Resource Allocation of EM R&D Projects 2001

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Introduction:

The Electronic Manufacturer (EM) company desires to choose R&D projects that will yield new products and lead to growth of the company over the next 3 years. There are a number of proposals for Research and Development funding for 2001. It must prioritize these projects for funding. This paper describes the process used to estimate the benefits and the costs of each proposal and relates these to the objectives of the company.

This paper sets the context for this evaluation by first describing the company and providing background of the wireless electronics market. This is the market that EM competes in. The result of this process is a set of identified set of R&D proposals to fund which provide the highest benefit / cost for the company when evaluated in terms of the company's objectives.

Company Background:

The EM Company designs and manufactures radio frequency (RF) electronic components for the wireless industry. This industry has a great amount of diversity in the products produced with everything from pagers to cell phones to basestation hardware to traffic light controllers. The only thing that equals the diversity of the products produced is the rate of evolution of the technologies employed with technologies changing and improving every 12 to 18 months. EM Started Commercial Operations in 1994 and has expanded operations in the commercial area every years since 1994. EM currently manufactures and ships in excess of 5 million parts annually.

The keys to succeeding in this fast moving industry are the introduction of new products and technologies with regularity, the ability to deliver large amounts of product at a low price, on schedule, with excellent reliability, that demonstrate superior technical performance. When a new technology is developed it can rapidly obsolete the current product of a competitor and the market may vanish within months of a new products introduction. This is driven by the seemingly insatiable desire for consumers to have a "hot" feature in their phones. Sometimes this is cosmetic, sometimes it's a higher data rate, sometimes its better reception that causes these radical demand fluctuations.

Due to this fickle nature of demand for a particular product it is necessary to constantly evaluate new technologies and to optimize the introduction of technologies and products to minimize risk and maximize profit potential to the company. The introduction of a new product may require capital spending and the application of significant design engineering, management, production, and manufacturing engineering resources to introduce the product and to initiate and maintain production

The company currently produces its products using highly automated assembly machines. A fully automated line takes months to set up and may cost in excess of $3 million. EM has adopted a modular approach that allows the equipment to be used to build a variety of products.

. The EM Company faces several external challenges at the current time that add to the uncertainty of this decision. The company has been under investigation by the SEC

for accounting irregularities and this has produced several relevant developments. The CEO and the CFO have both resigned, the stock has been delisted from NASDAQ, the stock price has fallen dramatically and the credit line has been frozen. All of these limit the ability of the company to raise capital funds and recruit talented people that may be needed to launch a new product.

Market Background:

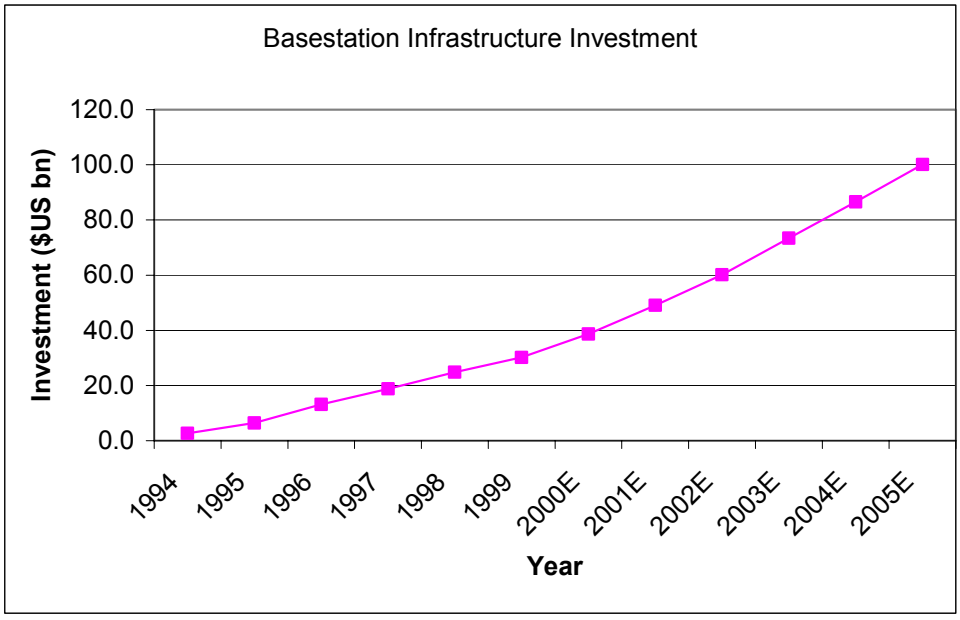
The cellular electronics market is dominated by large original equipment manufacturers (OEMs). Eight of these OEMs produce in excess of 90% of the cellular basestations in the world. EM has three of these OEMs

- Nokia
- Motorola
- Seimens

as its major customers. The nature of the business is mass customization in which each Customer requires custom modifications to the base product. Customers buy from EM for customer service (customization) and performance (lowest noise in the industry allows high data rates and improved range). The company holds 9 patents related to this field.

The wireless electronics market is growing rapidly currently and there are several areas that present great opportunities. Figure 1 shows the rate of growth anticipated in cellular infrastructure over the next 5 years. Clearly this is a tremendous opportunity for EM to excel.

Figure 1 Growth of Cellular Infrastructure Investment



This market can be segmented into modifications of existing infrastructure, bandwidth increases to cellular infrastructure to support broadband services, and increases in frequency to avoid spectral crowding and allow larger bandwidths to be achieved more easily. All of these are expected to grow and Oscillator has aimed its development efforts and is proposing developing products to expand into the adjacent market of subscriber electronics.

Methodology for Resource Allocation:

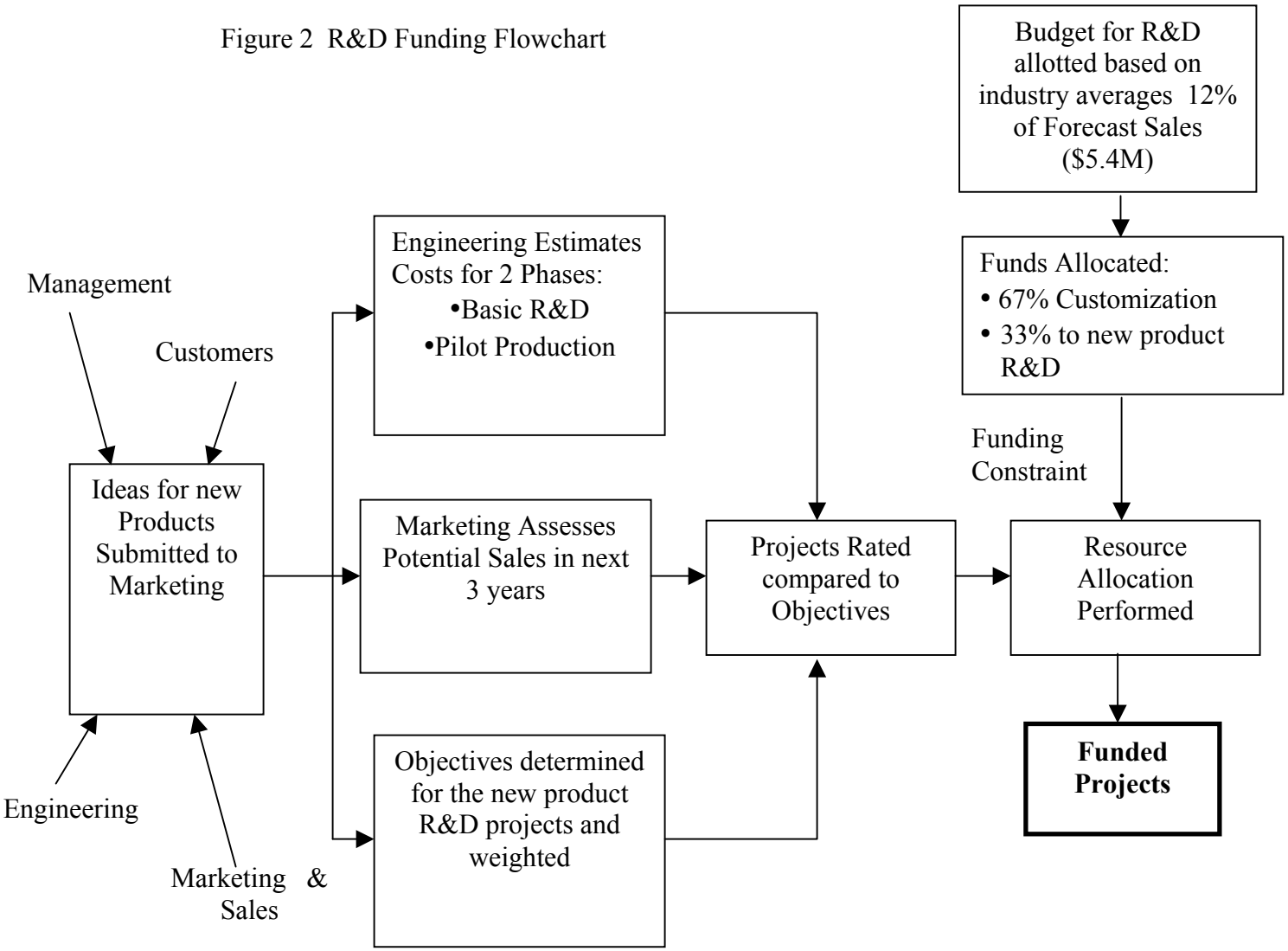
The R&D funding process is best viewed as a flowchart. This is shown in Figure 2. The total funding for R&D is derived from examining companies in the same SIC code for the percentage spent on R&D and applying this percentage to the expected sales in the following year. The industry average percentage is 12%, this results in $5.4 million allocated to R&D for 2001.

As was mentioned before, the market is one of mass customization. This means R&D funds can be viewed as divided in two, the first set of funds (67%) is allocated to customization. This money is used to fund the engineering time and materials needed to modify an existing product to meet the needs of a particular customer. The second segment of funds is that devoted to the development of new products, this is matched to the desired growth rate for the company, 33%. This produces the funding constraint for the allocating the funds.

There are many good ideas for new products and these flow into marketing from a variety of sources such as management, engineering, customers, and sales and marketing. These ideas then must be quantified for evaluation, this is a parallel path in which management, engineering, and sales and marketing play a role. The engineering department has the responsibility to estimate the cost of developing the product in two segments, the prototype phase to prove the concept, and the pilot production phase in which a basic manufacturing capability is established. The marketing department has the responsibility of estimating the sales revenues that will result from the product over the next three years assuming 1 year development. Management has the responsibility of establishing the objectives of the company and the relative importance of each objective.

These objectives form the basis for evaluating the projects. Figure 2 shows all three of these inputs and the funding constraint flowing into a resource allocation box. In the section, each of the R&D proposals is evaluated using a ranking system against the objectives established by management. In addition, the costs estimated from engineering for the prototype development phase is entered. The EXPERT CHOICE software synthesizes a set of eigenvalues to weight the objectives based upon a pairwise comparison. Eigenvalues are also established for the ranking categories and these are use to establish a total benefit in terms of company objectives for each proposal. A resource allocation is then performed by launching EXCEL with its Solver Option. The software calculates a benefit / cost ratio for each project and creates a table that shows the different projects that would be funded at each funding level. This is a simple linear programming exercise where the alternatives are the projects, the benefits are derived from the objectives and rankings and the constraint is the funding level. In this case the funding level is $1.8 million. The result of this synthesis is an identified set of projects that would be funded.

Figure 2 R&D Funding Flowchart



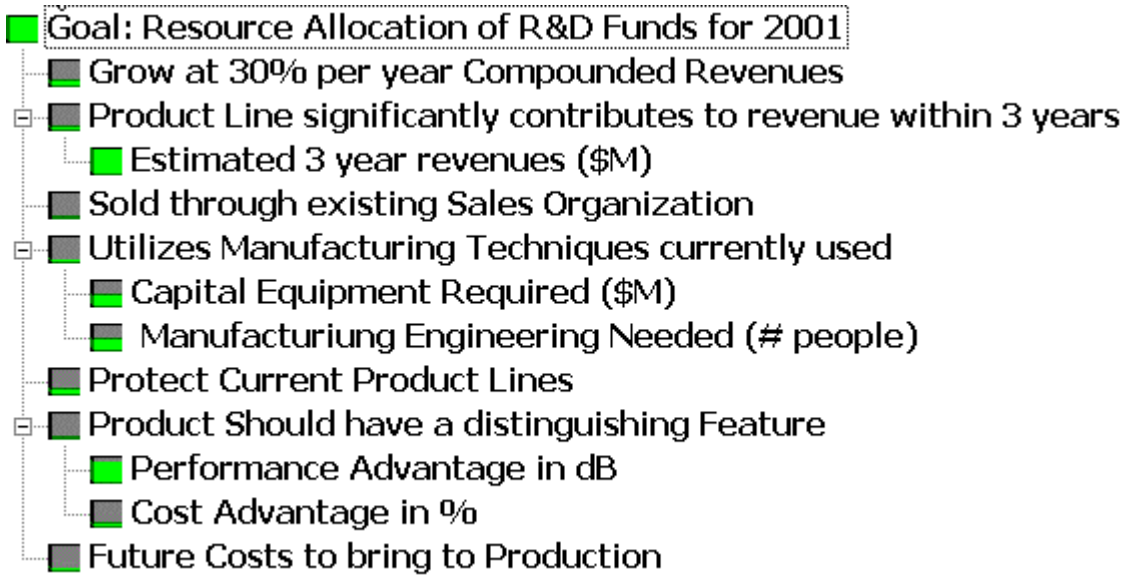
Objectives

The task of management in this process was to establish the objectives for the company and to establish the relative priorities of those objectives. This was done using EXPERT CHOICE. Management established the following objectives for the R&D Projects:

1. Grow the company at 50% compounded per year in revenues.
2. The new product must contribute 10% of the revenue in 3 years.
3. The product should be able to be sold by the existing sales and marketing organization to utilize existing infrastructure and dilute selling costs.
4. The product should utilize current or slightly modified manufacturing techniques employed by the EM Company.
5. The current product offerings and revenue streams should be protected.
6. The product should have a distinguishing feature, the company is unwilling to compete as a lowest cost supplier.

These objectives were entered into a hierarchy in EXPERT CHOICE. This is shown in Figure 3.

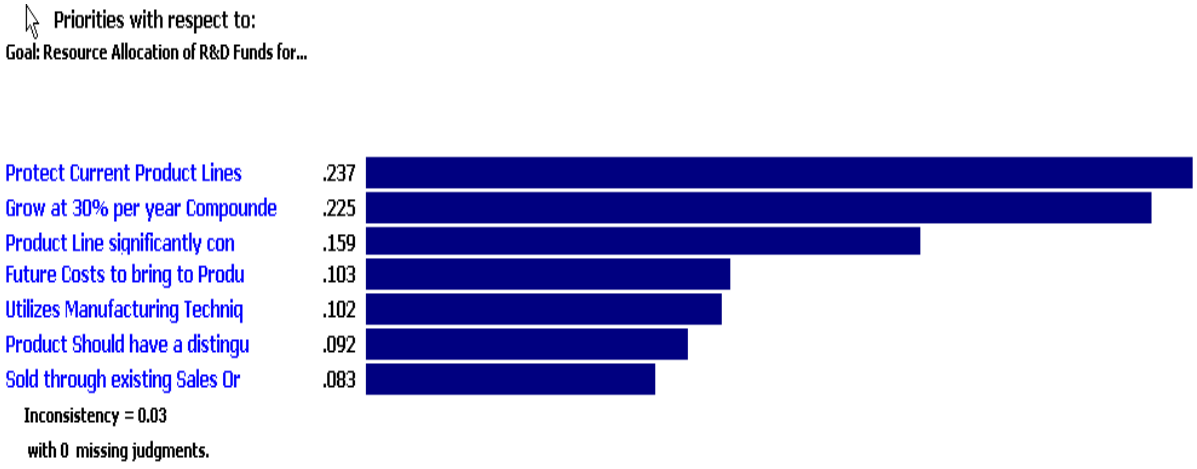
Figure 3 Hierarchy for Allocating R&D Funds



Importance of Objectives:

The next task was to establish the importance of each of these objectives, a pairwise comparison was done. In this every objective was compared to the other objectives using a verbal scale of EQUAL, MODERATE, STRONG, VERY STRONG, and EXTREME to indicate the amount of preference one objective had over another alternative. These judgements were assigned to a numeric scale ranging from – 9 to +9 where 1 was EQUAL and 9 EXTREME. These judgements were synthesized into eigenvalues and a set of weightings for the objectives resulted. These weightings are shown in Figure 4. Protecting the current product offerings was the most important objective established by management followed closely by growing the company at30% per year and having the product line contribute significantly within 3 years.

Figure 4 Results of Prioritizing Objectives



Alternate R&D Proposals:

Management had established the objectives for the R&D department and a number of R&D ideas had been gathered that were worthy of evaluation. These ideas are described in Figure 5.

Figure 5 Description of R&D Proposals

Project Name	Description of Project
DRO	Dielectric Resonator Oscillator: High stability, high frequency oscillator used in emerging wireless markets such as MMDS and LMDS. This is aimed at capturing an emerging market.
Improved Noise	Improvement of the existing product offering to incorporate electronic device and material changes. This is aimed at retaining a competitive advantage in the existing market segment.
PLL IC Development	Contract with a design services company to develop an Integrated Circuit (IC) that could be sold with each oscillator currently sold. This would allow potential future vertical integration.
Mixer Development	Utilize new technology developed to design a new product that could double the dynamic range of cellular radio channels. This would replace costlier hand wound items or ICs depending on the application.
Broadband	Design a set of frequency sources to address the next generation broadband services that are being design and conceived now. These products would support data rates up to 1000 Mbytes/sec.
Power Dividers	Design a product to compete against a product currently being offered in the market. This product is being used in conjunction with every oscillator the company currently sells, this would be a common point of sale.
LMDS Transceiver	Design a transmit, receive module for use in MMDS and LMDS set top applications. This is an emerging market that has minimal vendors supporting the application
Subscriber Module	Design a frequency source for use in handset applications. This must be low cost and addresses a different, much higher volume market that the infrastructure market currently being serviced

Estimate of Costs for R&D Projects:

Engineering estimated the cost to prototype each project. The cost estimate is shown in Figure 6. There are several major categories of costs would be incurred in each project. The labor time for each category is in weeks of effort. The equipment rental, raw material, physical space, and tooling expenses are estimate based on experience an verbal quotes. These costs are rolled up based upon rates established in the accounting department.

Figure 5 Engineering Cost Estimate for Prototype of R&D Projects

Category	Rate / hr	DRO	Improved Noise	PLL IC	Broadband	Mixer	Power Divider	LMDS Transceiver	Subscriber Module
Scientists	$81	26	30	26	20	26	26	19	13
Sr Engineers	$60	13				52	26		26
Engineers	$42	26		104	78	52		52	52
Associate Engineers	$30	0	30			52			
Sr Technician	$31	0							52
Technician	$24	26	30		52	104	26	26	
Manufacturing Personnel	$15	4	4						
Total Personnel Costs ($k)		$187	$165	$259	$246	$459	$172	$174	$257
Equipment Rental ($k)		$8	$10	$0	$0	$10	$8	$8	$0
Raw Materials ($k)		$12	$20	$100	$20	$30	$20	$20	$20
Space Required (sq ft)		1500	2000	1500	1500	2000	1000	1000	1200
Rent Expense ($k)	$1	$9	$14	$36	$27	$48	$6	$12	$15
Tooling Expenses ($k)		$12	$5	$0	$5	$25	$5	$0	$5
Manuf. Line Time (hrs)	$250	0	80	0	20	80	20	10	40
Manuf Costs ($k)		$0	$20	$0	$5	$20	$5	$3	$10
Total		$228	$234	$396	$303	$593	$216	$217	$307
all costs are in $k									

Description of Evaluation Levels:

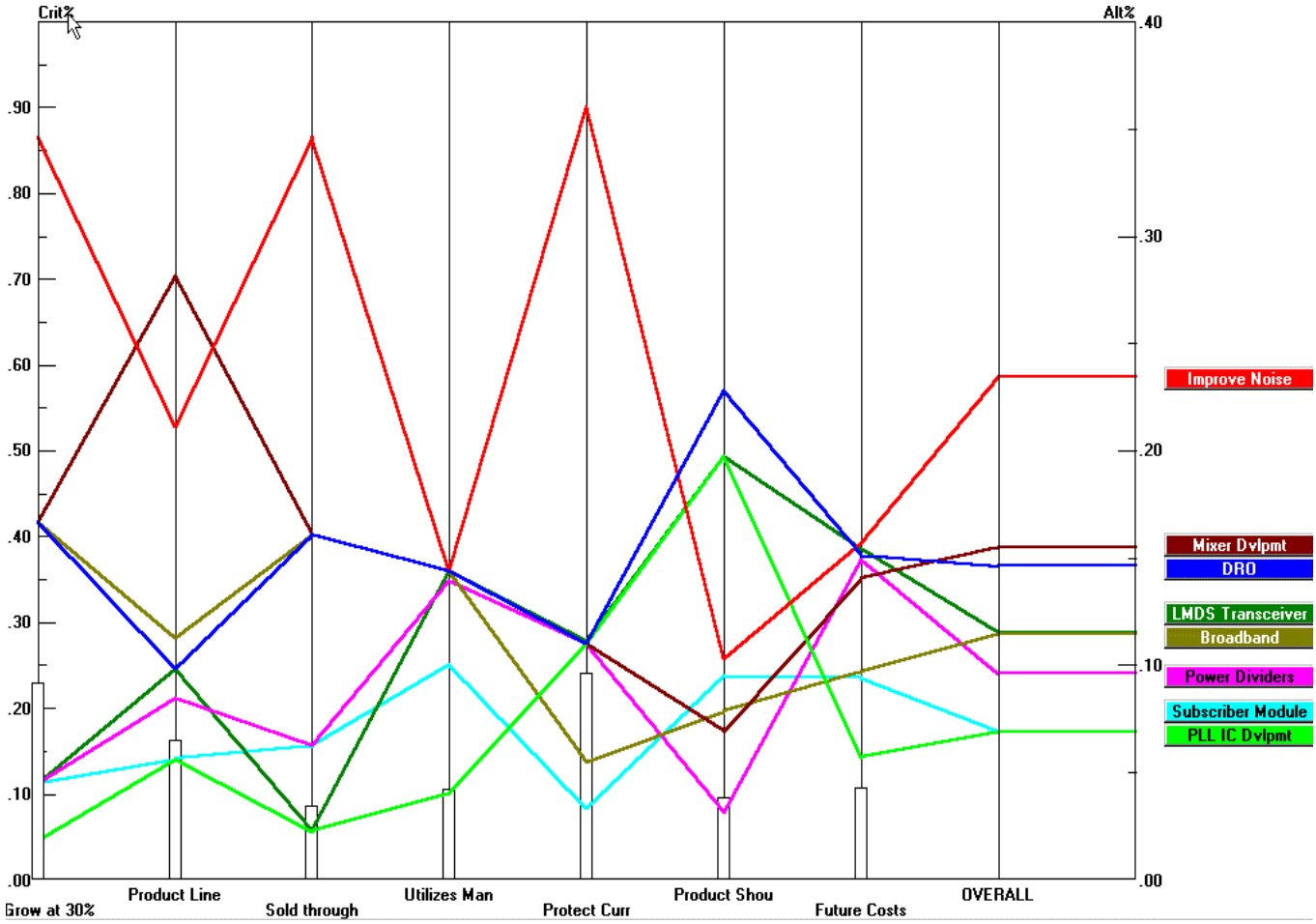
The alternatives were rated based upon the objectives. Figure 6 shows these evaluation levels. The objective of growing revenues 30% a year was evaluated in discrete steps based on an estimated probability. The estimated revenues resulting from the product was a linear scale from 0 to 50 based on millions of dollars estimated by marketing. The objective of selling the product through existing channels was evaluated in discrete steps based upon the amount of sales staff training needed to effectively sell the product in the field. Capital equipment needed to establish production was another evaluation criteria, since this spending tends to occur in discrete "chunks" the amount of capital spending needed to establish production was also estimated in discrete amounts between 0 and$6M. This data was furnished by manufacturing engineering. The number of manufacturing engineers also estimated by manufacturing engineering based on similarity to existing manufacturing processes. This is an increasing scale from 1 to 10. A key objective was protecting core business, there were several categories created for this objective. Protecting the core business was highest, followed by protecting a segment, but establishing a new line was more important than protecting a poor segment, " a dog". Performance and cost advantages are critical to success in the market. Two increasing scales were used to evaluate these, 0 to 100% was used for the cost scale and 0 to 10 dB was used for the performance scale. Decibels (dB) is a common comparative measurement used in the industry with 3 dB being twice as good and 10 dB being ten times as good. The last criteria the proposals were evaluated against was the cost to complete the next step, pilot production. This and the capital represent the total added cost to bring the product to production.

Figure 6 Evaluation Scales used to Evaluate R&D Proposals

Objective	Description of Evaluation Levels
Grow at 30% Compounded per Year	Guaranteed: > 98% Very Likely: 70 –98% Likelihood of high market demand Likely: 50 – 70% Unlikely: 20 – 50% Long shot: < 20 %
Estimated Revenues	$0 – $50 M based on Marketing's estimate of total discounted revenues over the next three yrs
Sold Through existing sales outlets	New Staff: Complete retraining required Some Retraining: 10 – 40 hours retraining Little Retraining: 5 –10 hours retraining Good To Go: No retraining
Capital Equipment required	0 to $1M $1M to $2.5M Engineering Estimate $2.5M to $4 M greater than $4M
Number of Manufacturing engineers	Manufacturing engineers are in short supply. This is the estimate of the number required to prove the concept.
Protects Current Product Lines	Protects Core Business Protects Segment Protects Dog No Customers
Estimate of Performance Advantage	0 to 10 dB scale of the performance advantage the product is likely to have in THE CRITICAL PARAMETER over existing offerings in the market
Cost Advantage	0 to 100 % scale of cost advantage over competitors in the marketplace.
Future Costs	The next stage is Pilot Production, this is the engineering estimate of the amount needed to accomplish

After the proposals were ranked a sensitivity analysis was performed and the results were examined. The sensitivity plot is shown in Figure 7. The noise improvement proposal was a clear choice in the benefit to the company based upon its high desirability by customers, the fact that this protected a core business segment and was sold through the existing sales organization. Other product developments such as DRO and Mixer development that extended the product line were the next choices.

Figure 7 Sensitivity Analysis of R&D Proposals



Results of Resource Allocation:

The resource allocation considers more than the sensitivity analysis and benefits to EM which are depicted in Figure 7. The resource allocation considers the benefit / cost ratio of each project and attempts to maximize the benefit at each funding level. Figure 8 shows the rankings of each alternative and the estimated costs associated with each proposal.

Figure 8 R&D Proposal Rankings and Estimated Costs

		RATINGS	INCR	RATINGS	STEP	STEP	RATINGS	INCR	INCR	DECR
Alternative	Costs	Grow at 30% per year Compounde	Product Estimated 3 year revenues ($M)	Sold through existing Sales	Utilizes Capital Equipment Required ($M)	Utilizes Manufacturi Engineering Needed (# people)	Protect Current Product Lines	Product Performanc Advantage in dB	Product Cost Advantage in %	Future Costs to bring to Production
DRO	228	Very Likely	14	Little	0.25	1	No Current	6	50	288
Improve Noise	234	Guarenteed	30	Good to Go	0.5	1	Protects	3	10	263
PLL IC Dvlpmt	396	Long Shot	8	New staff	3	4	No Current	6	10	732
Mixer Dvlpmt	593	Very Likely	40	Little	0.5	1	No Current	1	50	340
Broadband	303	Very Likely	16	Little	0.5	1	limited	2	20	545
Power Dividers	216	Unlikey	12	Some	0.25	2	No Current	1	0	297
LMDS	217	Unlikey	14	New staff	0.5	1	Protects	6	10	275
Subscriber	307	Unlikey	8	Some	0.5	4	Protects	3	0	558

These benefit of each proposal was synthesized from the rankings and benefit cost ratio was calculated. Figure 9 shows these ratios in the column labeled B/C. The red box is where the funding constraint has been entered. EM calculated that it desired to spend 33% of $5.4 million or $1.8 million in 2001. The constraint of 1800 has been entered to reflect this amount in thousands of dollars. The program has chosen the combination of proposals with the highest B/C ratios and kept the total spending below 1800. The gray box shows the total spending of $1,791,000 and the proposals highlighted in yellow are the projects selected for funding.

Figure 9 results of Resource Allocation

Alternative	*Benefits*	*Costs*	*DVS*	*F. Benefits*	*F. Costs*	*B/C*	*Musts*	*Musts Nots*
DRO	0.493	228	1	0.493	228.0	216.22807	0	1
Improve Noise	0.842	234	1	0.842	234.0	359.82906	0	1
PLL IC Dvlpmt	0.219	396	0	0.000	0.0	55.30303	0	1
Mixer Dvlpmt	0.532	593	1	0.532	593.0	89.71332	0	1
Broadband	0.401	303	1	0.401	303.0	132.34323	0	1
Power Dividers	0.333	216	1	0.333	216.0	154.16667	0	1
LMDS Transceiver	0.377	217	1	0.377	217.0	173.73272	0	1
Subscriber Module	0.231	307	0	0.000	0.0	75.24430	0	1
				2.978	1791.0			
					1800			

An alternate presentation of the data is shown in Figure 10. This shows the progression of project that would be funded as the funding profile increases from $0 to in excess of $2.5 million. The funded cost colum row shows the amount of funds needed to fund any projects labelled FUNDED in the columns. This allows the management to examine a continum of projects and funding levels.

Figure 10 Progression of Funded Projects vs. Funding Level

Alternatives/Budget	$216	$432	$648	$864	$1,080	$1,296	$1,512	$1,945	$2,161	$2,594
DRO			Funded	Funded	Funded	Funded	Funded	Funded	Funded	Funded
Improve Noise		Funded	Funded	Funded	Funded	Funded	Funded	Funded	Funded	Funded
PLL IC Dvlpmt										Funded
Mixer Dvlpmt								Funded	Funded	Funded
Broadband				Funded	Funded	Funded	Funded	Funded	Funded	Funded
Power Dividers	Funded					Funded	Funded	Funded	Funded	Funded
LMDS Transceiver					Funded	Funded	Funded	Funded	Funded	Funded
Subscriber Module							Funded		Funded	Funded
Cost, Funded	$216	$234	$462	$765	$982	$1,198	$1,505	$1,791	$2,098	$2,494
Benefit, Normalized	9.71	24.56	38.94	50.64	61.64	71.35	78.09	86.87	93.61	100.00
Benefit, Funded	0.33	0.84	1.34	1.74	2.11	2.45	2.68	2.98	3.21	3.43

The EM Company examined the results of this resource allocation and has decided to fund the projects selected in Figure 10 at the $1,505,000 level for 2001. This leaves a reserve of almost $300,000 for projects that may exceed budget or good ideas that arise during the next year and need exploratory funding. By being able to examine the complete spectrum of projects and funding with quantified benefits, it was easy to make a rational choice on the projects to fund and this was quickly done.

References:

Forman, Ernest H. *Decision by Objectives (How to convince others that you're right)*. Expert Choice 2000 . Pittsburgh Pennsylvania.