Building the Exascale Software Center

The Exascale Software Center Planning Team

Presentation at the IESP meeting, October 2010

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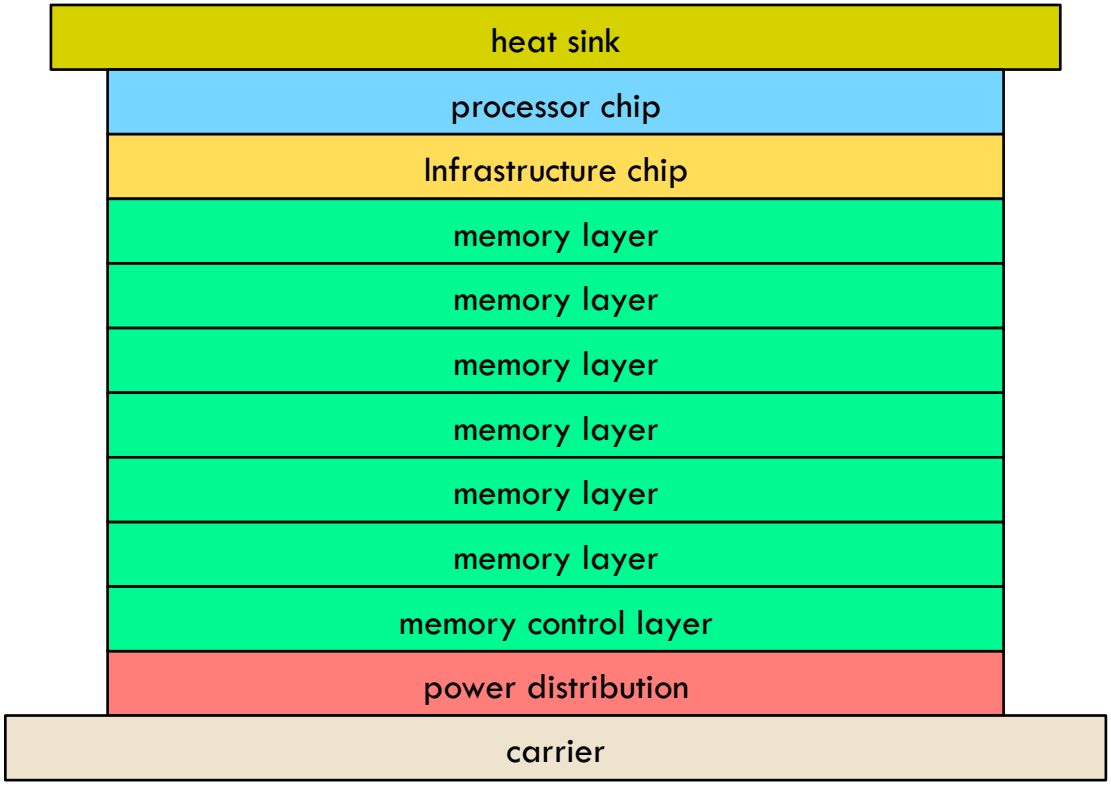
+ Large team of folks from national laboratories and universities

Potential System Architecture Targets

System attributes	2010	"2015"		"2018"	
System peak	2 Peta	200 Petaflop/sec		1 Exaflop/sec	
Power	6 MW	15 MW		20 MW	
System memory	0.3 PB	5 PB		32-64 PB	
Node performance	125 GF	0.5 TF	7 TF	1 TF	10 TF
Node memory BW	25 GB/s	0.1 TB/sec	1 TB/sec	0.4 TB/sec	4 TB/sec
Node concurrency	12	O(100)	O(1,000)	O(1,000)	O(10,000)
System size (nodes)	18,700	50,000	5,000	1,000,000	100,000
Total Node Interconnect BW	1.5 GB/s	20 GB/sec		200 GB/sec	
MTTI	days	O(1day)		O(1 day)	

Biggest Disruption: Node Architecture is Changing



- 100x – 1000x more cores
- Heterogeneous cores
- New programming model

- 3d stacked memory

- Smart memory management

- Integration on package

Context: Planning for Exascale

Platforms
- Systems: 2015
- Systems: 2018

Cross-cutting Technologies

Co-Design Application Teams

Exascale Software

Goal: Ensure successful deployment of coordinated exascale software stack on Exascale Initiative platforms

Exascale Software Center

within co-design framework

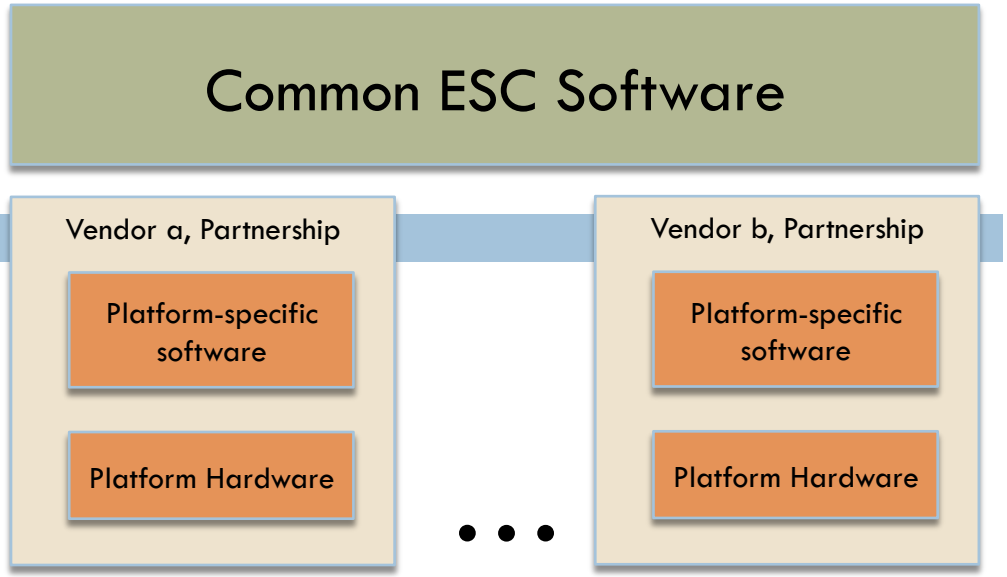
Ultimately responsible for success of software:

- Identify required software capabilities
- Identify gaps
- Design and develop open-source software components
  - Both: evolve existing components, develop new ones
  - Includes maintainability, support, verification
- Ensure functionality, stability, and performance
- Collaborate with platform vendors to integrate software
- Coordinate outreach to the broader open source
- Track development progress and milestones

Exascale Software Center (in 1 slide)

- Scope
  - Deliver high quality system software for exascale platforms
    - ~2015, ~2018
  - Identify software gaps, research & develop solutions, test and support deployment
  - Increase the productivity and capability and reduce the risk of exascale deployments
- Cost:
  - Applied R&D: ~10-20 distributed teams of 3 to 7 people each
  - Large, primarily centralized QA, integration, and verification center
- Schedule Overview
  - 2010 – Q1 2011: Planning and technical reviews
  - April 2011: *Launch Exascale Software Center!*
  - 2014, 2017: SW ready for integration for 2015, 2018 systems respectively

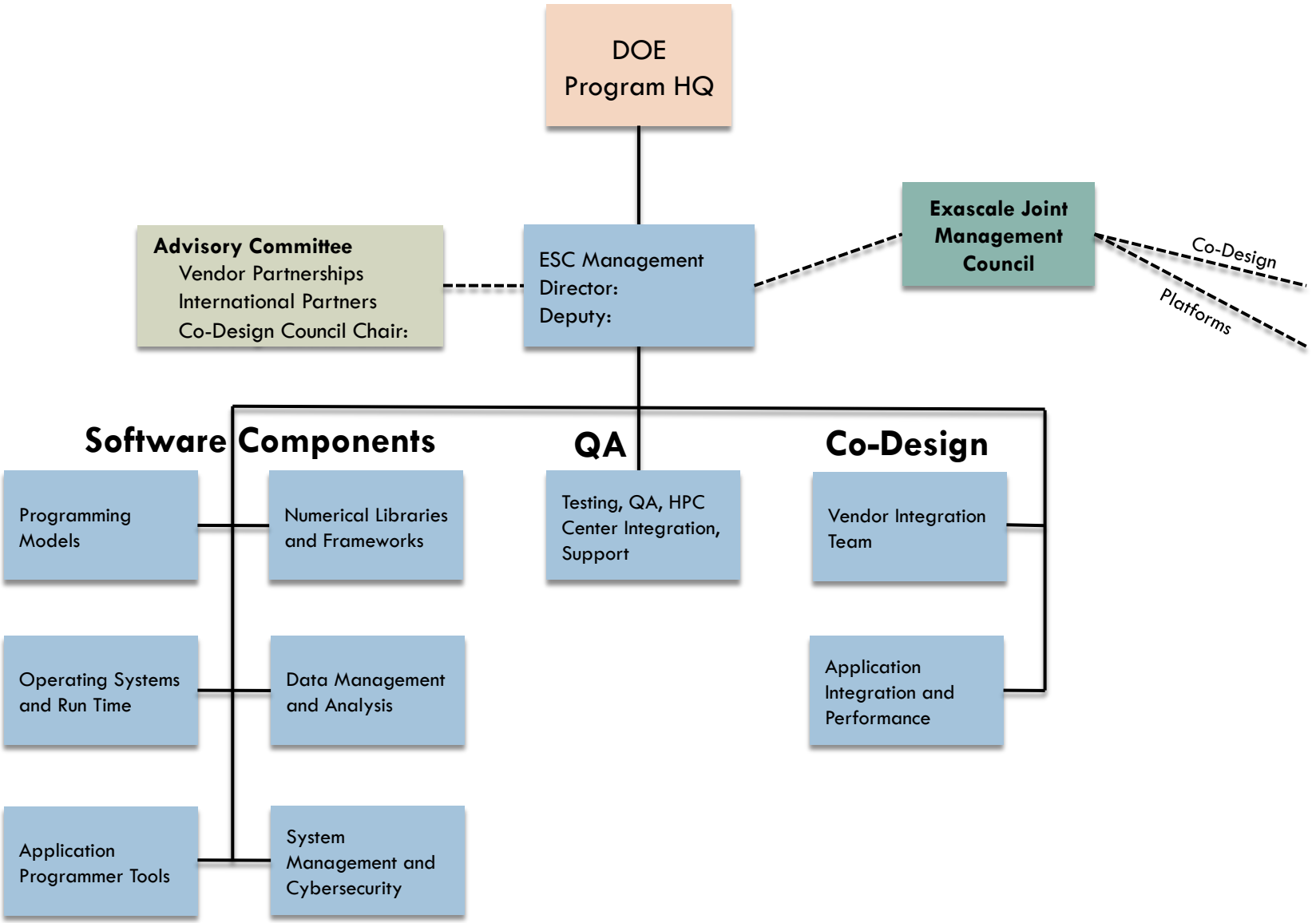
Assumptions



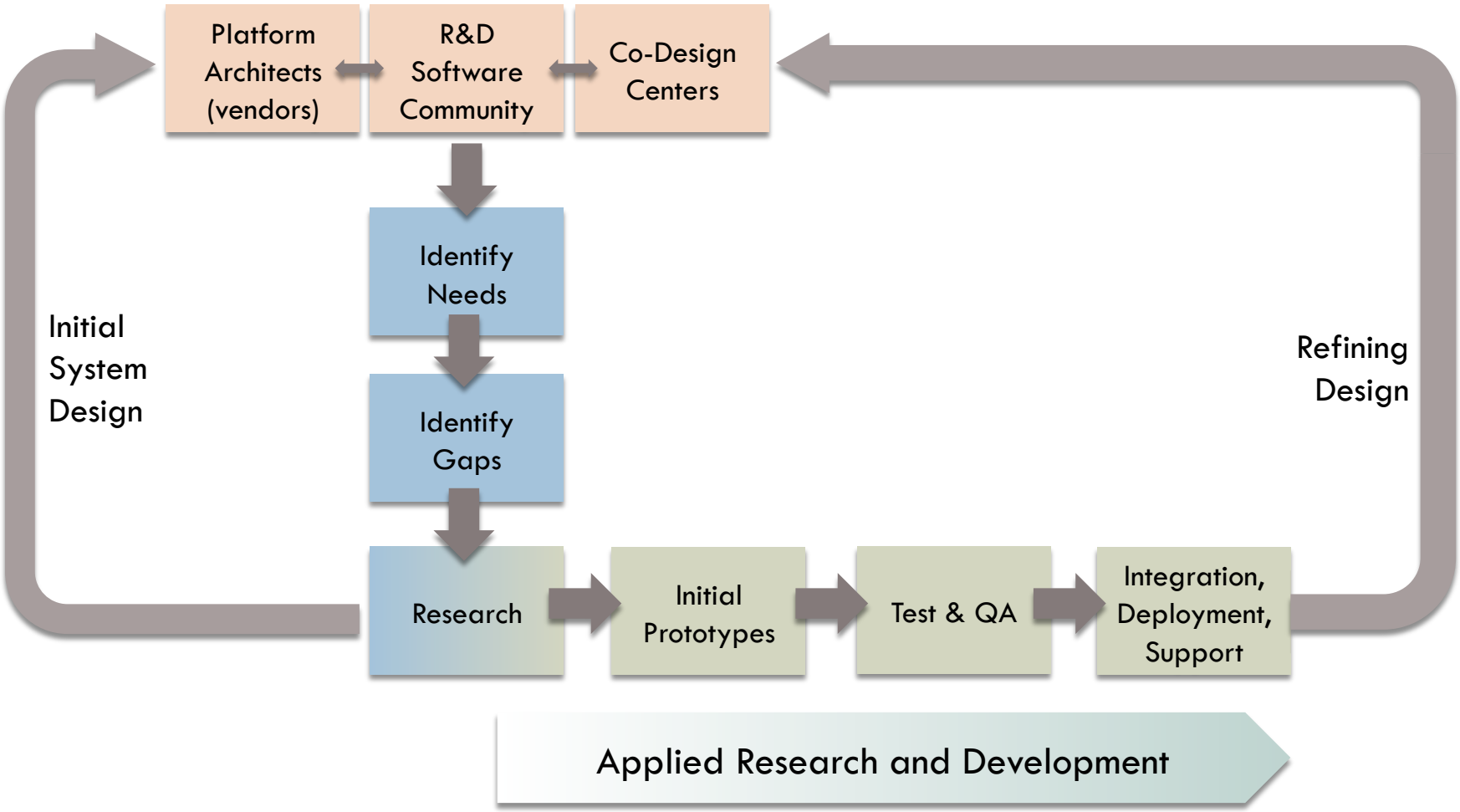
- Several vendor platform partnerships
- ~2015 early scalability demonstration systems
  - Arch 2010-2011 ; System build 2015
- ~2018 exascale system
  - Arch 2014-2015 ; System build 2018

- Co-design centers provide initial applications
- ESC:
  - Partnership funding agencies, labs, and universities
  - Responsible for the common software environment for EI systems
  - All development will be open source, with BSD-style license preferred over GPL
  - Some components will be integrated and supported by vendor, others will be provided atop basic platform, supported by ESC
  - Vendor-specific components will be part of their platform strategy
    - E.g.: system management, RAS, compiler, etc

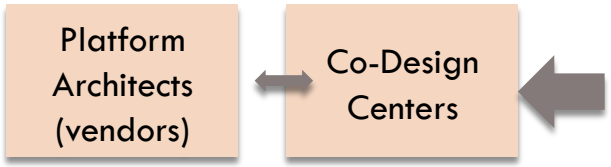
ESC Organization Chart



The Exascale Software Center and Co-Design Processes



Vendor Co-Design Model



- Want something like ESC to coordinate and take *real* responsibility for features and milestones
  - Improved leverage over projects that are currently less responsive than needed
- Do not want "toss over the wall" strategy. "hardening" cannot be done by different team
- Need to manage risk of final machine functionality, performance, stability and acceptance
- Key ESC models:
  - ESC developed -- vendor integrated and supported
    - Two test and development environments needed, with careful planning, linking, and tracking of known issues
  - ESC developed – ESC provided, and supported
- Formalized roles between ESC and Vendors for development, risk, support, and acceptance
- Feedback and progress tracking between ESC and vendors must be shared
- Application co-design centers should coordinate discussions of system software through ESC
- NDA material for roadmaps, across co-design centers, etc will be difficult to coordinate

	Examples of software package	Primary developer	First-level Support Provider	Second-level Support Provider
1	RAS, system mgmt, compilers	Vendor	Vendor	Vendor
2	OS, MPI, PAPI, math libraries	ESC	Vendor	ESC
3	Performance tools, I/O libraries	ESC	ESC	ESC
4	Perl, Python	Broader Community	Vendor	
5	Eclipse IDE	Broader Community	Broader Community	

Application Co-Design Model

- Want something like ESC to coordinate and take *real* responsibility for features and milestones
  - Improved leverage over projects that are currently less responsive than needed
- Want to know specifics about hardware and available software
- Applications will provide best estimates of needs for exascale science:
  - Data movement, memory sizes, programming models, etc
- Applications will test and evaluate prototype system software
- Need help managing risk of final machine functionality, performance, stability and acceptance
- Formalized roles between ESC and App Co-Design Centers for development, risk, support, and acceptance
- Feedback and progress tracking between ESC and App Co-Design Centers
- Coordinate discussions of system software through ESC
- NDA material for roadmaps, across co-design centers, etc will be difficult to coordinate

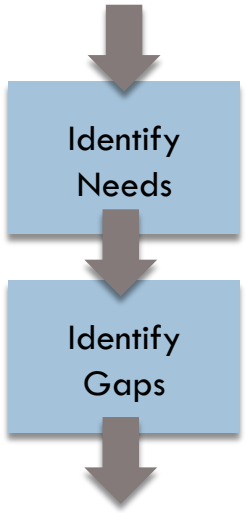
International Co-Design?

- Tomorrow's breakout
- Europe --- Asia --- US

Selecting ESC Components

Making the hard choices

- ***ESC is responsible for delivering successful software***
  - Technical evaluation:
    - Criticality to successful deployment and key applications
    - Technical risk for achieving goal
  - Project team evaluation:
    - Team history of delivering high-quality, applied software
    - Management and institutional support



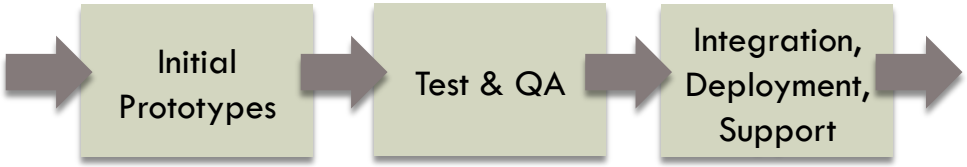
- ESC will make component selection and resource decisions based on criticality and risk
  - continuous evaluations of progress; adjust resources

ESC will have a range of components

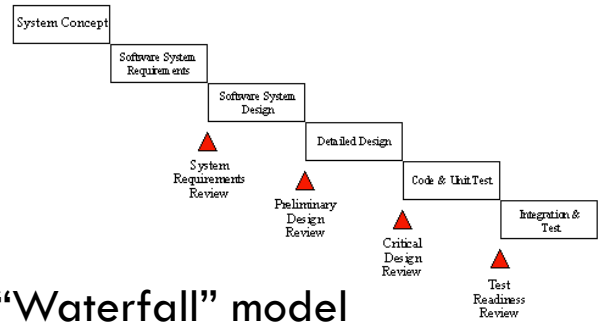
Technical Evaluation Matrix

		Low Risk	Moderate Risk
ESC Supported	Important		
Vendor Supported	Critical		
	Most Critical		

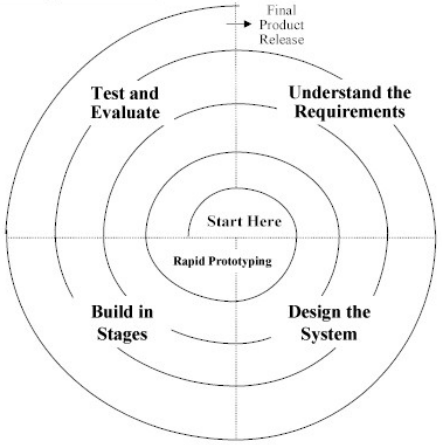
ESC Software Development



- Successful applied R&D teams are built around clear goal of delivering working, supported packages
- Good software hygiene can't be someone else's job
- ESC must **work with successful teams existing processes** or in some cases, boot new teams within institutions with excellent history of deployed software
  - Probably not feasible to launch new team at site without history of software success
- Formal plans and milestones and reviews are necessary for each component
- Co-design feedback and risk-based assessments work well with spiral development discipline for software (common in R&D)



Classic "Waterfall" model



"Spiral" model

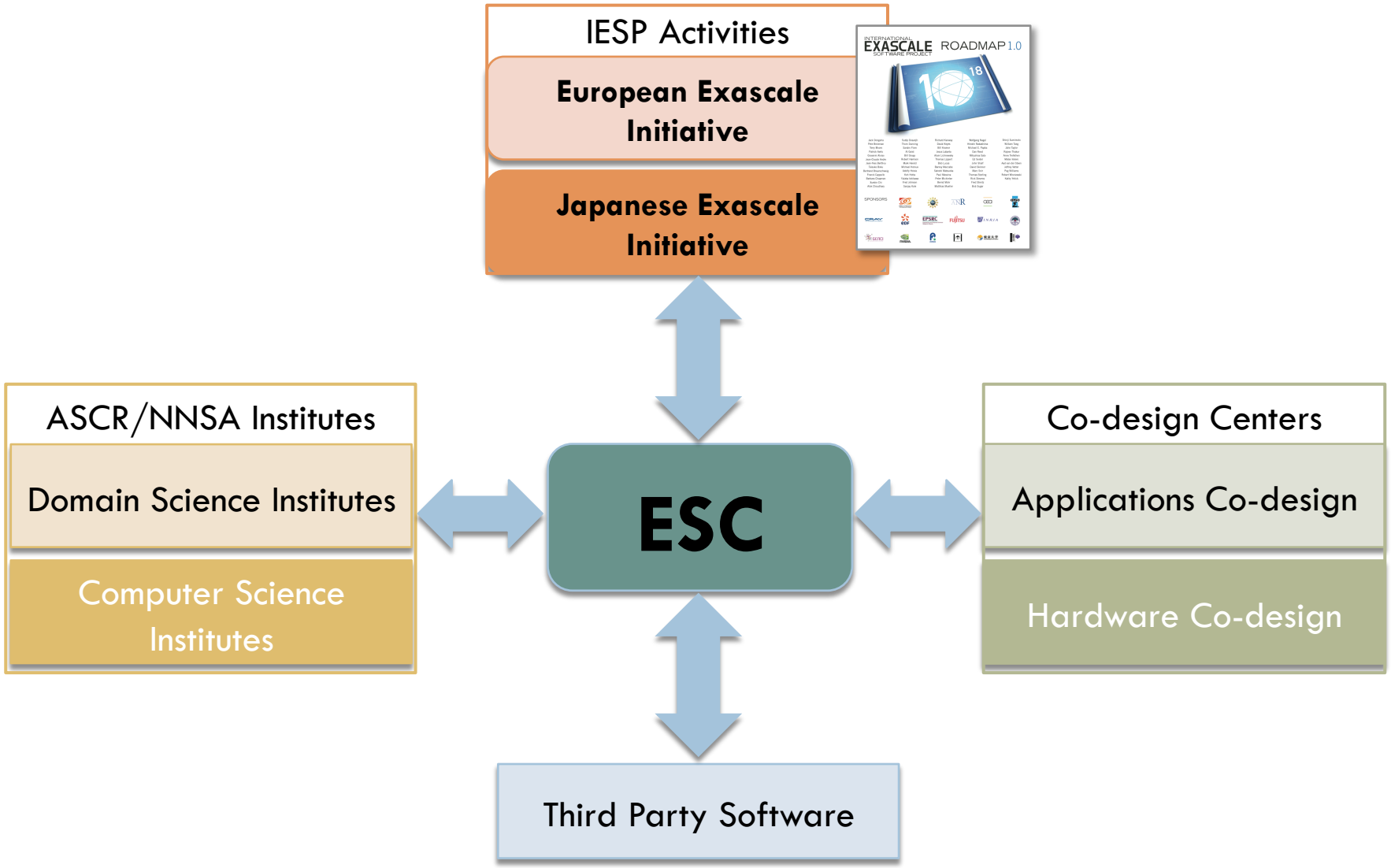
Required Processes for ESC Components

- Formulation of clear deliverables with specific targets for functionality, performance, and stability
- Defined team management plan and risk tracking
- Documented software development plans
  - QA (unit tests, integration, etc)
  - Performance testing
  - Documentation, support
  - Bug and new feature tracking
- Resource accounting
- Technical review schedule
- Release schedule
- Integration plan

Distributed Project Staffing Approach

- "ESC Component Teams" should be located where their center of mass has demonstrated success
  - E.g: Math libraries at UTK, Performance tools at UOregon and Rice, etc.
- Each Component Team will have at least one "embedded" QA and testing staff member provided by ESC
  - Position will be held by professional QA/build engineer (i.e., not a student or postdoc)
  - Candidates will be approved by ESC director of QA and have performance appraisal "matrix input"
- Each of the 4 sites (2 NNSA, 2 SC) must have local ESC team members responsible for integration
  - Will belong to production computing division, not R&D division
- QA, integration, and support team will be primarily at one site
- Resources dedicated to collaboration and software development infrastructure is required

Community Engagement



ESC High-Level Milestones (under development)

Computer	Description	Date
2018	Launch the Exascale Initiative and start the Exascale Software Center.	2Q11
2015	Report on 100PF needs, identified gaps, and researched solutions	4Q11
2015	Vendor agreements on integration roles and timelines complete	2Q12
2015	Deployable packages created in all five target areas	3Q13
2015	QA and Support infrastructure to create production quality developed	3Q13
2015	Initial version of software on prototype hardware complete	2Q14
2015	Integration of packages, testing, and enhancement of SW stack complete	3Q15
2015	Integrated SW stack deployed on 100+PF systems	4Q15
2018	Report on 1EF needs, identified gaps, and researched solutions	2Q15
2018	New target areas and teams incorporated into ESC based on assessment	4Q15
2018	Deployable packages in all targeted Exascale areas created	3Q16
2018	QA and support infrastructure for new areas developed	3Q16
2018	Initial version of software on prototype hardware complete	2Q17
2018	Integration of packages, testing, and enhancement of SW stack complete	3Q18
2018	Integrated SW stack deployed on 1EF systems	4Q18

Next Steps

- Develop software planning documents:
  - Definition of review materials
  - Formal review in April 2011
- Build application co-design liaisons, develop plan for jointly evaluating key software
- Build links to IESP organizational plan
- Begin technical evaluation and ranking of key software components
- Link to NSF, NASA, DARPA, and other groups