Program Assessment Rating Tool (PART) – Charge April 2005

As you know, the Administration developed the Program Assessment Rating Tool (PART), comprised of assessment criteria on program performance and management. The Department, in conjunction with FESAC, produced the three long-term (FY 2015) PART performance measures for the Fusion Energy Sciences program in 2003, listed in Enclosure 1. The roadmap of objectives and performance targets toward the long-term PART measures is shown in Enclosure 2.

An independent, expert panel must conduct a review and rate the program's progress toward achieving the long-term PART measures on a triennial basis. I would like FESAC to conduct this review. As outlined in Enclosure 1, please rate the progress on each of the three long-term PART measures as excellent, minimally effective, or insufficient, including the rationale for your ratings. Please use the short and intermediate-term milestones from FY 2005 to FY 2009 shown in Enclosure 2 for Burning Plasma; Fundamental Understanding; Configuration Optimization; Materials Components, and Technologies; and Future Facilities as a guide in assessing the program's progress toward achieving the three long-term PART measures.

If FESAC believes that the program is not making adequate progress toward any of the three long-term (FY 2015) measures, please recommend how the program's performance could be improved.

Please send me your report by the end of January 2006.

Program Plan for Fusion Energy Sciences:
Roadmap of Objectives and Performance Targets

2006 2008 2010 2012 2014 2016

Burning Plasma

⬢ The Department’s role in the ITER is established **(2005)** INTL

⬡ Demonstrate progress in developing a predictive capability for key aspects of burning plasmas using advances in theory and simulation benchmarked against a comprehensive experimental database of stability, transport, wave-particle interaction, and edge effects. **(2015)**

Initiate experiments on the National Ignition Facility (NIF) to study ignition and burn propagation in IFE relevant fuel pellets **(2012)** NNSA

Fundamental Understanding

Achieve a fundamental understanding of tokamak transport and stability in pre-ITER plasma experiments **(2009)**

Major aspects relevant to burning plasma behavior observed in experiments prior to full operation of ITER are predicted with high accuracy and are understood **(2015)**

Evaluate the process affecting the transport of petawatt laser energy in dense plasmas **(2009)** NNSA

Create and measure properties of high energy density plasmas using intense ion beams, dense plasma beams and lasers **(2012)**

⬡ Demonstrate progress in developing the fundamental understanding and predictability of high energy density plasma physics, including potential energy producing applications. **(2015)** NNSA

and here

Configuration Optimization

Evaluate the ability of the compact stellarator configuration to confine a high temperature plasma **(2012)**

⬡ Demonstrate enhanced fundamental understanding of magnetic confinement and in improving the basis for future burning plasma experiments through research on magnetic confinement configuration optimization. **(2015)**

Achieve long-duration, high-pressure, well-confined plasmas in a spherical torus sufficient to design and build fusion power-producing Next-Step Spherical Torus **(2008)**

Demonstrate use of active plasma controls and self-generated plasma current to achieve high-pressure/well-confined steady-state operation for ITER **(2008)**

⬢ Advance plasma science and computer modeling to obtain a comprehensive, and fully validated, plasma configuration simulation capability. **(2020)**

Materials, Components, & Technologies

Start production of superconducting wire needed for ITER magnets **(2006)**

Deliver to ITER for testing the blanket test modules needed to demonstrate t feasibility of extracting high temperature heat from burning plasmas and for self-sufficient fuel cycle **(2013)** BES

Future Facilities

(Cross cut and support multiple objectives and targets):

ITER: construction begins for this international collaboration to build the first fusion burning plasma experiment capable of a self-sustaining fusion reaction. **(2006)** INTL

ITER: operation begins. **(2014)** INTL

Next-Step Spherical Torus (NSST) Experiment: construction begins to test the spherical torus, an innovative concept for magnetically confining a fusion reaction. **(2010)**

NSST: operation begins (2016)

Integrated Beam Experiment (IBX): Begin construction of an intermediate-scale experiment to understand how to generate and transmit the focused, high energy ion beam needed to power an IFE reaction **(2013)**

Interdependencies:

(Descriptions)

*Broadly with **ASCR** on computational developments, both hardware and software, affecting all facets of basic research and advanced instrumentation.*

INTL *=with international community on ITER*

BES *=with BES on nano-designed materials*

NNSA *=with NNSA*

⬢ =Key Intermediate Objective from DOE Strategic Plan
⬡ =Long Term Success Measure from PART

This timeline is for planning purposes only and does not constitute financial or contractual commitments by the Federal Government.

PART Panel was formed:

Gerald Navratil, Chair	Columbia University
Ray Fonck	Univ. of Wisconsin-Madison
Martin Greenwald	MIT
Grant Logan	LBL
William Nevins	LLNL
Scott Parker	Univ. of Colorado
Cynthia Phillips	PPPL
Ed Thomas	Auburn University
Françios Waelbroek	Univ. of Texas-Austin

April 11, 2005

Dr. N. Anne Davies
Office of Fusion Energy Sciences
Office of Science
U.S. Department of Energy
19901 Germantown Road-Mail Stop SC-50
Germantown, Maryland 20874-1290

Dear Anne:

At the April 7, 2005 meeting of the Fusion Energy Sciences Advisory Committee (FESAC), you asked the Committee to comment on, and improve, the intermediate milestones associated with the long-range goals of the fusion program in relation to the Program Assessment Rating Tool (PART). After examining the goals and milestones as presently written, and taking into account the discussion of this topic at our July 2004 meeting, FESAC has come to the following conclusions:

1. The long-range goals that FESAC previously approved remain appropriate.
2. The intermediate milestones may now require revision, for two reasons: they do not take into account the recent, very important report of the Priorities Panel, presented to FESAC today; and they may not be consistent with recently announced changes in fusion funding.

Therefore FESAC recommends that the Office of Fusion Energy Sciences reconsider and revise the intermediate milestones shown on the fusion program roadmap, using the Priorities Panel Report as a guide. The revised milestones would help in particular the newly formed Panel on Progress toward Long-range Goals.

Yours truly,

Richard Hazeltine
Chair, Fusion Energy Sciences Advisory Committee

Ten Year Goals for Fusion Energy Sciences

- **Predictive Capability for Burning Plasma**: Progress toward developing a predictive capability for key aspects of burning plasmas using advances in theory and simulation benchmarked against a comprehensive experimental database of stability, transport, wave-particle interaction, and edge effects

- **Configuration Optimization**: Progress toward demonstrating enhanced fundamental understanding of magnetic confinement and improved basis for future burning plasma experiments through research on magnetic confinement configuration optimization

- **High Energy Density Plasma Physics**: Progress toward developing the fundamental understanding and predictability of high energy density plasma physics

Office of Management and Budget
Program Assessment Rating Tool (PART)
Long Term Measures for Fusion Energy Sciences

Predictive Capability for Burning Plasma: By 2015, demonstrate progress in developing a predictive capability for key aspects of burning plasmas using advances in theory and simulation benchmarked against a comprehensive experimental database of stability, transport, wave-particle interaction, and edge effects.

- Definition of "Excellent" – Predict with high accuracy and understand major aspects relevant to burning plasma behavior observed in experiments prior to full operation of ITER.
- Definition of "Good" – Validate predictive models against the database for some important aspects relevant to burning plasma physics (e.g. energetic particles, instabilities, control of impurities, etc…)
- Definition of "Fair" – Validate predictive models against the database for a few aspects relevant to burning plasma physics (e.g. energetic particles, instabilities, control of impurities, etc…)
- Definition of "Poor" – Achieve only limited success in improving models and validating them against the database.
- How will progress be measured? – Expert Review every three years will rate progress as "Excellent," "Good," "Fair," or "Poor"

Configuration Optimization: By 2015, demonstrate enhanced fundamental understanding of magnetic confinement and in improving the basis for future burning plasma experiments through research on magnetic confinement configuration optimization.

- Definition of "Excellent" – Resolve key scientific issues and determine the confinement characteristics of a range of innovative confinement configurations.
- Definition of "Good" – Develop understanding of the key scientific issues for several innovative magnetic confinement configurations currently under investigation.
- Definition of "Fair" – Develop understanding of the scientific issues for a limited number of innovative magnetic confinement configurations currently under investigation.
- Definition of "Poor" – Achieve little progress towards understanding the scientific issues concerning innovative magnetic confinement configurations.
- How will progress be measured? – Expert Review every three years will rate progress as "Excellent," "Good," "Fair," or "Poor"

Inertial Fusion Energy and High Energy Density Plasma Physics: By 2015, demonstrate progress in developing the fundamental understanding and predictability of high energy density plasma physics, including potential energy-producing applications.

- Definition of “Excellent” – Develop experimentally-validated theoretical and computer models, and use them to resolve the key physics issues that constrain the use of inertial fusion energy drivers in future key integrated experiments needed to understand the scientific issues for inertial fusion energy and high energy density physics.
- Definition of “Good” – Use experimental data to develop understanding of the key physics issues that constrain the use of inertial fusion energy drivers in future key integrated experiments needed to understand the scientific issues for inertial fusion energy and high energy density physics.
- Definition of “Fair” – Use experimental data to develop a limited understanding of the key physics issues that constrain the use of inertial fusion energy drivers in future key integrated experiments needed to understand the scientific issues for inertial fusion energy and high energy density physics.
- Definition of “Poor” – Achieve little progress in understanding the key physics issues that constrain the use of inertial fusion energy drivers in future key integrated experiments needed to understand the scientific issues for inertial fusion energy and high energy density physics.
- How will progress be measured? – Expert Review every three years will rate progress as “Excellent,” “Good,” “Fair,” or “Poor”

Goals and Milestones

Burning Plasma

✓ Establish the Department's role in ITER **(2005) INTL**

- Begin U.S. contribution to ITER for this international collaboration to build the first fusion burning plasma experiment capable of a sustained fusion reaction **(2006) INTL**
- Continue vendor qualification for long lead procurements for ITER in the area of superconducting strand and jacket materials **(2006)**
- Refine theoretical and experimental understanding of transport, stability, wave-particle interactions, and edge effects in tokamaks **(2009)**
- Initiate design and fabrication of the first test blanket module to be installed on ITER **(2011) BES**
- Evaluate discharge scenarios for ITER based on major tokamak results **(2012)**
- Begin ITER operation **(2014) INTL**

o Progress toward developing a predictive capability for key aspects of burning plasmas using advances in theory and simulation benchmarked against a comprehensive experimental database of stability, transport, wave-particle interaction, and edge effects **(2015)**

✓ = Key Intermediate Objective from DOE Strategic Plan
o = Long Term Success Measure from PART
INTL = with international community on ITER
BES = with BES on nano-designed materials
NNSA = with NNSA
Interdependencies: Broadly with **ASCR** on computational developments, both hardware and software, affecting all facets of basic research and advanced instrumentation.

Goals and Milestones (continued)

Configuration Optimization

- Achieve long-duration, high-pressure, well-confined plasmas in a spherical torus sufficient to begin design of a Next-Step Spherical Torus **(2008)**
- Demonstrate use of active plasma controls and self-generated plasma current to achieve high-pressure/well-confined steady-state operation for ITER **(2009)**
- Evaluate the ability of the compact stellarator configuration to confine a high temperature plasma **(2012)**
- Begin construction on the Next-Step Advanced Facility (NSAF) to test an advanced fusion concept for magnetically confining a fusion reaction **(2014)**

o Progress toward demonstrating enhanced fundamental understanding of magnetic confinement and improved basis for future burning plasma experiments through research on magnetic confinement configuration optimization **(2015)**

✓ Advance plasma science and computer modeling to obtain a comprehensive, and fully validated, plasma configuration simulation capability **(2020)**

✓ = Key Intermediate Objective from DOE Strategic Plan
o = Long Term Success Measure from PART
INTL = with international community on ITER
BES = with BES on nano-designed materials
NNSA = with NNSA
Interdependencies: Broadly with **ASCR** on computational developments, both hardware and software, affecting all facets of basic research and advanced instrumentation.

Goals and Milestones (continued)

High Energy Density Physics

- Evaluate the process affecting the transport of petawatt laser energy in dense plasmas **(2009) NNSA**
- Initiate experiments on the National Ignition Facility (NIF) to study ignition and burn propagation **(2012) NNSA**
- Create and measure properties of high energy density plasmas using intense ion beams, dense plasma beams, and lasers **(2012)**
- Begin construction of an intermediate-scale, Integrated Beam Experiment (IBX) to understand how to generate and transmit the focused, high energy ion beam needed to power an inertial fusion energy (IFE) reaction **(2014)**

o Progress toward developing the fundamental understanding and predictability of high energy density plasma physics **(2015) NNSA**

✓ = Key Intermediate Objective from DOE Strategic Plan
o = Long Term Success Measure from PART
INTL = with international community on ITER
BES **=** with BES on nano-designed materials
NNSA = with NNSA
Interdependencies: Broadly with **ASCR** on computational developments, both hardware and software, affecting all facets of basic research and advanced instrumentation.

Next Steps:

Discussion and Input from FESAC on Intermediate Milestones:

- Improved relation to Priorities Panel and Facilities Panel structure of Scientific Campaigns?
- Adjustment of key dates in light of present view of ITER schedule and planned out year budgets?

Panel can complete work quickly using Inertial Fusion Energy Panel (2004), Priorities Panel (2004), and Facilities Panel (2005) reports as primary input:

- Advice on format of response?

represent the building blocks of fusion energy science, the table below illustrates the interconnectedness of fundamental studies of the plasmas state and the related importance to fusion science, non-fusion science, and other fields of physics.

Understand the role of magnetic structure on plasma confinement and the limits to plasma pressure in sustained magnetic configurations.		
Key Questions	**Fusion Science Examples**	**Related Science Examples**
T1. How does magnetic field structure impact fusion plasma confinement?	Optimize the magnetic configuration	Coronal loops; planetary magnetospheres
T2. What limits the maximum plasma pressure that can be achieved in laboratory plasmas?	Maximize fusion power density	The Earth's magnetotail; Jupiter's magnetosphere
T3. How can external control and plasma self-organization be used to improve fusion performance?	Radio frequency, bootstrap and dynamo generated currents	Dipole confinement; Magnetospheres

Understand and control the physical processes that govern the confinement of heat, momentum, and particles in plasmas.		
Key Questions	**Fusion Science Examples**	**Related Science Examples**
T4. How does turbulence cause heat, particles, and momentum to escape from plasmas?	Energy confinement, helium removal	Astrophysical accretion flows; Solar convection zone
T5. How are electromagnetic fields and mass flows generated in plasmas?	Generation of flows leading to transport barriers, and confining magnetic fields	Astrophysical, solar and planetary dynamos
T6. How do magnetic fields in plasmas reconnect and dissipate their energy?	Performance limiting instabilities	Solar flares; Magnetospheric storms

Investigate the assembly, heating, and burning of high energy density plasmas.		
Key Questions	**Fusion Science Examples**	**Related Science Examples**
T7. How can high energy density fusion plasmas be assembled and ignited in the laboratory?	Implosion of plasmas to high energy density	Stellar interiors
T8. How do hydrodynamic instabilities affect implosions to high energy density?	Retention of symmetry in implosions	Stellar explosions
T9. How can heavy ion beams be compressed to the high intensities required for creating high energy density matter and fusion conditions?	Increased peak ion beam power for fusion targets	Multi-species beam-plasma physics for high energy ion accelerators

Learn to control the interface between the 100 million degree plasma and its room temperature surroundings.		
Key Questions	**Fusion Science Examples**	**Related Science Examples**
T10. How can a 100-million-degree-C burning plasma be interfaced to its room temperature surroundings?	Fuel and power exhaust	Plasma processing

Learn to use energetic particles and electromagnetic waves to sustain and control high temperature plasmas.		
Key Questions	**Fusion Science Examples**	**Related Science Examples**
T11. How do electromagnetic waves interact with plasma?	Heating and control of current profiles in plasmas	Radio emission from space; Communication disruptions
T12. How do high-energy particles interact with plasma?	Confining fusion alpha particles	Aurora Borealis; Astrophysical jets; Solar flares

Understand the fundamental properties of materials, and the engineering science in the harsh fusion environment.		
Key Questions	**Fusion Science Examples**	**Related Science Examples**
T13. How does the challenging fusion environment affect plasma chamber systems?	Plasma-material interactions	Plasma processing; Nuclear physics; Fluid mechanics
T14. What are the operating limits for materials in the harsh fusion environment?	Lifetimes of fusion components	Neutron effects on material structure
T15. How can systems be engineered to heat, fuel, pump, and confine steady-state or repetitively pulsed burning plasmas?	Tools to carry out fusion science	Technical spinoffs to other areas of science