Strategic Management of Technology: Thirteen Common Pitfalls

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In recent years, Arthur D. Little has been applying its *Third Generation R&D* principles to a wide variety of technology management assignments. Many of our clients are process and/or production companies (e.g., major oil companies, chemical manufacturers, and pulp and paper producers) that continue to face difficult technology management decisions. In an era of dramatically reduced R&D spending in these mature industries, managers are nevertheless coming to see technology management as a key strategic driver for operational improvement and sustained market performance. Although among our client firms we see a wide range of technological sophistication, we've noticed that many companies – even the most sophisticated – make similar mistakes. In this article we highlight 13 technology management „pitfalls" we often see in the process industries, but which are common in a range of other industries as well.

1. Excessive Focus on „What" Rather Than „How"

Over the past several years, process companies have used technology advancements to derive dramatic improvements in operational efficiency, even while R&D budgets have radically declined. But to maintain recent rates of innovation, these companies will need to focus more on *how* they are applying technology, rather than simply on *what* technologies to employ.

When faced with challenging growth targets, most companies still instinctively respond by asking, „What new silver-bullet technologies should we invest in?" when they should ask, „How can we best identify, select, acquire, manage, and ensure consistent application of our technology?" (Incidentally, silver-bullet technologies are best identified not by consultants, but by properly managed technology monitoring/forecasting and competitor/supplier analysis.) Much of Arthur D. Little's third-generation technology management work is designed to address these latter issues.[1] When properly applied, third-generation practices help eliminate the other pitfalls described below.

2. Failing to Develop a Technological „Strategic Architecture"

Technological „strategic architecture" is a formal expression of the direction a firm wishes to take with respect to technical innovation. In effect, it sets the role of technology in a business context and establishes broad boundaries within which the technology effort can act. And yet, few companies possess such a set of guiding principles for the R&D function that go beyond generic „motherhood" mission statements. Often at the root of this problem is a poorly understood or communicated strategic vision for the company as a whole.

In most companies, a technology vision/mission statement will not suffice. Although such statements can be useful if they clearly contribute to a company's strategy and are sufficiently specific to ensure the commitment of staff, a proper strategic architecture is critical for those charged with developing and implementing technology. The accompanying exemplary strategic architecture for a fictional pulp and paper company (Exhibit 1) clearly communicates the ways in which technology is expected to help realize the company's vision. It focuses on leveraging existing assets, provides targets for new product launches, and provides guidelines for technology acquisition (including what, who, and how) as well as technology monitoring. The associated vision statement provides a clear indication of the company's desired technological positioning (in this case, indicating an intent to pursue a *fast-follower* generic technology positioning).

3. Automatically Preferring a Technology Leadership Strategy

While not universal, this bias is shared by a surprising number of executives both within and beyond the process industries. Even in high-tech industries, where companies rely heavily on new product development, a technology leadership strategy is not always the best course for achieving exceptional market performance. Although companies should develop leadership visions for their *overall business* in whatever industry segments they choose to compete in, such visions do not necessarily require leadership in technology development. Rather, companies must develop concepts of how they will most cost-effectively identify, source, and integrate technology to increase cycle times, lower costs, and improve reliability and safety.

We see three generic types of technology strategy (excluding the default of „no discernible strategy").

All have their places, but their merits are not clearly understood by many process industry managers:

Leadership (or Pioneer). In industries such as pulp and paper, as well as oil exploration, production, and refining, it is difficult to justify a technology leadership strategy on operational grounds alone. Few companies have uniquely specialized assets or technologies, and the competitive advantages derived from innovation are difficult to sustain. Leadership strategies are also risky and expensive, since it is far more difficult to push back the frontiers of knowledge than it is to adapt and apply the discoveries of others. Except in small niches within

the commodity process industries, companies should seek technology leadership positioning only when this positioning is linked to an overall business strategy requiring technological differentiation.

Exhibit 1

An Illustrative Technology Vision Statement and Strategic Architecture

Vision Statement

Through technology we will establish leadership in low-cost/value-added groundwood and groundwood-related products and continuously be one of the first three companies to exploit major, return-justified, technological changes.

Strategic Architecture

• Develop high-value added papers (and other products) to leverage our wood stands and our existing mill assets

• Support the launch of major new products at two- to three-year intervals concurrently in the major developed countries

• Develop relationships with the leaders in pacing technologies to enable us to monitor their progress and, where advantageous, influence their direction

• Develop partnerships with the developers of key technologies to enable us to be among the first three to install them

• Monitor all major technological changes that will affect our existing and potential businesses in the next 15 years

• Use qualified partners and subsidiaries as avenues for radical technological change

Fast Follower (or Early Adopter). Many companies are also discovering that even the fast-follower approach is not necessarily cost-efficient from an operational standpoint. The risks of applying technologies before a dominant set of best practices has been established can be substantial. However, fast-follower strategies can be effective in counteracting any possible benefits of differentiation (in the eyes of important customers/stakeholders) that might otherwise be achieved by a clear leader. Such strategies may also be beneficial to fleet-of-foot companies that possess exceptionally strong technical adaptation and market intelligence competencies.

Strong Follower (or Smart Adopter). Strong followers apply new technologies only after best practices have been established. In essence, they let others make the mistakes and try to maximize operational cost effectiveness by applying new technology „right the first time." In the pulp and paper industry, for example, most firms have adopted this strategy, thereby avoiding the risks of major capital investments in new technologies until the „bugs" are shaken out. Although not as demanding as the strategies described above, the strong-follower strategy still requires considerable technical skills, which differ from those required of successful pioneers and fast followers.

4. Using Inappropriate Project Selection Techniques

Most process companies now follow what we call a „second-generation" approach for **R&D** project selection, driven primarily by operating managers' perceptions of their business units' technology requirements. However, these priorities are often poorly thought out and overly focused on meeting today's operational needs, rather than on anticipating the requirements of tomorrow.

In response to these articulated requirements, technology providers then typically send back a list of proposals to operating units for consideration. Those proposals receiving the most „ticks" from the various user groups are funded while those receiving little support are dropped. The problem with this tactical approach, quite apart from the quality of the original needs list, is that it can produce a technology program at odds with the corporation's overall business strategy. Applying third-generation principles, we use techniques such as portfolio analysis to encourage a more holistic project selection approach, which helps optimize the overall technology program.

In several recent process industry assignments, we've witnessed companies using the „tick and cross" approach to determine R&D activities. More often than not, the operating units generating the largest free cash flow (usually those with the most mature assets) can afford to invest the most in technology, and therefore have the most „say" in the selection process. Technological activities are thus heavily skewed toward the most cash-rich units, which are not necessarily those most in need of technological support. Clearly, these companies' technology programs are often far from optimally aligned with business strategy.

We recently saw this problem at an upstream oil company, which had predicated its growth objectives largely on new discoveries and increased recoverable reserves, but was placing the bulk of its technology investments in mature assets. After an initial third-generation workshop, the company quickly realized and corrected the problem – substantially increasing investments in exploration and other sub-surface technologies. The workshop also helped clarify the value and benefits offered by particular exploration/production technologies, prompting asset managers to increase year-to-year R&D funding from 70 percent of the previous year's funding to over 120 percent.

5. „Salami Slicing" the Technology Program

When facing R&D or technology budget cutbacks, many companies tend to apply across-the-board cuts in an attempt to share the pain equally among interest groups. This pitfall occurs most commonly in companies that lack a purposeful, strategy-driven framework for prioritizing and managing technology provision activities. The „salami-slicing" approach invariably leads to late delivery of important new technologies (and thus to further declines in the credibility of the technology function), low morale among researchers who cannot deliver on time, and a loss of critical skills and, eventually, competitive advantage.

In our technology management work, we regularly help companies avoid this pitfall by applying a strategic framework that allows all interested parties to raise and discuss technology issues openly and honestly and to arrive at decisions in a rational and transparent manner. This framework also enables firms to identify and focus resources on those technologies in which excellence is essential and to differentiate such key areas from those in which it's „good enough to be OK."

6. Omitting Technical Service from the Technology Portfolio

Too many process companies still treat technical service as a „black box" – shying away from specifically identifying these activities and including them in their portfolio of technology programs. This is understandable, since the value of two aspects of technical service – catastrophe avoidance and maintenance of ongoing operations – is difficult to measure financially. And the third aspect of technical service – profit improvement/cost reduction – is very difficult to predict. In addition, technical service staff are often dedicated solely to one business unit and are seen as the exclusive „property" of that unit, and not of the company as a whole.

By failing to consider technical service activities within the context of the overall technology portfolio, companies short-change themselves in at least three ways:

• Because technical service information is not collected, no one can see the „big picture" regarding these skills and activities, making it impossible to leverage them across the company.

• Such practices reinforce the barriers between R&D and technical service activities, as well as those among technical service activities in different business units – which usually share common problems.

• Without a strategic and purposeful framework, the company cannot manage similar activities within R&D and technical service, both of which are concerned with acquiring and applying technical knowledge.

7. Omitting External Sources from the Technology Portfolio

More than ever, companies are depending on external suppliers for sourcing and applying technology. Unfortunately, most of our process industry clients do not manage these outsourced functions as part of their technology portfolios, incorrectly regarding their internal technology functions rather than the technologies themselves, as the units of analysis. This pitfall gives rise to problems described in number 6.

In many cases, the company's culture may be at work in creating this problem. The „heroes" of technology organizations tend to be those who have made successful in-house developments. Meanwhile, critical external technology projects may be managed by „failed" scientists, or on a part-time basis by junior researchers who have neither the commercial knowledge nor breadth of technical experience needed to rapidly identify and internalize tomorrow's winning technologies.

We recently helped a paper company establish clear responsibilities and milestones for managing external technology sources. Technology managers must now ensure that the mills will receive and apply necessary external technologies.

8. Maintaining Inappropriate Leadership in Base Technologies

Process companies are often guilty of hanging on to leadership in technologies that once offered significant competitive advantage, but have since lost their luster. Having gained „star" status within the corporation over the years, these technologies (and their lauded developers) tend to hang around like aging celebrities,

championed by influential groups with vested interests in maintaining the status-quo. Companies often fail to recognize the extent to which these technologies have matured, so that competitors either possess them or can access them easily from suppliers.

Culling these sacred cows can be extremely difficult, especially in firms that conduct cost-benefit analyses of technology, since operational profits are a lagging indicator of innovation rates. Many of these base technologies score high in conventional cost-benefit assessments, even though further advances in these areas will offer little additional business benefit. More often than not, these base technologies can provide the same or better value if sourced from external suppliers.

In an especially fruitful third-generation assignment we conducted with a technologically sophisticated oil company, managers recognized the need for open and honest debate on how to identify and eliminate these sacred cows and how to reach agreements for managing such technologies in the future. During the process, we developed a questionnaire on indicators of a mature technology, which the company will use to promote reasoned debates on dealing with aging technologies.

9. Failing to Implement Successfully Developed Technology

In our opinion, this is the biggest crime of all in technology management. To try but fail is understandable, but to try, succeed, and then fail to apply is inexcusable. This pitfall is common in first- and second-generation companies, in which managers tend to treat the symptoms of poor technology uptake by strongly monitoring technology transfer activities in their final stages.

Only by genuinely involving technology users and providers throughout all stages of the technology management cycle (from strategy development and needs identification, through to successful application) can genuine „ownership“ of the technology program be fostered in all stakeholders. This ownership creates a strong „pull“ from the user community, whose members become personally committed to ensuring quick and successful application, rather than being forced to use the technology by performance contracts or similar means. First- and second-generation approaches normally fail to create this degree of ownership and commitment from users. Under these conditions, one can expect, at best, passive acceptance of a technology program, with little user pull or commitment to its success.

10. Failing to Evaluate the „Consequences of Success“

„If we'd known how much it would cost us to scale-up and commercialize this process, we'd never have started the R&D in the first place.“ We hear this complaint far too often from process companies (especially in refining and chemicals) that have completed technologically successful R&D programs only to find that implementation costs will be outrageous. Before initiating R&D and other technology acquisition activities, companies must be sure to analyze the consequences of success.

11. Lacking a „Balanced Scorecard“ of R&D/ Technology Metrics

Many technology management systems in use today cause behavioral distortions, or their metrics produce no value because they are essentially designed to ensure „success.“ For example, the performance-contract approach used by some second-generation companies often encourages technology managers to commit only to low-risk (and therefore low-reward) activities, which are probably better performed by third parties. Perhaps this is why companies using this approach tend to believe they can outsource much of their technology development activities.

Traditional cost-benefit approaches for quantifying the financial value of a technology have also fallen into disrepute in many companies that have realized just how subjective these assessments actually are. In many cases, the presence of a friendly engineer in the business unit appears just as important in achieving a high benefit assessment as the inherent qualities of the technology itself. With due care and diligence, the vast majority of technology functions can beat target returns on technology investment by a substantial margin.

In first-generation companies, where an important metric is often R&D project success, high reported rates of technical success are common. But closer examination usually reveals that this success is due only to woolly objective-setting, wherein objectives can hardly fail to be met, but are of virtually no value to business operations. For example, the corporate research department of a major European energy company regularly achieved technical success rates of more than 90 percent, except in one technical area. However, its overall output was considered virtually worthless by the company's business units. The only area that did provide significant value to the business units was the „underachiever,“ where success rates were nearer 60 percent because it had set objectives that were much more specific and challenging.

Many of our clients are now recognizing the need for some form of balanced scorecard for managing technology. Such scorecards use a portfolio of metrics that not only measure R&D performance without producing behavioral distortions, but also provide a holistic, balanced view of how a company's technology activities are

responding to stakeholder needs.

12. Incorrectly Diagnosing the Causes of Falling Technical Productivity

When technical productivity falls, most companies instinctively blame the quality of their technical resources and/or management. But, in any corporation, technical productivity is a function of several complex forces. In our diagnostic work, we focus on three main parameters of technology performance: the quality of resources, the quality of objective setting, and the quality of „working together." In most companies we've examined, declining technical productivity is usually due to problems in the user community, or to excessively strong „fiefdoms" within the company that inhibit the efficient horizontal flow of information.

13. Failing to Engage Top Management

Whatever the industry, the most pressing problem we deal with regarding technology management is engaging top management – particularly the CEO. We've found that by using third-generation practices – especially strategic architecture – companies can strongly improve their top management's focus on technology management issues. Most importantly, technology managers must learn to talk in top management terms: dollars and cents.

For example, using simple option theory approaches to value technology programs, we have been able to fully engage top management in technology strategy development, including helping them focus on appropriate areas of emphasis. These approaches also force top managers to more explicitly define technical and commercial risks up front. When both business and research staff understand the primary uncertainties and risks associated with different technical options, they can dedicate appropriate attention to these issues from the outset of each project.

[1] *See: P. A. Roussel, K. N. Saad, and T.J. Erickson,* Third Generation R&D*, Harvard Business School Press, 1991.*

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