Sources of Information Used in New Product and Process Technology Planning within the Electron Device Industry

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Abstract—**A survey of participants in the electron device industry has been conducted to identify best practices in the sources of information used in new product and process technology planning. The frequency of use of each source of information is quantified for both tactical and strategic time frames. Further, statistically distinguishable clusters of most-frequently used sources of information are identified as a result of this work. Distinctions also are identified between those sources of information most typically used for tactical versus strategic technology planning cycles.**

I. Introduction

The speed and accuracy with which information can be gathered, interpreted, and turned into revenue-generating new products or cost-reducing new processes can mean the difference between the financial success and failure of a business. As such, at both the tactical and strategic levels, industrial technology forecasting [1] and roadmapping [2] require extensive and reliable sources of information.

While consumer product suppliers have relatively free access to customer information by probing demand directly, component and subsystem suppliers often are challenged in their pursuit of such information. This is because their customers typically are not entirely transparent regarding the details of their future needs, often due to concerns about divulging sensitive competitive information. As a result, component and subsystem suppliers typically probe multiple sources of information in order to construct a more complete picture of the future competitive environment.

In the current work, we identify the most frequently used sources of obtaining tactical and strategic information in the new product and process planning cycles in a component and subsystem industry. The electron device industry is studied as a particular example of such an industry. An extensive survey of industry participants is employed to quantify the frequency of use of these sources of information.

II. Experimental Method

The first step in the development of this study was to identify a pool of survey participants that represents an industry predominantly at the component and subsystem levels of the value chain. Membership in the IEEE Electron Devices Society (EDS) was chosen as the criteria for participation in this survey. This choice was made since EDS membership requires a modest financial investment by paying EDS dues. Because of this investment, EDS membership is not taken as lightly as, for example, requesting a free subscription to a trade magazine and, thus, is a not unreasonable indicator of interest in the electron device industry. Membership in the EDS is listed as 13,298 in the IEEE 2000 Annual Report. Further, the Annual Report identifies that the IEEE's overall membership is 59.2% from industry. Therefore, the EDS membership provides a sufficiently large pool for the purposes of this study.

The survey instrument was developed by conducting in-depth interviews with industry participants with diverse experience in the component and subsystem levels of the value chain. Six individuals were interviewed with collective experience spanning: multiple levels of the value chain (materials, components, subsystems); multiple sub-industries within these levels of the value chain, including both the electron device industry (semiconductor devices and non-semiconductor devices) and the optoelectronic device industry; multiple sizes of organization (ranging from start-up to $30 billion in annual revenues); multiple levels of management responsibility (ranging from practicing engineer to general manager); and multiple functional disciplines (product engineering, process engineering, manufacturing, research and development, sales and marketing).

These individuals were asked to identify sources of information used in planning new product and new process technology developments. They were asked to list these sources for each of the following time frames: less than one year to commercialization; one to two years to commercialization; two to three years to commercialization; and three to five years to commercialization.

Sixteen different sources of information were identified in this first phase and included in the full survey. These sources are listed here, as presented in the survey:

1. Specific orders placed by customers
2. Order trends for current products
3. Customer roadmaps and technology plans
4. Customer information obtained by your company's design and R&D engineers
5. Customer information obtained by your company's applications engineers
6. Customer information obtained by your company's sales and marketing force
7. Press releases issued by your customers

8. Information from your customer's customer or from the end user about how much they value the characteristics of your product
9. Information from your customer's customer or from the end user about what features they would prefer in your product
10. Competitor product benchmarking
11. Multi-source agreements (agreements with a small number of competitors to offer products with interoperability and interchangeability)
12. Industry standards and standards organizations
13. Industry market reports
14. Senior technical visionaries within your organization (senior engineers and scientists)
15. Senior non-technical visionaries within your organization (senior marketing and sales)
16. Technical conference presentations and technical journal publications

The survey instrument was constructed by asking participants to indicate the frequency of use (on a five-level scale ranging from "never" to "heavily") of each source of information for planning both tactical and strategic new product and process technology developments.

As an additional feature of this study, the survey instrument also included a set of questions asking participants to identify the frequency of participation by general management, sales and marketing management, and technical management in the decision-making process for both tactical and strategic new product and process technology developments. These questions were asked of the participants to gain insight into who most often used the sources of information identified in the main part of this investigation.

The tactical time frame was chosen to be less than one year to commercialization and the strategic time frame was chosen to be between three and five years to commercialization. These decisions were made based on the responses obtained from the in-depth interviews. We found a gradual variation of use of the sources of information as time to commercialization increased from less than one year to three to five years. The extreme time limits were chosen in order to obtain the greatest distinction between the tactical and strategic time frames. Note that none of the participants in the in-depth interviews indicated that a significant amount of new product or process development occurred in their organization with time to commercialization exceeding five years.

The instrument then was refined through feedback from three additional industry participants and three non-industry participants. These individuals were asked to review the survey for clarity and omissions. Only minor modifications were necessary based on this feedback.

A beta test of the survey instrument was conducted by sending requests via email to IEEE EDS members asking them to respond to the web-based survey. A total of 203 requests for survey participation were sent to potential participants. Approximately ten days after the initial request, a second, follow-up request was also sent. Emails to 46 potential participants were returned as undeliverable, so that 157 surveys were counted as delivered. A total of 19 survey responses were received. None of these respondents suggested additional sources of information. Thus, it was not necessary to modify this aspect of the survey. The beta test response rate of 12.1% (19/157) was believed to be acceptable considering that only a portion of those to whom surveys were sent would be involved in the technology planning process and, thus, have the corporate knowledge to be in a position to respond. Since some respondents indicated in the comments field that they were from government laboratories, we chose to include a demographic question in the full survey regarding the sector that the participant came from (government, industry, academic). This information was used to remove all non-industry participants from the full survey.

The full survey was conducted over a four-week period in early 2002. As with the beta test, requests for participation were sent via email to EDS members asking them to respond to the web-based survey. Again, a second, follow-up request was sent approximately ten days after the initial request. A total of 4,011 requests for survey participation were sent to potential participants (those for whom there was no obvious government or university affiliation). Emails to 1,003 potential participants were returned as undeliverable, so that 3,008 surveys were counted as delivered. A total of 419 responses were received. Of the 419 responses, 11 contained corrupted data and were eliminated as unusable. Further, 18 self-identified as being from the government sector and 28 self-identified as being from the academic sector; all 46 of these responses from non-industry participants were eliminated from the study. Finally, 3 responses were eliminated from the study since they contained statements in the comments field indicating that the respondent's organization was only involved in long-term research and development and, as such, they did not believe that they could appropriately respond to the full survey. After these corrections, the final sample size used for the analysis portion of this study was n = 359. As with the beta test, the overall response rate of 13.9% (419/3,008) is believed to be acceptable considering that only a portion of those to whom surveys were sent would be involved in the technology planning process and, thus, have the corporate knowledge to be in a position to respond.

III. Survey Analysis and Results

Since we seek to identify the most frequently used sources of information in this study, we focus our attention on responses where the survey respondent identifies a source of information as being used either "often" or "heavily", the two highest levels of information usage.

In order to statistically interpret the survey results, we define an outcome A such that A = {the set of events where a source of information is used by a survey respondent either "often" or "heavily"} and the probability of A occurring by p. We can model the number of occurrences of A as a binomial random variable and can calculate confidence intervals for p by using the following equation [3],

$$\text{Probability}\left[p \in \hat{p} \pm Z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \right] = 1-\alpha$$

where $\hat{p}$ is the point estimate for p (in this case the observed frequency of A occurring), n is the sample size (n = 359), and 1-α represents the probability range of the confidence interval, denoted by $\hat{p} \pm Z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$. Note that this is an approximation, which holds when np > 5 and n(1-p) > 5. Both criteria are met in all instances discussed here.

The frequency of use of each source of information, based on these definitions, is quantified for both tactical and strategic time frames to commercialization and exhibited in Table I. Also exhibited in Table I are the frequencies of participation of each of the three functional management types in the decision-making process. Values of $Z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$ corresponding to α = 5% (i.e. a 95% confidence interval) are also shown in Table I (identified as "95% CI").

Sorting the data of Table I by tactical and strategic time frame frequency of use, we can identify the most-frequently used (50% or greater frequency) sources of information for tactical and strategic technology planning, shown in Table II.

Further, distinctions can be made between those sources of information most typically used for tactical versus strategic new product and process technology planning cycles. By taking the difference in frequency of response for each information source and making appropriate modifications to the confidence interval calculation [3], we can identify those sources used primarily for either short-term or long-term planning horizons. This data is shown in Table III.

Table I

	Sources of information	**Tactical time frame**		**Strategic time frame**	
		Frequency	95% CI	Frequency	95% CI
1.	Customer orders	69.4%	4.8%	20.3%	4.2%
2.	Order trends	59.9%	5.1%	30.9%	4.8%
3.	Customer roadmaps	54.9%	5.1%	61.3%	5.0%
4.	Customer information from engineers	51.8%	5.2%	50.7%	5.2%
5.	Customer information from applications engineers	57.9%	5.1%	40.7%	5.1%
6.	Customer information from sales and marketing	66.0%	4.9%	43.5%	5.1%
7.	Customer press releases	17.5%	3.9%	11.1%	3.3%
8.	Customer's customer info - value characteristics	35.9%	5.0%	27.9%	4.6%
9.	Customer's customer info - features	39.8%	5.1%	40.1%	5.1%
10.	Benchmarking competitors	59.3%	5.1%	46.2%	5.2%
11.	Multi-source agreements	19.8%	4.1%	15.6%	3.8%
12.	Industry standards	41.5%	5.1%	42.3%	5.1%
13.	Market reports	29.8%	4.7%	32.0%	4.8%
14.	Technical visionaries	43.7%	5.1%	65.7%	4.9%
15.	Non-technical visionaries	36.8%	5.0%	35.4%	4.9%
16.	Technical conferences and journals	27.9%	4.6%	44.8%	5.1%
	Participation in the decision-making process				
	General management	61.8%	5.0%	60.2%	5.1%
	Sales and marketing management	69.4%	4.8%	53.5%	5.2%
	Technical management	78.6%	4.2%	81.3%	4.0%

Table II

	Sources of information for tactical time frame planning	Tactical time frame frequency
1.	Customer orders	69.4%
6.	Customer information from sales and marketing	66.0%
2.	Order trends	59.9%
10.	Benchmarking competitors	59.3%
5.	Customer information from applications engineers	57.9%
3.	Customer roadmaps	54.9%
4.	Customer information from engineers	51.8%
	Sources of information for strategic time frame planning	**Strategic time frame frequency**
14.	Technical visionaries	65.7%
3.	Customer roadmaps	61.3%
4.	Customer information from engineers	50.7%

Table III

	Sources of information	Tactical time frame frequency minus Strategic time frame frequency	
	Primarily used for tactical time frame planning	*Frequency difference*	*95% CI*
1.	Customer orders	49.0%	6.3%
2.	Order trends	29.0%	7.0%
6.	Customer information from sales and marketing	22.6%	7.1%
5.	Customer information from applications engineers	17.3%	7.2%
10.	Benchmarking competitors	13.1%	7.2%
8.	Customer's customer info - value characteristics	8.1%	6.8%
7.	Customer press releases	6.4%	5.1%
	Primarily used for strategic time frame planning	*Frequency difference*	*95% CI*
16.	Technical conferences and journals	-17.0%	6.9%
14.	Technical visionaries	-22.0%	7.1%

In order to facilitate visualization of these results, we plot this data in Figs. 1 and 2.

Fig. 1 exhibits the results of the sources of information survey, with the tactical time frame frequency of use data plotted along the horizontal axis and the strategic time frame frequency of use data plotted along the vertical axis. 95% confidence intervals are also shown for both the tactical and strategic time frames.

Fig. 1 also graphically exhibits the data of Table II with the cluster of responses labeled A being those sources of information that are primarily used for tactical time frame planning and the cluster of responses labeled B being those sources of information that are primarily used for strategic time frame planning. The clusters of response labeled C and D represent less frequently used sources of information that are statistically distinguishable.

The data of Table III also can be identified in Fig. 1 in that those sources of information primarily used for tactical time frame planning are found in the lower right hand corner of the plot, while those primarily used for strategic time frame planning are found in the upper left hand corner of the plot.

Fig. 2 exhibits the results of the frequency of participation in the decision-making process survey, with the tactical time frame frequency of use data plotted along the horizontal axis and the strategic time frame frequency of use data plotted along the vertical axis. 95% confidence intervals are also shown for both the tactical and strategic time frames. Data point A of Fig. 2 represents decision-making participation by technical management, with data points B and C representing decision-making participation by sales and marketing, and general management, respectively.

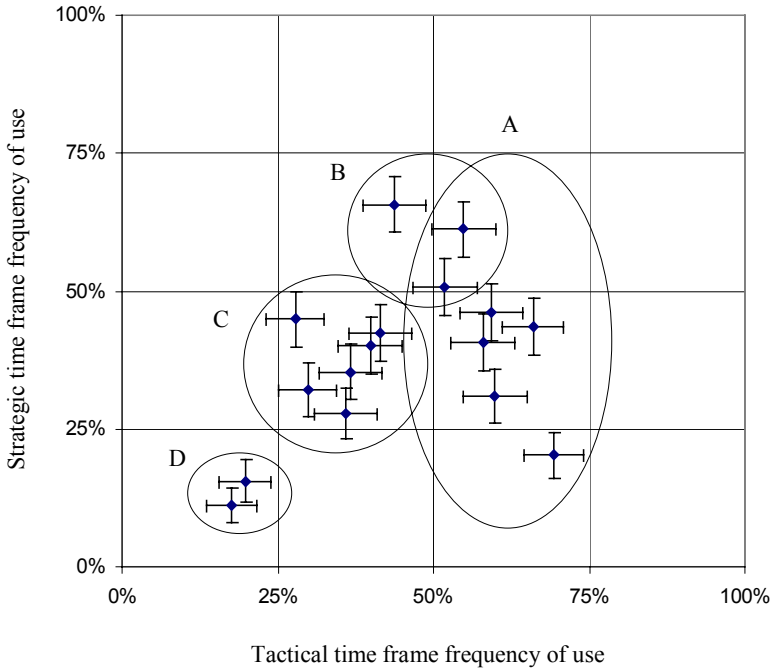

Fig. 1 Frequency of use of the various sources of information used in new product and process technology planning within the electron device industry, mapped by tactical and strategic time frame

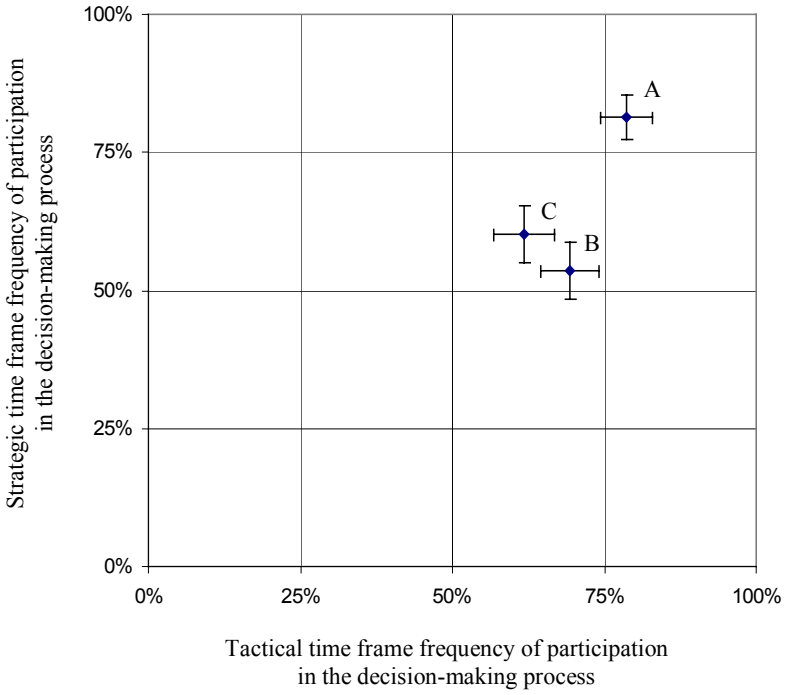

Fig. 2 Frequency of participation in new product and process technology planning within the electron device industry by technical management (A), sales and marketing management (B) and general management (C), mapped by tactical and strategic time frame

IV. Observations and Conclusions

This work documents both the identity of best practices and the frequency of use of these practices as sources of information in new product and process technology planning within the electron device industry.

The most striking result of this study is that direct customer input overwhelmingly dominates the technology planning culture within the electron device industry. All but one of the most-frequently used sources in the tactical time frame and all but one of the most-frequently used sources in the strategic time frame (see Table II) rely directly on customer information. Further, this sentiment was summarized well by one of the full survey participants in the comments field with the statement, "customers rule marketing, marketing rules us."

While customer focus has been the conventional wisdom in the business community for some time, there has been dissent, most notably from Clayton Christensen in *The Innovator's Dilemma* [4] where he identifies the strategic pitfalls of such a mindset. In particular, Christensen notes that many companies fail by following demand presented by current customers at the expense of seeking to develop new, innovative products for new customers and new needs. Thus, it appears that the electron device industry could easily be the target of disruption of the type that Christensen has identified [5].

A second interesting result of this work is that even the most frequently used sources of information are employed "often" or "heavily" no more than 70% of the time, what appears to be relatively low usage. This seems to indicate that there is room for improvement industry-wide by increasing the use of such sources of information in the technology planning process.

Third, a decoupling of contact from the firm's customer's customer (or end user) is evident from this study. Only two of the sixteen sources of information identified during the in-depth interviews with industry participants indicated contact with the firm's customer's customer. Further, industry participants reported in the full survey that these two sources were used only moderately (in cluster C in Fig. 1). Such a lack of information from higher levels of the value chain can be expected to cause significant strategic problems for component and subsystem level suppliers.

Fourth, the results of the survey on participation in the decision-making process are interesting in that the participants in the full survey (all members of a technical society and, thus, most likely technologists) feel that technical management not only participates more frequently in strategic technology planning decision-making, but also more frequently in tactical technology planning decision-making. Considering the conclusion that customer focus drives decision-making, this result at first appears somewhat contradictory. However, it may indicate that technical management is in more intimate and meaningful contact with the customer pool than even perhaps sales and marketing management.

Finally, the results of this study suggest a number of options for further investigation, including improving less frequently used information sources to make them more valuable, gaining a better understanding of the effective use of the most frequently used information sources, and investigating the extent that these results hold in other component and subsystem level industries.

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