Report of the Community Planning Process (Phase I)

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Nate Ferraro	*Princeton Plasma Physics Laboratory*
Lauren Garrison	*Oak Ridge National Laboratory*
Nathan Howard	*Massachusetts Institute of Technology*
Carolyn Kuranz	*University of Michigan*
John Sarff	*University of Wisconsin*
Earl Scime (emeritus)	*West Virginia University*
Wayne Solomon	*General Atomics*

Thank you!

- To the Community for the critical work you have all done providing input into the process through Initiatives, Expert Groups, Workshop participation, and for bearing with us as we travel the path together

Overview of the Process

Goals

- To produce strategic recommendations for each of four topical areas and four cross-cutting areas, generated from community input
- Provide both near-term actionable recommendations and a long-term strategic outlook (**strategic plan**), highlighting opportunities for US leadership
- To the extent possible, to prioritize among these recommendations with community consensus
- To deliver these recommendations to FESAC by March, 2020

The community has come together to deliver a successful outcome!

What is consensus?

- Firstly: Essential everyone given an opportunity to be involved and their voice heard
  - Respect others' opinions and views
  - Look for the positive aspects of ideas

- Consensus will involve compromise
  - It is not: I get everything I want, but is: *A plan I can live with*
  - It is not: A simple majority vote, but is: *A widespread agreement amongst the community*
  - It is not: The loudest voice that wins, but is: *The best ideas that triumph*

- Every public voice of disunity erodes confidence in our community and reduces support from stakeholders

We tried to ensure all voices were heard

- Announcements sent to DPP-CPP Google Group
  as well as APS-DPP, GEC, USBPO, UFA, and ANS mailing lists
- >100 expert group meetings, open to anyone interested
- 5 focus groups
- 15 webinars
- 6 Town halls
- 5 dedicated workshops

Together, we stuck to the plan to make a plan!

Done!

Workshop #1

- Plenary presentations by Advocacy Groups
  - Address questions in “template”
  - Initial feedback from community
- Expert group sessions
  - Agreement on process by which to evaluate initiatives
  - Update and report on gaps and research opportunities that need to be addressed
  - Initial evaluation of proposed initiatives
- Cross-cutting group sessions

olomon / CPP MFE-FM&T opening / July 22, 2019

Activities after workshop #1: Evaluate and refine Initiatives

- Initiative submitted after July 1 deadline will be evaluated via remote meetings/discussions
- Expert groups will generate responses to Advocacy Groups, iterate as required
- Advocacy Groups will address these to improve initiatives
- Missing initiatives can be formed as identified during gap evaluations
- Merging of initiatives to strengthen, become more inclusive, and build consensus

Sample slides from 1st MFE/FM&T workshop

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Activities after workshop #1:

Done!

Workshop #2

- Hear from Advocacy groups on updated/combined Initiatives or new Initiatives identified in gaps, based on feedback from workshop #1
- *<Possibly> Discuss "Initiatives" from the community to develop the prioritized (topically) strategic plan*
  Working with professional facilitator to crystalize process
  Welcome community input on this step
- Develop strategic outline (particularly for next 10 years), and populate with strategic elements from Initiatives
- Use co-location to continue identifying the cross-cutting elements and themes across FES

Activities after workshop #2:
Write up Findings
- PC lead expert groups to summarize findings
- PC assemble prioritized list of recommendations as possible
- PC and Chairs summarize strategic outline and strategic elements as discussed at workshop
- Summaries will be made available for comments and feedback to entire community prior to Snowmass

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Done!

"Snowmass": January 2020 (estimated)

<u>Opportunity for all topical areas to come together to craft a coherent plan</u>

- (prior to Snowmass) Program Committee should draft a written strategic plan within topical areas based on Workshop #2 and make these available for community review
- PC will outline plans and how they connect to Initiatives and reflect Expert Group feedback
- Make adjustments and merge ideas to forge a consensus, within and across topical areas

How this process will occur is still being developed and is open to community input

Aspirations:

- Consider budget scenarios beyond "blue sky" to avoid asking FESAC to make all tough decisions
- Demonstrate a process that results in community consensus which can be revisited in the future

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Sample slides from 1st MFE/FM&T workshop

Together, we stuck to the plan to make a plan!

Done!

Done!

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olomon / CPP MFE-FM&T opening / July 22, 2019

Activities after workshop #1:

W.M. Solomon / CPP Houston opening / January 17, 2020

Wrapping up

- The PC will finalize strategic plan based on the discussi received during CPP-Houston
  - Co-chairs will prepare Executive Summary - plan to release by end of January
  - Follow-up with webinar (or similar) to collect feedback
- Report distributed to community by mid-February 2020
  - Chit system to receive community feedback and suggestions
  - PC and Chairs will resolve comments and/or clarify meaning as input is received
- Presentation of report to FESAC 16-17 March 2020

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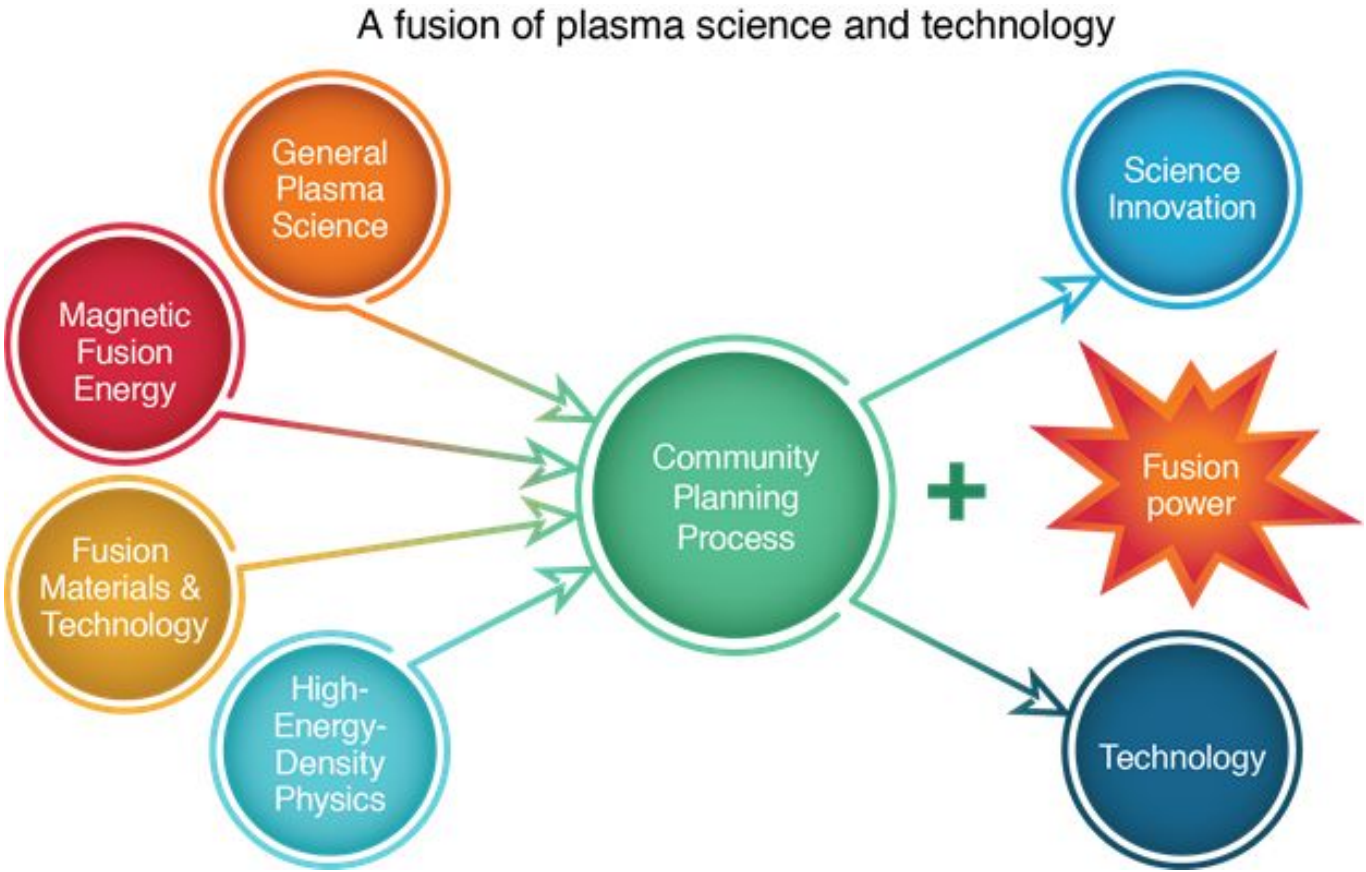
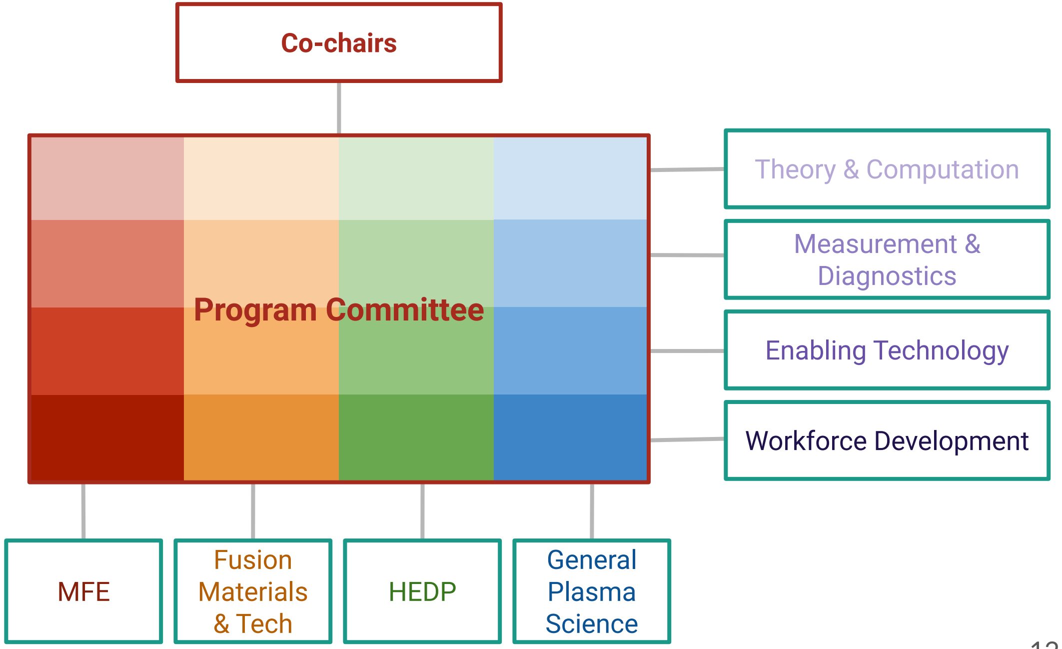
Sample slides from Houston workshop



Artwork by Jennifer Hamson LLE/University of Rochester, concept by Dr. David Schaffner, Bryn Mawr College

Committee organizational structure

The **Program Committee** is organized in subgroups to produce **recommendations** in eight topical and cross-cutting areas



Program Committee

Magnetic Fusion Energy

Ted Biewer, ORNL
Dan Brunner, CFS
Cami Collins, GA
Brian Grierson, PPPL
Walter Guttenfelder, PPPL
Chris Hegna, Wisconsin
Chris Holland, UCSD
Jerry Hughes, MIT
Aaro Jarvinen, LLNL
Richard Magee, TAE
Saskia Mordijck, William & Mary
Craig Petty, GA
Matt Reinke, ORNL
Uri Shumlak, Washington

Fusion Materials and Technology

John Caughman, ORNL
David Donovan, UTK
Karl Hammond, Missouri
Paul Humrickhouse, INL
Robert Kolasinski, Sandia
Ane Lasa, ORNL
Richard Nygren, Sandia
Wahyu Setyawan, PNNL
Steven Zinkle, UTK
George Tynan, UCSD

Program Committee

High Energy Density Physics

Alex Arefiev, UCSD
Todd Ditmire, UT Austin
Forrest Doss, LANL
Sean Finnegan, LANL
Arianna Gleason, Stanford/SLAC
Stephanie Hansen, SNL
Louisa Pickworth, LLNL
Jorge Rocca, Colorado State
Derek Schaeffer, Princeton
Cliff Thomas, LLE/University of Rochester

General Plasma Science

Daniel Den Hartog, Wisconsin
Dan Dubin, UCSD
Hantao Ji, Princeton
Yevgeny Raitses, PPPL
David Schaffner, Bryn Mawr
Steven Shannon, NC State
Dan Sinars, SNL
Stephen Vincena, UCLA

Program Committee was Integral to Success

- The program committee put in a tremendous amount of work to enable a successful outcome in a short amount of time
- Weekly (or more) meetings of the program committees occured in the main topical areas
- Frequent Expert Group and Cross-cut Group meetings (~weekly)
- Periodic check-ins with David Newman and Don Rej
- Weekly meeting of all co-chairs
  - Biweekly meetings with Facilitator
  - Almost daily meetings among MFE +FM&T co-chairs
  - Facilitator provided training sessions for the PC on how to moderate discussions

Avenues for Community Input

Advocacy Groups

- Self-organized groups of community members (not led by Program Committee)
- Provide input to process by submitting informational **white papers** or **initiative proposals**

Expert Groups

- Groups of technical experts, led by Program Committee members
- Open to participation from any and all interested community member
- Provide community review of initiative proposals

HEDP & GPS Expert Groups

High Energy Density Plasmas

Hydrodynamics: HED Hydrodynamics, Magnetized HEDP, Laboratory Astrophysics

High Intensity Laser Plasmas: Nonlinear Optics and Laser Plasma Interactions, Relativistic HED and High Field Science, Intense Beams and Particle Acceleration

HED Atomic Physics, Warm Dense Matter and Materials, Nuclear Physics

Theory and Computational Modeling

IFE Driver and Reactor Technology and High Yield Target Physics

Facilities and Diagnostics: Laser Facilities, Pulsed Power Facilities, X-ray Light Sources, Radiation Sources

General Plasma Science

Create Disruptive Technologies

Understand the Plasma Universe

Advance the Foundational Frontier

FST Expert Groups

Magnetic Fusion Energy

Boundary & Divertor Plasma Physics
Transport & Confinement
Energetic Particles
Transients
Scenarios
Global Context and US Leadership

Fusion Materials and Technology

Fusion Materials
Blanket, Tritium, and Systems
Plasma Material Interaction & Plasma Facing Components
Magnets & Technology
Measurements & Diagnostics

Cross-Cutting Groups

Workforce, Diversity and Inclusion

- FM&T: David Donovan(UT-Knoxville), **Chair**
- GPS: David Schaffner (Bryn Mawr)
- HEDP: Sean Finnegan (LANL)
- MFE: Uri Shumlak (U Washington)

Measurement & Diagnostics

- HEDP: Johan Frenje (MIT), **Chair**
- FM&T: Rob Kolasinski (SNL)
- GPS: Daniel Den Hartog (UW-Madison)
- MFE: Ted Biewer (ORNL)

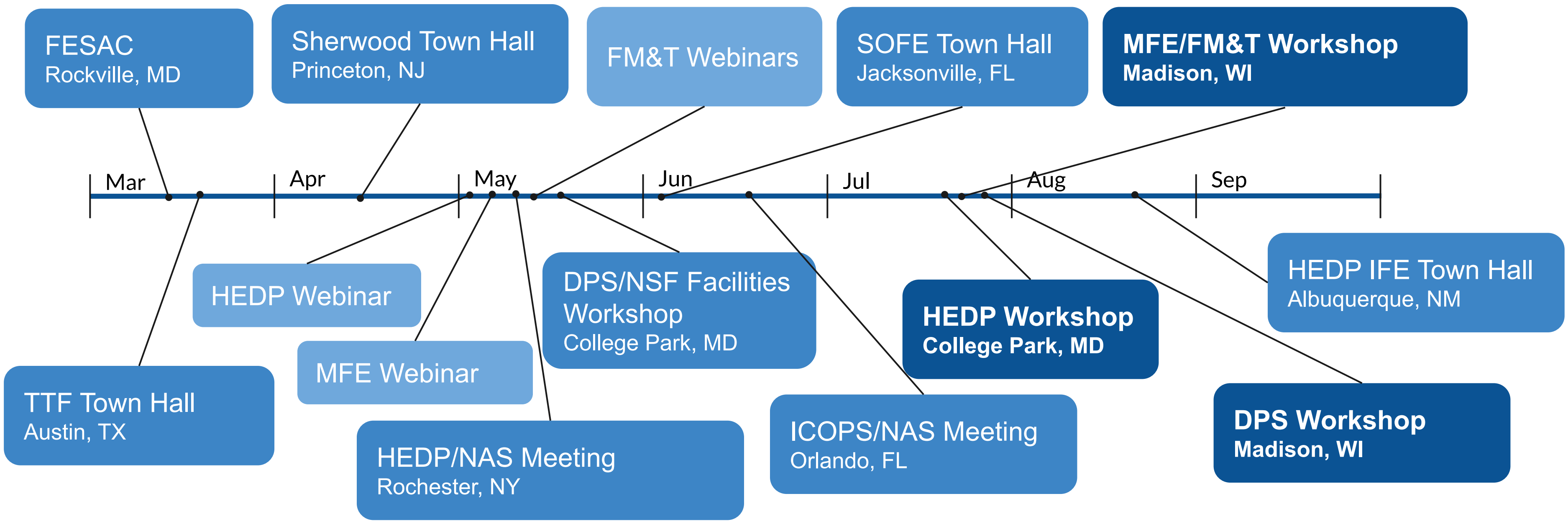
Theory & Computation

- MFE: Chris Holland (UCSD), **Chair**
- FM&T: Karl Hammond (U. Missouri)
- GPS: Daniel Dubin (UCSD)
- HEDP: Forrest Doss (LANL)

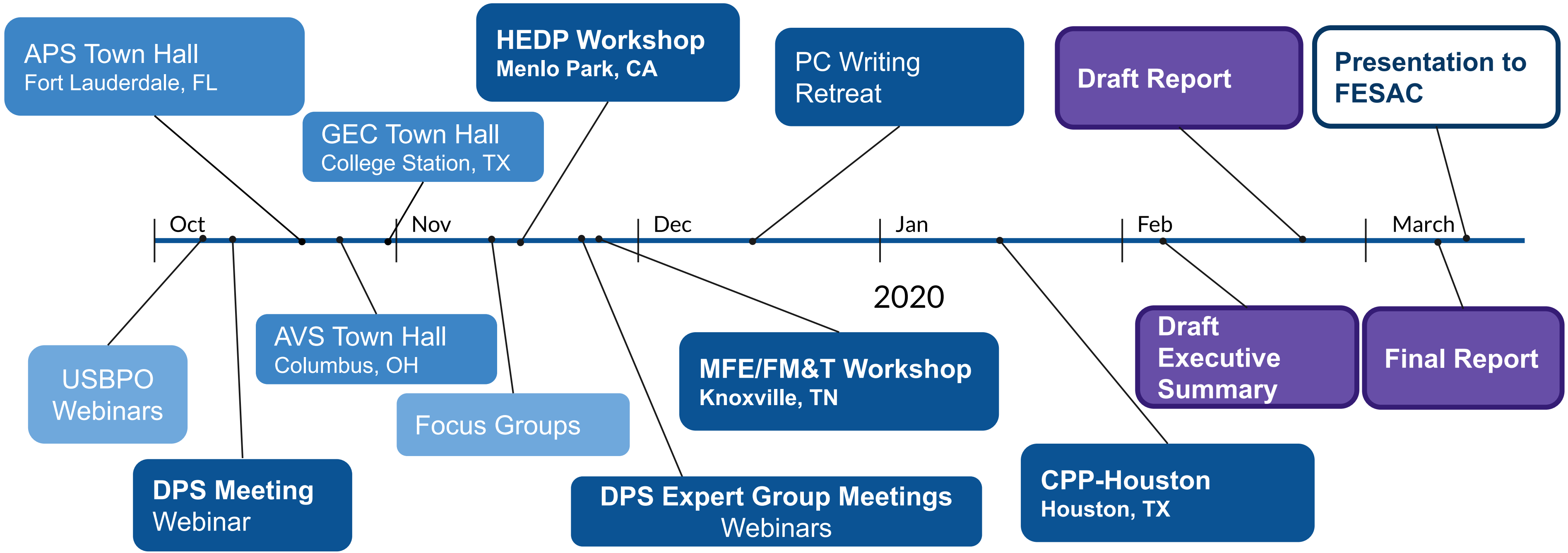
Enabling Technology

- DPS: Steven Shannon (NC State), **Chair**
- FM&T: Richard Nygren (SNL)
- HEDP: Todd Ditmire (UT Austin)
- MFE: Dan Brunner (CFS)

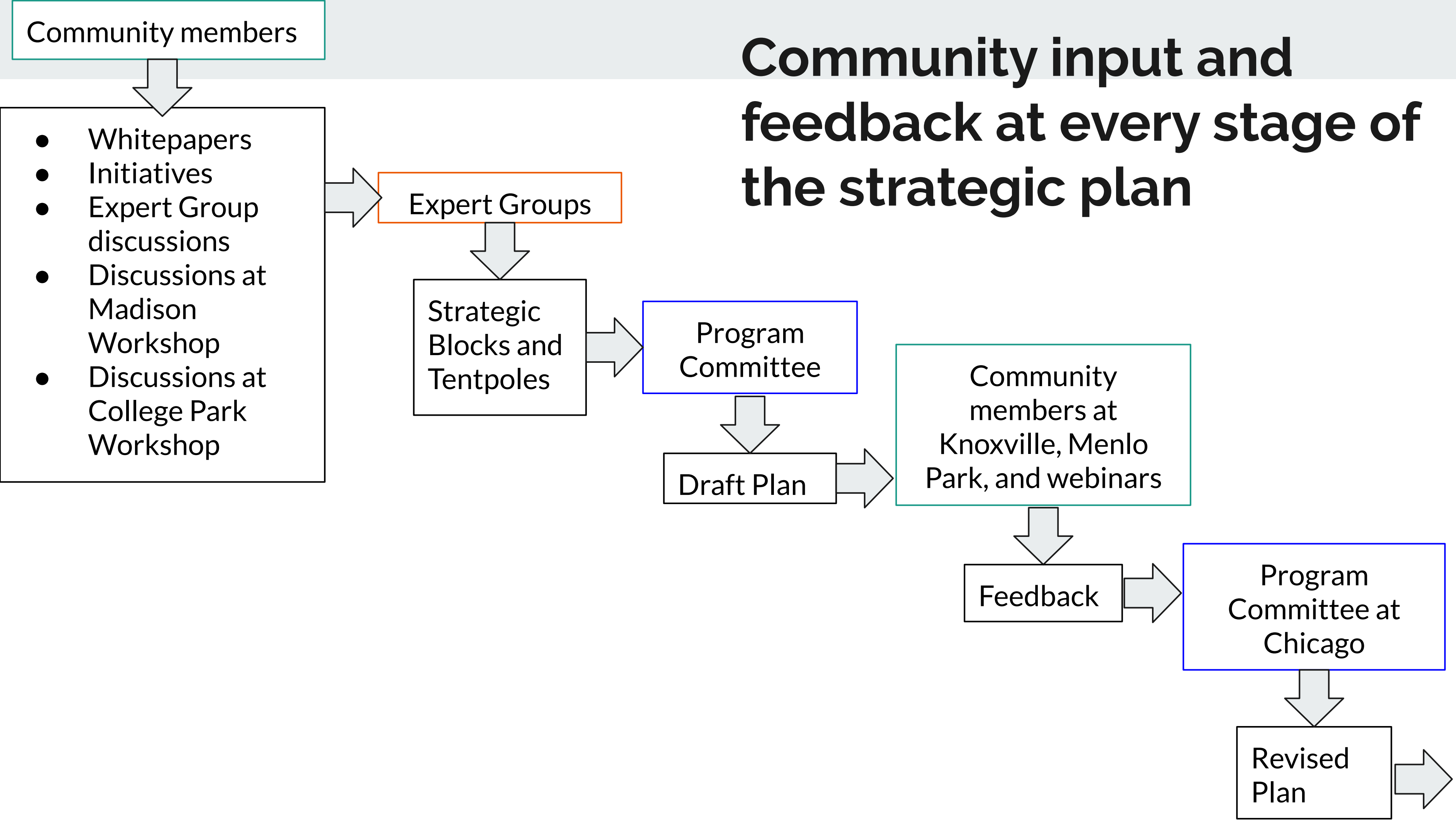
Events During the CPP



Events During the CPP (cont'd)



Community input and feedback at every stage of the strategic plan



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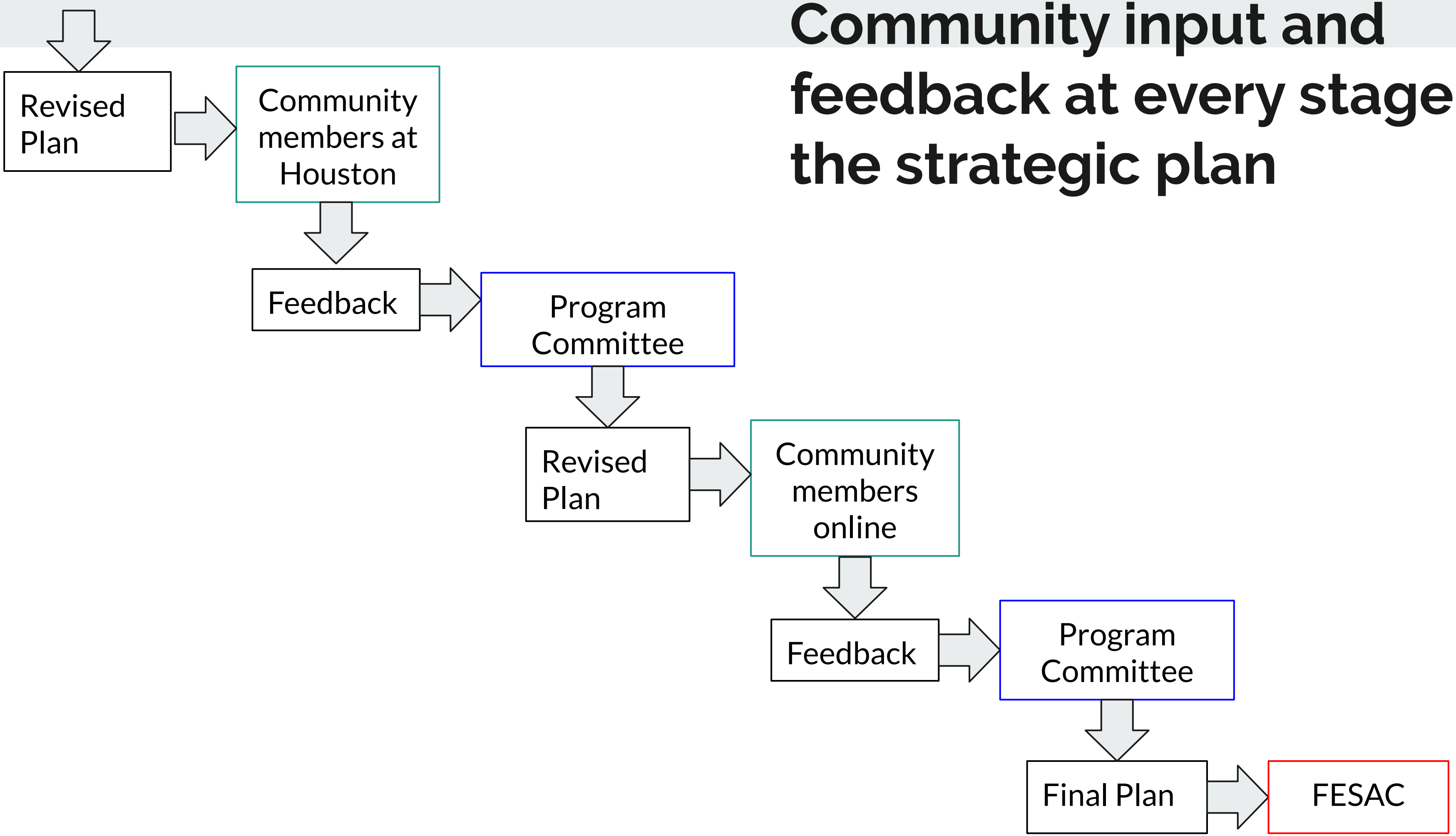
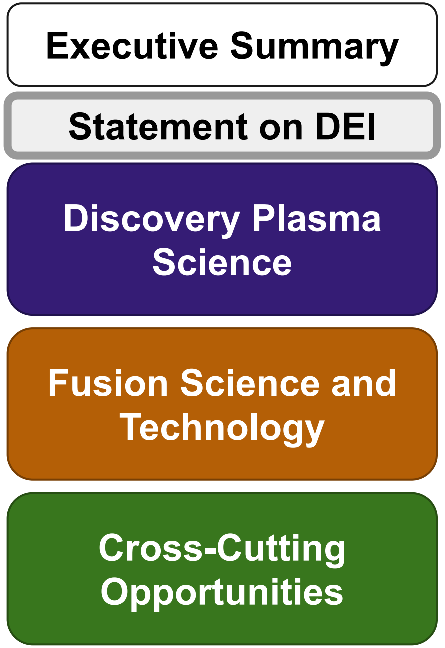


Structure of Plan

The Plan is Organized into Three Main Parts

- **DPS:** Discovery Plasma Science
  - Primarily based on input from GPS and HEDP topical areas
- **FST:** Fusion Science and Technology
  - Primarily based on input from MFE and FM&T topical areas
  - Includes IFE (from HEDP topical area)
- **CC:** Cross-Cutting Opportunities
  - Input sourced from all topical areas



FST and DPS Are Inextricably Linked and Synergistic

- FST and DPS are critical and complementary areas that must work together to achieve ambitious goals
  - FST research is driven by the mission for a low-cost fusion pilot plant
  - DPS research is broader, and addresses science beyond the FST goal
- We believe these areas have strong intellectual ties, a shared history, and can coexist harmoniously and constructively within FES
- The order of the FST, DPS, and Cross-cut chapters is not meant to convey priority

"We very much have a strong opinion that this is both a discovery science and an applied energy, and there's no reason to say it's either-or, and I mean that very strongly. … We want the community to realize that it is not a zero-sum game between any of those topics" [1]

— Under Secretary of Energy for Science, Paul Dabbar

[1] Remarks to FESAC, reported in AIP Bulletin, Dec. 18, 2018

Topical Areas Merged to Form a Coherent Plan

- MFE+FM&T merged
  - These two topical areas had combined workshops at Madison and Knoxville with great success
  - At Knoxville Workshop, all sessions were completely combined
  - The report chapter on Fusion Science and Technology has complete integration of these topics
- GPS+HEDP merged
  - Address common science questions, distinguished by the tools used
  - Merger motivated by community feedback
  - Implemented after second round of workshops (HEDP Menlo Park, GPS town halls)
- IFE merged into FST plan (FST-SO-H) together with alternative MFE configuration research
  - FST-SO-H developed after MFE/FM&T Workshop (Knoxville) & HEDP Workshop (Menlo Park)
  - Inertial Fusion Energy was a high priority HEDP areas at Menlo Park supported by community letter
  - New recommendations on alternative MFE configuration research supported by community letter

Cross-Cutting Opportunities

- The Cross-Cutting Opportunities section has recommendations in four categories
- This section represents opportunities that will benefit all areas of plasma science

Cross-Cutting Opportunities

- Theory and Computation
- Measurement and Diagnostics
- Enabling Technology
- Workforce, Diversity, and Inclusion

Science Drivers

- DPS and FST have each identified major *Science Drivers* that motivate research

Discovery Plasma Science	Fusion Science and Technology
Explore the Frontiers of Plasma Science	Control, Sustain, and Predict Burning Plasmas
Understand the Plasma Universe	Handle Reactor Relevant Conditions
Create Transformative Technologies	Harness Fusion Power

Objectives and Recommendations

- DPS and FST are further organized into *Objectives* and *Recommendations*
  - Objectives represent goals
  - Recommendations represent steps to achieve an Objective

- *Program Recommendations* are broader recommendations that fall outside of specific objectives or are interconnected to many objectives

Executive Summary

Statement on Diversity, Equity, and Inclusion

Discovery Plasma Science

DPS Vision, Mission, & Criteria

DPS-Wide Program Recs.

DPS1: Frontiers of Plasma Sci.

Program Recs.

Objectives
- Recs.

DPS2: Plasma Universe

Program Recs.

Objectives
- Recs.

DPS3: Transformative Tech.

Program Recs.

Objectives
- Recs.

Fusion Science and Technology

FST Vision, Mission, & Values

SD1: Burning Plasma

SD2: Handle Reactor Conditions

SD3: Harness Fusion Power

Objective
- Recs.

Objective
- Recs.

Program Rec
- Recs.

Program Rec
- Recs.

Cross-Cutting Opportunities

Theory & Computation
- Recommendations

Measurement & Diagnostics
- Recommendations

Enabling Technology
- Recommendations

Workforce, Diversity, Inclusion
- Recommendations

Main Findings and Recommendations: FST

Community Embraces a Mission-Driven Program

Vision Statement

Our vision is for fusion energy to be a major source of safe, economical, and environmentally sustainable energy in time to address critical energy and security needs of the U.S. and the world.

Mission Statement

Establish the basis for the commercialization of fusion energy in the U.S. by developing the innovative science and technology needed to accelerate the construction of a fusion pilot plant at low capital cost.

- Echoes key recommendation of National Academies report
- Will benefit from FES partnering with private industry and other offices

Fusion Pilot Plant (FPP)

- Goal is to demonstrate capability that demonstrates technical feasibility while also projecting to commercial viability
- Three deliverables were considered to define an FPP
  - Produce net electricity from fusion
  - Establish the capability of high average power output
  - Demonstrate the safe production and handling of the tritium, as well as the feasibility of a closed fuel cycle
- Tokamak is the leading concept. However, optimized stellarators, inertial fusion, and other alternate concepts could ultimately lead to an attractive FPP.

FST Covers the Full Breadth of the Program Required for an FPP

(PR-C) Growing partnership with private industry

(PR-A) Multidisciplinary FPP design studies

Science Drivers

Control, sustain, and predict burning plasma

(SO-D) Tokamak physics basis
(SO-E) Stellarator physics basis
(SO-F) Magnet, heating, and current drive science & technology
(SO-H) IFE & alternative confinement approaches

Handle reactor relevant conditions

(SO-A) PFC and PMI science & technology
(SO-B) Structural and functional materials science & technology

Harness fusion power

(SO-C) Blanket science & tech. and Tritium Processing
(SO-G) Licensing, RAMI, balance of plant

(PR-B) Participation in ITER

(PR-D) Integrated Modeling

(PR-E) Diagnostic Development

Design and construction of fusion pilot plant at lowest possible capital cost

Burning Plasmas

- ITER is the best opportunity to participate in burning plasma experiment at the scale of a reactor. The U.S. should remain a full participant.
- Existing facilities (DIII-D, NSTX-U, international collaborations), and theory and modeling, are important to help us prepare for and extrapolate to burning physics regimes.
- Private ventures may also provide opportunities to access burning plasmas. We should support these endeavors and leverage these opportunities.
- A new tokamak facility (NTUF) is needed that is capable of handling power exhaust at conditions typical of an FPP while simultaneously demonstrating the necessary plasma performance.
    - Conceptual design should be started immediately and operations should begin in 2020s

Fusion Materials

- Need to rapidly expand research in fusion materials and technology
  - Required for nearly any plausible pilot plant design, and likely set the timescale on which any FPP could be successful
- Immediately begin design and construction of a Fusion Prototypic Neutron Source (FPNS)
  - Generate world-leading data on the degradation of materials when exposed to neutrons from fusion
- Expand program for the development of structural and functional materials for fusion
- Targeted investments should be made in fusion blanket and plasma facing component (PFC) programs

Embrace Innovation

- Research should focus on developing solutions to well-known challenges in fusion energy development by emphasizing exploration and utilization of new, potentially transformative science and technologies.
  - There are many examples in the report of areas where a relatively small investment could yield significant or transformational progress.
- There should be multi-institutional, multi-disciplinary FPP design studies. This will help identify cost drivers and inform research priorities accordingly.
  - We need additional innovation to achieve a commercially viable design. Program needs to be flexible and shouldn't lock in a design at this point.
- Program must closely partner with private industry to drive innovative technologies for a commercially competitive product.

How We Did Prioritization

- Discussion of prioritization began during the CPP Knoxville workshop and at CPP-Houston the attendees applied Prioritization Assessment Criteria (PACs) to the FST program.
- PACs, were derived from the 2017 Austin workshop values, discussed at CPP Knoxville, finalized by the MFE+FM&T PC, presented and discussed at CPP Houston, and ranked in their importance by the Houston attendees

1. Importance to FPP Mission
2. Urgency
3. Impact of Investment
4. Using Innovation to Lower Cost
5. U.S. Leadership and Uniqueness

See Appendix A for the definition of PACs presented at Houston and results of this prioritization

Main Findings and Recommendations: DPS

DPS is motivated by a common vision and mission

Vision Statement
Realize the potential of plasma science to deepen our understanding of nature and to provide the scientific underpinning for plasma-based technologies that benefit society.

Mission Statement
Develop fundamental understanding of the unique dynamical behaviors of plasmas, demonstrate that our understanding is true, and identify opportunities where the unique properties of plasmas can be used to engineer technologies that support a growing and sustainable economy.

Criteria

Development of the recommendations were guided by the rank-ordered criteria:

1. Establish US leadership in plasma science through world class facilities and reproducible theory, computation and measurements
2. Create transformational applications of plasmas to benefit society
3. Maintain breadth of the research program to benefit from innovation and high risk discovery
4. Engage the entire community of stakeholders, including national laboratories, universities, and industry
5. Capitalize on the potential of interdisciplinary applications of plasma research

Structure of the DPS chapter

DPS-Wide Programmatic Recommendations

- Build
- Support
- Collaborate

DPS1: Explore the Frontiers of Plasma Science

- Specific programmatic recommendation(s)
- Science Objectives
  - Recommendations (topical)

DPS2: Understand the Plasma Universe

- Specific programmatic recommendation(s)
- Science Objectives
  - Recommendations (topical)

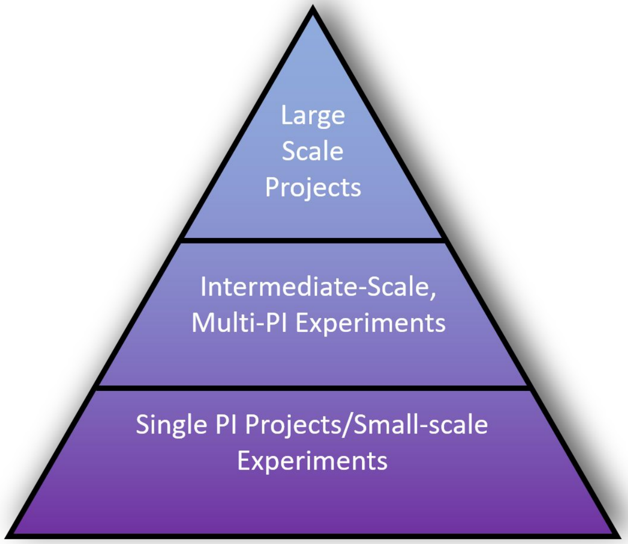
DPS3: Create Transformative Technologies

- Specific programmatic recommendation(s)
- Science Objectives
  - Recommendations (topical)

		DPS1					DPS2			DPS3			
		DPS-A	DPS-B	DPS-C	DPS-D	DPS-E	DPS-F	DPS-G	DPS-H	DPS-I	DPS-J	DPS-K	DPS-L
Build	Invest in an intermediate scale general plasma science facility						x						
Build	Invest in a multi-PW facility that can access intensities beyond the current state of the art	x	x			x			x				x
Build	Invest in facilities over a broad range of scales	x	x	x	x	x	x	x	x	x	x	x	x
Build	Improve and upgrade national HED infrastructure at multiple scales particularly at LaserNetUS facilities	x	x		x	x	x	x	x				x
Build	Couple long pulse multi-kJ and multi-PW lasers with an XFEL, which can be done at the Matter in Extreme Conditions instrument	x			x	x			x				x
Build	Provide upgrades for GPS facilities to leverage current FES investments in frontier-level science.						x	x		x	x	x	
Build	Co-locate plasma devices at established facilities to leverage community expertise across the plasma science community	x	x		x		x	x	x				x
Support	Support steady funding of plasma science	x	x	x	x	x	x	x	x	x	x	x	x
Support	Support fundamental data needs	x	x	x	x	x	x	x	x	x	x	x	x
Support	Support science centers	x					x	x	x				
Collaborate	Further investment in target fabrication capabilities, and in theory and computation support for LaserNetUS experiments	x	x		x	x	x	x	x				x
Collaborate	Establish ZNetUS to coordinate and increase access to pulsed power facilities and necessary computational tools		x	x			x	x	x				
Collaborate	Establish MagNetUSA for a wide range of experimental researchers and for increasing accessibility to DOE supported facilities		x				x	x					
Collaborate	Support collaborative research networks in low-temperature plasma science									x	x	x	
Collaborate	Establish a network program to build new hardware capabilities and support the acquisition of diagnostics to be shared between facilities						x	x	x	x	x	x	
Collaborate	Establish a network program to develop of an open-source, programming ecosystem for plasma physics and advance computational plasma science	x	x	x	x	x	x	x	x	x	x	x	x
Collaborate	Expand partnerships	x	x	x	x	x	x	x	x	x	x	x	x

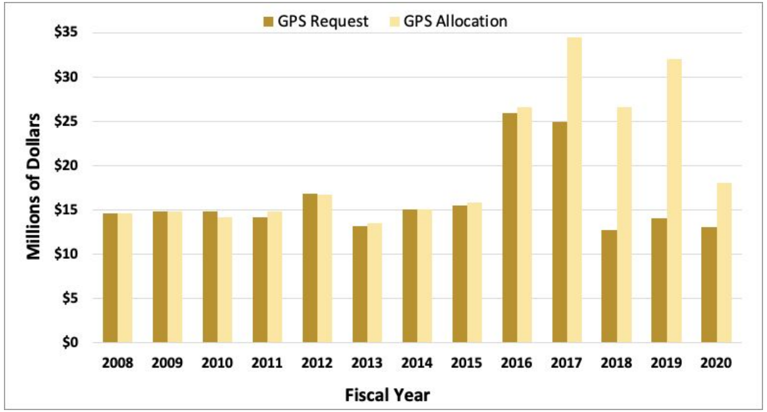
Build

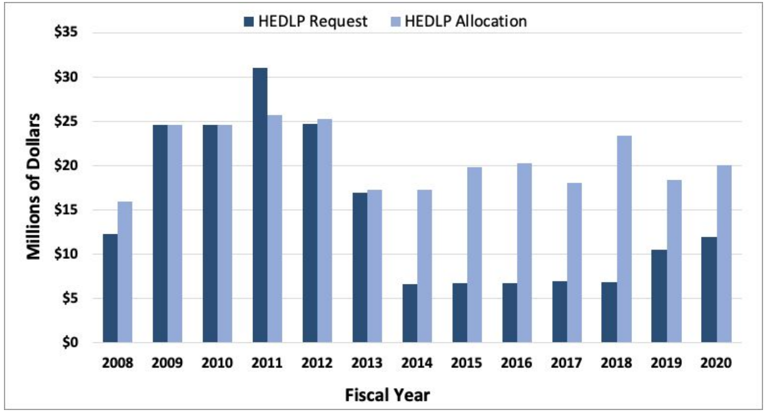
- Invest in new facilities
  - GPS facility to investigate the solar wind in the lab
  - Multi-PW laser, increased repetition rate
  - Broad range of scales
- Upgrade current facilities
  - Upgrade LaserNetUS facilities
  - Couple long pulse multi-kJ and multi-PW lasers with an XFEL
  - Upgrade current GPS facilities
- Co-locate facilities
  - Sources with diagnostics
  - Facilities to create unique states of plasma
    - Ex: Multi-PW laser and dense multi-GeV electron beam to investigate quantum plasmas



Support

- Steady funding of plasma science
    - Stabilize year-to-year variability
    - Reverse the flat/downward trend in funding
- Fundamental data needs
    - Cross sections, AMO data
    - Open access databases
- Create Science Centers
    - To address time-critical science problems
    - Flexible, frequent, allow junior faculty to join

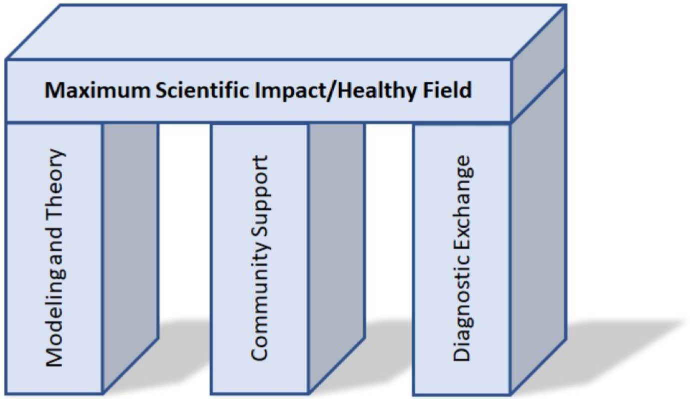




Collaborate

- Expand Networks
  - Expand support for LaserNetUS
  - Establish ZNetUS
  - Establish MagNetUSA
  - Continue support for LTP collaborative research centers
  - Establish a diagnostic support network
  - Establish a network to foster an open source programming ecosystem

- Expand Partnerships
  - Support existing partnerships: FES/NSF, FES/NNSA
  - Establish new partnerships: FES/NASA, FES/NIH, FES/BES, FES/USDA, etc



DPS-1: Explore the Frontiers of Plasma Science

- Objectives
    - DPS-A: Understand how intense light couples its energy to matter
    - DPS-B: Explore how magnetic fields control transport and influence self-organization in plasmas across scales
    - DPS-C: Advance understanding of plasmas far from equilibrium and at interfaces
    - DPS-D: Advance understanding of strong coupling and quantum effects in plasmas
    - DPS-E: Create and explore antimatter plasmas

- Prioritize support for single PI research
    - Many frontier science questions can be addressed by small-group or single PI research
    - Allows curiosity-driven research that is less subject to programmatic constraints
    - Increases the role of plasma at universities, grows the field, increases its visibility

DPS-2: Understand the Plasma Universe

- Objectives
  - DPS-F: Understand plasma interactions between the Sun, Earth, and other objects in the solar system
  - DPS-G: Understand the origin and effects of magnetic fields across the universe from star and planet formation to cosmology
  - DPS-H: Understand the causes and consequences of the most energetic, extreme, and explosive phenomena found in the cosmos

- Implementation of programmatic recommendations
  - Build (solar-wind relevant facility, and facilities at a broad range of scales)
  - Support (MagNetUSA, science centers
  - Collaborate (DOE/NASA partnership)
- Support theory, modeling and data analysis to connect laboratory data to space data

DPS-3: Create Transformative Technologies

- Objectives
  - DPS-I: Develop plasma-based technologies that contribute to a **stable national energy infrastructure**
  - DPS-J: Develop plasma-based technologies that enable **advanced manufacturing**
  - DPS-K: Develop plasma-based technologies that improve the **physical well being of society**
  - DPS-L: Develop plasma-based technologies that provide **secondary sources** and other new capabilities, to benefit fundamental science, industry, and societal needs

- Increase support for single-PI-scale research projects
  - Allows fast-paced development from concept to engineering devices
  - Much of this research does not require large-scale facilities or teams
- Foster public-private partnerships
  - To accelerate technology transfer

Each science objective makes topical recommendations

Example:

DPS-2: Understand the Plasma Universe

- DPS-G: Understand the origin and effects of magnetic fields across the universe from star and planet formation to cosmology
  - Expert Groups: HEDP and GPS
  - Recommendations
    - Support further understanding of the origin of the planetary magnetic fields, stellar dynamos, and the origin of magnetic fields on galactic and cosmological scales
    - Support studies of magnetic field effects during formation of stars and planets (including exoplanets) in accretion disks and stellar jets
    - Support further studies of atomic and molecular spectroscopy in astrophysical environments

Main Findings and Recommendations: Cross-cuts

High level goals for the CPP cross cutting activity

- Identify scientific and technological opportunities that are overlapping of the four topical areas (FM&T, GPS, HEDP, MFE)
- Identify organizational or strategic frameworks that advance or leverage common areas of interest or need among the topical areas for the purpose of advancing fusion and plasma science broadly
- Identify research methods and tools in neighboring disciplines outside of fusion and plasma science that would advance science and technology broadly through coordinated research activities

Example cross-cutting recommendations: TC & MD

Theory and Computation

- Harness innovations in advanced scientific computing tools and increase capacity computing to improve fundamental understanding and predictive modeling capabilities.

Measurements and Diagnostics

- Pursue innovations in diagnostic development that advance our understanding of basic plasma science, improve our ability to control fusion plasmas, and enhance survivability in extreme environments.

Example cross-cutting recommendations: ET & WF

Enabling Technology

- Support public-private partnerships across the full breadth of fusion and plasma science.

Workforce, Diversity and Inclusion

- Embrace diversity, equity, and inclusion, and develop the multidisciplinary workforce required to solve the challenges in fusion and plasma science.

Diversity, Equity, and Inclusion

Diversity, Equity, and Inclusion (DEI) Statement

“The Discovery Plasma and Fusion Science and Technology community recognizes that having a healthy climate of diversity, equity and inclusion is critical to solve the challenges we face in our field. We acknowledge, as a community, that our current (and historically) unhealthy climate is a serious problem and we commit to taking immediate action to achieve equitable, diverse, and inclusive outcomes ...”

- The Workforce, Diversity, and Inclusion cross-cutting section provides greater detail and makes recommendations to improve DEI in fusion and plasma science

Summary

Remaining Questions

- The issue of cost was never addressed. We only considered benefits.
- No prioritization was attempted between FST and DPS.
- Program balance between HEDLP and GPS was not considered.
- Within FST, tension between urgency and commercial viability was never resolved.
  - The community wants to move forward urgently, but doesn't want to lock in an FPP concept yet.
  - We echoed the National Academies' call for an FPP at low capital cost, as a proxy for commercial viability. However, this is not defined. How do we know when we are ready to build?

Summary

- There is community consensus to pursue *all* recommendations in the report in the long-range strategic plan, in a blue-sky scenario
- FST: focus on science and technology that leads to the construction of a Fusion Pilot Plant
- DPS: realize the potential of plasma science to deepen our understanding of nature and provide the scientific underpinning for plasma-based technologies that benefit society
- Report contains many recommendations that can be enacted in the near term, by FES and with partners, and focuses on activities within a 10 year horizon
- This process brought the community together. We recognize that achieving ambitious goals will require united action across many disciplines.
- Community planning should be repeated every 5–7 years to adjust plan as necessary and to maintain community involvement.

Thank You!
Good Luck, Subcomittee!

Artwork by Jennifer Hamson LLE/University of Rochester, concept by Dr. Jeffrey Levesque, Columbia University.