by the light gray curve in the background of Figure 2. The downward loop of the curve records the investment to develop the product. As the product goes to market, it begins to return value, and the upward loop of the curve records its financial return to the company over its life span.

Of course, a purely sinusoidal curve would not be a happy result for a company, because return over the product's life would only equal investment. All companies work to reduce the size of the investment segment, both by shortening it in time and diminishing its dip. All companies also work to increase the size of the return segment, by extending its height and lengthening it over time.

In today's marketplace, a design strategy can support these objectives in three ways (Whitney 1994).

First, to shorten the length of the investment segment, the development process must be shortened. From simple physical prototypes for individual concepts, to computer-generated, close-to-real experiences, fast design prototyping can substantially shorten development time (arrow 1 in Figure 2) by close-coupling ideation and evaluation.

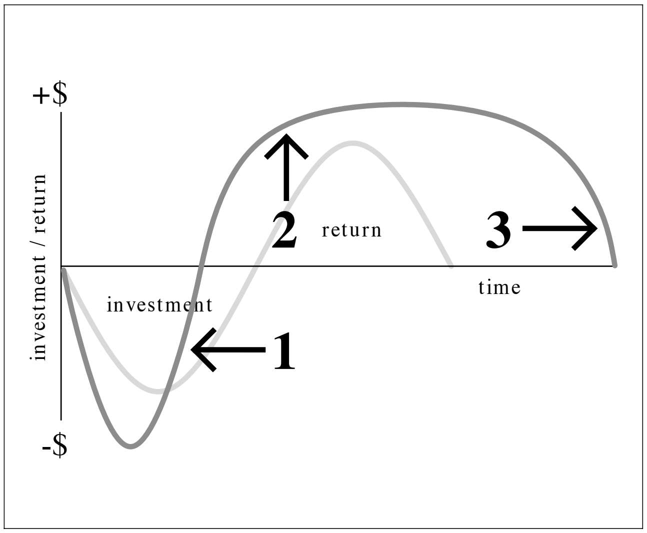


Figure 2. Improving the investment/return curve.

Second, to raise the return portion of the curve, the quality of the product must be improved. Human-centered design puts the focus for the design of details where it belongs—and where it is appreciated—on the users of the product. Products sell better if they are better designed for their users—all of them. This involves a deep appreciation of ergonomics and physiological, cognitive, social and cultural human factors. The principles of human-centered design can be gathered here through Structured Planning to raise quality and, consequently, return on investment (arrow 2).

Finally, to lengthen the return portion of the curve, it must be difficult to develop competing products that can steal the product's success. Structured Planning treats products and their supporting services as systems in which ideas are integrated systematically. Products conceived in this way are difficult to copy because their features are systemic. Elements of the design interact in interlocking components of hardware, software and service. Copying any one or few individual components will not produce equivalent qualities (arrow 3).

Reforming the development process to implement a full design strategy requires all three of these individual strategies, but the major reform that must be made is an organizational one that affects how investment is deployed (Figure 3). Too often today little or no attention is given to the amount and quality of *exploration* necessary for sound product concepts.

The development process must be changed from a one-step process, in which an already determined concept is turned into a specification, to a two-step process wherein a distinct development stage is devoted to exploration and determining the concept (Figure 4). The traditional process for which the issue is only "how to make it" must be reconstituted to two separate stages: *what to make* before *how to make it*. The product of the new *planning* stage of development is the concept; it becomes the "project statement" or "design brief" for the *designing* stage that follows.

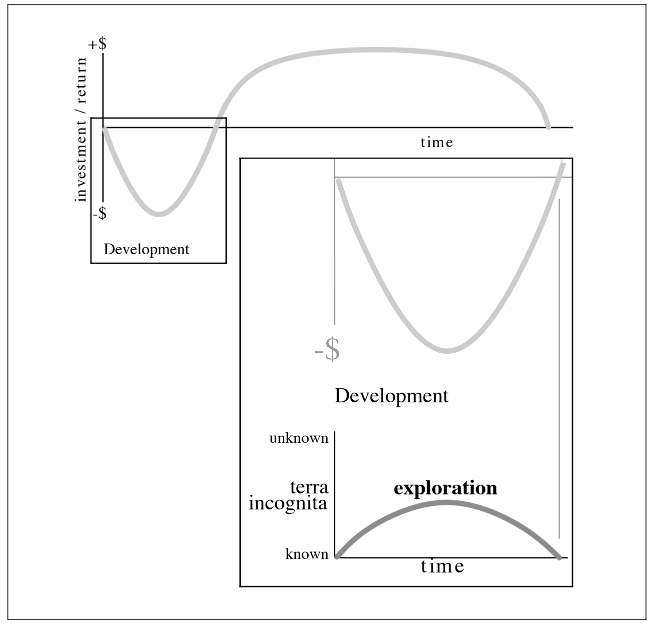


Figure 3. Exploration. The use of investment.

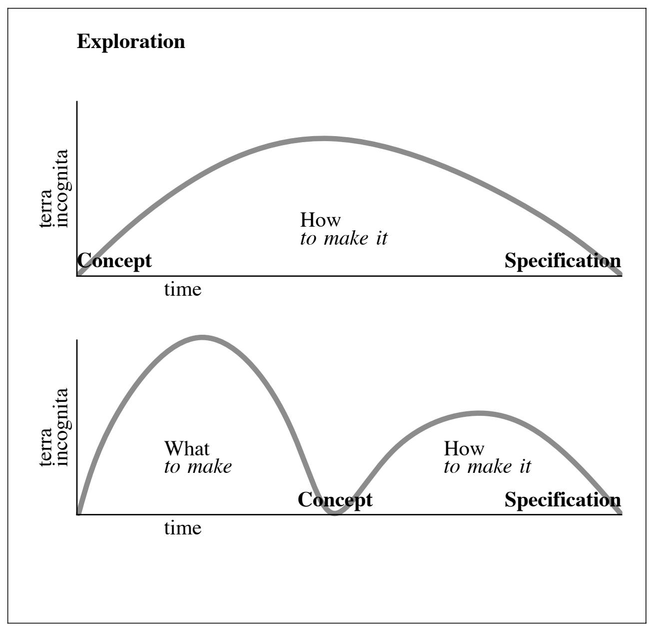


Figure 4. Above: 1-step development *designing;* below: 2-step development *planning + designing*.

The Development Environment

At its simplest, development is the process of producing an artifact or institution in response to an understanding of a problem or opportunity in context. Artisans do this routinely today; before the industrial revolution, it was the normal means of production. In essence, it is a direct form of "mak-

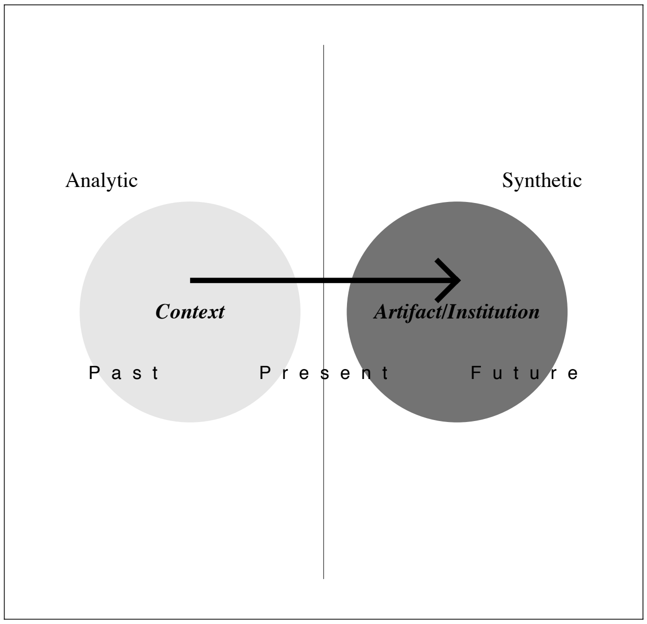


Figure 5. Direct development.
Create *artifact* or *institution* to fit *context*.

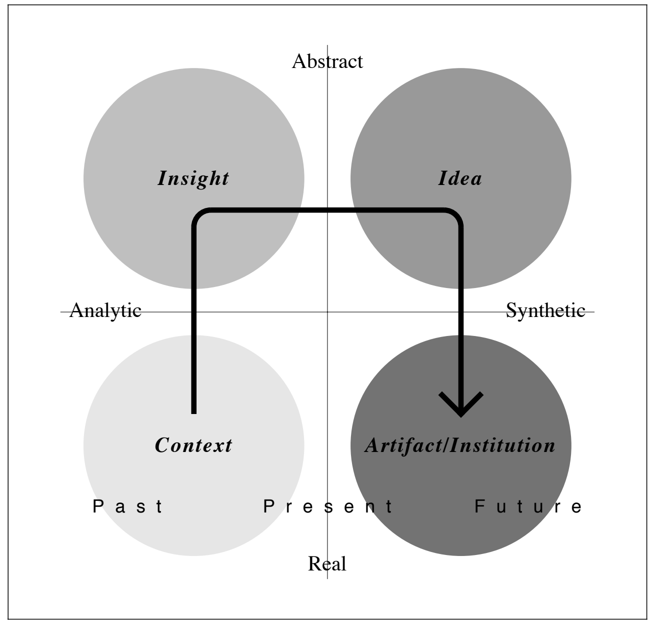


Figure 6. Development through design. Draw *insight* from *context;* convert *insight* to *idea;* turn *idea* into *artifact* or *institution*.

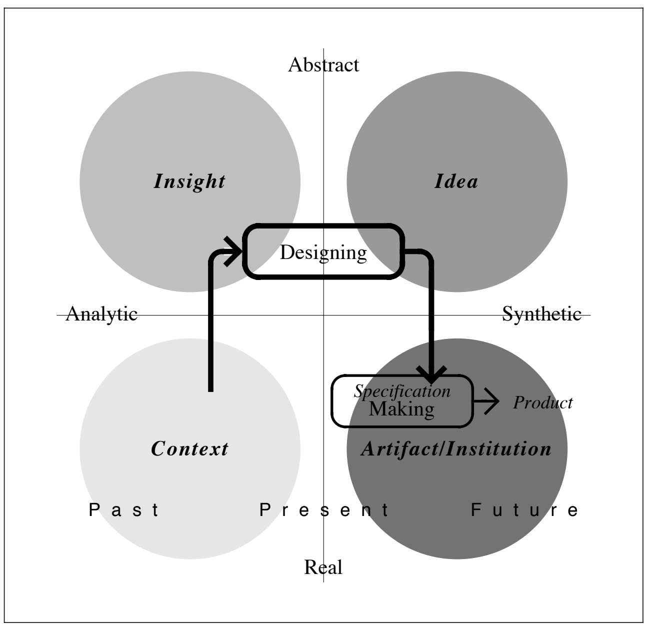


Figure 7. One-step designing.

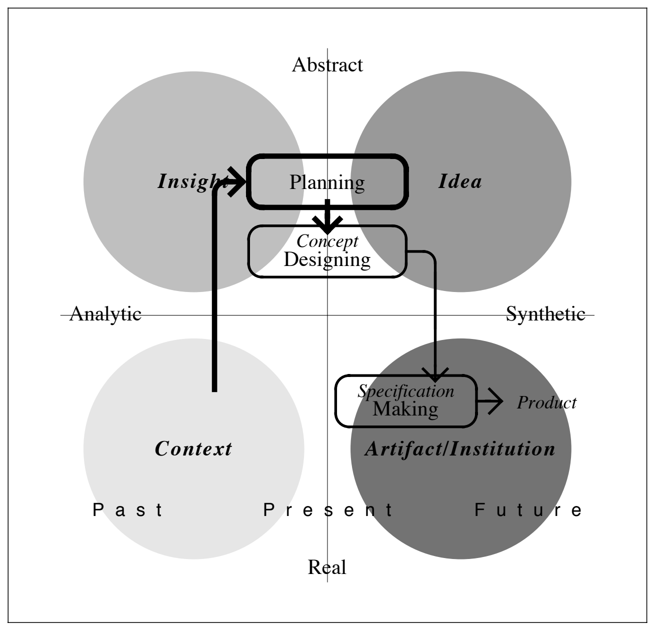


Figure 8. Two-step designing + planning.

ing" that moves between the realms of the analytic and the synthetic without formal intermediate steps (Figure 5).

When systems of production reach a stage of sophistication at which designing and making are done by separate professionals, the development process gains another dimension (Figure 6). There is a distinction now between abstract and real, and the process of development moves to the abstract. Insights are drawn from context, converted at an abstract level to ideas and turned back to the real as specifications for artifacts or institutions.

The one-step development process is represented in this environment as a process of *designing* (Figure 7). The process begins with a concept, usually at least partially formed. Most frequently, the concept is an old one to be revised. Sometimes it is a preconceived new one, brought to attention by someone influential within the organization. Too often, it is simply a competitor's product—to be matched at least, exceeded if possible.

The two-step development process, as a step toward reformation, adds a *planning* stage before the designing stage, separating formally the process of concept formation from the process of turning a concept into a specification (Figure 8). Planning is where "the right mountain" is discovered before the climb begins. Structured Planning operates in this stage.

To optimize the planning and designing activities, a third stage should precede planning (Figure 9). *Metaplanning* in the three-step model is concerned with *planning the planning and designing processes* (Peng 1993). From the metaplanning level, product development projects are initiated by projecting areas of interest, modeling contexts, identifying issues, establishing project resources, selecting, modifying and developing planning/designing methodology, and preparing a preliminary project charter.

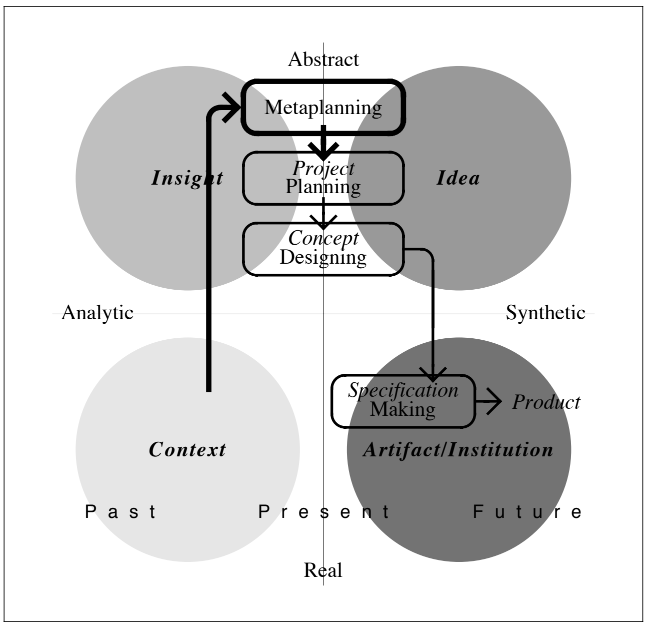


Figure 9. Three-step metaplanning + planning + designing.

Metaplanning is particularly important for the full-scale implementation of a development process incorporating advanced-planning teams. In the emerging new model for development, multiple planning teams operating in offset parallel sequence will be trained, briefed and given their charters by metaplanning departments. The processes of designing and planning will be as much a subject for development as the products they are used to develop. Those responsible for metaplanning will be closely associated with those responsible for the development of design processes, and as better tools for planning and designing are developed or obtained, they will be custom-tailored through metaplanning to the goals of projects being initiated.

The Business Context

In most business organizations large enough to have specialized departments for development, the Development function has strong links to Research and Marketing as well as Manufacturing. Specific terms and descriptions differ among companies, but the general model places the concerns of Research with problems farthest distant in time, the concerns of Manufacturing with those most current, and those of Marketing and Development in the middle. The various forms of design and engineering expertise intermingle with those of other relevant disciplines within these functional groupings.

Technological possibilities are investigated by Research; user interests are most commonly explored by Marketing. New projects are initiated with engineering consultation for do-ability, and there is little or no involvement of other design expertise. The two and three-step models presented here reform these procedures by substantially augmenting the development process with design and other human-centered expertise at the front end of the process.

This has ramifications for the relationships between Development and the other functional units. In Figure 10, Research, Development and Marketing are shown as activities functioning in parallel. The three stages of the development process are shown within Development because they are supported primarily from that functional unit. Depending on the stage of a project's progress, the relationships between it and Research and Marketing are different, evolving as ideas coalesce.

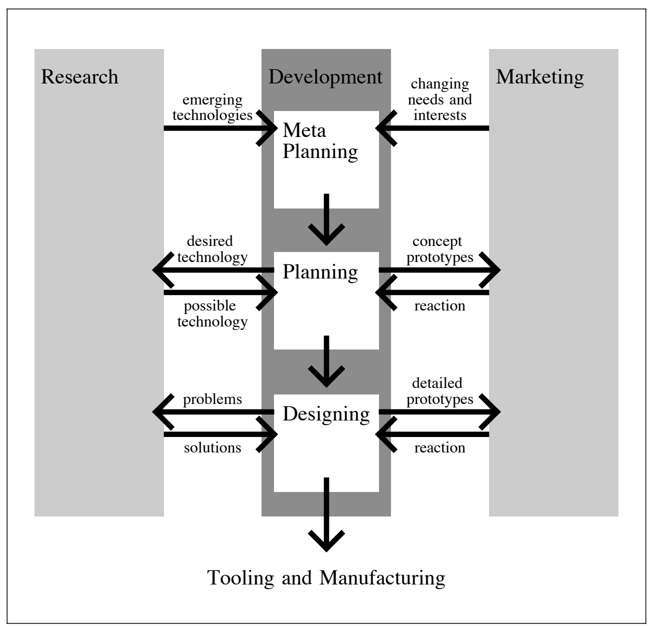


Figure 10. The business context: appropriate interactions at appropriate times.

Before project initiation, the relationship between Development and Research (at the metaplanning level) is one of technology assessment. The question is, "What impending technologies within or outside the company should be explored for implementation in new products?" The relationship with Marketing at this stage is similar: "What needs and interests are emerging in segments of society?" Neither of these questions elicit product proposals; rather, they launch processes of scouting, exploring and trend spotting.

At the planning stage of development, the relationships change to direct associations between a planning team and the special expertise of the functional group. Planning teams need suggestions and confirmations of technologies from Research as they propose ideas. They need criticism and field evaluations from Marketing as they develop prototypical concepts.

When a project has reached the designing stage, relationships between Development, Research and Marketing are more traditional. Technological problems and solutions are handled by Research (when they are not manufacturing related); detailed demonstrations and prototypes are field-tested by Marketing. At this stage, the members of the planning team will have returned to their functional groups as champions of the project.

STRUCTURED PLANNING IN THE DEVELOPMENT PROCESS

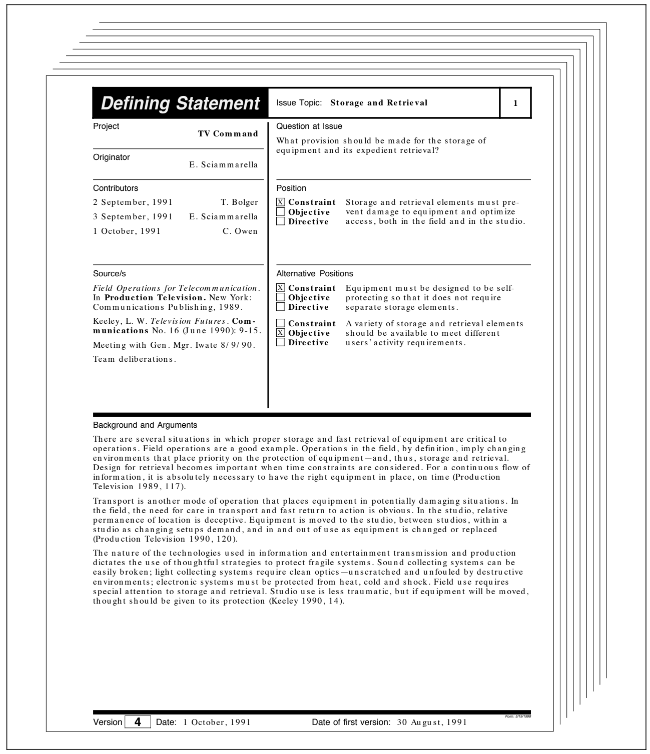
Within the spectrum of the development process, Structured Planning provides tools for the *planning stage* of development. From its inception as a response to general inadequacies in the design process, it has evolved to offer specific remedies for deficiencies of planning. To meet the breadth problem, for instance, it advocates segmentation of the development process. The existence of planning as a concept development stage separate from designing grows out of this advocacy. To meet the depth problem, as another instance, it has within its tool kit a process of *Action Analysis* expressly designed to seek out *all* users of a product and to gain insight about their needs from their behavior.

The tools of Structured Planning, some computer-supported, can be custom-tailored to a project and can be used with other planning tools. In essence, Structured Planning supports planning and concept development in two major ways: (1) it provides a philosophy, framework and information handling formats for discovering what needs to be done—with insight for *why;* and (2) it organizes this information in the best way for planners and designers to use it.

In its most general formulation, it progresses through five phases.

Project Definition

The first phase of Structured Planning is concerned with project definition (Figure 11). Working with a preliminary project charter and an initial set of issues selected as relevant by the project initiators (metaplanning), a planning team works to investigate the issues, develop arguable positions and, through discussion and follow-up research, converge upon positions that optimize project goals. The phase concludes with a set of documents (Defining Statements) that effectively define the project.


Defining Statement | Issue Topic: **Storage and Retrieval** | 1

Project: **TV Command**

Originator: E. Sciammarella

Contributors
2 September, 1991 — T. Bolger
3 September, 1991 — E. Sciammarella
1 October, 1991 — C. Owen

Source/s
Field Operations for Telecommunication. In **Production Television.** New York: Communications Publishing, 1989.
Keeley, L. W. *Television Futures*. **Communications** No. 16 (June 1990): 9-15.
Meeting with Gen. Mgr. Iwate 8/9/90.
Team deliberations.

Question at Issue
What provision should be made for the storage of equipment and its expedient retrieval?

Position
[X] **Constraint** [ ] **Objective** [ ] **Directive** — Storage and retrieval elements must prevent damage to equipment and optimize access, both in the field and in the studio.

Alternative Positions
[X] **Constraint** [ ] **Objective** [ ] **Directive** — Equipment must be designed to be self-protecting so that it does not require separate storage elements.
[ ] **Constraint** [X] **Objective** [ ] **Directive** — A variety of storage and retrieval elements should be available to meet different users' activity requirements.

Background and Arguments

There are several situations in which proper storage and fast retrieval of equipment are critical to operations. Field operations are a good example. Operations in the field, by definition, imply changing environments that place priority on the protection of equipment—and, thus, storage and retrieval. Design for retrieval becomes important when time constraints are considered. For a continuous flow of information, it is absolutely necessary to have the right equipment in place, on time (Production Television 1989, 117).

Transport is another mode of operation that places equipment in potentially damaging situations. In the field, the need for care in transport and fast return to action is obvious. In the studio, relative permanence of location is deceptive. Equipment is moved to the studio, between studios, within a studio as changing setups demand, and in and out of use as equipment is changed or replaced (Production Television 1990, 120).

The nature of the technologies used in information and entertainment transmission and production dictates the use of thoughtful strategies to protect fragile systems. Sound collecting systems can be easily broken; light collecting systems require clean optics—unscratched and unfouled by destructive environments; electronic systems must be protected from heat, cold and shock. Field use requires special attention to storage and retrieval. Studio use is less traumatic, but if equipment will be moved, thought should be given to its protection (Keeley 1990, 14).

Form: 5/19/1998
Version **4** Date: 1 October, 1991 Date of first version: 30 August, 1991

Figure 11. Project Definition. Issue-based project description.

Action Analysis

In the second phase (Figure 12), a process called Action Analysis is used to uncover in detail what the product must do. The failure of conventional planning to seek out *all* users and consider their problems in depth is addressed in this phase. Action Analysis is a top-down analytic technique for establishing the functions that must be performed by the product and its users (considered as a system). The system, as it begins to emerge from the project definition phase, is analyzed progressively: first to establish the modes in which it will operate (e.g., *distribution, transport, use, storage, maintenance, repair, adaptation, retirement*—or, in the specific example of Figure 12, [a television production system]: *studio operations, field operations, pre-production, production, post-production, management, transportation, etc.*); second, to identify the major activities that will take place within each mode of operation (under *production,* for example: *recording, participating* and *conducting*); and, finally using Activity Analysis forms (Figure 13), to specify the functions that the system or user will perform in each activity. These *Functions* are the "criteria" against which the system must be planned; the system must perform all the Functions well. They usually number in the hundreds, and

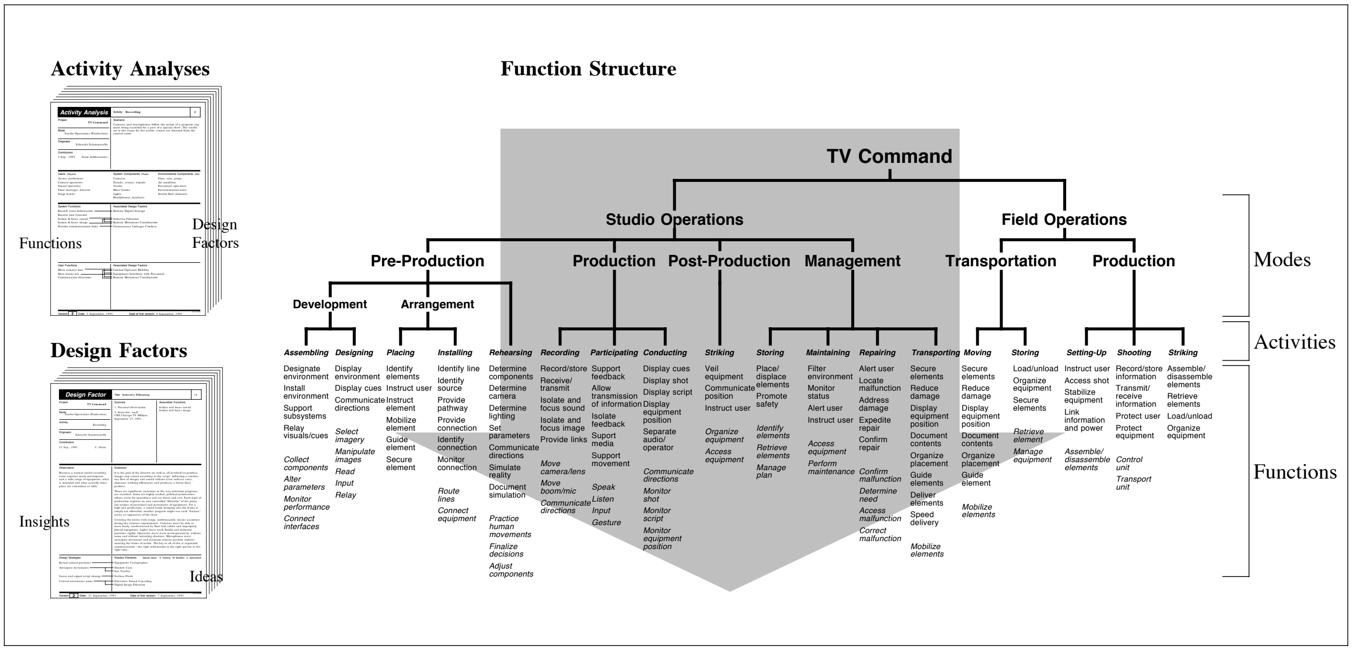
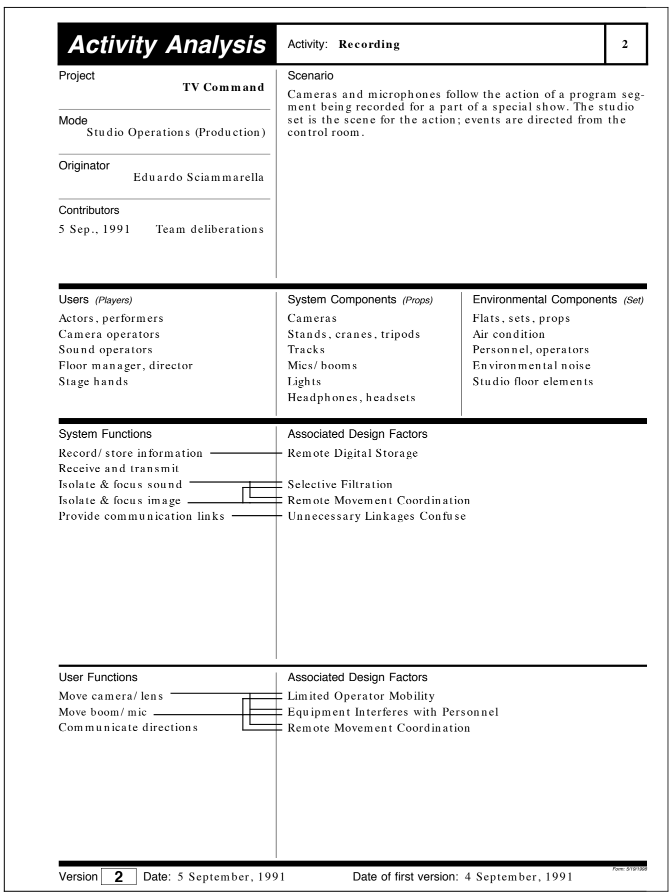


Figure 12. Action Analysis. Top-down analysis of functionality for all users.



Activity Analysis Activity: **Recording** 2

Project: TV Command

Mode: Studio Operations (Production)

Originator: Eduardo Sciammarella

Contributors: 5 Sep., 1991 Team deliberations

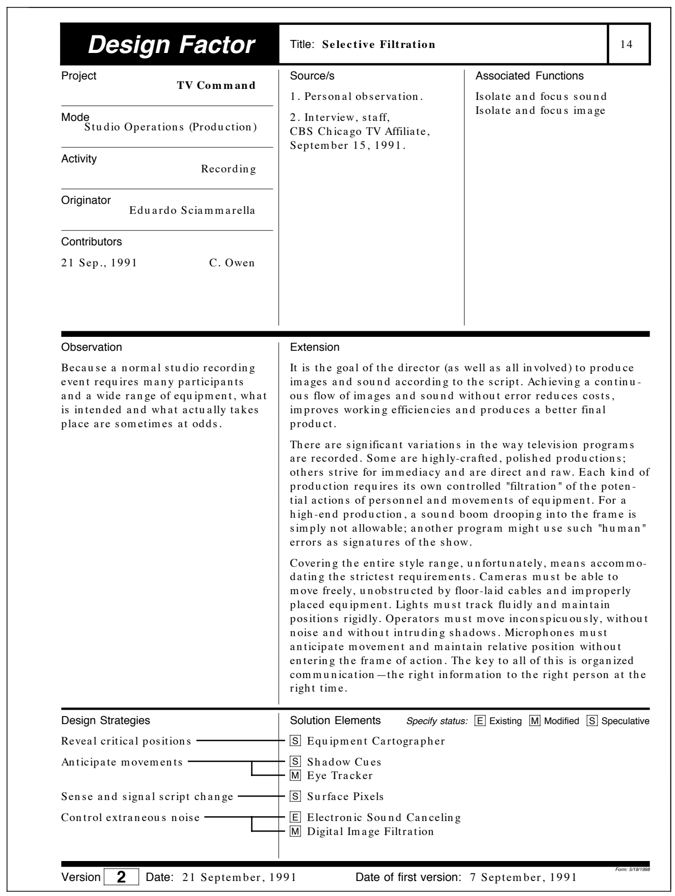
Scenario: Cameras and microphones follow the action of a program segment being recorded for a part of a special show. The studio set is the scene for the action; events are directed from the control room.

Users *(Players)*	System Components *(Props)*	Environmental Components *(Set)*
Actors, performers	Cameras	Flats, sets, props
Camera operators	Stands, cranes, tripods	Air condition
Sound operators	Tracks	Personnel, operators
Floor manager, director	Mics/ booms	Environmental noise
Stage hands	Lights	Studio floor elements
	Headphones, headsets	

System Functions	Associated Design Factors
Record/ store information	Remote Digital Storage
Receive and transmit	
Isolate & focus sound	Selective Filtration
Isolate & focus image	Remote Movement Coordination
Provide communication links	Unnecessary Linkages Confuse

User Functions	Associated Design Factors
Move camera/ lens	Limited Operator Mobility
Move boom/ mic	Equipment Interferes with Personnel
Communicate directions	Remote Movement Coordination

Version 2 Date: 5 September, 1991 Date of first version: 4 September, 1991 Form: 5/19/1988



Design Factor Title: **Selective Filtration** 14

Project: TV Command

Mode: Studio Operations (Production)

Activity: Recording

Originator: Eduardo Sciammarella

Contributors: 21 Sep., 1991 C. Owen

Source/s:
1. Personal observation.
2. Interview, staff, CBS Chicago TV Affiliate, September 15, 1991.

Associated Functions: Isolate and focus sound; Isolate and focus image

Observation: Because a normal studio recording event requires many participants and a wide range of equipment, what is intended and what actually takes place are sometimes at odds.

Extension: It is the goal of the director (as well as all involved) to produce images and sound according to the script. Achieving a continuous flow of images and sound without error reduces costs, improves working efficiencies and produces a better final product.

There are significant variations in the way television programs are recorded. Some are highly-crafted, polished productions; others strive for immediacy and are direct and raw. Each kind of production requires its own controlled "filtration" of the potential actions of personnel and movements of equipment. For a high-end production, a sound boom drooping into the frame is simply not allowable; another program might use such "human" errors as signatures of the show.

Covering the entire style range, unfortunately, means accommodating the strictest requirements. Cameras must be able to move freely, unobstructed by floor-laid cables and improperly placed equipment. Lights must track fluidly and maintain positions rigidly. Operators must move inconspicuously, without noise and without intruding shadows. Microphones must anticipate movement and maintain relative position without entering the frame of action. The key to all of this is organized communication—the right information to the right person at the right time.

Design Strategies	Solution Elements (Specify status: E Existing, M Modified, S Speculative)
Reveal critical positions	S Equipment Cartographer
Anticipate movements	S Shadow Cues
	M Eye Tracker
Sense and signal script change	S Surface Pixels
Control extraneous noise	E Electronic Sound Canceling
	M Digital Image Filtration

Version 2 Date: 21 September, 1991 Date of first version: 7 September, 1991 Form: 5/19/1988

Figure 13. Activity Analysis distinguishes Functions and insights associated with them (Design Factors).

they record the needs of many users, not just buyers and operators.

In the process of uncovering Functions, particular attention is paid to noticing problems and opportunities, potential or actual, that arise as the Functions are performed. Insights are gained here for why things work or don't work well. These, along with ideas for what do about them, are noted first on the Activity Analysis forms and then written up in separate documents called *Design Factors*. Associated with the Functions for which they were observed, they become a major resource for the synthesis phase of planning yet to come and for other development and manufacturing stages downstream in the project.

Design Factors record the qualitative information most useful for planning and design. This is where the results of critical observations and research studies are crystallized and built into the information base as a part of the collective memory for the project. Essential during the project as the bases for ideas, they continue to have value through the life of the product (and its follow-on adaptations) as the underlying information upon which the design was based. With similar Design Factors from other projects, they define a major new form of corporate memory—a record of insights applicable to any project with similar aspects of function. Figure 13 shows an Activity Analysis form (left) and a Design Factor document (right) expanded from one of Associated Design Factor notations entered in the study of the activity. The Design Factor relates a relevant insight from an interview.

The Design Factor document contains a number of entries. Most important, however, is information of two kinds: *information about the problem (or opportunity) detected*, and *information about what might be done about it*. The fact that problem and solution are both covered in the same document is not accidental. It is important that when insights are recognized, ideas be sought for how to use them; and it is important that when insight information is retrieved at a later date, the range of ideas expressed when the insight was gained be there for further reflection.

The "Observation" section is the first of two sections dealing with a problem/opportunity. An Observation is usually a single sentence in which an insight is recorded about a Function. As much as possible, it *distills the essence* and summarizes behavior important to understanding what happens as the Function is performed.

Associated with the Observation section is an "Extension" section. In this section, explanatory material is placed to extend or develop the information of the Observation. No matter how thoughtfully worded, a summary Observation is seldom able to convey enough information to develop an insight adequately. The *whys* that are inevitably asked are addressed in the Extension. Primary research may be introduced; background material may be discussed; examples may be cited; contributing phenomena other than those mentioned in the Observation may be mentioned; side effects may be considered. After examining the Extension section, a reader should understand the Design Factor, appreciate its value and even anticipate how the insight might be used—the subject of the following "idea" sections.

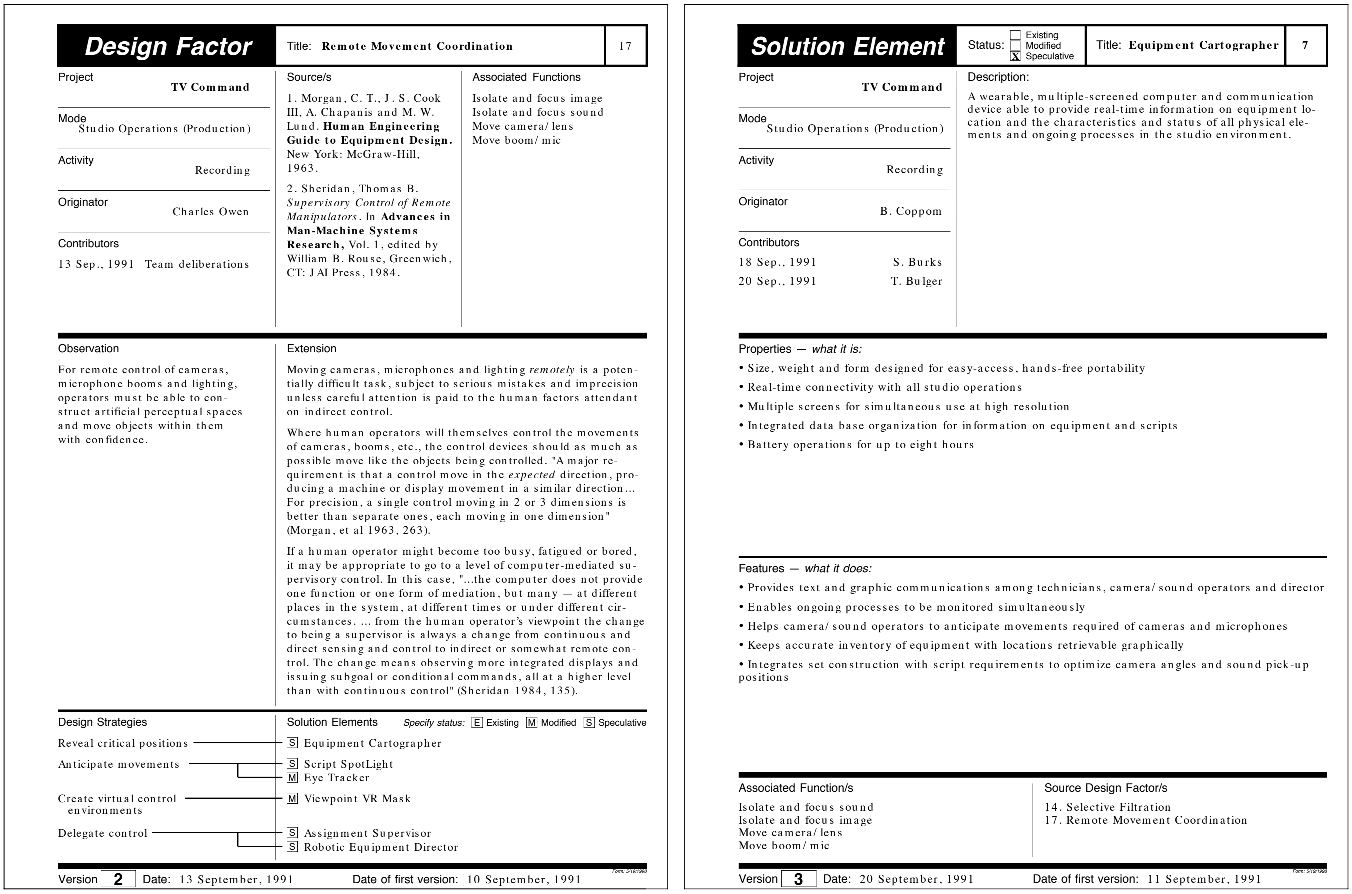
"Design Strategies" is the first of two sections dealing with solution ideas. By definition, "Design Strategies are generalized suggestions for how to use the information of the Observation and its Extension. For a format, they take an imperative verb phrase, carefully crafted to abstract a strategy without specifically describing a solution idea.

Specific ideas go into the "Solution Elements" section. Solution Elements come in three kinds. The first is *Existing*; this is something that already exists and potentially can be integrated into the system solution. It may be already owned by the organization or may be incorporable through purchase, alliance or other arrangement. The second is *Modified*. In this case, the inspiration already exists, but is modified to fit the occasion. The third kind is *Speculative*, so named because it is a new idea (more than a simple modification of an existing idea).

Solution Elements are preliminary ideas. They are responses to individual Design Factor insights and may or may not be used in the final overall concept. They are important for determining interaction among Functions in the structuring phase of the process—and may actually be used in the overall solution—but, at the time they are written, they are immediate reactions to insight, capturing the creative thoughts of the moment. For a format, Solution Element titles take a noun phrase. Noun phrases express concepts well and are easy to remember—especially if they include colorful phraseology. A good name for a Solution Element (modified or speculative) combines an adjective and a noun in an evocative title. Such a title, once explained, is readily retained in memory, and a wealth of detail associated with the concept is usually recalled with it.

Other sections on the Design Factor form serve the needs of the knowledge base. The "Originator" section identifies the author of the Design Factor, subsequently, its sponsor. "Contributors" record the authors of changes and when they were made. "Associated Functions" tie the Design Factor to the Functions for which it was written. A "Title" names the Design Factor for retrieval. Entries in "Source/s" follow standard footnote format, and Extension entries contain footnote indicators where appropriate. If the information is from the Originator's direct observation or personal experience, the Source entry is "Personal observation".

Solution Elements, once given names, are developed on their own document forms. This is done to collect as much detail about the idea as can be obtained at the best time to do so—when the idea is fresh. In Figure 14, a Design Factor introducing ergonomic insights inspired by Functions identified for the Recording activity generates several Solution Elements. One, "Equipment Cartographer", is shown in its document form at the right. The Solution Element form is a simple version of what will be elaborated considerably as System Elements in the final presentation of the project as a system. It is a single page with three important sections:



Design Factor | Title: **Remote Movement Coordination** | 17

Project: TV Command

Mode: Studio Operations (Production)

Activity: Recording

Originator: Charles Owen

Contributors: 13 Sep., 1991 Team deliberations

Source/s:

1. Morgan, C. T., J. S. Cook III, A. Chapanis and M. W. Lund. **Human Engineering Guide to Equipment Design.** New York: McGraw-Hill, 1963.

2. Sheridan, Thomas B. *Supervisory Control of Remote Manipulators*. In **Advances in Man-Machine Systems Research,** Vol. 1, edited by William B. Rouse, Greenwich, CT: JAI Press, 1984.

Associated Functions:
Isolate and focus image
Isolate and focus sound
Move camera/lens
Move boom/mic

Observation

For remote control of cameras, microphone booms and lighting, operators must be able to construct artificial perceptual spaces and move objects within them with confidence.

Extension

Moving cameras, microphones and lighting *remotely* is a potentially difficult task, subject to serious mistakes and imprecision unless careful attention is paid to the human factors attendant on indirect control.

Where human operators will themselves control the movements of cameras, booms, etc., the control devices should as much as possible move like the objects being controlled. "A major requirement is that a control move in the *expected* direction, producing a machine or display movement in a similar direction... For precision, a single control moving in 2 or 3 dimensions is better than separate ones, each moving in one dimension" (Morgan, et al 1963, 263).

If a human operator might become too busy, fatigued or bored, it may be appropriate to go to a level of computer-mediated supervisory control. In this case, "...the computer does not provide one function or one form of mediation, but many — at different places in the system, at different times or under different circumstances. ... from the human operator's viewpoint the change to being a supervisor is always a change from continuous and direct sensing and control to indirect or somewhat remote control. The change means observing more integrated displays and issuing subgoal or conditional commands, all at a higher level than with continuous control" (Sheridan 1984, 135).

Design Strategies | Solution Elements (Specify status: E Existing, M Modified, S Speculative)

Reveal critical positions — S Equipment Cartographer

Anticipate movements — S Script SpotLight; M Eye Tracker

Create virtual control environments — M Viewpoint VR Mask

Delegate control — S Assignment Supervisor; S Robotic Equipment Director

Version 2 | Date: 13 September, 1991 | Date of first version: 10 September, 1991

Form: 5/19/1986

Solution Element | Status: ☐ Existing ☐ Modified ☒ Speculative | Title: **Equipment Cartographer** | 7

Project: TV Command

Mode: Studio Operations (Production)

Activity: Recording

Originator: B. Coppom

Contributors:
18 Sep., 1991 S. Burks
20 Sep., 1991 T. Bulger

Description:

A wearable, multiple-screened computer and communication device able to provide real-time information on equipment location and the characteristics and status of all physical elements and ongoing processes in the studio environment.

Properties — *what it is:*

- Size, weight and form designed for easy-access, hands-free portability
- Real-time connectivity with all studio operations
- Multiple screens for simultaneous use at high resolution
- Integrated data base organization for information on equipment and scripts
- Battery operations for up to eight hours

Features — *what it does:*

- Provides text and graphic communications among technicians, camera/sound operators and director
- Enables ongoing processes to be monitored simultaneously
- Helps camera/sound operators to anticipate movements required of cameras and microphones
- Keeps accurate inventory of equipment with locations retrievable graphically
- Integrates set construction with script requirements to optimize camera angles and sound pick-up positions

Associated Function/s:
Isolate and focus sound
Isolate and focus image
Move camera/lens
Move boom/mic

Source Design Factor/s:
14. Selective Filtration
17. Remote Movement Coordination

Version 3 | Date: 20 September, 1991 | Date of first version: 11 September, 1991

Form: 5/19/1986

Figure 14. Design Factors suggest ideas, treated as Solution Elements.

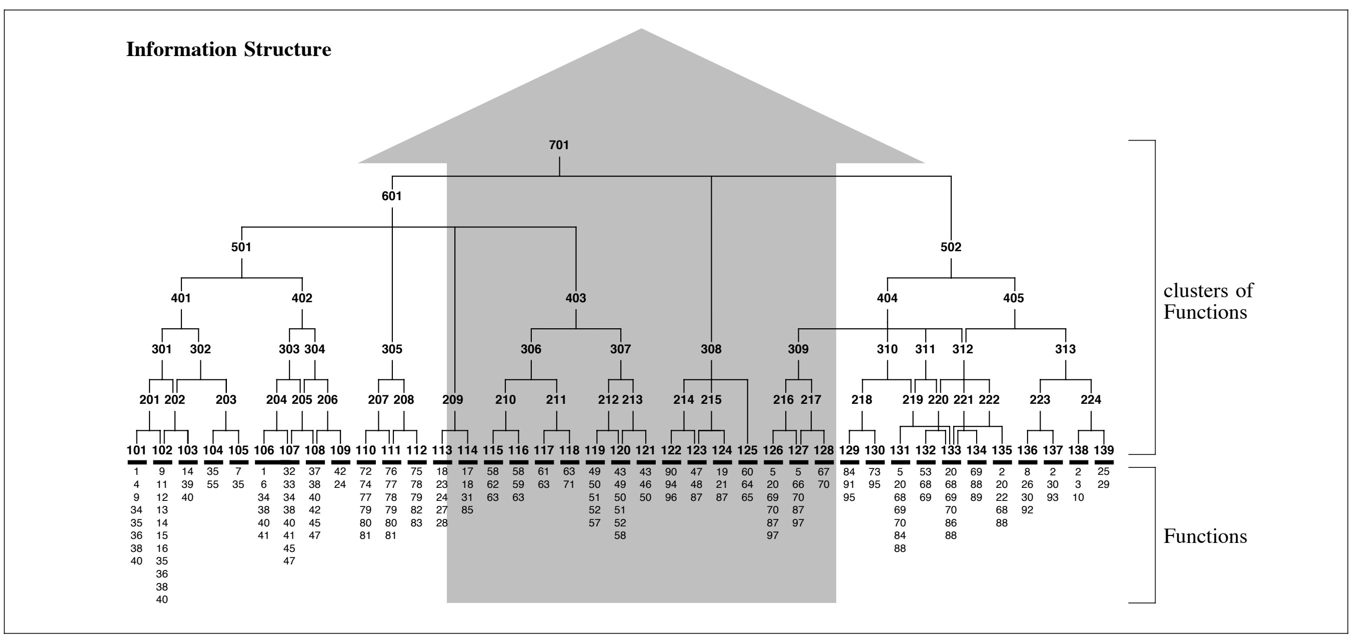


Figure 15. Structuring. Bottom-up reorganization of Functions based on design ideas (Solution Elements).

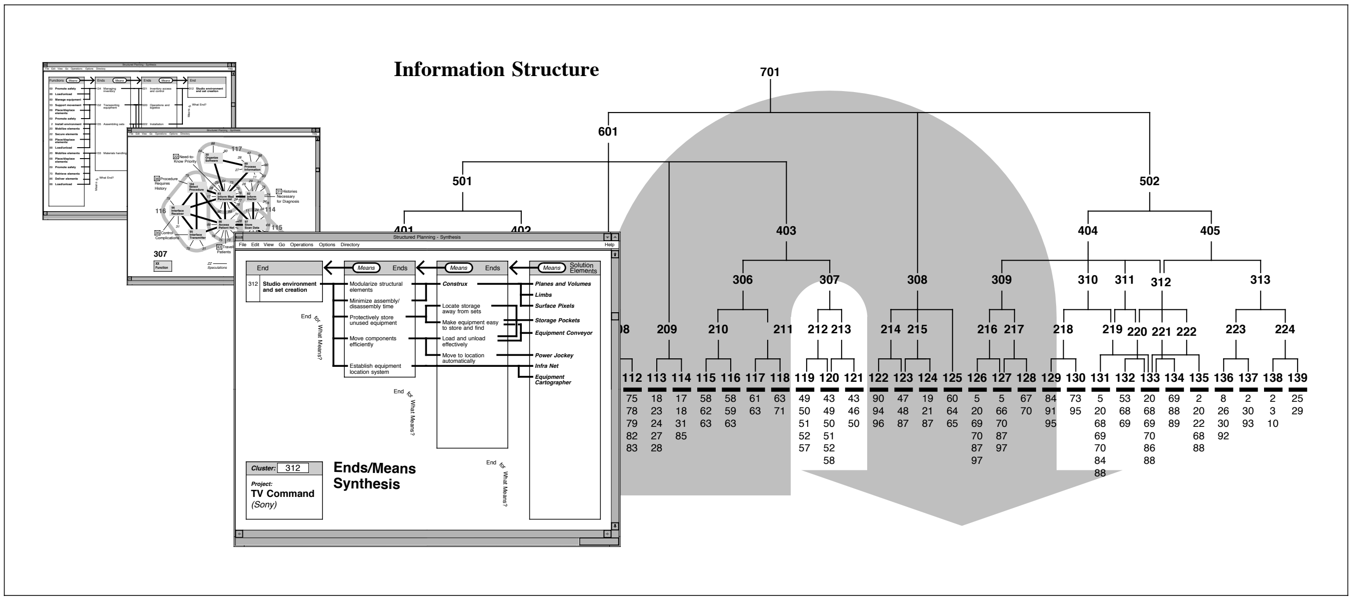


Figure 16. Synthesis. Bottom-up, top-down idea generation; means/ends analysis, cluster analysis, ends/means synthesis.

a brief description of an idea, a list of its *properties* (what it is), and a list of its *features* (what it does). These latter lists, given in bullet form as noun phrases for properties, verb phrases for features, not only are a fast and effective way to describe a concept, but also form the basis for communicating it to engineering (properties) and marketing (features).

Structuring

Phase three of Structured Planning is concerned with reorganizing the Functions, optimizing their organization for synthesis (Figure 15). The Function Structure produced by the top-down analysis of phase two is ideal for uncovering what needs to be done; *but it is fatally flawed as a guide to creating a new concept!* Excellent for analysis, it is an extremely poor choice for synthesis.

Because it was created by establishing categories and filling them downward, the Function Structure produced by Action Analysis (and, indeed, any organization produced by categorically-developed, top-down analysis) inherently inhibits cross-category thinking. In the analysis of a housing system, for example, Functions such as *Sense fire* and *Recognize intrusion* would show up in separate categories—probably under Fire Protection and Security. For synthesis, this isolating form of organization is counterproductive. A better organization would be one in which Functions are placed together on the basis of whether they *have potential for using components of the developing system in common*. In the housing example, an infrared heat sensor able to detect a developing fire might also be used to sense an intruder, suggesting that the two Functions should be considered together when ideas are being developed. Cross-category thinking is stimulated by this form of organization, and the potential for holistic, multifunctional ideas is increased significantly—with all that means for products that are hard to copy.

In the structuring phase, Structured Planning's computer programs work from the bottom up using the hundreds of ideas already generated as Solution Elements to reorganize the Functions into an *Information Structure*. This hierarchy of Functions (with associated Design Factors) is especially well suited to the creative needs of the planning team. The reformed clusters cross former categories, and Functions can appear in more than one cluster. The Information Structure naturally anticipates well-designed artifacts and institutions.

Synthesis

A number of techniques exist for expanding team creativity. Many of them can be used in this phase. Because of the attention given during the Action Analysis phase to collecting ideas as they occur, there are typically hundreds of ideas already available to the planning team as Solution Elements. Because the Structuring phase has organized the Functions into an Information Structure optimized for design, there is a "road map" to follow while considering them.

One of the more useful synthesis tools is a bottom-up/top-down procedure that employs Means/Ends Analysis and Ends/Means Synthesis (Figure 16). Working from the bottom up, Means/Ends Analysis helps the team to understand the new organization of Functions through finding appropriate labels to describe the branches of the Information Structure. Working downward, Ends/Means Synthesis helps the team to select, refine, modify and invent ideas as "means" to meet the needs inferred from the newly labeled "end" branches. In the process, System Elements are created as final elements of the system. They may be direct restatements of Solution Elements already described and associated with the Functions of the cluster under consideration, or they

System Element | Status: ☐ Existing ☐ Modified ☒ Speculative | Title: **Environmental Image Mapping** | 1

Project: **TV Command**

Contributors: Team deliberations

Source (if *Existing* or *Modified*):

Superset Element/s: None

Subset Elements: None

Related Elements:
2. Infra Net
3. New Senses
   c. Gesture Glove
   f. Virtual Viewer
4. Thunder Dome
   a. Thunder-D Grip
6. Construx
   b. Surface Pixels
   c. Shadow Cues

Description:
A system of software and hardware able to produce "virtual" sets that do not require extensive physical constructions. Sophisticated software creates three-dimensional, highly realistic computer environments that can be combined with video takes of real actors on a skeletal "blue" set.

Properties — *what it is:*
- Software able to produce three-dimensional computer models of environments.
- Software able to map visual imagery onto simple computer produced frameworks to produce realistic three-dimensional environmental objects.
- Virtual reality software for creating sets.
- Skeletal physical structures able to roughly duplicate physical elements in the virtual environment.

Features — *what it does:*
- Speeds the construction of sets and programs.
- Eliminates the high cost of authentic sets through the use of skeletal "for actors only" structures.
- Extends possibilities for program settings to the entire range of environments capturable as images in visual data bases.
- Exploits virtual reality processes to enable the same image data to be used for design and finished productions.
- Enables television production to be distributed widely among low-cost sites.

Version 1 | Date: 4 December, 1991 | Date of first version: 4 December, 1991

System Element | Continuation page: 1 | Title: **Environmental Image Mapping** | 1

Fulfilled Functions:
27, 29, 34, 35, 37, 38, 41, 42, 55, 56, 57, 59, 62, 66, 67, 82, 91, 92

Associated Design Factors:
35, 37, 41, 44, 45, 46, 78, 80, 85, 101, 102, 133, 134, 142, 155, 167, 168, 177, 180, 192, 193

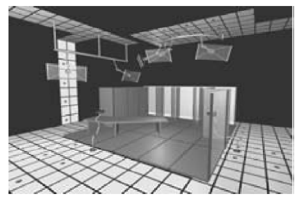
Discussion

Until now, studio productions required individualized studio sets. The entire concept of "studio" work was built around the idea that control of the environment could be optimized only on location—in a studio set. Movie and television sets of the past (and today) have ranged from minimal sets, little more than seating with controlled lighting, to mammoth, exceedingly complex and expensive recreations of entire environments.

The revolution in computer processing of the last decade brings the concept of set to a new level of awareness. A variety of inventions, from matting techniques and computer-controlled movements in film making to texture mapping in computer graphics, have made it possible to create realistic three-dimensional images that combine human actors and environments constructed from data bases.

Environmental Image Mapping takes maximum advantage of this capability both to reduce the cost and complexity of the sets, and to increase the flexibility and speed at which sets can be constructed and struck. The elements of ***TV Command***'s studio system are designed to work synergistically with this specialized approach to virtual reality.

After a set is designed in virtual reality using the **Thunderdome,** it is prepared by assembling basic **Construx** building elements in an arrangement that approximates the intended environment. The physical **Construx** elements are for the actors' convenience only. Actors move around tables, sit in chairs, walk through doors, etc. as they would in a conventional set.



What the actors see is the skeletal **Construx** set with cues on surfaces wherever they need them—on the floor, walls, desks—any flat surface. The cues, produced with **Shadow Cues** and produced with **Surface Pixels,** are invisible to the television audience.

What the audience sees is quite another picture. From the studio's data bases, detailed images are mapped into a three-dimensional model of the set maintained in the computer. This model of the desired environment (for example the living room of a contemporary home) is integrated with the studio cameras' images of the actors on the live set. The result is an image for transmission that looks as if the actors are on location.

Figure 17. Communication. Concept as plan described in detail by *System Elements,* each with Related System Elements, Description, Properties, Features, Fulfilled Functions, Associated Design Factors and Discussion.

may be modifications/combinations of Solution Elements—seen in a new light by the juxtapositions of the Information Structure—or they may be wholly new ideas invented as a response to the newly seen interactions. Always requiring thoroughness and pointing the way to cross-functional innovation, are the Functions with their associated Design Factor insights that terminate each branch of the structure.

Communication

Invariably, the result of the Synthesis phase is a substantial number of innovative, highly interrelated ideas. To extract full advantage from this wealth of material, the ideas must be organized for optimal communication to those responsible for the next stage of development. At the end of the planning stage, the product is still a concept; many details must be resolved creatively in the designing stage before it can be produced.

The concept is communicated as a Plan made up of an Overview and many System Elements, each describing an idea for hardware, software, a procedure or an organizational concept (Figure 17). The Overview presents the major elements of the concept and their relationships. The System Elements provide the details.

Each System Element has a title and seven information sections.

The first section lists System Elements that are closely associated in operation or purpose, providing a hypertext-like mapping among the ideas for better understanding the Plan. Elements closely associated are discriminated as Superset Elements (elements for which the subject element is a part), Subset Elements (elements considered a part of the subject element), and Related Elements (elements at the same level of detail). Next, is a short Description summarizing the System Element's general properties and features. Third, is a list of Properties describing *what the System Element is*. This list, expanded and refined from one or more Solution Elements or newly developed in the Synthesis process, sets forth the essential qualities that must be provided in the design. Fourth is a list of Features describing *what the System Element does*. Similarly derived from precursor Solution Elements or new ideas evolved during Synthesis, this list establishes what is expected of the System Element in terms of its functionality. Statements in both lists must be crafted carefully to make sure that the essence of the planners' idea will be retained without overly constraining the freedom of the designers. The fifth section lists the Functions Fulfilled by the System Element. This enables designers and

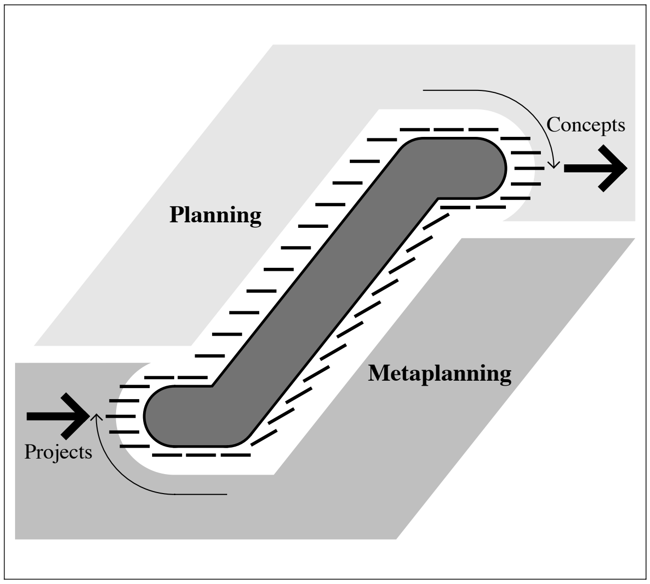


Figure 18. Escalator delivery. Predictable delivery; reliable innovation.

decision makers to track ideas back to the Activities and Functions for which they were envisaged. The system must perform all the functions that have been assigned to it. Sixth, is a section for Associated Design Factors, closing the loop from Function to insight to idea. The Design Factors highlight the original problems, opportunities and insights that inspired the Solution Elements and, ultimately, the System Element. Finally, there is a thorough Discussion of the idea with illustrations, calculations, examples and any other support that may be useful. The purpose of this section is to present the idea as fully and clearly as possible. If the designers are unable to develop a better idea, they should be able to refine one from the planners' information in this section.

ESCALATOR DELIVERY

Like it or not, the pace of new product introduction will not slacken. Serious competition will effectively curtail long product life spans. And any hard times ushered in by economic crises will only sharpen the competitive situation; reduced markets require a larger market share for a company to stay even. Although Structured Planning can significantly extend a product's life span by raising levels of innovation and distributing design features systemically, all products are vulnerable over time. Companies with fast reaction strategies bring down competitors' products by reverse engineering them and getting to market quickly with low-cost, patent-evasive alternatives made possible by minimal development costs.

The *Design Strategy* for development pits higher quality products that are more innovative and difficult to copy against the fast reaction strategy. *Escalator Delivery* adds another dimension, to give the Design Strategy a one-two punch. Made possible by a reformed development process, Escalator Delivery (Figure 18), is also a strategy for fast delivery. It is not, however, a reaction strategy—it is a parallel development process.

At the heart of Escalator Delivery is the concept of Advanced Planning Teams. Advanced Planning Teams are small teams of individuals assembled from relevant functional units, supported in their tasks by Development, and guided by planners trained in Structured Planning team techniques. Borrowing from a naval analogy, members of a team are members of a task force. They are "on loan" from their type commands, to which they return when their task is completed.

While temporarily assigned to an Advanced Planning Team, members are responsible for the development of a concept for a new product, system or service to be produced. When their task is completed, they return to their functional units as champions of the project. They (and those that follow them to other teams) also bring back to their functional units new cross-discipline skills and broader knowledge of their organization's resources, development capabilities and philosophy.

Escalator Delivery gets its name from the process by which advanced planning teams are assembled, charged and deployed. Through the metaplanning process, planning projects are conceived and initiated continuously, drawing widely on the human resources of the organization's functional groups for the makeup of teams. Once begun, the process delivers new concepts at a predictable frequency. Given similar planning timetables, deliveries follow each other in the same frequency that projects were initiated, no matter how long the planning takes. The process resembles an escalator, with new concepts following behind each other at a predictable delivery rate. The effect is to have new concepts available just fast enough to defeat fast-reaction competitors. Just as the competition successfully brings its copy into the market, its target is obsolete, replaced by a new one more conceptually advanced.

CONCLUSIONS

Design thinking, fortified with appropriate tools, can contribute much more significantly upstream than downstream in the development process. International competition has proven this. The worldwide recession of the '80's heightened sensitivity considerably, and the looming slowdown now will add an emphatic endorsement. Design is now recognized as the upstream resource most likely to keep organizations competitive under the new economic realities.

A Design Strategy contains elements to speed development, add value and extend product life spans. To speed development, fast prototyping and Escalator Delivery contribute swift response to changing conditions: fast prototyping collapses both planning and designing time; Escalator Delivery supplies innovative concepts predictably and reliably. Adding value requires getting the details right. Human-centered design, directed through Structured Planning ensures that the product is designed well for people and conceived well in the first place. Extended product life span is a natural result of the systemic approach of Structured Planning.

As evidence for the value of the Design Strategy, an issue last year of ***Trendsetter Barometer***, a U.S. business newsletter (Young 1997), announced that: "Breakthrough" revolutionary products have created sales booms for companies that produced them (Young 1997). Of the fastest growing companies in the U.S., more than one third launched breakthrough products in 1995 and 1996. Collectively, the revenues of these companies soared 1,850% over the last five years. How did they achieve this success? First, by innovating revolutionary concepts: a majority applied new technology; 47% found new uses for existing technology. Second, by organizing themselves to implement a design strategy: the greatest number of successful ideas, 33%, came from team-oriented research and development processes; almost as many came from cross-functional teams or think tanks.

Reforming the development process enables the philosophy of product integrity embodied in the Quality Pyramid model, adding value for individual, institution and society (Figure 19).

From design core to capstone and cladding, the Quality Pyramid links quality to *design*. Structured Planning implements the model to produce concepts that are superior *by design:*

• *different*—freshly imagined to match the best of new technology to emerging needs and interests,

• *better*—thoroughly and systemically thought through for all users, and

• *right*—sensitively positioned to meet environmental, personal, social and cultural needs.

The strategy is straightforward; tools to implement it are available; and the road to reform beckons, urged by both competition and opportunity. The rewards will go to those who commit. But the commitment required is more heart than purse. Of all the resources necessary for business or institutional success, the least costly is design. A Design Strategy, implemented with information-age tools, is a blueprint *today* for success.

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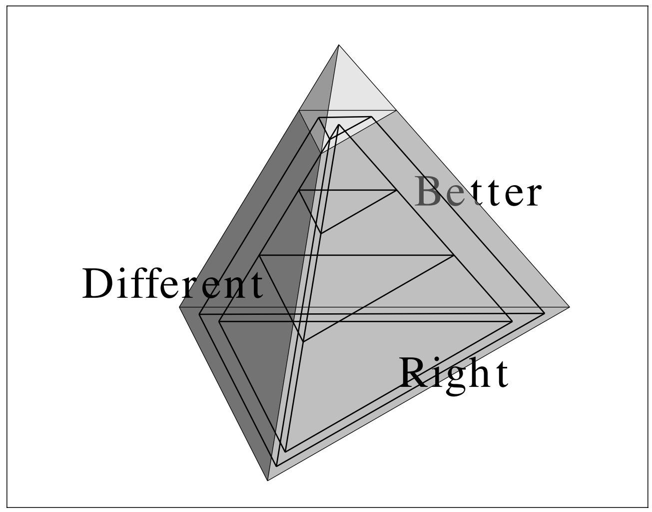

Figure 19. The Quality Pyramid.
Better products through sound *design strategy*.