CONVERSATIONS

Avoiding the Valleys of Death

A “System Readiness Level” metric could provide a baseline for lean product development.

Many are familiar with Technology Readiness Levels (TRLs)—a concept, first developed by NASA in the 1970s, that’s used to benchmark a technology’s development progress on a scale of 1 to 9. And many have also heard of the “valley of death” at TRLs 4 to 6, when a technology must bridge the gap between demonstration of a lab prototype and the road to actual commercialization.

Yet TRLs may not tell the whole story, according to Sean Ross, Air Force Research Laboratory, USA, Bruce Cahan, Stanford University, USA, and Cahan’s former student Ethan Strijbosch. Instead, they have developed a more comprehensive metric, System Readiness Levels (SRLs), encompassing not only technology readiness but issues related to system integration, manufacturability and financing. OPN recently talked with Ross and Cahan to learn more.

Q. How did you get interested in these ideas?

ROSS: At the Air Force Research Laboratory we’ve lamented for years about the “valley of death.” And I’ve been associated with projects that, for whatever reason, didn’t transition to commercialization. So, I’ve been very curious about what makes a successful technology—how do you get it out of development and into a product? That got me thinking generally about these concepts, and about the possibility of putting together different kinds of readiness-level metrics.

Then, while I was at a conference, I realized I was only two hours from Kitty Hawk, NC, where the Wright
brothers first demonstrated powered flight. I'm in the Air Force, so I took a side trip there and was inspired to do a deep dive into this pioneering period of flight and how that industry developed in the United States. That experience gave me a really different view of how technologies get developed and transitioned to customers, and how technical innovation at a laboratory level starts to become an industry.

Around that time, I was introduced to Bruce Cahan, who brings a totally different background than mine—he’s not a tech developer; he teaches business and financial innovation at Stanford University. He gave me a course in “Financial Engineering 101.” And suddenly all these ideas started clicking, and we became colleagues in this project.

Q. Your SRL metric really combines four different types of readiness levels. Where do these come from?

ROSS: When you look at the development of an innovation, you’re really looking at four concurrent processes: technology development, manufacturing development, interface maturity and business maturity. These processes reflect four basic questions. What is the new product? How will you manufacture it? Does it work in its intended environment? How will it be financed, marketed and distributed, and compete in the marketplace? We looked at those processes and the four metrics that track them: TRL; Manufacturing Readiness Level, or MRL; Integration/Interface Readiness Level, or IRL; and Business/Investor Readiness Level, or BRL. And we realized that while the four processes occur concurrently, the four metrics don’t progress concurrently. For a technology developer, TRL 9 feels like the end of a long journey, while the investor is only midway through—probably still in the product refinement stage of BRL 7.

Using the principles of linear algebra, we’ve synchronized these four metrics into one, the SRL, to form a single, non-overlapping system readiness metric. And in doing this, we identified 14 distinct SRLs that we think create a baseline narrative for successful lean development. [For a look at the 14 SRLs, see urbanlogic.org/readiness-levels-drive-innovation/]

Q. What does this mean for the concept of the “valley of death” for a developing technology?

ROSS: It means there’s more than one—in our work, we’ve actually identified five distinct valleys of death, at different SRLs.

The first one is at SRL 0 and TRL 1—it’s simply the leap from having an idea to getting funding and a team to develop it. How many millions of ideas are there that never go anywhere? And the second valley of death comes at the point of getting the technology out of development and to an actual demonstration. Here, you have to work on integration issues in particular. A good example from my own area, directed-energy weapons, is fiber lasers. These things are amazing acoustic couplers, and any time you take one out of the lab and, say, on a truck or a plane, suddenly you have to worry about the optical...
implications of vibration. If you didn’t think about that back in the lab, you’ll have to completely redesign your entire architecture. 

The third valley of death is the one most people think about—you’ve gotten to a prototype, and now you need to get a customer base interested enough to move from there to a real product. Here, business, integration and manufacturing concerns all come into play. And after crossing that valley, you come to the fourth valley of death: Can you grab enough market share, early enough, to sustain the enterprise and move to full production? There’s almost never a case in which only one person or company has a marvelous idea; there’s a competitor. So, there’s this knock-down, drag-out based on manufacturing and distribution efficiency.

Q. OK, that’s four—what’s the fifth valley of death for a technology?
ROSS: The fifth valley is reaching the end state: Can you successfully compete and cooperate in the marketplace? Is your system sustainable in the long haul? Organizations often get complacent here and may not keep up with changes in customer needs and expectations, competitors or laws.

And if you ignore any of these valleys of death—if you just expect your customers to instantly see the value of your product, if you don’t think about integration early enough or if you think that just coming up with new ideas is sufficient—that’s going to kill your project.

Q. You’ve looked at SRLs specifically in the context of the history of flight. Are there any examples from there you’ve found particularly revealing?
ROSS: One is the system readiness of the Wright brothers’ planes in 1904, right after their first demonstration of powered flight. Their big blunder was attempting to seize market share through patent lawsuits at what we’d call BRL 4, the stage of market validation, which they shouldn’t have done until BRL 8, the stage of building market share. Meanwhile, their biggest competitor, Glenn Curtiss, and others skirted patent injunctions and worked on BRL 5, 6 and 7 activities—business-model and customer development, product refinement—through air shows, free pilot training and dual-use technologies.

The Wrights did none of those things. As a result, they sold only about 100 planes and trained about 100 pilots before Orville sold out to one of his engineers, and the company was eventually bought out by Curtiss and became Curtiss-Wright.

So that misstep killed their project; that’s why there’s no technical legacy from the Wright brothers in modern aircraft. If the Wrights had known about SRL ratings, they would have asked themselves if spending all their energy pursuing patent lawsuits at that early BRL, rather than innovating, was really the best use of their time … Sometimes what appears to be a technical issue is actually a financial or organizational issue that’s getting in the way.

Q. But Curtiss-Wright had its own problems with keeping ahead of the curve.
ROSS: Definitely. After Curtiss bought the Wrights’ company, the Curtiss-Wright Company became the dominant aircraft manufacturer until World War II. But how many people have ever heard of Curtiss-Wright? It’s still in business, but it’s not a major player.

Why did that happen? A new innovation, jet engines, came along, and the company was slow in adapting to it. So, Curtiss-Wright got left behind. It thought it was at SRL 13—a sustainable system—but with the new innovation, it was really back at SRL 8 or 9 seemingly overnight.

Customer expectations, innovations, missions, regulations—all of these things can shift quickly and affect your readiness. It can decline even if your product stays the same.

Q. Bruce, your focus is the business and financial side of the equation. How do investors and availability of capital play into this?
CAHAN: The readiness levels we’ve come up with are all about moving toward an outcome, and investors and markets want to see that kind of momentum when they do their due diligence.
diligence. “Irrational exuberance” is considered a market phenomenon, but it’s also an engineering phenomenon—the idea that it’s cool if we can build something at all. But if you build it as a “highway to nowhere,” or you don’t have a marketing plan, then there can’t be follow-on capital, and the research will never get out there.

If we can’t get research out into customers’ hands, constraints on capital such as those we’re seeing today—from pandemic, war, global conflict, climate change—are going to cause some of the innovation capital sources to seize up. We’re already seeing this kind of slowdown in Silicon Valley.

Investors’ risk tolerance and maturity of investment are different along the pathways of these readiness levels. Investors will come and go, and that’s normal. That’s the ecology of money, so a refreshing supply of risk-based capital is needed. But if the technologists building the innovations don’t understand this ebb and flow, they’re going to under- or overshoot what the market is prepared to fund at a given moment. Tracking just one kind of readiness metric isn’t enough; we need financial engineering alongside technology engineering. So, showing that you have a pathway to assure innovation gets built and used by customers might be a competitive talking point for your investors.

I think you also have a perspective on this from the point of view of diversity, equity and inclusion.

CAHAN: Yes. I study nontraditional funders and entrepreneurs. Part of the reason underrepresented groups haven’t been able to get capital for their innovations is they don’t always speak the language of money. They don’t necessarily know the terminology to seek the right investment that matches the actual stage of development of their company.

Pitching successfully can be a real challenge if that language wasn’t part of the community you were born into or allowed to grow into. With these SRLs, there’s a consistency of language within the framework that we think can help overcome the barrier of, “Well, I wasn’t born into this system, so I don’t know how to work this system.”

Let’s say I’m interested in putting this integrated, SRL thinking into practice at an organization. How can I begin to do so?

CAHAN: That’s a good question! I’ve found that interoperability or multidisciplinary interdepartmental thinking is not for the faint of heart and requires perseverance. A good first step is to make allies of the decision-makers in an organization who have budget authority, since they bear the cost of failed projects. When you talk to the source of financing, suddenly people listen to you with greater attention.

ROSS: In my experience, which is largely in government organizations, the biggest impediments to implementation of these ideas are success criteria. You have to broaden your definition of success. The whole team has to be able to come together, so that the scientist doesn’t think they’re successful when they come up with an idea that no one ever uses.

In successful companies, they understand that a success for one is a success for all. It’s a system progress mindset that has to be adopted by the organization and needs to show up in everything. That includes compensation: Do employees get rewarded for a success in another department that they enabled, or only for their own narrow work? And organizations need to recognize that financial engineering is as legitimate a subject for research and modeling and analysis as any of the technical subjects.

The views expressed are those of the interviewees and do not necessarily reflect the official policy or position of the Department of the Air Force, the Department of Defense or the US government.