Highlights of the 2007 Roadmap

Bob Pfahl
China SMT Forum 2007

Advancing manufacturing technology

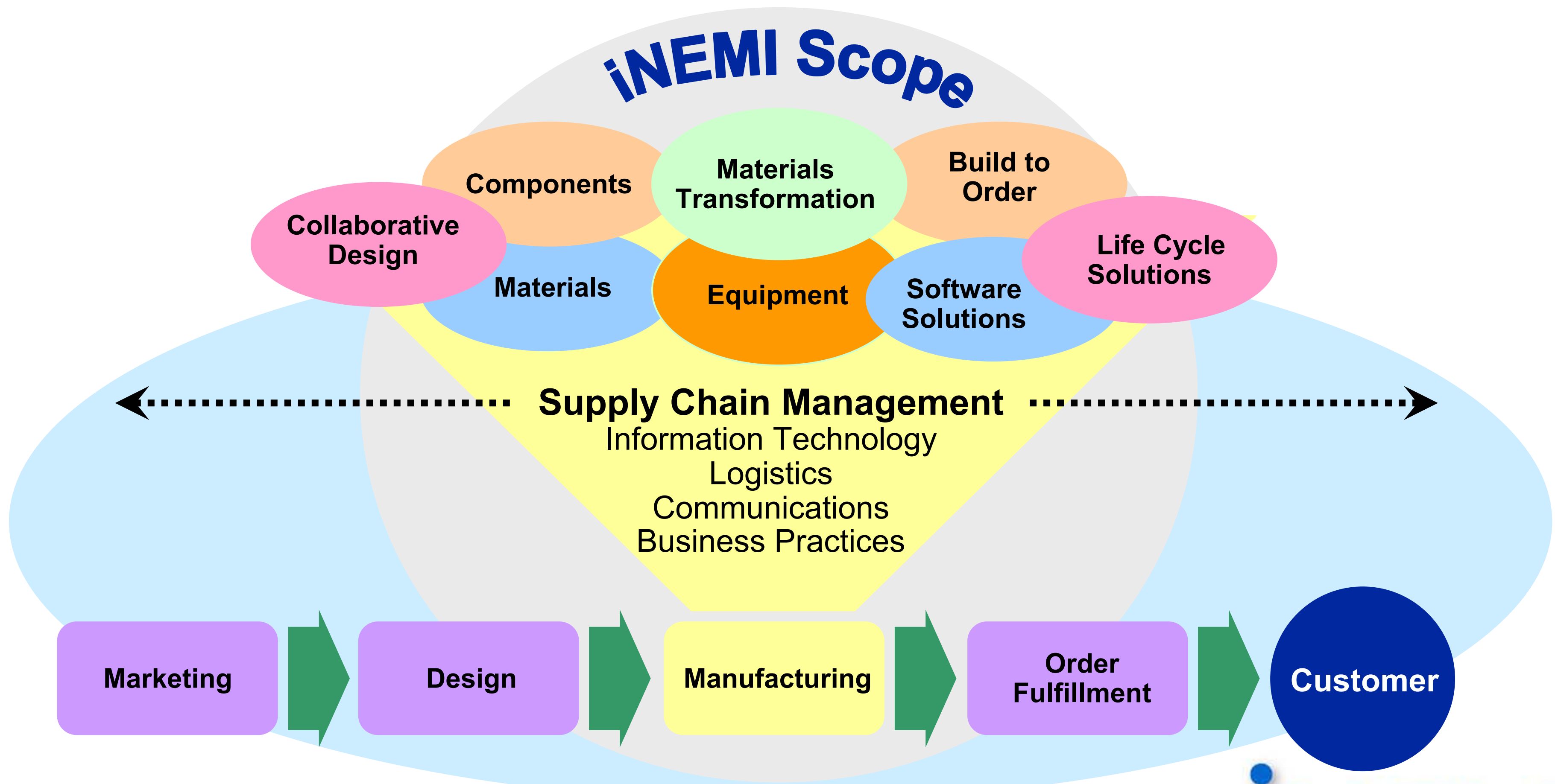
Topics

- iNEMI Overview
- iNEMI Roadmap
  - Definitions
  - Structure
  - Linkages
  - International participation
  - Leadership
  - Conclusions
  - Next steps

iNEMI

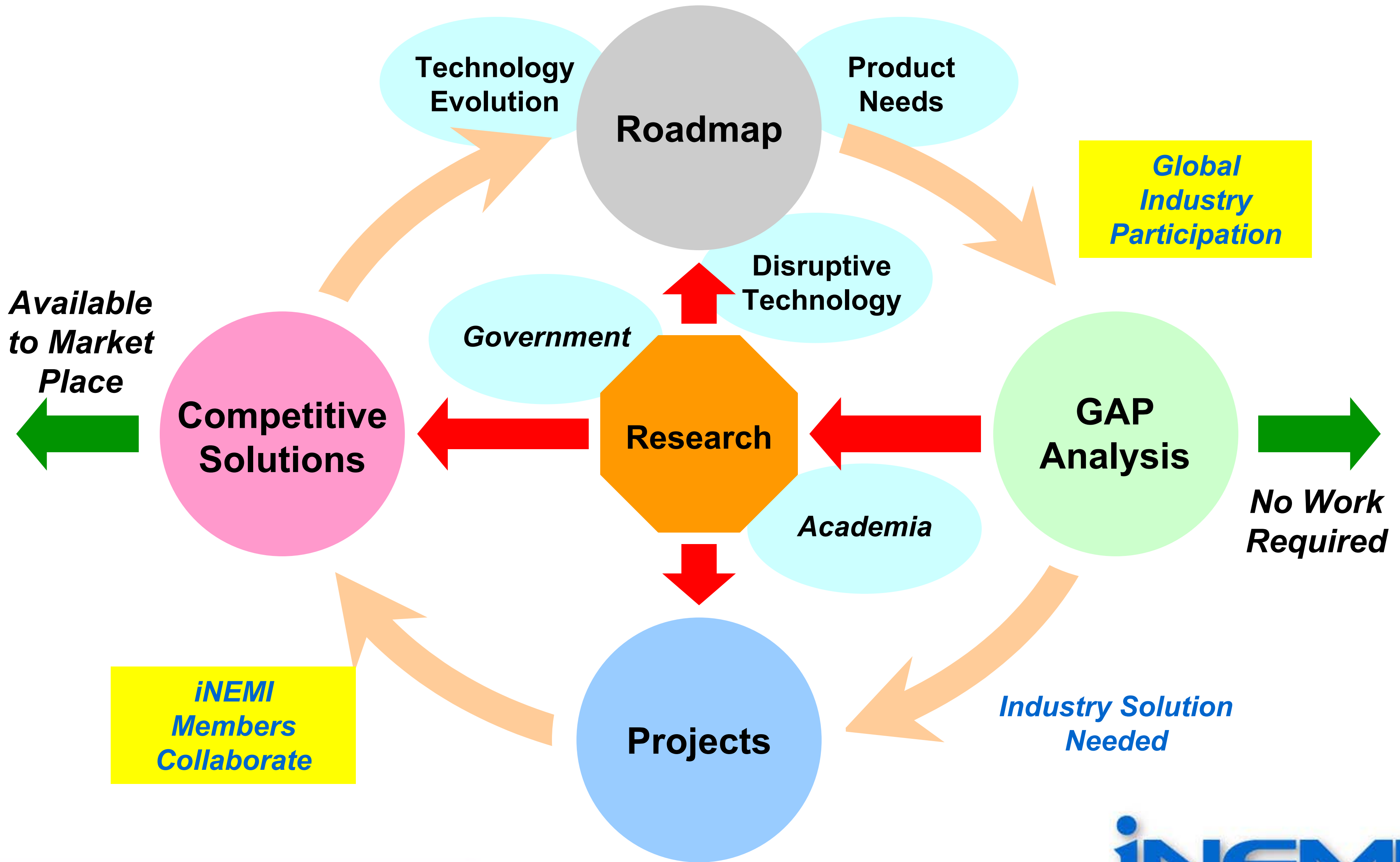
iNEMI Mission

***Identify** and **Close** TECHNOLOGY GAPS which includes the development and integration of the electronics industry supply infrastructure.*



iNEMI

Methodology



OEM/EMS Members

Alcatel·Lucent

DELPHI

Medtronic
Alleviating Pain · Restoring Health · Extending Life

Microsoft®

MICRO SYSTEMS
ENGINEERING

JABIL

MOTOROLA

SOLECTRON®

Sun®
microsystems

symbol®
The Enterprise Mobility Company™

Supplier Members

Association/Consortium, Government, Consultant & University Members

ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES®

NIST
National Institute of Standards and Technology

Développement
économique
et régional

Some Definitions…

- PEGs – Product Emulator Groups
  - “Virtual Product” defining future product technology attributes
  - Key cost and density drivers
- TWGs - Technology Working Groups
  - Develops roadmaps
  - Presently 19 TWGs of “content experts”
- TIGs - Technology Integration Groups
  - Develops technical Plan based on:
    - Roadmap findings
    - Gap analyses
  - iNEMI Projects are formed under TIGs

Organization

Technology Working Group

Technology Working Group

Technology Working Group

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Technology Working Group

Technology Roadmapping

19 Industry TWGs

Product Need Roadmapping

5 Industry PEGs

Product Emulator Group

Product Emulator Group

iNEMI Board of Directors

Elected by iNEMI Council Representatives
EMS Directors
OEM Directors
Supplier Directors
Strategic Objectives
Operational Responsibility

iNEMI Staff

Secretary to BoD
Communications
Membership Development
Technical Facilitation

Technical Committee

EMS, OEM, Supplier & Academia/Government Representatives

Research Committee

EMS, OEM, Supplier & Academia/Government Representatives

Implementation

7 iNEMI TIGs

Optoelectronics TIG (Technology Integration Group)

Medical Electronics TIG

Substrates TIG

Board Assembly TIG

System in Package TIG

Environmentally Conscious Electronics TIG

Heat Transfer Technology TIG

Board of Directors

Directors

- Dr. Nasser Grayeli, VP of Assy Technology & Mfg., Intel – Chairman
- Dr. Marc Benowitz, Director Reliability & Eng. Infrastructure, Alcatel-Lucent
- Monroe Huang, Mgr. Mfg. Technology Dev. , Delphi Electronics & Safety
- Dan Shea, CTO, Celestica, Inc.
- Dr. Katharine Frase, VP Technology, IBM Microelectronics
- Dr. Sundar Kamath, CTO Assembly Technology, Sanmina-SCI
- Eugene McCabe, Senior VP Operations, Sun Microsystems
- Minoru Okamoto, VP CCC Electronics, Tyco Electronics
- Jeroen Schmits, President, Universal Instruments
- Michael Toben, Director Pkg. & Finishing Technology, Rohm & Haas
- Dr. Iwona Turlik, Corp. VP Physical Realization Research Ctr., Motorola

Ex officio Members

- Dr. William Anderson, Director, EEE Laboratory, NIST
- Fred Kuhlman, Co-Chair iNEMI Technical Committee, Delphi
- Jim McElroy, CEO, iNEMI
- Dr. Robert Pfahl, VP of Operations, iNEMI

2007 Roadmap Priorities

- Maintain strong linkages with other roadmaps.
- Strengthen and realign Product Emulators.
- Expand regional, global roadmap meetings.
- Expand emphasis on disruptive events (business & technical).
- Expand emphasis on identifying market needs and business situations.
- Increase quantification of needs.
- Prioritize Research and Deployment needs.
- Increase strategic vision of the roadmap: 2013-2017
- Release at APEX 2007-February 2007

International Roadmap Workshops

- Gained Additional Participation by holding regional workshops in Asia, Europe, and North America.
  - Asian Workshop held in conjunction with HDP '06 Conference at Shanghai University.
  - European Workshop held in conjunction with Semicon Europa at Messe Munchen.
  - North American Workshop held at iNEMI Headquarters in Virginia.
- Goal of increased participation achieved!
- Laying foundation for further participation on future cycles.

Statistics for the 2007 Roadmap

- > 500 Participants
- > 265 Companies/organizations
- 17 Countries from 4 Continents
- 19 Technology Working Groups (TWGs) (added Organic & Printed Electronics)
- 5 Product Emulator Groups (PEGs)
- Over 1300 Pages of Information
- Roadmaps the needs for 2007-2017

2007 Product Emulator Groups (PEGs)

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
Office Systems / Large Business / Communication Systems	Products which seek maximum performance from a few thousand dollar cost limit to literally no cost limit
Medical Products	Products which must operate within a highly reliable environment
Automotive	Products which must operate in an automotive environment
Defense and Aerospace	Products which must operate in extreme environments

2007 Technology Working Groups (TWGs)

Modeling, Simulation, and Design

Connectors

RF Components & Subsystems

Test, Inspection & Measurement

Sensors

Passive Components

Thermal Management

Organic & Printed Electronics

Packaging

Optoelectronics

Semiconductor Technology

Mass Storage (Magnetic & Optical)

Ceramic Substrates

Energy Storage Systems

Organic Substrates

Board Assembly

Final Assembly

Customer

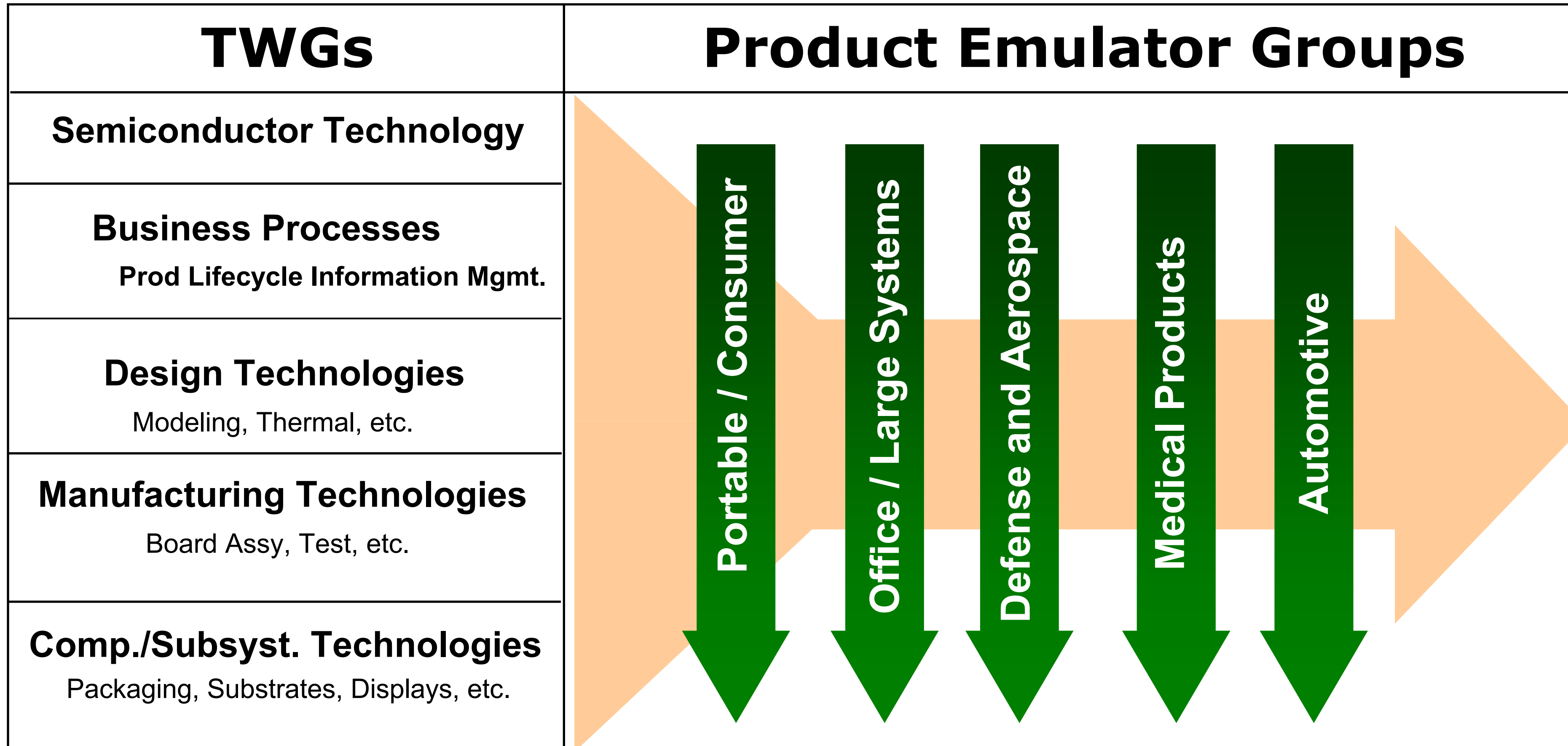
Product Lifecycle Information Management (PLIM)

Environmentally Conscious Electronics

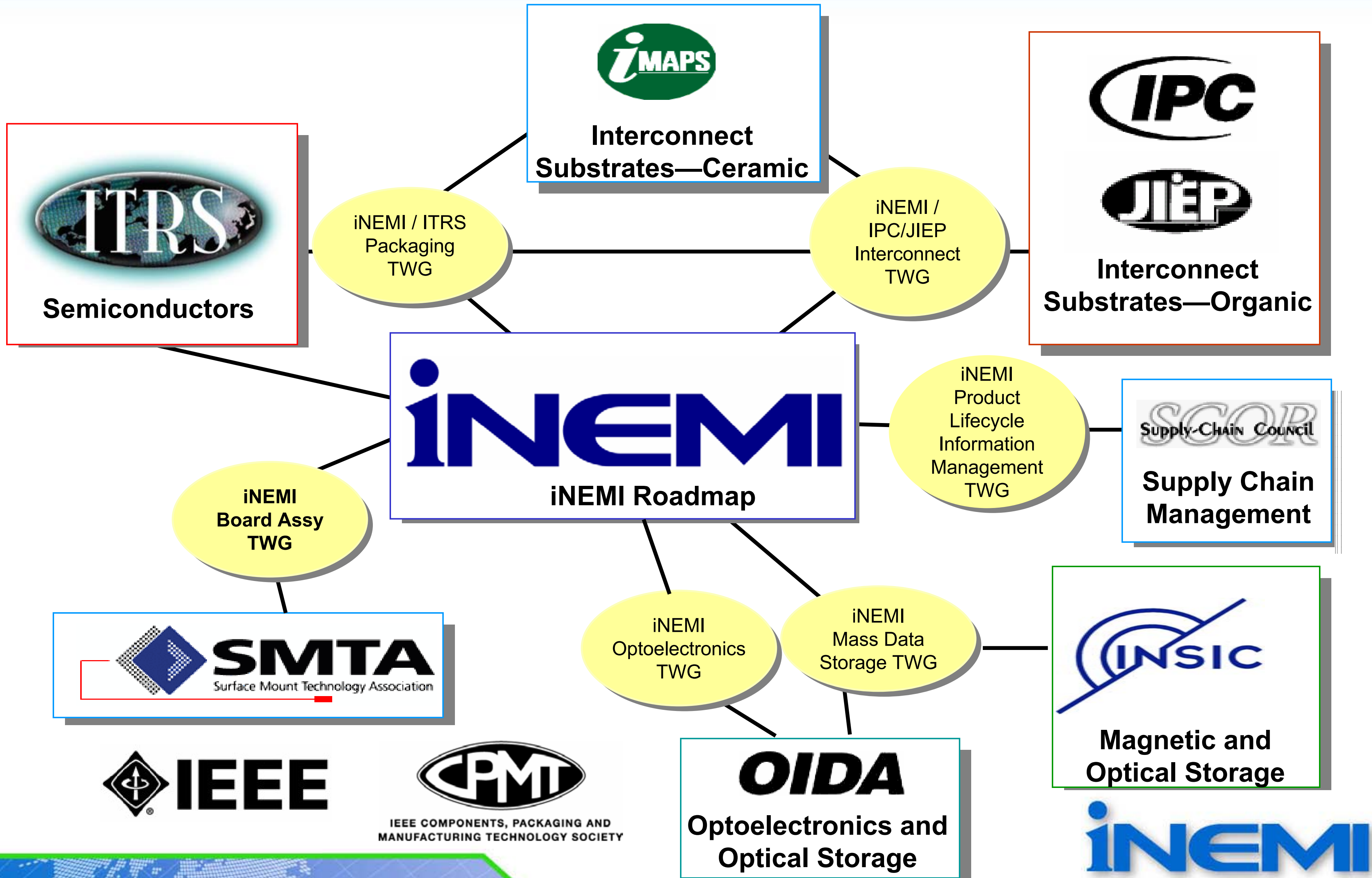
Red=Business Green=Engineering Blue=Manufacturing Blue=Component & Subsystem

Roadmap Development

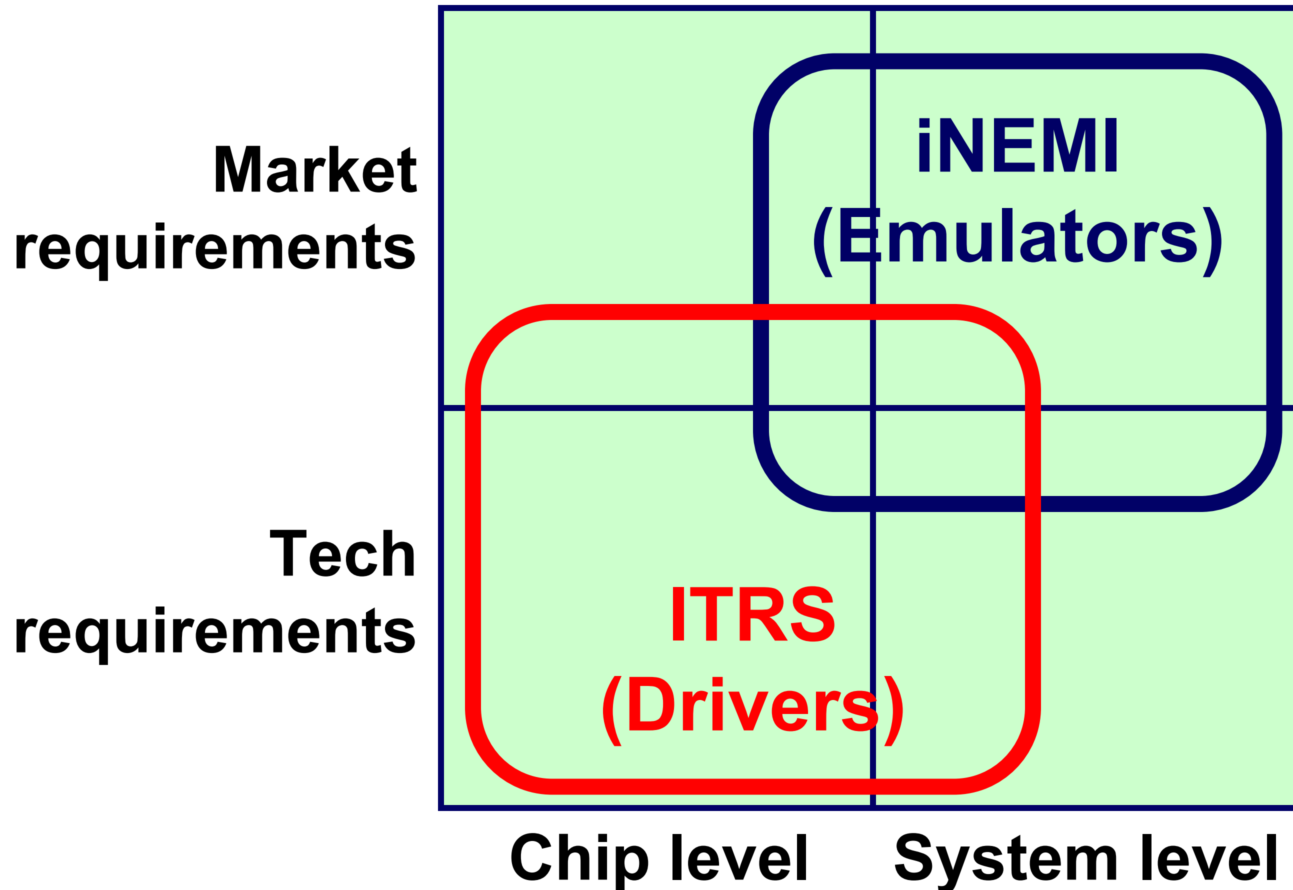
Product Sector Needs Vs. Technology Evolution



9 Contributing Organizations



Identified Needs
Increased Linkage Between ITRS and iNEMI Roadmap



Top Down Input to Roadmap

- **iNEMI Innovation Leadership Forum was helpful in Establishing A Top Down Vision of the Industry as the foundation for the Roadmap:**
  - **Innovation driven by Consumer: killer experience.**
  - **Innovation links Invention to the Market, must have social value**
  - **Concept of "Open Innovation" thru collaboration, partnering**
  - **Collaboration takes various forms, new business models**
  - **Intellectual Property protection, management**
  - **Interoperability, Open source/standards**
  - **On-demand, flexible: what/when/where you need it**
  - **Consumer Electronics demands shorter cycle times**

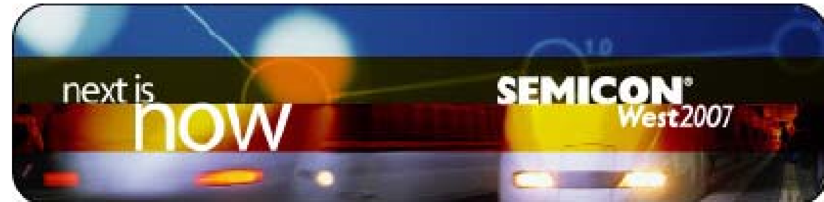
VALUE CREATION IN THE SUPPLY CHAIN

ls17.034bes-chain

	Electronic Materials *$81Bn*	Active Components *$228Bn*	IC Assembly Services *$8.8Bn*	Passive Components *$197Bn*	EMS Assembly *$127Bn*	2005 Finished Equipment *$1,126Bn*
Typical Companies	Sumitomo Bakelite, DuPont, Ablestik	Intel, STMicro, LSI Logic	Amkor, ASE, SPIL	Tyco, Molex, AVX, Sharp	Solectron, Sanmina-SCI, Flextronics	Dell, HP, Cisco, Nokia, Teradyne, Visteon, Siemens
Gross Margin	**30%**	**45%**	**17%**	**25%**	**6%**	**30%**
Operating Margin	**10%**	**15%**	**8%**	**8%**	**2%**	**8%**
R&D	**7%**	**15%**	**2%**	**5%**	**< 1%**	**8%**
Margin Value	**$8Bn**	**$34Bn**	**$0.7Bn**	**$16Bn**	**$3Bn**	**$90Bn**
R&D Value	**$6Bn**	**$34Bn**	**$0.2Bn**	**$10Bn**	**$1Bn**	**$90Bn**
%Total R&D	**4%**	**24%**				**64%**

Source: Prismark Partners

iNEMI at 2007 Industry Venues



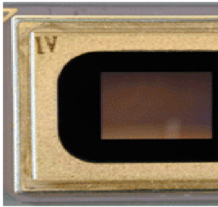
2007 iNEMI Roadmap -Highlights & Trends

State of the Art

Situation	Examples	Implications
Market / product sector convergence:		
Medical-consumer	Home diagnostics	User-friendly interface, higher volume / lower cost
Automotive-entertainment	DVD in the car	Harsher environment for consumer products
Communication-entertainment	Transmission of music & pictures	Increased integration & greater miniaturization
Computing-entertainment	Integration of PC with media centers	Harmonization of interface standards
Miniaturization and thinner	Ultra-thin cell phones, low-profile packaging, stacked thin die	Ongoing technology and manufacturing investments in package and HDI.
NPI limited by environmental requirements	Growing list of requirements: China RoHS, EU REACH, etc.	Adds complexity and uncertainty to design and start-up. Global harmonization is needed.
Outsourcing of manufacturing continues to grow faster than overall industry	Migration to India and Vietnam	Integration of design & mfg. functions is more challenging than ever. More impetus for industry standard DFX methodology.
R&D moving to lower-cost regions / emerging markets	Technology centers in China & India	More responsive to local needs. Moving away from “one size fits all.” Changing role for developed regions.

Anticipated Paradigm Shifts		
Shift	**Examples**	**Implications**
Electronic packaging materials will change over the next decade to meet reliability requirements	As density increases, today's material properties present barriers: TCE mismatch, dimensional stability, etc.	Investments in new materials systems. May require rethinking traditional reliability validation methodology.
Optical interconnect by 2017? No!	Work remains at exploratory level.	Competing technologies can meet needs at lower cost.
Low-frequency (printed) electronics for data input	Alternative technology for RFID item-level tags	Facilitates low cost point required by some applications.
New forms of data Input: displays, cameras, sensors, speech	Collision avoidance, smart RFID tags (e.g., sensors).	Drives new growth areas for electronics. Simplifies or enhances user experience.

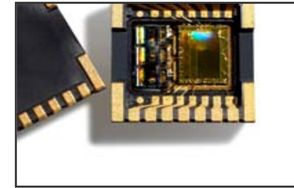
Examples of Sensors



5MP CMOS Imager
(Kodak)

Bioanalyzer (Agilent Technologies)

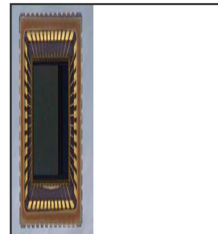
Silicon Microphone
(Knowles Acoustics)



Angular Rate Gyroscope
(Silicon Sensing Systems)

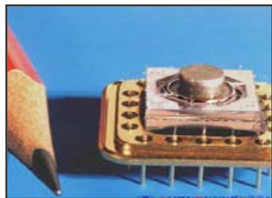
X-Wire Pedal Sensor
(Hella)

Oxygen Sensor (Delphi)

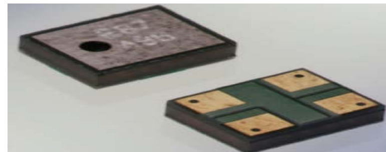


Adaptive Cruise Control Radar Module
(Continental Automotive Systems)

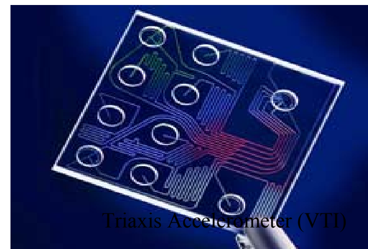
Methanol Concentration Sensor
(Sensata Technologies)



Rollover Angular Rate Sensor
(Robert Bosch)



Digital Light Processor DLP™
(Texas Instruments)



Triaxis Accelerometer (VTI)

Side Impact Sensor
(Robert Bosch)

Diesel Common Rail Sensor
(Sensata Technologies)

NOx Sensor
(Siemens VDO)

10-Year Challenges

Challenge	Description
Closing technology gaps:	
Active device technology	New CMOS structures; “beyond CMOS” topologies.
Thermal management	New materials and active cooling techniques.
Communications bandwidth	Growing requirements for moving data across the environment (from hand-held devices through the network).
Design and simulation tools	Ability to do concurrent design for circuit, thermal, mechanical, etc.
Science-based environmental improvements	Current regulations may not consider full “cradle to grave” impact.
Creating new product markets with social value:	
Energy	Higher efficiency power supplies, new energy sources for portable products.
Healthcare	Home diagnostics connected to healthcare professionals.
Security	Tamper-proof recognition / validation.

Board Assembly Roadmap

Chair: Dr. Dongkai Shangguan (Flextronics)
Co-chair: Dr. Ravi Bhatkal (Cookson)
Co-chair: David Geiger (Flextronics)

Advancing manufacturing technology

Key Trends

Business Environment

- **Higher level of service demands or opportunities placed on EMS**
- **EMS companies are expanding offerings to include services in a wider range of a product's life cycle**
- **Increased role of EMS and materials suppliers in R&D and process development**
- **Continued migration to low cost regions**

Operation		Today	Time	>	>		Future
Concept / Definition	2005	OEM	OEM	OEM	OEM	OEM-ODM	OEM-ODM
	2007	OEM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
Product Technology Development	2005	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
	2007	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
Design (Board Module)	2005	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
	2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
Design (Hardware Drivers)	2005	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP
	2007	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP	OEM-CDM-SUPP
Design (System)	2005	OEM	OEM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
	2007	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
Design (System Software)	2005	OEM	OEM	OEM	OEM	OEM-ODM	OEM-ODM
	2007	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
Design Maintenance	2005	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	EMS	EMS
	2007	EMS	EMS	EMS	EMS	EMS	EMS
Process Technology Development	2005	OEM	EMS	EMS	EMS	EMS-EQUIP	EMS-EQUIP
	2007	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP
Process Research and Development	2005	EMS-OEM	EMS-OEM	EMS-OEM-EQUIP	EMS-OEM-EQUIP	EMS-OEM-EQUIP	EMS-OEM-EQUIP
	2007	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP
Test Functional Development	2005	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
	2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
Manufacturing Test (AOI / X-Ray) Development	2005	EQUIP	EQUIP	EQUIP	EQUIP	EQUIP	EQUIP
	2007	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP
Reliability Evaluation	2005	OEM	OEM	OEM	OEM-ODM	OEM-ODM	OEM-ODM
	2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
Compliance Testing	2005	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
	2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS	EMS	EMS
Application Engineering	2005	OEM	OEM	OEM	OEM	OEM	OEM
	2007	OEM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
Failure Analysis	2005	EMS-OEM	EMS-OEM	EMS	EMS	EMS	EMS
	2007	EMS	EMS	EMS	EMS	EMS	EMS

Key	
OEM	Original Equipment Manufacture has primary resposibility
ODM	Original Design Manufacture or EMS developing and marketing products has primary responsibilty
EMS	Electronics Service Provider has primary responsibilty
SUPP	Component supplier to board assembly has primary responsibility
EQUIP	Equipment/materials supplier for board assembly has primary responsibility
OEM-CDM-SUPP	Combination of OEM, ODM, & Component Suppliers responsibility
EMS-OEM-EQUIP	Combination of OEM, ODM/EMS & Equipment/Material suppliers responsibility
EMS-EQUIP	Combination of Equipment/Materials suppliers and EMS/ODM responsibility
EMS-OEM	Combination of EMS & OEM responsibility
OEM-ODM	Combination of OEM and ODM responsibilty

Key Trends

Main Drivers for Development in Board Assembly

- Conversion Cost Reduction
- Reduction in Time-to-Add-EMS and NPI Time
- Increased Component I/O Density
- Transition to Environmental and Regulatory Compliance
- Higher Quality Expectations / Lower Defect Rates

Table 2: Forecasted conversion to Lead-free by product

	2005	2007	2009	2015	2017
PORT	SnPb	Pb-Free	Pb-Free	Pb-Free	Pb-Free
MED	SnPb	SnPb	Mixed	Mixed	Pb-Free
DEF	SnPb	SnPb	SnPb	SnPb	SnPb
AUTO	SnPb	SnPb	Pb-Free	Pb-Free	Pb-Free
OFF	SnPb	Pb-Free	Pb-Free	Pb-Free	Pb-Free
COMM	SnPb	SnPb	Pb-free	Pb-free	Pb-free

Key Trends

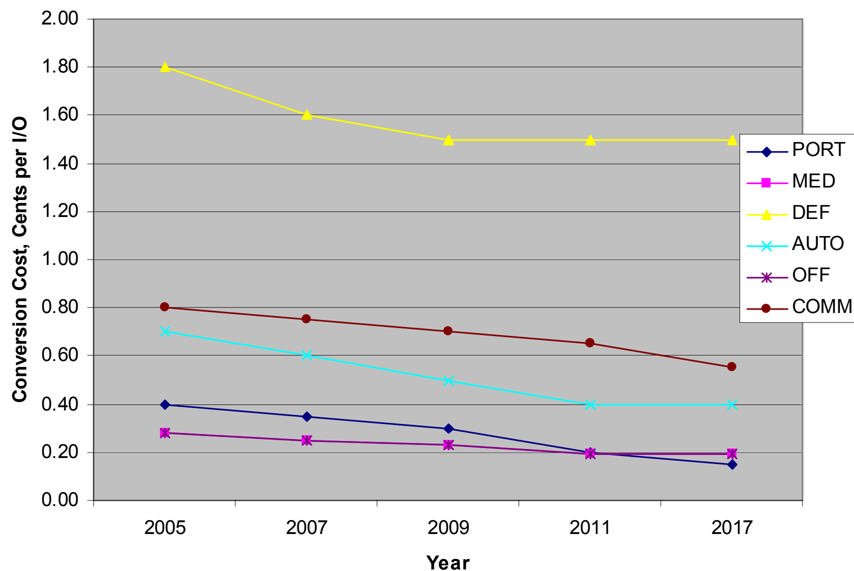


Figure 1*: Board assembly conversion cost forecasts by product sector*

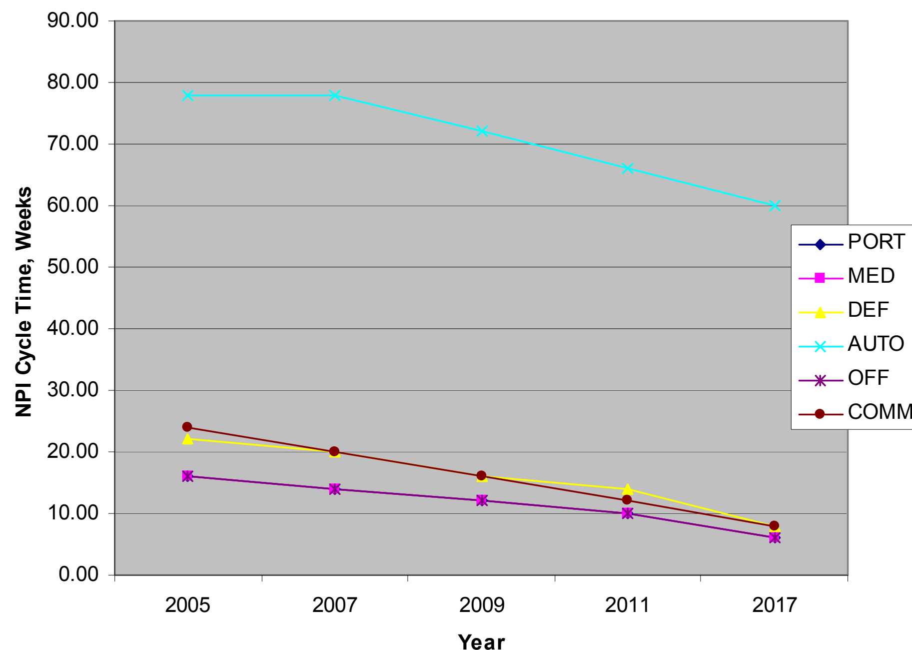


Figure 4*: NPI Cycle Time by product sector*

Cost to take a group of parts and convert them to a functioning electronic assembly, i.e. price of a completed PCBA (including test, material procurement cost, etc.) minus the material cost

Time from when a design is released for alpha prototyping to the time when it is released for production - assuming that the prototype parts are available at release

(Source: iNEMI Product Emulator Groups)

Key Trends

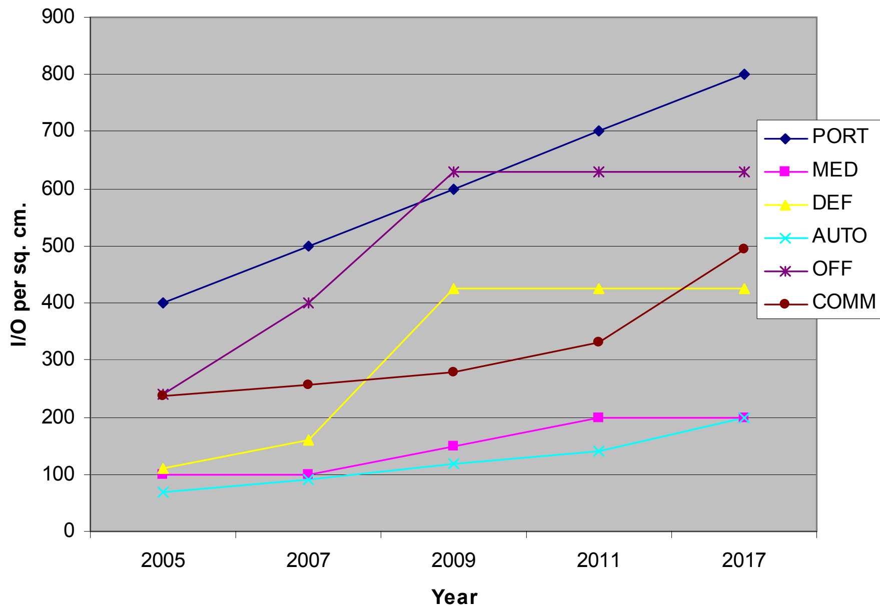


Figure 5: Maximum Component I/O Density by product sector

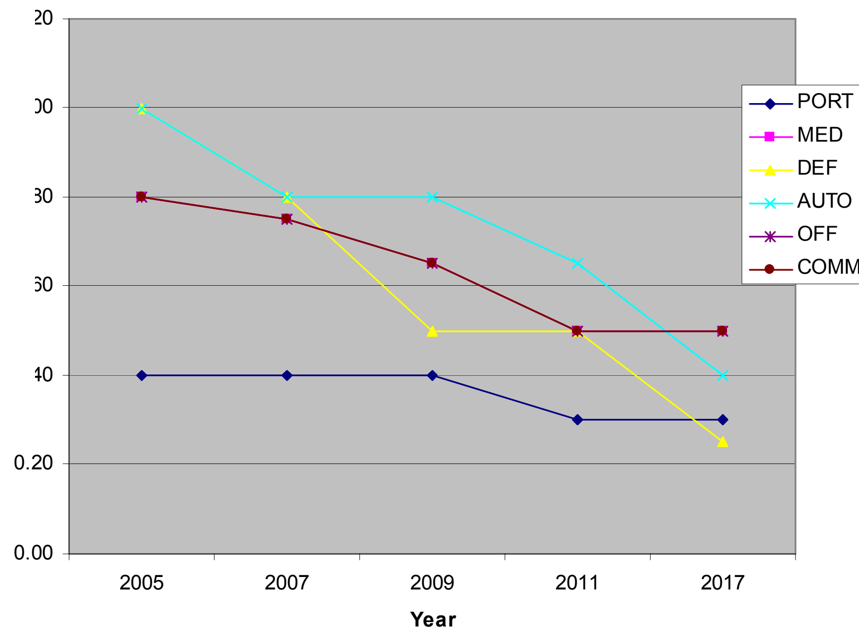


Figure 6: Minimum Area Array Package Pitch

Technology Gaps and Challenges

Materials

- **PCB / Substrate**
  - Higher use of flexible (especially for Portables) and low loss materials (especially for Communications and Medical)
    - Increased use of LCP
  - Availability of low cost board technology to handle very fine pitch high I/O devices
  - Decreasing pad diameters impacting the reliability of the second level assembly
  - Transition to embedded passives (in Portables)
  - Lead-Free applications

- **01005**
  - Component availability for the range of values required
  - Cost
  - Assembly process development

Technology Gaps and Challenges

Equipment

Placement Equipment

- Capability to monitor the incoming component quality real-time, during the placement process (while still providing a reasonable ROI)
- Integration of press fit technology in the SMT process will improve productivity with the higher adoption of flexible tooling
- Odd form capabilities
- Flexible circuit assembly
- Increased capabilities with aggressive pricing

Business Issues / Potential Barriers

- Emerging technologies
  - With R&D transitioning to low cost geographies, government, academia and industry consortia will need to formulate ways to adopt and develop emerging technologies (such as nano-technology) into the board assembly process, in the global outsourcing environment
- DFM in the global outsourcing environment requires closer interactions and collaboration across the supply chain
  - Industry standards need to be further developed to facilitate and streamline information flow

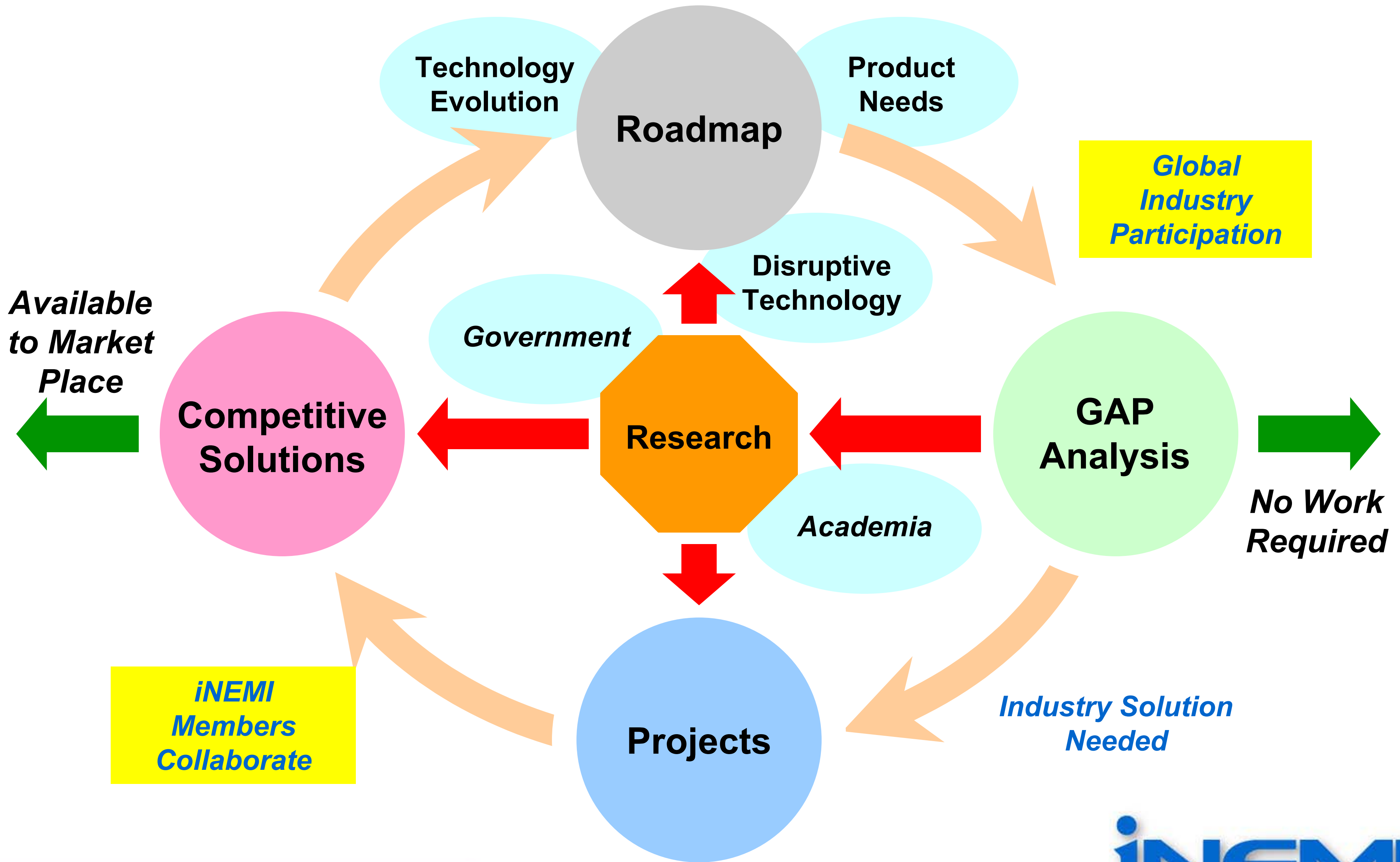
Summary

- Miniaturization is a key driver in electronics industry:
  - IC Packaging
  - Board Assembly
  - Increased functionality of End Product
- End product manufacturing is increasingly commoditized:
  - Migration to low cost geographies
  - Relentless cost pressures
  - Low margin business
- New technologies are required to keep pace:
  - Green materials
  - Nanomaterials (e.g. temp. reduction of Pb-free solders)
  - Warm Assembly.
- Have covered only highlights from 1 of 19 roadmaps
- Many more details in full Roadmap

Next Steps for iNEMI Members

Advancing manufacturing technology

Next Step: Gap Analyses



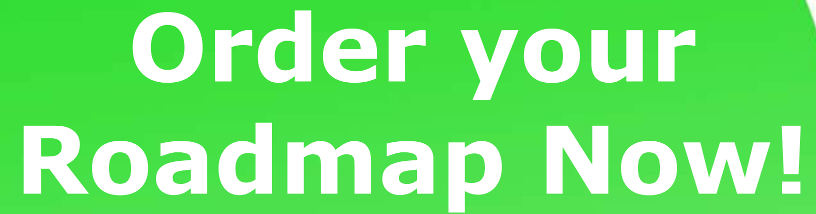
Mining the 2007 Roadmap

***Identify* and *Close* TECHNOLOGY GAPS which includes the development and integration of the electronics industry supply infrastructure.**

- **Technical Committee is reviewing gaps to identify new projects**
- **Prioritization will be a key element of the gap analysis**

Some Projects Currently being Proposed by members to address identified gaps

- **Halogen-Free Printed Wiring Board Assemblies**
  - **Focus on High End Products**
  - **Impact of High Temperature reflow on reliability**
  - **High Frequency Electrical Performance**
- **Substrate Surface Finishes for Pb-Free Assembly**
  - **Component Finishes for High Reliability Applications**
  - **Substrate Finishes for high yield volume production**



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