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International Electronics Manufacturing Initiative

**Thrust Areas for  
the Electronics  
Industry:  
Miniaturization and  
the Environment**

*Bob Pfahl  
IMPACT 2009  
October 22, 2009*

Advancing manufacturing technology

# Outline

- **Introduction**
- **2009 iNEMI Roadmap: Highlights**
- **Miniaturization: Systems Packaging Evolution**
- **Energy and The Environment**
- **Conclusions**



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# Introduction

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# Who Are We?

- **iNEMI organization:**
  - Corporate membership
  - Not-for-profit, R&D consortium
  - Collaboration defined by organization by-laws, intellectual property policy, and project agreements.
- **Member companies/organizations:**
  - Leadership OEM, EMS, and Supplier companies
  - Government labs
  - Academic Institutions.
- **Small staff provides services to facilitate global collaboration (USA, Asia & Europe):**
  - Support to help organize & manage projects
  - Communication services for collaboration
  - Manage Relationships with other Organizations.

# Current OEM/ODM/EMS Members



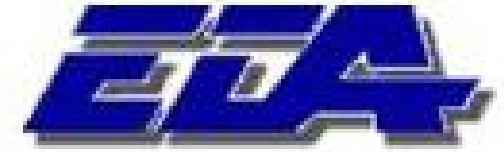
# Current Supplier Members



Electronic Materials



# Current Association/Consortium, Government, Consultant & University Members



ASSOCIATION CONNECTING  
ELECTRONICS INDUSTRIES®



**ITRI**  
Industrial Technology  
Research Institute



**NIST**

National Institute of Standards and Technology



# Deliverables

*“Advancing Manufacturing Technology”*

**iNEMI provides five important deliverables:**

- 1. Technology roadmaps**
- 2. Technology deployment projects**
- 3. Research priorities**
- 4. Forums on key industry issues**
- 5. Position papers to focus industry direction**

# Leadership through Innovation

- A proven approach for identifying the technology needs and gaps of the industry through our roadmapping process
- A strong track record of developing supply chains to introduce new materials, processes, and technologies into production
- A research vision with three major thrusts:
  - **Miniaturization**
  - **Energy & the Environment**
  - **Medical Electronics**



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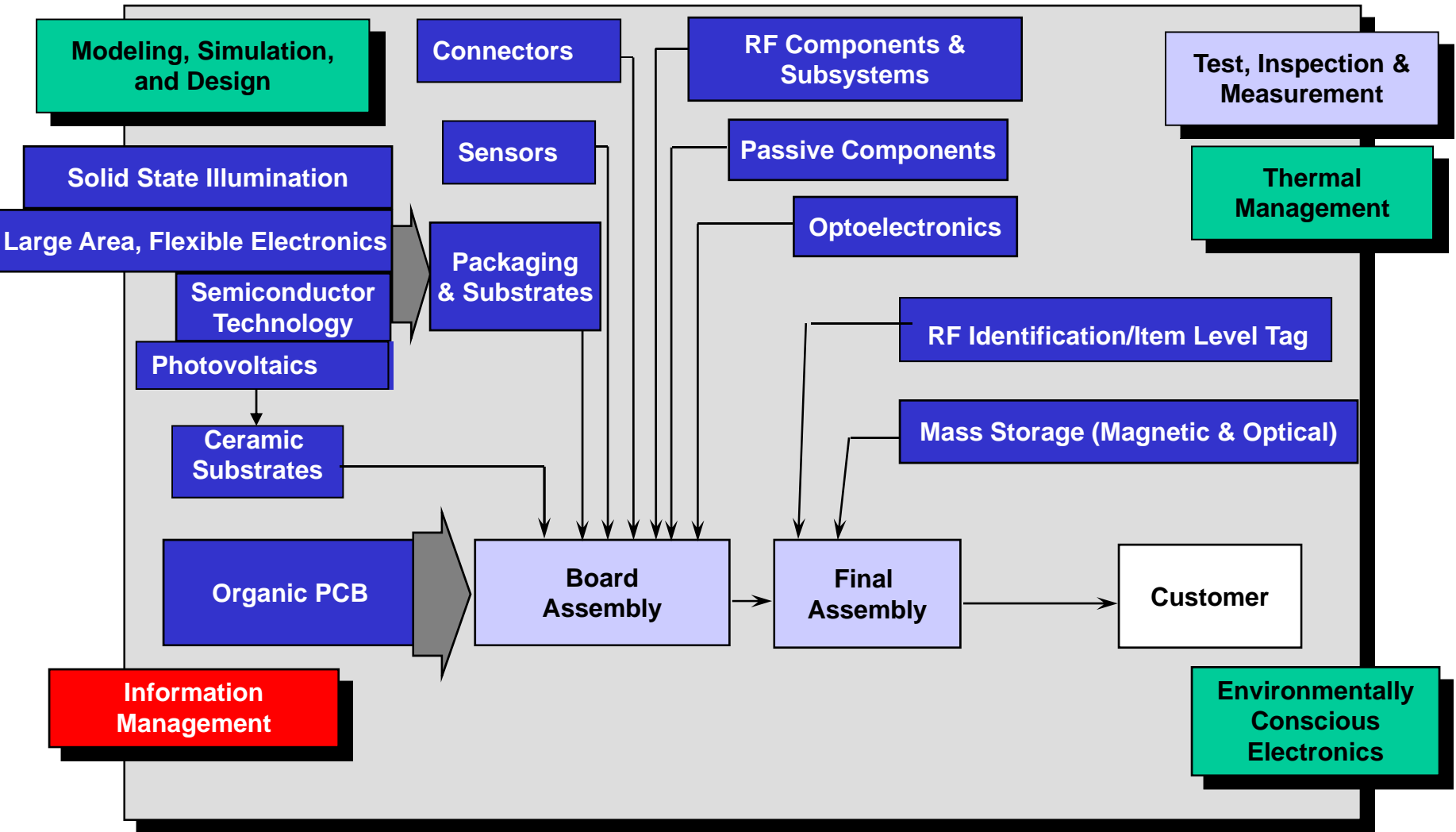
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## 2009 iNEMI Roadmap: Highlights

*Business Issues*  
*Product Issues*  
*Technology Issues*

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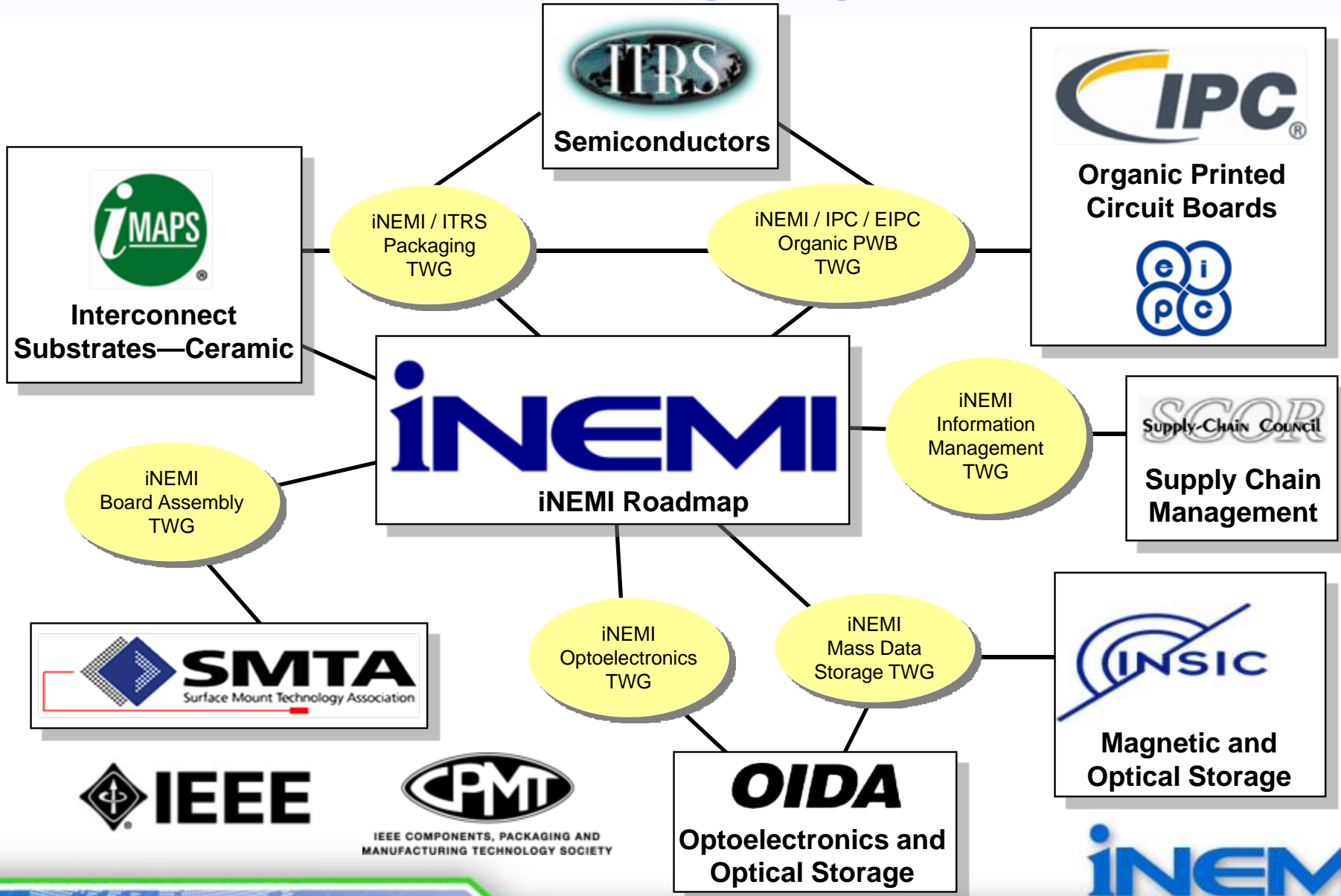
# 2009 Technology Working Groups (TWGs)



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

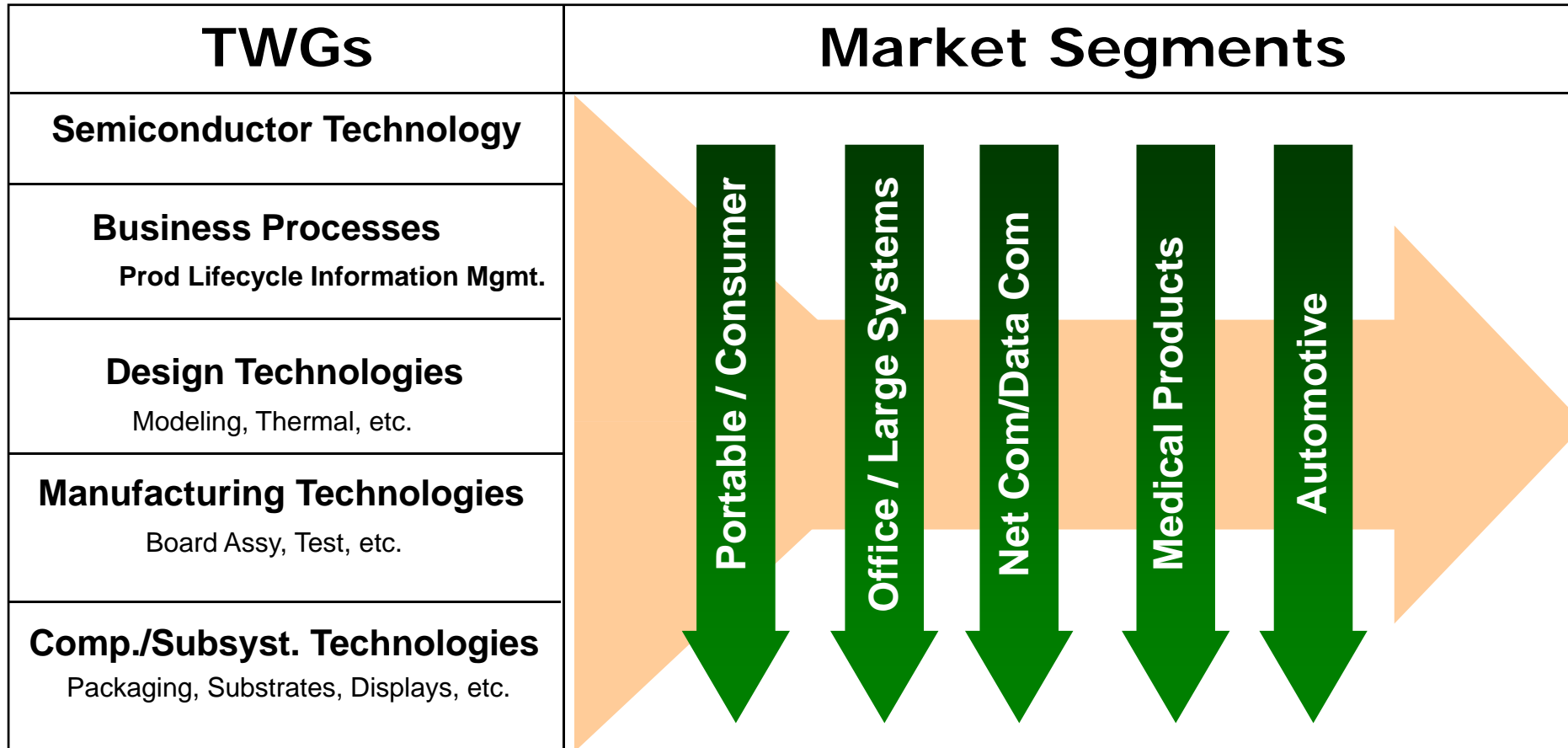


# Nine Contributing Organizations



# Roadmap Development

## Product Sector Needs Vs. Technology Evolution





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## Business Issues

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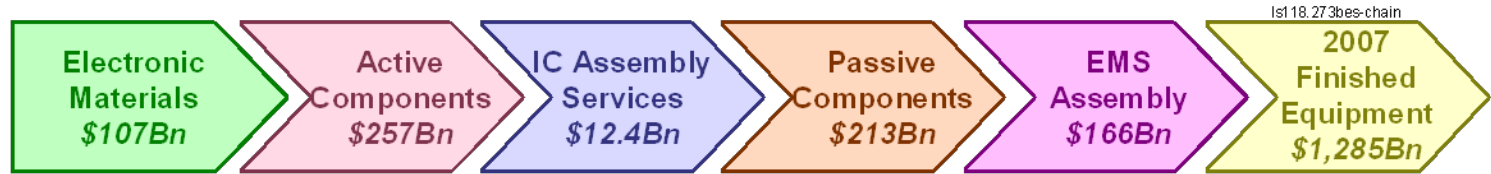
# Changing Market

- **Growth of Electronics Content in Automotive**
- **Convergence (Driven by wireless/portable products)**
  - **Medical-Consumer**
  - **Automotive-Entertainment**
  - **Communication-Entertainment**
- **Medical Electronics focus shifting towards diagnostics/prevention vs. therapy.**
  - **Motivations: reduce cost & improve outcomes**
  - **High volume consumer oriented**
  - **Challenge of quick regulatory acceptance**

# Strategic Infrastructural Changes

- **The restructuring of the electronics industry over the last decade from vertically integrated OEMs to a multi-firm supply chain has resulted in a disparity in R&D needs versus available resources.**
- **Restructuring has created skill gaps at various nodes of supply chain.**
- **Critical needs for research and development exist in the middle part of the supply chain (IC assembly services, passive components and EMS assembly) and yet these are the firms least capable of providing the resources.**
- **A partial solution has been the development of vertical teams to develop critical new technology while sharing the costs.**

# VALUE CREATION IN THE SUPPLY CHAIN



ISI18.273bes-chain

## Typical Companies

Sumitomo Bakelite, DuPont, Henkel

Intel, STMicro, LSI Logic

Amkor, ASE, SPIL

Tyco, Molex, AVX, Sharp

Sanmina-SCI, Flextronics, Jabil, Hon Hai

Dell, HP, Cisco, Nokia, Teradyne, Visteon, Siemens

## Gross Margin

40%

40%

17%

25%

6%

30%

## Operating Margin

10%

10%

8%

8%

2%

8%

## R&D

7%

10%

2%

3%

< 1%

3%

## Margin Value

\$11Bn

\$26Bn

\$0.2Bn

\$17Bn

\$3Bn

\$103Bn

## R&D Value

\$5Bn

\$26Bn

\$0.2Bn

\$6Bn

\$1Bn

\$38Bn

## % Total

### R&D

7%

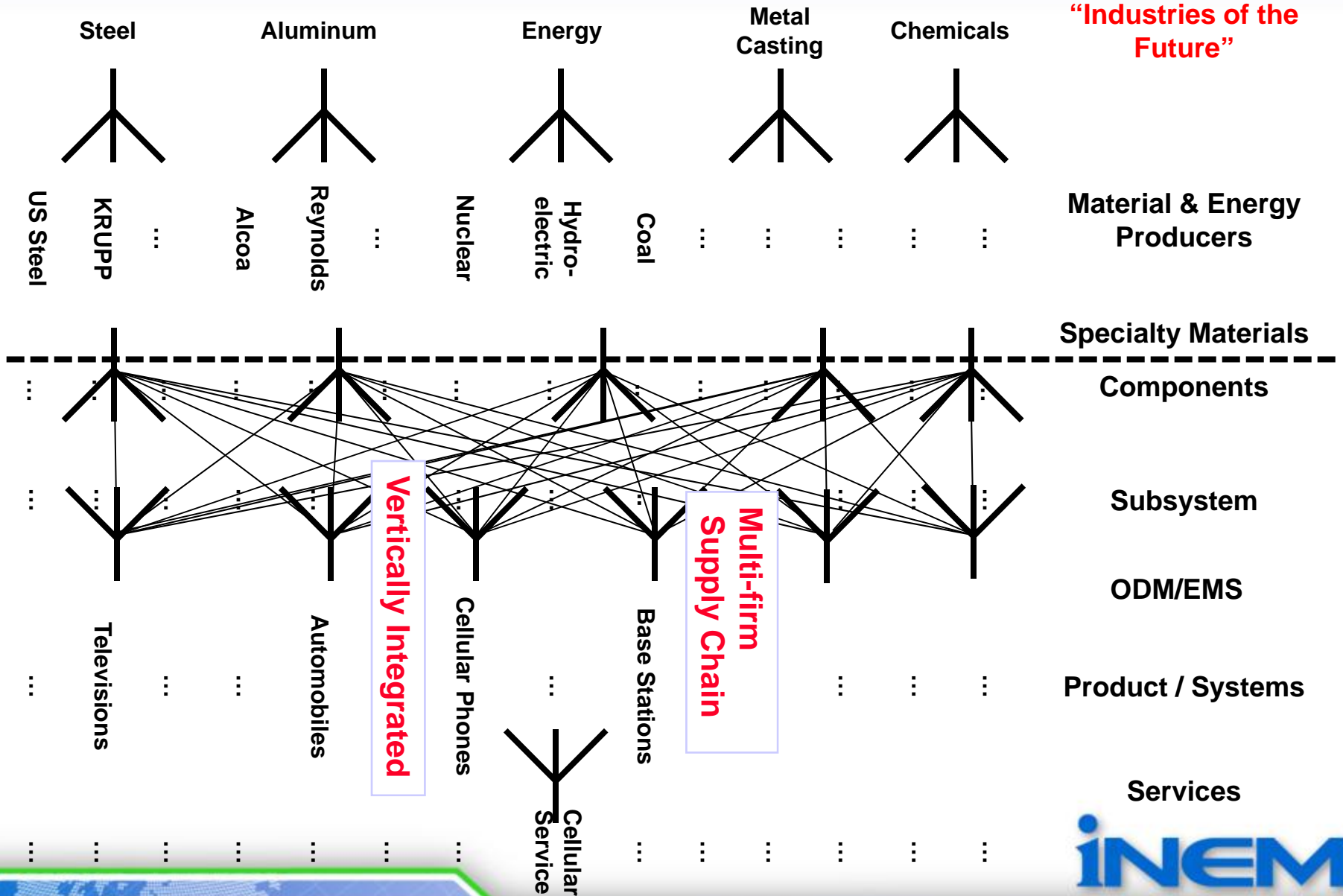
34%

8%

51%



# Industrial Structure





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## Product Issues

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# Product Issues

- **Miniaturization and Thinner**
- **Quality, reliability, cost**
- **Time to market**
- **Increasing Material Restrictions**
- **Increased focus on Energy Reduction**
  - Both product & manufacturing
  - Life-cycle approach
- **Counterfeit Products**



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# Technology Issues and Needs

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# Key Technology Issues

- **Semiconductors:**
  - **Scaling and next generation technology**
- **Packaging: More than Moore**
  - **New level of packaging blending Semiconductor back end and assembly/packaging, infrastructure.**
  - **Stacked Die**
    - **Cooling**
    - **Through hole via process and reliability**
    - **Assembly accuracy required for PoP, stacked die, etc. not consistent with today's Board Assembly equipment.**
    - **Reliability**
  - **New capability to close the gap between chip and substrate interconnect density: "Shortstopper"**
    - **Silicon Interposer**
    - **Organic**

# Identified Needs

## Manufacturing Technologies

- **Manufacturing processes to accelerate miniaturization**
- **Assembly processes that support 3-D structures and low temperature processing.**
- **Warpage Reduction**
  - Wafer
  - Package
  - PWB
- **Lower testing costs, particularly for new non-digital technologies**



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# Miniaturization: Systems Packaging Evolution

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# Evolution of Packaging Technology

- 1965-Through hole discretetes
- 1975-Through hole devices (DIP's etc)
- 1985-Surface Mount Technology
- 1995-Area Array Packaging (Flip chip to BGAs) and HDI
- 2005-SiP
- **2015-3D Packaging**

**Key:**

Developed by Vertically Integrated Firms

**Developed by Multi-firm Supply Chains**

# The Pace of Change in Packaging is Increasing

- **As traditional CMOS scaling nears its natural limits other technologies are needed to continue progress**
- **This has resulted in an increase in the pace of systems packaging innovation.**
- **Many packaging processes have outpaced Roadmap forecasts. Among these are:**
  - **Wafer thinning and handling of thinned wafers/die**
  - **Wafer level packaging**
  - **Incorporation of new materials**
  - **3D integration**

**“Consumerization” of electronics  
is the primary driving force.**

# System level Integration in the Package

The most important trend in packaging is the incorporation of system level integration through **System-in Package**

- This enables equivalent scaling through functional diversification
- The result is a demand for new packaging capability requiring new technology and new materials:
  - Higher interconnect density in package
  - Increases thermal density
  - Test access challenges
  - More difficult demands associated with ensuring reliability

# Digital Convergence-Multifunction Systems

Motorola Q™ Global



- Telephone
- Mobile Computing
  - ✓ Windows Mobile 6.1
  - ✓ Windows Media Player
  - ✓ QWERTY keyboard
  - ✓ 320x240 display
  - ✓ Opera browser
  - ✓ DataViz Documents to Go
  - ✓ Messaging
  - ✓ Up to 32GB of storage
- GPS receiver
- Record and Play multiple audio formats
- Integrated 2.0 megapixel camera
- Video
  - ✓ Capture at 15 fps
  - ✓ Playback up to 30 fps
  - ✓ Multiple video formats supported



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# What Characterizes an electronic “system”

## An OEM’s Perspective

- **Performs specified Function**
- **Cost**
- **Physical Size**
  - It could fill a room or be an electronic Package
- **Reliability Expectation**

# System Package Reliability

- **The reliability of new technologies which are critical for the miniaturization of electronics and the continued growth of the consumer electronics market is not well understood**
  - **Different Process and Materials can be used to implement a common function.**
  - **There is limited industry wide data on the reliability of these new technologies under various use conditions**
  - **There is limited characterization data available on the types of failure mechanism and related test methods for acceleration of failure mechanisms**
  - **New technologies are being introduced faster than our ability to fully understand reliability.**

# Industry Supply Chain

- **Traditional Integration Flows: Clearly Defined Roles by hierarchy interconnect levels.**
- **Advanced Technology ( SIP, 3-D) Integration Flows:**
  - Not necessarily defined by traditional interconnect levels
  - Manufacturers have used existing technology strengths
    - Utilized their most efficient processes and existing capital equipment to minimize cost
  - Same functional “system” might contain totally different technology
    - Failure Modes may be different
    - Reliability must be the same
- **Technology and Technologists alone will not determine the evolution of 3-D Integration**
  - Technology that can quickly, reliably & competitively respond to Market Needs will win, leading to convergence of packaging alternatives

# iNEMI Packaging Substrate Workshop

**Date:** November 17-18, 2009  
**Conference Venue:** Newton Room, Lucent Tower  
Nagoya, Japan  
**Hotel:** Marriott, Nagoya  
**Cost:** Members \$250; Non-members \$400  
**Meeting scope:**



- **Industry workshop to identify gaps in organic substrate technology that need to be addressed to facilitate miniaturization of electronics packaging. The workshop will:**
  - **Feature speakers from OEMS, Semiconductor Firms, Packaging Firms, Substrate Providers (Cisco, Intel, STATS ChipPAC, TI, ASE, Ibsiden, Kyocera, Nan Ya, UMTC)**
  - **Review organic substrate technology roadmaps and compare vs. industry requirements – Identify Gaps**
  - **Brainstorm options and priorities**
  - **Establish action groups to address specific issues raised in meeting**





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## Energy and The Environment

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# 2009 Environmentally Conscious Electronics (ECE) Roadmap

## Five Chapters

- **Materials**                      **Holly Evans, Strategic Counsel, LLC**
- **Energy**                              **Valerie Rickman, ITI**
- **Recycling-Reuse**                      **Jason Linnell, National Center for Electronic Recycling**
- **Eco-Design**                      **Cliff Bast, Acer, Inc.**
- **Sustainability**                      **Markus Stutz, Dell**

# Trend Analysis

- **To produce environmentally-conscious electronics the industry must continue to keep pace with:**
  - Continuing emergence of material restrictions
  - Energy efficiency requirements and renewable energy
  - End-of life requirements
  - Holistic Eco-design requirements
  - Sustainable business practices
- **As many of these issues are shared by industry, it's best to work together!**



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**Materials**

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# Materials

## Short Term Needs - Identified in 2009 Roadmap

- **A strategy and action plan to facilitate low risk conversion of high-reliability applications to Pb-Free solders**
- **Prepare for possibility of additional substance restrictions under RoHS and/or REACH (HBCDD, phthalates)**
- **Proactive programs to convert to halogenated flame retardant (HFR) - free and PVC-free material alternatives**

# iNEMI HFR-Free Leadership Program

## Consortium Objectives

- 1. Identify technology readiness, supply chain capability, and reliability characteristics for “BFR-free” alternatives to conventional printed circuit board materials and assemblies**
  - Spans electrical and mechanical properties
  - Includes assessing if board/system design modifications can overcome material property limitations
- 2. Define technology limits for BFR-free materials across all market segments**
  - Initial focus is on client platforms (desktop, notebook)
  - Goal is to drive laminate supplier slash sheet content

# Program Highlights

- **A broad transition to halogen-free materials could become quite disruptive**
- **Existing halogen-free materials are worse than existing brominated FR4 on several key parameters**
- **This effort is focused on driving tradeoffs across design, fabrication, and materials to derive solutions**
- **95 People Attended Program Review in Taipei on April 15, 2009**
- **22 International Firms are members of the Program**

# HFR-Free Leadership Program

## 22 Global Firms



**DELPHI**



**FLEXTRONICS**



**Elec & Eltek 依利安達**



Electronic Materials



# Materials

## Recommendations

- **Need for development and implementation of good scientific methodologies to assess true environmental impacts of materials and potential trade-offs of alternatives (LCA-type approach)**
- **Greater involvement of industry on policy making for material restrictions to assure better understanding of trade-offs inherent in substitutions**



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## Energy

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# The Big Picture

## Climate/ Energy Example



### How do we get the facts and data?

- Standardized Product Lifecycle Assessment
- Identifies opportunities & issues
- Allows identifying what counts most

Global CO2 Emissions

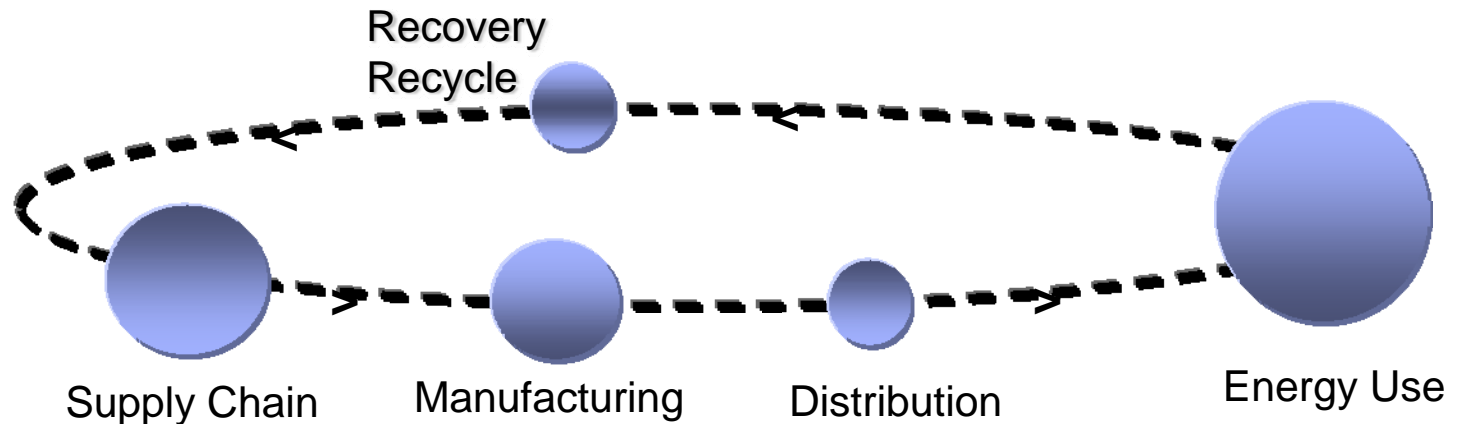
~ 40 Billion tonnes

~2%

ICT Sector  
~ 850 Mil tonnes

PC Sector

~ 320 Mil tonnes



Sources: Smart 2020 Report 2008; IDC; Gartner



# Energy Efficiency – Becoming More Common in the Marketplace

**It pays for businesses to “go green”**

Protecting the environment is not only good for the planet—it’s also good for business. When you make smarter choices that minimize toxins, lower your power and cooling costs, and bring your organization into compliance with regulatory standards, your company can boast about being a good corporate citizen while simultaneously reducing ongoing expenses in the datacenter. Call PC Mall for expert advice on minimizing your company’s environmental impact while maximizing its bottom line.

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**Lenovo takes an active role in combating climate change**

**lenovo**

Lenovo is committed to providing environmentally responsible, energy-efficient technology choices. In 2007, they joined the Board of Climate Savers Computing to support their efforts in reducing CO<sub>2</sub> emissions related to IT by 50% by 2010.

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Lenovo's green strategies include:

- All Lenovo ThinkPad notebooks, ThinkVision monitors and many ThinkCentre products launched from 2008 are ENERGY STAR® 4.0 compliant and deliver up to 70% energy efficiency improvements
- Lenovo systems with EPEAT Gold ratings contain up to 90% reusable and recyclable materials and ship in packaging that is 90% recyclable
- Lenovo Power Manager and BatteryStretch technologies offer adjustable power management

All Lenovo LCDs launched from 2008 are ENERGY STAR 4.0 and EPEAT Gold certified.

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# Energy

## Situation Analysis

- Energy Costs Impact End User
- Regulations impact technology choices
- Energy Management
  - Reducing Energy Use in Data Centers is a Market Opportunity
  - 2011 Roadmap will show **10 °C Increase** in Data Center Temperatures

## Needs

- More efficient power supply technology
- Harmonize energy management standards (Energy Star, EuP, etc)
- New innovative energy sources



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## End of Life: Recycling-Reuse

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# Recycling-Reuse

- **Develop metrics and infrastructure for effective resource management**
  - Quantify & promote dematerialization efforts underway within industry
  - Increase information sharing between brand owners and electronics recyclers to increase reuse/recycling efficiencies & lower costs
  - Prioritize product & packaging design features that will enable cost-effective, environmentally-responsible reuse/recycling, use data to influence emerging regulations and standards (Basel Convention, R2 guidelines, EPEAT, etc)
- **Identify opportunities for post-industrial & post-consumer recycled content**
  - Quantify use of recycled content metals and plastics in “common” electronic components today, identify opportunities for further R&D



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## Eco-Design

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# Eco-Design

- **Promote life cycle thinking**
  - Develop building block approach to LCAs in IT industry (iNEMI Eco-Impact Evaluator Project, in progress)
  - Participate in international carbon footprint standards, particularly as they relate to product carbon footprint (PCF) labeling (ex: GHG Protocol)
- **Encourage harmonization of green procurement standards in both B2B and B2C markets**
  - Prepare for revision to IEEE 1680 (EPEAT standard for PCs) and future EPEAT standards for printers, servers, etc
  - Identify key requirements differences in regional green procurement standards, work towards global harmonization (ex: painted plastics)
  - Address emerging retailer interest in sustainability “indexing” in EU, US
- **Engage in international eco-design standards**
  - Existing ICT/CE Vertical IEC Standard 62075
  - New Horizontal “Environmental Conscious Design” IEC Standard 62430



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**Sustainability**

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# Sustainability Requires Balancing Competing Objectives

- **Environmental Regulations do not always lead to sustainability**
  - **Legislating the use of corn based ethanol in automobile fuels without considering environmental, social and economic impacts**
  - **Legislating the use of Compact Fluorescent Lamps without requiring the development of a recycling infrastructure for the mercury in the lamps.**

# Sustainability

## Electronics as solution to climate change

- Smart city planning
- Smart buildings
- Smart appliances
- Dematerialization
- Smart industry
- I-optimization
- Smart grid
- Integrated renewables
- Smart work
- Intelligent transport

**Potential Impact: Reduction of 1 billion tons of Green House Gas emissions.**



# iNEMI Environmental Forums

**“The electronics industry must develop a strategic vision of sustainable electronics” iNEMI Board of Directors**

- **“iNEMI Sustainability Summit”, September 22-23, 2008, Motorola, Schaumburg, Illinois, USA**
- **“2008 Intel Forum on Environmentally Friendly Materials”, November 11-12, 2008, Shanghai, China**
- **“Environmental Leadership Forum” October 8, 2009; at SMTAI, San Diego, CA, USA**
- **“iNEMI-Intel Global ICT Environmental Initiatives”, October 27-28, 2009; Brussels, Belgium**

# Results from Forums

- **Two LCA Projects Established**
  - **Eco-Impact Evaluator for ICT Equipment**
  - **PVC Alternatives**
    - **LCA comparing PVC versus PVC-free cables**
- **Five Initiatives Under Evaluation**
  - **Develop market for postconsumer plastics as feedstock for “Green” products (ex. Polycarbonate, ABS)**
  - **Develop applications for post consumer blended plastics**
  - **Develop Carbon Footprint metrics**
  - **BFR-Free Connectors**
  - **Increased Harmonization of Regulations**

# Concluding Thoughts on the Environment

- **New global environmental requirements continue to multiply – faster than industry can effectively respond**
- **Industry needs to be more proactive in developing solutions that:**
  - **Are based on science and engineering, delivering value to customers**
  - **Are available in advance of new regulations**
  - **Can influence future regulations and stakeholder groups for more sustainable results**
- **iNEMI and its members plan to play a significant role in preparing industry for these future needs.**
- **Sustainability will be a major undertaking for industry as well as society.**
- **Electronic solutions can help to empower people to live a more sustainable lifestyle**



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## Conclusions

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# Strategic Infrastructural Changes

- **The restructuring of the electronics industry over the last decade from vertically integrated OEMs to a multi-firm supply chain has resulted in a disparity in R&D needs versus available resources.**
- **Restructuring has created skill gaps at various nodes of supply chain.**
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- **A partial solution has been the development of vertical teams to develop critical new technology while sharing the costs.**

# Concluding Thoughts

## Impact of the Recession

- **Strengthening of vertical development teams (across design / supply chain)**
- **Will delay new technologies requiring significant investments (both capital and R&D)**
- **Increased consortial activity on environmental efforts (reduce total industry investments)**
- **Industry must work together to determine their priorities for closing Technology Gaps**



[www.inemi.org](http://www.inemi.org)

Email contacts:

*Bob Pfahl*

*bob.pfahl@inemi.org*

*Haley Fu*

*haley.fu@inemi.org*



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