Exascale Computing Project Update

Douglas B. Kothe (ORNL), Director
Stephen Lee (LANL), Deputy Director

Presentation to the DOE Advanced Scientific Computing Advisory Committee (ASCAC)

December 20, 2017
The Exascale Computing Project in Context

ECP enables the continued US global strategic advantage in science and technology which is the foundation of future revolutions in technology development, energy security, scientific discovery, and national security.

• ECP is focused on significant mission-critical applications, including:
  – Stewardship of today’s stockpile and the growing threat of potential adversaries defeating U.S. weapons
  – Development of clean energy systems, improving our infrastructure resilience, designing new materials, adapting to regional water cycle changes, demystifying the origin of elements in the universe, developing smaller and more powerful accelerators for use in medicine and industry, …
  – Discover new knowledge from data in powerful DOE experimental facilities, environmental genomes, cancer research, high-fidelity simulations

• ECP is necessary, but not sufficient – the broader necessary ECI elements include:
  – Deploying exascale systems quickly enough to impact schedule-sensitive mission problems
  – Maintaining and advancing the “HPC ecosystem” after ECP
  – Developing U.S. industry and academia partnerships to ensure the benefits of advanced computing have broad and enduring impacts
ECP Strategic Goals and Outcomes

• **Goal: Applications**
  – Delivery of mission and science results using exascale systems enabled by ECP, each addressing an exascale challenge problem (problems of strategic importance and national interest, intractable without at least 50x computational power of today’s systems)

• **Goal: Software Technologies**
  – Deliver next generation DOE software capabilities for exascale applications and platforms, targeted to specific exascale systems as a high quality, sustainable product suite

• **Goal: Hardware and Integration**
  – Integrated deployment of specific outcomes and products on targeted systems at computing Facilities, including the completion of PathForward projects transitioning to Facility NRE (where appropriate), and the integration of software and applications on pre-exascale and exascale system resources at Facilities

• **Outcome: Accelerated delivery of a capable exascale computing ecosystem** providing breakthrough solutions addressing our most critical challenges in scientific discovery, energy assurance, economic competitiveness, and national security
  – **Capable**: a wide range of applications can effectively use the systems enabled by ECP, ensuring that both science and security needs will be addressed (affordable, usable, useful)
  – **Exascale**: application performance at least 50x of today’s systems
  – **Ecosystem**: all methods and tools needed for effective use of ECP-enabled exascale systems to be acquired by DOE labs (not just more powerful systems)
Activities Since Oct 1 2017

• Overall ECP design re-formulated and documented
  – Revised work breakdown structure (WBS)
  – New extended leadership team
    • 33 of the most experienced computational scientists, leaders, and project managers from your laboratories
  – Revised Key Performance Parameters (KPPs)
  – Revised Key Milestones (in Preliminary Project Execution Plan)

• Re-tooled our approach to project management processes and tracking
  – Devised a new approach to tracking progress (cost/schedule performance; dashboard)
  – Revamped resource loaded schedule
  – Fresh and close analysis of risks and risk management
  – Critical path analysis

• Plans for closer integration with HPC Facilities
  – A much more direct, mutually beneficial, and necessary tie for success
ECP has multiple necessary components to meet national goals

- **Application Development**: Develop and enhance the predictive capability of applications critical to the DOE
  - Andrew Siegel (ANL)
  - Erik Draeger (LLNL)

- **Software Technology**: Produce expanded and vertically integrated software stack to achieve full potential of exascale computing
  - Mike Heroux (SNL)
  - Jonathan Carter (LBNL)

- **Hardware and Integration**: Integrated delivery of ECP products on targeted systems at leading DOE computing facilities
  - Terri Quinn (LLNL)
  - Susan Coghlan (ANL)

- **Project Management**: Project scheduling, tracking cost tracking, analysis, and accountability across the entire project spread across the country
  - Kathlyn Boudwin (ORNL)
  - Manuel Vigil (LANL)
# Exascale Computing Project 2.0

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<td>Facility Resource Utilization 2.4.5</td>
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ECP Structure and Leadership Addresses Evolving Requirements
Possessing the requisite skills, experience and resources for success

• Structure: changes to the WBS structure (Oct 2017) needed to increase ECP focus on product delivery and “steady state” execution post-startup
  – AD changed from programmatic (e.g., “DOE Science & Energy”) to domain-based structure (e.g., “Chemistry and Materials”) to enable closer and more effective leadership and project management by domain science experts.
  – ST structure consolidated and streamlined, with aggressive movement into a critical product development stage after its initial R&D stage and line of sight of ST products to applications.
  – HI [formerly Hardware Technology (HT)] required expanded scope to more proactively and directly integrate - including a formal handoff of ECP products and technologies- with DOE HPC facilities.

• Leadership: size and complexity of ECP warranted a more empowered extended leadership team (ELT) with explicit roles, responsibilities, authorities, accountabilities (ECP Management Plan)
  – L2 leads: strategic thinkers (integrating their technical area within the larger US exascale ecosystem); tactical planners (relative to project management): influential (relative to the technical community and also within ECP); able to represent the full ECP scope in a compelling manner
  – L3 leads: technical leaders for sub-projects within their element, providing technical oversight and management; also serve as Control Account Managers (CAM) for their element
  – ELT (SLT+L2s+L3s): now involved in most leadership discussions, with SLT decisions based on informed-input from ELT
ECP Senior Leadership Team

**Doug Kothe, Director**
Doug is a leader in the development of computational science applications and formerly the Director of the CASL DOE Hub. He most recently led the ECP Application Development focus area, and is a veteran of DOE with 33 years of service at LANL (20), LLNL (1), and presently ORNL (12).

**Stephen Lee, Deputy Director**
Stephen is a computational physicist and a long time leader at LANL, with 30 years of experience in computational physics and code development. He was most recently the Division Leader for the Computer, Computational, and Statistical Sciences Division at LANL.

**Kathlyn Boudwin, Project Management Director**
Kathlyn has 25 years of experience working on large scientific and HPC projects for DOE and NSF. She was previously the Deputy Project Director for OLCF, Associate Project Director at SNS, and Project Controller for APS and Argonne Guest House at ANL. She holds both an MBA and a degree in economics.

**Andrew Siegel, Application Development Director**
Andrew is a Senior Scientist at ANL with appointments in the Mathematics and Computer Science and Nuclear Engineering Divisions. For the past decade he has led ANL’s program in simulation of advanced nuclear reactors. He has over 20 years of experience developing applications and using HPC systems to study problems in a broad range of disciplines including nuclear engineering, atmospheric science, astrophysics, and oceanography.

**Erik Draeger, Application Development Deputy Director**
Erik is the group leader of the High Performance Computing group in the Center for Applied Scientific Computing at LLNL, with over 15 years of experience developing and optimizing highly-scalable applications for physics and biology.
ECP Senior Leadership Team

**Mike Heroux, Software Technology Director**
Mike has been involved in scientific software R&D for 30 years. His first 10 were at Cray in the LIBSCI and scalable apps groups. At Sandia he started the Trilinos and Mantevo projects, is author of the HPCG benchmark for TOP500, and leads productivity and sustainability efforts for DOE.

**Jonathan Carter, Software Technology Deputy Director**
Jonathan has been involved in the support and development of HPC applications for chemistry, the procurement of HPC systems, and the evaluation of novel computing hardware for over 25 years. He currently a senior manager in Computing Sciences at Berkeley Lab.

**Terri Quinn, Hardware and Integration Director**
Terri is a long-time leader in high performance computing at LLNL, with over 20 years as a program manager for the Advanced Simulation and Computing program. She is the Associate Program Director for Livermore Computing Systems and Environment.

**Susan Coghlan, Hardware and Integration Deputy Director**
Susan is a respected computer scientist and leader in high performance computing at ANL, with over 20 years as an extreme-scale supercomputer and systems integration expert. She is currently the Argonne Project Director for CORAL.

**Al Geist, Chief Technology Officer**
Al is a well known computer scientist and an ORNL Corporate Fellow. He serves as CTO for the LCF at ORNL and Chief Technologist of the Computer Science and Mathematics Division at ORNL.

**Julia White, Technical Operations Manager**
Julia holds a Ph.D. in chemistry as well as an MBA, and has a wealth of experience in computational science. She previously held management roles at ORNL, PNNL, and Physical Review B and was most recently the program manager for INCITE, which allocates computer time on DOE leadership class computers.
ECP Application Development Leadership Team  
WBS 2.2: Diverse team bringing new ideas & approaches to results-driven application development

**Jack Deslippe, Chemistry and Materials Applications (2.2.1)**
Jack is the acting group lead of the Application Performance Group NERSC and leads the NERSC Exascale Science Applications Program (NESAP). Jack has a history of support and development of HPC apps in Materials Science and Ph.D. in Condensed Matter Physics from UC Berkeley.

**Tom Evans, Energy Applications (2.2.2)**
Tom is a Distinguished R&D Staff member and Team Leader of the HPC Methods and Applications Team in Reactor and Nuclear Systems Division at ORNL. He over 20 years of experience in the development of single- and coupled-physics development on HPC hardware spanning Office of Science and NNSA applications.

**Anshu Dubey, Earth and Space Science Applications (2.2.3)**
Anshu is a Computer Scientist in the Mathematics and Computer Science Division at ANL. She has a long history of working with all aspects of PDE based scientific software.

**Bill Hart, Data Analytics and Optimization Applications (2.2.4)**
Bill is a senior research in the Center for Computing Research (CCR) at SNL. As a researcher and former manager in CCR, Bill has led and championed research in scalable optimization, data science and cybersecurity. Bill has a Ph.D. in Computer Science from UC San Diego.

**Marianne Francois, National Security Applications (2.2.5)**
Marianne is the group leader of the Methods and Algorithms Group in the Computational Physics Division in the Weapons Physics Directorate at LANL. She has a history of developing methods for complex multi-material flow and Ph.D. in Aerospace Engineering from University of Florida.

**Phil Colella, Co-Design (2.2.6)**
Phil is Senior Scientist at in the Computational Research Division at LBNL, and a Professor in Residence in the EECS Department at UC Berkeley. His research has been in the area of numerical methods and HPC software development for partial differential equations.
Goal
Develop and enhance the predictive capability of applications critical to DOE across science, energy, and national security mission space

- Targeted development of requirements-based methods
- Integration of software and hardware via co-design methodologies
- Systematic improvement of exascale readiness and utilization
- Demonstration and assessment of effective software integration

32 WBS L4 subprojects executing RD&D
134 L4 subproject (P6) milestones delivered in FY17
318 L4 subproject (P6) milestones planned in FY18-19
Selected FY17 AD Highlights

Release

- CoPA co-design center prepared the HACC parallel FFT algorithm for broad distribution (milestone ADCD02-3)

Science Capability

- ExaSky performed large-scale Nyx simulation to interpret Lyman alpha observations, important for understanding the properties of dark matter and neutrinos (milestone ADSE01-26)

Algorithm or Physical Model Enhancement

- Combustion-PELE developed the capability to automatically predict the thermochemical properties for the combustion of syngas, natural gas, and butane (milestone ADSE14-57)

Performance

- ExaSMR demonstrated first ever full-core reactor simulation with continuous-energy MC on GPUs (milestone ADSE08-36)
AD Challenges

Challenges
Adopting and co-designing programming models that portably expose critical system features to attain portable, efficient performance. Dealing with extreme parallelism, increased faults, and complex node architectures.

- Exposing billion way concurrency in applications: instruction-level, SIMD, MIMD, shared and distributed memory.
- Optimizing applications for deeper and more heterogeneous memory hierarchies.
- Efficiently analyzing exabyte-sized data sets for scientific discovery.
- Avoiding bulk-synchronization and dynamically handling faults within applications.
ECP Software Technology Leadership Team

Rajeev Thakur, Programming Models and Runtimes (2.3.1)
Rajeev is a senior computer scientist at ANL and most recently led the ECP Software Technology focus area. His research interests are in parallel programming models, runtime systems, communication libraries, and scalable parallel I/O. He has been involved in the development of open source software for large-scale HPC systems for over 20 years.

Jeff Vetter, Development Tools (2.3.2)
Jeff is a computer scientist at ORNL, where he leads the Future Technologies Group. He has been involved in research and development of architectures and software for emerging technologies in HPC, such as heterogeneous computing and nonvolatile memory, for over 15 years.

Lois Curfman McInnes, Mathematical Libraries (2.3.3)
Lois is a senior computational scientist in the Mathematics and Computer Science Division of ANL. She has over 20 years of experience in high-performance numerical software, including development of PETSc and leadership of multi-institutional work toward sustainable scientific software ecosystems.

Jim Ahrens, Data and Visualization (2.3.4)
Jim is a senior research scientist at LANL and an expert in data science at scale. He started and actively contributes to many open-source data science packages, including ParaView and Cinema.

Rob Neely, Software Ecosystem and Delivery (2.3.5)
Rob has several leadership roles at LLNL spanning applications, CS research, platforms, and vendor interactions. He is an Associate Division Leader in the Center for Applied Scientific Computing, chair of the Weapons Simulation and Computing Research Council, and the lead for the Sierra Center of Excellence.
Goal
Build a comprehensive, coherent software stack that enables application developers to productively write highly parallel applications that effectively target diverse exascale architectures.

- Extend current technologies to exascale where possible
- Perform R&D required for new approaches when necessary
- Coordinate with and complement vendor efforts
- Develop and deploy high-quality and robust software products

56 WBS L4 subprojects executing RD&D
185 L4 subproject (P6) milestones delivered in FY17
426 L4 subproject (P6) milestones planned in FY18-19
Software Development Kits are a key design feature of ST and are an important delivery vehicle for software products.

**ECP software projects**
- Each project to define (potentially ≥2) release vectors

**More projects**
- **SDKs**
  - Reusable software libraries embedded in applications; cohesive/interdependent libraries released as sets modeled on xSDK
  - Regular coordinated releases
  - Hierarchical collection built on Spack
  - Products may belong to >1 SDK based on dependences
  - Establish community policies for library development
  - Apply Continuous Integration and other robust testing practices

- **Math SDK**
- **Tools SDK**
- **PM&RT SDK**
- **DataViz SDK**
- **Facility SDK**

**Fewer projects**
- **OpenHPC**
  - Potential exit strategy for binary distributions
  - Target similar software to existing OpenHPC stack
  - Develop super-scalable release targeting higher end systems

- **Direct2Facility**
  - Platform-specific software in support of a specified 2021–2023 exascale system
  - Software exclusively supporting a specific platform
  - System software, some tools and runtimes

- Assume all releases are delivered as “build from source” via Spack – at least initially
- Focus on ensuring that software compiles robustly on all platforms of interest to ECP (including testbeds)
# xSDK release 0.3.0 for ECP

### Scope and objectives
- Demonstrate the impact of community policies to simplify the combined use and portability of independently developed software packages.
- Increase formality of xSDK release process.
- Expand xSDK package members to include additional key ECP numerical libraries.

### Impact
- Lay the groundwork for addressing broader issues in software interoperability and performance portability.
- Improve access to numerical libraries for ECP apps.
- Provide ECP SDKs with an example release process.
- Build roles and experience for future exascale platform porting.

### Project accomplishment
- xSDK 0.3.0 released December 2017.
- xSDK 0.3.0 tested on key platforms at ANL, NERSC, and ORNL (Cori, Titan, Theta), also Linux and Mac OS X.
- Documented package compatibility with xSDK community policies.

### Spack install graph for xsdk-0.3.0

**Legend:**
- **xSDK** packages
- **Build dependencies**
- **Link dependencies**

Original xSDK math libraries: hypre, PETSc, SuperLU, Trilinos
New: MAGMA, MFEM, SUNDIALS

### Deliverables
- [xSDK](https://xsdk.info/download)
- [release-0-3-0](https://xsdk.info/release-0-3-0)
- [installing-the-software](https://xsdk.info/installing-the-software)
- [installxSDK](https://github.com/xsdk-project/installxSDK)
- [packages](https://xsdk.info/packages)
- [policies](https://xsdk.info/policies)
Challenges
Qualitative changes: Massive concurrency; Multi-scale, multi-physics, data-driven science; Ecosystem integration

- Billion way concurrency: Several novel compute nodes.
- Coupled apps: Physics, scales, in situ data, more.
- Data-driven: New software HPC environments, containers.
- Ecosystem: Part of a large, complex, evolving SW environment.
ECP HI WBS

Exascale Computing Project 2.0

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Hardware and Integration 2.4
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- Application Integration at Facilities 2.4.3
- Software Deployment at Facilities 2.4.4
- Facility Resource Utilization 2.4.5
- Training and Productivity 2.4.6
ECP Hardware and Integration Leadership Team
WBS 2.4: Possessing breadth and depth of knowledge and experience well-matched to objectives

**Bronis de Supinski, PathForward (2.4.1)**
Bronis is the CTO for Livermore Computing at LLNL, where he formulates LLNL’s large-scale computing strategy and oversees its implementation. He earned his Ph.D. in Computer Science from the University of Virginia. Bronis is also a Professor of Exascale Computing at Queen’s University of Belfast and an Adjunct Associate Professor in the Department of Computer Science and Engineering at Texas A&M University.

**Simon Hammond, Hardware Evaluation (2.4.2)**
Si has worked for over a decade in application performance optimization and hardware design. He received his Ph.D. from the University of Warwick where he worked extensively with the UK’s Atomic Weapons Establishment. He now works as a Research Scientist at Sandia’s CSRI on hardware/software co-design and next-generation computing architectures.

**Judy Hill, Application Integration at Facilities (2.4.3)**
Judy is currently the INCITE Program Manager for the LCFs and the Task Lead for INCITE Liaison Activities at the OLCF. She is heavily involved in application readiness activities at the OLCF. Judy holds a PhD in computational science with a subsequent 10+ years of experience bringing numerical methods and HPC expertise to a variety of application domains.

**Dave Montoya, Software Deployment at Facilities (2.4.4)**
David, the Technology Futures Lead for Software Environments in the HPC organization at LANL, has experience in workflow characterization, integrated application performance metrics, application/system workflow assessment, and coordinating of the NNSA tri-lab Common Computing Environment Project. He holds a BA in Information Systems Analysis from New Mexico State University and an MBA from the University of Rochester.

**Julia White, Facility Resource Utilization (2.4.5)**
Holds a Ph.D. in chemistry as well as an MBA, and has a wealth of experience in computational science. She previously held management roles at ORNL, PNNL, and Physical Review B and was most recently the program manager for INCITE, which allocates computer time on DOE leadership class computers.

**Ashley Barker, Training and Productivity (2.4.6)**
Ashley is the Group Leader for the User Assistance and Outreach team at the OLCF, where her group is responsible for facilitating access to OLCF resources, providing training, documentation, and technical support to users, collecting and reporting on user facility data, and acquainting the public with the work conducted at the OLCF through scientific highlights. Ashley earned her MS in information sciences from the University of Tennessee.
ECP Hardware and Integration: Delivery of integrated ECP/DOE facility products

Goal
A capable exascale computing ecosystem made possible by integrating ECP applications, software and hardware innovations within DOE facilities

- Innovative supercomputer architectures for competitive exascale system designs
- Accelerated application readiness through collaboration with the facilities
- A well integrated and continuously tested exascale software ecosystem deployed at DOE facilities through collaboration with facilities
- Training on key ECP technologies, help in accelerating the software development cycle and in optimizing the productivity of application and software developers

20 WBS L4 subprojects executing RD&D
38 L4 subproject (P6) milestones delivered in FY17
266 L4 subproject (P6) milestones planned in FY18-19
HI: Designed to enable integration of ECP’s products into HPC environments at the Facilities

ECP will demonstrate meeting objectives on Facility resources

ECP products

- Applications
- Software
- Early HW R&D

Hardware and Integration

- Facility resource utilization
- Developer training and productivity
- SW deployment at Facilities
- HW evaluation
- PathForward

Facilities

- ASCR and NNSA HPC Facilities
- US vendor system offerings

HI is the result of a maturing of ECP’s thinking about the end game
## Relevant Pre-Exascale and Exascale Systems for ECP

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<th>Pre-Exascale Systems</th>
<th>Exascale Systems</th>
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<td><strong>2013</strong></td>
<td><strong>2021-2022</strong></td>
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<td><strong>2016</strong></td>
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<td><strong>2018</strong></td>
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<td><strong>2020</strong></td>
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### Pre-Exascale Systems
- **Argonne**: IBM BG/Q Open
- **ORNL**: Cray/NVidia K20 Open
- **LLNL**: IBM BG/Q Secure
- **LANL/SNL**: Cray/Intel Xeon/KNL Secure
- **Mira**
  - IBM BG/Q Open
- **Titan**
  - ORNL Cray/NVidia K20 Open
- **Sequioa**
  - LLNL IBM BG/Q Secure
- **Theta**
  - Argonne Intel/Cray KNL Open
- **CORI**
  - LBNL Cray/Intel Xeon/KNL Unclassified
- **Trinity**
  - LANL/SNL Cray/Intel Xeon/KNL Secure

### Exascale Systems
- **NERSC-9**
  - ORNL IBM/NVidia P9/Volta Open
- **Summit**
  - LBNL TBD Open
- **Crossroads**
  - LLNL IBM/NVidia P9/Volta Secure
- **Frontier**
  - ORNL TBD Open
- **El Capitan**
  - LLNL TBD Secure
- **Sierra**
  - LLNL IBM/NVidia P9/Volta Secure
- **Trinity**
  - LANL/SNL TBD Secure

- **CORI**
  - TBD
- **Sequoia**
  - LLNL IBM BG/Q Secure
- **LLNL**
  - TBD Secure
- **TRINITY**
  - Secure
- **Mira**
  - Secure
- **IBM/NVidia**
  - Secure
- **P9/Volta**
  - Secure
### Selected HI FY17 Highlights: Training and Productivity Activities

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<tr>
<th>Date</th>
<th>Event</th>
<th># Registered</th>
<th># Attended</th>
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<tr>
<td>FY17 Q2</td>
<td>Introduction to ECP Project Mgmt Tools (Confluence &amp; JIRA)</td>
<td>N/A</td>
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<tr>
<td>FY17 Q3</td>
<td>Python in HPC</td>
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<td>132</td>
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<td>OpenMP Tutorial</td>
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<td>60</td>
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<td>FY17 Q4</td>
<td>Argonne Training Program on Extreme-Scale Computing 2017</td>
<td>168 (applied)</td>
<td>71 (selected)</td>
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<td>Intermediate Git</td>
<td>149</td>
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<td>Using the Roofline Model and Intel Advisor</td>
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<td>Barely Sufficient Project Management</td>
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<td>Scalable Node Programming with OpenACC</td>
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<td>FY18 Q1</td>
<td>HipChat Webinar</td>
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<td>Managing Defects in HPC Software Development</td>
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<td>TAU Performance System Webinar</td>
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<td>31</td>
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- Over 650 people have participated in ECP Training activities to-date
- ECP team members have led additional tutorials and workshops at events such as SC, ISC, and PASC.
- Have created documentation and best practices covering topics like ECP project management tools
- Launched Better Scientific Software website – resource for developer productivity and sustainability

Public training materials are archived on the ECP External Website: [http://exascaleproject.org](http://exascaleproject.org)

Internal training materials are found on the ECP Confluence Knowledgebase site: [https://confluence.exascaleproject.org/display/KB](https://confluence.exascaleproject.org/display/KB)
Collaboration between ECP and Facilities is Critical for Success

Engagement Plan starts with existing touch points and expands into formal activities of mutual benefit:

- **Application Development**
  - ECP will collaborate and share experiences in user programs, facility testbeds, and development work on pre-exascale and exascale systems
  - ECP will work with facilities to obtain access to vendor staff and system expertise for help in preparing applications for the exascale and pre-exascale systems

- **Software Deployment and Support**
  - ECP will collaborate with facilities staff to explore deployment and integration of software on production systems
  - ECP will closely collaborate with facilities staff on strategies for continuous testing and hardening of advanced software components on facilities architectures and within the facilities existing software stacks
  - Facilities will be actively involved in reviewing software projects and gap analysis

- **Hardware and Integration**
  - ECP and Facilities will hold joint training and workshops, with invitations to the trainings held by either organization to be open to the other organization
  - DOE pre-exascale and exascale systems will benefit from vendor R&D efforts supported by the DOE Pathforward program as will the Facilities and ECP applications
  - SC Facilities and ECP will collaborate in the allocation of facility resources to ECP to most effectively utilize the resources for science and exascale development
RFP for Continuous Integration Solution

• Released ECP RFP for a Continuous Integration Solution on 12/12/17.

• Selected vendor will deliver a secure, easy-to-use Continuous Integration (CI) solution for deployment at large-scale HPC facilities that will run on the real hardware at each site and in that site’s environment to test for hard-to-find bugs related to the site’s deployment environment. The solution should be deployable on-premises at the HPC facilities or as a trusted cloud application that can run jobs at HPC facilities.

• RFP closes 01/05/2018.

• RFP will be evaluated by members of ECP ST, AD, and HI teams along with designated members of the facilities.

• Activity will provide benefit to both ECP and the ASCR/NNSA computing facilities.

• RFP URL:  http://procurement.ornl.gov/rfp/6400015283/
**HI Challenges**

**Challenges**

Time pressure on HPC ecosystem and DOE facilities; Developing and maintaining strong collaborations with many facilities, AD, and ST; Standing up HI two years into ECP

- Shortened timeline: less time for HW innovations, app and SW development, facilities preparation and acquisition
- Integration with 6 facilities: building strong collaborations, aligning priorities and schedules
- HI late start: reduced time to achieve objectives, budgetary constraints
- Integration with AD and ST: many projects, connecting them with the facilities, building collaboration between many stakeholders
ECP Preliminary Design Report (PDR)

Present comprehensive technical design and approach to meeting ECP’s objectives (mission need, KPPs)

AD WBS L4 subproject example (cancer application)

ST WBS L4 subproject example (global arrays)
Selected Observations
- Review committee was impressed with the quality of the Preliminary Design Report (PDR) and its interaction with the ECP leadership team. The leadership team is fully staffed down through level 3 of the WBS with highly competent leaders.
- ECP has restructured and realigned their technical approach to reflect the changes to the project’s scope, schedule and budget in order to meet the overall project goals and KPPs.
- The project has engaged with the SC and NNSA facilities to begin planning for the successful deployment of exascale applications.

Selected Recommendations
- Review ECP milestones and Figures of Merit (FOM) for level consistency.
- Make sure each of the Software Technology (ST) projects have at least one impact goal which directly connects to one or more Application Development (AD) efforts.
- Clearly define how the risk register is developed and used (define risk categories, cost estimates, contingency, proposed mitigations).
- Once the technical and contractual details for the first two exascale systems are known, the Hardware and Integration (HI) focus area should review and update their preliminary planning, schedule, and risks to identify potential barriers to successfully achieving KPPs.
ECP: Summary

• We believe we have a good team and plan, executing full bore now

• Enjoying DOE stakeholder support (e.g., SC and Applied Offices for ECP applications)

• Still have work to do: tracking progress (dashboard), maintaining agility for highest ROI on RD&D, more proactive risk management, better integration with facilities

• Working to actively manage our highest risks

• Moving into a product development stage with more quantitative metrics

• Near term radar
  – ECP Independent Project Review (IPR): Jan 9-11, 2018 (ORNL)
  – ECP 2\textsuperscript{nd} Annual Meeting: Feb 5-9, 2018 (Knoxville, TN)