N76-19176

# 4. AEROSPACE LUBRICATION TECHNOLOGY TRANSFER TO INDUSTRIAL APPLICATIONS

By Thomas J. Loran and Bill Perrin

Ball Brothers Research Corporation
Boulder, Colorado

## SUMMARY

Transferring technology from the highly specialized aerospace industry to high-volume, commercial markets is quite difficult. It has required several years for Ball Brothers Research Corporation (BBRC) to penetrate the industrial market. In the course of this, BBRC experienced problems that are unique to aerospace oriented organizations. To overcome these problems required overhaul of marketing concepts, licensing techniques, and internal product security. As one would expect, designs had to incorporate trade-offs of cost and functional life whereas normal aerospace mechanisms need reliability and function as prime considerations. The program must have upper management support since flexibility in pricing and modifying normal aerospace procedures are mandatory to satisfy the low-cost/high volume market requirement.

## INTRODUCTION

We all know that the transfer of the technology gains made by our aerospace industry into the industrial mainstream has been (surprisingly) difficult. We are also aware of individual company efforts to spin off aerospace technology into the private sector that have ended in failure. Although many new products

resulting from the aerospace program have been featured in advertising, new product announcements, and special articles, many seem to disappear after a short period of time. NASA has recognized the magnitude of the technology transfer problem and among other things, has resorted to special TV announcements and the use of exclusive license arrangements to encourage the use of its technology. NASA's Technology Utilization Office is making an effective effort in coordinating our industry with the private sector. This paper discusses some of the difficulties BBRC encountered in entering new industrial markets with an aerospace lubrication and coating technology and the technical, financial, and managerial solutions that evolved and led to our success in this venture. We are pleased to review this experience with you and hope that others in our industry can benefit from it.

## BACKGROUND

Ball Brothers Research Corporation started a lubrication and coating technology in 1959 during the initial design of the Orbiting Solar Observatory (OSO) Satellite. Our engineers recognized that moving and rotating satellite mechanisms such as bearings, motors, and slip rings could not be reliably sealed and therefore would be exposed to vacuum for several months. The known lubricants and coatings were unsuitable because of high evaporating rates and unstable constituents. BBRC determined the fundamental properties of materials needed for long life in vacuum and formulated lubricant materials and processes to satisfy those theoretical needs. Several aerospace companies subsequently recognized the success of the OSO Satellite and BBRC's Vac Kote lubrication technology (as it was called) and began to request the same lubrication technology for their mechanisms. A lubrication service and consulting activity thus began at BBRC.

In 1965 BBRC began an aerospace mechanism product line that featured the use of the Vac Kote lubrication technology. Within 3 years a multimillion dollar business was flourishing that involved the design, fabrication, and lubrication of mechanisms for spacecraft applications. In 1969 BBRC began to concentrate on diversifying beyond the pure aerospace activity. Several product lines based on BBRC's aerospace technology were initiated. These new business areas included ocean systems, low light television, military hardware, environmental monitoring, antenna design, low cost housing, and Vac Kote lubrication technology. A consulting firm specialized in evaluating potential new business activities was employed to assist BBRC in evaluating these new product areas with regard to business potential and to establish business goals, objectives, strategies, and budgets. The project team that had successfully developed the aerospace lubrication and mechanism business was assigned the task of diversifying the Vac Kote lubricating and coating business into industrial and commercial areas.

A five-year plan was developed for the Vac Kote business center that estimated the investment and potential sales. Figure 1 indicates the chart as drawn in 1969. The break-even point would be in 1971 and the business was projected to grow rapidly. The determination of the sales slope and cost curve depended upon a number of factors such as magnitude of market, company assets for investment, and the return on assets potential as determined by the consultants computerized cash flow formulas. This business area was originally composed of twenty people, including project engineers, production technicians, materials engineers, and marketing personnel.

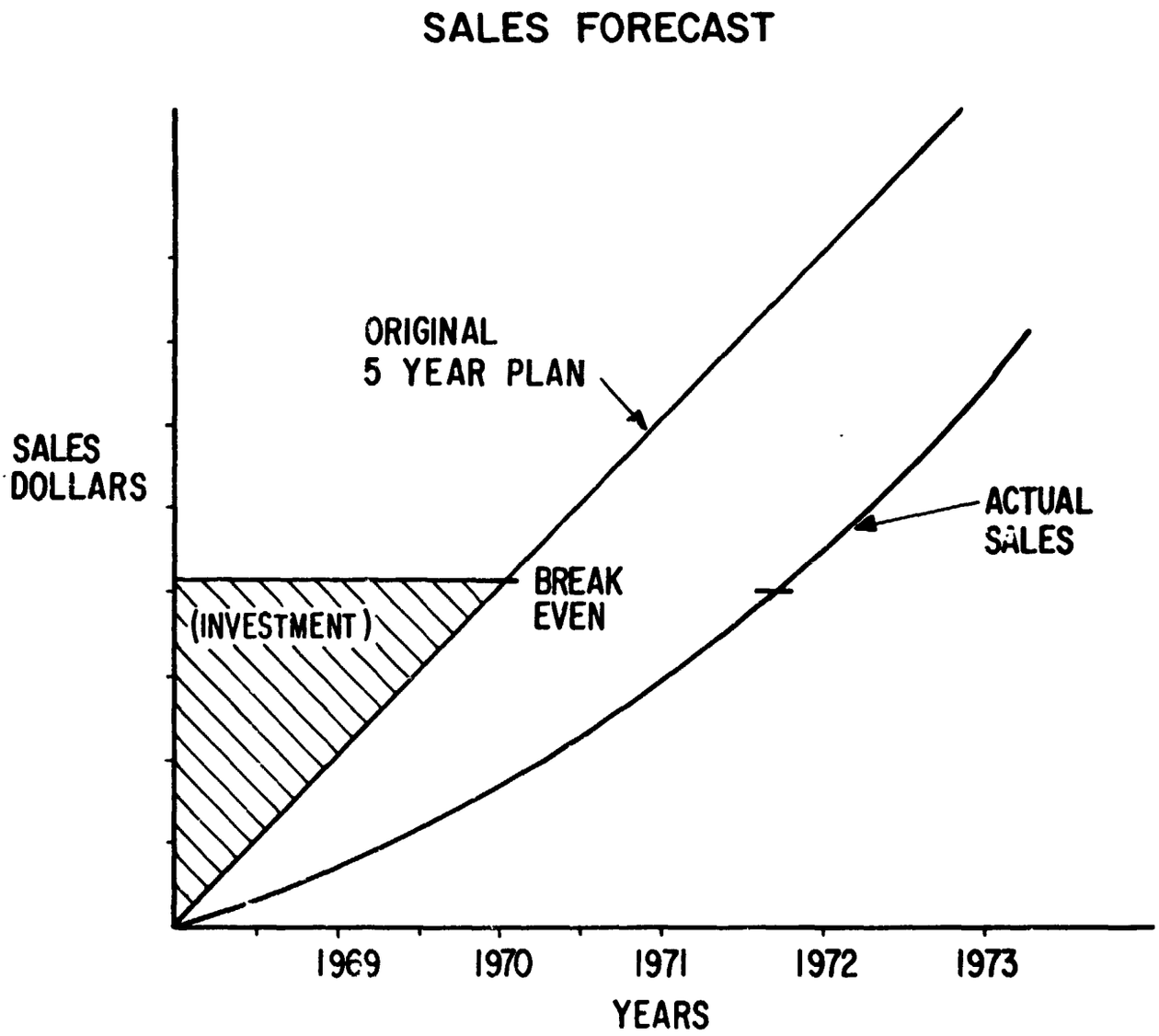


Figure 1

LESSONS LEARNED

Great difficulties (technical, financial, and managerial) were almost immediately encountered. We found that the "commercial" business was an entirely new ball game; our aerospace experience was actually detrimental to our pricing structure, sales methods, and customer service. The chart in Figure 2 indicates our rapid business demise.

# 1969 SALES CURVE

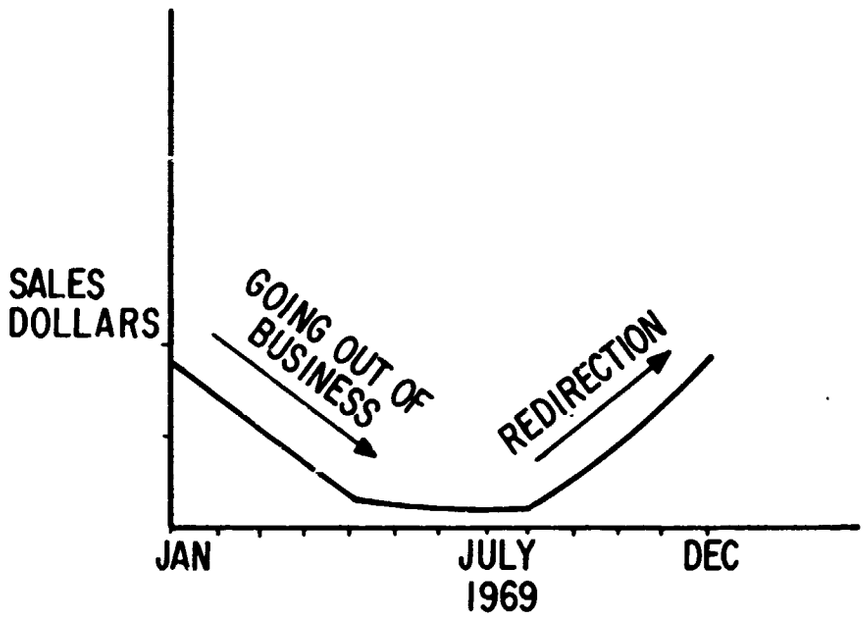


Figure 2

We found that industrial and commercial customers associated the word "Aerospace" with high costs and, unfortunately, they were right. We learned that our practice of maximum quality control, selection, and test of components to produce maximum reliability for the aerospace applications had to be modified. For aerospace applications we always recommend to the customer a complete program of analysis, immaculate processing, and confirmation testing required to produce high reliability. Flight history, engineering analysis, laboratory tests, and reliability

calculations support our material choices. For critical satellite applications, cost is usually a secondary concern. When potential commercial customers failed to respond to our proposals, we soon learned to ask the price range that would be consistent with the improvement in the performance and life of their products. With this change in approach we felt an immediate response in our sales. The customer was interested in product improvement only if increased reliability resulted in increased sales or increased profit.

We reacted to the need for pricing flexibility by developing price options that ranged from the lowest possible price with no testing, minimum quality control, and minimum paperwork to expensive options with various levels of testing, elaborate quality control, and extensive paperwork. Our customer could thus select a program that best fitted his technical and economic requirements. For example, DC motors can be prepared for vacuum operations and for long life applications at prices that vary from as little as 5¢ per motor to as much as $500 per motor. The 5¢ treatment is achieved by simply processing the motor brushes. The brushes are heated and impregnated with special lubricants in quantities exceeding 10,000 per lot. For $500 per motor, each individual brush is weighed before and after treatment to determine the lubricant absorption. The motor is then assembled and run until the brush conforms to the shape of the commutator. Extensive testing is then conducted. This ensures highly reliable motors for a specific, critical aerospace application. As a result of our flexible option pricing there is a complete range of prices between these two extremes.

Thus Lesson #1: <u>A commercial customer will only purchase a product at a price that results in a profit for him</u>.

Lesson #2 was much more subtle. We have learned that the team seeking to develop a new business area should have total responsibility for their destiny. The aerospace procedures manuals, proposal guides, and quality control levels should be available but not mandatory for use. To be responsive to the entirely different type of customer in the commercial marketplace (and thereby win sales), a program manager needs the flexibility to set policy "on the spot" and as required for the occasion. He must have the authority to provide free samples, quote prices, deliveries, terms, and conditions as the customer requires. Many times this is done on the scene in a customer's plant or on the telephone. Coordinating these judgments through the usual aerospace chain of command with enough of the details required for a good decision impedes and frustrates the effort and responsiveness of a business group. The aerospace management must trust the business judgment of the new business group and delegate policy making authority. Sufficient control exists by offering financial reward for the group for business success or "the parking lot" for failure. With this concept, upper level management sets broad business policy and monitors business performance on a quarterly or semiannual basis and does not become involved with the day-to-day decision making process.

Lesson #3: "Flexibility and diversity are mandatory!" Customer diversification and flexibility of business goals can either insure success or, if not used, guarantee failure. Originally only a few key companies were identified as potential customers. Cancellation of aerospace contracts taught us the need to expand the customer base. This one point is crucial - it resulted in the failure of some of BBRC's new business areas. Also, as you diversify, other opportunities that relate to the original goals occur. For example, our coating of movie film and aerospace components led us to the glass mold coating. This was

followed by rubber mold coatings and now we are pursuing plastic mold coatings. However one must not lose sight of the original goals; many contracts can easily take twice the time to develop than originally expected and the new business effort can easily be spread too thin with uncontrolled diversification.

We found that our technology base also had to be flexible to meet customer demands. To our surprise, our early aerospace formulations would solve very few commercial problems. Much to the consternation of our highly qualified engineers, the direction of the technical development had to be changed continually and sometimes the product tentatively "sold" prior to completion of laboratory testing in order to be timely. These decisions must be made by a commercially oriented program manager and are completely "against the grain" of conventional aerospace engineering practice. This can cause difficulties - especially if the technical people are not a part of the "commercial team" and thereby not continuously appraised of the total situation.

Lesson #4: The need for "establishing a team." We found that a team where an esprit de corps is created and proper rewards from the business success are given, significantly improves the probability of business success. With project, engineering, and production aware of the business direction of the team, changes in technical direction or production operations to respond to customer needs are understood and incorporated with minimum lost motion. The "team" also aids in the new product security. Every company has experienced loss of technology by personnel changing employment or leaving the company to start their own business. By limiting the number of people who have a "need-to-know" lowers the probability of losing technology that is not patented. Patents are not always the best method of protecting technology. Many foreign countries issue immediate patents where the USA usually takes 2-3 years. Therefore the technology can be

exposed prior to total development or at a time prior to the marketing thrust. Many times a trade secret is therefore a better sales method (classic example is Coca-Cola). Product security is then mandatory and with it the "team" concept becomes imperative.

## SUCCESSFUL COMMERCIAL MARKET PENETRATIONS

The Vac Kote lubrication and coating business evolved into a variety of products as indicated in Figure 3. A brief description of a few of these products will serve to illustrate the diversity BBRC has attained in the commercial area.

A product line that evolved early in our activity was based on special treatments for brushes used in DC motors and tachometers that had been developed for Aerospace applications. Previous research and tests proved that the moisture in graphite and metal-graphite brushes evaporates within hours in vacuum and after this loss, rapid brush wear ensues. BBRC found that impregnating brushes with special low vapor pressure lubricants would appreciably extend life and lower motor noise levels in vacuum. This same technique has been applied to commercial brushes for use in air operation to extend life and reduce EMI. Hundreds of thousands of brushes and other motor parts are now being processed at low competitive cost for the commercial market. One large European manufacturer has licensed and incorporated the Vac Kote technology in his motor production line. The U. S. Navy is also evaluating these treatments for submarine motor-generator brushes.

The glass container industry in Los Angeles had severe plant pollution problems caused by smoke-creating mold release lubricants and were threatened with industry-wide closing. BBRC

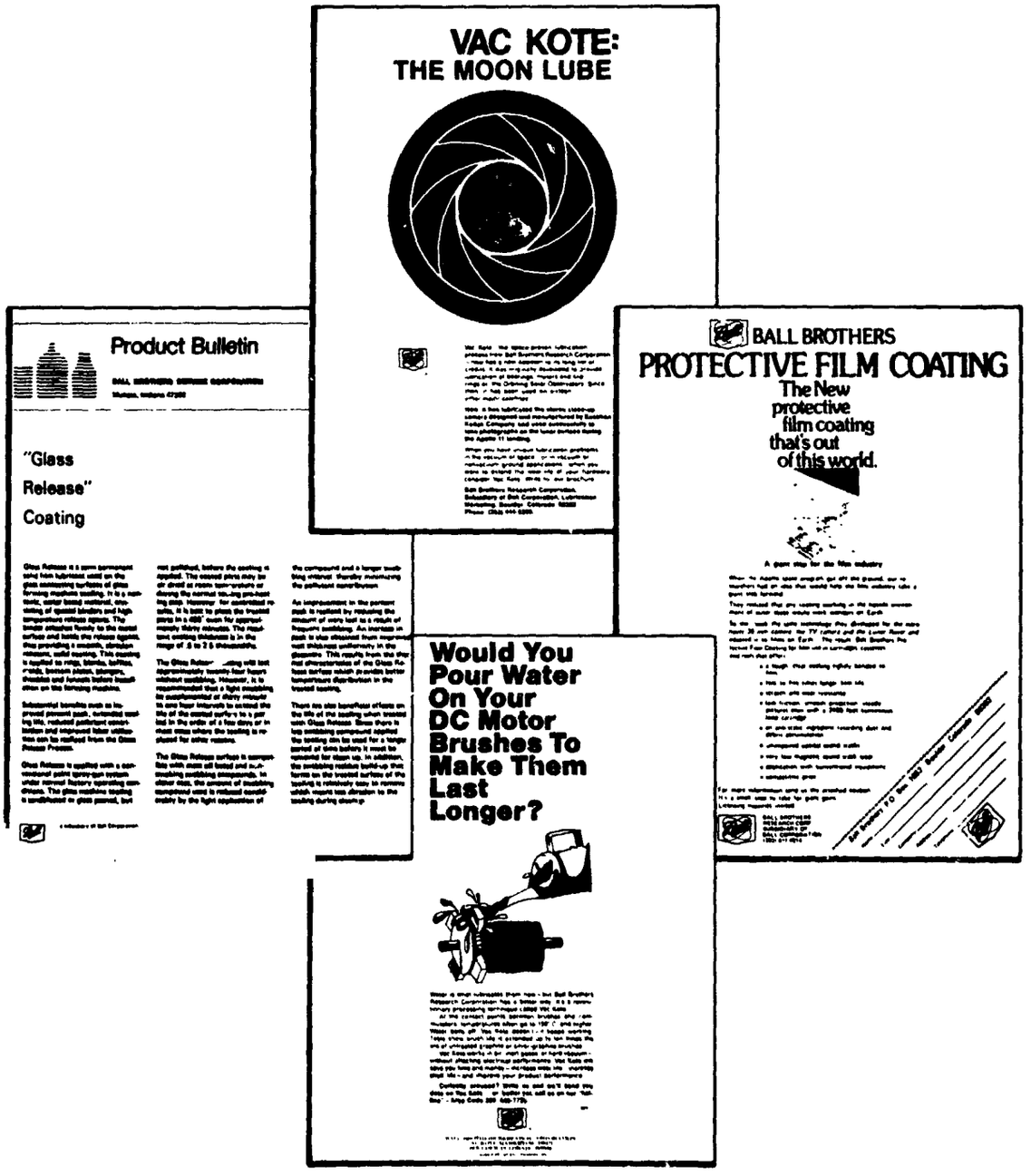


Figure 3. Typical Aerospace Products Successfully Transferred to Commercial Use.

devised a semi-permanent coating that eliminated the pollution, increased personnel safety, and reduced personnel exposure to high temperatures and noise. An added bonus for using this coating was increased bottle production that is four times more profitable than the coating cost. Four plants in Los Angeles, as well as five others in the U. S. and three in France, are now licensed to use this coating. Other glass plants throughout the world are scheduled for tests in the near future.

A special low friction, clear, tough coating is being applied to movie film to provide scratch and abrasion protection. Three film processing companies have licensed the process. This coating evolved from materials used for cameras on the Apollo Program.

Using special non-metallic coatings to protect magnetic memory surfaces for the computer industry is another aerospace technology spin-off. These protecting films on computer drums and discs replace the function of rhodium coatings on nickel-cobalt surfaces. This coating has been used for four years on production drums for a major U. S. computer manufacturer. Based on the success in this industrial field, head and tape wear in the sterilizable Viking tape recorder was lessened.

## LICENSING STRATEGIES

Recognizing some of our shortcomings such as limited marketing in new industries, high overhead and labor rates, and shortage of funds to staff a large business area suggested using a licensing sales mode. Licenses are difficult to sell because of legal negotiations, psychological blocks regarding payment of royalties, and foreign sales that complicate business relationships. However, the financial returns can be significant.

The license will sell if a customer can realize a large profit from the use of the product in his operation. BBRC's royalty fee is normally a small percentage of the profit that is realized by the use of our technology. Arriving at a fair dollar value can be difficult and involves extensive study of an industry to learn details about its costs. BBRC avoids the use of exclusive licenses for the obvious reason that the entire sales success from a product will then depend on the ability of only one organization or distributor. The licensing technique is especially attractive for business relationships with foreign companies since import duties and foreign restrictions can then be by-passed resulting in a lower priced product and increased sales.

## CLOSING THOUGHTS

Interestingly, problem solving for industrial applications has provided a synergistic effect by creating improved lubrication systems for aerospace applications at much lower costs. Lubricants used first for private industry solved the high temperature motor brush problem on the Lunar Rover. The commercial film lubricant has proven effective in reducing friction, wear and signal loss in the metallic recording tape for the Viking Mars Lander Recorder.

Combining production schedules of commercial and aerospace contracts improves efficiency and lowers costs. Expedient processing techniques were found to be applicable for many aerospace mechanisms thereby saving the industry many dollars.

As in almost every human endeavor, a continuous positive attitude and perseverence are mandatory for success in a venture such as this. A book would be required to discuss the many discouraging

events that occurred along the way. The unflagging positive attitude provided the persistence to "go the extra mile" to success. An example of this is illustrated by the following experience that almost resulted in the loss of a very profitable product line.

After almost two years of product development, demonstration, and customer cultivation that had taken us "to the negotiating table" with our potential customers, a dark horse competitor entered the market with a product that was significantly superior to ours and at 1/4 the cost. At this crucial moment a decision to withdraw could easily have been made with the acknowledged loss of investment. Our confidence in our technical ability and our positive attitude resulted in continuing our efforts in product development. The new product proved to be so significantly superior to the new competitor's product that cost was no longer a factor and we regained our former position in this market.

The business goal of diversifying the lubrication work at BBRC has been accomplished with a minimum of corporate funds. The staff has been increased to accomodate the new business during a period when other aerospace lubrication organizations were declining. We believe that our success resulted from the above lessons.