Karen Trzcinski, corporate director of Six Sigma; and Tom Kling, Master Black Belt and TRIZ expert, at Dow headquarters

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Dow Pairs Six Sigma and Innovation mistry

BY SUE REYNARD

With all the Six Sigma and innovation tools under one umbrella, employees can choose what works for them, says Trzcinski, here with Kling and Kevin McCarron, DFSS technology expert.

When innovation is the lifeblood of your company, you can't rely solely on the fickleness of inspiration.

This basic premise underlies research and development at The Dow Chemical Co. "Innovation is extremely critical to Dow's strategy to be the premier chemical company in the world," said Mike Costa, who recently retired as corporate director for Quality, Process and Architecture after 27 years with the company. "That means Dow not only has to run better than competitors, but also has to respond to changes in the marketplace by having new products to fill the demand space."

Dow answers these dictates with a systematic blend of Six Sigma, Design for Six Sigma (DFSS) and the creativity method known as TRIZ, which supplants inspiration with investigation. It has proven to be a powerful combination.

"Six Sigma and DFSS bring the kind of up-front decision making that makes sure the problems you're working on are important to the business," said Tom Kling, a longtime Dow employee who served as Master Black Belt for the installation and start-up of Six Sigma and DFSS in the company's 1,700-person corporate R&D department.

TRIZ, on the other hand, "helps you arrive at new solutions by importing technical solutions or scientific principles from other disciplines," he said. "So you solve design problems much more quickly."

1-2-3 Punch

Dow formally adopted Six Sigma in 1999. At first, the focus was on the basic DMAIC (Define, Measure, Analyze, Improve, Control) methodology. But it soon became clear that the DMAIC set of tools was not enough to solve all the challenges Dow faced.

So in the 2000/2001 time frame, the company added DFSS methods where innovation was needed. To strengthen invention ability even more, TRIZ (pronounced "trees") was woven in. TRIZ is the Russian acronym for the "Theory of Inventive Problem Solving."

The TRIZ methodology, which has come into more widespread use in the United States only since the early 1990s, was invented by the Russian scientist and writer G.S. Altshuller, who studied hundreds of thousands of patents to identify patterns in technology. "Altshuller found that many technical problems had been solved in multiple fields," explained Kling, who is a TRIZ expert. "He created a way for people to find solutions for their problems in what has already been discovered." (See "TRIZ: The Science of Creativity," page 41.)

The Six Sigma Umbrella

To encourage improvements and innovations throughout the company, Dow has deliberately integrated the training and application of all its improvement and innovation tools within the structure of Six Sigma. "Promotion relies in part upon having a minimum level of Six Sigma certification," Costa said. "The CEO has made it quite clear that the quality skill set is critical for every employee in the company and that Six Sigma will be used to drive performance across the portfolio of businesses."

Karen Trzcinski, who was tapped to succeed Costa as the corporate director of Six Sigma, said the company is keeping everything under the Six Sigma umbrella to minimize confusion and prevent wasted effort changing the label every few years. "Now any new addition is just another tool to put in Dow's toolbox," she said. "We've been able to integrate DFSS tools, TRIZ, and Lean con-

cepts like value stream mapping into the overall training."

Trzcinski's prior role was manager of the Work Process Methodology Expertise Center, which coordinates the training (see "A Full Toolbox," page 26). Trzcinski likes having the creativity tools blended in throughout the curriculum. "Innovation doesn't have to be a single humongous breakthrough," she said. "Innovation and creativity can enter into all projects. Any team can come up with great ideas and reduce them to practice. That's innovation, too. It doesn't only have to mean you're developing a brand new product."

Seeing the Forest Through TRIZ

The TRIZ discipline includes creativity tools that help teams understand functional needs and satisfy them in a more rapid time frame. For example, Dow wanted to convert a manufacturing plant that made polyethylene products to one that could also produce polypropylene products. Kling explained that developing the new design would normally take about a year, and conventional creativity methods would shorten the time to nine months. But the business need was to complete the conversion in six months. A TRIZ technique called *ideal final result* enabled the project team to identify ways to accelerate approvals and areas where they could process key activities in parallel in order to meet the six-month timetable, he said.

Kling also offered empirical proof of TRIZ's effectiveness as a creativity method. "With a group of 10 people in a brainstorming session, we'd often end up with anywhere from 200 to 500 solutions, but perhaps only 3 to 5 percent of those ideas would be useful. The rest would be dismissed quickly during evaluation," he said. "With the structured thinking and analysis that occurs with TRIZ methods, we've found that a similar group of people would get about 75 to 100 ideas, but at least half to two-thirds were viable. So there is a higher yield of useful solution ideas with TRIZ techniques."

Company Profile

Company name: *The Dow Chemical Co.*

Headquarters: *Midland, Mich., USA*

Number of employees: *43,000 worldwide*

2006 revenue: *$49 billion*

2006 net income: *$3.7 billion*

Primary business/offerings: *Plastics, chemicals, agricultural products, hydrocarbons, and energy products and services*

Website: *dow.com*

Another measure of TRIZ's value to Dow is the number of patents generated in design projects, Kling continued. "Typically, we'd generate one or two patentable ideas in a project. Using more advanced tools in TRIZ, we're able to define a whole range of alternatives and get six to eight patents in such a project." Some of those patents are put into practice immediately, and others can act as a competitive blocking mechanism – the company can describe the full range of inventions possible around a technology and get those patents before others even think of entering the space.

More Choices, Better Results

With Dow's combination of tools and methods, teams have a high success rate delivering the intended improvement, be it a step change or a paradigm shift (breakthrough). The company has run more than 11,000 projects over the past eight years. According to Kevin McCarron,

Black Belt Jennifer Trager, senior logistics specialist, and Henry Ward, director of Transportation Safety and Security, Global Supply Chain, head up a project team that is using DFSS and TRIZ to design a new rail tank car for transporting the most hazardous chemicals.

Master Black Belt and DFSS technology expert, "Only about 5 percent to 10 percent of those are what we'd call *innovation projects* – breakthrough projects that pull out the stops to achieve a new level of performance." The majority, he said, fall into what Dow terms either *implement* or *improvement* projects (the former akin to "just do it" projects where you implement already proven technology and the latter, basic DMAIC projects).

From a business standpoint, the integrated approach Dow uses also adds a needed flexibility. Innovation projects typically run eight to nine months, Costa said, while improvement projects run four to five months. DMAIC delivers an earlier return, he said, but when revolutionary change is needed, teams are able to tackle harder problems with advanced toolsets like DFSS and TRIZ.

Case in Point: Designing the Next-generation Railcar

The interaction of all the improvement and innovation tools can be seen in one of Dow's current projects – to design the next generation of rail tank cars for transporting the most hazardous chemicals.

"When we looked at this project, we recognized that traditional brainstorming and creativity techniques could not take us to the level needed in terms of improved safety and security," said Henry Ward, Dow's director of Transportation Safety and Security, Global Supply Chain.

The railcar design is a long-term project with multiple partners. Launched in April 2006, as of April 2007 it was at the design concept stage, near the end of the Explore phase of DFSS. The project is led by a core team of 10 people from the five participating companies – Dow, Union Pacific Railroad (the largest freight carrier in the United States), Union Tank Car Co. (which has built many of the tank cars in Dow's fleet), the Federal Railroad Administration and Transport Canada. To date, more than 60 people have been engaged on various sub-teams made up of design engineers, university researchers, contractors and specialists in emergency response, rail operations, rail maintenance, research and development, and logistics.

The benefit of interweaving TRIZ with DFSS became apparent immediately, according to Black Belt Jennifer Trager, a Dow senior logistics specialist and the project manager overseeing the railcar team.

PHOTO COURTESY OF DOW

Side impact testing of this staged tank car will enable the Federal Railroad Administration to develop its specifications for tank cars that haul toxic inhalation hazard chemicals. The testing also will establish a baseline for Dow to gauge its next-generation rail tank car improvements against.

"When you work through a house of quality – the design matrix done at the beginning of a QFD [quality function deployment] effort – you identify a lot of design or functional 'conflicts,' situations in which you traditionally face design trade-offs and may encounter compromises," she said. Resolving conflicts is one of the key strengths of TRIZ; the tools help teams find creative ways to provide the required functionalities while avoiding the conflict. "With TRIZ, we've taken the term trade-off out of our vocabulary," Trager said.

For example, the team came up with eight acceptability criteria for the design options, including performance, size, carrying capacity and weight. Ward explained that in traditional railcar design, steel is added to improve strength for crash protection. But train track restrictions limit the maximum weight of a car. Another conflict was that adding steel reduces the amount of commodity that can be transported, he said.

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–Henry Ward

At this point, the team latched onto a core TRIZ principle: Don't reinvent; use solution concepts discovered already. At Dow, that means not only accessing TRIZ databases to find conceptual solutions for similar problems from many other industries, but also maintaining databases of effective technologies and solutions used within the company.

TRIZ Solutions

The team learned that the Dow automotive business had already been challenged to develop materials that would provide crash protection without adding weight (for fuel economy) or using space (so cars could still be roomy). "Their criteria were exactly what we were looking for," Ward said. The team realized that the structural foams the automotive group had developed could be used in the new tank railcar to provide the necessary crash worthiness with superior performance, good economics and less weight.

In another case of "stealing" from themselves, the team glommed onto the work a safety team was doing to develop mechanisms that allow constant monitoring of a railcar's location and the condition of its contents. "The company is currently adding such devices onto existing railcars, and we're going to integrate them into the design of these next-generation cars," Ward said. That way, the company will be able to monitor the location and status of every railcar in its fleet and immediately detect any signs of tampering.

One of the key requirements to be addressed in the design was thermal protection of the tank cars in case of fire, such as in a derailment. But that type of insulation typically takes up a lot of space – another conflict. Once the team was able to define the technological problem – providing thermal insulation with minimal use of space – TRIZ databases helped them track down the solution in the aerospace industry. "With an inch of the material they are asked to solve. "Often in our design projects, we'll have some components that may require elements that already exist, so that's an *implement* solution," McCarron explained. "Or we may need to use DMAIC to *improve* the performance of other parts. And then there are improvements that require a change in the principle of operation or that we don't know how to address yet, and that's where DFSS and TRIZ come into play to drive *innovation*."

Over the years Dow has adapted the skills training to include the expanding list of topics. But that means people who received their training in the early years missed out on DFSS, TRIZ and Lean. The solution: "We offer stand-alone modules so people who didn't learn a topic before can do so now," Trzcinski said. "Also, we have some self-paced learning modules, so people can select a topic from our e-learning system to educate themselves."

A Full Toolbox

Dow is making a push to provide all employees with problem-solving and creativity tools. The training, which integrates all the various skills, is coordinated by the Work Process Methodology Expertise Center, located at Dow headquarters in Midland.

Based on Six Sigma structure, the skills are organized into four levels of Belt training: basic Green Belt, Green Belt project leader, Black Belt and Master Black Belt. Each level includes "training on a variety of innovation methods, tools and techniques, becoming progressively more challenging," said Master Black Belt Kevin McCarron, Dow's DFSS technology expert.

"Right now we're trying to elevate the skill sets in our technical population," explained Karen Trzcinski, Dow's new corporate director of Six Sigma and former manager of the center. "We've been training about 2,000 people each year to be Green Belt project leaders. With 30 people per session, that's a lot of training, and it is available all over the globe. People who want to get to a higher level of skills continue with Black Belt training, which is offered at the corporate center."

Trzcinski said the center includes "technology leaders" in four disciplines (DMAIC, DFSS, Lean, and data mining and modeling). These leaders help guide curriculum development, develop certification requirements, monitor their expertise areas for new methods, and facilitate communication among Dow's Six Sigma practitioner community.

Dow sees its integrated training as critical to helping teams choose approaches appropriate to the problems

use," Trager said, "we can get the same thermal protection as 4 to 8 inches of the current material we use."

DFSS Contributions

The other main contribution that DFSS and TRIZ made to the railcar design process was forcing the team to look at the design functions separately. As Ward explained, in current railcar design the tank serves three functions: It carries the load of the train; it has to contain the commodity (acting as a pressure vessel); and it has to protect the tank from external forces, such as in a derailment.

In the course of completing the functional analysis required by DFSS, the team realized that it was not necessary to require that the tank component fulfill all three functions. "We could separate the train loads from the tank and separate the protective function from the tank," Ward said. That separation opened new design avenues, which the team is exploring.

"DFSS also is helping us not just look at this railcar from a design point of view but to consider the whole life cycle," Trager said. "So we're thinking about how easy it is to fabricate and service, whether it will pass industry and government regulations, its maintenance requirements, and how it can be managed in an emergency response."

The team's goal is to have prototype railcars built in early 2008 and then start comprehensive crash testing. "We should start replacing cars in 2010 and complete the conversion of our high-hazard fleet by 2014," Ward said. "This is an extremely aggressive timeline given that we're looking at new technologies that have never been used in the railroad industry before. But DFSS and TRIZ are making it possible."

A Leap of Faith

Deciding to integrate toolsets like DFSS and TRIZ into a Six Sigma deployment requires a leap of faith because the gains are often quantifiable only in hindsight. But Costa thinks Dow's experience can serve as a benchmark for others. "Most corporate initiatives burn brightly for 18 months or two years, then die out," he said. Dow has been at this for nine years and has seen a return of "thousands of percent over investment."

"We found that if we articulate the right strategies and get the right toolsets to execute them in a systematic way. . .then our probability of success is much higher than companies who aren't as disciplined."

–Mike Costa

Costa credits Dow's success to constantly adapting their Six Sigma methods to the needs of the company. "We found that if we articulate the right strategies and get the right toolsets to execute them in a systematic way, using a very proven method, then our probability of success is much higher than companies who aren't as disciplined," he said.

Making its quality program Six Sigma centric – with the governance structure of Belts, Champions, Sponsors and the use of reviews – has enabled Dow to keep the toolsets and operating disciplines integrated with corporate strategy, Costa said. He urges companies to make sure they do *integrate* their efforts rather than pile on disjointed efforts. "Look at your company and understand where you will get the earliest payback, what elements of the income statement are most critical to manage first." Then, he said, step back and blueprint the methodologies that will help you achieve the necessary level of performance.

"Addressing some challenges requires incremental improvements in performance," Trzcinski said, "whereas addressing others requires a true step change – a breakthrough in performance. Integrating innovation tools with Six Sigma methodology gives Dow people a broader set of skills and tools. It enables them to apply the right tools at the right time to achieve the desired strategic result." ◆

Six Sigma Snapshot

Deployed: 1999

Penetration: 40% of workforce is engaged in Six Sigma projects

Projects:

- More than 11,000 projects completed using Six Sigma and innovation methodologies
- Nearly 50% of Dow's projects are linked to customer loyalty
- Minimum financial goal for a Six Sigma project is $250,000, with many delivering millions of dollars in value

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