Journal of Fusion Energy, Vol. 16, No. 4, 1997

Report from the Planning Workshop for the Fusion Energy Sciences Program

Stewart Prager,[1] Mohammed Abdou,[2] David Baldwin,[3] Richard Briggs,[4] George H. Neilson,[5] and Thomas Simonen[6]

1. INTRODUCTION

Sixty representatives of the fusion community and the Department of Energy met October 22–24, 1996 in a workshop to chart the short and medium term future of the nation's fusion energy science program. The fusion scientists represented nearly all the institutions and scientific areas covered by the fusion program. Plans were crafted to implement the goals of the restructuring recommended last winter by the Fusion Energy Advisory Committee. The workshop refined the vision of the fusion program, articulated the accomplishments expected over the next 5 years, suggested changes in organizational methodology, reaffirmed the U.S. community's commitment to ITER and agreed to participate in the international collaborative process beyond the Engineering Design Activities toward construction, described future roles for the Princeton Plasma Physics Laboratory as a national laboratory, and produced the beginning of plans for education and outreach to the larger scientific community and public. Each of these items is discussed below: Taken as a whole, they represent a sea change for the U.S. fusion program. This change was embraced by the workshop attendees. It forms the basis for a fusion and plasma science program which will continue to reap far-reaching benefits to the nation in the near term, and progress toward a renewable and attractive energy source for mankind in the long term. It is expected that the new program will be enduring. It is based upon principles which will evolve, but not be overturned, as the nation's energy and science needs evolve.

[1] Department of Physics, Chamberlin Hall, 1150 University Avenue, University of Wisconsin, Madison, Wisconsin 53706.
[2] University of California, Los Angeles, California 90024-1597.
[3] General Atomics, San Diego, California 92186-9784.
[4] SAIC, Pleasanton, California 94588.
[5] Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543.
[6] General Atomics, San Diego, California 92186-9784.

The world fusion program has been strongly collaborative since its inception. With recent improvements in information technology, and the increase in the relative strength of the European and Japanese programs, the collaborative nature of the program is expected to increase. Collaborations will cover essentially all areas of fusion science.

2. VISION FOR THE FUSION PROGRAM

Development of the scientific basis of the fusion energy source for future generations represents a grand challenge for science. Based upon the FEAC restructuring we articulated three major goals for the fusion energy sciences program.

2.1. Understand the Physics of Plasmas, the Fourth State of Matter

Plasma physics has been the prime engine driving progress in fusion energy research and conversely, the fusion program has been the dominant driver of plasma physics research. Hence, the advancement of plasma science is an intrinsic part of the program. Understanding the behavior of this prevalent state of matter poses an enormous challenge. Basic principles are being developed to understand the rich array of plasma waves, instabilities, spontaneous magnetic phenomena, turbulence, wave-particle interactions, plasma-wall interactions, and alpha particle physics. These emerging principles have advanced the understanding of behavior in complex systems. Beyond its own scientific value plasma science and its associated technology have pervasive import for many related scientific fields and industrial applications. Plasma science has greatly influenced our understanding of plasmas and magnetic fields in the earth's magnetosphere, the sun and other stars, and in galaxies. Plasma physics is at the forefront

0164-0313/97/1200-0299$12.50/0

in the study of turbulence and chaos, and in the pioneering development of large-scale computation. Applications of plasma knowledge extend to the manufacturing, materials, electronics, electrical power, computing, defense industries, and to high power accelerators. Plasmas are used in the manufacturing and processing of a wide variety of materials, from semiconductor chips to aircraft turbine blades. The new strategy for fusion research recognizes the utility of plasma research to the nation's science and technology base beyond fusion, as well as its continued central role in fusion energy development.

2.2. Identify and Explore Innovative and Cost-Effective Development Paths to Fusion Energy

The fusion energy endeavor requires a mix of basic science research, technology, development, and invention. The restructured program will encourage innovative approaches to fusion power, emphasizing concepts which may lead to cost-effective development paths and economical power plants. This endeavor fosters collaboration, rather than competition, among the different fusion concepts. There is a continuous spectrum of approaches to fusion, from the tokamak to closely related magnetic configurations to radically different magnetic configurations to inertial confinement. The new program will include both strong research in tokamak innovations and in non-tokamak concepts, including associated technology development. In recent years, the U.S. magnetic fusion program had narrowed to a nearly exclusive focus on tokamaks. The new program, appropriate to a long-term scientific endeavor, will depart radically from the past focus to embrace promising ideas covering the full spectrum of fusion approaches. It will also explore the scientific basis for innovative technologies and materials options capable of achieving the full potential of fusion energy.

2.3. Explore the Science and Technology of Burning Plasmas, the Next Frontier in Fusion Research

In all existing experiments the plasma is heated by external sources. In a burning plasma the alpha particles produced from the fusion reaction deposit their energy back into the plasma. External heating can be turned off in a self-sustained burning plasma. The presence of alpha particles can alter the waves, instabilities, and turbulence in the plasma in ways which elude the predictive capabilities of the present state of theoretical plasma physics. In addition, a burning plasma presents numerous technological challenges in areas such as materials and power handling. Thus, a burning plasma experiment represents a frontier in fusion research. Indeed, achievement of a terrestrial burning, self-sustained star would be a notable achievement for mankind. Such an experiment is costly and readily pursued through international collaboration.

3. FIVE YEAR ACCOMPLISHMENTS

The workshop addressed specific results expected to be delivered within 5 years. Six deliverables are identified, each keyed to the three goals listed above.

While a complete determination of deliverables remains to be developed, the following are illustrative of the exciting accomplishments expected from the new program.

3.1. Strengthened General Plasma Science and Education Efforts, with Connections to Other Scientific Communities (Goal 1)

The laboratory study of waves, instabilities, chaos, turbulence, and wave-particle interactions in plasmas for its fundamental importance will be emphasized in facilities of all scales in the restructured fusion program. Pursuit of fundamental plasma science occurs in small-scale experiments, which can often set up plasma conditions suitable for basic investigations, and in larger-scale facilities, which can often achieve physics regimes not accessible in smaller devices. We illustrate this emphasis through four examples. Contributions to this deliverable also accrue from the accomplishments listed in deliverables 3.2–3.4 below.

Chaos and Transport in Plasmas. In recent years it has become recognized that chaos governs the evolution of many physical systems. Plasmas, in particular, exhibit some of the most vivid examples of chaos. For example, it often happens in laboratory and space plasmas that the magnetic field becomes chaotic. This causes rapid particle and energy transport, a phenomenon of great consequence in many natural and laboratory situations. Fusion experiments offer unique opportunity to measure the transport specifically caused by chaotic magnetic and electric fields. Plasma measurement techniques have evolved so that over the next five years chaotic transport can be measured and understood in much greater depth than ever before.

The Dynamo Effect. The Earth, sun, other stars, and galaxies generate their own magnetic fields. The mechanism of this self-generation of magnetic field, the dynamo effect, remains a major unsolved problem in astrophysics. Remarkably, some laboratory fusion plasmas also partly generate the magnetic field that confines them in a process which has some similarities to the astrophysical dynamo. These plasmas represent the first laboratory example of spontaneous magnetic field generation. Over the next 5 years, experimental measurement will test the dominant theoretical model of the laboratory dynamo.

Plasmas with Self-Generated Current. An intriguing feature of toroidal plasmas is that at sufficient temperature and pressure, an electrical current can flow in the absence of an applied electric field—a current flows in a resistor with no voltage. In this effect, known as the bootstrap current, the energy for the current arises from the plasma pressure. A goal for the next 5 years is to produce and sustain plasmas in which nearly 100% of the tokamak plasma current is self-generated. If successful, it will confirm the fundamental plasma kinetic theory believed to explain and predict this effect.

Dynamics of Magnetic Reconnection. The release of magnetic energy as oppositely directed magnetic fields collide underlies a wide range of important phenomena from solar flares in the sun's atmosphere to magnetic sub-storms in the Earth's magnetosphere to disruptions in laboratory fusion plasmas. The scientific challenge is to understand how the magnetic field changes its topology—a result of the microscopic interaction between the plasma particles and electromagnetic forces. Fusion plasma experiments have spun off new experimental techniques to study reconnection in a controlled laboratory environment. Parallel advances in computational modeling have generated new ideas on reconnection in high temperature plasmas, which can be tested against laboratory measurements.

3.2. Substantial Progress in Scientific Understanding and Optimization of Tokamak Plasmas (Goals 1 and 2)

Tokamaks are the most mature magnetic confinement configuration. As such, they can advance basic physics and technology of high temperature plasmas and, in turn, employ the knowledge to optimize the tokamak plasma and provide data relevant to related toroidal magnetic concepts. Deliverables include

Determination of the Mechanism for Suppression of Turbulent Transport by Plasma Flow. A general mechanism for reducing turbulence in the electric field has been uncovered in recent years. It is observed that turbulence is reduced in the presence of sheared plasma flow. This effect significantly improves confinement in the tokamak and other plasma configurations. It may also play a role in nature, for example in suppression of turbulent mixing of the hole in the ozone layer in the Earth's atmosphere. A standard theoretical model is evolving to understand this effect. Experimental optimization and further study of shear flow turbulence suppression will provide a stringent test of the model.

Understand and Optimization of Classically Confined Plasma Regions. Recently, fine control of the internal structure of the magnetic field in the tokamak has surprisingly led to drastic suppression of turbulent transport in portions of the plasma. In the plasma core transport has been reduced to levels previously thought nearly unattainable—that determined by collisions between particles with no influence from turbulence. Theories are emerging to explain this phenomenon. Experimental investigation is expected to yield a comprehensive understanding of these regimes, and how to optimize them. Beyond its physics interest, if we can learn how to suppress turbulent transport it can reduce the minimum size for fusion power plants.

Understand Pressure Limits at Very High Temperature. The science of magnetohydrodynamics, in which the plasma is treated as an electrically conducting fluid, predicts fundamental pressure limits to confined plasmas. A modified fluid description has been developed to predict the pressure limit in extremely high temperature plasmas, where the fluid description becomes invalid. Tokamak plasmas are now able to reach the regimes necessary to test the pressure limit predictions of the modified fluid theory. Knowledge of how to substantially increase this limit would be an important breakthrough that would project to higher power densities and lower costs for fusion reactors.

Demonstrate Ability to Control Interaction of Hot Plasma with Cold Wall. A major scientific and technical challenge is to controllably distribute the intense heat from the multi-million degree plasma onto the surrounding wall while extracting helium exhaust and maintaining fuel purity. Methods have been developed to accomplish this by providing a magnetic shield between the hot plasma and the wall, and extracting the plasma energy as uniform, less damaging (to the wall) electromagnetic radiation. Existing tokamaks contain the magnetic shield and the intensity of heat flux necessary to test the concept.

Feedback Stabilize High Pressure Plasmas. Above a critical pressure, a magnetically confined plasma will become unstable and escape the confining magnetic field. The understanding of the limiting instabilities, disturbances that extend throughout the entire hot plasma, is sufficiently well-developed that techniques are being devised for feedback stabilization. The challenge of feedback stabilization of these complex disturbances is substantial. In the next five years, stabilization techniques will be tested which would enable the attainment of very high plasma pressure.

3.3. Significant Improvement in Comprehensive Modeling of Plasma Behavior, Based on Theoretical Understanding and Experimental Experience, and Exploiting Anticipated Advances in Large-Scale Computation (Goal 1)

Although the basic laws which govern plasma behavior are known in principle (Newton's laws and Maxwell's equations), in practice they are insoluble. In fact, the richness of their solutions comprises much of what we call plasma physics. As a consequence, new theoretical descriptions have had to be developed to describe usefully the plasma state. At the same time, advances in diagnostics have greatly improved the accuracy and completeness in measuring plasma phenomena experimentally. The merger of exquisite experimental measurements with computational and theoretical advances has been a powerful tool to understand and predict plasma behavior. Indeed, plasma physics has been at the pioneering forefront of computational physics. With the advances in scientific computing power anticipated in the next several years (for example, as part of the DOE science-based stockpile stewardship program) this capability can be enhanced greatly.

Thus, in the next several years we expect marked progress, illustrated in the examples that follow, in simulating basic plasma physical phenomena and in integrating isolated phenomena into increasingly comprehensive simulations of full plasma behavior.

Test of a Theoretical and Computational Model of Tokamak Microturbulence. We now have strong evidence supporting the theoretical predictions that small-scale turbulence drives energy loss in tokamaks. Recent advances in these theories have resulted in a turbulence model sufficiently simplified to allow computational solution, but sufficiently detailed, it is believed, to capture the key physics. In the next few years computational solutions for turbulent transport will be compared with results from the world tokamak database to test this "first principles" approach to understanding tokamak transport.

Development of a Two-Fluid Modeling Capability for Fusion Plasmas. All magnetic confinement configurations are vulnerable to large-scale waves and disturbances which impose strict limits on plasma behavior. Most of the physics of such large-scale activity in a plasma, such as magnetic reconnection as occurs in astrophysical plasmas, can be captured in a two-fluid description with appropriate dissipation. In such a description the plasma is described as a mixture of an electron fluid and an ion fluid interacting with each other through fields and particle collisions. A comprehensive code capability will be developed and implemented taking advantage of the rapid progress in massively parallel computers, which can treat many different magnetic configurations. It will be an invaluable tool for tokamak interpretation and alternative concept development.

Integrated Modeling Capability. Fusion plasmas contain a wide array of phenomena with vastly different properties and operating over widely different time and distance scales. At present, individual codes treat individual phenomena as mostly uncoupled effects, such as equilibrium, transport, stability, plasma-wall interactions, and electromagnetic wave injection for current drive. In experimental plasmas these processes are coupled. The coupling can produce new modes of behavior. With anticipated increases in computer power and software techniques it will eventually be possible to evolve all of these phenomena simultaneously to simulate comprehensively the behavior of a fusion plasma. Over the next few years an integrated code architecture will be developed which couples individual physics packages together. This integrated simulation capability will provide a plasma modeling capability that develops as our physics understanding matures.

3.4. Exploration of Several Non-Tokamak Fusion Approaches (Goal 2)

In five years a strong program to explore non-tokamak approaches (magnetic and inertial) to confinement will be in place. The activity will be aimed to advance our understanding of fusion science and to develop promising approaches to fusion energy. At that time, the programmatic distinction between tokamaks and alternative concepts will have given way to a seamless program which emphasizes the physics commonality among confinement approaches. Both toroidal and non-toroidal concepts will be explored, including inertial fusion energy which leverages off the stockpile stewardship inertial confinement fusion program. New experimental projects exploring several concepts in a range of scales will have been initiated. Innovations will be explored in enabling technologies, such as heating, current drive, fueling and diagnostics. These technologies provide the advanced tools needed to understand and optimize plasma behavior in the experiments, and are vital to their success. In addition to undertaking new initiatives, the following deliverables will be forthcoming from the projects already in process. As in tokamak research, these new projects will be carried out in an international context.

Create a Plasma with Very High Plasma Pressure. A tokamak with a minimal hole in the center of the donut takes on physics properties which differ substantively from the standard tokamak. One such property is that the plasma pressure (relative to magnetic field pressure) is predicted to be extremely high. The pressure limit of this magnetic configuration (known as the spherical torus) will be determined experimentally and compared with theoretical predictions. Construction of new spherical torus experiments is already underway as one of the first new initiatives of the restructured program.

Understand and Control Magnetic Fluctuations and Transport. The alternative concept known as the reversed field pinch presents the challenge of large magnetic field fluctuations. Based upon fundamental understanding of the magnetic turbulence, evolving from experiment and theory, techniques have been devised to suppress the fluctuation-induced transport. In 5 years, the techniques will have been applied to determine the promise of this approach from a transport viewpoint, and to reveal new information on chaotic magnetic fields.

Evaluate New Stellarator Configurations and Participate in the International Stellarator Program. The stellarator is a configuration in which the magnetic field structure is complex and provides a rich variety of possibilities. For example, a new stellarator configuration with special symmetry properties in the magnetic field has been proposed. The predicted favorable confinement properties of this configuration will be tested experimentally and compared with other devices, including the very large stellarators being built in Japan and Germany. In addition, collaborations with these foreign programs will be in place.

Evaluate Heavy Ion Accelerators as Drivers for Inertial Fusion. The beams in heavy ion accelerators are non-neutral plasmas that are particularly amenable to computer simulation. In five years the tools will exist to perform accurate particle simulations of beams in the entire accelerator, from ion source to target. Small experiments that are currently underway will validate the computer models. The Department of Energy, through its Defense Programs, will complete the construction of the National Ignition Facility (NIF) in about five years. The NIF seeks to demonstrate inertial fusion target ignition and will explore the science of burning inertially confined plasmas. The results from the NIF, in conjunction with the comprehensive accelerator simulations and experiments performed in the fusion energy sciences program will lead to a firm scientific basis for evaluating the potential of inertial fusion.

Establish Broad Theoretical Studies of Non-Tokamak Configurations. The advanced theoretical and systems studies developed for the tokamak and a small set of existing alternative concepts represents a great resource. This arsenal of theoretical and computational tools will be available to the fusion community and applied to the evaluation and advancement of new ideas.

3.5. Marked Progress in the Scientific Understanding of Technologies and Materials Required to Withstand High Plasma Heat Flux and Neutron Wall Load (Goal 2)

The U.S. will focus its efforts on basic and innovative research to gain the scientific understanding necessary to identify and evaluate low activation materials, technologies, and design options with the most attractive performance, safety, and environmental features. The research will be aimed at improving the scientific understanding and extending the performance limits for innovative concepts with high power density, high temperature capability, long life times, low parasitic neutron absorption, chemical reactivity, tritium permeability, decay heat, long-term activation, and cost. This new strategy will rely on theory, analysis, and phenomenological and computational modeling of fundamental scientific issues; will conduct selected laboratory experiments to measure and improve limiting thermal-physical-chemical-mechanical properties and to understand important material interactions and multiple-effect phenomena; and will participate in international collaboration in selected areas such as neutron irradiation experiments and technology testing on ITER (see also the sixth deliverable below).

The 5-year deliverables:

- Advance the sciences necessary for understanding and evaluating the performance and interactions of an attractive and compatible combination of structural, breeding, cooling, and plasma-facing materials.
- Develop role in proposed testing program on ITER.
- Identify and evaluate new high performance concepts for advanced technology with high neutron

wall load capability and attractive safety and environmental features.

- Evaluate the scientific feasibility of liquid wall-protection and cavity clearing schemes for IFE.

3.6. Positioned to Study Burning Plasma Physics and Develop Fusion Technologies Through International Collaboration (Goal 3)

It is a U.S. program objective to be a participant in an international collaboration on the construction of ITER; and in 5 years, based on present ITER project schedules, the site specific safety and licensing reviews associated with construction will be completed, the fabrication of all major tokamak components will be underway, the site specific design will be completed and construction will be underway on all primary buildings. In parallel, physics experiments and theoretical analysis worldwide will have demonstrated advanced modes for tokamak operation which will make it possible to operate ITER in steady state at high fusion power levels, divertor operation which dissipates the heat expected in ITER, and plasma operating methods and controls which greatly reduce the occurrence of tokamak plasma disruptions.

Progress towards the long-sought goal of fusion energy research to study burning plasmas will continue in the next five years by achieving the following deliverables:

- Participate in experiments with a deuterium-tritium mixture in the JET tokamak in Europe. Combined with completion of the TFTR data analysis understanding will be obtained on the confinement and instabilities generated by alpha particles which are produced in the fusion reaction.
- Complete the ITER Engineering Design Activities by maintaining the U.S. membership on the Joint Central Team, by operating through 1998 the San Diego Joint Work Site and by completing assigned design and research and development tasks.
- Participate in the construction of ITER at about the present financial level, assuming approximately constant overall fusion budgets. As discussed below, even if ITER construction is not authorized immediately after the conclusion of the Engineering Design Activities, the United States will complete the R&D tasks and remain committed to the international process focused on construction of a burning-plasma experiment.

4. CHANGES IN FUSION PROGRAM ORGANIZATION

The substantial scientific changes in the fusion program outlined above will be facilitated by accompanying changes in the organization of the program. Changes which will be implemented are:

Organize by Topical Teams. Topical working groups will be used increasingly to coordinate and stimulate activity in key scientific areas. The program will be driven more by topical teams and less by facilities teams.

Operate Experimental Facilities More as National Collaborative Experiments. Substantial facilities will be conceived, planned, and operated with collaborative, multi-institutional teams.

Increase Emphasis of General Physics Studies in Large Facilities. As part of the increase in emphasis on establishing the science base for fusion, the large facilities should welcome experiments which are aimed to increase physics understanding generally.

Form Study Groups in Particular Alternative Concepts as Well as Tokamak Innovations. To strengthen the advance into innovative confinement concepts, study groups will be formed which pull together experts in the diverse areas required to evolve a specific concept.

Support Enabling Technologies from Experimental Programs. With the reduction in funding for enabling technology, the experimental programs should assume additional responsibility to foresee the technological needs of the experiments. A user-developer working group will meet to establish priorities for longer term development of enabling technologies.

Integrate Inertial Fusion Energy Research into Overall Fusion Energy Program. Inertial fusion energy research should have closer scientific ties to the overall fusion energy program. The magnetic and inertial fusion energy efforts share research areas in plasma physics and technology. Increased scientific communications between inertial fusion and magnetic fusion researchers, through scientific meetings and other avenues, will be sought.

5. THE U.S. ROLE IN ITER AND INTERNATIONAL COLLABORATION

The workshop reaffirmed a strong resolve in the fusion science community to participate in ITER construction at the level recommended by FEAC. In such a plan, the U.S. will contribute at roughly the present ITER funding level. ITER represents a unique opportunity to explore the frontier of burning plasma physics and its associated fusion technology. International collaboration is essential for an experiment of this size, to incorporate all available technical expertise as well as cost-sharing.

The collaborative process which underlies ITER represents an opportunity for the U.S. which should extend beyond the present ITER design activity. In this regard, workshop attendees discussed U.S. options should ITER construction not move directly forward at the end of the EDA. The decision on ITER construction will be controlled by our international partners with relatively large financial participation. It is prudent to discuss the U.S. response to a delay or redirection of the ITER program. The workshop attendees believe that in either case, the U.S. should continue to participate in the research and development programs begun during the EDA, in order to participate in ITER construction or in an alternative international burning plasma experiment at about the financial level presently planned.

Such international participation, in burning plasma science and other fusion issues, represents a large opportunity for the U.S. The world fusion program has been strongly interactive and collaborative since its inception. With the increase in information technology, and the increase in the relative strength of the Japanese and European programs, the collaborative international nature of the program will increase. Collaborations will cover multiple aspects of the fusion program including coordinated experiments, joint theoretical efforts, development of shared experimental databases, sharing of computational tools, development of alternative concepts, and development of technologies which enable experimental advances.

6. THE ROLE OF THE PRINCETON PLASMA PHYSICS LABORATORY

The workshop attendees reaffirmed the importance of PPPL as a Department of Energy national laboratory for fusion and plasma research. This conviction stems from the programmatic utility of a national laboratory to a field of science, and from the value of the concentration of material and human resources at PPPL. As TFTR completes operation in 1997, and the restructuring program is implemented, the role of PPPL as a programmatic leader and as a research organization will change significantly.

The role of PPPL as the national laboratory for fusion science includes nurturing the core fusion competencies and breadth of research topics in the universities and labs, thereby assuming some stewardship for the scientific health of the nation's broader fusion program; and operating the facilities located at PPPL as national collaborative experiments in their conception, operation, and management, as is true for other labs as well.

The scientific composition of the laboratory will evolve from one dominated by a single large facility to one which emphasizes innovations in either tokamak or non-tokamak concepts through facilities in a range of scales. The National Spherical Torus Experiment (NSTX) experiment is an excellent step in this direction. In addition, highly productive collaborations can be exercised with the DIII-D and Alcator CMOD tokamaks, and with other facilities in the U.S. and abroad. PPPL engineering and technical collaborations with DIII-D and Alcator C-Mod can contribute to increased operation of those facilities, while physics collaborations will contribute to higher scientific productivity.

7. EDUCATION AND OUTREACH

It is clear that plasma physics and fusion science is insufficiently understood and appreciated by the public and the larger scientific community. Over the years, concerns have been raised regarding the ultimate practicality and desirability of fusion energy generation. These concerns will be examined and addressed in detail, incorporating recent developments in fusion science and related areas.

Workshop attendees were enthusiastically in favor of conveying the exciting and important results of our research to the public, the scientific community, the environmental community, and the schools. Plasma science should fascinate all of those parties. Initiatives were discussed such as communicating to the public through popular articles, upgrading and expanding plasma physics colloquia presented at universities with an eye toward casting our results in universal physics language, opening dialogue with the environmental community, expanding interagency dialogue among funding sources for plasma science, and including outside scientists more frequently in our review and advisory committees. Initial planning activity for these and related efforts is underway.