Current Issues in Technology Management

FALL 2005 ISSUE 4, VOLUME 9

SATM

STEVENS ALLIANCE FOR TECHNOLOGY MANAGEMENT

Technology Clusters and Innovation

Dr. M. Hosein Fallah

DIRECTOR'S NOTE

Technology clusters – geographical concentrations of related technology firms, including competitors, suppliers, distributors, and customers – are becoming more and prevalent around the globe. One of the important benefits of clustering is an enhanced rate of innovation. In our featured article, Hosein Fallah, Associate Professor in the Howe School at Stevens Institute of Technology, provides an understanding of the factors that drive increased innovation from technological clusters. This understanding can provide a source of competitive advantage for corporations, as well as having important implications for regional development policies.

Larry Gastwirt

STEVENS Institute of Technology

Introduction

Although technology clusters are not a new phenomenon, there is a surge of interest in clustering and strategies for cluster development by regional planners and economic development authorities. What is driving this renewed interest? Globalization of the value chain functions has opened up the opportunity for many developing regions to focus on technology clusters as a means of creating competitive advantage to attract and maintain high-tech corporations and increase economic development and growth of their regions. Bangalore is a shining example of a new and highly successful technological cluster attracting many high-tech corporations to the area. A global survey in 2003 identified more than 500 cluster initiatives around the world. Competing firms often cluster in the same geographic area, to have access to the opportunities and resources present in that area. Geographical proximity also facilitates interactions among researchers and engineers and is conducive to more innovations. There is evidence that knowledge spillovers in technology clusters contribute to an increased rate of innovation leading to creation and growth of new businesses. Companies moving to new clusters contribute to and benefit from these spillovers. Consequently, understanding the factors that drive the increased innovation is of great interest to R&D managers and could be a source of competitive advantage for corporations.

What is a Technological Cluster?

A technological cluster is a geographical concentration of related technology firms including competitors, suppliers, distributors, and customers; usually around scientific research centers and universities. For instance, in Europe, watchmakers clustered in Switzerland and fashion designers in Paris. In the United States, well known clusters include Detroit for the automotive industry, Hollywood for motion pictures, New York City for financial services and advertising, and Silicon Valley for electronics. Silicon Valley is a commonly used nickname for the southern part of the San Francisco Bay Area in northern California, originally referring to the concentration of silicon chip innovators and manufacturers, but eventually

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becoming a metaphor for the entire concentration of high-tech businesses. Thousands of high technology companies are headquartered in Silicon Valley. Among the recently constituted clusters is Bangalore, called the Silicon Valley of India due to the large concentration of technology companies.

A functioning technological cluster is composed of a number of players that work in concert to create a highly innovative and productive environment for the growth of the existing and creation of new businesses in the cluster. Figure 1 depicts the key players and structure of an effective cluster. The literature dealing with innovation in technology clusters has been studied under a variety of topics such as 'geographical clusters', 'industrial districts', 'industrial parks', 'innovation zones', 'learning regions', and 'innovation milieus'.

From a technology point of view, a cluster may be viewed as a multiple, overlapping ongoing and lagged technology initiatives. For example, Silicon Valley has seen a cluster of technology evolution across semiconductors, computing, software and information technology, and entertainment media projects, products and services. Within a technological cluster technology projects will emerge and diffuse over time following a life-cycle with four stages (Pouder and St. John 1996):

1. ***Origination*** – creating new products and services
2. ***Expansion*** – growing products and services
3. ***Convergence*** –maturing products and services
4. ***Reorientation***– shifting to other technologies; or decline if reorientation does not occur.

A growing cluster signals an opportunity and its success helps to attract rivals and other related businesses and create an inflow of talented workforce to the area. The evolution of a cluster is significantly affected by local, regional or national policies which could facilitate or hamper effective functioning of the cluster.

Why focus on Clusters?

Globalization has created fierce competition among regional economies. In the healthy regions, competitiveness and economic growth is driven by strategies that are focused on promoting innovation, often in clusters of inter-related industries. In recent years hundreds of cluster initiatives have been launched in various regions of the world. In a global survey in 2003, more than 500 cluster initiatives were identified. About half of the initiatives are driven by local or national governmental organizations (Solvell, et.al. 2003). In the US, the Council on Competitiveness created the "Clusters of Innovation" Initiative, in conjunction with the Institute for Strategy and Competitiveness at the Harvard Business School, led by Michael Porter, to support cluster analysis and track economic and innovation performance of US clusters over time. The Institute conducted an assessment of New Jersey's life sciences cluster in 2003 and made recommendations on ways to enhance its growth (Porter, 2003).

Many states have adopted cluster strategies to support specific technologies and to improve their economic development. For instance, the Texas legislature has passed a law which requires the state's economic development agency to identify and promote regional and statewide industry clusters. Other states with similar approaches include Kentucky, Louisiana, Maine, Oregon, Pennsylvania, Rhode Island, and Washington. In addition, some states have adopted cluster approaches by executive orders or strategic plans. For instance, Massachusetts had a plan, "Towards a New Prosperity: Building Regional Competitiveness", which includes cluster strategies (Krishna, 2002). In the UK, promoting cluster development has become a main component of the government's competitiveness policies and an essential part of the regional development policy (DETR 2000). Mobilizing the potential clusters in the EU is seen as critical to achieve the ambitious goal of the

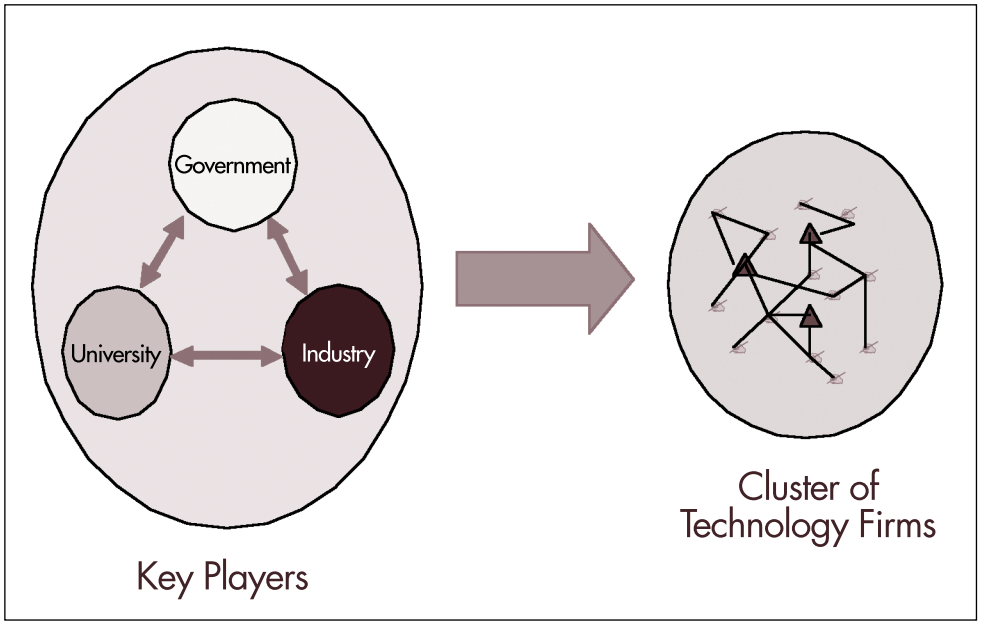

Figure 1. Technological Cluster

Lisbon Agenda to make Europe a competitive and dynamic knowledge based economy (European Council 2000).

The increased interest in cluster development is driven by a desire on the part of regional development authorities for economic growth. There are generally three advantages for a company to locate in a cluster. The first advantage is the presence of a large labor pool due to the geographical concentration of firms in the same industry or in closely related ones. The second advantage is the availability of related materials and other inputs at lower costs. These inputs include tangibles, like raw material and supplies, and intangibles like consultations and collaboration. The third advantage is the intensity of knowledge exchange that can lead to knowledge spillovers between nearby firms and institutions in the cluster. While the first two advantages of clustering have an indirect effect on the innovation output of a cluster, the third one has a direct effect on the innovation process of people and firms located in a cluster. Clustering can bring a wide range of other benefits to both businesses involved and the wider economy of the region (UK DTI, 2002). These benefits include:

- *Increased levels of expertise*. Due to close interactions, clusters provide companies with an opportunity for inter-firm learning and greater depth of understanding of their supply chain.
- *Ability of firms to draw together complementary skills.* Companies in a cluster can pull together complimentary resources to tackle more complex projects that as individual units they would be unable to do.
- *Potential for economies of scale.* Companies in a cluster can pull together demand for various raw materials to benefit from economies of scale in purchasing such material and to attract bulk discounts.
- *Strengthening social and other informal links.* Interactions in a cluster strengthen professional, social and informal linkages among the entities and the individuals leading to the creation of new ideas, new products and services and new businesses.
- *Improved information flow within a cluster.* Opportunities for face-to-face interactions and other communications mechanisms within clusters improve information flow helping innovators to have access to latest technology and market information, rapidly and efficiently. For example, venture capitalist can more easily screen and judge the good entrepreneurs, and in general, businesses can identify who provides good support services.
- *Development of the infrastructure.* Technology clusters enable development of physical infrastructure, e.g. communications and transportation facilities, as well as support services such as professional, legal and financial.

A functioning technological cluster is composed of a number of players that work in concert to create a highly innovative and productive environment for the growth of the existing and creation of new businesses in the cluster.

What Makes a Successful Cluster?

Although clusters are different in many aspects, successful clusters share a number of common features. According to a recent study by the UK Department of Trade and Industry (UK DTI, 2002), these common features are divided into three groups as follows:

Critical Success Factors:

- Presence of functioning networks and partnerships. Strong professional, social and informal networks are fundamental to the effectiveness of a cluster. Such networks may naturally develop within a cluster or be facilitated and promoted by intermediaries such as local associations, technology clubs or governmental agencies.
- A strong innovation base, with supporting R&D activities. Universities and research institutions are often the hubs for new ideas and basic research in the growing clusters. For example, Stanford continues to be a critical innovation base for Silicon Valley.
- Existence of a strong skills base. A highly skilled and mobile workforce ensures flow of information and development of new ideas.

Contributing Success Factors:

- An adequate physical infrastructure. Physical infrastructure plays a significant role in attracting companies to a cluster as well as facilitating interactions among the companies. The authorities in India recognized the importance of the infrastructure. Without adequate infrastructure, many multinationals with operations in Bangalore would have been reluctant or unable to set up operations there.
- Presence of large firms. Large firms act as anchors creating a viable economic base for the cluster to evolve.
- A strong entrepreneurial culture. Clusters grow with the creation of new businesses. A culture of entrepreneurship and risk taking encourages start ups and investment in R&D.
- Access to sources of finance. New technology start ups often can not survive without external sources of funding. Presence and willingness of VC's to invest in new start ups in a cluster is essential to the market success of new ideas and new entrepreneurs.

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Government policies often play a significant role in facilitating and providing financial support to new start ups in such clusters.

Complementary Success Factors:

Other factors such as presence of support services and general economic conditions could also affect the functioning of a cluster.

Clusters' Innovation Output

There is general agreement among researchers that technology clusters have higher innovation output. Much of the recent studies have been focused on identifying what contributes to this higher rate of innovation. Many researchers have attributed the increased innovation output of clusters to knowledge spillovers within the clusters. Some studies have used patent counts as a measure of the innovation output illustrating that companies within clusters generally produce more patents from their R&D investments than those outside the clusters. Jaffe (1989) used a "knowledge production function" to demonstrate that clustering does affect innovation. He showed that the total relevant activities of other firms influencing innovation of a particular firm can be represented by a "potential spillover pool" which is the weighted sum of the other firms' R&D investments, with weights proportional to the proximity of the firms to the one under consideration. He also used this model to measure spillovers between neighboring firms and universities using States as units for clusters (1989). Furman and Porter (2002) studied clusters' innovative performance and related the number of patents generated by a cluster to the R&D expenditures of the firms and universities in those clusters. Other researchers have studies innovative activities of clusters from their socio-cultural perspective. For instance Saxenian (1994) studied and compared the effect of cultural differences on Silicon Valley and Route 128 in Boston. From these studies one thing is clear; there is significant spillover of knowledge in technological clusters.

A growing cluster signals an opportunity and its success helps to attract rivals and other related businesses and create an inflow of talented workforce to the area.

Factors Influencing Innovation in Technological Clusters

While clustering of firms can lead to increased innovation, little is known as to the specific factors that drive the increased innovation output of technological clusters. This is an area of our current research. In a recent survey of inventors in the telecom industry, we found the following factors to have significant influence on the inventors in clusters for coming up with their inventions as compared to those not in clusters (Ibrahim and Fallah, 2005):

- Interacting with subject matter experts in the local area.
- Personal relationships developed with other researchers in the local area.
- Having interactions with customers, suppliers, competitors who are present in the local area.
- Brainstorming sessions with people in the local area.
- Informal meeting with people in the local area.
- Observing products or prototypes that are developed in the local area.
- Knowledge gained from tracking state of the art innovations in the local area.
- Knowledge sharing sessions with people in the local area.
- Being presented with a problem or need locally.
- The working environment of the local area.

These factors point to the importance of access to tacit knowledge for innovation which can be gained in face-to-face interactions and the fact that opportunities for such interactions are much more for those in a technological cluster than those in isolated areas. The working environment of the clusters was rated as having the greatest influence on innovation, which points to some of the intangible attributes and motivators of creativity that exist by simply being in a vibrant and active geographical area. Corporate executives and managers can promote creativity and innovation in their organizations by focusing on the practices that mostly influence the inventors.

Factors that did not seem to matter whether or not the inventors were in clusters include:

- Accessing publications or papers from local authors.
- Attending presentations or lectures in the local area.
- Formal meetings with people in the local area.
- Conferences, seminars and/or workshops in the local area.
- Social gatherings in the local area.

These factors indicate that people can access explicit knowledge such as publications virtually from anywhere. One does not have to be in a cluster to access publications, or attend seminars or conferences. Furthermore, while informal knowledge sharing plays a significant role, social gatherings by themselves don't seem to contribute much to innovation.

Implications for Regional Policies

The globalization of the value chain has created intense competition among the multinationals, forcing them to look for opportunities anywhere in the world where they can achieve or sustain a competitive advantage. Outsourcing and

off-shoring, while driven by the need to access cheaper resources, are moving up the value chain to contract R&D. This has opened up the opportunity for many developing countries to focus on cluster development as a means to advance their technological capabilities and grow their economies. Observing the success of India with Bangalore, China is developing a number of industrial parks. The regional competition puts many existing clusters at risk of decline if policy makers and regional planners do not take the steps to improve the effective functioning of these clusters or create mechanisms for re-orientation of the clusters. Two recent cases illustrate this point. Last year Californians approved a $3Billion dollar bond issue to invest in private stem-cell research. This initiative is likely to reorient much of Silicon Valley toward bio-tech innovation. The scale of investment is also likely to attract the best researchers to California. This reorientation will backfill the recent losses of high-tech jobs and creates new opportunities in Silicon Valley. Another example is the contrast between Texas and New Jersey. Texas has aggressively pursued cluster strategies for six technologies, one of which is information and communications. New Jersey, on the other hand, has no strategy to maintain and grow its telecom cluster. As a result, Texas has continued to grow its telecom sector even in a period of industry downturn, while New Jersey's telecom sector continues to decline. As shown in Table 1, Texas more than doubled its telecom patent output per year between 1996 and 2004, moving from 5th place to 2nd place after California, in the top ten ranking of the states. In the same period, New Jersey dropped from 2nd position to 4th position. New Jersey still has a significant base of telecom innovation. But, in the absence of a strategy to reinvigorate this cluster, its capabilities will continue to erode. ■

Table 1. Ranking of the Top 10 States by Telecommunication Patents

RANK	NUMBER OF TELECOM PATENTS			
	State	**Year 1996**	**State**	**Year 2004**
1	California	1489	California	3785
2	New Jersey	628	Texas	1124
3	Illinois	574	New York	976
4	New York	574	New Jersey	949
5	Texas	517	Illinois	744
6	Florida	402	Massachusetts	658
7	Massachusetts	322	Florida	534
8	Maryland	212	North Carolina	441
9	Arizona	202	Maryland	318
10	North Carolina	190	Arizona	278

Source of Data: USPTO

...regional competition puts many existing clusters at risk of decline if policy makers and regional planners do not take the steps to improve the effective functioning of these clusters or create mechanisms for re-orientation of the clusters.

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Dr. Hosein Fallah is an Associate Professor at Stevens Institute of Technology. His research interest is in the area of management of innovation with a focus on telecommunications industry. Prior to joining Stevens, Dr. Fallah was Director of Network Planning and Systems Engineering at Bell Laboratories.

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Roundtable Meeting Take-Aways

TURNING INNOVATION INTO A POWERFUL BUSINESS STRATEGY:

Overcoming the Obstacles to Innovation

The July 12 Roundtable meeting, held at the Infineum Business and Technical Center in Linden, NJ, focused on methods and practices for surmounting the numerous barriers to innovation. Facilitators were Larry Gastwirt of Stevens and Ron Eilertson of Teknor Apex. This was the third in a series of Roundtables aimed at unlayering the broad subject of innovation. The topic, and the facilitators, evoked a most vigorous results-oriented discussion. As a result of the interest, the assembly decided to continue discussion of this important topic at the September 20th Roundtable meeting.

Larry drew from the learnings of past Roundtables and Conferences to lead a discussion of overcoming innovation barriers. Employing the definition of innovation as the creation of value through the implementation of new ideas, which previous discussions regarded as the best to use, he noted that different obstacles arise throughout the various stages of the innovation process. He also pointed out that barriers differ in impact depending on the risk associated with the specific innovation. For everything summarized below, Larry pointed out that Leadership's role is to ensure that all functions of the entity encourage innovative behavior in all employees. Indeed, most of the means discussed for overcoming barriers to innovation fell under the responsibilities of Leadership.

Larry used six stages of the innovation process to describe the principal barriers and means for overcoming them. (He pointed out that, per Tony LeStorti's presentation at the last Roundtable meeting, one could add an up-front stage 0 to reflect a Preparation stage, during which leadership establishes and communicates the strategic intent of the business and the broad criteria for success -- the "wallpaper" surrounding innovators that sets the boundaries for innovation).

The following is a brief overview of the key means to overcome the impediments to innovation, by stage -- his PowerPoint presentation, available from the SATM office, provides more details. Included in this presentation is a summary of the findings of the SATM study on innovation.

1. ***Generation and enrichment of ideas***
   a. Adopt and effectively communicate a clear innovation strategy.
   b. Instill innovation norms within the organization.
   c. Apply practices associated with highly innovative organizations as reflected in the SATM Innovation Model studies -- specifically, the practices associated with strategic drivers, leadership, and support systems for idea generation.
   d. Use "Idea Mining" techniques, referring to Steve Wiet's presentation at the 2005 Alliance Conference. (It was suggested that this may be a good Roundtable topic for a future meeting).

2. ***Collection and preliminary assessment of ideas***
   a. Install or renovate formal idea collection process – and use it!
   b. Maintain market knowledge function.
   c. Apply practices to enhance "collaborative" behavioral dimension (from SATM Innovation Model results).

3. ***Identification and prioritization of specific opportunities***
   a. Commit the necessary resources (correlated with study outcomes of Koen/IRI).
   b. Develop specific screening criteria and apply portfolio management to

shelve poorer projects -- especially for the lower risk activities.

4. ***Refinement and development of specific opportunities***
   a. Commit dedicated resources.
   b. Remove resources from poorer projects earlier.
   c. Conduct comprehensive market and technology analyses.
   d. Define detailed business cases, reflecting risk appropriately (as described by Peter Koen, Stevens, in chart from SATM 2005 conference).

5. ***Prototype testing and refinement***
   a. Employ quick trials, refinements and reiterations (per Lynn and Reilly).
   b. Research to understand potential markets and identify lead customers.

6. ***Market introduction / implementation***
   a. Carry out quality processes to perform the up-front activities.
   b. Maintain competitive intelligence function.
   c. Create deeper consumer knowledge (a la Wiet).

The last portion of Larry's presentation was a summary of other organizational practices that overcome barriers to innovation. He reviewed the five principles for overcoming barriers to "blockbuster" innovations, from the Lynn and Reilly research -- assure intimate involvement of senior management, have clear, specific and stable goals, employ "lickety-split" improvisation, assure effective information exchange, and promote collaboration focusing on goals. His PowerPoint presentation includes the remaining organization practices of the SATM study, under the categories employee selection, employee development, reward and recognition systems, and multi-functional team structures.

Interesting comments, as part of the discussion of the above, were:

- Innovation barriers are for both what and how to do it. Although we discussed mostly the what to do, it was pointed that the tools must be provided to get the jobs done
- Culture is the biggest barrier to innovation, demanding a review and improvement of the behavioral norms associated with successful innovative organizations (see SATM Model)
- Innovation is a means to achieve business goals, not an end. The business defines the need and innovation is the means for achieving that end.
- The "formula" for innovation is a merger of business strategy (the direction of the organization) and the investment of resources (hard and soft) in innovation. Only innovation that is part of the business is a strategy. It is the combination of solid business practices, imagination and a culture that motivates innovation. A recent article in Business Week magazine supports this latter comment.
- In formal strategy development, the Opportunities and Threats of a SWOT analysis define the business and the Strengths and Weaknesses help define the needed innovation culture.

The second facilitator was Ron Eilertson of Teknor Apex. Teknor Apex had strategically decided five years ago that innovation -- getting more ideas and getting new and better products into their marketplace -- was of paramount importance to their continued success. They decided to use the SATM Innovation model and associated survey to identify focus areas for their efforts. One of Teknor Apex's business units, Vinyl Products, joined the technical group in participating in the survey in 2000.

The Innovation Survey looked at the four behavioral dimension categories as well as the seven management practice areas to compare themselves to best of breed companies from the Alliance database. Participants were also asked their opinions of the most important factors they believed could have the most dramatic effect on the outcome. Results of their analysis are presented in Ron's PowerPoint presentation, available from the SATM office.
One of their findings was that the technology function believes that they are more innovative than the business considers them. Using the gaps uncovered from the overall survey results, Teknor Apex established a focus team to prioritize improvement activities. Many of the team's recommendations to improve management practices have been, or are being, implemented. In the past five years, they have made progress in about half of the key areas identified, including leadership training and innovation reward and recognition programs. Some of their specific changes are summarized in Ron's presentation.

The top five obstacles limiting innovation at Teknor Apex today are:

1. Not enough good ideas
2. We do not for the most part have a focused market approach for new product development
3. Our CTC (Stage-Gate) process is too complicated
4. We have too many projects for the available resources
5. There are few business goals for new product development

...leadership's role is to ensure that all functions of the entity encourage innovative behavior in all employees. Indeed, most of the means discussed for overcoming barriers to innovation fell under the responsibilities of Leadership.

Teknor Apex has developed a detailed plan for the future to address their shortfalls. Among these is a transfer of responsibility for their new product development process to the business units, from the technical group. They have identified the need to have metrics for individual businesses and to better tie Marketing to the innovation process. They are attempting to do a better job of resource allocation so more effort can be placed on the highest priority projects. Both from the survey and their opinions, there still are too few good ideas getting into the pipeline. Teknor Apex believes they are good at implementation but not so good at the front-end. As a result, much more effort will be placed on the early stages of the innovation process. ■

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UPCOMING EVENTS

SEMINAR

Responsive Organizational Dynamism –
Managing Technology Life Cycles using Organizational Learning Techniques

November 2

The fifth seminar in the Technology Management Seminar Series, sponsored by SATM in collaboration with the Columbia University School of Engineering, will be presented by Dr. Arthur Langer, Columbia University School of Continuing Education, speaking on **Responsive Organizational Dynamism**. This is an approach to how organizations can respond to challenges posed by the introduction of new technologies.

Dr. Langer introduced this concept to readers of our Spring 2005 issue. He postulates that technology– which by its nature produces change – has a special role to play in changing organizational behavior and culture. Dr. Langer will focus on this role and on the role of information technology functions within organizations. He will address such issues as: What are the generic aspects of information technology that have made it an integral part of strategic advantage for many organizations? How do organizations respond to these generic aspects as catalysts for change? How should organizations and individuals adjust to technology's short-term and long-term impacts?

The Seminar will take place on Wednesday, November 2 at the Columbia University campus (Schapiro Center). Light refreshments will be served at 6:30, and the Seminar will begin at 7:00 PM.

Combined Roundtable and SATM Advisory Board Meeting

November 17

The 2005 SATM Advisory Board meeting will take place at 1 PM on Thursday, November 17, followed by the November Roundtable meeting from 2:00-5:00 PM. As is our custom at the final Roundtable meeting of the year, Howe School faculty members will present selected research findings and discuss their business implications.

The meeting will take place on the Stevens Campus, Howe Center Skyline Room. All attendees are encouraged to attend the entire meeting and to partake in a buffet luncheon from 12:00-1:00 PM.

For further information on these and other Alliance activities, contact Dr. Lawrence Gastwirt: **212-794-3637 • lgastwirt@aol.com**

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