

Managing Technology-Driven Innovation Risk: How to Turn Uncertainty into Advantage

Taking an active approach to technology risk management can reduce uncertainty and increase the expected value of outcomes

By Scott Daniels and Michael M. Baltay

Managing risk is a keystone of any business. However, the term “risk management” often carries a defensive connotation, especially in the circle-the-wagons mindset of our current economy.

As it specifically pertains to technology investments, the notion of risk management similarly motivates a protective mindset and more often than not results in overly conservative approaches to innovation-led growth. With an overwhelming emphasis on incremental improvements to protect product lines, sustain competitive advantage, or increase the efficiency of production systems, technology investments are frequently geared toward reactionary objectives designed to maintain an organization’s core competencies and insulate it from competitive threats. In this regard, risk *itself* can become a paralyzing constraint to growth.

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The Peril of a Defensive Mindset

One needs look no further than the U.S. auto industry to see the impact of such a defensive mindset.

For years, the Big Three automakers focused on growing capacity and lobbying for protectionist regulation as they exploited high-margin businesses (trucks and SUVs) rather than technology differentiation. U.S. auto executives failed to act on the societal shift toward “green” cars and other sustainable technology. In short, they did not manage technology risk in a way that enabled them to survive in the short term while investing for the long haul.

We all know the rest of the story. U.S. automakers fell behind foreign competitors in electronics technology and alternative-energy drives. By systematically avoiding risk and uncertainty (thus taking a defensive posture) rather than viewing these emerging technologies as a significant growth opportunity, they ceded important strategic ground to Toyota and others.

Toyota took a variety of risk positions that created competitive advantage as it developed eco-friendly engine technology, experimenting with direct injection gasoline engines, lean-burn engines, electric vehicles, and hybrid power train systems before launching the Toyota Hybrid System in 1997. The Prius, launched in Japan later that year, was the first model based on that technology and the first mass-produced hybrid vehicle on the market. As Toyota proved with its hybrid strategy, companies that take an active approach to technology risk management can mitigate uncertainty and increase the chances of high-value, successful business outcomes.

Overcoming this constraint requires viewing technology risk management as an opportunity—a chance to grow the business through strategic investment that leads to more substantive innovation. Certainly, CEOs understand the importance of technology as an innovation opportunity multiplier; U.S. companies spent some \$377 billion on R&D in 2008¹ in an effort to develop new products, platforms and grow their businesses. Too often, however, these investments don’t result in significant value or game-changing innovations. For every iPod, there are tens of thousands of incremental advancements that deliver, at best, marginal growth for a business.

There are many reasons why major technology investments fail to deliver:

- Diversity of stakeholders, agendas and management expectations of R&D often make it difficult to effectively align technology strategy with business and market objectives.
- Longer return horizons typical of technology-led innovation make it difficult to reconcile high-risk / high-cost bets with shareholder value inordinately driven by short-term performance.
- The best technology does not always win, as external, and often unforeseeable, factors play a critical role in the societal, cultural and network forces that influence adoption.
- Some senior management teams simply don’t want to (or can’t) invest in an innovation that may disrupt the organization’s established norms—business models, processes, or distribution channels.²

What is the common theme to these challenges? High uncertainty and the potential for unmitigated negative outcomes often act as barriers to step-out growth. Incremental expansion feels more “natural,” rewards short-term results and typically has fewer “moving parts,” making for easier management. Further, as the global recession adds even more complexity and risk to business models, corporate leaders in “hunker-down” mode are finding it even more difficult to make bold decisions that allow them to achieve (or maintain) a market or industry leadership position.

Regardless of an organization’s tolerance for risk, management teams can fundamentally improve the way they manage risk in technology investments. By taking an active portfolio risk management approach to technology investments, companies can reduce risk without stifling innovation and avoid mortgaging the future for the sake of the present. In an environment that has caused many executive teams to shy away from high-risk bets, these methods, when implemented as part of a systematic approach to technology risk management, can actually allow them to take more chances, while improving the odds of success. While these techniques are not new, and some enterprises may employ them periodically in technology, they are not used effectively at the strategic business planning level. It’s time for executives to embrace technology risk management, and to see it as a form of competitive advantage and enabler of innovation, rather than something to avoid.

A Strategic Framework for Technology and Innovation Risk Optimization

Researchers have found that companies that institutionalize risk-management practices tend to be more innovative. These companies address risk in a systematic manner. As a result, they are using techniques that allow them to learn and adapt quickly to changing conditions—and are more likely to achieve breakthrough innovation than companies that rely on established routines and past experiences to manage risk.³ A more offense-oriented mindset will recognize that a strategy of carefully constructed and well-managed risks provides a superior set of technology-led growth options. This approach broadens the nature of the strategic conversation, and expands the landscape of growth platform possibilities that senior management teams have to consider.

When examining technology investment risk, management teams should first ask themselves four important questions:

- **What is our organizational tolerance for risk?** A company’s aversion to or acceptance of risk-taking can vary widely; the approach to R&D and bold innovation investments should begin by establishing risk and reward objectives and stretch targets. All stakeholders, from senior management to project managers, need to share a common understanding of the organization’s risk tolerance. Even more importantly, they need to set targets to outperform competitors and to exceed return levels

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for any chosen risk preference. These actions will help to define how risk should be managed across the portfolio of projects and ensure that product, technology and business strategies are consistent.

- **What is the makeup of the uncertainty and where does it reside?** It is essential to recognize the difference between the likelihood of success and the variance of potential outcomes. All too often, “likelihood of success” is the predominant metric discussed, when in reality, rarely is success defined or achieved in clearly stated terms. Business leaders must insist upon understanding the critical variables involved, and the range of individual outcomes that contribute to the expectations of overall success. This allows managers to know what to monitor, as well as what to manage to improve the likelihood of a beneficial outcome. Of particular importance is determining which uncertainties are derived from the technology itself and which are external to the company—such as market adoption, regulatory or standards issues.
- **What interdependencies exist among our different technology initiatives?** If a group of technologies is being developed with similar objectives or from a single platform, do they “move” together? In other words, if one technology fails, will the others fail as well from the same common cause? Do multiple approaches rest upon the same under-

lying risk? Pharmaceutical companies often designate “lead” and “backup” compounds when developing a new drug, with the belief that if the lead fails, they can use the backup. But as is often the case, these two compounds are interdependent because they are based on the same underlying biological response mechanism to a class of drugs or common chemistry. This means that if the class or mechanism is unsafe or ineffective, then all the drugs in that class or mechanism tend to face the same issue. On the other hand, high degrees of independence can be found when simultaneously considering both medicinal chemistry and biological approaches to addressing the same disease.⁴

- **What is our time horizon?** Do you have a hard deadline for the release of a new product, because the technology is only one element of a new product or growth initiative? Or is your timing more speculative and therefore can be staged based on your progress? For example, in competitive markets, say consumer products or cellular communications, a company’s market share and competitive position rely significantly on delivery of a consistent cadence of new product innovations, often determined by forces outside the firm’s control. These are examples where the time horizon is reasonably firm and fixed. In other cases, the governing factor is return on investment, say real estate holdings, where a company has

more flexibility in its time horizon to sell when the market is hot and hold when market conditions will not yield good returns.

With the context set by the answers to these questions, a management team can then consider which risk-management methods are most applicable for their situation. We believe there are three common portfolio management techniques that are just as effective in mitigating technology investment risk.

Diversification: Separating Your Eggs into Different (and Independent) Baskets

Diversification has long been applied to financial portfolios to flatten the aggregate volatility of returns around a target result. The objective is to design a collection of investments that is spread across multiple, independent drivers of expected return and deviation (volatility) that, in aggregate and on balance, meet the desired returns and risk tolerance of the investor. The tradeoff is that flattening volatility often reduces expected return and this is why it is crucial to fully understand objectives and risk tolerance in the design of portfolios.

Applied to technology investments, diversification means creating a combination of technology positions or initiatives that would not be expected to simultaneously fail from a common cause. Investing in multiple technology

approaches that offset one another, or that are uncorrelated, can often increase the overall value of the R&D portfolio by reducing uncertainty. The diversity doesn't have to be defined by technology; it can also be created around markets, customer needs or even management competencies.⁵

Diversification is most valuable when a company can spread risks across investments that do not share a common uncertainty, so that the likelihood of all of them failing is minimized. There's a delicate balance between striving for scale economies by concentrating on one technology platform (dependent technology investment)—so that lessons from one can be valuable to the others—while not putting all the technology eggs into a single basket.

Take, for example, alternative automotive drive technology. The commercial success of technologies such as all-electric battery-powered vehicles (whose current range limitations lessen their appeal to consumers) will hinge in part on the creation of a charging station infrastructure. Other technologies, such as hybrid gasoline-electric, take advantage of existing infrastructure. The shrewd technology entrepreneur recognizes the risk-spreading nature of these approaches: If the fast-charging infrastructure takes off, then all-electric models become more attractive. Conversely, if infrastructure investment stalls, the adoption of hybrids may ac-

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celerate. In some cases, both approaches may flourish. In this regard, fuel cell technologies represent a singular, non-diversified type of bet (the infrastructure and technology is completely different from hybrid and all-electric), which is one of the main reasons the Obama administration decided to drastically reduce its research funding. Only when you understand all the major uncertainties, such as the price of gas, the cost and performance of batteries, dependencies on infrastructure, desires and behaviors of consumers, evolution of competing alternatives, and the relative interdependencies of each, can you optimize your risk position.

When developing a risk portfolio for technology, it's important to accept that an individual technology risk often can't be changed significantly without time, investment, and learning. But a company can derive a better position by carefully combining that risk with others to mitigate its *overall* exposure. Also note that excess risk spreading can itself lead to adverse results. For example, when managing a stock portfolio, management teams must take care not to spread their portfolio too thinly as this can reduce expected returns to an unacceptable level. For technology investments, this could mean overly diluting scale economies—which are one main benefit of a common technology platform—and driving actual returns negative.

The ultimate goal of a diversification strategy is to lower the variance of expected ag-

gregate returns on technology investments, by spreading risk across multiple, independent variables.

Options: Spend a Little Now to Limit Future Downside and Lock in Upside

An option involves making a small investment now for the right, but not the obligation to participate in a bigger future upside by making a further investment later. These proven financial vehicles are becoming more popular as a means to safely speculate on risky but promising technology. They provide a way to minimize the potential downside of an unproven technology—in which the range of potential outcomes is broad—while locking in upside (the option to buy) in case the technology proves worthy of further commitment.

The key to an option is that it provides flexibility and clarity in the nature of the commitment for investors (for example, by building in specific off-ramps and on-ramps). An option often allows risk to be shared among partners according to their knowledge, contribution, and individual risk posture. Projects can be funded incrementally, with specific milestones used to review, apply what's been learned, and decide whether to continue with or expand the investment. An “options mentality,” researchers at the Rensselaer Polytechnic Institute conclude, offers an evaluation process similar to the experimentation processes that R&D teams com-

monly use.⁶ In such a process, an organization invests more when their researchers succeed. When they develop new knowledge, the organization invests in further research and development, to build more knowledge.

Consider how pharmaceutical companies reduce risk exposure through options, often in the form of joint- or co-development initiatives. Pfizer made a formal commitment to this process when it established an incubator as a means to tap into high-risk technologies with minimal upfront investment. The Pfizer Incubator screens startups with innovative life sciences technologies and provides them with lab space, operational resources and access to Pfizer's scientific assets.

Pfizer's initial investment in a start-up—typically in the form of a 24-month funding commitment—represents an option; continued funding is provided as the start-up achieves milestones (spaced roughly in six-month increments). If the technology is proven and has potential for commercialization, Pfizer exercises its option to be the first to acquire the rights to the technology at a fair price without paying the premiums that are typical in competitive bidding processes.⁷

Options are most valuable in situations where new information, over time, will lead to improved estimations of expected returns (and thus desirability and risk of further investment). Options are also valuable where participation in the project can be parsed out in relatively small increments, and spread over multiple investors. This way, each investor bears only a small portion of the whole risk, and/or time, such that incremental investments are tied to progression and evolving perspectives on the outcome. The tradeoff for options is typically that access to the upside is diluted across multiple players. Options also can create discrete hurdles for technology research projects which can reduce efficiency and introduce added complexity and risk.

Forward Commitments: Trade Some of Tomorrow's Upside Potential for Increased Certainty Today

If a technology itself is proven but is surrounded by other large market uncertainties, and the leadership team wants to exchange some level of upside for increased certainty, a forward commitment may be the right tool. Forward commitments are an effective way to increase stability in an environment fraught with market uncertainties or other external variances outside of the technology itself. With a forward commitment, a company essentially trades some potential upside in

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return for increased stability (often of demand) by committing to certain terms of trade in advance of project completion.

These contracts require counterparties to have opposite views on the same risk. They are commonly used in commodities trading to protect against price variances, as well as to fund the building of capital-intensive production facilities, such as merchant electricity and industrial gas plants, to support project financing structures. In agriculture, a corn grower and a buyer might lock in the purchase of a crop early in the season at an agreed price. This protects both the buyer (by ensuring product at a known price even if the crop becomes scarce, due to drought or other unforeseen events) and the producer (by ensuring sales at a known price in case of an abundance of crops that drives prices down). In other words, both sides benefit from predictability and a guarantee of future business, regardless of market conditions—they have swapped their risk positions.

Forward commitments are useful in technology investments when a company has a relatively fixed timeframe in which to invest—when the launch of the technology or product is inevitable—and when there are significant market (in particular, price and availability) uncertainties. With technology-driven innovation, the primary uncertainty to successful commercialization often lies not in the technology or product itself (often *fundamental* feasibility of most technologies is known early on), but in unpredictable market and customer adoption.

Forward commitments, or contracts, are very common in the airline industry. Take, for example, the Boeing 787. In 2001, Boeing replaced its Sonic Cruiser project with its designated 7E7 aircraft development project, which morphed into being called the Dreamliner or 787. The aircraft's design is unique and innovative, using 20 percent less fuel, providing 45 percent more cargo revenue capacity, having the capability of using two different engines, using composite materials for most of its construction, and offering passengers new features such as enhanced air filtration, larger windows and special lighting to reduce jet lag. Boeing is constructing three models of the 787: baseline 787-8, short 787-3, and the stretch 787-9. In April 2004, four years before the first Dreamliner was expected to be in service, Japan's All Nippon Airlines (ANA) placed an order for 50 Dreamliners, a mix of thirty 787-3s and twenty 787-8s, worth \$6 billion with the first delivery expected in 2008.

It is speculated that as a customer of the aircraft launch, ANA received a 40-50 percent discount from the list price.⁸ In 2007 the list price for a 787-3 was between \$146 million and \$152 million, and \$157 million to \$167 million for the 787-8. ANA was taking a risk that Boeing would develop and deliver the aircraft (which it plans to do in August 2009, after a 15-month delay). In return, ANA received a discount on the purchase price. For its part, Boeing significantly diminished the uncertainty of its potential customer base for the 787, and won a

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Technology Risk Management: Four Guiding Principles

There's no one-size-fits-all solution for managing risk in your technology investments. But companies can improve their chances for success by adhering to these four basic principles and embedding risk management practices and capabilities into their strategic arsenal.

- 1. Understand the context.** Clarify objectives and desired outcomes from a business perspective, not a technology perspective, to define more alternatives for mitigating risk. If the objective, for example, is to maximize the return on a technology asset or successfully commercialize an existing technology (technology perspective), the options may be more limited than if the objective is reframed around meeting a specific customer need or maximizing share of market for a particular customer segment. The latter framing opens up opportunities to reduce uncertainty by combining and sequencing multiple investments.
- 2. Determine the range and character of outcomes of individual risks.** Identifying the primary sources of uncertainty and assessing the range of potential outcomes or variance around a set of risks is more important than only considering the expected likelihood of success. Many projects don't fall neatly into risk levels; rather, they achieve a range of success or failure. Savvy technology investors demand to know the set of multiple potential outcomes and the critical drivers that influence them. They embrace variance and uncertainty, rather than forcing teams to boil it down to a single estimate. In addition, successful technology innovators clearly understand the primary determinants of variance and the causal interrelation or codependence among individual uncertainties. They seek to minimize the drivers and isolate investment portfolios from common causes of failure.
- 3. Develop a toolkit and familiarity with three basic technology risk management strategies.** The first is diversification, the spreading of risk across multiple sources. The second is an option, the willingness and ability to trade a modest amount of future upside for greater access to, or certainty around, market conditions, while buying time to observe and learn before making full investments. The third is a forward commitment, a trading of risk between multiple parties according to their unique individual postures.
- 4. Stage technology decisions. Remain flexible and experiment where possible to learn.** Identify what decisions have to be made and when they need to be made. Continuously monitor the evolving situation and be willing to adapt the selected strategy as required.

return on its \$10 billion development investment. Currently, there are 850 firm orders from 60 airlines and delivery is sold out beyond 2014. When a project, such as the Dreamliner, requires such a huge up-front development cost, it is prudent to invest some potential profitability to ensure market demand will exist when the project is complete.

Optimizing Technology-Driven Innovation Risk

Technology investments require a commitment that runs through business cycles or leadership changes; they cannot simply be turned off and on as conditions allow. Often, however, the risks inherent in any technology project are not well considered or addressed in a strategic manner.

To deliver truly breakthrough performance, executive teams need to develop a better understanding of their company's tolerance for risk and evolve from a defensive posture toward a proactive, offense-oriented and strategic investment mindset. Applying a more systematic approach to technology risk management will reduce the constraints of technology-driven innovation and help companies become more agile in the face of market and other uncertainties while expanding their potential for competitive advantage and broadening their platforms for long-term growth.

Implementing these strategies and guiding principles will take some time and effort, but

in our experience, the effort is usually repaid quickly and many times over. In this article, we have described strategic aspects of managing technology and innovation risk. To be effective, companies need to incorporate these principles into their planning processes and establish a decision-making structure to support technology investment choices. They need to build out specific tools and tailor examples for their company and industry, to establish a common language for investment portfolio management. They need to test and experiment with small investments to build confidence and experience. Most importantly, companies need to establish behavioral objectives that ensure true collaboration between financial, technology and development functions, to prevent a siloed approach to innovation.

Companies that properly incorporate these established risk optimization strategies into their every-day operations and build capabilities to do so in a transactional manner will find themselves outmaneuvering less adept competitors. They will begin to recognize the opportunities inherent in technology uncertainty, rather than avoiding them. Managing technology for business success does not require a PhD, and if executives demonstrate leadership, they will develop a critical strategic advantage.

ENDNOTES

¹2009 Global R&D Funding Forecast, R&D Magazine, December 2008, referenced at <http://www.battelle.org/news/pdfs/2009RDFundingfinalreport.pdf>

²For more on this topic, see “The Innovator’s Dilemma,” by Clayton M. Christensen, (Harvard Business School Press, 2003).

³Gina Colarelli O’Connor, T. Ravichandran, Daniel Robeson, “Risk management through learning: Management practices for radical innovation success,” Aug. 5, 2008, Journal of High Technology Management Research, p81.

⁴Peter Steele, “Diversification Delivers,” June 2007, European Pharmaceutical Contractor, p. 30. Referenced at <http://science.thomsonreuters.com/m/pdfs/klnl/2007-06/diversification.pdf>

⁵Francesca Gino, Gary Pisano, Michael R. Sorell, Mark Szigety, “R&D Portfolio Strategy, Diversification and Performance: An Information Perspective, 2006, p7.

⁶O’Connor, Ravichandran, Robeson, “Risk management through learning: Management practices for radical innovation success,” p75.

⁷Pfizer website, referenced at <http://thepfizerincubator.com/funding.html>

⁸“Boeing 787 Dreamliner: Aircraft Profile”, Aviation Spectator, Referenced at <http://www.aviationspectator.com/resources/aircraft-profiles/boeing-787-dreamliner-aircraft-profile>

For additional reading on risk, the author recommends *Against the Gods: Remarkable Stories of Risk*, by Peter L. Bernstein (Wiley), available at <http://www.amazon.com/Against-Gods-Remarkable-Story-Risk/dp/0471295639>.

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Monitor works with the world's leading corporations, governments and social sector organizations to drive growth in ways that are most important to them. The firm offers a range of services—advisory, capability-building and capital services— designed to unlock the challenges of achieving sustained growth.

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