# Advanced Materials Development–How Do We Define Success?

David M. Schuster and Michael D. Skibo

How do we define success for a business based on a new or advanced material? This is a simple question, but one which does not appear to have a simple answer. One possible response is: The investment must produce a salable product that can be sold at a price and quantity sufficient to bring a satisfactory return on investment (ROI). Unfortunately, that definition is of little help in choosing investment opportunities in new materials development. ROIs are not forecasts; they are computed after the fact. Any attempt to forecast an ROI is, at best, a wild guess.

As engineers and scientists, we want to believe that a true technical breakthrough will practically ensure commercial success. This is, however, far from true. In the past 10 years, hundreds of patents have been awarded for promising new materials exhibiting properties superior to those already in existence. Few are being used and still fewer can be considered to be commercial successes. The real success of an important technological advance, as we have learned from experience, depends as much on entrepreneurial strategy, marketing ingenuity, and price competitiveness as on the innovation itself.

> The investment must produce a salable product.

Furthermore, advanced materials are even more difficult to commercialize and market than most other new products because in many cases your customers are not the end-users. The initial customers are the semi-fabricators of basic product forms; their customers, in turn, are the fabricators of end-use items, and their customers are the ultimate consumers or end-users who create the product demand. Consumers must be made aware of performance improvements, cost effectiveness, and other advantages your product offers—or there will be no demand.

## The Metal Matrix Composite Story

As an example, let us consider the development and commercialization of metal matrix composite (MMC) materials, in which we have been involved for many years. In particular, let us look at the evolution of a low-cost ingot metallurgy approach to producing them.

We realized in 1982 that the barrier to commercializing MMCs was not only technical but also economic, and we began a small development program at Science Applications International Corporation (SAIC) in San Diego, California. We believed that if MMCs could be made cheaply, they might become significant substitutes for other materials. We began developing a molten metal mixing process to introduce ceramic particles into liquid aluminum. During the first three years, we developed procedures, applied for patents, and started making plans for scaling up the process. We call this the *invention* stage.

Although early technical efforts were successful, SAIC could not provide the large amount of funding needed to obtain the economies of scale necessary for major reductions in the cost of manufacturing the composite. By 1985 we decided to offer the technology to major metal producers who had the resources to commercialize it on a large industrial scale. Recognizing the advantages of the MMC (see Table), Alcan Aluminum Corporation purchased the technology from SAIC, and we launched into the next stage of development, i.e., *scale-up and cost reduction* of the process.

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Acquisition by Alcan provided the extensive resources needed for the ingot-metallurgy MMC technology. Plans were made to construct a pilot plant capable of producing 1,500-pound batches of MMC. And then, late in 1987, Alcan made the bold decision to construct a production plant with an annual capacity of 25 million pounds. Major industrial capacity for producing an MMC (called Duralcan Composite) would finally be realized. This laid the foundation for the *application identification and development* stage.

The next two years were spent building the production plant, refining process technology, producing small quantities of material from the pilot plant to help seed the market, and developing semifabrication processes, scrap handling practices, ceramic particulate supply sources, specific market applications, and more. Toward the end of that period, Duralcan USA began to market the composite through person-to-person, face-to-face sales. They decided against launching a broad advertising and promotional campaign to tell other potential users about the advantages and availability of Duralcan. After two years of this type of promotion, only two or three small commercial applications of Duralcan were in production and a handful more were under consideration. Although there was no shortage of interest in the composite, the difficulties associated with introducing the composite into industries unfamiliar with these types of materials had been underestimated. The importance of educating the designers, other end-users, and also semifabricators about the properties and characteristics of MMCs had not been understood.

By April 1990 the production plant was commissioned. Duralcan USA, concerned with what they interpreted as

**Properties of Cast Aluminum Composites as Compared to Unreinforced Aluminum**

- Higher elastic modulus (stiffness)
- Higher strength
- Lower coefficient of thermal expansion
- Improved wear resistance
- Increased thermal conductivity (in high-silicon foundry composites)

Like aluminum, cast aluminum composites can be recycled and/or reclaimed. Their fabrication methods—casting, extrusion, forging, rolling, machining, etc.—are consistent with the existing manufacturing base.

insurmountable problems associated with developing many small commercial applications, made a strategic decision to focus marketing mainly on automotive applications, primarily brake rotors and drive shafts. Markets other than automotive were considered secondary and were to be pursued only after automotive acceptance of Duralcan MMC was assured. Unfortunately, the introduction of new materials for automotive applications is a long, slow process requiring test after test before approval, and large-scale secondary fabrication technology must be developed and proved long before actual production begins. The understanding that might have been gained through the commercialization of small, less price-sensitive applications would not be available to guide the automotive thrust.

Technical achievement is not enough.

To date, Alcan has spent well over $100 million on commercialization and application development of Duralcan MMCs, and more will be required before the automotive industry accepts it. The goals, of course, are application of the material on a massive scale and retention of a major market share. This *industrial utilization* stage of materials development (i.e., to obtain and hold market share, which MMCs have yet to reach) will naturally go to companies able to deliver the highest quality and lowest cost materials.

The development of MMCs illustrates the stages through which new materials must progress. These stages—invention, scale-up and cost reduction, application identification and development, and industrial utilization—need not be distinct. Indeed it is preferable that there be overlap and simultaneous pursuit, but they all must occur for materials development to succeed.

The MMC story is still unfolding. We recently formed a new company, MC-2l, Incorporated (Metallic Composites for the 21st Century) to identify, develop, and facilitate new applications for MMCs. We believe there is a large opportunity for those who can deliver MMCs for commercial uses such as high-speed computer parts, recreational equipment (e.g., bicycle components) and a wide variety of yet-to-be-identified applications. We intend to bridge the technical gap between the production of primary MMC ingot and billet and the secondary fabrication and end-use, thereby facilitating the application of the composite in commercial products. As new applications are developed for the composite, designers will have greater confidence in specifying MMCs. For more than 25 years the industry as a whole has viewed MMCs as promising advanced materials, capable of providing properties not attainable in common engineering materials. These composites are finally available at prices that allow production of cost-effective finished products.

### What Then Is Success?

It seems clear that, above all, any new *business must produce a salable product*. Technical achievement, no matter how important, is not enough. There are countless examples of widely acclaimed technological advances which have been commercial failures.

So, the product must be new. It must also be *significantly different* from products already available. It must offer the buyer some meaningful advantage. It must have the potential to bring a future cash flow, the present value of which must be significantly greater than the cost of the investment.

Even then, commercial success is not assured. There really is not an easy way to predict success. At best, each investment is an educated guess. There is no way to determine beforehand whether a new development, no matter how promising, will be an eventual commercial winner. The most promising are likely to require longer investment streams to exploit their potential. The greater the promise, the longer profitability is likely to be postponed. Careful analysis and study of a potential opportunity will increase the probability of success, but there is no way to eliminate risk. Even after a new product is successfully introduced, there is always the chance it will be copied or leap-frogged by another product.

So success depends on more than just investment in a good idea. It requires conviction and speed. It requires early recognition of the product's potential. It requires early commitment to the investments required to obtain and hold market share. It also requires an understanding that the easiest, most rewarding way to acquire market share is to grab it early, to be the leader.

It was Ralph Waldo Emerson who first suggested, "Build a better mousetrap, and the world will beat a path to your door." He didn't know what he was talking about. The world will *not* beat a path to your door. The world must be made aware of the advantages and availability of your product. It takes intelligent, imaginative advertising and promotion, and hard selling. For new materials, it means you have to inform, educate, and excite not only the potential end-users, but also the semi-fabricators. It means that you must have a pricing policy that makes your product cost effective when compared to the materials you hope to replace.

The problem is much like the problem faced by the Pittsburgh Reduction Company (Alcoa's forerunner) when it tried to introduce aluminum more than 100 years ago. It took five years to persuade an iron kettle manufacturer to try making kettles out of aluminum. They couldn't just sell aluminum as they wanted. They first had to produce aluminum kettles and other products themselves to get others interested. For MMCs and other new materials to be widely accepted, we may have to do much the same thing.

New or advanced materials can affect the way people work and live. They can also improve the competitiveness of any nation's commercial products. However,

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these benefits can accrue only if the materials can be commercialized and applied, and if end-products can be manufactured from them profitably.

We, perhaps more than anyone else, are convinced of the immense commercial potential of metal matrix composites. In a way it may be inappropriate to measure the success of such a large, long-term development as MMCs on the basis of return on investment to any one company. Perhaps a better measure of commercial success of MMCs will come when every potential user is aware of the advantages of these materials, and when the only decision to be made is which composite should be used in a given application.

***David M. Schuster** and **Michael D. Skibo** are currently with MC-21, Incorporated (Metallic Composites for the 21st Century) San Diego, California. They formerly worked together at Alcan Aluminum Corporation's Duralcan USA Division, Science Applications International Corporation (SAIC), and Sandia National Laboratories, and have spent essentially their entire professional careers developing and applying advanced materials, especially metal matrix composites.*