A Call to Action—A National Technology Roadmap for Telecommunications

David Smith

Mr. David Smith is the Chief Operating Officer of Strategic Pathways International (SPI), an integrated professional service group dedicated to assuring that its clients achieve exceptional success in today's information-driven operating environment. Before co-founding SPI, he was the Technology Transfer Manager at SEMATECH, a high tech R&D consortium in the semiconductor industry. Mr. Smith helped produce and author a 15-year technology roadmap for the semiconductor industry—the SIA Technology Road Map Workshop—which has been cited by the Clinton Administration as the model for other industries to follow. He served on the SIA Technology Roadmap Steering, Coordination, and Implementation committees and produced the final document. Mr. Smith received his B.S. in Radio, Television, and Film from the University of Texas at Austin and is a recipient of the SEMATECH Eagle Award for the 1993 Strategic Plan.

There are many business issues, not unique to the telecommunications industry, that are striking at most institutions today:

- Increased competition.
- Converging technology.
- Increased options.
- Ever increasing cost of the "means" of doing business.
- Marketplace confusion.

Few industries have done as well as the semiconductor industry in responding to these challenges. Not only did they meet the challenge by working together to improve processes and supplier relationships through the Semiconductor Industry Association (SIA), they also produced a "National Technology Roadmap" for the industry. This roadmap brought together producers, suppliers, academia, customers, and the government—all to create a common vision for future semiconductor technology.

The players which make up the telecommunications industry must heed a similar call. As this nation and the world enter a new millennium, businesses and individuals are learning a new language—one made up of ones and zeros and bits and bytes. It is a time when 75% of Americans want open competition in all communications markets, according to one recent national public opinion survey. Challenges and issues such as these will force change in this industry.

Why use the SIA Roadmap as the model? First of all, it works and has been through an update process. Secondly, like the semiconductor industry, the pace of change is very rapid, and capital costs are high. These and many other similarities make it a good model. In addition, many of the players in the telecommunications marketplace have a presence in the semiconductor industry and have seen the power of the SIA roadmap.

The SIA Roadmap

In November 1992, 179 of the country's key semiconductor technologists assembled to create a common vision of the course of semiconductor technology over the next 15 years. The group included industry scientists and engineers, suppliers, and customers, plus representatives from academia, government agencies, and the national laboratories. Their charter was to:

- Evaluate likely progress in key areas relative to expected industry requirements and to foreign competition.

• Identify how available resources might best be used to ensure that the U.S.-based semiconductor industry would have the necessary basic technology and technological options for success in the competitive world market.

To help evaluate progress and identify the resources, a broad vision statement was developed.

THE ROADMAP VISION

Semiconductor technology is the driving force for the information age. The U.S. semiconductor industry must maintain leadership in this enabling technology if our country's other information-based industries are to remain competitive in the global marketplace. To do this, serious technological and manufacturing issues must be confronted. We believe that additional progress against these goals can best be achieved through improved teamwork among industry, academia, and government on pre-competitive technology issues.

The goal of this vision was to make the best use of available U.S. resources, to encourage government attention to top-priority needs, and to rely on the existing research structure of the community as much as possible to accomplish the roadmap mission. In short, the roadmap would help focus the various entities involved in U.S. semiconductor research on a common vision of the future. The desired result was that the United States would receive the maximum value for its investment in semiconductor research and development. (If you were to replace the word "semiconductor" with "telecommunications," these would be excellent starting points for a telecommunications roadmap.)

ROADMAP DEVELOPMENT

The second update of the SIA National Roadmap has just been published, but, because the telecommunications industry is just beginning the journey, I will focus on the first meeting as an example of how the telecommunications industry should proceed.

The core of the workshop activity consisted of the deliberations of 11 working groups assigned to develop technology roadmaps in the areas shown in Table 1. The telecommunications industry requirements can likewise be broken down into a similar set of working groups. These working groups should be

selected by a high-level steering committee made up of representatives of all the stakeholders. Some possible groups from this industry might include those shown in Table 2.

While a multitude of technical obstacles were identified, five overriding technical challenges emerged from the SIA working groups' roadmaps that, if not resolved, would decrease the rate of progress or, in the extreme, stop progress in integrated circuit (IC) technology. These five potential show stoppers were:

• Patterning, materials, and processes for device structures for dimensions below 0.25 micrometers.
• Electrical interconnections, both on and off the semiconductor chip.
• Electrical test-time, cost, and capability.
• Design, modeling, and simulation capability for all elements of IC technology and products.
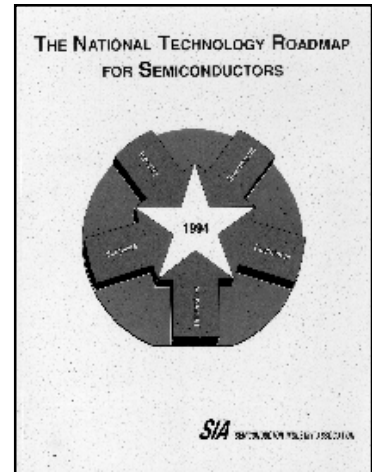• Software capability, availability, and quality for all aspects of IC technology and manufacturing.

Table 1
SIA Roadmap Working Groups

Chip Design and Test	Process Integration
Lithography	Interconnect
Materials and Bulk Processes	Environmental Safety & Health
Manufacturing Systems	Manufacturing Facilities
Process/Device/Structure CAD	Packaging
Equipment Modeling	Equipment Design

The working groups also identified critical technology competencies that, at that time, fell short of the requirements needed to meet the overall roadmap goals. Actions to address many of these pervasive issues extended beyond the detailed working groups' recommendations. These technology competencies, listed in Table 3, required increased focus on a national level by industry, government, and academia.

Table 2
Suggested Telecom Industry Roadmap Working Groups

Local Loop	Manufacturing Systems
Process Integration	Manufacturing Facilities
Cable	Telco
Wireless	Programming Content
Advanced Intelligent Network	Multimedia
Environmental Safety & Health	Security and Reliability
PCS	

Table 3
Critical Technology Competencies

Materials
Sensors for Process Control
Metrology
Modeling and Simulation
Reliability and Quality
Manufacturing-Critical Software Engineering
Contamination-Free Manufacturing

In addition, there were several issues affecting the entire technology environment that could have had a dramatic impact on the industry's ability to successfully complete the roadmaps.

These issues were separated into three broad areas:

INDUSTRY STRUCTURE ISSUES
• Changing the IC producer/system developer interface
• Wafer size
• Environmental safety and health
• The invention-commercialization gap

COST CONTROL ISSUES
• Cost of wafer processing
• Cost-effective facilities
• Cost of test

TECHNOLOGY TRADE-OFF ISSUES
• Power/performance limitations

The workshop roadmaps addressed leading-edge, mainstream IC technology. Device technology needs anticipated for a broad range of applications drove the roadmap, and memory and logic requirements were both incorporated.

Each group's discussions focused on one major IC technology area, from research through commercialization. Cost, a primary consideration throughout the workshop, was budgeted among the technology areas. Each SIA technology working group produced detailed roadmaps and reports for its technology. Their deliberations were coordinated with other groups throughout the workshop.

The success of U.S. semiconductor producers in competing for future world markets rests on developing the capabilities outlined in the roadmaps. In addition, each producer must merge its individual technological capabilities into integrated development, design, and production competence and also must collaborate effectively with suppliers, customers, and others to produce the best total solutions for competitive electronic product needs. This is also true in the telecommunications industry. As we approach the end of the 20th century, information is a critical force shaping the world's economic system. In the next century, the speed with which information is created, its accessibility, and its many uses will cause many fundamental changes in our global economy.

In summary, the proceedings of the SIA workshops raised many issues that the semiconductor industry needed to face as it moved forward into a new period of cooperation. This cooperation required a common vision that spanned the entire semiconductor industry (including its suppliers and customers) and extended to include academia, government, and electronics users. The pervasive importance of semiconductor-based electronics—coupled with the high cost, complexity, and sophistication of IC technology of the 1990s—compelled the creation of this new shared vision. Success would require expanded teamwork and cooperation throughout the private and public domestic semiconductor infrastructure. It had to be a vision driven by customer and systems needs, not by technology alone.

A Telecommunications Industry Roadmap

The telecommunications industry is experiencing many of the same issues that persuaded the SIA to convene the National Technology Roadmap effort. We see the previously distinct telecommunications, information, and mass media industries coming together in a technological convergence. Boundaries that once separated the types of networks used to

deliver voice, data, and video services are increasingly becoming blurred. Multiple networks composed of different transmission media—fiber optic cable, coaxial cable, satellites, radio, light, and copper wire—will carry a broad range of telecommunications and information services and technology to our businesses and homes.

It is a time for the telecommunications industry to build upon the lessons from the semiconductor industry and begin the process for the creation of a national telecommunications roadmap to help guide the industry and its suppliers over the next several decades. It is time to issue a call for action to address the issues and to proactively plan on how to leverage the resources required to maximize the investments and resources we have. The goal should not be to produce an industry which has higher capacity, faster switching, more powerful processing, better compression, or more versatility. Rather, the goal should be to produce a roadmap to serve as a guide not only to the producers, but to all the stakeholders in the industry.

This telecom roadmap must not be built around any one technology or set of products, but rather must be needs-driven. It should address what is required for the telecommunications industry to be successful in the next five, 10, and 15 years. Additionally, it can be used as a benchmark for funding and development by suppliers, universities, and government. This roadmap will not pick winners and losers, but will serve as a guide for a better leveraging of resources.

Of course, in a field as dynamic as telecommunications, it is impossible to predict the future with certainty. To be of ongoing utility, the roadmaps will need regular updating as the future terrain becomes more clearly visible. The goal should be to have a current set of roadmaps that all parties working within or associated with the telecommunications industry can consult when examining their research and advanced technology development priorities. Even the government is beginning to see the benefits from this type of planning.

In *The Global Information Infrastructure: Agenda for Cooperation*, Ronald H. Brown (Secretary of Commerce), Larry Irving (Administrator, National Telecommunications and Information Administration), Arati Prabhakar (Director, National Institute of Standards and Technology), and Sally Katzen (Administrator, Office of Information and Regulatory Affairs) state:

Harnessing the global potential of information and communications technologies to do this

will require collaboration among the industries that will build, operate, provide, and use services and information available over the evolving national networks. It will also require cooperative efforts among countries, working together bilaterally, regionally, and through multilateral organizations, to facilitate the interconnection of their respective networks and the sharing of information among nations.

The telecommunications industry associations, manufacturers and service providers, the key suppliers to the industry, academia, and government must come together to lay the foundation for producing the roadmap by selecting a coordinating, steering, and framework committee to begin the trip toward leveraging the collective efforts of this industry. For the United States to remain at the forefront of telecommunications technology over the next 15 years, we will have to modify our approach to technology development. One strategy for winning is outlined in Table 4.

The bottom line: To meet the challenges of global competition, the telecommunications industry must have its needs defined in the roadmaps. The approach

---

Table 4
Telecom Industry Roadmap Strategy

A Shared Vision	A commonly understood view of technology needs as a basis for improving the effectiveness of U.S. development efforts
Strengthened Industry Linkages	Improved cooperation among telecommunication producers/ suppliers, their customers, and their suppliers to reduce time to market
Improved Industry/ Government Cooperation	Focus industry and government attention on collective technology needs
Sustained Support for Technology Developments	Maintaining support for promising new inventions and ideas long enough that their commercial values can be assessed

to developing longer-range telecommunications technology must be changed.

Conclusion

In closing, let me quote from Dr. Gordon Moore from the foreword to the SIA Semiconductor Technology Workshop Conclusions:

> The semiconductor industry has proved that it can advance more rapidly by cooperating in pre-competitive areas. It has demonstrated the ability to recover competitiveness in the world's markets by means of focused programs addressing its shortcomings. I believe that it is likely that other industries could benefit by emulating the model that the semiconductor industry has pioneered. Of course, many improvements to the model are still possible, and alternatives should be considered depending on the specific situation. To continue the improving competitiveness trend, it is important that unnecessary duplication of efforts be minimized and that proper attention be directed toward long-range technical problems.

In 1916, President Woodrow Wilson said, "America is not anything if it consists of each of us. It is something only if it consists of all of us." The telecommunications industry will only achieve its full potential if it works together. Join me in this call to action to begin the process of creating the national telecommunications roadmap to guide this industry into the 21st century. ΠΤΩ