



Summary of the
International Workshop
MFE Roadmapping in the ITER Era

*Princeton, New Jersey, USA
7-10 September, 2011*

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Princeton Plasma Physics Laboratory

**Fusion Power Associates Annual Symposium
Washington, DC
14 December 2011**

Outline

- Background and motivation
- Workshop goals and organization
- Outcomes
- Next steps internationally



MFE needs a roadmap that goes all the way to commercial power plants.

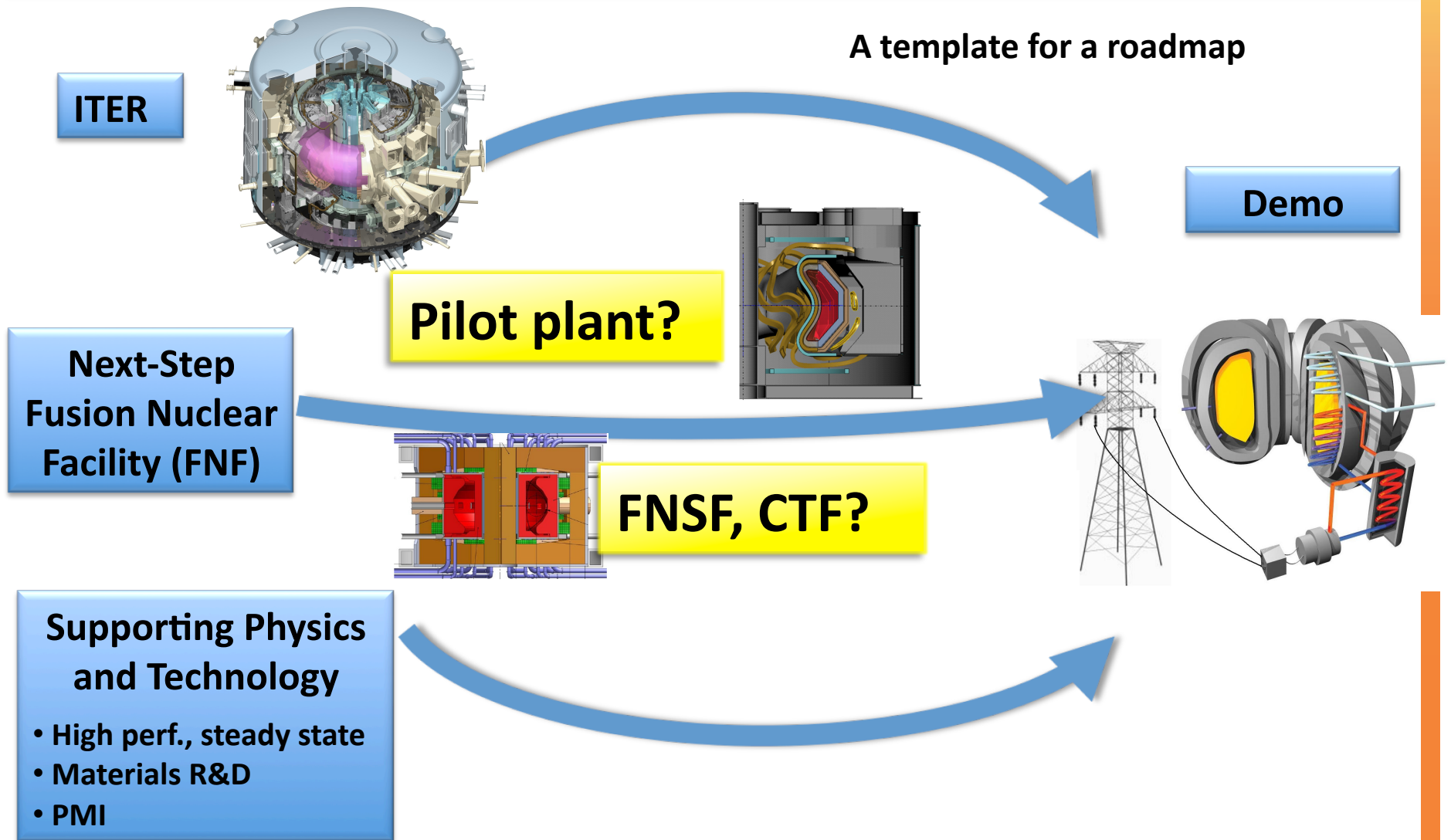
- A plan that enables answers to the questions: when? how much? what risk?
- A framework for ordering priorities, deciding on next steps, managing risks.

International Context for MFE Roadmapping

- ITER means that MFE is on an energy path.
- There is renewed focus worldwide on studies and planning for Demo and next steps.
 - Aggressive national fusion strategies in some countries.
- Planning requires, at least, a high level of awareness of each others' programs.
 - Take into account all technical advances and plans.

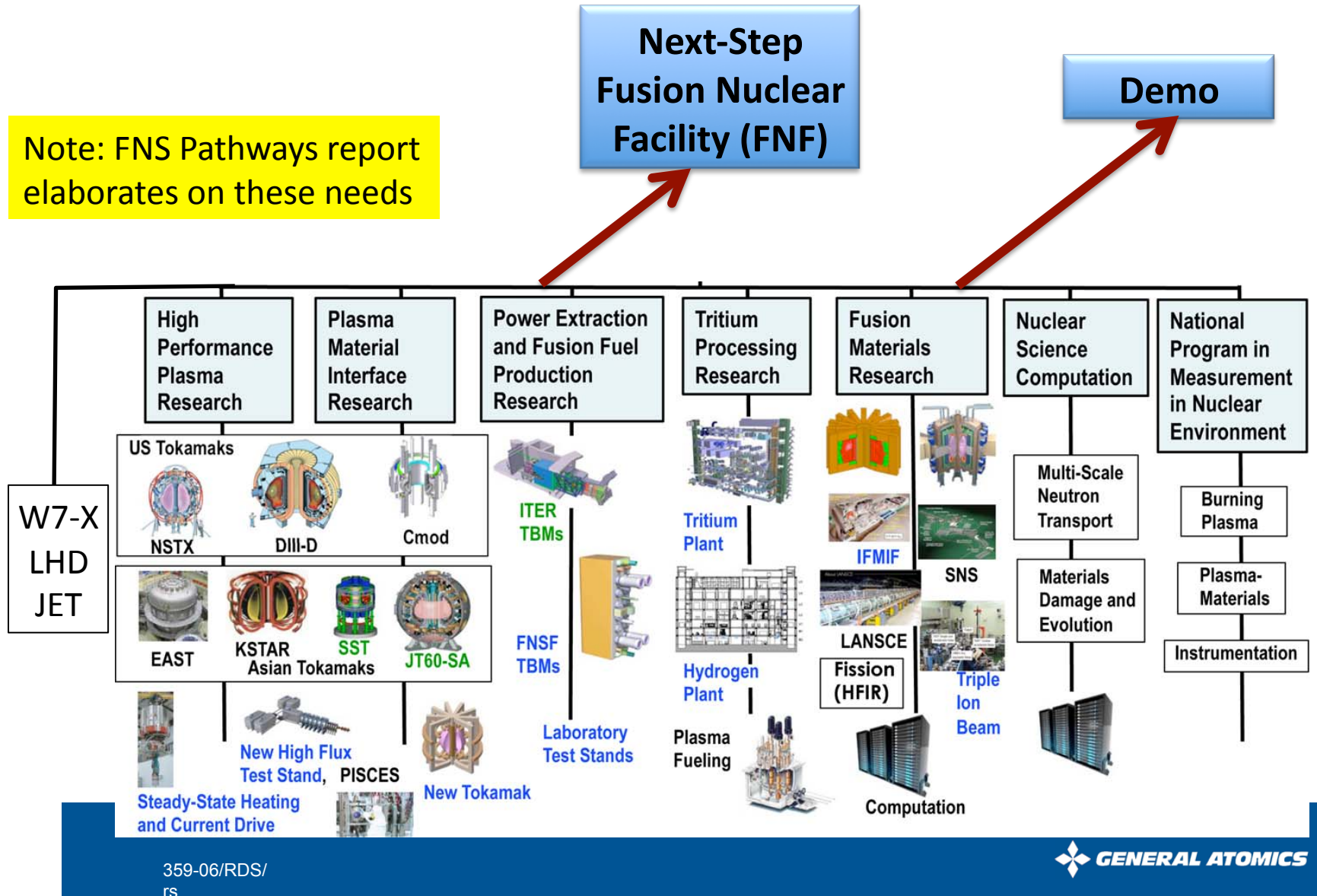
What Do We Need to Do Besides ITER?

A template for a roadmap



“Supporting Physics and Technology” Opportunities for International Coordination?

Note: FNS Pathways report elaborates on these needs



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Acknowledgment (and apologies) to General Atomics

What is the Role of a Next-Step Fusion Nuclear Facility (FNF)?

A range of FNF missions is under discussion world-wide

- Fusion nuclear science (materials in a fusion environment)
- Blanket testing / tritium self-sufficiency
- Prototyping of power plant design and maintenance
- Reliability / availability data
- Net electricity generation.

The U.S. needs an internationally-informed, national effort to make the Mission Need case for its FNF.

- What are the prerequisites for Demo?
- What issues are best resolved in an integrated nuclear facility vs. in smaller facilities, simulated environments, computation?
- What are the risks in the step to an FNF? in the step from an FNF to Demo? What if we went straight to Demo?

The case for an FNF must withstand international judgment.

Roamapping Workshop Goals

- Foster an international technical discussion:
 - On the science and technology issues and prerequisites for Demo, and
 - On the missions, requirements, and risk tradeoffs for major nuclear facilities on the path to Demo.
- Provide a vehicle to inform the planning of strategies and future devices in the various countries.



International response shows that the need was widely felt; timing was good.

An International Committee shaped the workshop goals and agenda.

Mohamed Abdou, U.S.

Steve Cowley, UK

Gianfranco Federici, EU-EFDA

Boris Kuteev, Russia

Jiangang Li, China

Farrokh Najmabadi, U.S.

Robert Wolf, Germany

Hartmut Zohm, Germany

David Campbell, ITER-IO

Shishir Deshpande, India

Yutaka Kamada, Japan

Gyung-Su Lee, Korea

Stan Milora, U.S.

Hutch Neilson, U.S. (chair)

Hiroshi Yamada, Japan

Facts

- 65 registered attendees from ~10 countries including all ITER parties.
- 3.5 days. 28 talks, 9 posters, 4 summaries, 2 general discussions. Posted at:
<http://advprojects.pppl.gov/Roadmapping>.
- Workshop topics & summarizers:
 - Technology.- G. Federici, EU
 - Physics-Technology integration & optimization- R. Wolf, Germany
 - Major facilities on the path to Demo.- J. Li, China
 - Perspectives on Demo and the roadmap. D. Maisonnier, EU
- A summary is in preparation for submission to *Nuclear Fusion*.

Wide Interest in Workshop Outcomes



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What road forward to DEMO?

-Hutch Neilson, Princeton Plasma Physics Laboratory

Fusion World

What is the best way forward to commercial fusion energy?

This important topic reunited fusion researchers from ten countries from 7-10 September at the campus of Princeton University in Princeton, New Jersey. Organized by an international committee of fusion leaders and hosted by the Princeton Plasma Physics Laboratory (PPPL) the workshop, entitled "Magnetic Fusion Energy: Roadmapping in the ITER Era" occurred at a pivotal moment in the history of magnetic fusion development. As the ITER project is now launched on its mission to answer outstanding questions on the control of a burning plasma, countries all over the world are planning—with renewed intensity—the research and facilities needed to harness fusion energy for commercial use.



Sixty-five fusion researchers from ten countries came together at Princeton this month to chart the roadmap to magnetic fusion energy. Photo: PPPL

The international workshop provided a timely forum for the exchange of technical information and strategic perspectives on how to best tackle the remaining science and technological challenges on the way to a magnetic fusion DEMO (demonstration device) and commercialization. The participation of a large number of the world's leading fusion science and engineering researchers reflected the widely felt sense of urgency to collaborate more closely on these challenges.

The workshop was organized around four topics: fusion technology; physics-technology integration and optimization; major facilities; and perspectives on DEMO and the roadmap to DEMO. Participants, including participants from all of the ITER Members, advocated a remarkably consistent timeline for the next-step facilities, despite some variation in the scale and scope of the facilities being considered. All agreed that serious planning should begin now, leading to construction in the 2020s and operation in the late-2020s to mid 2030s.



Tasks to be accomplished on the road to a fusion DEMO include materials R&D, component testing, reliability and availability growth, and electricity generation. Options presented at the workshop ranged from fusion nuclear science facilities for materials research and component development, to pilot plants or demos designed to integrate the science and technology of a fusion system and demonstrate readiness for commercialization. At the same time, it was recognized that there is much to be done in smaller, more focused programs, utilizing computation and simulated environments to expedite progress, in order to develop the fusion nuclear science and technologies for integration and testing in large nuclear facilities. It was also agreed that ITER should be exploited to the fullest extent possible to make progress on these issues.

The scale and complexity of the outstanding challenges in fusion development that were highlighted at the workshop underscore the necessity of working together internationally. A continued international commitment to the success of ITER is viewed as both essential to technical progress and to the credibility of the field. At the same time, new mechanisms are needed for experts to collaborate toward better technical understanding of the major development issues and options for resolution. The formation of international working groups was suggested to address key technical issues where currently understanding diverges, for example: the physics and technology assumptions and models used in fusion system codes; the strategy for fusion materials development; and the requirements and state-of-readiness for the various next-step facility options.

A summary of the workshop is being prepared for publication, and a list of participants and all of the presentation material is available here. For further information, contact Hutch Neilson at hneilson@pppl.gov.

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Newsletter articles published or in preparation...

- ITER Newsline
- Fusion Power Associates Program Notes
- Japan Society of Plasma and Fusion Research (H. Yamada)
- Fusion in Europe (G. Federici)
- ANS FED Newsletter
- IEEE NPSS Newsletter
- PPPL Weekly

Workshop Discussion Highlights

- Common perspectives among many countries on the timing of next-step FNF: Begin serious planning now, construct in the 20's, operate in the late 20's to mid-30's.
- Choice of next-step mission / scope is not obvious.
 - Menu includes: steady-state plasma control; materials R&D; component testing; reliability & availability growth; electricity generation.
 - How large a step is appropriate? What are the risks? What gaps to commercial fusion would remain?
 - Physics and engineering assumptions: what is “conservative”? what is “aggressive”?
- Strategy for materials development, particularly irradiation testing, is not obvious. What capabilities are needed, and when?
- Choice of magnetic configuration for Demo is not obvious. New interest in pulsed tokamaks, stellarators.

General Conclusions

- The scale and complexity of the outstanding challenges of fusion development necessitate continuing international collaboration.
- A continued international commitment to the success of ITER is critical both to technical progress and to the credibility of the field.
- We need a way for experts to collaborate internationally in reaching a better technical understanding of the major development issues and the options for resolving them.
 - IAEA “Consultancy Meeting on Strategic issues and milestones on the way to a demonstration fusion power plant,” 9-11 January 2012.

Strategic Issues Requiring International Follow-Up

(and Terms of Reference for IAEA Consultancy Meeting)

The assumptions used in fusion design codes.

- What assumptions can be used in the design basis for facilities ready to start construction in the next ~10 years?

The strategy for fusion materials development.

- The planning for materials development and facility construction needs to be made self-consistent.

The strategy for blanket development.

- Must address both materials and engineering issues, and lead to self-consistent solutions.

The strategy for plasma exhaust solution development.

- Need physics and technology solutions that are self-consistent and compatible with plasma performance and tritium breeding.

The requirements / state-of-readiness for next-step facility options.

- The plan for closing readiness gaps in key fusion technologies and the plans for next-step facility construction need to be made self-consistent.

Summary

- Workshop succeeded in addressing an urgent international need to start discussing the roadmap.
- Strategically important technical issues, where there are divergent views on the correct strategy, were identified and now need international follow-up.