The Center for Energy-Smart Electronic Systems

January 2014

an NSF Industry/University Cooperative Research Center

Enabling Energy Efficient Data Centers for New York and the Nation

The Center for Energy-Smart Electronic Systems

Center Vision: To create electronic systems that are self sensing and regulating, and are optimized for energy efficiency at any desired performance level.

ES2 works in partnership with industry and academia to develop systematic methodologies for operating information technology, telecommunications, and electronic systems and cooling equipment

The ES2 Team

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The University of Texas at Arlington

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Villanova University

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The Georgia Institute of Technology

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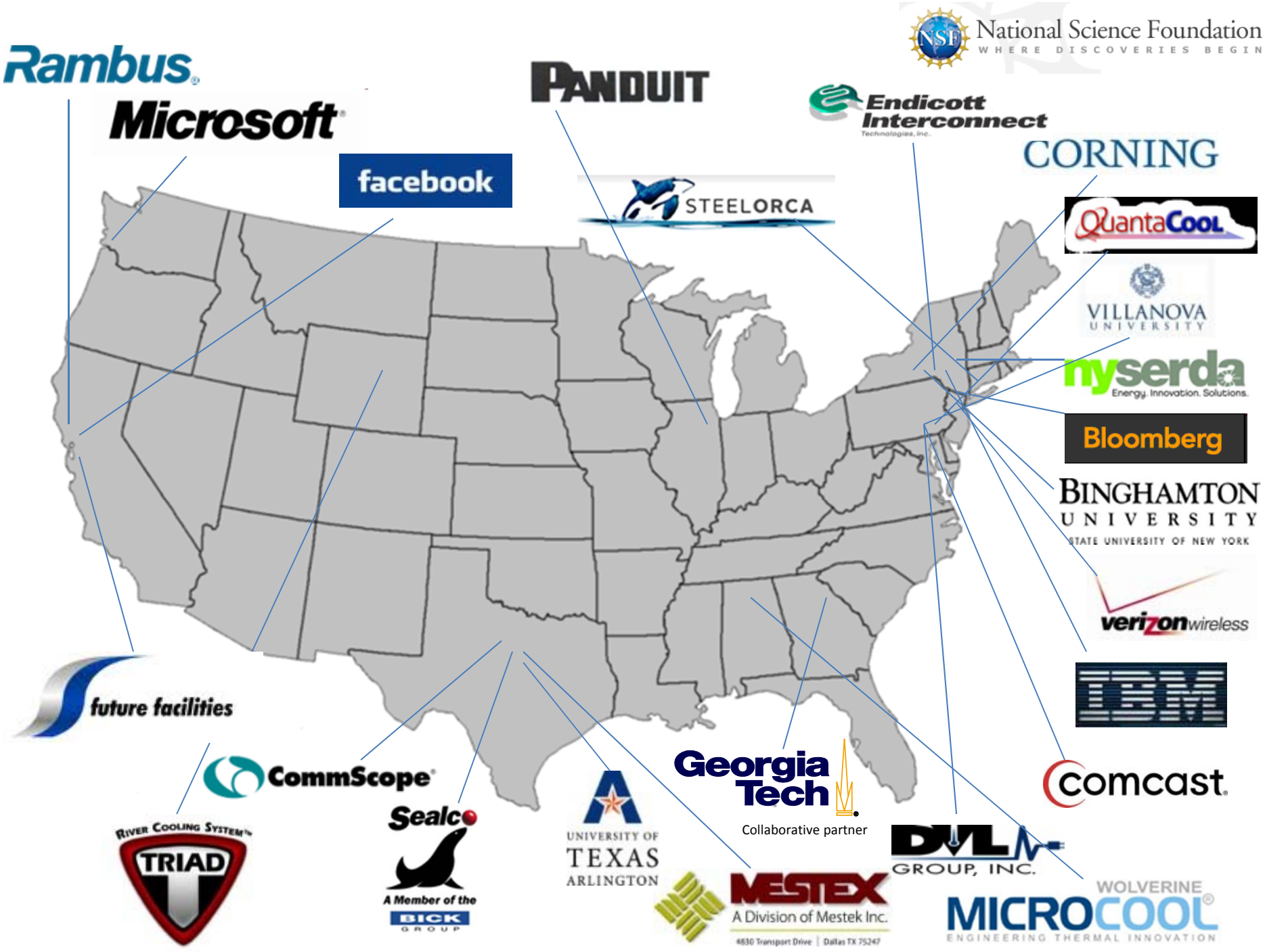
ES2 Industry Partners

Founding members of NSF Industry/University Cooperative Research Center
First Industrial Advisory Board meeting: December 8-9, 2011

- **Corning, Inc.**
- **IBM**
- **Panduit**
- **Microsoft**
- **Bloomberg**
- **Degree Controls**
- **Facebook**
- **Future Facilities**
- **Internap**
- **Sealco/Bick Group**
- **Wolverine Microcool**
- **NYSERDA**
- **Commscope**
- **Verizon**
- **Comcast**
- **Steel Orca**
- **DVL**
- **Mestex**
- **Quanta Cool**
- **Rambus**
- **Triad Tiles**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WHERE DISCOVERIES BEGIN
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Bloomberg
BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK
verizon wireless
IBM
comcast
future facilities
CommScope
Sealco
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RIVER COOLING SYSTEMS
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UNIVERSITY OF TEXAS ARLINGTON
Georgia Tech
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4830 Transport Drive | Dallas TX 75247
WOLVERINE MICROCOOL
ENGINEERING THERMAL INNOVATION

Why have a roadmap ?

A roadmap process is an approach to connect your organizational vision, values and objectives to tactical and strategic actions that enable the achievement of those objectives

A roadmap MUST be a dynamic and responsive plan

Key elements of a successful I/UCRC roadmap:

- Developed inclusively, Academia-Industry-NSF
- Contributes to the integration of research, technology and business
- Displays the interaction between research and development and products over time
- Defines: actions, interdependencies, routes and alternate routes (back up plans)
- The projects must be intrinsically collaborative

The life cycle for a roadmap

Formative Stages:

- Setting the vision, developing a timeframe, defining organizational goals and objectives
- Developing the initial roadmap

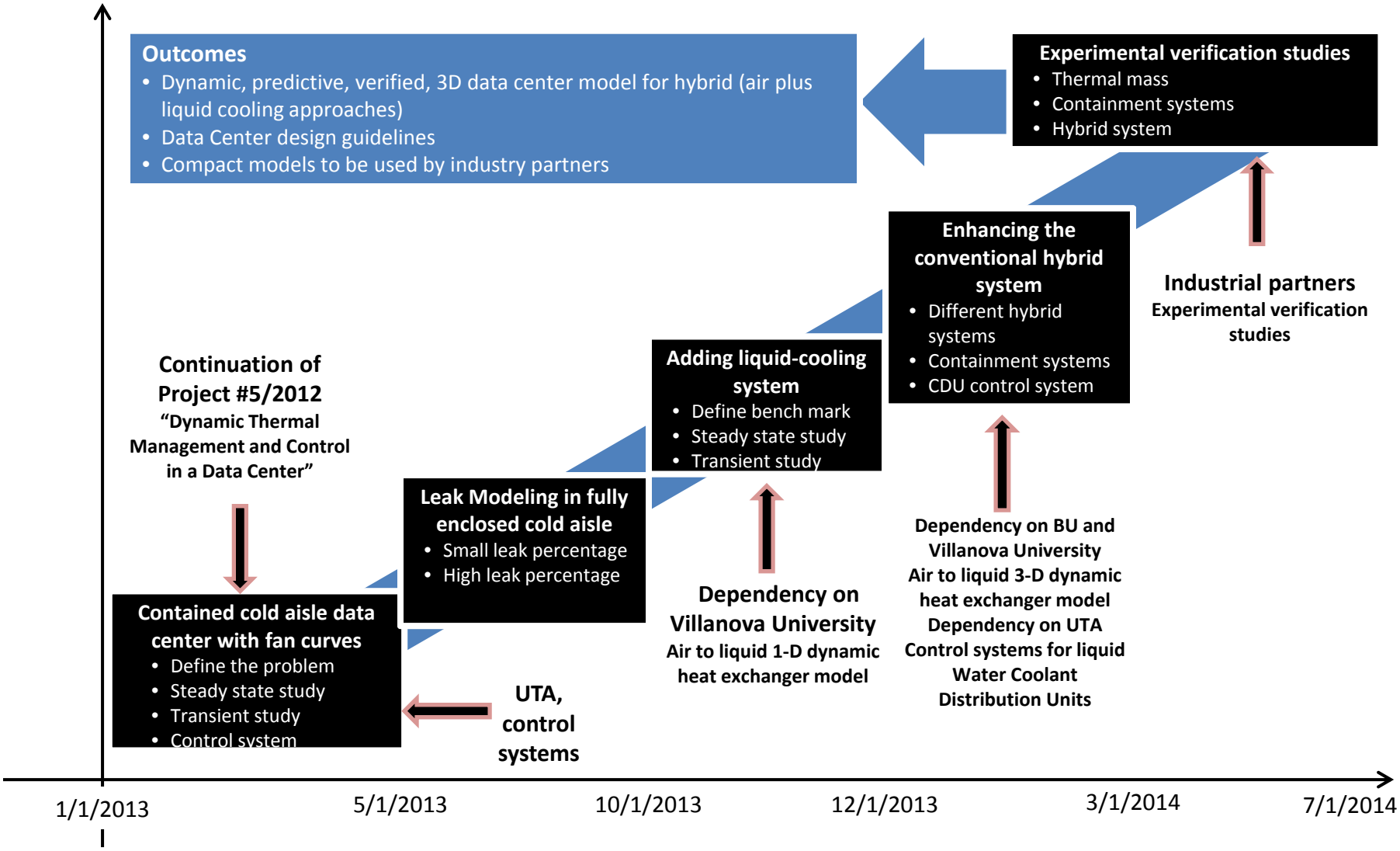
Cyclical Stages (annual or bi-annual):

- Implementation of the roadmap
- Updating and adjusting the roadmap

How we established our initial roadmap

- Vision and mission setting
- In full consultation with partner companies
- Defined key product related objectives, then defined key gaps in knowledge and research objectives
- Defined projects and dependencies between them

Example of a project road-mapping activity from 2013


Outcomes
• Dynamic, predictive, verified, 3D data center model for hybrid (air plus liquid cooling approaches)
• Data Center design guidelines
• Compact models to be used by industry partners
Experimental verification studies
• Thermal mass
• Containment systems
• Hybrid system
Enhancing the conventional hybrid system
• Different hybrid systems
• Containment systems
• CDU control system
Industrial partners
Experimental verification studies
Adding liquid-cooling system
• Define bench mark
• Steady state study
• Transient study
Continuation of Project #5/2012
"Dynamic Thermal Management and Control in a Data Center"
Leak Modeling in fully enclosed cold aisle
• Small leak percentage
• High leak percentage
Dependency on Villanova University
Air to liquid 1-D dynamic heat exchanger model
Dependency on BU and Villanova University
Air to liquid 3-D dynamic heat exchanger model
Dependency on UTA
Control systems for liquid Water Coolant Distribution Units
Contained cold aisle data center with fan curves
• Define the problem
• Steady state study
• Transient study
• Control system
UTA, control systems
1/1/2013
5/1/2013
10/1/2013
12/1/2013
3/1/2014
7/1/2014

Five-Year Technology Roadmap

Determining key intrinsic energy consumption inefficiencies at every level, from devices to entire systems

Techniques for managing data centers synergistically using predictive models for computing workload and thermal trends

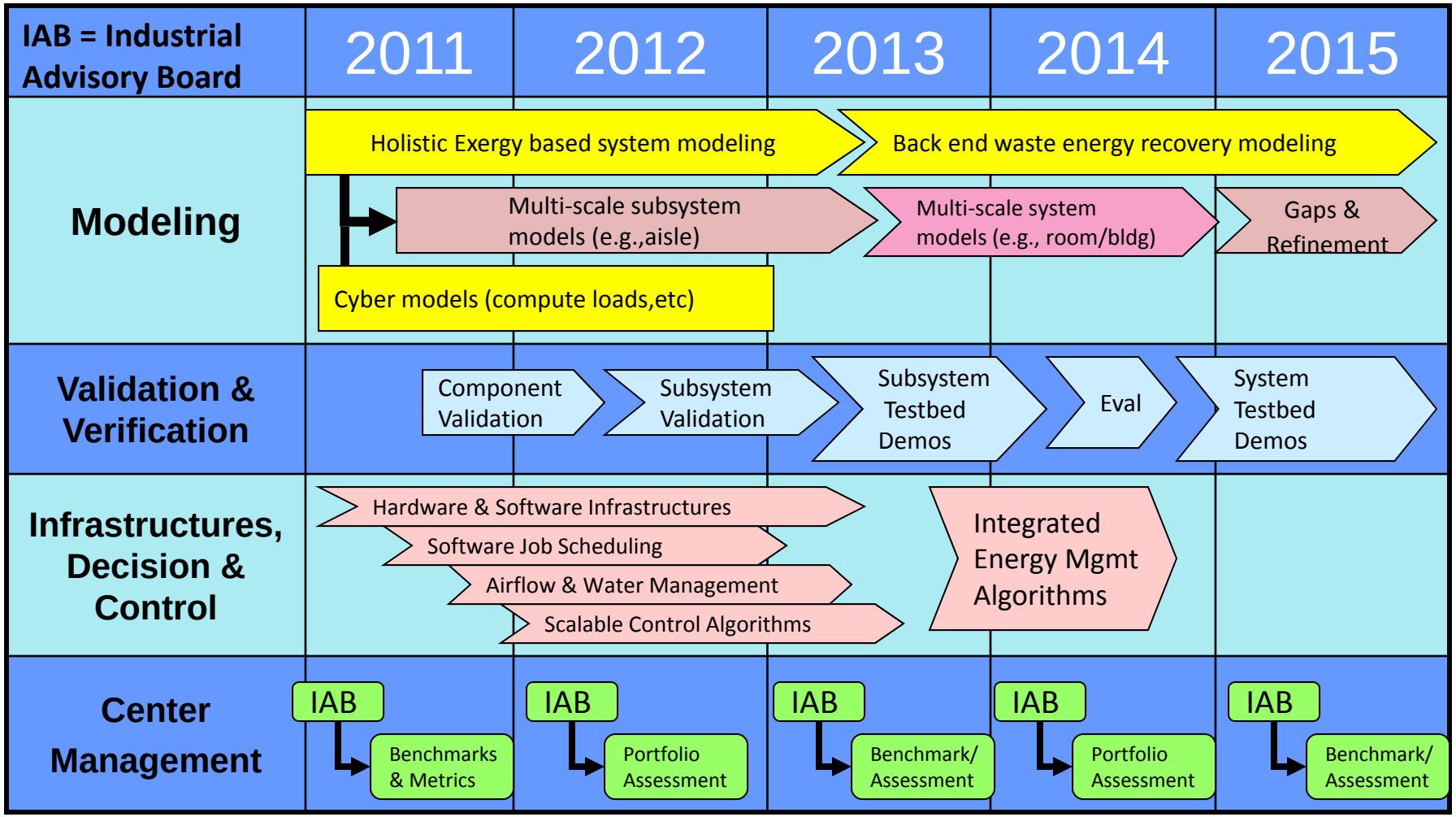
Linux kernel level techniques for implementing energy-aware virtualization, scheduling and synergistic management of the IT equipment and cooling systems

Microarchitectural techniques for improving energy-efficiency of server chips, DRAM and storage systems

Airflow and liquid cooled system management techniques using compact models continuously validated with live data

Techniques for improving the energy efficiency of buildings and containers

Center Roadmap



ES2 Research Progress Highlights

- Designed and implemented short-term load prediction mechanism
- Completed initial implementation of group-based scheduling scheme that can control temperature distribution within a data center
- Developed a comprehensive analytical-numerical study for transient analysis of cross-flow heat exchangers
- Developed thermal dynamic models for cross-flow heat exchangers and solved numerically for predicting the impact of variations in inlet temperature and mass flow rates
- Designed and implemented energy-budget constrained and temperature-aware VM allocation and scheduling techniques.
- Implemented significant parts of VM/load/energy usage/temperature reporting software
- Used simulation models to demonstrate energy savings potential using integrated silicon photonics technology and parallel fiber links for storage servers

Where ES2 stands with the roadmap

- We are completing our second year of funded projects
- We have just started to discuss conducting a deep examination of our roadmap, including an examination of our objectives

Thank you