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Strategic Analysis of Opportunities to Improve Manufacturing Performance

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ALCOA

The Strategic Analysis Group at ALCOA was established about ten years ago. The group developed a methodology called Manufacturing Opportunity Analysis that it uses to plan and apply new technology to ALCOA's eighty plants worldwide (mining, smelting, and fabrication). The methodology was developed to assure that ALCOA could base its technology-related decisions on sound scientific and economic reasoning. The methodology looks for opportunities for increased profitability and customer satisfaction through developments in technology and in the marketplace.

The S-curve is one of the primary technology assessment tools that the Strategic Analysis Group uses to assess the likely performance improvement from continued investment in a given technology. An S-curve starts with a marginally increasing slope, but after an inflection point, the slope becomes marginally decreasing as the technology matures. A company needs to make a strategic judgment about when to shift its investments towards newer technology as the older technology reaches its theoretical limit.

John applied the S-curve approach to consumption of electrical energy when smelting aluminum oxide (Kilowatt Hours per pound of aluminum oxide smelted). The theoretical limit, based on lab experiments, etc., is that 2.89 KWH are required to convert a pound of aluminum oxide into aluminum (by breaking its molecular bonds). The practical limit in 1990 was 6.55 KWH with the prospect of achieving approximately 1/2% improvement per year. Given the present mature state of aluminum smelting technology, a lot of effort is required to achieve marginal improvements in efficiency.

A plant manager generally requests the Strategic Analysis Group to look at a plant or a major sub-operation of a plant. Manufacturing Opportunity Analysis is fact-based and data intensive in its quest for scientific and engineering understanding of a manufacturing process, but it also relies on the insights of empowered employees at all levels including nontechnical managers and factory employees. The process of inclusion and buy-in is equal in importance to the numbers generated. John finds that involvement of cross-functional teams leads to greater depth of understanding among plant personnel and greater focus and aggressiveness in pursuing improvements.

The understanding of the manufacturing process that is generated is translated into preliminary equations from which forecasts of potential process improvements are made in such parameters as recovery, up-time, productivity, quality, and development time. These equations are supplemented with financial calculations of improved margins from cost savings or enhanced output. Next, key enablers that can produce the potential process improvements are identified. These enablers include enhanced worker problem-solving capability (work teams, worker training) and/or capital investment. Lastly, a roadmap for implementing these enablers is developed.

John illustrated the use of this methodology with extrusion recovery. First, historical data on extrusion recovery from presses are calculated. The recovery data can be broken into the current sources of scrap loss. Theoretical and practical limits are developed as are projections of reasonable improvement per year. These projections are based on what new technologies might yield and what

competitors are doing and are likely to do over the next five to ten years. An assessment then follows on the likely impact of the improvement on profit margins. The analysis also can include breakdowns of financial benefits due to capital versus continuous improvement, and what parameters produce the greatest benefit (Pareto analysis).

Data generated by the Manufacturing Opportunity Analysis demonstrates where the potential for improvement exists, but this must be followed by development of a strategic plan for implementation. The group's analysis suggests that there is more to gain financially from increased output than from cost savings. Therefore, future profitability depends on new product innovation and market share penetration. There may not be significant cost savings possible with present technology, and there is strong incentive in the industry to find incremental improvements in its existing manufacturing base (about $3 billion for ALCOA), than to find radical process innovations that could lead to massive write-offs. ALCOA is investing somewhat in ceramics and has some plants that produce wire harnesses and plastic closures, but it sees its future primarily remaining in aluminum.

Product Design Strategy in the Global Firm

Karen Rajczi
Bell-Northern Research

Bell-Northern Research (BNR) is the R&D arm of Northern Telecom, having a role equivalent to that of Bell Labs at AT&T. BNR has facilities in Ottawa, Ontario, which is the world headquarters for Northern Telecom, and in Richardson, Texas. Bell-Northern's most successful major product is Norstar, a digital switching system, which is now being sold in 43 countries. Karen worked as a software engineer in Richardson before coming to Ottawa a few years ago (but she recently returned to Richardson). While in Ottawa, she worked on a study to help BNR decide on the kinds of products to develop. She indicated that while the company had made significant progress in reducing development time and delivery to customers, it still needed to make progress on clarifying what products to develop in the first place. This latter issue was growing more important as the company's marketing focus became increasingly global.

Karen developed a Global Product Grid to help clarify the dimensions that influence the company's global design strategy. One dimension of the grid focuses on product design input, i.e., the range of customers queried and the level of detail of input sought per customer. The other dimension focuses on product design output, i.e., how generic or tailored the product will be to the needs of the company's diverse customers. Karen gave examples of companies with products that fell into each of the quadrants created by the two dimensions.

There are two major types of risk that companies need to consider when assessing how to position a product within the Global Product Grid. "Opportunity risk" is the probability that the product will not respond quickly enough to emerging global market opportunities. This risk is high if markets are "stacked," i.e., emerge simultaneously, and low if they are "staggered," i.e., emerge sequentially. "Right product risk" is the probability that the product will not be well-matched to the diverse markets that it serves. The risk is high if market needs are "heterogeneous" and low if market needs are "homogeneous."

The design issues that companies should consider can be characterized by trade-offs. Products designed to meet a company's diverse markets are likely to be more complex and difficult to maintain and service. Some of this complexity might be reduced through thoughtful consideration of product modularity and the expected evolution of the product over a three to five year period, but this is likely only if the product is designed initially from a global perspective. However, products that are complex also take longer to reach the market and generally are more costly. Thus, break-even or payback on the product must be considered from the perspective of a platform that yields a family of products that will produce enough total volume to breakeven over all the countries served.

Karen characterized Norstar as a product that was designed solely on the basis of market input from North America because that was the market it initially served. As the product expanded to markets in Europe and Asia, a significant amount of investment was needed to redesign the product for each new country served. Europe, for example, requires a much more software intensive product than does North America. Karen has discussed her framework with senior management. They have expressed some interest in it, but are unsure about how realistic it is to design a product initially for all future markets. Karen currently is interviewing design and manufacturing personnel who are working on two or three products that are being globalized. She wants to track how decisions are made over time.

Karen is now back in Richardson, Texas working with wireless systems, which are expanding rapidly in Eastern Europe. Expensive infrastructure investment in underground cables thus can be bypassed. Eastern Europeans are "lead-users" to be studied for future trends. Design or product groups in Ottawa, Dallas, and Raleigh communicate regularly with regional marketing groups for the United States, Canada, Europe, and Asia/Pacific. There is still not much contact between these groups and manufacturing which is performed primarily in Canada.

Countries still differ dramatically in requisite technology, so it is difficult to build common platforms. Also, Northern Telecom has done very well with proprietary technology, but this is now less feasible with globalization. Common standards and protocols will allow Northern Telecom's customers, e.g., MCI and Sprint, to differentiate their services. Some initiatives are underway to cope with complexity by establishing global or at least overall European standards. Joint ventures or acquisitions in established European companies have led to closer contact with markets.

Measuring Manufacturing Performance Through Activity-Based Costing with Productivity Accounting

John Bicheno
University of Buckingham

John discussed a study that he had undertaken in a British car company that implemented JIT. The study began in 1988 when the car industry was booming The company also was considering streamlining its product line so it was receptive to a productivity-based analysis of its product costs. John began by looking at implementation stages of JIT and at seven potential areas of operational waste, e.g., overproducing, waiting, transporting, processing, unnecessary motion, unnecessary stock on hand, and defective goods. He also explored bottlenecks in the production process. From an Activity-Based Cost (ABC) perspective, he looked at the contributions of support functions to line functions and to cost drivers of activities that made up the line functions.

The main focus of John's presentation was the link between activity-based costing and productivity accounting. He showed a nine-box model developed by Basil Van Loggerenberg of South Africa in which profits can be broken down into contributions from productivity and from price recovery. Usually profit focuses solely on changes in revenue or in cost (three boxes). The nine-box model adds three boxes for changes in productivity (change in product quantity minus change in resource quantity) and three boxes for changes in price recovery (change in product price minus change in resource price or cost). This model proved useful for analyzing public utilities in South Africa to determine how much an increase in profit was due to an increase in productivity and how much was due to an increase in price recovery. Profit changes based on any resource can be calculated by considering that Value = Quantity x Price.

John showed several grids that can be developed by taking pairs of contributors to profit and arraying them on perpendicular axes. The grid to which he devoted the remainder of his discussion, called the "profit grid," was based on arraying price recovery and productivity on two respective axes. The axes measured relative change between accounting periods, while a 90 degree diagonal through the grid represented zero change in profitability, i.e., equal and opposite changes in productivity and price recovery. Any company could then be positioned on the grid. Companies placed above the diagonal reflect a positive change in their profitability between periods. However, a good company increases its profits by productivity improvement, while a not-so-good company increases its profits from high (resource) price recovery.

ABC can be combined with productivity-based accounting by selecting activities that drive the costs and quantities of critical resources. In the JIT implementation study, five "resources" were selected for analysis of their contribution to profit; inventory, operations, rework, maintenance, and set-up. A measure was developed for each activity and changes were recorded over three time periods between 1988 and 1992. The data showed that all activities except inventory initially contributed negatively to profit, suggesting that JIT may produce a decrement in performance during its initial implementation. However, by the third period, operations, inventory and rework contributed positively to profit. Their positive contributions more than made up for the increased cost attributed to set-ups and maintenance.

This analysis can help managers better understand the production process and presumably change their behavior. The economic situation in the U.K. has changed dramatically since the study started and has led management to shift its focus to other matters. Also, the cost measures used in this study should be supplemented with measures that relate to customer satisfaction, e.g., product quality and delivery time. The five measures selected for this study were believed to be the highest cost drivers. Sometimes the selection of measures requires judgment and can lead to contention among managers. In the above illustration, for example, increased setup and maintenance costs may be necessary for overall improvement in other costs, but those who manage these activities should be rewarded for their contribution to overall improvement. Finally, these measures look at relative change within a single company. A company also needs to benchmark its changes against the performance of other companies.

Tracking Product Life Cycle Performance

Gerry Susman and **Rocki-Lee DeWitt**
The Pennsylvania State University

Gerry reviewed the results of a 1986 survey on different financial performance criteria used by 100 companies to assess new product development performance. In descending order of frequency were revenue size, operating profit, return on investment (ROI), payback period, gross margin, and return on net assets (RONA). Net present value (NPV) and market share were not mentioned in this study, but another survey ranked NPV at about the same level as RONA and the latter at about the same level as revenue size.

No single measure is perfect; each has benefits and drawbacks. Gerry reviewed these benefits and drawbacks and then discussed what an ideal measure might look like. The measure should be product-based to maintain a strategic focus, account for type of product (brand new product, derivative, etc.), be cumulative over the life of the product, take the total investment into account, and approximate cash flow (correct for depreciation and period expenditures for working capital).

Rocki-Lee presented the results of a survey that was completed by Forum participants. The aggregate results were similar to those from the 1986 survey. However, these results also were analyzed by type of product developed. Market share, sales volume, operating profit and ROI were heavily and consistently used (60-100%) for all types of product types. The greatest contrasts, however, were on gross margin for brand new products (35%) versus derivatives (70%), payback period for brand new products (0%) versus derivatives (70%) and substantially modified products (100%), market share for brand new products (100%) versus derivatives (75%), sales volume for brand new products (65%) versus derivatives (100%), and NPV for brand new products (65%) versus derivative products (42%). These data suggest that payback and gross margin are not likely to be used for brand new products, while market share and NPV are likely to be used. Gross margin, payback, and sales volume are more likely to be used for derivative products and substantially modified products than for brand new products.

Discussion of these results shed some new light on justifying new products and tracking the performance of product development projects. First, if several measures are calculated and are sufficiently consistent, then confidence can be increased in the merits of the product proposal. Second, multifunctional teams should be used so that measures favored by different functions, e.g., marketing prefers sales volume, can balance each other. Team dynamics can help to reach consensus on a proposal's merits and to make commitments to each other and to management. Third, the background of the CEO significantly influences what kinds of projects will be supported. About half the time, this bias drives the analysis as much as the analysis drives the decision. Fourth, NPV is good for assessing investments in new equipment, but not very good for new product proposals because heavy judgment is required to get accurate data. Lastly, a company may need to proceed with an investment in new technology simply because the competition has already done so. If the latter succeeds in developing the new technology, then the company may lose market share. The decision to proceed is based on strategic judgment rather than on a specific financial calculation.

Other points were raised about how to treat prior investments in a new product, e.g., investment in R&D or in existing factory capacity, when calculating a financial measure of performance. Most

participants said they would not ignore such investments, but instead treat them as leading to revised product platforms, increased factory capacity for other products, development of worker skill and talent, and contributing to the companies core competencies.

The exercise of calculating NPVs may have value by providing discipline to the capital allocation process even though the initial numbers may be soft. Persons may improve their ability to forecast sales and costs by comparing actual numbers to forecasted numbers. It can lead to the identification of persons who are talented in developing such forecasts or at least for them to earn credibility for using accurate numbers. Calculating ROIs can be valuable also even though having the investment as the denominator can lead to distortions, e.g., the ROI looks worse at the start of the project than it does later when the asset base depreciates. The reason is that use of ROI might motivate managers to shrink working capital and to utilize assets more efficiently through JIT or similar initiatives.

Strategic Technology Planning: Developing Roadmaps for Competitive Advantage

David Hall
HRB Systems, Inc.

HRB Systems develops intelligence gathering systems primarily for the military. Its contracts include system support and development, analysis and algorithm development and technologies and products such as parallel processing, natural language processing, artificial intelligence, and signal processors. HRB spends about $3 million a year on internal research and development projects. Dave's presentation focused primarily on how such projects are developed and evaluated.

HRB has an excellent reputation for developing high technology products. The company is organized into strategic business units and emerging "business expansion units." Its external environment was fairly stable throughout the 1980s, but as the Department of Defense market declines it faces dealing with some new customers (DOE, NASA), fierce competition with aerospace companies for relatively small contracts, and rapidly expanding use by its customers of commercial off-the-shelf products.

Dave discussed HRB's process model for selection of technology and R&D projects. Projects are assessed against the company's competitive and technological environments and for consistency with the company's strategic focus. HRB Systems has excellent internal resources for technological forecasting, but rely primarily on consultants for market and competitive analysis.

The company's technology forecasting objectives include identification and evaluation of new products and processes as well as identification of opportunities and potential threats related to investment in such technologies. Most new technologies already exist, but the company tries to extrapolate three to five years ahead to see what developments are likely. Dave reviewed a number of forecasting techniques, e.g., surveillance, projection, normative, expert opinion and integrative, and used a "technology roadmap" to illustrate likely developments in AI/Expert Systems through the year 2001. He discussed some common-sense guidelines that can help avoid being dazzled by technological wonder, such as remembering who their customers are and what they want, how social and ethical concerns might influence a technology's development, and generally being wary of simplistic projections based on today's assumptions.

HRB Systems continually explores external sources for ideas on new technology in the federal government (NASA, NSF, DARPA, DOE), industry (joint ventures and consortia such as MCC) and universities. Dave mentioned their use of memoranda of understanding (MOUs) with the federal government which involve no costs, but alerts federal agencies of HRB Systems' interest in certain technologies. He also mentioned recent exploration of Pennsylvania's resources such as PENNTAP, incubators, etc.

Dave discussed the company's process for selecting R&D projects. Senior management sets the priorities and business direction, middle management operationalizes the R&D requirements, generates ideas and drafts proposals (with technical staff), then selects promising proposals for evaluation. Senior management annually reviews proposals and decides how to allocate resources for funding.

HRB uses a variety of processes and techniques for selecting projects. Their customers' requirements as defined in requests for proposals (RFPs) offer major guidance. Each proposal is assessed according to technical and business criteria and by a "productivity estimate" i.e., sales generated per investment dollar. They try to build a portfolio that consists of multiple projects for various customer segments. Most projects are funded full-blown, but some are given seed money for up to three years to demonstrate the value of promising technologies. Each project is assessed quarterly, but funding is re-assessed on a yearly basis. Each project must compete against new projects for limited available resources. If a project shows only limited progress, it could be terminated in favor of a new project.

Dave showed a 2x2 matrix that HRB uses to evaluate projects. It evaluates projects on a technical and business basis. Projects with a high technical and business evaluation would be rated as having the highest potential. Projects with high business, low technical scores might need some technical rework, while projects with low business, high technical scores might lead to refocusing a SBU to take advantage of the technology. Projects generally range from $50,000 to $500,000. Approximately 10% of funds is held in reserve for unexpected investment opportunities during the year.

Dave doesn't believe that the business evaluation process benefits much from use of complex econometric models nor from reliance on any single index such as sales/investment. Rather, HRB tries to assess what the competition is doing, looks at life cycles in products and processes and what their customers want. The company augments its technology assessment capability by funding technology working groups which specialize in tracking and championing specific technologies. It also relies on exchanges between sister divisions within E-Systems, its parent company. There is no sure way to keep the company's focus balanced between short-term and long-term objectives, but senior management has been getting involved earlier in the technology assessment process to help specify technology requirements and business objectives.