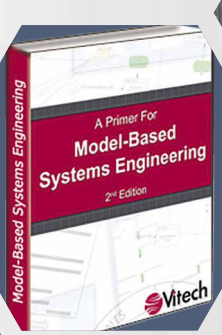
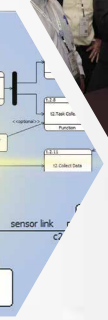
GREATER THAN THE SUM OF ITS PARTS:

A Brief History of Vitech Corporation





Vitech
Est. 1992

25 YEARS

Systems Engineering Excellence

1

I KNEW I WANTED TO BE A SYSTEMS ENGINEER

David Long, CEO of Vitech Corporation

The work of a systems engineer isn't always obvious.

It's an airplane that flies smoothly and lands without incident. It's an automobile that gently alerts the driver when drifting out of its lane or sensing a vehicle in its blind spot. It's a nationwide package-moving company that relies on dozens of independent software packages to move millions of parcels every day from point A to point B. It's a rocket that blasts off into space, taking human beings and supplies to a distant space station—able to safely complete its mission and return to Earth.

In fact, the success of a systems engineer might be noted more by the lack of a problem than by any fanfare or hoopla. And systems engineers like it that way.

To put it another way, what is the value of a problem not encountered? David Long, CEO of Vitech Corporation, often asks this koan-like question when speaking to audiences about systems engineering. Dealing with a problem once it occurs is much more expensive than avoiding the problem altogether.

Long founded Vitech Corporation in 1992. The venture which began as an undergrad project has grown to become an enterprise with a product used by thousands across the globe. It all started rather by accident.

Long was a science-minded undergrad at Virginia

> *"Systems engineering was my field of interest. Programming was my hobby. Combining the two made for an interesting capstone design project."*
>
> —David Long

Tech in the early 1990s, following in the footsteps of his father, a systems engineer, and majoring in engineering science and mechanics. "My father taught me to see the world through a systems lens," Long said. "I knew I wanted to be a systems engineer, and engineering science and mechanics provided a solid foundation."

In 1991, the lanky youth had, for a senior project, written software to support the design process for modeling and designing complex systems. This computer-aided system design tool was focused on the fundamentals needed to capture requirements, corresponding functions, physical architecture, and linking the three concepts together.

"Systems engineering was my field of interest. Programming was my hobby," Long said. "Combining the two made for an interesting capstone design project."

For a person of his interests and aptitudes, Long happened to be in the right place at the right time. Systems engineering—a field that had begun in the 1950s and '60s—while no longer in its infancy, was still an emerging discipline. And two of the biggest names in the field—Benjamin Blanchard and Wolter Fabrycky—were professors at Virginia Tech. They had just come out with the second edition of their landmark *Systems Engineering and Analysis* in 1990, a book that has been called "the definitive text on systems engineering." They had also built one of the premier graduate systems engineering programs of the day, and had a design lab specifically devoted to the discipline—an unusual thing at the time. The lab was focused not only on research, but also on developing supporting processes, methods, and software in order to provide students hands-on experience with the tools they would encounter in the business world.

In addition to spending hours in Blanchard and Fabrycky's lab, Long served as resident advisor in his dorm. He credits this experience with giving him the leadership skills he would later use as a CEO. "The soft skills that I learned on one side of campus complemented the 'hard' skills I learned on the other side of campus," he said.

Long recalled that Blanchard and Fabrycky's course was unusual in other ways as well. Approximately 90 percent of the students were actually practicing engineers pursuing their master's degree in the evening. They were scattered at remote sites around the state with classes taught by TV broadcast from Virginia Tech's Blacksburg campus.

"As an undergrad, I had the opportunity to take these graduate courses because of the systems background my father had infused in me and internships I had held," Long said. "Not only did I have the opportunity to learn from two industry pioneers, but I also partnered with Dinesh Verma [founder of the School of Systems and Enterprises at Stevens Institute, who was then a Ph.D. student in Industrial Engineering] on the course design project. That chance collaboration began a lifelong friendship and has fostered a number of systems

collaborations that have continued through the years."

While Blanchard and Fabrycky's lab had specialty academic tools to support the "ilities" key to systems engineering analysis (reliability, maintainability, availability, etc.), they did not have an architecture tool—a way to visually conceive of a multi-faceted construct with many independent parts. An architecture tool would support the full systems engineering design process—from requirements through functional analysis to physical architecture and implementation—complementing the other engineering tools in the lab. Long thought he could build such a tool.

He began the project his senior year, thinking of it as a tool for academic use. Then, as a master's student, he refined it. "I was on a path to a Ph.D. in industrial engineering with a focus on systems, and never intended to start a company," Long recalled.

But there was another company at the time with a tool that filled the need for a systems engineering software solution. That company was Ascent Logic Corporation. "The tool was Requirements Driven Design, or RDD-100," Long reflected. ("Requirements" is one of the four domains of systems engineering, the other three being behavior, architecture, and testing and evaluation.) "It was a big, expensive tool that cost $50,000 a seat. It ran on Sun or HP Unix workstations."

With RDD-100, Ascent Logic built on the pioneering work that Long's father, Jim Long, led at TRW (now part of Northrop Grumman). In the late '60s and early '70s working on ballistic missile defense, Jim developed a methodology and supporting government toolset for developing large systems with significant embedded software content. It embodied the concepts that today we call "model-based systems engineering."

The U.S. Army funded continued research and development in this area, resulting in Software Requirements Engineering Methodology (SREM), Systems Engineering Requirements Engineering Methodology (SYSREM), and Distributed Computing Design Software (DCDS). Ascent Logic built on this foundation to create RDD-100, the first commercial integrated system design environment of its kind.

"It was applied to countless complex systems challenges and was incredibly powerful, including some capabilities that have yet to be replicated in modern systems engineering tools when used by an expert," Long recalled. "However, it was 'expert friendly'—a euphemism for 'user-hostile'—and inaccessible for most systems engineers."

Long had a lighter-weight tool for desktop PCs, and he thought it would be a nice part of Ascent Logic's product line. His program was a model-based systems engineering software tool that integrated all the key components of building a system: people, processes, data, and documentation.

"I offered Ascent Logic the chance to license the product and distribute it in parallel with RDD 100 to create a more powerful and accessible tool suite," Long recalled. "Instead, they wanted to buy all rights for a small sum and offered me a job as a programmer." He had another idea. He decided to form his own company.

It was the summer of 1992. In a few months, the fledgling company made its first sale, a DOD contract.

2

A YOUNG COMPANY, AN INFLUENTIAL MENTOR

Jim Long, INCOSE Fellow and Model-Based Systems Engineering pioneer

"I was the only employee for several months," Long recalled. He self-funded the venture, working out of his parents' home in Vienna, Virginia. When it came time for his first hire, he didn't have to look far for talent. In February of 1993, he signed on his father, Jim Long, as president.

"He was the 'outside' guy, doing consulting and sales," Long said. "I was the 'inside' guy, working on developing the software."

Jim Long was an inspiration not only for his deep knowledge of systems engineering, but also for the way he lived his life. By all accounts, Long was a quintessential Midwesterner, possessed of a strong work ethic and good, solid values. "With over 40 years in the systems engineering industry, no one had a bad thing to say about him," according to David.

Zane Scott, vice president for professional services at Vitech, concurred. "You couldn't know Jim for more than about five minutes before you liked him. He was tremendously credible. You trusted him, and you liked him."

Long, senior, had been born in the small town of Hoopeston, in rural east central Illinois, where his father was a tenant farmer. Through application and industry, he grew up to be the first in his family to go to college. He attended General Motors Institute in Flint, Michigan, which was, during the middle part of the 20th century, an in-house training venture run by GM that followed an innovative

curricula: work and school were inter-mixed in 6-week rotations. It was a structure that matched the young man's sensibilities; he thrived on the combination of theoretical learning and practical application.

Jim went on to work at TRW in the late 1960s and early '70s, where he initiated and then led the pioneering work on Software Requirements Engineering Methodology (SREM) and then Systems Engineering Requirements Engineering Methodology (SYSREM). Because TRW was a leader in its day in the production of aerospace, automotive, and defense-related products, it was a great place to be if you were developing the practice of systems engineering.

Jim inspired in his son a way of thinking that David later realized was systems thinking. "The way he taught me to see the world was all systems concepts," David recalled. "Before I knew what systems engineering was, I knew I wanted to be a systems engineer."

One thing Jim taught David was "the law of conservation of systems engineering." It states that once you pick a problem, the amount of systems engineering required to solve that specific problem is fixed. The question then becomes, "Should you do the systems engineering up front? Or at the integration and testing point?"

But it's a trick question. Most people do systems engineering at the integration and test phase, when they see that things aren't coming together well. However, the cost incurred by inserting systems engineering at this late stage is often 50 to 100 times that of implementing it in the design phase. This is simply a corollary of famed software engineer Barry Boehm's adage, "The earlier you catch an error in software, the cheaper it is."

Sadly, the famous engineering saying is borne out all too often: "Never enough time to do it right, but always enough time to do it over." By which is meant, "We don't take time to do it right *the first time*."

Jim Long was an advocate of doing things right the first time—taking the time to think things through *before* implementation. "His contributions to how we do things are immeasurable, making the systems perspective a defining characteristic of how we build and operate Vitech rather than something we simply advocate," said David.

One of Jim's seminal contributions was the systems concept of STRATA™—a way of thinking through a problem using a layered approach. At each level of design, each domain of systems engineering—requirements, behavior, architecture, and validation and verification—receives no more detail in its delineation than is necessary for that level. This contrasts with the classic waterfall approach in which requirements were worked to completion before beginning to think about behavior or architecture. Jim realized that requirements, behavior, and architecture were coupled, and that top-level behavior and architectural decisions impact second-level requirements.

With STRATA, by a judicious apportioning of problem capture and analysis, a solution is developed layer by layer.

Using a waterfall approach, one can fall prey to the temptation of developing one facet of a problem all the way to a granular level, which often results in unnecessary or inappropriate work which must then be reversed later based upon insights gained from the behavior and physical architecture. The layered approach is also far more resilient to changes in schedule and funding, always providing a cohesive systems design that is progressively elaborated with additional detail as time and money permit.

With STRATA, by a judicious apportioning of problem capture and analysis, a solution is developed layer by layer. At each step of the way, the picture of a solution emerges in greater and greater detail across the entire structure.

Jim turned over the reins of Vitech to David in 2005 so that he could focus on his role as Chief Methodologist, continuing to advocate for systems engineering while teaching and mentoring project teams to help them advance their systems engineering capabilities. The methodology Jim advanced was not born in the lab—it was born from practical experience on the most complex problems. Jim spent his career continuing to evolve

and advance the methodology based upon new problems, new experiences, internal ideas, and industry innovations. To him, systems engineering was more about a mindset and approach than a series of steps in a defined process. It was also inherently about the application and value delivered to the ultimate customer.

David acknowledges the enormous debt he owes his father. "I had the pleasure of working with him for 18 years," he said. "He sacrificed a classic father-son relationship so that we could work together, and because of that I had the opportunity to learn from one of the masters of our practice. And I wasn't the only one learning from him. I am constantly reminded by senior leaders across systems engineering who sat in a class or worked on a project led by Jim. He left his mark on systems engineering, and every day I strive to continue the groundbreaking work he began at TRW."

For his contributions to the practice of systems engineering, Jim was made a fellow of the International Council of Systems Engineering and named an "Eminent Engineer" of Tau Beta Phi, the engineering honor society. He passed away in 2010 at the age of 74.

Jim Long, behind the counter, speaks to a conference attendee in the late 1990s.

3

AN EMERGING ENTERPRISE

When Long (David) sat down to consider a name for his company back in the summer of 1992, one did not have the luxury of searching the Internet, either for inspiration or simply to avoid those names already in use. Long came up with a name, but when he went to register it with the state, he learned that it had already been taken. "I came up with some more names, but they, too, were taken."

After more deliberation, he finally hit on Vitech, short for "vital technologies." Vitech was thus Vitech from the very beginning—a name that has served the company well.

The story of naming the software was a somewhat winding road as well. "People always ask what CORE stands for, believing it's an acronym for systems engineering concepts," David notes. "From the earliest days, I referred to the base capability being developed as 'the core,' knowing that we would continue to deliver greater capability over time. Though I explored other names, 'the core' stuck, so in 1993 the product officially became known as CORE, which represented the center and essence."

Vitech's first commercial customer was the National Security Agency, which was doing security analysis of hardware. "Our product allowed them to model security requirements, external threats, vectors for cyber-attacks, and corresponding tests to verify performance," Long recalled. "The NSA team had prior exposure to RDD-100 from Ascent Logic, so they understood the concepts, but were looking for an easier-to-use desktop implementation. As they learned about the development of CORE, they felt it was exactly what they needed. In fact, to best serve their needs, CORE 1.0 was released significantly before the planned launch date. NSA was our first customer and remains a customer to this day." From there, growth was organic and gradual, much of it via word of mouth.

Today, the software is used as a base around which exercises are written in systems engineering textbooks.

CORE™ would go on to achieve such renown within the systems engineering community that it became the go-to product used to teach model-based systems engineering. Today, the software is used as a base around which exercises are written in systems engineering textbooks such as Dennis Buede and William Miller's book, *The Engineering Design of Systems Models and Methods* (published by John Wiley and Sons, 2016). The software has in fact been embedded in this classic systems engineering textbook since its first edition in 2000.

The growth of Vitech as a company paralleled the growth of systems engineering more generally. In the mid-1990s, the systems engineering community was still a small, interconnected world. "You knew who was doing systems engineering. You understood their problems," Long said. What would

First corporate training room, Vienna, Virginia

become the international professional association of systems engineers, International Council on Systems Engineering, or INCOSE, had just been founded in 1990 as the National Council on Systems Engineering in the United States. (It would not become the international body INCOSE until 1995.) At the time, systems engineering under that name was almost exclusively practiced in aerospace and defense; it wouldn't be until later that automotive and other industries would recognize similar practices and begin to align under the title "systems engineering."

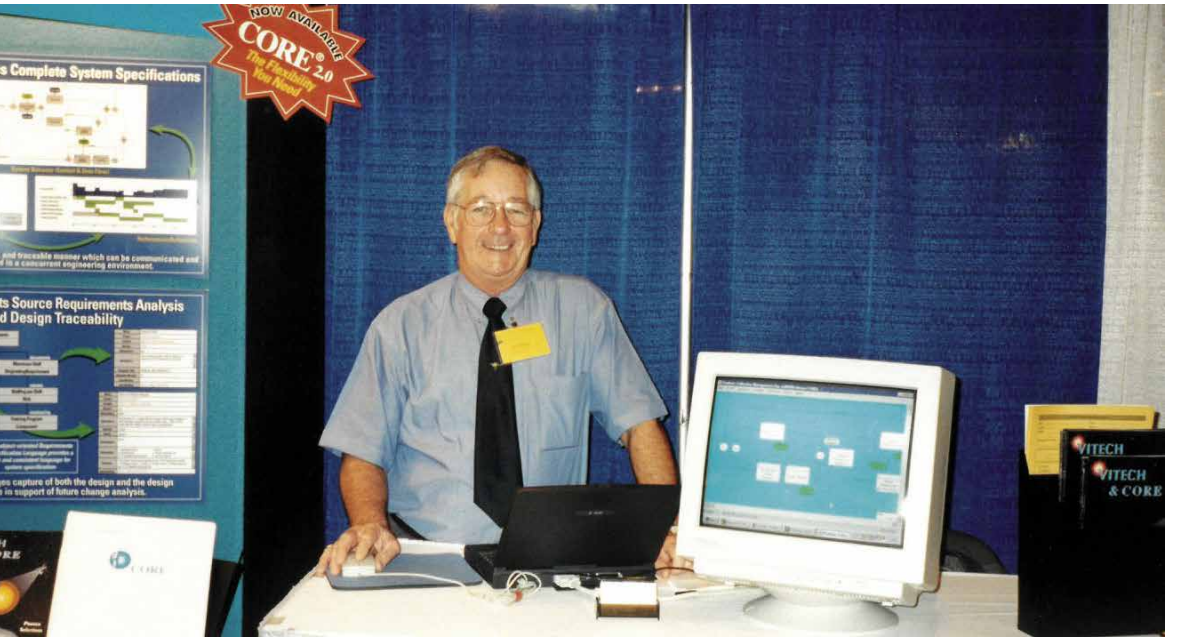
In the early years, the company grew in customers and capabilities. Vitech delivered multiple point releases in the 1.x series to meet internal expectations of the capabilities necessary to support a model-driven systems design process. As the team grew, in 1995 it moved into corporate office space in Vienna, Virginia, outside of Washington, D.C. In 1998, CORE 2.0 was released, enabling systems engineering teams to collaborate live working from a single source of truth for their project as they addressed systems requirements, behavior, architecture, and test.

As the dawn of the new millennium loomed, many around the world became concerned about the threat of Y2K—the potential for systems based on old software coding to malfunction at the turn of the century. While Y2K was not in Vitech's traditional systems design space, it did lead to an interesting project that complemented Vitech's portfolio of aerospace and defense projects.

A national flood insurance provider approached Vitech deeply concerned about Y2K. While they had been preparing for the time when midnight struck on December 31st, 1999, in September of 1996, they realized that their deadline would come three years earlier. They had overlooked the fact that flood insurance is written on a three-year term, and thus found themselves scrambling to meet a December 31st, 1996 deadline. Upon realizing this, company representatives turned to Vitech for systems engineering expertise to quickly understand their processes and the underlying systems, so that they could then quickly develop an implementation and test strategy to meet the looming and immovable deadline.

The fix for the Y2K problem uncovered a greater issue, but fortunately one that Vitech's methodology and CORE software could address: The overall structure of the company's various flood insurance policy pathways and supporting groups was extremely complicated. They had 70-80 data sub-systems distributed over 26-27 locations. Moreover, their system architecture was poorly documented, and the structure was too complex for one person to keep it all in his or her head.

Recognizing the reality of the schedule, the systems engineers at Vitech realized that a multi-pronged strategy was required. First, the only way to manage final certification of the system was via an interface control document. Each data center manager would ultimately certify that if they received Y2K-compliant data, they would generate Y2K-compliant data (allowing each data center to be treated as a black box subsystem with the internal implementations



Terry Deecke, Vitech's Australian value-added reseller, staffs the Vitech booth at the 1998 INCOSE International Symposium in Vancouver, British Columbia.

ignored). Second, process models were developed to clearly capture the processing steps and, more importantly, the associated data as flood insurance policies moved through the system. Team members on this project, from both the company and Vitech, made giant maps of company processes that they then taped to the wall so they could visualize the program and discover any hiccups. Testers took colored pencils and followed the process on the maps around the room, identifying duplicate test paths that could be dropped to save time, and unaddressed paths for which new tests were written.

By using CORE, the company was able to reengineer their systems in only a couple of months, addressing both the Y2K problem and the issue of their unwieldy and uncoordinated insurance policy processes. In addition to spending less time on the problem, the company was able to design better coverage by addressing the gaps they discovered. Without systems engineering, there is little doubt that they would have been unprepared to serve clients on January 1st, 1997.

4

A NEW MILLENNIUM

By the early 2000s, several more versions of CORE had been released, and Vitech had served as a systems engineering consultant and mentor for numerous companies and government agencies. But several team members were chafing at the growing Washington, D.C.-area congestion, so Vitech began to look for a second location within driving distance of the capital.

Virginia Tech's Corporate Research Center—dedicated to developing high-tech companies, adjacent to Long's alma mater, and a half-day's drive to DC—fit the bill. Vitech opened a satellite office at the park in 2003. At that time, the two offices were operated as sister units. The Blacksburg office in southwest Virginia became the primary location for software development and the back-office team, and the Northern Virginia office remained the home for sales and professional services given its proximity to DC.

It was during this time that Vitech landed a contract as part of the U.S. government's Future Combat Systems, or FCS, effort. FCS, a venture to revamp and revision the infantry based on modern technology, was one of the biggest undertakings of the army since World War II. While this massive effort is generally regarded as unsuccessful, there were pockets of brilliance.

United Defense Limited Partnership (UDLP), now part of BAE Systems, was a big player in this effort; their contribution was to be a redesign of their classic infantry carrier vehicle, the Bradley. In the newly conceived version, the infantry carrier vehicle was to have a sensor feeding real-time data back to a command post. One of the project's systems engineering managers came to a Vitech training class taught by Jim Long. At the end of the four-day course, David Long recalled, "He said, 'This is great! Where could I find myself some engineers who could do this?'"

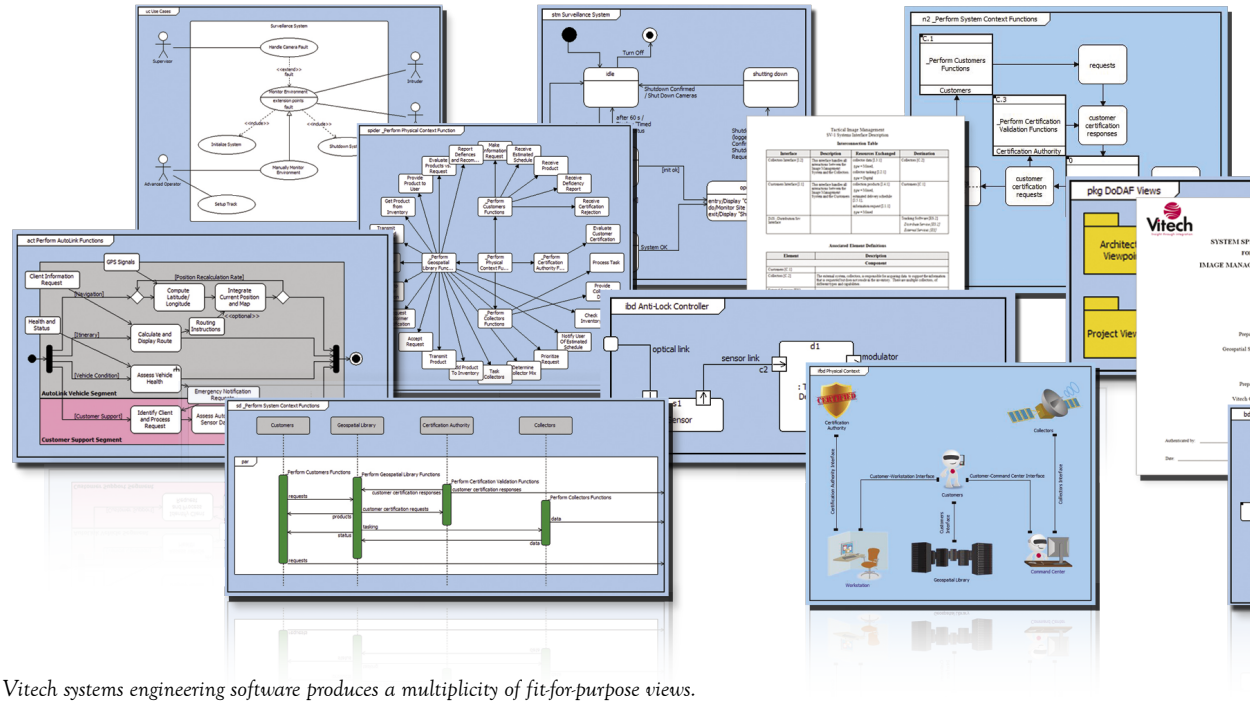
Jim said, "You're looking at them."

So it came to be that UDLP engaged Vitech—both the CORE software and engineers—to develop the project. With UDLP's expertise and Vitech support, the team was able to create a robust systems design. Jackie McGettigan, a senior systems engineer at Vitech, became the owner of all systems interfaces.

David Long recalled the weekly status-check meetings that McGettigan would attend. "At each of these meetings, the team lead would ask a question that no one could answer," Long said. "There'd be a 15-second pause. Someone would say, 'We'll get that answer for you tomorrow. But Jackie would pipe up with the answer—crisp and correct."

McGettigan had all the fundamental architecture modeled in CORE, and with the software doing its job of providing a single source of truth, she had ready access to the needed information. "She didn't have to go ask a team or flip through a ton of documents. She just checked the model, and it was right there." The outcome was that the customer had the information they needed when they needed it, and could move forward without a day's delay.

In 2005, the company began developing GENESYS™, its next generation systems



Vitech systems engineering software produces a multiplicity of fit-for-purpose views.

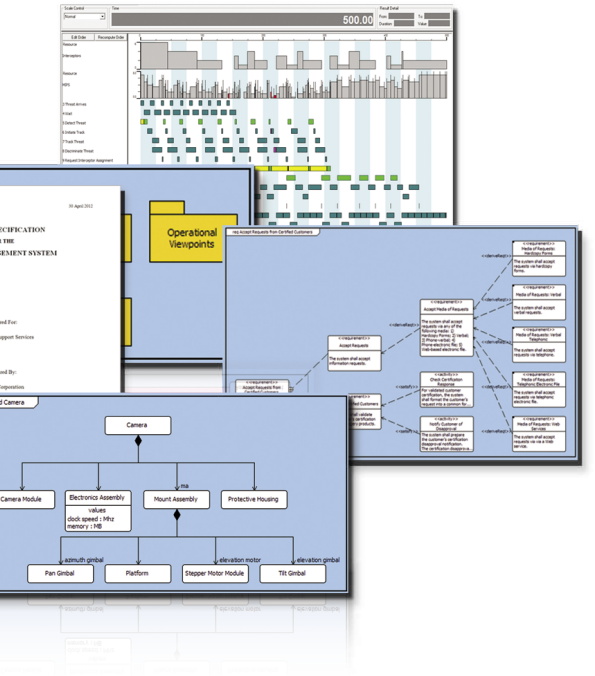
engineering environment. While CORE was integrated from requirements through architecture and test, it was built on 1990s technologies. As a result, it was fundamentally a closed system, not well suited to maximize the value of systems engineering through connection to other engineering tools or the greater corporate enterprise. With GENESYS, Vitech sought to leverage its collective insights from CORE and countless systems engineering engagements. GENESYS would represent the next advance in systems engineering environments, continuing the line of innovation reaching back to 1967 and the foundational work of Jim Long at TRW.

In October of 2011, GENESYS was launched.

In parallel with GENESYS, Vitech continued to develop new versions of CORE to serve its many clients and advance the greater industry. Guided by the principle of "balanced reflection," Vitech strove to blend the best of industry with its own advances and insights. Recognizing the value of supporting operational architectures integrated with systems engineering, Vitech extended CORE to natively support the U.S. Department of Defense Architecture Framework (DoDAF) as a byproduct of good systems engineering. Vitech then extended the many integrated representations in CORE to include SysML (to which Vitech was a founding contributor) alongside traditional systems representations. In parallel, Vitech added new capabilities to bring additional power to its integrated, model-based systems engineering environment while continuously working to ease the burden of systems engineering and enhance the user experience of CORE.

Zane Scott, vice president for Professional Services and a board member of INCOSE, began his tenure at Vitech during this time, starting as a contractor in 2009. He recalled the ability of CORE to create insights for customers. "We were working with a government client that was engaged in process re-engineering and improvement. We'd elicit their process and then put it all into the CORE database. Then we'd use a big plotter and print out an Enhanced Functional Flow Block Diagram—the most complete representation of behavior in a system. When we took the diagram to the process owner, we'd tell them, 'Based on our discussions with you, we think this is your process,' and they'd say, 'Well, but I do this, too.'"

Invariably, the process owners would gain insight into their processes and see how they could improve things. After all the changes, the customer would wind up with an "as-is" picture and a "to-be" picture,



with new insights about how to do things. "They'd go away with the to-be pics, and their question was, 'When can we get started?'" Scott recalled.

"The customers were able to dialog with us and make changes on the fly until the model matched their process. This showed them the areas where they could make improvements, and they provided the suggested changes," Scott remembered. "The result we hadn't planned on was that they now 'owned' the model because they recognized themselves in it. Both the 'as is' picture and the 'to be' vision were their work product. The biggest challenge in managing process change—convincing the process owners to make the changes—disappeared. They were ready to move forward on their own ideas."

It was during this project that Scott met Jim Long. The government sponsors had asked Scott to present an introductory overview on project management to some of the contractors and process owners. The approach he chose to drive home the importance of thinking through all aspects of a system before implementing it was a novel one. "I taught them how to do laundry."

Scott brought in two boxes, one to represent a washer, and the other a dryer. Then he had a stack of washcloths, some red, some white, and, unknown to the participants, some were pink. "They had to do a work breakdown structure of the process and follow it. If they failed to include the step of separating red from white, I'd hand them the pink washcloths." It was an object lesson on the importance of eliciting a complete set of requirements.

Long, Sr. had been in the back of the room, observing. Long had alerted Scott at the beginning of class that he could only stay until lunch. But when Scott looked up at about 1:30, Long was still there. "He stayed all afternoon and then invited my facilitation partner and me to eat dinner with him and the Vitech engineer who was on our team," Scott recalled.

At dinner, Long, with his characteristic directness, said to Scott, "You've been using CORE for about six months; what else would you use it for?" Scott explained that he would use it as a cold case tool for solving unsolved crimes. "I'd take everything I know and feed it to the tool. I'd have the tool tell me where the gaps are. Closing those gaps would then be my investigative plan."

"Hmm," Long rejoined. "What else would you use it for?"

"I'd use it in doctor's offices as a diagnostic tool. I'd use it to look at systemic interactions." Long challenged Scott's idea: Doctors would never buy such a tool from a non-physician!

"I told him I wouldn't try to sell it to doctors; I'd sell it to their malpractice providers," Scott recalled.

At that point, Long said, "You need to be working for Vitech." That began a relationship that would culminate in Scott joining Vitech in 2009.

Scott remembered an important lesson from that conversation with Long. "First, Jim was looking for applications of the concepts behind CORE outside of the ways we were already working. Like most people," Scott said, "I looked to my own background (in law enforcement) for the application, but Jim's question made me focus on the conceptual level at the same time. Concepts applied to real world problems are the essence of effective problem solving. That's the challenge that brought me to Vitech."

5

THOUGHT LEADERSHIP FOR A DEVELOPING DISCIPLINE

Recognizing that a true systems engineering practice comprises a way of thinking which is supported by an effective set of processes, methods, and tools, Long has always known that training and education would be a key part of the business. For Vitech, that meant training in a specific sense—how to tackle a particular problem and bring all the power of CORE to bear on it—but also in a broader sense: How would a systems thinker look at a given problem? How do we apply systems thinking to the big problems of our time?

In a world where problems are becoming orders of magnitude more complex than they were in a technologically simpler time, Long believes that systems engineering is needed more than ever. Yet the profession of systems engineering has seen a hollowing out of its ranks, what some have called the "bathtub effect." Many engineers who performed systems engineering functions, though perhaps not under the title "systems engineer," were hired into their respective industries in the 1960s and '70s. New hiring then dropped off for a number of years before recent college grads were again hired to perform these functions. When one graphs this on paper, it looks like a transect view of a bathtub.

To encourage young engineers to pursue a career in systems engineering, Vitech management decided to provide its software free to universities. Thus was born, in 1997, the university program.

This endeavor allows students to apply real-world systems engineering software, often for the first time. CORE in the Classroom provides free access to the full capability of CORE to instructors and students alike as graduate and undergraduate students study systems engineering. Ph.D. and post-doctorate researchers apply full commercial versions of CORE and GENESYS in their academic research as they advance the state of the art in systems engineering. Graduates describe the program as invaluable, opening their eyes to the power of an integrated systems engineering environment while reinforcing the systems engineering principles and methods used during requirements elicitation and management, behavior analysis, architecture definition, systems integration, and validation and verification.

Ray Hudson, aerospace systems architect and lecturer in the Aerospace Engineering Department at California State Polytechnic Institute, Pomona, reflected on the value of this program:

> *Through the gift of CORE licenses from Vitech, we at the Aerospace Engineering Department at Cal Poly, Pomona have been able to craft a senior-standing, model-based systems engineering elective course which follows on from our Fundamentals of Systems Engineering course which all students must take as part of our curriculum. In this upper division course, we use CORE to specifically teach the concepts of relational knowledge used to describe a target system's operational scenarios, its functional underpinnings, its physical architecture, and the requirements and analysis that tie the entire knowledge base together. Student feedback has been very positive, especially from those who went on to become systems engineers upon graduation.*

David Long served as president of the International Council on Systems Engineering, or INCOSE, from 2014-2016.

Since the program began, more than 80 universities around the world have taken part, and tens of thousands of students have learned the principal concepts as well as the nuts and bolts of systems engineering.

By 2009, Long realized that there were enough misperceptions about the practice of systems engineering—even among systems engineers—that a basic overview of the discipline was in order. Together with Scott, he wrote a book that would become *A Primer for Model-Based Systems Engineering*. The book reviews the basic concepts of model-based systems engineering, and serves as a call to consider the foundational principles behind the concepts.

Since its publication in 2010 and with a second edition in 2011, the primer has served as an instructional text to students new to the discipline, as well as a guidebook for practitioners seeking to refine their craft. The book has been translated into a number of languages, including Japanese.

The primer's reach has been significant. Scott reported a lunchtime conversation at a conference when his seatmate at the table told Scott that he was designing an internal model-based systems engineering course for his company. When Scott offered to collaborate and share resources, the engineer told him that he had already found a book that fit the bill perfectly. In answer to Scott's inquiry about the name of the resource, he was told that it was a "Primer for Model-Based Systems Engineering," but he couldn't remember the names of the authors. When Scott revealed his role in writing the book, the engineer asked him to autograph his copy!

By the first decade of the 21st century, Long's presentations and participation at systems engineering conferences around the world had earned him a name for himself and his company within the community. Vitech has been a supporter of the International Council of Systems Engineering (INCOSE) since Vitech's inception in 1992. Vitech has been a long-standing member of the Corporate Advisory Board, providing support and guidance to the organization. In addition, Vitech team members have been active in technical working groups, at the local chapter level, and in leadership roles. Both Long and his father served as president of the Washington Metropolitan Area Chapter, then the largest chapter in INCOSE. Long was subsequently elected to multiple roles on the international Board of Directors, including a term as INCOSE's Director for Strategy. In 2006, Long received the prestigious INCOSE Founders Award in recognition of his many contributions to the systems engineering organization.

In 2012, Long was asked and then elected by INCOSE members to complete a presidential term

David Long (right) confers the Founders Award on Art Pyster at INCOSE 2015.

that had been vacated by the death of his close friend and fellow systems engineer David Wright. (In fact, before his death, Wright and Long were so frequently seen together at INCOSE events that they were referred to as "the two Davids.") This meant finishing out Wright's remaining year as president-elect and then serving two years as president. Long completed his term as president in January 2016.

As INCOSE president, Long helped INCOSE close out and celebrate its first 25 years while positioning the organization for the future. During his term, INCOSE drastically increased its publication of impactful products, alone and in partnership, including technical guides, frameworks, and the fourth edition of its foundational *Systems Engineering Handbook*. INCOSE diversified its publications, developing a new practitioner's magazine emphasizing the applications dimension of the profession. Among many other initiatives, Long supported the development of *Systems Engineering Vision 2025* to guide systems engineering as it rises to the challenges of the future, and chartered the INCOSE Institute for Technical Leadership to help develop the next generation of systems engineering leaders for INCOSE and the greater profession. Perhaps most importantly, Long led the redefinition of the organizational core values, principles, long-range plan, and strategic objectives for INCOSE's second quarter century.

While Long worked to advance INCOSE and its products, he also served as an ambassador and advocate for the greater systems engineering profession. During his presidency, Long delivered over 100 keynotes and presentations while visiting over 75 organizations and supporting 42 events on five continents. He counseled senior leaders around the world in government, aerospace, automotive, health care, energy, and transportation on the value, practice, and future of systems engineering. Long's signature address, *Building for Tomorrow: Towards 21st Century Systems Engineering*, delivered at the 25th anniversary INCOSE International Symposium in 2015, was referenced across systems engineering as a unifying challenge to advance the systems engineering practice.

As Long concluded his term as INCOSE president, he left INCOSE with a guiding principle and a critical reminder instilled in him as a student at Virginia Tech. Citing Virginia Tech's motto *Ut Prosim* (That I May Serve), Long reminded systems engineers of their mission and commitment to serve customers, stakeholders, and the greater world as they deliver value through their systems in an effective and efficient manner. Quoting poet Nikki Giovanni, Long challenged INCOSE that "We are better than we think and not quite what we want to be," balancing appreciation for what we have achieved and those who make it possible with grace when we fall short and hunger for a better tomorrow for INCOSE and systems engineering.

6

INSIGHT 2011 AND SYSTEMS ENGINEERING FOR A NEW ERA

Twenty-five years in any business is not without its ups and downs. In 2008, as the national economy suffered a downturn, business at Vitech contracted as well. Coincidentally, this was at the same time as the company was developing GENESYS. Dealing with business contraction and a development cycle that was taking longer than expected was stressful to all involved.

Long's advice for weathering such a setback? "You have to be working in an area you love. It goes beyond passion." For him, sticking with the business was not a choice. "Systems engineering is in my DNA."

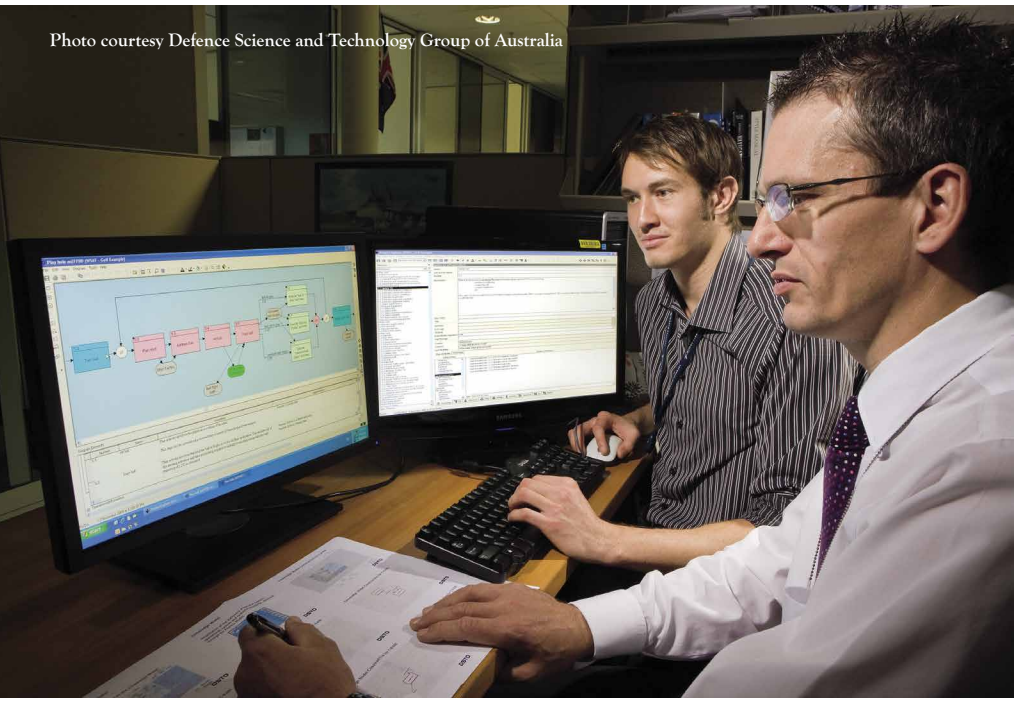
"You have to be working in an area you love. It goes beyond passion."

—David Long

By 2011, GENESYS was set to debut, and Vitech was ready with a few other changes as well. Vitech hosted a grand affair to celebrate the simultaneous launch of GENESYS 1.0, CORE 8 (a landmark release in its own right), and the second edition of the primer.

Vitech's efforts to evangelize about systems engineering have not been without challenges. Zane Scott noted that this is partly because, "It's an odd field. It didn't evolve from a set of principles. It grew from an application. It's as if people invented cardiology and then developed medicine from that, instead of the other way around."

Because of this history, systems engineering picked up processes that are stamped with aerospace and defense practices and terminology. "Initially, that was all the systems engineering practice knew," Scott said. "But systems engineering today is not constrained by any one area of application or any one type of system."



Kevin Robinson (foreground) and Wayne Power examine a model in CORE. Robinson is Senior Systems Analyst with the Defence Science and Technology Group of the Australian Government.

This change in landscape, Scott contends, means that the discipline of systems engineering has got to change as well.

Further, Scott says, we are at a time that demands creativity. While engineers may not commonly be thought of as creative types, Scott notes that "creativity is coming up with new ways to combine old elements. Albert Einstein called it combinatorial play." Systems engineering provides the framework for thinking that enables just this kind of creative combining. In addition, Scott says, "You've got to be curious. There are no creative people who are not curious."

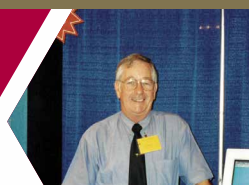
Scott challenges audiences to think of additional realms where systems engineering can provide value. Transportation, healthcare, and energy, he suggests, are all industries that could benefit from systems thinking. Another example: "What about how U.S. Veteran's Affairs delivers healthcare? We have a big bulge of demand coming," Scott said. "We can't take what we did for World War II vets, which was designed for them, and use it for our current veterans. Hospitals are rife with problems for systems engineers."

But it's not just a new way to think about process, according to Scott. "It's a change in consciousness."

Long concurs, and notes this about systems engineers: "We think broadly. Most classical engineers are trained to think deeply. To successfully deliver systems, you need both breadth and depth. It's a rare mindset. It's what makes systems engineering and Vitech's journey a continuing pleasure and a continuing challenge."

As the company moves into its next quarter century, Long is optimistic about its prospects and that of systems engineering more generally. "In many ways, systems engineering is just hitting its stride. We're just beginning to see all the ways in which the practice brings value to our complex world. We are seeing the value of the systems perspective and the applicability to a diverse range of systems. And we are seeing systems engineering slowly mature from an art and practice to a true discipline."

At Vitech, the team continues to think up new ways to expand the practice of systems engineering. "Making good systems engineering practice more accessible is what drives us every day as we advance our methodology and supporting software, and as we work with organizations to raise their systems engineering capability," said Long. "We look forward to our next 25 years."



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