

APPENDIX **1D****Gemplus on Real Options in High-Tech R&D**

*The following is contributed by Jim Schreckengast, Sr. Vice President of Gemplus International SA, the world's leading provider of smart cards and solutions for the telecommunications, financial, government, and IT industries. Gemplus is one of the most innovative companies of its kind, carrying a significant investment in research and development (R&D) aimed at driving forward the state-of-the-art in secure, ultrathin computing platforms, wireless security, identity, privacy, content protection, and trusted architectures.*

Gemplus is a high-tech company. Such companies assign great importance to R&D, because high-tech companies often derive their primary competitive advantage through technology, and R&D plays a pivotal role in determining the technology position of these companies. Effective management of R&D is difficult and involves significant uncertainty. Moreover, company resources are limited, so it is critical for management to invest R&D resources wisely, considering the many types of value that can be produced by these resources. Gemplus recognizes the complexity of managing R&D efforts in rapidly changing and competitive environments and has used real options analysis to improve the effectiveness of R&D investment decisions.

One of the most significant challenges in R&D is the management of innovation. Management of this process is difficult, because successful innovation usually involves the discovery and generation of knowledge, while exploiting existing knowledge and capabilities in an attempt to generate value through new products and services, to differentiate existing offerings, to lower costs, and to disrupt the competitive landscape. Each successful innovation may be used as a building block for further R&D efforts, enabling the firm to create a sustainable competitive advantage through a cohesive R&D program that blends and builds on previous results. For example, a firm pursuing low-power, wireless communications technologies for tiny wearable computers might discover that their latest approach to reducing power requirements has

the capability to generate fine-grained location and speed information as a side effect of communication. This location information could enable the firm to begin generating a new family of location-based services, while enhancing routing and switching in dynamic wireless networks. Further, the company might recognize that expansion of investment in fine-grained location technologies could position the firm favorably to compete in context-rich service delivery, if the market for these services materializes in two years. In addition, the R&D director might conclude that investment in this technology will improve the firm's ability to manage bandwidth and resource utilization, if the results of current research in peer-to-peer network architectures prove promising.

The chain of loosely connected innovations in the previous example is surprisingly representative of the events that unfold in practice within a high-tech industry. While prediction of a specific sequence of innovations is usually infeasible, successful companies often develop innovation systems that recognize the potential for these chains and develop R&D systems that can stimulate their creation while retaining the flexibility to capitalize on the most promising among them over time.

The complexities of analyzing technical uncertainty, market uncertainty, and competitive movements in a rapidly changing industry often drive management to either shorten the time horizon of R&D projects to the extent that each project has a very predictable (and often unremarkable) outcome, or to assemble R&D projects as a collection of desperate "bets" in the hopes of finding one that "wins" for the company. The former approach tends to restrict flexibility, because project managers will focus energy and resources on short-term tasks that are directly linked to the limited scope of each project. The latter approach dilutes R&D resources across many unrelated projects and overlooks potential synergies between the outcomes of these efforts. Furthermore, by viewing the R&D portfolio as a collection of "bets," management may fail to recognize the many opportunities that usually exist to control, refine, and combine the intermediate results of these projects in a way that enhances the total value of R&D.

Traditional valuation techniques for R&D (e.g., decision trees and NPV) may exacerbate the fundamental problems associated with investment analysis and portfolio management, because these techniques rely solely on information available at the time of the analysis and cannot accurately value flexibility over time. The limitations of these techniques often go unrecognized by decision makers, resulting in suboptimal R&D investment decisions.

Gemplus uses an R&D management approach that recognizes three key realities for its industry:

1. Uncertainties are resolved on a continuous basis as R&D is conducted, competitive conditions change, and market expectations evolve.

2. There is a significant lag that exists between the time a company begins to invest in a technology and the time when the company can wield that technology effectively to generate new products and services.
3. The most valuable R&D investments are those that simultaneously build on existing, distinctive competencies while generating capabilities that enhance the firm's flexibility in light of existing uncertainties.

These realities compel Gemplus to manage R&D on a continuous basis and to invest while significant uncertainties exist, valuing the flexibility created by R&D investments. Each R&D project carries a primary purpose but may also carry a number of secondary objectives that relate to the value of real options associated with expected capabilities delivered by the project. Gemplus manages a portfolio of R&D innovation efforts in the context of a technology road map that makes the most significant real options apparent, and relates the strategic direction of the company to the flexibility and competitive advantage sought by its R&D efforts.

Once the most significant real options have been identified, each R&D project is valued in the context of this road map. Research proposals are evaluated based on the value of the information generated by the work, together with the relevant capabilities that may be generated and the flexibility this affords the company. Gemplus has seen up to 70 percent of the value of a research proposal arise from the real options generated by the research. Development projects are typically valued for their primary purpose and for real options arising from R&D management flexibility (i.e., expansion and contraction in the course of portfolio management), technology switching capabilities (e.g., when it is unclear which technology will emerge as a dominant design), and real options created in the context of the technology road map (e.g., multipurpose technologies). Although a development project usually has a much smaller percentage of its value attributed to real options, the difference can be significant enough to alter R&D investment decisions that would have otherwise favored a less flexible or less synergistic effort.

R&D efforts also result in the generation of intellectual property. Patents are of particular interest, because they can affect the firm's ability to protect products and services derived from the patented technology. Further, patents may be licensed, sold, or used to erect barriers (i.e., entry, switching, substitution, and forward or backward integration), as well as to counter infringement claims by third parties. Thus, patents may carry significant value for the firm, and this value reflects the real options associated with the invention now and in the future. Gemplus believes that correct valuation of intellectual property, and patents in particular, leads to improved intellectual property strategies and more effective research prioritization. Thus, Gemplus has changed its intellectual property strategy and valuation process to explicitly incorporate the value of real options created by R&D patents.

Acquiring technology from outside the firm is often an integral element of a good technology strategy. Thus, R&D managers must determine how to value technologies accurately. Like direct R&D investments, technology acquisitions may carry a significant value associated with real options. Acquisition valuation should include comparables, the value for direct exploitation of the technology, and the value of real options associated with the technology. Such valuation should also consider real options forgone by the current technology owner and the game theoretic aspects of bidding competitively for the technology with others. Gemplus considers real options analysis to be a critical ingredient to accurate valuation of technology acquisitions and has augmented its process to include this analysis.

It should be noted that recognition of the value associated with real options in R&D must be combined with a process for acting on the decisions associated with these real options. If real options are not effectively linked with the ongoing R&D management process, it may be difficult to realize the values projected by the real options analysis. For instance, Gemplus found that the value of R&D management options was highly dependent on the life cycle and review that was applied to projects and programs. For example, a hardware development project often follows a traditional “waterfall” life cycle with natural checkpoints at the conclusion of investigation, specification, design, and implementation. These checkpoints present an opportunity to take advantage of what has been learned over time and to alter the course of the project. The project could be expanded or reduced, changed to incorporate a new capability from a recently completed research project, or perhaps altered in a more fundamental way. Software development projects, however, may follow a more iterative life cycle, with less time between cycles and fewer natural checkpoints. These differences should be considered carefully when identifying management options associated with a project.

Of course, all of the activity associated with real options analysis in R&D is aimed at more accurately valuing technological choices, so that the best decisions are made for the firm. The experience at Gemplus thus far suggests that these efforts are worthwhile. Real options analysis is a powerful financial tool that meshes nicely with the complexities of managing a collection of projects and research activities that inherently carry significant uncertainty, but also represent great potential value for the firm.