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Product Integrity by Design

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Product Integrity

The concept of "Product Integrity" (coined by Keith McKee, Director, IIT Research Institute) grew out of a series of interdisciplinary meetings held at IIT Center in 1990. First discussed in print in the proceedings of the Product Integrity Symposium (***Product Integrity.*** Linda Cooper, ed., Symposium proceedings, Chicago: IIT Center, Nov. 1, 1990), the concept was invented in response to the need for an idea broader in scope than *quality* or even *total quality* to evaluate whole-institution participation in the character of products and services.

The holistic nature of *integrity* is as compelling as a principle as it is as a word. It captures what we instinctively know to be true for the best-of-the-best's in any endeavor—that they seem to excel in all ways. Those with integrity have no flaws.

Product Integrity, by definition, involves all aspects of a product's existence—from production to retirementi—and touches all who come in contact with the product from producer to user, planner to servicer. What actually or potentially takes place at *each* contact, moreover, plays a role in determining Product Integrity. Recognizing this requires an extension of view by virtually all who have management responsibilities in a corporation. From the design standpoint, attainment of integrity for a product, its accompanying services and communications means systematic design consideration from a host of new viewpoints—viewpoints very likely not normally solicited.

Quality

In an issue of the ***Design Processes Newsletter*** (Vol. 1, No. 5), I explored the notion of "quality" as a hierarchical concept. From a direct measurement of the *craftsmanship* applied in the production process, quality can be extended upward to a measure of *design details* for their improvement of performance, human factors and appearance—and, ultimately, on up to an appreciation for the *concept* developed as the essence of the product. Craftsmanship afforded the arena for competition in the corporate quality wars of the last decade. Only in recent years has detail design been widely viewed as a higher ground for competition; with this recognition has come also the ascendence of design in the corporate pantheon. As yet generally unrecognized, but by far the most effective level on which to compete, is the next and highest level: concept. A product with a better concept sweeps the marketplace.

Design tools for working at these three levels exist. At the lowest level, quality assurance methods now abound. W. Edwards Deming, the American pioneer in quality control theory, decades ago told all who would listen how to detect and reduce defects in manufacturing. Present-day theorists in computer-aided design, computer-aided engineering, ergonomics and visual semantics are providing similar expertise at the detail design level. At the concept level, less is known, but the Structured Planning process developed at the Institute of Design is a pioneering effort. I will discuss how this process is important to the notion of Product Integrity.

It is at the concept level of quality that design makes significant contribution to the achievement of Product Integrity. Holistic by definition, Product Integrity is more than a profile of quality indexes and, most emphatically, requires more than just excellent design. But everyone would agree that a great concept is a hallmark of Product Integrity. To be a great concept, a product must achieve a degree of design sophistication, innovation and attention to need that well exceeds achievement by checklist. Successful design is necessary at all levels of quality, but there must be *significant* conceptual success in addressing a panoply of production, use and service issues and their impacts on society and environment. In essence, when it operates at the top of the quality pyramid, design operates also in the realm of Product Integrity.

Conceptual Design

Structured Planning is a design planning tool for operations at the conceptual level. Two characteristics of the process directly support the achievement of Product Integrity: the capacity of the process to incorporate and use a wealth of information in both breadth and depth, and the ability of the process to juxtapose information in the right place and time to encourage the evolution of organic, holistic concepts.

Action Analysis

The Structured Planning process contains an extensive information collection phase called **Action Analysis.** The purpose of this phase of the process is to establish what the product, system, service or other entity under design must do (**Functions**), and to gain insight about what may take place when this is done (**Design Factors**).

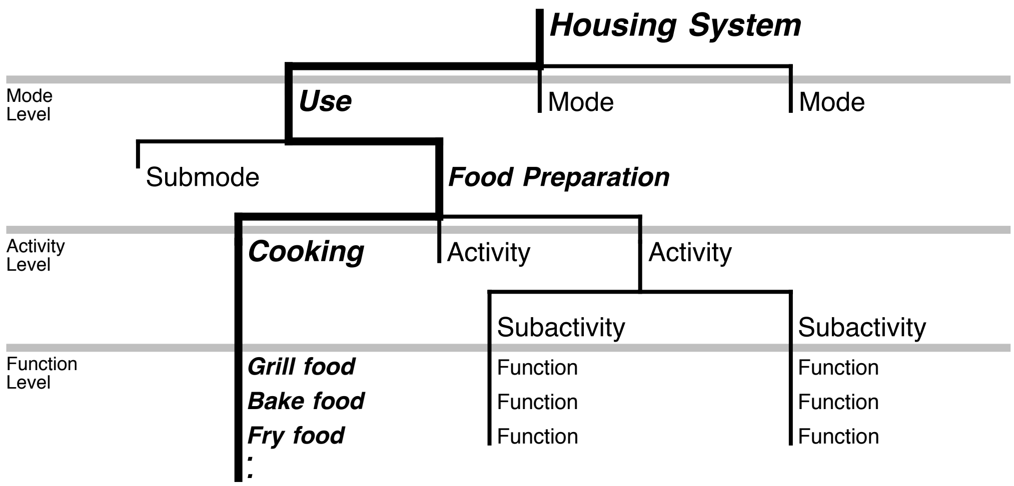
At a similar stage in most product development processes, information collecting consists of the examination of competitive products, market studies on existing products and the elicitation of needs and/or ideas from potential users. The focus is almost always on existing products, their purchasers or users. Two things are wrong with this approach.

First, there is usually no serious attempt to develop a new concept. The effort in this product development model almost always goes into refinement of an existing concept. An idea already exists (the current product to be improved) or is obtained with little effort (a product fortuitously conceived by someone with enough influence to have it considered). Market research is often suggested as a tool at this stage, but it is not a good choice. Contrary to conventional wisdom, market research can do very little here—the scene comes to mind of the Wright brothers in 1900 meeting in their bicycle shop about what to do for a new product. It isn't likely that a market research firm would bring them the concept of an airplane... Market research can help evolve a concept, but is inappropriate for inventing one.

The second thing wrong is that the search for information usually reaches only the primary users of the product: those who operate it for its intended use. Those it misses are the very users who could reveal many of the needs that should be considered in its design. They are the many secondary users of the product—those who make it, distribute it, store it, sell it, maintain it, repair it, remodel it, recycle it, retire it, etc. Through the eyes of each of these "users", a product looks radically different. Each user sees it in terms of the functions he has to perform with it, and each can contribute to the development of a better concept.

Structured Planning addresses the first problem as a matter of principle. It formalizes a split between concept design and detail design with the goal of developing a concept of design quality high enough to attain Product Integrity—before detail design is even begun. The goal is an innovative, sophisticated, thoroughly thought-out concept described elaborately enough to be evaluated and used as the project specification for an equally thorough (more conventional) detail design process.

Action Analysis, as the primary information collecting phase of Structured Planning, addresses the second problem. Guiding the search is a Function Structure created to assure good coverage of *all* Functions—most especially those not normally recognized in conventional product development.



A three-level, top-down analysis is used to find **Functions** *that cover the requirements of a system. The result is a* **Function Structure.**

A Function Structure is a three-level hierarchy topped with the "system" under consideration and successively layered below with **Modes** of operation, **Activities** and, finally, **Functions.** Modes of operation are the major kinds of behavior alluded to above—maintenance, repair, retirement, etc.—along with "use", the mode frequently only considered. Activities are the "purposeful performances" engaged in to accomplish the tasks set out by the Modes. An Activity, as described for the process, is the set of actions performed by users and system. A "theater" metaphor helps when developing a description: in an Activity "scene", users are the players, system elements are the props, and environmental elements are the set. As a scene is walked through, the actions of users and system are identified and pinpointed. These are the Functions that the designer is ultimately concerned with—what the system must be capable of doing (or supporting) well.

The comprehensive list of Functions assembled by building the Function Structure establishes the *breadth* of the information base called for by Action Analysis. *Depth* is provided by "insights" about how the Functions are performed. These are recorded as **Design Factors,** documents—virtually structured essays—recording what goes right (or wrong) when the Functions are performed. Anecdotal observations and qualitative information, supported with facts and numbers as available and prodded for design implications, supply the deep understanding on which to build thoughtful solutions. Functions and Design Factors by the hundreds together form the information base from which a Structured Planning design team works.

Action Analysis	Activity/Event: Cooking	10
Originator C. Owen	Project Housing System	Mode Use (Food Preparation)
Users Cook Cooking helpers	System Components Stove Oven Microwave oven Pots and pans Recipes Food ingredients Refrigerator Freezer Utensils Work surfaces	Environmental Components Work surfaces Task lighting Sinks Storage units Garbage disposal Used and unused vessels

System Functions	Associated Design Factors
25. Grill food	
26. Bake food	
27. Fry food	
28. Boil food	
29. Steam food	
30. Heat food	
32. Defrost food	
33. Cool food	
34. Freeze food	
35. Check progress	***50.*** Process-dependent tests
36. Clean utensils and containers	
37. Transfer foods between containers	
38. Set up controls	***51.*** Initialization Uncertainty
39. Dispose of garbage	
40. Stir pots	
41. Add ingredients	

User Functions	Associated Design Factors
42. Prepare sauces	***52.*** Ingredients don't mix
43. Consult recipes	***53.*** Non-linear scaling
44. Prepare servings	

Design Factor	Title: Process-Dependent Tests	50
Originator C. Owen Project Housing System Mode Use (Food Preparation) Activity Cooking	Source/s Personal observation	Associated Functions **35.** Check progress

Observation	Extension
Tests for "doneness" or satisfactory cooking progress vary considerably in the test applied and the variable observed.	There is no simple test for satisfactory progress that can be applied to all forms of cooking. While temperature is involved in all, other variables that frequently change much more rapidly than temperature are often the signs examined to determine progress. For meats, including fish and poultry, it is usually possible to monitor temperature. For boiling potatoes, the "firmness" of a potato is tested, usually by inserting a fork. Some vegetables are cooked by boiling away water; in that case the level of remaining water is monitored. Vegetables that are steamed are frequently steamed for a set period of time. Sauces sometimes are cooked until they "thicken", a condition determined by appearance and viscosity. Since cooking is dependent upon temperature, it may be possible to correlate all tests with temperature in some way associated with the specific food and its quantity, but this has not been demonstrated.

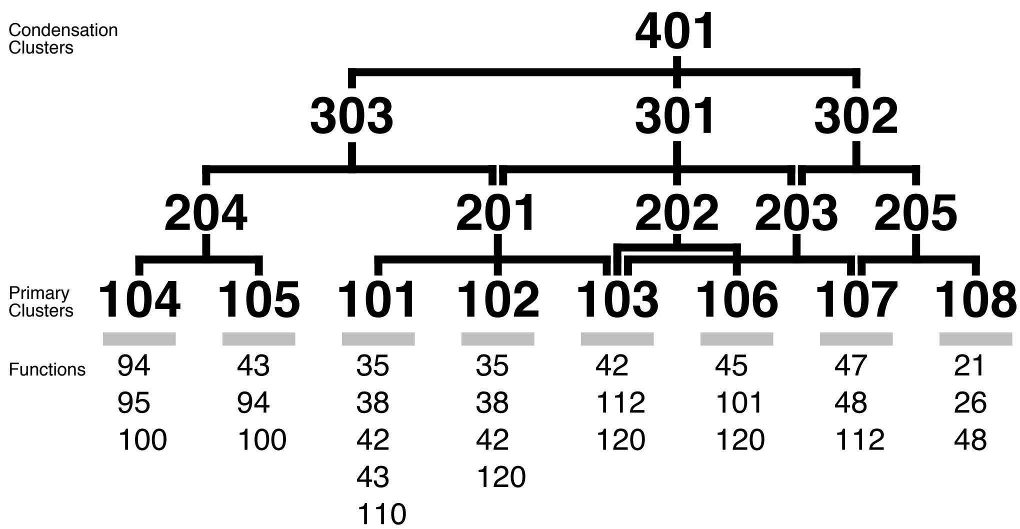
Design Implications	Speculations
Test multiple variables.	**83.** Multiple-Condition Sensor
Correlate condition to temperature.	**84.** Micro Sampler

Action Analysis *information collecting forms (left) are used to identify* ***Functions*** *for an activity and to associate insights, as* ***Design Factors,*** *with them.* ***Design Factor 50,*** *for example, is associated with* ***Function 35. On a*** **Design Factor** *form (right), the insight is developed to provide qualitative information. On it also, the insight is applied to the generation of ideas (****Speculations****) for how to fulfill the* ***Function.***

Structured Information

Having good, insightful, broadly-based information meets one objective for a design process committed to Product Integrity. Having it in the right place at the right time meets the other. The problem with having a lot of information is that the more you have, the more difficult it is to organize. Given the goals of Product Integrity, it is particularly important that an organizational scheme put things together in such a way that maximum synergy is generated among the ideas that come up for consideration. In other words, Product Integrity would be well served if the components of the product elegantly solved multiple problems, performed multiple functions, and did all with an economy of means. The elegant solution not only does things with style, it does them with a simplicity that belies the effort that went into its design.

Structured Planning organizes the information produced by Action Analysis using two computer programs, RELATN and VTCON, created for the purpose. At the heart of the RELATN program is a special "measure of interaction", a mechanism that finds and links Functions in the information base that have a strong likelihood of being fulfilled by the same component or components of a design solution. This approach to information organization is unique and deals directly with the design problem inherent in the Product Integrity goal of holism. To achieve holistic solutions, components need to have "organic" associations with each other, working in concert to achieve the purposes of the system. The best way for this to come about is for the design team to *see the right Functions together* in the design process. Conventional data bases associate data items by their common membership in classes, frequently marked by keywords (for example, all Functions to do with electrical systems for a house in an "electrical" category; all Functions concerning plumbing in the "plumbing" category). The RELATN program associates them, instead, by their potential for being fulfilled by the same design ideas. The **Information Structure** then created by the VTCON program provides the organization to reveal clusters of related Functions and how they relate to others.



Hierarchical clustering by the **VTCON** *program produces an organization of the entire set of Functions—an* ***Information Structure.*** *Information structures may include hundreds of Functions.*

Conclusions

Product Integrity is a big idea. Because it subsumes all aspects of producer/consumer/observer relations, it can only be achieved with similarly sweeping principles and policies. For design policy, this means that conceptual levels of designing should be separated from detail levels of designing—in the same way that strategy is separated from tactics. Separately recognized and emphasized, the conceptual design planning process can get the concept right before detail commitments are made.

Effective conceptual design begins with the commitment to innovation. It continues with a systematic identification of *all* Functions that can be identified for the product in *all* of its modes of operation, and a search for the insights that will lead to better understanding and better ideas. Organized so that they can be optimally seen together for potential synergistic effect, the Functions and associated Design Factors constitute an Information Structure well-matched to the requirements of design for Product Integrity.

The value of design to Product Integrity is fundamental; high-quality design is vital at all levels. What is newly apparent, is that design at the concept level can play a *critical* integrative role in shaping the product to the needs of its many masters. To that end, Structured Planning is becoming a workhorse of the new corporate advanced planning teams.