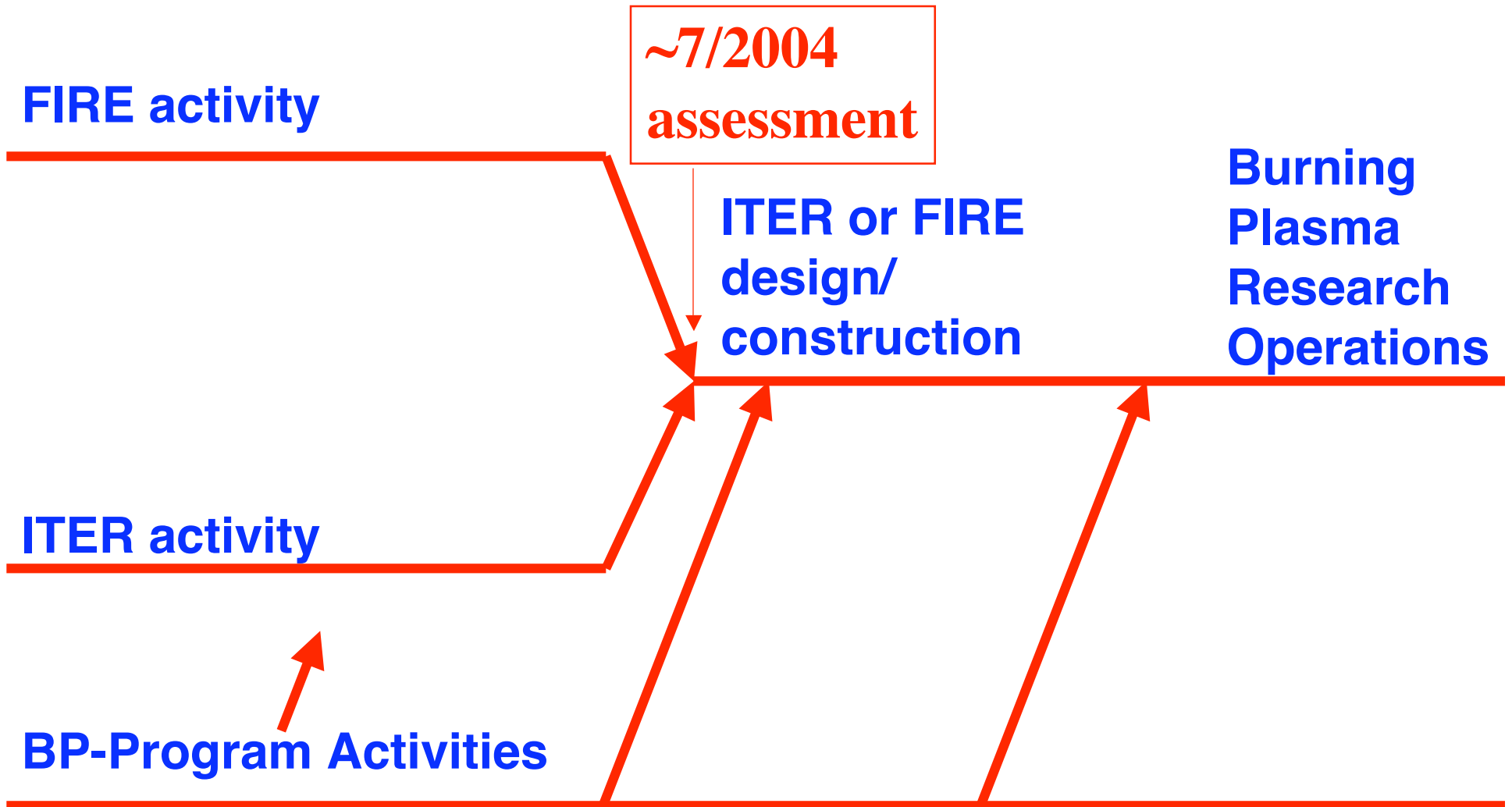

Burning Plasma Physics Program

Progress along the dual path...

Ned Sauthoff

**FESAC
Gaithersburg, MD
7/31/03**

The FESAC US Burning Plasma Plan



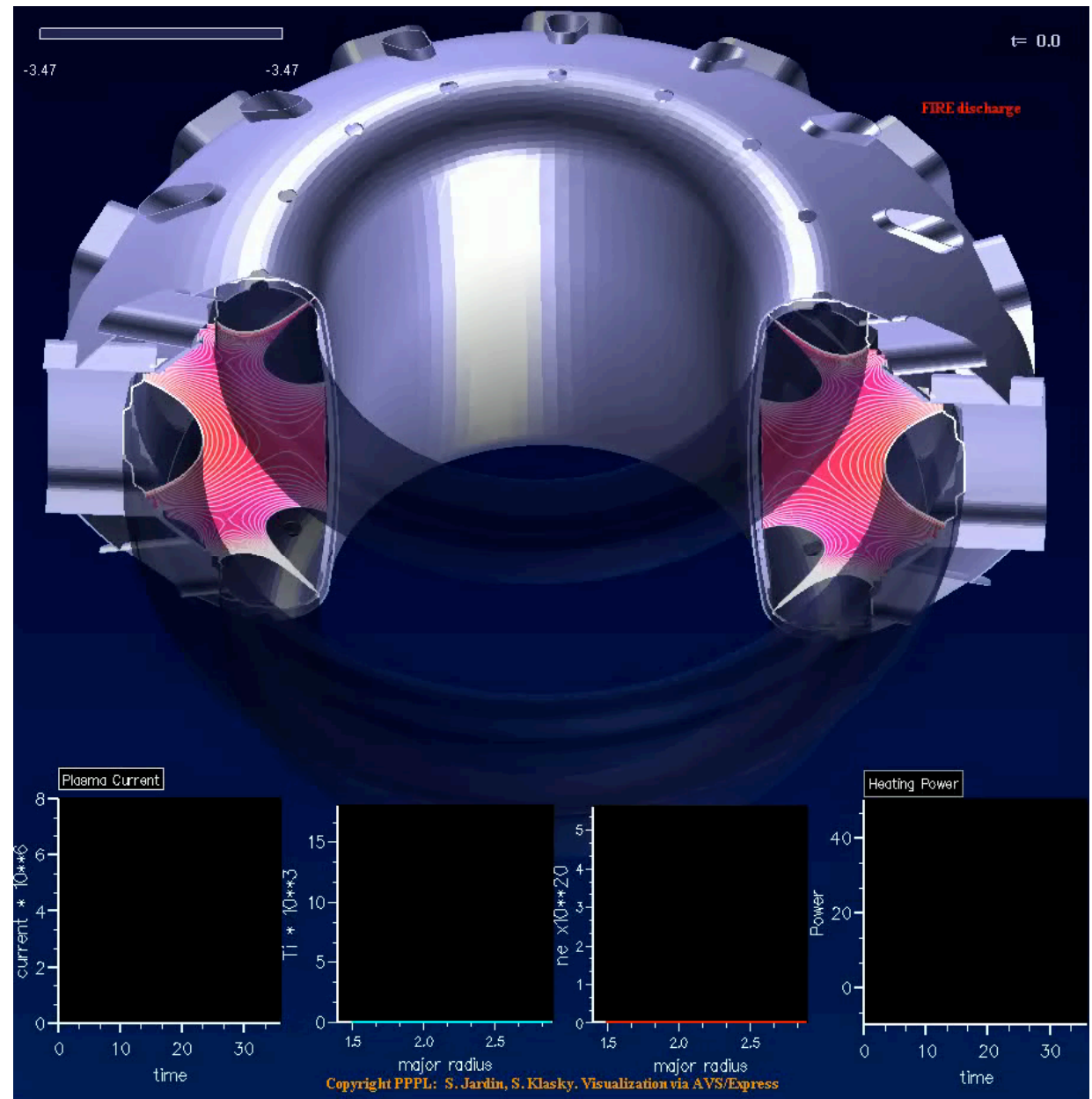
Areas of Major FIRE Activities

- **Advanced Tokamak Modes (ARIES as guide)**
(q , Q , A, SN/DN, q_N , f_{bs} ,)
 - RWM Stabilization - What is required and what is feasible?
 - Integrated Divertor and AT
 - Plasma Control (fast position control, heating, current-drive, fueling)
- **High Power Density Plasma Facing Components**
 - High heat flux, low tritium retention
- **Diagnostic Development and Integration**
- **Integrated Simulation of Burning Plasmas**

FIRE, the Movie

Simulation of a Standard H-mode in FIRE - TSC

- physics based transport (GL23-03)
- $m = 1$ sawtooth Model - Jardin et al
- other effects to be added - Jardin et al



FIRE Progress in FY 2003

- **Response to Snowmass and NSO-PAC Critiques**
 - Tripled pulse repetition rate by cooling both sides of TF inner leg
 - SBIR on insulation looks promising for increasing lifetime shots
 - “Steady-state” ARIES-like mode ($\beta_N \sim 4$, $f_{bs} \sim 80\%$) developed
 - Doubled the pulse length of AT mode up to $5 t_{CR}$
- **Work in Progress**
 - Completing disruption stresses analysis and disruption physics (ITPA)
 - Modeling of edge and divertor plasma power handling and extending power handling capability for AT modes (ITPA)
 - Feasibility study of resistive wall mode coil integrated with first wall (ITPA)
 - Study of a generic diagnostics integrated with shield and first wall
 - Extending Burning Plasma simulations to include advances in MHD instabilities and physics based transport
- **FIRE Physics Validation Review (update of Snowmass Review) in the Fall**

Areas of Synergy and Possible Joint Work (FIRE, ITER)

- **Plasma Facing Components (Divertor and First Wall materials)**
 - high power density, long pulse capability
 - elm erosion and disruption survivability
 - low tritium retention
- **Vacuum Vessel (blanket modules and shielding port plugs)**
 - blanket module test assemblies (nuclear heating, low activation)
 - disruptions
 - integrate with closely coupled control/stabilization coils and diagnostics
- **Plasma Heating, Current Drive and Fueling**
 - development/design of ICRF, LHCD systems for BP scenarios
 - interface with fusion environment (esp. launchers)
- **Diagnostics Development and Design Integration**
 - new diagnostics for $J(r)$, $E(r)$, fluctuations, alpha particles
 - integration with fusion environment (e.g., radiation induced conductivity)
- **Development of Advanced Operating Modes and Plasma Control systems**

ITER-related activities

Support of
US ITER Negotiations

ITER Transitional
Arrangements

US Preparations for
ITER Construction

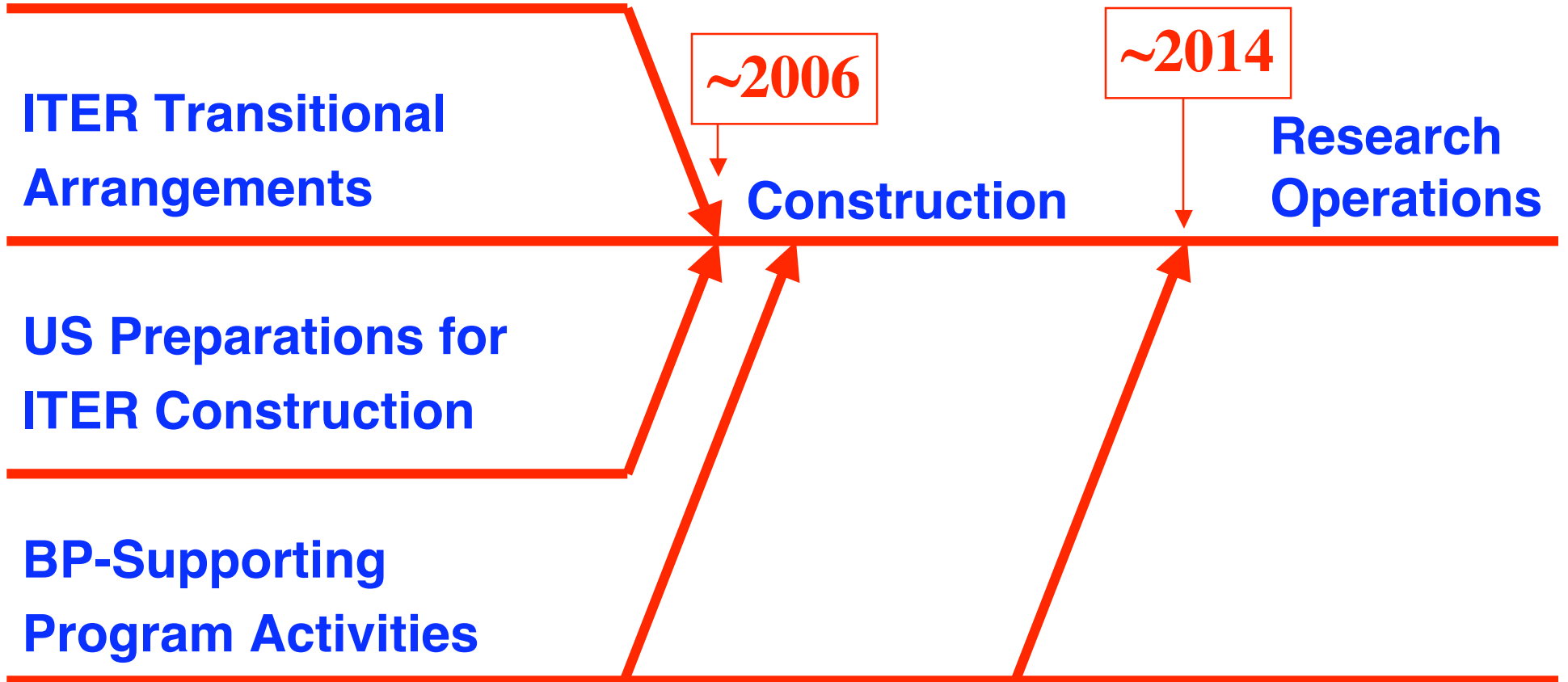
BP-Supporting
Program Activities

~2006

Construction

~2014

Research
Operations



Upcoming ITER-related activities

**Support of
US ITER Negotiations**

**ITER Transitional
Arrangements**

**US Preparations for
ITER Construction**

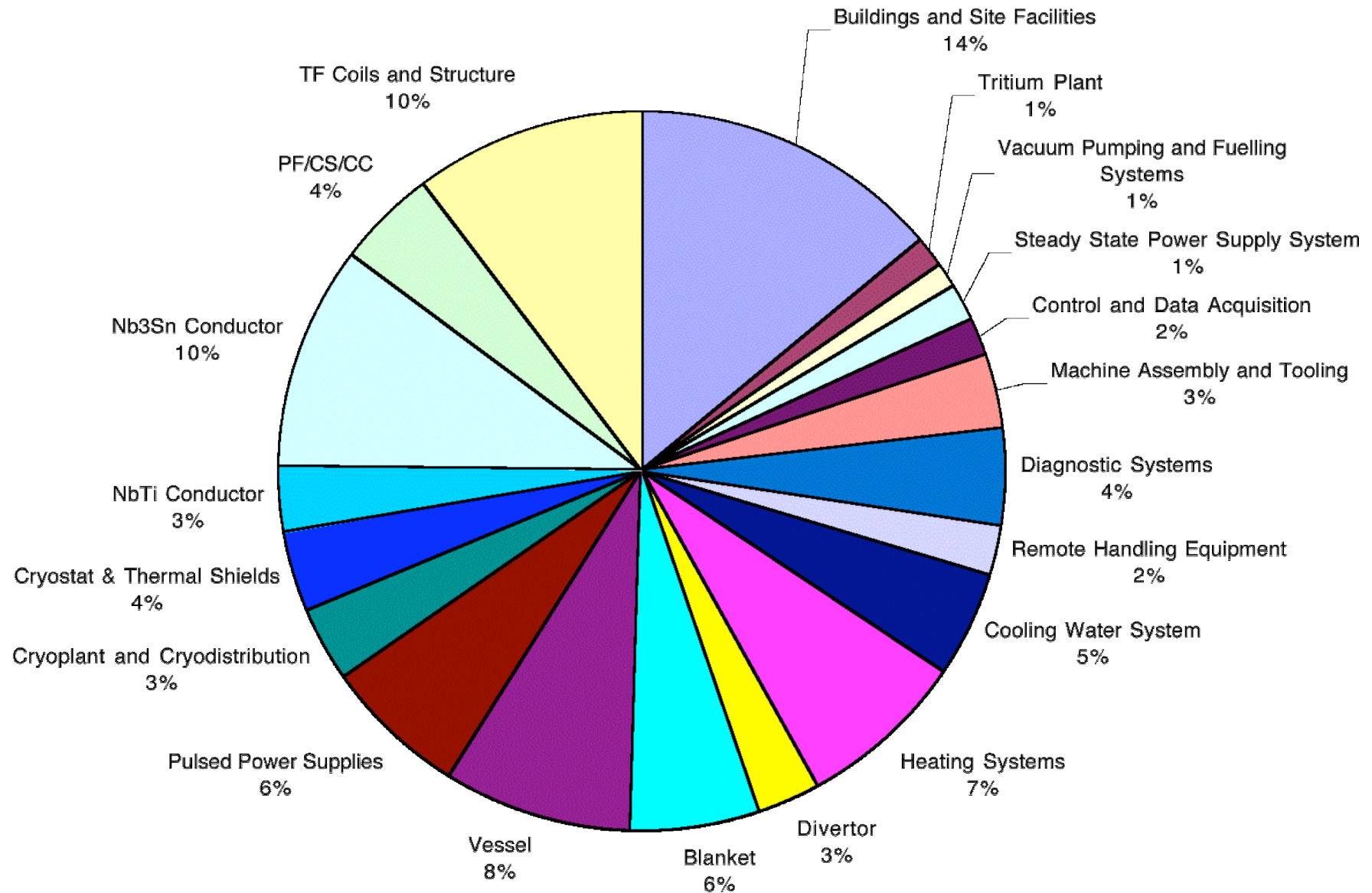
**BP-Supporting
Program Activities**

- **“Levels of Interest” in packages for “in-kind contributions”**
- **Contributing input to discussions**

NRC Burning Plasma Letter-Report

- **The fusion program strategy should include cost estimates and scenarios for involvement in ITER, integration with the existing fusion science program, contingency planning, and additional issues as raised in this letter.**
- **The United States should pursue an appropriate level of involvement in ITER, which at a minimum would guarantee access to all data from ITER, the right to propose and carry out experiments, and a role in producing the high-technology components of the facility, consistent with the size of the U.S. contribution to the program.**

Direct Capital "Value"

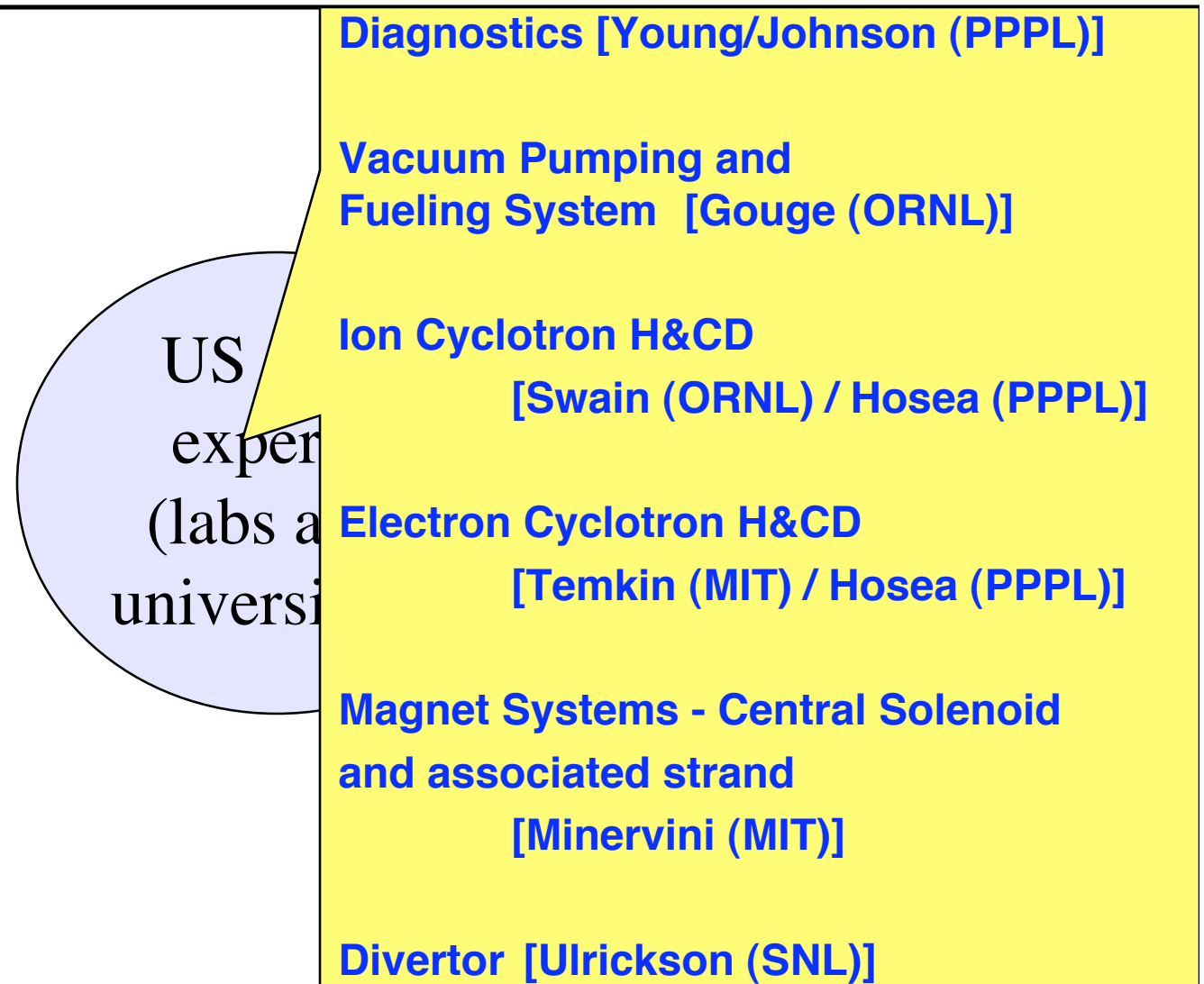


US cost-estimation for each procurement-area of interest

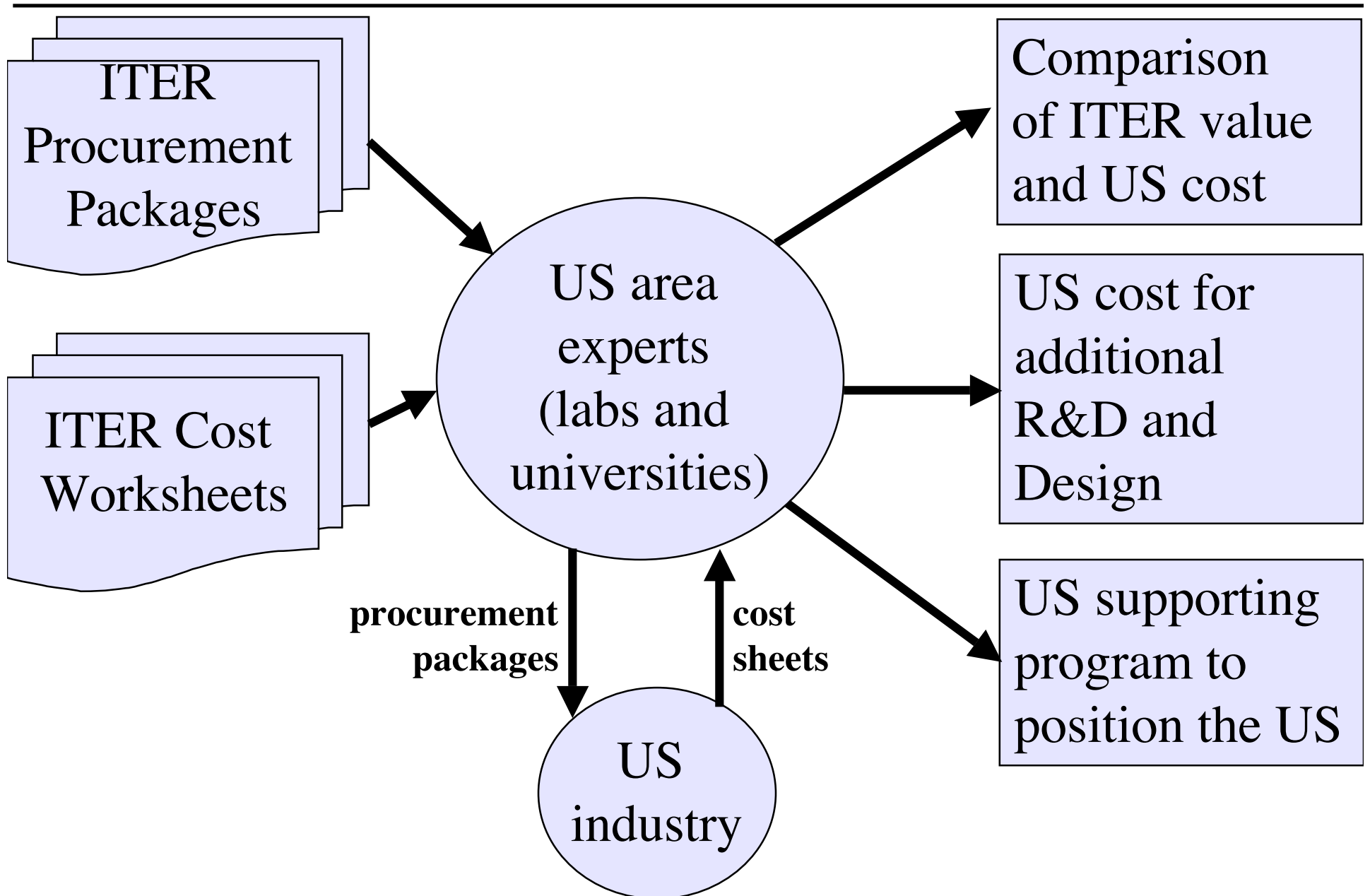


US area
experts
(labs and
universities)

US cost-estimation for each procurement-area of interest



US cost-estimation for each procurement-area of interest



Burning Plasma Program Advisory Committee

- **Formed to advise the US ITER Planning Officer**
- **Membership**
 - Stewart Prager (U. Wis.), chair
 - Mohamed Abdou (UCLA)
 - Réjean Boivin (GA)
 - Harold Forsen
 - Jeffrey Freidberg (MIT)
 - Richard Hawryluk (PPPL)
 - E. Bickford Hooper (LLNL)
 - Stan Milora (ORNL)
 - Gerald Navratil (Columbia)
 - George Tynan (UCSD)
 - James Van Dam (UTex)

BPPAC activities

- **levels of interest of the programmatic-area of each of the 85 procurement packages.**
- **considerations for US levels of interest in the actual performance of the 85 ITER procurement packages**
- **considerations for the organizational structure and arrangements for the conduct of US ITER activities**

Some possible considerations for the selection of US offers, to be elaborated and prioritized by the BPPAC

- 1. US research positioning**
- 2. ITER-value per dollar**
- 3. Relative strength or leverage of US contribution to ITER**
- 4. Contributions to US fusion program**
- 5. Enhancement of fusion-relevant capability of US industry**
- 6. US industrial opportunity**
- 7. Development of US fusion workforce**

Upcoming ITER-related activities

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**BP-Supporting
Program Activities**

- “Levels of Interest” in packages for “in-kind contributions”
- **Contributing input to discussions**

NSSG-8 and 9 Groups

- **Management Structure**
 - Construction and Operations Phases
 - Research Participation in ITER during the Operation Phase (JA input)
- **Risk**
- **Procurement Systems/Methods**
- **Procurement Allocations**
- **Staffing**
- **Financial Regulations**
- **Intellectual Property**
- **Decommissioning**

Management Structure

- **International Organizational Structure**
 - Effectiveness and efficiency of the project should be primary
- **Director-General's / Organization's authority**
 - technical control
(design integration, change control, ...)
 - procurement control
(vendor qualifications, inspections, progress payments, ...)
- **Earned value system**
- **Research phase**
 - task forces
 - experimental planning committee
 - scientific merit metric

Risk

- **Uncertainties and risk can be reduced but not eliminated**
 - technology and cost
 - quality and production-rates of superconducting strand and PFCs
 - detailed fabrication methods
 - excessive sharing of procurement packages, ...
 - delays in delivery
 - design changes
- **Active risk management is key to success --- concept is fully supported**
 - Identifying the risks
 - Assessing the risk impact and likelihood; ranking risks by severity
 - Formulating risk-management strategies
 - Managing the risks (avoid, transfer, share, mitigate, deal with, ...)
 - R&D, prototypes and demonstrated methods, QA and testing, penalty/incentive clauses, ...
 - strong project management, earned value reporting, clear interfaces, reserves, insurance, ...
 - Reviewing the risk register and responding to changes in risk

Procurement Systems/Methods

- **Procurement systems and methods**
 - In-kind contributions (specific scope and value-credit)
 - party-contracted (normal case)
 - Organization-contracted (case-by-case basis)
 - Cash-fund contributions
 - Party fund (possibility)
 - General fund (for assembly and installation, ...)
- **Balance of control/roles (between organization and parties)**
 - technical control,
 - vendor qualification approval,
 - progress payments,
 - acceptance tests, ...

Procurement Allocations

- **P-series of meeting considering cost-sharing on a global basis (i.e., not distribution of procurement packages)**
- **Working group developing guidelines on sharing of tasks**
 - reduced sharing to simplify interfaces, avoid duplication, increase uniformity, ...
 - adopted International Team Leader's re-partitioning of procurement packages
- **Working group shared and discussed expressions of interest in packages**

Staffing

- **Range of arrangements**
 - secondees
 - pro's: continuity of employment, return to home position...
 - direct employees of Organization
 - pro's: commitment
- **Term limits**
 - shorten to increase project flexibility
 - lengthen to attract staff and achieve continuity

Financial Regulations

- **Generalize to “Project Resource Management Regulations”?**
 - Manage all resources --- not just cash
 - includes in-kind contributions
- **Tracking of progress --- “Earned Value Reporting”**
- **Cash fund**
 - on-site integration
 - to support central procurements
- **Reserve-fund / Buffer-fund**

Intellectual Property

- **IP created by:**
 - Organization
 - Party
- **application area:**
 - fusion (royalty-free use by parties)
 - non-fusion / commercial (royalty-charged)
- **territorial restrictions:**
 - Organization-owned
 - party-owned

Decommissioning

- **Amount of the decommissioning fund**
- **Timing of the creation / build-up of the fund**

Upcoming ITER-related activities

**Support of
US ITER Negotiations**

**ITER Transitional
Arrangements**

**US Preparations for
ITER Construction**

**BP-Supporting
Program Activities**

- Performance of “Home Team” tasks
- **Secondees**
 - Naka
 - Garching
 - ITER Site (future)

ITA Task Requests

- **Qualification of industrial suppliers of Nb₃Sn strands with increased value of J_c**
- **Stress analysis of the helium inlet regions**
- **Conductor performance and design criteria (transverse load effects)**
- **CS jacket weld defect assessment**
- **Divertor Diagnostic Side Plates Design**
- **Design of Special Divertor Diagnostic Cassettes including cassettes with in-vessel viewing access**
- **Tolerance Study of the Divertor**
- **Development of Resources Loaded Schedule of Assembly**

Physics Tasks and Working Group

- **Neoclassical Tearing Modes in Inductive Operation**
- **Resistive Wall Modes in Non-inductively Driven Plasma**
- **Disruptions and their mitigation in Inductive Operation**
- **Plasma control**
- **Plasma transport simulations**
- **Divertor**
- **Edge pedestal and ELMs in Inductive Operation**
- **Diagnostic Working Group**

Secondees

- **During the EDA, the US provided ~35 secondees to the Joint Central Team.**
- **The construction-phase secondee assignments would be to a combination of:**
 - the ITER site, and
 - Field Teams in the ITER party territories
- **10% of the total ITER Central Construction Management Team staff level would be comparable to our EDA level:**
 - ~8-12 professionals at the ITER Site
 - ~8-12 support staff at the ITER Site
 - ~10-13 professionals on Field Teams
 - ~19-26 support staff on Field Teams

Upcoming ITER-related activities

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**BP-Supporting
Program Activities**

- **Development of the US ITER Project Management Plan**
- **Positioning the US to perform agreed procurements**
 - **Performance of long-lead-time work on Critical Path Tasks**
 - **US reviews**

Upcoming ITER-related activities

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**BP-Supporting
Program Activities**

- Experiments, theory and modeling aimed at key questions for burning plasmas (design and operation)
- R&D and Design on Diagnostics, Heating and Current Drive Systems
- Re-establish US participation in the ITER Test Blanket Program
- Planning for the ITER Research Phase

Upcoming ITER-related activities

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Arrangements**

Construction

**Research
Operations**

**US Preparations for
ITER Construction**

**BP-Supporting
Program Activities**

- **Secondees**
- **“In-kind” contributions**
- **“Cash-fund” contributions**

Upcoming ITER-related activities

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**Research
Operations**

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ITER Construction**

**BP-Supporting
Program Activities**

- **Scientific Merit should be dominant criterion**
- **“Magnitude of contribution”, rather than “Nature of contribution” should matter for decision-making**

US topics on Research Participation in ITER

- **Development of the Burning Plasma program**
- **Drafting visions and plans on ITER research operations (building on the Japanese paper on Research Participation in ITER during the Operation Phase)**

Development of the Burning Plasma program

- **Beginning a Burning Plasma (BP) Program now on ongoing world experiments,**
 - We need not wait to implement a BP program
 - We should develop the tools and the culture for remote operation by international topical teams
- **Culminating with experiments on ITER**
 - Community-involvement in program planning
 - Participation in experiment-proposal and assessment
 - Participation in experiments and analysis
 - Publication and presentation

Research Participation in ITER during the Operation Phase (JA input)

- **Organization**
 - DG proposes general program, approved by ITER Council
 - Experimental Planning Assembly
 - Science/Operations Divisions
 - Task Forces
- **Opportunities for specific experimentation**
 - “reviewed primarily on the scientific basis, taking into account each Member’s overall contribution”
- **Remote participation tools, analysis tools, theory and modeling**
- **Participation from Members**
 - on-site and remote participation
 - party-specific Remote Access Centers?

Drafting visions and plans on ITER research operations

- **We in the US can build on the Japanese draft paper, aiming at refining a vision for ITER's research activities**
 - Programmatic decision-making
 - Topical task forces
 - Run-time allocation
- **We have a wide range of experiences on collaborations on JET, DIII-D, etc.**
 - JET Joint Undertaking model: strong central team made of secondees from Association laboratories
 - EFDA-JET model: host organization for operations, and task forces from laboratories for the conduct of the science program
 - DIII-D model with a strong host institutions and collaborating major laboratories

Possible US Approaches to Studying Possible Research Participation

- **The Fusion Facilities Coordination Committee (FFCC) has taken the first step in commenting on the Japanese paper**
- **The BPPAC could lead an effort to develop a U.S. view by the time of the APS meeting in November**
- **The ITPA coordinating committee could initiate international discussions**
- **Other???**

ITPA and the paradigm for ITER research

- **International topical groups**
 - Diagnostics
 - MHD, Disruption and Control
 - Steady State Operation, Heating and Current Drive and Energetic Particles
 - ITB and Transport
 - Confinement Database and Modeling
 - Pedestal and Edge
 - Sol and Divertor
- **ITPA may be moved to ITER auspices**
- **ITPA may be a forum for discussing the ITER research management and operations environment, practices, tools, ...**
 - Consider desired arrangements
 - Prototype tools and procedures

ITER-related activities

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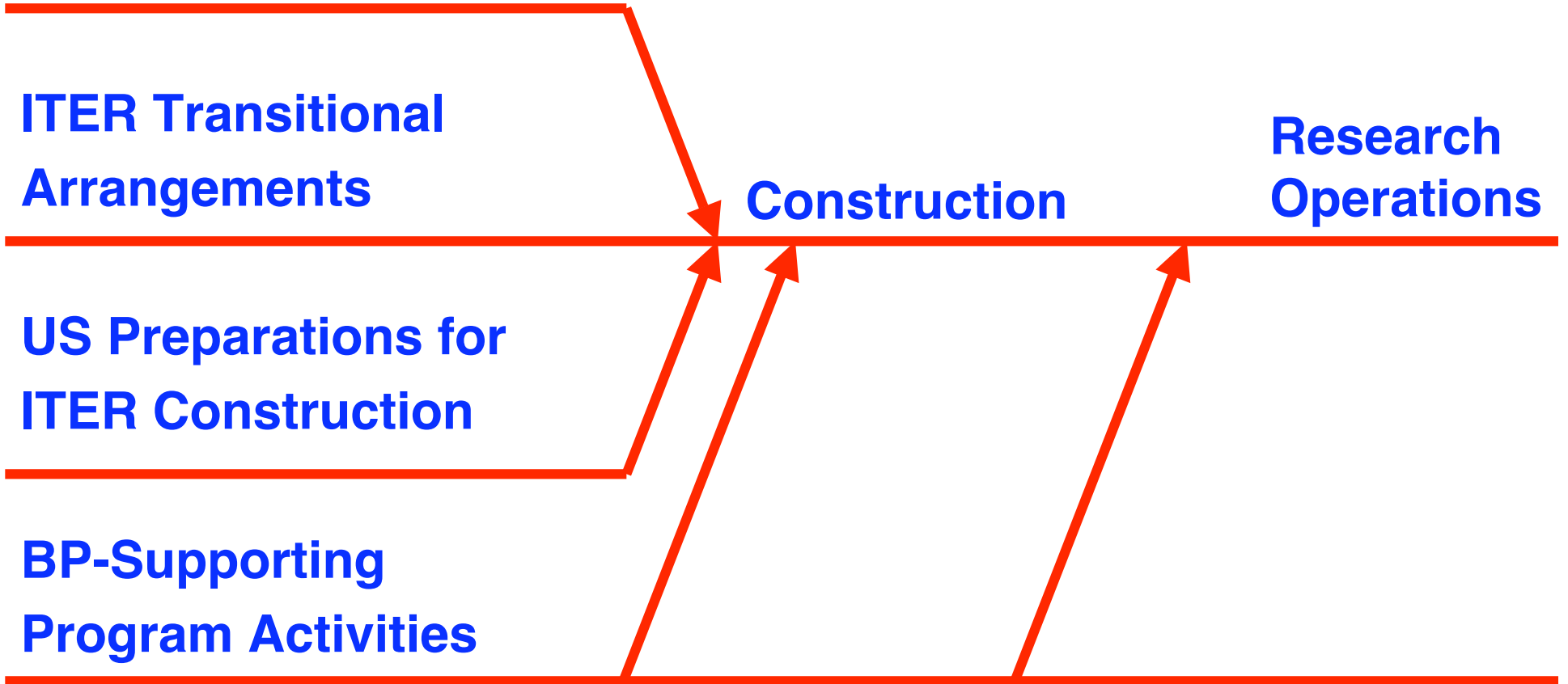
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**BP-Supporting
Program Activities**

Construction

**Research
Operations**



Parting Message

- **Both FIRE and ITER are making progress toward the study of burning plasmas**
 - FIRE physics and engineering design
 - ITER
 - Negotiations
 - ITER Transitional Arrangements
 - US preparations for ITER construction
- **We need to work together to**
 - position for the study of burning plasmas
 - maximize the effectiveness of the burning plasma activities -
--- construction and operations
 - assure opportunities for the full fusion community