The science of invention

Can a theory cooked up by a Soviet labor camp survivor solve today's thorniest engineering problems -- and make the world a better place?

BY MARK WALLACE

"This is your day," says Zion Bar-El, beaming like a proud father from the podium of the Waterford Room at the Sheraton Tara Hotel in Nashua, N.H. His audience of about two dozen scientists, educators and engineers, clad in casual-Friday wear, strain to make out his words over the drone of liturgical chanting emanating from somewhere nearby. Out in the hall, an endless procession of New Hampshire Knights of Columbus in full regalia -- bearing pennants and wrapped in sashes -- is making its way to the Sheraton's Grand Ballroom for a weekend of fraternal high jinks.

Bar-El, chief executive of Ideation International, rambles on, introducing chief technology officers, professors and a handful of journalists from Japan. He is apologetic about gathering his audience in this out-of-the-way New England burg, and promises that "next year will be Puerto Rico, Jamaica, Hawaii, one of those." None of the places he names seems any more fitting a venue in which to discuss a revolutionary new science, but to the tenacious little group at the Sheraton, that's exactly the point. They've descended on Nashua for the weekend -- about 100 of them, all told -- to confer on a discipline whose basic tenets include the notion that the best ideas are often to be found in the least likely of places.

The "science of inventive problem solving," which they've come to discuss, is certainly one of those unlikely places. Originally developed in 1940s Soviet Russia by Genrich Altshuller, a young naval patent agent, TRIZ, as it's known by its Russian acronym, seems at first nothing more than another tired exhortation to think outside the box. But closer inspection reveals a highly refined set of tools and patent and technology databases in use by engineers in some of America's biggest companies. Ford Motor Co. used the "science" to solve an idle-vibration problem, resulting in a handful of new patents for the company. DaimlerChrysler looked into the future of steering column technology. Johnson & Johnson developed new feminine hygiene products.

While it's a source of pride for any inventor to see the fruits of his labor in use around the world, friends and associates say that Altshuller, who died in 1998, had loftier intentions for his science. Having begun life as a scientist, Altshuller ended it as a visionary. His transformative experience was a stay in Joseph Stalin's labor camps, where he watched the Russian intelligentsia imprisoned there die off practically unnoticed. But far from dousing Altshuller's creative flame, the experience only fanned his idealism. He may have set out in his work to teach a shorter route to innovation, but he concluded with the idea that innovation might provide a surer road to a free society.

Altshuller saw TRIZ as nothing less than the solution to the world's social ills, not merely a way to grease the wheels of technological progress. He hoped his work would liberate people's minds. But thus far it has been used only as a problem-solving technique, albeit successfully: Engineers at companies like Boeing, Kodak, National

Semiconductor, Northern Telecom and even NASA are applying the methodology with startlingly impressive results. It may be a low-tech solution for a high-tech world, but it may also be a more lasting answer than things like software agents and total-quality-management packages. In fact, TRIZ may be a solution that transcends technology altogether.

On an engineering level, TRIZ works, say those familiar with it, by breaking down the process of problem solving and innovation into discrete elements, each of which is expanded through concrete techniques to catalyze engineers' thinking along specific lines. Nowhere in the methodology is there to be found so facile an instruction as "Let your mind roam free." As Altshuller writes, "It is not enough to say, 'Extend your imaginative thinking about something.' The methods for achieving this must be explained." Part of TRIZ's task is to explain these methods by using the host of technical principles culled by Altshuller and his disciples through close examination of innovations gone by.

It was Altshuller's stroke of brilliance to view the problems of engineering and innovation in terms of technical contradictions, the concept around which TRIZ pivots. "An invention is the removal of technical contradictions," Altshuller writes, and a moment's reflection proves him correct.

Even the incandescent bulb, perhaps the world's most famous invention, was made possible by the resolution of a technical contradiction. Electric current passing through metal filaments produced light as early as 1801, but the filaments burned themselves out too quickly to be of use. The contradiction: The filaments must burn hot enough to produce light but not so hot as to consume themselves. It was not until the late 1870s that Sir Joseph Wilson Swan and Thomas Alva Edison resolved the contradiction. Placing the filaments in a vacuum allowed them to produce light without burning themselves out too quickly.

One contradiction that TRIZ has not managed to resolve is that between Altshuller's idealism and the current rush to commercialize his work. Though Altshuller was no doubt aware there was money to be made through the application of TRIZ, he insisted that the science itself remain in the public's hands -- just as biology and mathematics, say, are the property of anyone who can grasp them. Altshuller certainly would have been startled to find someone hawking the movie rights to TRIZ.

"I'm looking to go after [Steven] Spielberg for a movie," Bar-El tells me in Ideation's hospitality suite, as the New York Knicks squeak past the Toronto Raptors on a muted television nearby. The idea is not as far-fetched as it sounds, given Altshuller's harrowing life story. Born in 1926 in Tashkent, the capital of Uzbekistan, Altshuller was awarded his first author's certificate (the Soviet-era equivalent of a patent) when he was just entering high school, according to Victor Fey, a former student of his. By 1946, the 20-year-old Altshuller, with several more patents under his belt, was working as a Soviet navy patent examiner and, according to Boris Zlotin, a longtime associate of Altshuller's, planned a career as a military engineer.

It was in the naval patent office that Altshuller first discovered the tenets that would lead him to TRIZ, discerning a common pattern of solutions to technical problems across a diversity of fields. The first thing he did with his

theory, however, was find a new way to put his foot in his mouth. Concerned over the dismal state of the Soviet Union after World War II, Altshuller and an associate, Rafael Shapiro, wrote an earnest letter to Stalin.

"They wrote a letter that stated that the country was in ruins after World War II, and that there were not many resources to recover it," says Fey. "He suggested to use TRIZ. Of course he had to prove this, so Altshuller put together a graph of innovation, and found there were two valleys in the graph. One was in 1937, with Stalin's first pogrom, and the other was in wartime." In 1949, Altshuller was arrested, interrogated and tortured. Finally, he "confessed," as had so many other "dissidents" before him, and was sentenced to 25 years in the infamous Vorkuta labor camp, at the northern tip of the Ural Mountains, above the Arctic Circle.

"He was in jail because, No. 1, he was Jewish," says Bar-El in his thick Israeli accent, "and because it's against the law to make the Russian people creative."

Stalin's most brutal despotism, though, couldn't dim Altshuller's creativity. Until his death in 1998, Altshuller burned as brightly as any of Edison's filaments, and often in just as rarefied an environment as a vacuum; much of his work was done while he was imprisoned in the gulag.

"Altshuller was in the labor camp along with many other representatives of the intelligentsia," says Fey. "He realized that in order to survive, not physically but mostly spiritually and mentally, he had to ask these people to teach him. Every night after they went back to the barracks, they would teach him: physics, math, art history, literature, whatever was available. This allowed these people to survive longer than they would have without Altshuller."

Zlotin, who worked with Altshuller in Russia for nearly two decades, relates his surprise at discovering Altshuller's vast knowledge of Verdi operas: "I said, how do you know these? You had time to go to opera? He said, 'Never, but my neighbor in the barracks was the world's best specialist on Verdi's music, and he would sing me all his operas at night.'

"For Altshuller, this camp was first a place of education," Zlotin says in his heavily accented English. "He studied 14, 16 hours per day, and in this way he had huge knowledge in pretty unexpectable areas."

It was this wide-ranging knowledge across "unexpectable" areas that allowed Altshuller to develop a problem-solving methodology applicable to just about any discipline you'd care to name. Inventor David Levy, whose portfolio includes work on the functional layout of the Apple PowerBook, calls the methodology "tremendous." (Though he does not use TRIZ formally, Levy says his practices naturally echo those found in the discipline.) "The most exciting part about TRIZ is, it's not limited to how to make a widget," says Levy. "It's how to approach problem solving, it's how to approach relationships, it's how to approach societal problems. It's really how to be creative and to observe the world and solve problems."

TRIZ leads engineers to generate potential solutions at a much faster rate than mere brainstorming would. "I'm used to seeing novel ideas once every six months -- if your engineer wakes up on the right side of the bed," says

David Patrishkoff, chief technology officer and head of R&D at Dura, a maker of specialty automotive parts. With TRIZ, "we're seeing dozens and dozens of novel ideas. I am totally excited."

Patrishkoff believes Altshuller's science -- and some "very interesting" patent strategies -- can help him "control the competition" through technology forecasting. "TRIZ is high-speed R&D, generating ideas at least 20 times faster than normal R&D groups," Patrishkoff says excitedly. "Do we patent them all?" Patrishkoff is considering a form of "patent fencing" in which high-level innovations developed through TRIZ might be published as a "trap" for competitors. Broader ideas, meanwhile, on which the published concepts depended, would be pushed through the patent process. "Even if we don't get market share, we're going to pick up on royalties," he grins.

Altshuller, if he's listening, must be spinning in his grave. He was probably among the first to mine patent files -- his original theories were based on a survey of more than 40,000 patents, and current databases used by computer-based TRIZ programs cover millions -- but he is more the Charles Ives of science than an early venture capital cowboy. Just as Ives refused to copyright his musical compositions, Altshuller always insisted that his ideas remain in the public domain, say those who knew him, and he was not particularly happy when TRIZ's stateside commercialization began.

"Altshuller said TRIZ is not for this," says Zlotin. "TRIZ should be only for all human beings to get." Now chief scientist at Ideation International, a TRIZ consultancy, Zlotin describes Altshuller as "Communist, but not idiotic Communist like people who like power. He was Communist in the sense of Jesus Christ; he wanted to make, for all people, something good."

"Altshuller wasn't interested in designing another gadget or another gizmo," says Fey, who runs a consultancy called the TRIZ Group and teaches TRIZ at Indiana's Wayne State University. "TRIZ was perceived by him as a way to develop creative people." To that end, a large part of Altshuller's efforts in Russia consisted of establishing education programs in schools and colleges throughout the country. According to Ideation's Bar-El, there are similar programs at universities in 25 countries around the world.

Bar-El, perhaps more than anyone else, is responsible for bringing TRIZ to the United States in an organized fashion. A former microchip engineer and marketing manager, he was semiretired when TRIZ was first brought to his attention by a friend, in early 1992. "I was ready to move to Las Vegas and buy a 7-Eleven," he says, graying curls peeking from his open shirt collar.

By 1993, he and two partners had tracked down TRIZ scholars in Israel and Russia, including Altshuller, and had hired two of them, Zlotin and his wife, Alla Zusman, as the core of a new company. With aerospace and automotive engineering concern Allied Signal (now part of Honeywell) as its first customer, Ideation set about solving problems that had stumped the company's top engineers. By 1994 it was pulling down more than a million dollars a year in revenues, a figure that's expected to approach $10 million by the end of 2000 -- not bad for a company promoting the "new science" of an obscure Soviet-era inventor who spent some of his best years in a labor camp.

"Altshuller was never broken by the camps," says Fey. "On the contrary. He had no tolerance for stupidity or arrogance in authorities. Altshuller was the only guy I knew who not only had certain principles, but he lived by those principles." And, inventor that he was, "he wouldn't adjust to the world around him; he would change the world to adapt to his needs."

People, as well as technology, were affected by Altshuller's "superstrong" charisma. "It was dangerous," says Zlotin. "After our first meeting [at a monthlong TRIZ seminar], when I returned to St. Petersburg, my friends start laughing because I start moving like him, my gesticulation became close to him, my smile became like Altshuller's. Not because he wants this. He was a very good person. But such incredibly strong character, such strong influence, such strong brain."

Though Altshuller was freed after Stalin's death in 1953, it would be several more years before he felt safe in publishing his theories. To support himself in the meantime, he turned to writing science fiction, under the pen name Genrich Altov. English translations of three of Altshuller's stories, collected in a book called "Ballad of the Stars," reflect not only Altshuller's views of the inventive process but his struggle to maintain his scientific faith amid crushing adversity and solitude. Science fiction, to Altshuller, was more than just a way to put bread on the table. Despite the fact that the ideas contained in sci-fi tales are often completely outlandish, as he writes in his exegesis of TRIZ, "The Innovation Algorithm," they remain useful for catalyzing research and inventiveness: "SF helps overcome psychological barriers on the road to [the] 'crazy' ideas without which science cannot continue its development." Altshuller even went so far as to catalog these concepts in a "Registry of Contemporary Science Fiction Ideas."

In 1959, Altshuller published his first paper describing the process at the core of "classical" TRIZ: the algorithm for inventive problem solving (ARIZ). Since its initial publication, ARIZ has undergone an almost constant process of revision at the hands of Altshuller's disciples. In its essence, ARIZ consists of three phases: problem definition, identification of technical contradictions and exploration of possible solutions.

"In many ways, the ability to ask the right questions is more powerful than the ability to answer them," says inventor Levy. "It's the difference between knowledge and wisdom." Other auditors of the methodology agree. Mike Weiner -- who is consulting for Ideation on the licensing of several inventions developed through the TRIZ process, including a "next-generation" electric razor whose blades revolve as well as rotate, and a newfangled diaper fiber said to dramatically increase absorptive capacity -- likens inventive thought to an unlikely pursuit: "People are very inventive, and most people don't understand that they are. They don't know how to discern potentially valuable and creative thoughts from all the other thoughts and noise of the day. I equate it to comedy. If you want to be a comedian, you have to learn the process of thinking up and telling funny jokes, an important component of which is not telling the nonfunny ones."

Though initially impressed by TRIZ's results, Weiner relates his surprise at finding that Bar-El and Ideation seemed to be unaware of the huge moneymaking potential at their disposal. "It's the old story -- the shoemakers' children have no shoes," says Weiner in frustration. "These people are very devoted to this thing, whereas they

probably could make a considerably greater amount of money if they did what they're now beginning to do a little more of, which is to offer invention-for-hire services, with royalties. But they're doing this to change the world for the better."

Despite their hopes for a blockbuster biopic, Altshuller's disciples seem to have inherited much of his zeal. For Altshuller, who never set foot in a free society, "TRIZ was not a goal in itself," says Fey. "He had a very strong philosophical belief that the degree of welfare in society largely depends on the number of creative individuals in society. He held that if any society had even 5 percent of people like Einstein, it couldn't be a fascist society."

Even Edison scowlingly admitted that though he could improve machines, he could not improve men. But perhaps he had too little faith. Altshuller, having come through the gulag with an intensified commitment to freedom and society, spent his life wondering not how to build better inventions but how to build better inventors. In the process, he may have invented a science that will allow us to do both.