FUSION SIMULATION PROGRAM (FSP): OVERVIEW

FSP PROGRAM ADVISORY COMMITTEE MEETING

September 17-18, 2009

W. M. Tang

FUSION SIMULATION PROGRAM (FSP)

Outline of Overview Talk:

I. Mission & Vision
II. Organization
    a. management structure
    b. membership
III. Situation Analysis
    a. time-line
    b. planning guidelines
IV. Planning Elements
    a. cross-coordination between groups (with respect to schedules & interfaces)
V. Milestones & Deliverables
VI. Outreach Activities/Plans
VII. Concluding Comments

FSP MISSION

- **The goal of the Fusion Simulation Program (FSP) is to enable scientific discovery of *important new plasma phenomena* with associated understanding that *emerges only upon integration*. This requires developing a predictive integrated simulation capability for magnetically-confined fusion plasmas that are properly validated against experiments in regimes relevant for producing practical fusion energy.**

FSP VISION

- ***The Fusion Simulation Program (FSP) will provide the capability to confidently predict toroidal magnetic confinement fusion device behavior with comprehensive and targeted science-based simulations of nonlinearly-coupled phenomena in the core plasma, edge plasma, and wall region on time and space scales required for fusion energy production.***

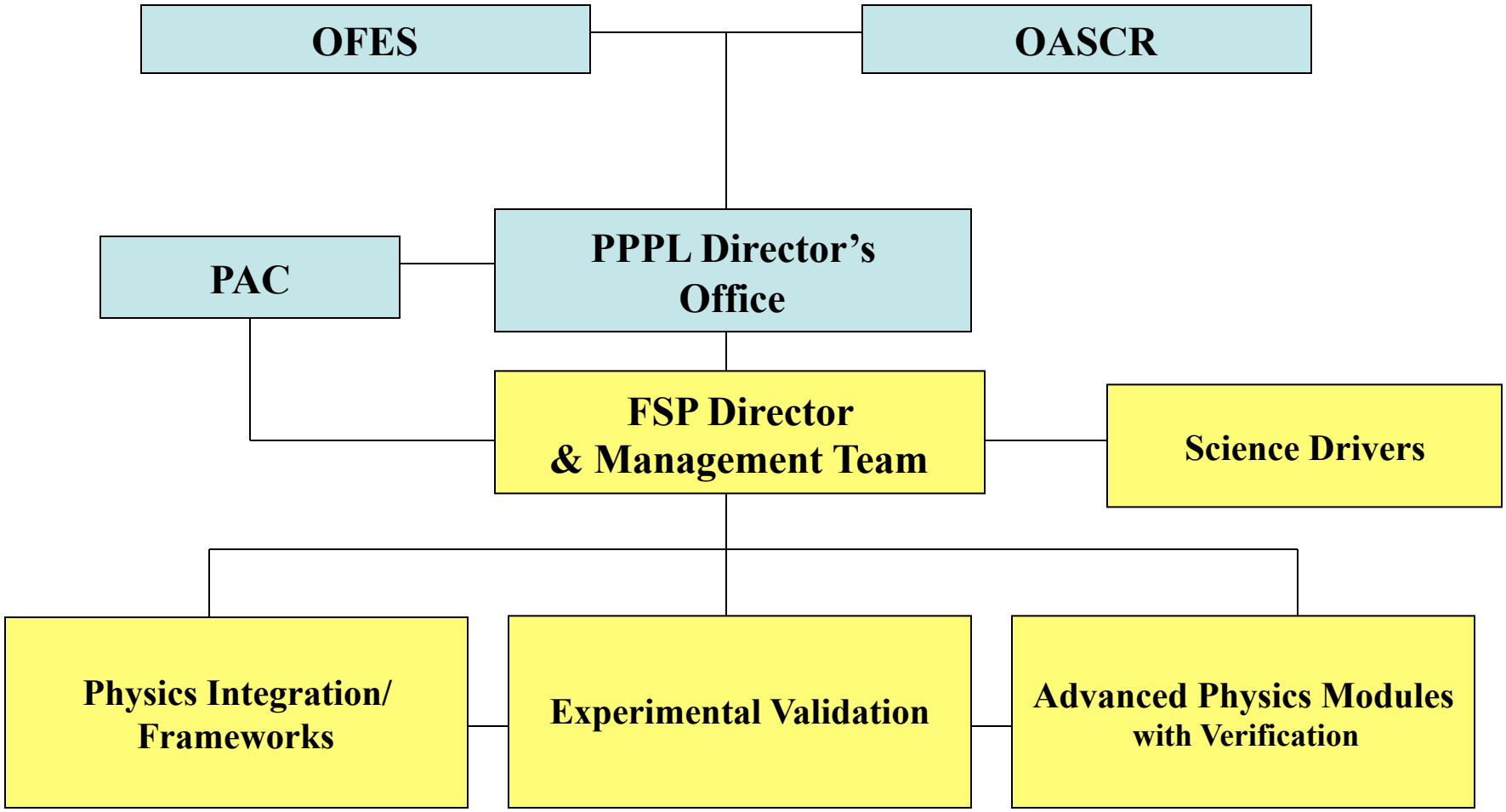
– **Integrate the knowledge from key multi-scale physical processes to continually improve fidelity for extending whole-device modeling capabilities *beyond current applicability domains*.**

– **Produce a framework in which physics component-codes interact efficiently to *enable unprecedented capabilities* to compute experimental observables, interpret experimental data, and explore the consequences of theoretical models.**

– **Incorporate modern software engineering and software quality assurance to *ensure the reliability, robustness, and ease-of-use of the tools* that are developed.**

– **Create the most advanced suite of predictive codes under a unified framework and distribute it to and provide support for the fusion community to *maximize US investments in experimental facilities (especially, ITER) and in HPC resources (especially, the Leadership Class Facilities) to produce the scientific basis for an economically and environmentally attractive source of energy*.**

Management Structure for FSP Planning/Program Definition



FSP PROGRAM DEFINITION/PLANNING MANAGEMENT TEAM*

- **Director** (*W. Tang, PPPL*), **Deputy Director, Project Manager** (*D. Kothe, ORNL*)

- **Science Drivers** (*Lead, A. Kritz, Lehigh U.*) with Supporting Team

- **Frameworks/Physics Integration** (*Lead, J. Cary, Tech-X*) with Supporting Team

- **Experimental Validation** (*Lead, M. Greenwald, MIT, co-Lead, V. Chan, GA*) with Supporting Team

- **Advanced Physics Modules** (*Lead, X. Tang, LANL*) with **Verification** (*L. Diachin, LLNL*) with Supporting Team

*W. Tang (PPPL/PU). D. Batchelor (ORNL), H. Berk (IFS), J. Brooks (Purdue U.), J. Cary (Tech-X/U. Colorado), V. Chan (GA), C.S. Chang (NYU), P. Colella (LBNL), L. Diachin (LLNL), P. Diamond (UCSD), M. Greenwald (MIT), D. Keyes (Columbia U.), D. Kothe (ORNL), A. Kritz (Lehigh U.), W. Nevins (LLNL), A. Siegel (ANL/U.Chicago), X. Tang (LANL), G. Tynan (UCSD)

CURRENT FSP SITUATION ANALYSIS

- **The FSP team is currently funded to carry out a detailed "planning study" during the next two years (beginning July of FY '09 & ending July of FY '11) -- in coordination with DOE-SC (OFES and OASCR)**

- **Deliverables include:**

  FSP mission statement, vision, and an appropriate implementation plan with a "living roadmap" of scientific software deliverables/milestones and associated time-lines with work breakdown structure (WBS)

  - **Assessments of current capabilities with associated "gaps analysis"**
  - **Equivalent to "Project Definition" phase in *Project Management* language, leading to *Critical Decision 1 (CD-1)***
  - **Although the FSP does not fall strictly under the provisions of DOE Project Mgt. Order 413.3 A, associated *"best practices" will be adopted to ensure its success***
  - **Valuable "lessons learned" from experiences of other major targeted software development projects such as ASC [e.g. -- FY06 ASC Program Plan]**

FSP Time-line

- FESAC FSP panel report (*recommendation for OFES to proceed with the "Project Definition" phase of the FSP)* - October 2007
- ASCAC FSP panel report (*recommendation for OASCR to partner with OFES in the FSP*) -- July 2008
- PPPL-led Proposal submitted (December 2008) in response to DOE RFP http://www.sc.doe.gov/grants/FAPN09-04.html
  - *Team of 6 national labs, 2 companies, and 9 universities* to carry out the Project Definition/Planning for the FSP
  - Proposal favorably peer-reviewed and recommended for acceptance - *March 2009*
  - *With initial release of funding, FSP Planning Mission* just began in *July 2009* and will extend over next 2 years (i.e., all of FY '10 and through June/July 2011)
  - July, 2011: Delivery of Final FSP Project Definition Plan to DOE
  - *Goal is for FSP* to be *jointly supported* by DOE-SC's Office of Fusion Energy Science (*OFES*) and Office of Advanced Scientific Computing Research (*OASCR*)

- *Based on a favorable outcome of DOE-SC review and the availability of appropriated funds, the full FSP would likely be launched in FY 2012*

CURRENT FSP PLANNING GUIDELINES

- **FSP Proposal was very favorably *peer-reviewed by 9 experts (FES & ASCR) from U. S. and international community* and strongly recommended for acceptance**

- **Advise from Reviewers:**
  - ***Prioritization:* cautionary to properly prioritize -- avoid "lowest common denominator" approaches and being "all things to all people"**
  - ***Approach:* "lead with the science" and be cognizant of strategic importance of delivering practical nearer-term software capabilities to the user community (based on vetted user requirements)**
  - ***Validation:* need to demonstrate strong coupling to experimental observations/data**
  - ***Risk Mitigation:* nearer-term deliverables should be based on reasonably well-known software platforms, and new physics components should be benchmarked/tested vs. simpler models**

FSP PLANNING ELEMENTS

- *Science Drivers (A. Kritz)*
  - Identify criteria for and prioritization of critical scientific challenges & associated "gaps"
  - Critical evaluation of components, frameworks, V&V, and management plans to ensure consistency with science drivers
  - Timeline for delivery of needed scientific capabilities ("scientific roadmap")
  - Plan for monitoring progress in delivering on science drivers

- *Frameworks/Physics Integration (J. Cary)*
  - Follows from science drivers and user needs
  - Incorporates best practices and available software, including physics components
  - Specification of overall FSP software that takes one from concept to research result
    - Physics composition
    - Workflow composition
    - Engineering infrastructure and process plan

FSP PLANNING ELEMENTS

- *Advanced Physics Modules (X. Tang)*
  - Plan for identification, improvement, & creation of advanced software components to be used as modules
  - Assess mathematical and CS infrastructure component needs
  - Gaps analysis: "What's needed and what's present/absent?"
  - Decision-making process for component criteria and prioritization
  - Verification plan
  - Plan for component life cycle, standards, deliverables, schedules
  - Libraries and tools requirements and plan
  - Connection to LCF capabilities with associated readiness and requirements and plan

- *Experimental Validation (M. Greenwald)*
  - Review and documentation of lessons learned, including outreach
  - Identification gaps in capabilities and methodologies
  - Validation requirements and plan (code/component "pedigree"?)
  - Experimental coordination plan
  - Validation documentation strategy
  - Risk assessment
  - Integration of V&V into FSP

FES community involvement with the FSP

- **The FSP planning team will draw input from:**
  - *(i) The major OFES national ReNeW process -- a major source of community input on key FSP topics as well as with ongoing TTF, BPO, ITPA activities*
  - *(ii) The current writing of a major DOE report on "FES Grand Challenges and Computing at the Extreme Scale" – workshop (Spring, '08) involving over 100 of the top scientists from the FES, Applied Math, and Computer Science communities*
- **Project definition deliverables will include plans for continuing interaction & coordination with:**
  - *the FES analytic theory & modelling communities to help address: (1) key physics gaps in the models implemented in the FSP codes; & (2) effective process for incorporating improved theoretical models into the FSP simulation tools*
  - *the FES experimental community to help address: (1) key physics gaps in the models implemented in the FSP codes; & (2) formulation of a successful and credible verification and validation plan*

**Also will engage international integrated modeling efforts -- coordination with EU, Japan, … in addressing needs of the international ITER Organization*

FSP Program Definition Milestones

- **Identify science drivers for FSP with associated *"gaps analysis"***
  - ***Establish criteria for choosing science drivers and assessing both science gaps and software gaps -- identified, e.g., in recent major workshops: (1) FES ReNew; and (2) DOE-SC Workshop on "Grand Challenges in FES.***
- **Develop *program and management plans to address the gaps*, and produce a *living-scientific-road-map that identifies deliverables***
  - ***Cognizance of strategic importance of delivering some nearer-term software capabilities to the user community as well as connection to longer-term development of those capturing the needed science.***
- **Develop plan for *inclusion of requisite expertise from the community needed to address the FSP goals with prioritization***
  - **FSP information briefings/site visits beginning in October '09 to vet proposed plan with larger community (e.g., at PPPL (9/14) & planned at GA, MIT, IFS, U. Wisconsin, …….)**
  - **Public meetings of the working groups (e.g., Science Drivers) planned for next APS-DPP Meeting and at future public venues such as TTF, Sherwood, etc.**
  - **Targeted workshops groups (Science Drivers, Frameworks, V&V, Advanced Modules) -- to be scheduled**
  - **National web-site and working group "wikis" (up and operating now with continuing improvements)**

FSP Program Definition Milestones

- **Produce a *program execution plan (PEP)*, including:**
  - ***conceptual design of the FSP***
  - ***initial technical approaches***
  - ***work breakdown structures (WBS) with associated milestones***

- **Estimate the *manpower, computing resources [both LCF ("capability") & Mid-range ("capacity")], and funding* requirements based on this technical plan**

- **Work with the scientific community, OFES, and OASCR to successfully launch this program after this FSP Program Definition/Planning phase**

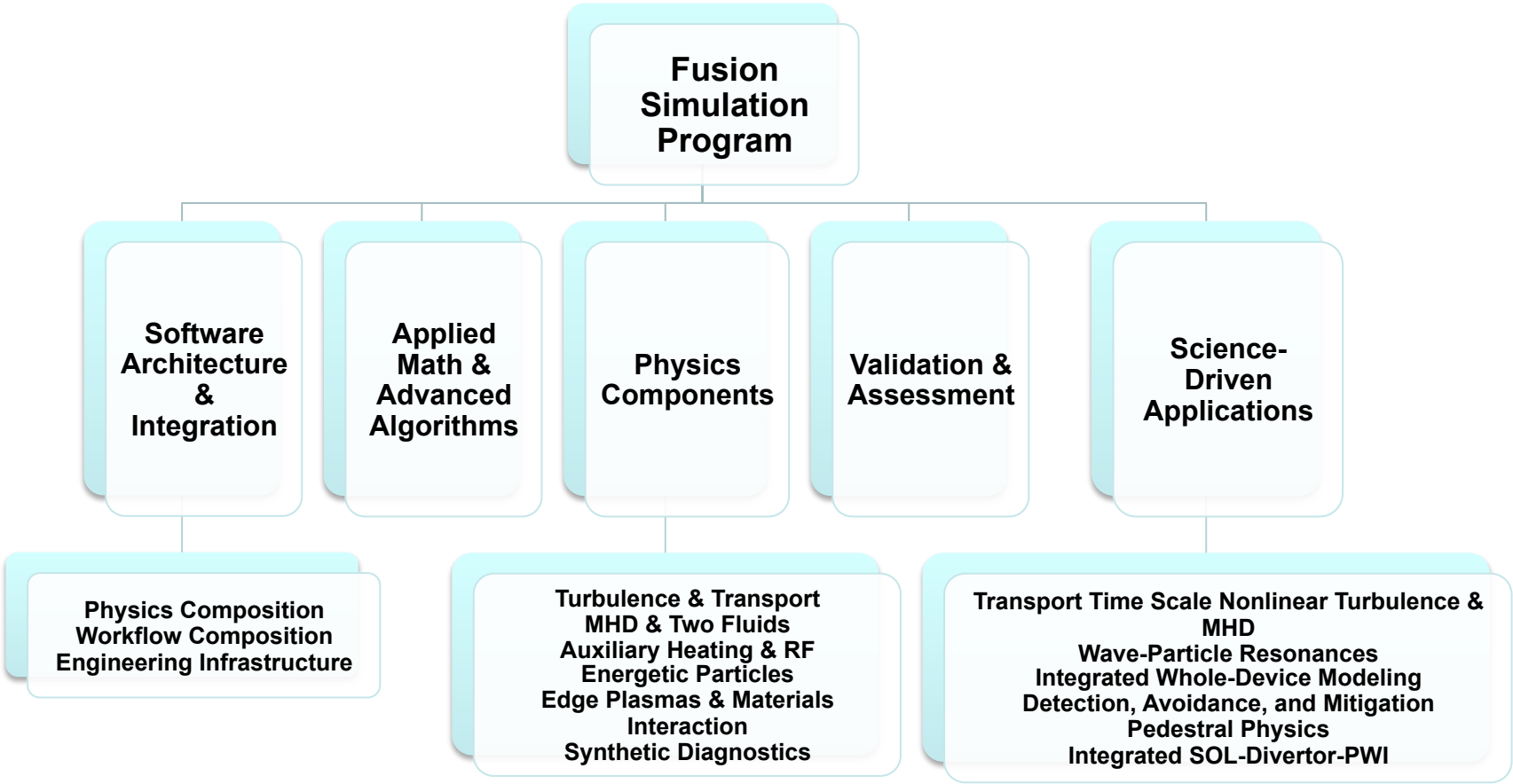
FSP PROJECT EXECUTION PLAN (PEP)

- Mission Statement
- Project Description
  - Project Scope
  - Technical Objectives
  - Science Drivers
  - Impacts on FES Experiment and Theory Programs
  - Consequences of "no FSP"
- Technology Acquisition Strategy
  - Performance Considerations
  - Cost Estimates
  - Operational, Design, and Execution Considerations
  - Interfaces with Other Projects
- Management Organizations and Responsibilities
  - Integrated Project Team
  - DOE-SC (OFES & OASCR)
  - DOE Labs & others (Site Offices)
- *Work Breakdown Structure (WBS)*
  - WBS Elements
  - Project Milestones
  - Project Changes
- Risk Management
- Quality Assurance
- Cyber Security

FSP STRATEGIC PLAN

- Overall direction, policy, work areas – focus on next 5 yrs + vision for next decade and beyond
- Strategy and deliverables to accomplish stated objectives and goals
- Defines WBS and management team members and responsibilities
- Details principal program elements, their strategies, and performance indicators
- Include Level 1 milestones and associated top 10 risks
  - Level 1 milestone: 1-2 annually (program-wide impact)
    - e.g. -- demonstrated FSP simulation capability
  - Level 2 milestone: ~$1-5M per milestone; (key contributing element)
    - e.g. -- formal FSP software release
  - Level 3 milestone: <$1M per milestone; (needed supporting element)
    - e.g. -- documentation, report
- First draft in October '09, near-"final" in December '09
  - Current Activity: core FSP team developing initial overall plan & identifying milestone set and risks
- Emulate program plan format/content of other programs (ASC,…)

FSP Strategic Plan
A Draft Work Breakdown Structure (WBS)



The final and most appropriate WBS will likely evolve during the FSP definition and planning phase as a result of discussions with clients, customers, and users.

FSP IMPLEMENTATION PLAN

- "Who does what and when"
- The set of objectives that need to be accomplished along the way to achieve stated goals
- Product descriptions or all FSP program elements, sub-elements, projects
  - Yearly planned activities and deliverables for each product (L2/L3 milestones)
  - Decreasing fidelity in out-years
- Milestone co-dependencies are defined
- Explicit timelines and resources associated with each activity are defined and tracked
  - need to include experienced project management professionals and use PM tool like Primavera Enterprise to track progress
- *The Implementation Plan is the most difficult and final deliverable*
  - All FSP activities and efforts will have been articulated, planned, resource-loaded, and ready for execution

CONCLUDING COMMENTS

- **The FSP team is currently funded to carry out a detailed "planning study" during the next two years (beginning July of FY '09 & ending July of FY '11) -- in coordination with DOE-SC (OFES and OASCR)**

- **Deliverables include:**

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  - **Assessments of current capabilities with associated "gaps analysis" and risk assessments**
  - **Valuable "lessons learned" from experiences of other major targeted software development projects such as Climate Modeling, ASC [e.g. -- FY06 ASC Program Plan], etc.**
  - **Equivalent to "Project Definition" phase in *Project Management* language, leading to a *(CD-1)-like Decision***
  - **Although the FSP does not fall strictly under the provisions of DOE Project Mgt. Order 413.3 A, associated *"best practices" will be adopted to ensure its success***
  - **More specifics in D. Kothe's presentation**