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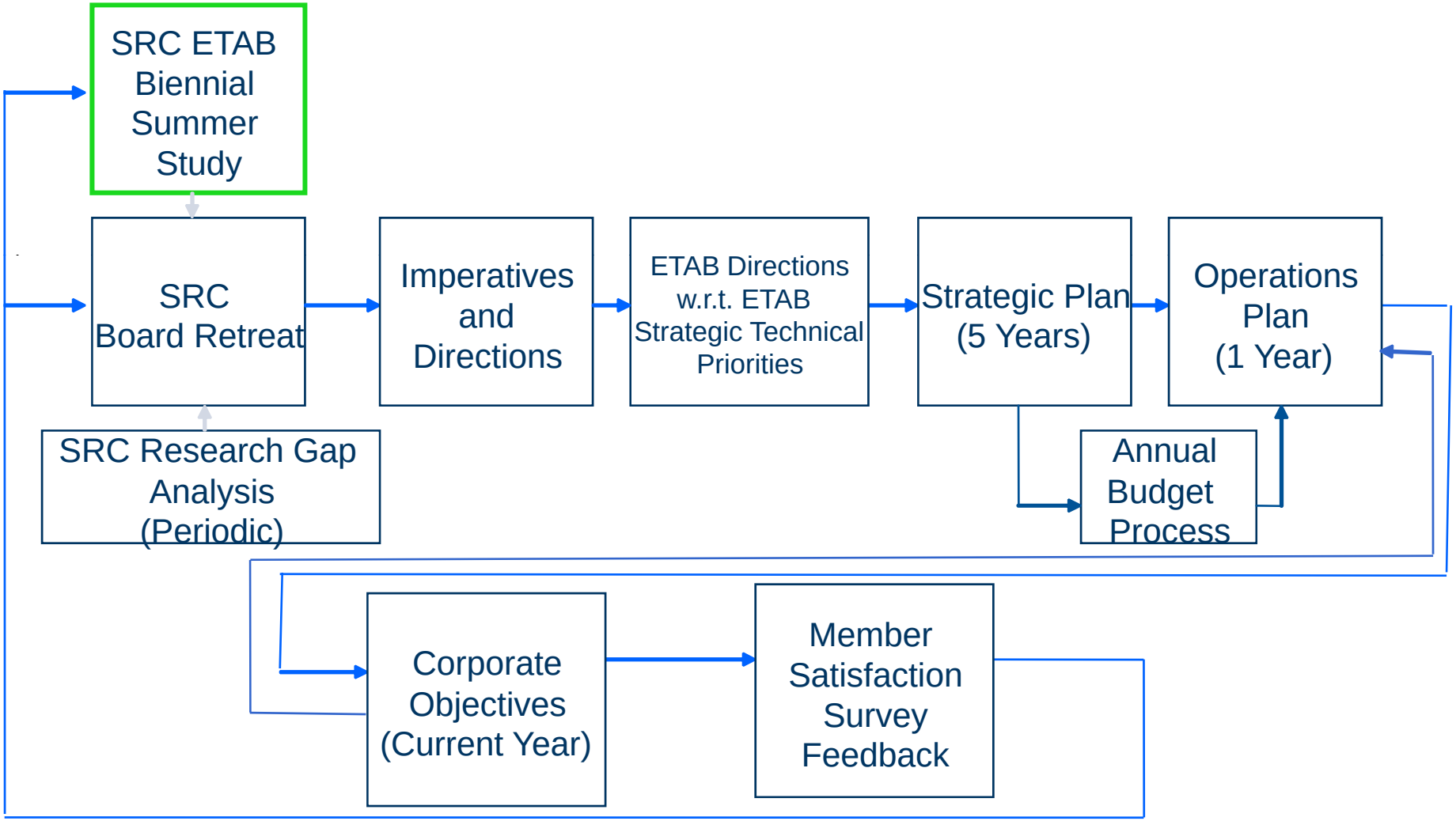
GRC Summer Study

SRC-GRC Strategic Planning Summary

Steve Hillenius

June 29, 2009

Business Planning and Execution Process/Cycle



Strategic Priorities – 2010 - 2014

- Continue scaling research in devices and technology
- Memory
- Functional Diversification - Applications
  - Bio-compatibility
  - Nano-bio electronics
  - Integrated sensors
  - Integrated energy/power issues
- Homogeneous/Heterogeneous Multicore Architectures
  - Multicore architectures
  - Morphic architectures
- Analog and Mixed Signal Design & Technology
  - Integrated applications
- Coping with Variability/Reliability Issues
- Design and Technology Solutions for Thermal/Power

CADTS

- Functional Diversification - Applications
  - System-level specification, coverage, mapping, verification, test
- Design Solutions for Thermal/Power
  - System-level power and thermal estimation and reduction
- Coping with Variability/Reliability Issues
  - DFM through robust and resilient design for both analog and digital
  - Stochastic design techniques and methodologies
  - Process aware synthesis and physical design tools
- Homogeneous/Heterogeneous Multi-Core Architectures
  - System-level specification for cores, hardware acceleration and software that encompass performance, thermal, cost, etc.
  - Systematic post-silicon bring-up and debug
  - Memory subsystem test and validation
- Analog and Mixed-Signal Design
  - Synthesis, physical design, test and verification

ICSS

- Homogeneous/Heterogeneous Multi-Core Architectures
  - Architectures, languages, and tools to support multi-core programming, debug, and optimization
- Analog and Mixed-Signal Design
  - Ultra low-power circuits, better passive elements, emerging apps
- Functional Diversification - Applications
  - Novel architectures and circuits for emerging embedded applications
  - Multi-metric system-level exploration for diverse domains
- Coping with Variability/Reliability Issues
  - Architecture and circuits for robust systems (analog and digital)
  - Systematic post-silicon bring-up and debug
  - Variability-aware adaptive architectures
- Design Solutions for Thermal/Power
  - Active feedback between thermal solutions and processor
  - System-level power and thermal estimation and reduction
- Memories
  - Circuits, cells, and architecture for emerging memory approaches

NMS

- Centered, low variability fabrication technologies
  - Demonstrate that the percent of manufacturing variability need not increase with functional density, i.e. with respect to dimension, overlay, placement, composition, architecture, etc.;
- New cost curves for nanoelectronics fabrication
  - Develop novel materials, process, and equipment options that:
  - Enable extensible nanoelectronics fabrication, defect detection, and yield management into the sub-10 nm domain and
  - Leverage the existing fabrication infrastructure;
- Functional diversification
  - Design, identify, and enable the integration of customized materials with electronically useful functionality for high value application opportunities;
- Sustainable, high performance fabrication
  - Extend sustainable, benign, high performance nanomanufacturing technologies into the sub-10 nm domain.

DS

- Track and push ITRS-driven CMOS scaling towards limits
  - Advanced Si structures, gate stack, source/drain resistance…
- Ensure success of III-V program in NCRC
  - Explore collaboration with SEMATECH
- Develop novel nonvolatile memory of non-charge-storage type of cells
  - In particular, resistive RAM and ferroelectric RAM
- Manage ramping up AMS program
  - As part of functional diversification
- Modeling and simulation
  - New device physics from nano-scale structures
- Compact modeling for advanced devices and analog devices
- Improve device variability and reliability

IPS

- Continue scaling research in devices and technology
  - New materials and processes for interconnects and packaging
  - Novel interconnect structures
  - Interconnect and packaging TCAD
  - Metrology/modeling for nanoscale materials and structures
- Functional Diversification - Applications
  - Nano-engineered materials and processes that enable functional diversification
  - Packaging for functional diversification
  - Integration of sensors, energy harvesters and storage
- Homogeneous/Heterogeneous Multicore Architectures
  - Increased I/O bandwidth
- Coping with Variability/Reliability Issues
  - Reliable interconnects at 16 nm and 3D
  - Manufacturing options for reducing variability and enhancing reliability
- Design and Technology Solutions for Thermal/Power
  - Novel approaches for heat removal

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CADTS Strategic Themes

Consensus/Divergence

William Joyner
June 29, 2009

CADTS Themes: Consensus/Divergence

- Areas of consensus
  - Power
  - DFM, variability
  - Faster tools through parallelism/multicore
  - Importance of test, verification
- Areas of divergence
  - System-level design tools
  - Tools for software
  - Balance: LPD, test, verification, systems; digital/analog

CADTS Areas of Consensus

- Power
  - Power grid improvement
  - Power reduction/optimization
- DFM, variability
  - Process-aware design tools
  - Synthesis with variation awareness
- Faster tools through parallelism/multicore
  - Using parallelism to speed up CAD and test algorithms
  - CAD, test for multicore – NSF collaboration
- Importance of verification, test
  - Post-silicon validation
  - Analog, digital test
  - Early life and late life failure analysis and avoidance

CADTS Areas of Divergence

- System-level design tools
  - Definite member need
  - Will it detract from circuit-level tools?
  - How to coordinate with ICSS
- Tools for software
  - Hardware/software becoming critical to some members
  - How far can we go without “mission creep”?
- Balance: LPD, test, verification, systems; digital/analog
  - Maintaining critical mass
  - Differentiating LPD, systems
  - Digital/analog balance and analog design vs digital emulation

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ICSS Strategic Themes

Consensus/Divergence

David Yeh
June 29, 2009

ICSS Themes: Consensus/Divergence

- Areas of consensus
  - Need for both digital and analog
  - Importance of multi-core
  - Importance of system-level design

- Areas of divergence
  - Software
  - Parallel execution: GPU vs. CPU, homogeneous vs. heterogeneous, programming models
  - Application spaces

ICSS Areas of Consensus

- Need for both digital and analog
  - Especially for design of systems
- Importance of multi-core
  - Likely to be large part of Systems thrust
- Importance of system-level design
  - New applications bring higher focus on system design
  - Need to work out system tools with CADTS

ICSS Areas of Divergence

- Software
  - Characteristics of application software
  - Impact on design, reliability, performance
- Parallel execution
  - CPU vs. GPU
  - Homogeneous vs. heterogeneous
  - Programming models
- Application spaces
  - Products
  - Power constraints
  - Both for digital and analog

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NMS Strategic Themes

Consensus/Divergence

Daniel J.C. Herr
June 29, 2009

NMS Themes: Consensus/Divergence

- Areas of consensus
  - Directed self-assembly
  - ESH material stewardship, process improvement, and impact of nanomaterials
  - Centered and reduced variability processes
  - 3D characterization, defect detection, and correlation to macroscopic properties at the atomic and nano-scales
- Areas of divergence
  - Functional diversification
  - ITRS emerging research materials/processes
  - NGL extensibility/limits

NMS Areas of Consensus

- Directed self-assembly
  - Focus on ERM research requirements that target 2012-13 results and a potential 2016 insertion option for smart resists, with enhanced resolution and dimensional control.
- ESH material stewardship, process improvement, and impact of nanomaterials
  - Enhance material management/stewardship;
    - Reduced material usage, waste, and material cost;
  - Reduce fabrication energy footprint and related costs.
  - Reduce the impact/risk of inserting new materials.
- Centered and reduced variability processes
  - Enable extensible fabrication of ITRS system options.
- 3D characterization, defect detection, and correlation to macroscopic properties at the atomic and nano-scales
  - Requires integrated metrology and modeling;
  - Non-destructive characterization of buried interfaces/structures.

NMS Areas of Divergence

- Functional diversification
  - Some companies value a vehicle for exploring application-specific materials.
  - Identify targeted areas of common interest and avoid dilution, while resource constrained.
- ITRS emerging research materials/processes
  - Some ITRS identified ERM application opportunities are aligned with GRC's strategic horizon.
  - Identify targeted areas of common interest and avoid dilution, while resource constrained.
- NGL extensibility/limits
  - A few companies value targeted research in EUVL and imprint lithography.
  - Most companies perceive that additional GRC research in this area will have diminishing impact on the technology, which is transitioning to the development phase.

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DS Strategic Themes

Consensus/Divergence

Kwok Ng
June 29, 2009

DS Strategy: Consensus and Divergence

- Areas of Consensus
  - Nonvolatile memory
  - Modeling and simulation

- Areas of Strategic Divergence
  - Digital technology vs. analog/mixed-signal technology
  - Scaling CMOS device: Classical (Si) vs. non-classical (III-V)

DS Areas of Consensus

- Nonvolatile memory
  - Within Memory thrust, nonvolatile memory is of highest interest.
  - Most tasks are non-charge-storage type; resistive RAM and Ferroelectric RAM.

- Modeling and simulation (TCAD and compact modeling)
  - Agreed to have balance between modeling and technology.
  - In compact modeling, might be divergence of priority on digital devices vs. analog devices.

DS Areas of Divergence

- Digital technology vs. analog & mixed-signal technology
  - Similar to (or part of) scaling vs. functional diversification.

- Scaling digital CMOS device: Classical (Si) vs. non-classical (III-V)
  - Issue compounded by the Center (NCRC) which was started before ETAB could allocate funding on thrusts directly. (Funding level already reduced from $1.3M/yr to <$1M/yr.)
  - Also compounded by the fact that total funding on digital has dropped due to the ramp up of analog & mixed-signal.

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IPS Strategic Themes

Consensus/Divergence

Scott List
June 29, 2009

IPS Themes: Consensus/Divergence

- Areas of consensus
  - Functional diversification expansion into 3D
  - Increased reliability focus
  - Exploring interconnects/package and design interactions

- Areas of strategic divergence
  - Functional diversification expansions into bio-compatibility and memory
  - Emphasis of BEP versus PKG research
  - Timing of transfer of IFC portfolio into IPS

IPS Areas of Consensus

- Functional diversification expansion into 3D
  - 3D process, modeling and system optimization focus
  - New IPC center formation
  - Joint BEP and PKG funding
- Increased reliability focus
  - Mechanical and electrical reliability challenges increasing
  - Improved metrology, fundamental understanding and process solutions are required
- Exploring interconnect / package and design interactions
  - Broader, system level optimization required
  - Multi-core initiative a good start, but need sharper focus
  - Potential joint funding for 3D design, or design for interconnect

IPS Areas of Divergence

- Functional diversification expansions into bio-compatibility and memory
  - Only 3D had large majority support for FD expansion
  - Other FD areas such as bio-compatibility and interconnect centric memory do not currently have consensus support
  - RCP or new proposal selection process may fund these areas
- Emphasis of BEP versus PKG research
  - Members increasingly polarized: suppliers-BEP, fabless-PKG
  - Generates bimodal scores and proposal selection disharmony
  - New proposal selection process may help diffuse tension
- Timing of transfer of IFC portfolio into IPS
  - Portfolio rationalization minimizes overlap and transfer
  - Depends on the future charter of the Connectivity Center