QFD and TIPS/TRIZ

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Introduction: "TIPS" is the acronym for "Theory of Inventive Problem Solving," and "TRIZ" is the acronym for the same phrase in Russian. TRIZ was developed by Genrich Altshuller and his colleagues (Ref. 1,2,3,4) in the former USSR starting in 1946, and is now being developed and practiced throughout the world. (Ref.5).

TRIZ research began with the hypothesis that there are universal principles of invention that are the basis for creative innovations that advance technology, and that if these principles could be identified and codified, they could be taught to people to make the process of invention more predictable. The research has proceeded in several stages over the last 50 years. Over 2 million patents have been examined, classified by level of inventiveness, and analyzed to look for principles of innovation. The three primary findings of this research are as follows:

1. Problems and solutions were repeated across industries and sciences
2. Patterns of technical evolution were repeated across industries and sciences
3. Innovations used scientific effects outside the field where they were developed

Much of the practice of TRIZ consists of learning these repeating patterns of problems-solutions and patterns of technical evolution, and methods of using scientific effects, and applying the general TRIZ patterns to the specific situation that confronts the inventor. Figure 1 describes this process.

Early research indicates that inventors using TRIZ experience improvement of 70% to 300% or more in the number of creative ideas that they generate for solving technical problems and in the speed with which they generate innovative ideas. (Ref. 6). When TRIZ was first introduced to practitioners of Quality Function Deployment, the appeal was immediate. (Ref. 7,8 US introduction, Ref. 9,10 Japanese introduction)

QFD has been winning proponents because of the clarity with which it identifies customers’ needs, organizational technological capabilities, design properties, reliability problems, functional capabilities, and the relationships between all these factors. Many QFD users found themselves overwhelmed with the richness of these data: once they knew the relationships between the customers’ needs and their own abilities to satisfy those needs, they wanted further help to create the innovative product and service designs that would meet or exceed the customers’ needs. TRIZ is the family of tools that gives QFD practitioners the help they need to innovate to satisfy their customers.
QFD and TRIZ:

Each of the major tools of TRIZ can be used in a variety of stages of Quality Function Deployment. For simplicity, the tools of TRIZ will be explained briefly, and a correlation matrix will be proposed to identify the opportunities to use TRIZ to enhance QFD.

There are many ways to organize the tools and techniques of TRIZ. A flow chart is useful when introducing TRIZ, since it shows how the tools are related, as well as what they are. Figure 2 is a typical flow chart used for either a product design or process development problem.

The first stage is analysis. Tools shown on the flow chart are

- **Functional Analysis**—familiar to QFD users. Analyze the system, subsystems, and components in terms of the functions performed (not the technologies used.) One new technique in TRIZ is "trimming"—examining each function to see if it is necessary, and, if it is, whether any other element of the system could perform the function. Breakthrough designs and reductions in cost and complexity are frequent results of functional analysis and trimming.

- **The Ideal Final Result**—familiar to QFD users as the customers' demanded quality. Express the situation in terms of why the innovation is needed, using technology-independent and implementation-independent language. Strategic breakthroughs frequently come from the insight gained at this step. Quality improvement opportunities can be identified finding what elements make the system non-ideal.

- **Resource Analysis**. Identification of the available things, energy sources, information, functions, and other elements that are in or near the system, that could be combined with the elements of the system to improve it. QFD practitioners will find that an awareness of the uses of resources in TRIZ changes the way that they conduct customer observation visits (Ref. 2.)

- **Locating the Zone of Conflict**—familiar to quality improvement researchers as "root cause analysis." Understanding the exact cause of the problem. The "zone" refers to the time and place that the problem occurs. A new tool, anticipatory failure determination (Ref. 12) introduced by Kaplan, Zusman, and Zlotin, reverses the process, and guides the researcher to look for ways to cause failures, to increase understanding of how to prevent the failures.

$$\text{Ideality} = \frac{\Sigma \text{Benefits}}{\Sigma \text{Costs} + \Sigma \text{Harm}}$$
If the problem has been solved in the analysis phase, developers frequently proceed to implementation. If it has not been solved, or if alternate solutions are desired for maximum creativity, the data-based tools, Principles, Prediction, and Effects, are used. In many TRIZ applications, all three of the data-based tools of TRIZ are used. The flow chart shows a decision (diamond symbol ◊) indicating the choice of tools.

- **Principles (also called resolution of contradictions)** Technical contradictions are the classical engineering "trade-offs." The desired state can't be reached because something else in the system prevents it. Physical Contradictions are situations where one object has contradictory, opposite requirements. TRIZ guides the developer to design principles that resolve the contradiction, once the contradiction is defined in terms of standard parameters. See Appendix 1 for examples and Ref. 13 for the complete database, with examples.

- **Prediction (also called Technology Forecasting):** TRIZ identifies 8 patterns of technical evolution. Designs of systems, subsystems or components can be deliberately moved to the next higher stage.
within a particular pattern, once the pattern is identified. The 8 patterns are

1. Increased Ideality
2. Stages of Evolution
3. Non-uniform development of system elements
4. Increased dynamism and controllably
5. Increasing complexity, then simplicity
6. Matching and mismatching of parts
7. Transition to micro level and use of fields
8. Decreased human interaction (increased automation)

○ Effects: Use scientific and engineering phenomenology and effects outside the discipline in which they were developed. Tools include data bases, science encyclopedias, and searches of the technical literature to find alternate ways to achieve the functions that are needed to solve the problem. Classical examples include the use of geometrical solutions to mechanical problems (use of a Moebius strip doubles the lifetime of a belt) and use of biological solutions to chemical problems (tailored bacteria that "eat" contaminants, instead of complex filters) as well as use of common science from one area that is unknown in others (Carbon-14 dating was well-known in chemistry for 30 years before archeologists learned about it.)

The last block in the flow chart is Evaluation of Solutions. Solutions are compared to the Ideal Final Result, to be sure that the improvements do advance the technology and meet the customers’ needs. Multiple solutions may be combined to improve the overall solution using a Feature Transfer (Ref. 14) which is similar to Pugh concept selection and improvement (Ref. 15.)

The flow chart shows that remaining problems are resolved by iterating the process. The advantage of TRIZ is that the iterations are very fast, and a great number of innovative ideas are developed at each stage.

The general problem solving process of TRIZ can be used whenever the product or process developer has inventive problems. Specific tools that may be useful by themselves during Quality Function Deployment are listed in Figure 3, and the stages of QFD in which they are useful are indicated.

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TRIZ Tools are used throughout QFD
The use of TRIZ to enhance the practice of QFD is very new. Research will continue to find ways to integrate these methods to help all product and process developers create innovative solutions that win market leadership by solving customer problems.

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