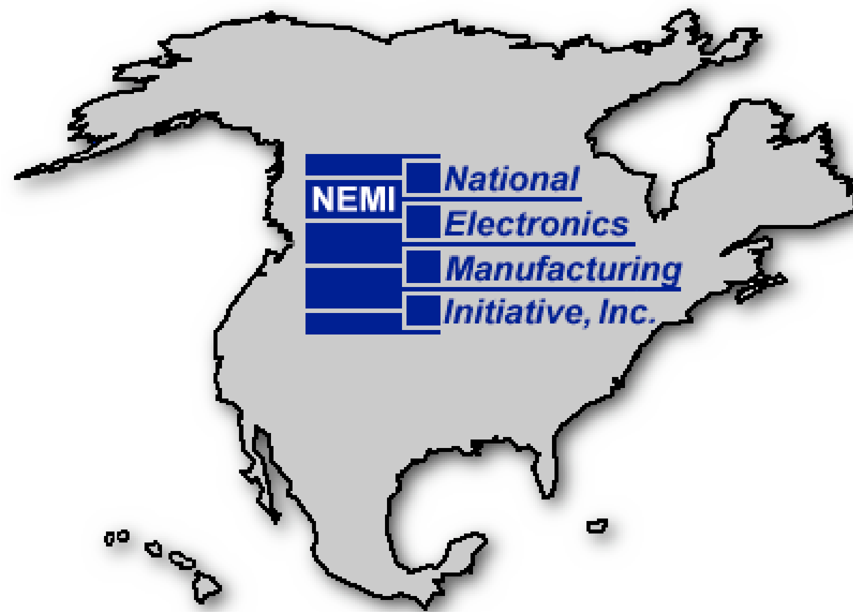

NEMI Product Emulators
Roadmapping Industry Needs and Closing Technology Gaps

Bob Pfahl

Outline of Presentation

- Background on NEMI and its Organization
- NEMI's Roadmap Drivers
  - Technology
  - Market
  - Cost
- Review of Product Sector Emulators
- Highlights of Individual Roadmaps
- 2004 NEMI Roadmap
- Summary

What Does NEMI Do?

Leverage the combined Power of Member Companies to Provide Industry Leadership

- **NEMI Roadmaps the Needs of the North American Electronics Industry**
- **NEMI Identifies Gaps (both business & technical) in the North American Infrastructure**
- **NEMI Conducts Industry Forums on Emerging Topics**
- **NEMI Stimulates R&D Projects to fill Gaps**
- **NEMI Establishes Implementation Projects to Eliminate Gaps**
- **NEMI Stimulates Standards to speed the Introduction of New Technology & Business Practices**

Major Accomplishments

- Roadmapping
  - Global acceptance as the source that provides a system view of electronics manufacturing – published biennially
  - Coordinated with other major organizations: SIA, IPC, OIDA, NSIC, Supply Chain Council, USDC
  - Has accurately predicted emergence of a number of manufacturing technologies (e.g. Microvia PWB, open systems architectures in mfg. software)
  - Broad industry view (2002 version created by 370+ people from 170 companies/organizations)
  - Evolving to address changing priorities: Supply Chain Management, Environmentally Conscious Electronics, Distributed Manufacturing Model

NEMI Organization

Chair
Technology Working Group

Chair
Technology Working Group

Chair
Technology Working Group

Chair
Technology Working Group

Roadmapping

18 Industry Groups

NEMI Board of Directors
Elected by NEMI Council
Representatives
EMS Directors
OEM Directors
Supplier Directors
Strategic Objectives
Operational Responsibility

NEMI Staff
Secretary to BoD
Communications
Membership
Development
Technical Facilitation

Technical Committee
EMS, OEM, Supplier & Academia/Government Representatives

Business Leadership Team
EMS & OEM Representatives

Implementation

5 NEMI Groups

Optoelectronics
Technology Integration Group

Substrates
Technology Integration Group

Board Assembly
Technology Integration Group

Factory Information Systems
Technology Integration Group

ESE (Lead Free, Etc.)
Technology Integration Group

Connect with and Strengthen Your Supply Chain

NEMI Manufacturing System Model

Factory Information Systems (PLIM)

Modeling, Simulation, and Design Tools

Connectors

RF Components

Passive Components

Optoelectronics

Mass Storage (Magnetic & Optical)

Displays

Energy Storage Systems

Test, Inspection & Measurement

Thermal Management

Semiconductor Devices

Packaging

Ceramic Substrates

Organic Substrates

Board Assembly

Final Assembly

Customer

Environmentally Conscious Electronics

Green = TWG & TIG

Blue = TWG

White / Shadowed = Cross Cut TWG

R.C.Pfahl

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Connect with and Strengthen Your Supply Chain

Roadmap Structure - 18 TWGs

Semiconductor Technology
- Digital Silicon Technology

Business Processes / Technologies
- Product Lifecycle Information Management

Design Technologies
- Modeling, Simulation, and Design Tools
- Thermal Management
- Environmentally Conscious Electronics

Manufacturing Technologies
- Board Assembly
- Test, Inspection, and Measurement
- Final Assembly

Component / Subsystem Technologies
- Connectors
- Packaging
- Interconnection Substrates - Organic
- Interconnection Substrates - Ceramic
- Passive Components
- RF Components
- Optoelectronics
- Displays
- Mass Data Storage
- Energy Storage Systems

NEMI Affiliations

OIDA
Optoelectronics and Optical Storage

USDC
Displays

NEMI Optoelectronics TWG

NEMI Mass Data Storage TWG

INSIC
Magnetic and Optical Storage

NEMI Supply Chain Management TWG

SCOR Supply-Chain Council
Supply Chain Management

NEMI / SIA System Drivers

NEMI Roadmap

SIA
Semiconductors

NEMI / SIA Packaging TWG

NEMI / IPC Interconnect TWG

IPC
Interconnect Substrates—Organic

IMAPS
Interconnect Substrates—Ceramic

Connect with and Strengthen Your Supply Chain

NEMI Technical Planning Methodology

Roadmapping

Technical Planning

NEMI Manufacturing System Plan

Product Sector Requirements

National Electronic Manufacturing Roadmap

NEMI Gap Analysis

NEMI Implementation Plan

NEMI Projects

Roadmap Drivers: Defining Future Needs

NEMI

- Product Sector Requirements (Emulators)
  - Technology Drivers
  - Market Drivers
  - Cost Drivers

ITRS

- Moore's Law

NEMI Example

- 1994 Portable Emulator Defined Need for Area Array Packaging
- Area Interconnect Required Higher Density PWBs
- Emulator defined cost objectives for PWBs
- Implementation Programs were established to create infrastructure

2002 Product Sectors (Emulators)

Product Sector	Characteristics
Consumer	High volume Consumer Products for which cost is the primary driver
Portable	Hand held, battery -powered products driven by size and weight reduction
Office Systems	Products which seek maximum performance within a few thousand dollar cost limit
Large Business Systems	High-end products for which performance is the primary driver
Automotive/Defense	Products which must operate in extreme environments

Roadmap Development

Product Sector Needs vs. Technology Evolution

TWGs	Product Sectors
Digital Silicon Technology	Consumer
Business Processes Product Lifecycle Information Mgmt.	Portable
Design Technologies Modeling, Thermal, etc.	Office
Manufacturing Technologies Board Assembly, Test, etc.	Auto & Aerospace
Components / Subsystems Packaging, Substrates, Displays, etc.	Large Business Systems

Connect with and Strengthen Your Supply Chain

Format for Product Sector Reports

- Executive Summary
- Introduction
- Situation Analysis
  - *Key Drivers: cost, performance, size, market*
  - *Benchmark state of Industry and Technology*
- Roadmap of Quantified Key Attribute Needs
  - Comparison with Previous Roadmap
- Critical (Infrastructure) Issues-
- Technology Needs: Research, Development, Implementation
- Gaps and Showstoppers
- Recommendations on Priorities and Alternative Technologies
- Contributors

Consumer Product Sector Characteristics

- High volume products for which cost is the primary driver
- Includes products such as television, portable radios, CD players and low-end portions of the cell phone and personal computer markets.
- In a majority of cases products are built outside of North America.
- A well-designed product, produced in a well managed, high-velocity, supply chain (close to its market) is becoming a more successful business model than single dimension manufacturing cost business models.
- Since the host manufacturing country is often one of the best markets for low cost consumer products, it is usually possible for an OEM (Original Equipment Manufacturer) to provide designs, components, and other knowledge in order to participate in ramping to volume manufacture of a consumer product that may be new to the country.

2002 Key Parameters For Consumer Product Sector

First Year of Significant Production	Metric	2003	2005	2007	2013
Cost					
Board Assembly (Conversion) Cost	¢ per I/O	0.4	0.35	0.3	0.15
Substrate Cost (4 layer)	$\$/cm^2$	0.0085	0.007	0.006	0.003
IC Package Cost	¢ per I/O	0.4	0.35	0.3	0.2
Design-Packaging Density					
Average Component I/O Density	I/O per cm^2	20	24	28	35
Package I/O Pitch (Perimeter)	mm	0.5	0.5	0.5	0.5
Max I/O per package	I/O/pkg	208	256	280	360
Package I/O Pitch (Area Array)	mm	1.00	0.80	0.80	0.65
Substrate Lines and Spaces	microns	125	100	100	65
Components per cm^2	$\#/cm^2$	3.2	3.4	3.6	4.2

2002 Key Parameters For Consumer Product Sector (continued)

Critical Components		2003	2005	2007	2013
Solder	Composition	Pb/Pb-Free	Pb-Free/Pb	Pb-Free / Low Temp	Low Temp/ Pb-Free
Display	Resolution Technology Color Cost	Indicator LCD BW $2	Alpha/num LCD Flexible BW $2	Pixel OLED Flexible YES $3	1 _ VGA OLED Flexible Full $4
Semiconductor Memory	DRAM+ROM	16MB	32MB	128MB	256MB
Interconnect Substrate	Type	4 layer	4 layer	PI/RTR	Mylar/RTR
Passive Components		0603	0402	Embedded	Embedded

Consumer Product Sector (2000 vs. 2002)

First Year of Significant Production			*2001*	*2003*	*2005*	*2007*	*2011*	*2013*
Year	*Parameter*	*Metric*	*Cost*					
2000	Board Assembly (Conversion) Cost	¢÷I/O	0.6	0.5	0.4		0.22	
2002			0.5	0.4	0.35	0.3	0.2	0.15
2000	**Substrate Cost (4 layer)**	$/cm^2	0.0138	0.0114	0.009		0.005	
2002			0.01	0.0085	0.007	0.006	0.004	0.003
2000	Package Cost	¢ per I/O	0.5	0.4	0.35		0.28	
2002			0.5	0.4	0.35	0.3	0.25	0.20
Density, Dimension, Number			***Value***					
2000	**Max I/O per package**	#	208	256	280		470	
2002			160	208	256	280	320	360
2000	Package I/O Pitch (area array)	mm	1.00	1.00	0.80		0.65	
2002			1.00	1.00	0.80	0.80	0.65	0.65
2000	Package I/O Pitch (perimeter)	mm	0.5	0.5	0.5		0.5	
2002			0.5	0.5	0.5	0.5	0.5	0.5
2000	Average Comp I/O density	I/O/cm	15	20	24		33	
2002			15	20	24	28	33	35
2000	Max Component Density	Parts/ cm^2	23	26	28		31	
2002			23	26	28	29	31	32
2000	Avg Component Density	Parts/ cm^2	2.8	3,2	3.2		3.5	
2002			2.8	3.2	3.4	3.6	4.0	4.2
2000	Substrate Lines/Space (laminate)	µm	125	100	100		75	
2002			125	125	100	100	75	65

Consumer Product Sector Summary

- The packaging metrics trends for consumer products continue to track with those established in previous roadmaps.
- Cost trends are on track or perhaps even slightly ahead of trend.
- Substrate costs have decreased significantly over forecasts and are reflected in the metric chart.
- Soon, electronic product unit volumes will regularly exceed one billion/year.
  - Such volumes may force consumer product leaders to develop totally new and unique packaging and manufacturing technologies that are intrinsically designed to give lower product cost.
  - This scenario contrasts with present low cost, consumer electronic product, design strategies that generally employ older, well-established, technology approaches.

Portable Product Sector Characteristics

- Hand held, battery-powered products driven by size and weight reduction
- Typical products are high-end cell phones, palmtop computers, PDA's, and wireless email or short messaging devices
- The key operational elements are:
  - packaging and technology
  - supply chain or business
  - design architecture
- These elements are driven by the market, the applications, and the software
- The need for rapid introduction of complex, multifunctional new products has favored the development of functional, modular components
- Modular design increases the flexibility and shortens the product design cycle, and places the technology risk and test burden on the producers of the modules

2002 Key Parameters for Portable Product Sector

First Year of Significant Production	Metric	2003	2005	2007	2013
Cost					
Board Assembly (Conversion) Cost	¢ per I/O	0.5	0.45	0.4	0.3
Substrate Cost (6-layer, blind/buried)	$\$/cm^2$	0.055	0.04	0.03	0.03
Microvia Board Cost (4-layer)	$\$/cm^2$	0.04	0.03	0.025	0.015
IC Package Cost	¢ per I/O	0.7	0.65	0.5	0.4
Design-Packaging Density					
Average Component I/O Density	I/O per cm^2	70	80	100	140
Max Component I/O Density**	I/O per cm^2	280	320	350	450
I/O per Component, avg.	#	6	7	7.5	9
Package I/O Pitch (Perimeter)	mm	0.5	0.5	0.5	0.5
Max I/O per package	I/O/pkg	324	400	424	480
Package I/O Pitch (Area Array)	mm	0.5	0.5	0.5	0.5
Substrate Lines and Spaces	microns	75	65	65	35
Substrate Pad Diameter*	microns	225	200	175	125
Components per cm^2	$\#/cm^2$	15	15	17	25

2002 Key Parameters for Portable Product Sector (continued)

Frequency on Board	MHz	150	250	300	400
Critical Components					
Solder	Composition	Lead/Lead-Free	Lead-Free/Lead	Lead-Free	Lead-Free
Semiconductor Memory	DRAM+ROM	256MB	.5GB	1GB	3GB
Interconnect Substrate	Type	4 + µ-via	4 + µ-via	RTR, µ-via	µ-via, RTR
Mass Memory, <12.5 mm thick	HDD	3.5G	5G	8G	30G
Passive Components		0201	0201	Embedded	Embedded

Portable Product Sector (2000 vs. 2002)

Year	Parameter	Metric	2001	2003	2005	2007	2011	2013
	First Year of Significant Production		*2001*	*2003*	*2005*	*2007*	*2011*	*2013*
Year	**Parameter**	**Metric**	**Cost**					
2000	Substrate Cost (6 layer, blind/buried)	$/cm^{2}	0.10	0.10	0.09		0.07	
2002			0.07	0.05	0.04	0.03	0.03	0.0
2000	Microvia Board Cost (4 layer)	$/cm^{2}	0.095	0.09	0.08		0.05	
2002			0.05	0.04	0.03	0.02	0.02	0.0
	Density, Dimension, Number		***Value***					
2000	Max I/O per package	I/O/pkg	256	288	312		360	
2002			256	324	400	424	450	480
2000	Av. I/O per package	I/0÷pkg	3.6	4.0	4.4		5.0	
2002			3.6	6	7	7.5	8	9
2000	Substrate Lines/Spaces	µm	60	35	30		20	
2002			100	75	65	65	50	35
2000	Components/sq. cm	#/sq.cm	15.5	20	23		30	
2002			15	15	15	17	22	25
2000	Substrate Pad Diameter	µm	120	80	70		50	
2002			250	225	200	175	150	125
2000	Frequency on Board	MHz	250	300	350		500	
2002			100	150	250	300	350	400

Portable Product Sector Summary

- The need for rapid introduction of complex, multifunctional new products has favored the development of functional, modular components.
- Modular design increases the flexibility and shortens the product design cycle, and places the technology risk and test burden on the producers of the modules.
- Cost trends are on track or perhaps even slightly ahead of trend.
- Substrate costs have decreased significantly over forecasts and are reflected in the metric chart.
- The packaging metrics trends have been changed by the introduction of modular components:
  - Component density has been reduced
  - Pad size has been increased
  - Line spacing has been increased
  - Frequency on substrate has been reduced

Office Product Sector Characteristics

- Products which seek maximum performance within a few thousand dollar cost limit.
- Encompasses low-end servers and high-end personal computers, both desktop and laptop.
- Over the past two years the market has leveled after substantial increase in the volume during the last five years.
- Products have migrated towards legacy-free products.
- Supply chain optimization becomes critical for cost control.
- A continued focus on shorter, seasonal production cycles.
- Key needs include:
  - Reduction in cost for Printed Wiring Board substrates with advanced technologies
  - Higher glass transition temperature for lead-free and high density interconnects (HDI).
  - More tightly controlled impedances without cost impacts.

Office Product Sector (2000 vs. 2002)

FIRST YEAR OF SIGNIFICANT PRODUCTION			2001	2003	2005	2007	2011	2013
Roadmap Year	Parameter	**Metric**						
Cost								
2000	Board Assembly (Conversion) Cost	¢ per I/O	0.32	0.29	0.26		0.19	
2002			0.31	0.28	0.25	.23	0.19	0.19
2000	PWB Cost (4 layer Conventional)	$\$/cm^2$	0.014	0.014	0.014		0.014	
2002			0.013	0.013	0.013	0.013	0.013	0.013
Design Packaging Density								
2000	Average I/O Density	I/O per cm^2	10	14	16		20	
2002			10	14	16	18	20	20
2000	Maximum I/O Density	I/O per cm^2	160	240	400		630	
2002			160	240	400	630	630	630
2000	PWB Size	cm^2	600	400	300		200	
2002			600	400	300	300	200	200
2000	Average Component Density	parts/ cm^2	1.7	2.1	2.4		2.8	
2002			1.7	2.1	2.4	2.4	2.8	2.8

Office Product Sector Summary

- Supply chain optimization becomes critical for cost control
- For North American manufacturing costs of Office Systems products to be competitive with worldwide manufacturing costs, labor costs must be driven even lower through large component placement automation and the automation of motherboard test
- A continued focus on shorter production cycles for selling seasons, and mass customization
- Reduction in cost for Printed Circuit Board (PCB) substrates with advanced technologies
- The costs of assembly/test, as well as costs of the printed wire substrate, are down slightly; a 7% decrease in cost of board assembly/test, and a 3% reduction in the cost of a four-layer printed wire board
- The average via diameter is up slightly (due to reliability concerns on smaller vias), 16 mils to 18 mils in diameter

Large Business Product Sector Characteristics

- High-end products for which performance is the primary driver.
- Characterized by very high contact counts, high clock frequency, high reliability, high power and scalability.
- Product examples are routers, communications switches, mainframes, scientific computers, servers and cellular base stations.
- The market has seen significant erosion particularly in telecommunications and long-haul fiber optic systems.
- The packaging and design technology has changed from proprietary to commercial.
- In 2000 organic packaging and substrates were introduced for cost reduction, they are now being used for performance.

Large Business Product Sector (2000 vs. 2002)

First Year of Significant Production			2001	2003	2005	2007	2010	2013	2016
Year	Parameter	Metric	Cost						
2000	Board Assembly (Conversion) Cost	¢÷I/O	1.0	0.8	0.75			0.65	
2002				0.8	0.75	0.7	0.65	0.6	0.55
2000	Substrate Cost (14 layer, no blind/buried)	$\$/cm^2$	0.15	0.14	0.13			0.10	
2002				0.14	0.13	0.12	0.11	0.10	0.09
2000	(28 layer, blind & buried vias)	$\$/cm^2$	0.65	0.45	0.43			0.38	
2002				0.45	0.43	0.41	0.39	0.38	0.36
2000	(48 layer, blind & buried vias)	$\$/cm^2$	1.15	1.05	1.00			0.90	
2002				1.05	1.00	0.95	0.90	0.85	0.80
2000	Package Cost (High Density Ceramic/w/ Area Connector	¢÷I/O	3 - 12	3 - 10	2 - 8			1 - 6	
2002				3 - 10	2 - 8	2 - 7	1 - 6	1 - 5	0.8 - 4
2000	Package Cost (High Density µvia Laminate w/ Area Connector	¢÷I/O	1 - 10	0.5 - 8	0.4 - 7			0.1 - 4	
2002				0.5 - 8	0.4 - 7	0.3 - 6	0.2 - 5	0.1 - 4	0.08 - 3
	Density, Dimension, Number		Value						
2000	Max I/O for 50 mm square SCM w/ full area array	#	2500	3249	4356			6400	
2002				3364	4096	4356	4900	5476	7056
2000	Max I/O for 100 mm square MCM w/ full area array	#	5184	8100	12544			16384	
2002				8464	10000	11025	12100	13689	15129
2000	Package I/O Pitch for SCM (area array)	mm	0.8	0.7	0.6			0.5	
2002				0.65	0.625	0.6	0.55	0.5	0.45
2000	Package I/O Pitch for MCM (area array)	mm	1.25	1	0.8			0.7	
2002				0.95	0.9	0.85	0.8	0.75	0.7
2000	Package I/O Pitch (perimeter)	mm	0.5	0.4	0.4			0.3	
2002				0.4	0.4	0.35	0.3	0.3	0.25
2000	Max I/O Density (area array)	$I/0 \div cm^2$	156	196	256			400	
2002				237	256	278	331	400	494
2000	Max I/O Density (perimeter)	$I/0 \div cm^2$	40	48	56			64	
2002				48	56	58	66	70	80

Large Business Product Sector Summary

- Integrated chip packages are being introduced for clock rates of 20 - 30 GHz and above to eliminate discontinuities between the semiconductor component and the package.
- Introducing integrated passive devices including resistances (R), inductances (L), and capacitances (C), to form high Q resonant circuits into the packaging substrate is desirable for better electrical performance and lower cost.
- Novel heat removal techniques are required for cooling a chip that dissipates 100 W. minimal thermal resistances and novel heat removal techniques.
- There is uncertainty in the role that optoelectronics (OE) will play in future electronic packages.
- The stand-alone high-end RF business, as exemplified by cellular base stations, will not succumb to commoditization.

Automotive Product Sector Characteristics

- **Products which must operate in extreme environments**
- **Increased reliability is required for longer warranties.**
- **Faster qualifications required to meet time to market.**
- **Increased power requirements have made the automotive suppliers turn to 42 V sources.**
- **There is a growing market for office and entertainment systems in addition to engine management, and comfort systems.**
- **Need to respond quickly to environmental legislation and customer specifications.**
- **Conversion of analog sensor components to digital will require a systems architecture change to take advantage of monolithic silicon technology to allow a shift to a system that can distribute power at a higher voltage and control commands at a high frequency on a single wire.**

Automotive Product Sector (2000 vs. 2002)

First Year of Significant Production			1999	2001	2003	2005	2009	2011
Roadmap Year	**Parameter**	**Metric**						
Cost								
2000	Substrate Cost (4 layer w/microvia)	$/cm^2		0.09	0.07	0.05		0.03
2002	Substrate Cost (4 layer w/microvia				0.04	0.03		0.02
2000	Conversion Cost (4 layer w/microvia)	¢ per I/O		0.7	0.6	0.5		0.2
2002	Conversion Cost (4 layer, w/microvia)				0.7	0.6		0.4
2000	IC Package Cost	¢ per I/O		0.5	0.4	0.3		0.1
2002	IC Package Cost				0.7	0.6		0.4
Design-Packaging Density								
2000	Max Component Complexity	I/O per part		200	250	300		400
2002	Max Component Complexity				325	400		500
2000	Avg. Component Complexity	I/O per part		80	100	120		150
2002	Avg. Component Complexity				50	60		70
2000	Max I/O Density (4 layer w/microvia)	I/O per cm^2		40	50	70		100
2002	Max I/O Density (4 layer w/microvia)				50	150		200
2000	Avg I/O Density (4 layer w/microvia)	I/O per cm^2		20	30	40		60
2002	Avg I/O Density (4 layer w/microvia)				20	30		50
2000	Max Component Density	prts per cm^2		50	100	150		200
2002	Max Component Density				60	80		100
2000	Avg Component Density	prts per cm^2		2.1	2.6	3.0		3.5
2002	Avg Component Density				3.0	4.0		5.0
2000	Package I/O Pitch (perimeter)	mm		0.5	0.4	0.4		0.3
2002	Package I/O Pitch (perimeter)				0.5	0.4		0.25
2000	Area array pitch (array package)	mm		1.0	1.0	0.8		0.7

Automotive Product Sector Summary

- The 2000 NEMI roadmap predictions for 2002 automotive products have been validated in key areas.
  - A notable exception is that the anticipated microvia technology has not been widely embraced due to unsettled cost, reliability, and infrastructure issues.
- Longer warranties have increased reliability requirements.
  - However, correlation information between field data and screening tests is difficult to obtain.
  - Reliability test stipulations have become stringent and time consuming, having an adverse effect on the electronic product development cycle.
  - Ironically, at the same time, reduced time- to- market has become the key to competitiveness.
- Increased power requirements have made the automotive suppliers turn to 42 V sources, to keep the current levels low for efficient thermal management.
- In addition to the traditional engine management, and comfort and entertainment systems of the past, there is a growing market for office and entertainment systems that rival those in an office or home.
- A market discriminator is the manufacturers ability to respond to environmental legislation and customer specifications.

Defense/Aerospace Product Sector Characteristics

- Products which must operate in extreme environments
- There are instances where commercial components become obsolete before the defense system goes into production.
- There is increasing interest in the use of MEMS technology.
- There is no longer a dedicated supply chain for "mil-spec" components. Ruggedized commercial components are now used.
- Typical products require both forward and backward traceability as well as stringent control of material and process change.

Military/Defense Product Sector: Key Parameters

P	Attribute	2003	2005	2007	2013	Comments
P	PW B Cost $/cm²$					
·	FR4 (12 layer)	1.5	1.5	1.5	1.5	
·	FR4 (12 layer with buried vias)	2.5	2.5	2.5	2.5	
·	FR4 (12 layer with buried and μ-vias)	2.7	2.7	2.7	2.7	Based on:
·	Constrained (i.e. aramid) (12 layer)	1.7	1.7	1.7	1.7	6U VME (6" x 9")
·	Constrained (12 layer with buried vias)	2.7	2.7	2.7	2.7	
·	Constrained (12 layer with buried and μ-vias)	2.9	2.9	2.9	2.9	
	Max Component Complexity, I/O per part	1200	1350	1500	2000	
	Ave Component Complexity, I/O per part	10 / 100	15 / 110	20 / 120	20 / 140	With passives / without Passives
	Package I/O (perimeter) mm	0.4	0.4	0.4	0.4	Majority 0.5mm
	Area Array Pitch (array) mm	0.8	0.65	0.5	0.25	
PWB Size – Area cm^2		200-3600	200-3600	200-3600	200-3600	Typical sizes 6 in x 9 in
Backpanel Size – Area cm^2						As large as 38 in long

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Defense/Aerospace Product Sector Summary

- As in previous years, the 2002 roadmap for the introduction of technologies follows the roadmaps associated with the Portable and Large Business Systems product sectors.
- Introduction of specific technologies continues to lag behind the commercial market.
- This delay is caused by the desire to establish product maturity, understand reliability limitations, and develop and qualify ruggedization techniques.
- Thermal management requires innovative techniques: An example is the deployment of components with increased allowable junction temperature, which simplify the board layout.

Selected Highlights from NEMI TWGs

- Organic Substrate Roadmap
- RF Roadmap
- Thermal Management Roadmap

2002 Forecast of Pad Sizes By Product Sector (Organic Substrate Roadmap)

First Year of Significant Production			2001	2003	2005	2007	2010	2013	2016
Parameter	**Metric**	**Pad Size**							
Automotive and Aerospace Products	mm	2000	575	500	400		100		
		2002		500	400	400		100	
Portable Products	mm	2000	120	80	70		50		
		2002		225	200	175		125	
Office Systems Products	mm	2000	500	400	400		300		
		2002		400	400	300		300	
Business System Products	mm	2000	360	330	300		200		
		2002		200	250	280	331	200	

- **This increase in density is also expected to occur with increases in thermal mass associated with the assembly to compensate for heat dissipation generated by the circuit. This will create a contradiction with a need to reduce the soldering temperature and narrow the heat-affected zone.**

Cellular handset: Key Attribute Needs (RF Roadmap)

Parameter	Metric	2003	2005	2007	2013
RF section cost (for a given function)	Relative to costs in 2000	0.7	0.35	0.17	0.05
Number of freq bands		2	4	6	6
Number of Antennas (Diversity)		1	2	2	3
Number of Modulation formats		2	4	5	5
Data transmission rate (peak)?	kb/s	14	160	1500	11,000
Transmit Peak-to-Average Ratio (worst)	dB	4 dB	5 dB	5 dB	4 dB
Talk time	minutes	90	120	160	200
Battery Voltage	V	3.3	2.7	1.5	1.2
RF section area	mm^2	1800	1200	800	500
RF component thickness	mm	2.5	1.5	1.5.MEMs	1.0,MEMS
From Portable emulator:					
Average Component I/O Density	I/O per cm^2	70	80	100	140
Max Component I/O Density**	I/O per cm^2	280	320	350	450
I/O per Component, avg.	#	3.6	4.0	4.4	5.0
Package I/O Pitch (Perimeter)	mm	0.5	0.5	0.5	0.5
Package I/O Pitch (Area array)	mm	0.5	0.4	0.25	0.2
Max I/O per package	I/O per pkg	256	288	312	360
Flip Chip I/O Pitch (Area)	mm	0.25	0.25	0.20	0.10
Substrate Lines and Spaces	microns	60	35	30	20

Notebook Computer CPU Power Trend (Thermal Management Roadmap)

Notebook CPU Power (Watts)

70
60
50
40
30
20
10
0

High Performance

Mini-Notebook

2001 2003 2005 2007 2009 2011

Year

Connect with and Strengthen Your Supply Chain

2004 NEMI Roadmap

- **Coordination discussions with ITRS**
  - **ITRS IRC**
  - **ITRS Packaging TWG**
- **Coordination discussions with IPC**
- **Result in tweaks to the process and emulators**
- **Technical Committee will focus on strengthening the 2004 Emulators**

Strengthening the 2004 Emulators

Emulators	Characteristics
Portable/Consumer	High volume Consumer Products for which cost is the primary driver including Hand held, battery -powered products driven by size and weight reduction
System in a Package	Complete Function Provided in a Package to System Manufacturer
Office Systems	Products which seek maximum performance within a few thousand dollar cost limit
Large Business Systems	High-end products for which performance is the primary driver
Specialty Emulators	**Defined by Operating Environment**
Automotive	Products which must operate in an automotive environment
Defense and Aerospace	Products which must operate in extreme environments

Strengthening the NEMI Emulators: Next Steps

- **Technical Committee will recruit Emulator Groups and Emulator Chairs during 3Q 2003**
  - **3 carryover OEM Chairs (Office Systems, Defense, Automotive)**
- **TC will reinforce the need for business situation analysis and strengthen the technical metric requirements in the Emulator chapters**
- **4Q03: Emulator Groups develop emulators - Submit Draft by 2/1/2004**
- **Technical Committee reviews Emulator chapters at APEX Meeting in Anaheim (2/24 – 2/26/04).**

Increased NEMI-ITRS Cooperation

Trends

- **SIA/ITRS moving towards market pull vs. technology push.**
- **NEMI moving towards more global focus.**
- **NEMI will strengthen its product emulators**
- **NEMI emulators impact ITRS System Design TWG**
- **NEMI participation in this meeting**
- **ITRS participation in the NEMI TC meeting.**
- **These trends present opportunities for increasing collaboration between ITRS and NEMI roadmaps.**

Summary

- **Review of Product Sector Emulators**
  - Technology: "System in Package" emerging as technology driver
  - Market: Technology needs delayed by the economy
  - Cost: Placing more emphasis on Supply Chain Management
- **2004 NEMI Roadmap**
  - Will strengthen the 2004 Emulators
  - Will focus the discussion on business issues