Transitioning Technological Innovation – *A Market Perspective*

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***Abstract* — This paper discusses the results of investigations into market acceptance issues that could influence the adoption of advanced electronics materials. While many new electronics materials technologies could bring distinct advantages to particular parameters or device features, the marketplace typically introduces variables that are sometimes problematic for successful transition. In order to achieve commercial acceptance, which is also critical to assured access for certain defense systems, many factors must be considered beyond superior technical advantages.**

INTRODUCTION

In high technology industries today, the ability to bring technological innovations to market is critical to sustain an enterprise over a significant time period. Successful technology transition in the electronics materials and devices industry is increasingly more important. This is due to factors such as time to market, fabrication costs, and competition which pose constraints on organizational investments in new technologies. Furthermore, the Department of Defense (DoD), a major investor in microelectronics R&D, has been considering significant changes in its programs due to commercial leadership in many areas of R&D. Given the factors influencing microelectronics R&D, it is more important than ever that investors (both government and private) understand how to critically examine the "pathways to market" for a candidate technology. This paper will address evaluation of alternative technologies for investment from the perspective of the marketplace. The author will describe a framework that is used to evaluate technology transition paths in the context of extended enterprises within a competitive environment.

METHODOLOGY

We recognize that competitive success in commercial markets is the responsibility of individual firms, not the government. The government's role in technology transition is one of encouraging private industry to take full advantage of technologies developed with public funding by providing access to them and removing obstacles to their use by the private sector.

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Competing successfully in commercial markets is a complex endeavor that requires considerably more than technology.

Booz•Allen has had substantial experience in understanding and characterizing the nature of competition in the marketplace. These characterizations are drawn from interviews, hands-on analysis, and literature in the field. More specifically, one can characterize markets as being served by extended enterprises (one or more firms in a vertically integrated infrastructure) that deliver innovations

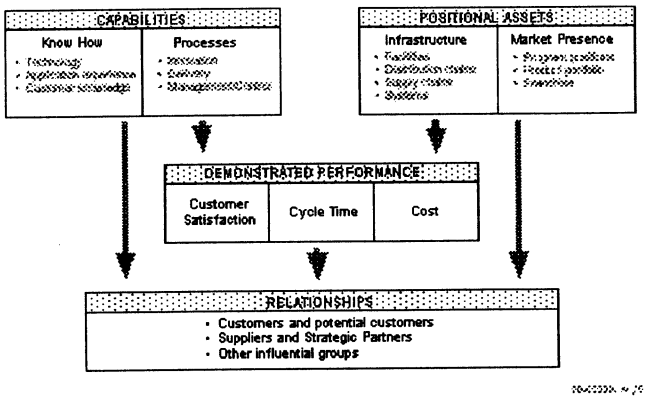

Figure 1. The Extended Enterprise

to the market to satisfy specific market needs (Figure 1).

Extended enterprises are successful when they possess unique capabilities that enable them to deliver these innovations more effectively. Extended enterprises are effective when they possess unique capabilities that enable them to deliver these innovations more efficiently.

In this competitive model, technology has an impact only when it leads to innovations that are relevant to the market or when it provides new, uniquely competitive capabilities for serving the market. In fact, in this model, innovations may not involve technological improvements or inventions. An innovation could be in new approaches to inventory management. The lesson for technology commercialization proponents is that successful technology transition begins at the marketplace. Technology Integration ideas of Iansiti

While they consult closely with technology developers in government laboratories and in industry, government sponsors of dual-use technology investment have not always been able to perform the rigorous market investigations required to maximize the probability for a viable commercial industrial base. Fundamental market and industry infrastructure questions must first be answered if government is to develop successful commercialization strategies:

- What are the commercial market segments to which the technology in question applies ?
- How do these commercial markets regard technological change and under what circumstances are they likely to adopt the technology in question ?
- What is the competitive environment within which firms in the commercial marketplace have to operate?
- What innovations does the new technology offer potential customers?
- Do customers look to government-sponsored or competing technologies to offer performance gains? cost savings? process/cycle-time improvements?
- What risks do customers perceive in switching from incumbent technologies, processes, or product suppliers?
- What qualifying conditions or barriers need to be met or overcome before the customers will consider the merits of adopting a new technology (e.g., legal, regulatory, financial, infrastructure)?
- What are the infrastructure requirements to support the new technology and how do they compare with the infrastructure currently in place (e.g., training, design tools)?

Figure. 2 illustrates a market evaluation methodology. For our analysis,

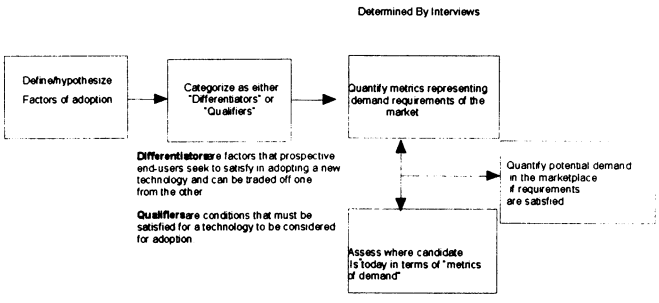

Figure 2. Market Evaluation Methodology

we use a technology transfer business model, developed through many engagements with government and industry. The methodology typically includes extensive secondary source research and interviews with the representatives of all the major players in the extended enterprise including discussions with end-users and government personnel.

Our analysts use a multistage approach to identify the factors that would trigger adoption for a candidate technology, distinguishing between two types of factors – "differentiators" and "qualifiers." Differentiators are triggers for adoption, generally improvements over the current state of the art, such as better price/performance ratios.

Qualifiers are necessary but not sufficient conditions that must be met before a technology would be considered for adoption. If the qualifiers are not satisfied, the differentiators will not be considered. Frequently, only differentiators are taken into account in market studies, but our teams have found that both factors need to be taken into account by the market when evaluating a new technology.

Differentiators can be modeled as performance/cost tradeoffs. In the case of computer CPUs, the tradeoff may be increased processing power or speed for increased cost. To make an accurate evaluation, one must understand the key performance metrics for a market and what factors are driving the selection of particular metrics. To be complete, an analysis must include an evaluation of the alternatives competing with a new technology, and how they are likely to develop in response to the new competitive threat.

Moreover, even if the technology meets performance/ cost requirements, it will not be adopted if it fails to satisfy critical qualifiers. Qualifiers tend to be seen as essential to the success of a product or business, and a technology is viewed as "high risk" if it fails to satisfy the qualifiers. It is worth noting that because of the differing capabilities, a new technology may satisfy the qualifiers for some companies and not others.

LESSONS LEARNED

There are several lessons learned from multiple cases of different competitive technologies that we have been engaged with over the last several years. Some cases we have first-hand experience with are described in the table below.

The cases noted below lead to similar observations that other analysts have made. In particular, we have observed how much of the common wisdom regarding the commercialization of technology is generally not true when examined from the perspective of actual cases where competition has been an important element.

Table 1. Summary of Market Potential

Technologies	Early Observations	Current Observations
GaAs v. Si	Silicon advancements systematically competed with GaAs market segments; oriented to specialized military markets	Emergence of wireless markets / high speed data comms; small companies exploited DoD investments; new competitors emerging (CMOS, SiGe)
HTS filters v. room temperature	HTS offered superior Cellular band filter performance for wireless base stations;	Infrastructure build out matured; QoS/ producibility was problematic; specialized apps
MCT v. IGBT Smart power electronics	High current /power market segments seemed to favor MCTs; additional support from quality power and smart power paradigm	IGBTs improved performance and poised for HEV markets; utilities influenced by deregulation in U.S. foreign incumbents offshore

Source: Booz•Allen Analysis

GaAs- Gallium Arsenide, HTS- High Temperature Superconductors, MCT –MOS Controlled Thyristors,IGBTs- Insulated Gate Bipolar Transistors,QoS- Quality of Service, HEV- Hybrid Electric Vehicles

Some select recurring observations are discussed below.

- The federal government may be an early adopter... but that is not a sufficient condition for sustained maturation. The public sector can underwrite and eliminate some financial risk, but eventually markets must underwrite production and maturation. In many cases we have noted that government applications alone will not be able to sustain an extensive infrastructure but longer term funding allows for a technology to remain persistent in the marketplace. Persistence in the market allows a technology to be underwritten until marketplace dynamics provides a window of opportunity [ref. X] Persistence also allows development of human capital, training, and supply relationships in the face of competition and market changes. *Myth- first to market wins.*

- New product development managers (and government system Program Managers) don't care about technology ... they are largely interested in managing risk in the context of their development objectives. Risk is composed of schedule, cost, relationships, and performance. A new technology needs to have some degree of maturity that is suitable to the new product development time frame and must offer superior value added in one or more product features. An assured vendor base (greater than one) is considered critical *Myth- the best technology usually prevails.*

- There is a distinct difference in the way incremental and radical technologies are managed ... in the case of radical or disruptive technologies markets are not defined enough to be subjected to traditional analysis. Many incremental or sustaining technologies are improvements on existing product platforms that have established extended enterprises. This type of technological innovation is readily supported by industrial R&D and is transitioned by "business units" which are tied to the market or customer. Moreover, the market analysis is traditional and influenced by the incumbency of the technology in question. Radical technologies tend to "learn their way" to the market within the stewardship of smaller organizations that aren't closely tied to the traditional business units or product line managers (e.g., venture cells, acquisitions, or spin-offs). In fact, it has been noted by many practitioners that organizations that nurture radical technologies can more readily seize opportunistic and smaller markets which may eventually grow into more competitive technologies[ref x].. *Myth- larger firms, especially those with sophisticated market analysts, will overwhelm smaller players.*

LOOKING AHEAD- GaN AND SiC

Many of the lessons learned are applicable to any advanced technology – whether it is motivated by a novel idea or responding to market demands. In fact, it has been shown that the best technology is often not the preferred technology from the perspective of the marketplace. When the competitive environment is taken into account, the preferred technology is the one that offers distinct value-added, has access to markets, and has acceptable risks.

When considering the emergence of materials such as GaN or SiC the possibilities for establishing themselves in the marketplace will depend largely on economical fabrication, design tools, and at least a distinct toe-hold in the market. Furthermore, the early entry (or "toe-hold") should ideally be poised to deliver value in growing markets where costs may be driven down, new investment capital is more accessible, and a skill base can mature.

Historically, the DoD has provided an early entry point for developing the capability to deliver new electronics materials. However, in the present and forseeable future the business case (i.e., critical requirements) for DoD investments needs more careful attention since the expectation is for the private sector to lead in the development of new electronics innovations. Stated another way, government sponsors want to know why they should

invest in a technology that has little possibility of commercial interest.

An important place to look for early market entry would be where there is common ground between defense and growing markets (such as power electronics, wireless communications, optical network products, and transportation). In addition to identifying early adopters of an emerging technology, sponsors should also carefully consider the alternative technologies. This consideration is underscored by the experience of GaAS vendors in the wireless communications markets where they are continually challenged for their market share [ref x].

SUMMARY

Many of the lessons learned are applicable to any advanced technology – whether it is motivated by a novel idea or responding to market demands. In fact, it has been shown that the best technology is often not the preferred technology from the perspective of the marketplace. When the competitive environment is taken into account, the preferred technology is the one that offers distinct value-added, has access to markets, and has acceptable risks. Finally, the way R&D companies or enterprises are organized and managed is just as significant, if not more so, as any other factor in determining successful transition to market.

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