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Letter from the Chair, Wayne Houlberg, Fusion Energy Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee

I suppose there are always many challenges for someone chairing a division of a professional society, but this year seems particularly loaded with challenges associated with changes in ANS and the fusion program. The ANS has been undergoing a series of self-assessments to improve the way it serves its members. This year we will be addressing the relationship between the divisions and the society in an Infrastructure III meeting in March. Fusion Energy has different needs than many of the other divisions because of its focus on long-range research and because of the strong ties of many of its members to other professional societies. These must be accommodated in the assessment. At the June meeting in Nashville many of you expressed the desire to schedule our next Topical as a stand-alone meeting and exploring ways to better coordinate our Topicals with other fusion meetings. The Idaho and Northern California Sections, with the Fusion Energy Division of the Atomic Energy Society of Japan have put together an excellent proposal to host the next Topical in Park City, Utah in October 2000. It was unanimously endorsed by the FED Board and is being sent to the National Program Committee for calendar placement as this letter is being written. We have had a very positive indication of interest from IEEE to merge this series of Topicals with their Symposia on Fusion Engineering that are held in odd numbered years. We have appointed a group to further explore this possibility.

The changes in the fusion program in the past few years have been dramatic, although we are still trying to rebuild it into a sensible program. There will be many opportunities during the next year ÷ through FESAC, the Snowmass meeting and various reviews ÷ for community input. Some major elements of this assessment of interest to FED members will be redefinition of the technology element of the program in light of the U.S. withdrawal from the ITER program and the balance between inertial and magnetic emphasis. Below I provide more details on FESAC and ITER. Feel free to contact me or any of the other Board members with input to these issues. That is what we are elected for. Because we collectively have more influence, it is a good reason for us to maintain our ANS membership and recruit our other colleagues to our cause. I thank you for your vote confidence in me to lead the FED during this year and hope I am up to the many challenges. I have certainly gained a much better appreciation of the efforts of my predecessors in this job.

FESAC: The DOE Fusion Energy Sciences Advisory Committee (FESAC) has received a new charge from DOE Director of Energy Research Martha Krebs. The first part of the charge consists of preparing a report on the opportunities and the requirements of a fusion energy science program, including the technical requirements for fusion energy for the near term (5 years), mid-term (20 years), and the longer term. She would also like to see the report contain an assessment of the technical status of the various existing program elements for input to the upcoming Secretary of Energy Advisory Board (SEAB) review of the Magnetic and Inertial Fusion Energy programs. FESAC chairman John Sheffield has assembled a panel, which he will personally chair, to address this part of the charge. The other members of the panel are: Charles Baker, Stephen Dean, Nat Fisch, Jeff Freidberg, Richard Hazeltine, Gerald Kulcinski, John Lindl, Gerald Navratil, Cynthia Phillips, Stewart Prager, Don Rej, John Soures, and Ron Stambaugh. Others may be added. The panel held its first meeting October 13-14 in Washington. It is the panel's intent to ask for 2 page reports describing the major elements of the fusion program. The panel report is scheduled to be presented to FESAC at its next meeting January 13-15 at Livermore.

The second part of the charge is for FESAC to lead a community assessment of the restructured program thus far, including recommendations for further redirection given projected flat budgets for fusion. With this assessment as background, Krebs would like FESACâs recommendations on the proof-of-principle experiments now under review, recommendations regarding the balance between tokamak and non-tokamak physics, and between magnetic and inertial fusion energy. She would like to receive this second report by September 1999, so it can be used to prepare a program plan/roadmap for submission to Congress with the FY2001 budget.

As an ex-officio member of FESAC representing ANS, it is important for me to see that technology and energy views are well represented in these reports. In her letter, Krebs notes "In FY 1999 we will suspend our ITER design efforts but still complete important and related technology research. At the same time we will work with our ITER partners to identify complementary international collaborations." Krebs notes the recent restructuring of the program towards more of a science emphasis but states, "However, fusion will never be simply a science program; it must have an energy vision, as well. This dual nature of the program will always cause tension within the community. The continued call for clearly defined progress toward energy application, from Congress and others, will highlight that tension."

ITER: The ITER Parties announced at the end of their October 20-21 meeting in Yokohama that the European Union, Japan, and Russian Federation have confirmed their intention to continue the ITER EDA for three years consistent with the principles of the Agreement, each providing resources at the level previously planned. The U.S. reported that, because of the unavailability of appropriations for its continued ITER participation, it has been necessary to suspend U.S. participation in ITER design work while completing its R&D tasks. The remaining three partners in ITER remain committed to progress toward possible future decisions on the realization of ITER. The Russian Federation delegation indicated that they will consider the possibility of proposing a site for ITER construction. Previously, sites have been offered in Canada, Europe and Japan. The U.S. Delegation restated its wish to see ITER built.

The U.S. indicated its desire that all ITER personnel now at the ITER Joint Work Site in San Diego, including the Director, vacate the site by the end of January 1999. The Council decided that the Director, Robert Aymar, would relocate to the ITER co-center in Garching, Germany, and that the Deputy Director will be based at the co-center in Naka, Japan. The Council further decided that Dr. Chuyanov, currently at the San Diego site, would assume the leadership of the the Garching co-center, replacing Ronald Parker, who has been recalled to the United States. The chairmanship of the ITER Technical Advisory Committee (TAC), a position that has been held by Paul Rutherford of the U.S., will now be held by a scientist from Japan. Aymar told the Council that the arrangements proposed and approved by the Council gave him confidence that it would be possible by July 2001 to deliver the technical output required to support a construction decision as previously foreseen.

FED Slate of Candidate, Bill Hogan, Lawrence Livermore National Laboratory, Livermore, California

I am delighted to report that we have an excellent slate of candidates running for next year FED offices. It was gratifying that, when asked, so many very busy people recognized that the functioning of FED depends on the volunteer effort of interested and qualified people and that they were willing to step forward and contribute. Now it is up to the membership to be equally committed to the success of FED by examining the qualifications of each candidate and voting. I know there is some discouragement within our community due to decreasing budgets. However, it is exactly at such times that we must pull together and participate in making the division stronger. I encourage you all to vote!

Vice Chair:

Kathryn A. McCarthy
Idaho National Engineering and Environmental Laboratory

L. John Perkins
Lawrence Livermore National Laboratory

Secretary/Treasurer:

Sandra Brereton
Lawrence Livermore National Laboratory

Executive Committee Candidates:

James P. Blanchard
University of Wisconsin, Madison

Lee Cadwallader
Idaho National Engineering and Environmental Laboratory

Rick Kurtz
Pacific Northwest National Laboratory

Jeff Latkowski
Lawrence Livermore National Laboratory

Craig Olson
Sandia National Laboratories, New Mexico

Scott Willms
Los Alamos National Laboratory

Ongoing Fusion Research:

Virtual Laboratory for Technology, Charles Baker, Director Virtual Laboratory of Technology, University of California, San Diego

The Virtual Laboratory for Technology (VLT) was established on October 1, 1998 by the Department of Energy's Office of Fusion Energy Science (OFES) as part of the restructuring of its Technology Program, which will transition from emphasis on ITER-specific tasks to a broad portfolio of design, analysis, and R&D activities that serve OFES domestic programs and international collaboration interests. Charles Baker (UCSD) and Mike Saltmarsh (ORNL) were appointed the Director and Deputy Director, respectively.

Beginning in FY 1999, the Technology Program will shift its emphasis to enabling technologies that support domestic plasma experiments and provide opportunities for access to experiments and facilities worldwide with test conditions and capabilities not available in the U.S. The Technology Program will also carry out fusion device design and systems studies, as well as address scientific issues and seek innovations for materials and technologies needed in the long-term for fusion to achieve its potential as an attractive energy source. The Technology Program encompassed by the VLT includes the OFES budgetary elements of Plasma Technologies, Fusion Technologies, Advanced Design and Advanced Materials.

The mission of the VLT is to facilitate the simulation of a traditional single-laboratory setting with central leadership and with interconnection of people and facilities through strong and effective communication linkages, data and hardware sharing, and cross-institutional teaming to fully integrate tasks conducted at many performing institutions. As a mechanism for organizing and integrating the performing institutions that will carry out the Technology Programâs diverse, interrelated activities, the VLT will provide the vehicle for coordinating program elements and for obtaining community participation in program planning.

The Director and Deputy Director of the VLT will provide clearly defined Technology Program leadership in the U.S. fusion community for program advocacy, representation among fusion program leaders, communications with internal and external customers and stakeholders, and consensus building. Specific responsibilities include to lead the Technology Program community in domestic and international discussions and activities, to lead the Technology Program community in its roles toward preparing strategic and technical program plans and roadmaps, to serve as Technology Program representatives in fusion program leader activities and as the spokespersons for the Technology Program in U.S. fusion community affairs and councils of program leaders, to provide points-of-contact for information on Technology Program activities and increase the visibility of these activities through the use of internet web sites, periodic newsletters, brochures, etc., to encourage development of standardized, computer-based data bases (e.g., a materials database handbook), and to establish committees to advise them on programmatic policies and procedures.

The VLT Director and Deputy Director will assist OFES in coordinating Technology Program activities and their collaboration connections to the international fusion community, improving coordination with physics activities in OFES, improving understanding in the fusion community of the value, need for, and progress of Technology Program activities, promoting outreach and communication with related scientific and technical communities, enhancing quality and uniformity in processes for program planning and initiatives, and coordinating fusion community input on program resource needs and priorities.

The activities of the VLT will be focused on four principal areas with a coordinator for each area as follows:

* Enabling Technologies Stan Milora (ORNL)

* Advanced Technologies Mohamed Abdou, (UCLA)

* Advanced Materials Everett Bloom (ORNL)

* Advanced Design Farrokh Najmabadi (UCSD).

Plans for incorporating IFE into the VLT are being developed.

The U.S. Fusion Materials Program, Bill Wiffen, Office of Fusion Energy Sciences, U.S. Department of Energy, Washington, D.C.

Fusion Materials Research, one of the earliest established of DOE's fusion technology programs, is in the midst of planning and modest rebalancing in response to review by FESAC and the organization of the Virtual Laboratory for Technology (VLT). The materials program was initiated in the mid 1970âs in recognition of the limits placed on fusion power systems by the performance capabilities of structural materials in energy conversion components. These uniquely challenging limits arise from the requirements of the highest neutron flux levels ever envisioned in a power system, the unexplored neutron spectrum, the multicomponent chemical environment, the high temperatures needed for thermal efficiencies, and the limitations on element selection set by U.S. criteria for safety and waste disposal (or materials recycling).

The evolution of the program since its inception has been guided by materials performance needs identified in the continuing series of power plant/system studies. Evaluation of candidate materials has established that no commercially available materials can meet the needs of fusion. The combination of system needs and materials attributes has led to a focus on three structural material systems--vanadium alloys, best matched to liquid --> -- lithium blankets; silicon carbide composites, attractive for helium cooled --> --blankets; and advanced ferritic steels adaptable for several coolant options. --> --

The current program addresses the unique features of the fusion environment, relying wherever possible on the materials science and development programs for other uses. This leads to an emphasis on the long term effects of exposure to neutrons, with a mix of experiments to establish material property changes and modeling/analysis to understand and extrapolate the results. The goal is of course a mechanistic understanding of materials behavior that will eventually lead to a fully predictive capability for materials in fusion power systems.

The major materials program participants are ANL, ORNL, and PNNL, with significant contributions also made by Auburn (in partnership with Tuskegee), LLNL, RPI, UCLA, and UCSB. Research results are regularly reported in the Fusion Materials Semiannual Progress Report (the series DOE/ER-0313), in the proceedings of the International Conference on Fusion Reactor Materials (held biannually and published in Journal of Nuclear Materials), as well as in numerous other topical conferences and journals.

The U.S. program is highly integrated within the international fusion materials development activities. Bilateral collaborations with Japan (separate agreements with JAERI and with the Monbusho-funded university community) and with Russia extend the abilities of each partner to conduct the expensive and time consuming fission reactor irradiation experiments that are needed to partially simulate the fusion environment. Coordination of international activities is accomplished through the IEA Implementing Agreement on Fusion Materials, where program activities of the European Union, Japan, PR China, Russia, Switzerland, and the United States are regularly discussed, coordinated, and planned for complementary activities. (While Canada is still a member of this agreement, they are currently inactive). The IEA Fusion Materials group is currently moving to strengthen these international ties. A workshop held at Riso National Laboratory, Denmark in October 1998 has laid the groundwork for a stronger coordination of the efforts of the member parties, to maximize the collaboration on subjects of common interest while recognizing the unique requirements, goals and directions of the individual national programs. The results of this workshop will be a white paper, with the workshop organizers Tatsuo Kondo (Japan, chair), Everett Bloom (US), and Karl Ehrlich (EU) taking the lead in preparing the document.

Planning of the U.S. program for the next several years is also being updated under the VLT. This planning is described in the roadmap/white paper soon to be available via the VLT home page and in the two-page program description being produced for the FESAC January meeting.

The Fusion Materials Program was most recently reviewed by FESAC during the first half of this year, with an expert panel co-chaired by Sam Harkness and Charlie Baker. FESAC recommended strengthening the theory/modeling component of the program, more complete integration of activities with other elements of the Fusion Program, a continuing search for innovation, and consideration of the materials needs of IFE systems. The first response to the FESAC recommendations was the chartering of a group to evaluate the needs and methods of strengthening the theory/modeling/analysis activities within the program. Roger Stoller (chair), Howard Heinisch, and Bob Odette have produced a draft roadmap on these program issues and will lead a community-wide workshop in Boston on December 3-4, 1998 to complete input. The draft roadmap is on the web site www.ms.ornl.gov/Rems/workshops.htm and comments are welcome. The output of the workshop and the resulting roadmap will help DOE in planning any program redirection to begin to meet identified needs.

NIF Use Planning Activities Proceeding Well, Ken Schultz, Director of Inertial Fusion, General Atomics, San Diego, California

The concrete and steel rising at Lawrence Livermore National Laboratory are rapidly making the National Ignition Facility (NIF) a reality, with the aluminum target chamber and the many laser components not far behind. With the machine progressing rapidly, DOE is now developing serious plans for its utilization. The status of this plan was reviewed at a recent NIF Users' Group meeting, held at General Atomics on October 15. Ann Satsangi, at the DOE Office of Inertial Fusion and NIF, is coordinating the NIF Use Plan with input from four major user groups. The current status of the NIF Use Plans of each of these groups was presented: Ignition, presented by Tom Bernat of LLNL, Weapons Physics, presented by Bill Krauser of LANL, Radiation Effects, presented by Craig Wuest of LLNL, and Basic Science / Inertial Fusion Energy, presented by Richard Petrasso of MIT. There is also close coordination with the Joint Central Diagnostics Team, whose plan was presented by Allan Wootton of LLNL. The rapid and visible progress on the NIF facility and the initiation of serious technical planning activities for its use, bolster the feeling of enthusiasm and excitement on this challenging project.

The most advanced of the four NIF Use Plans is the NIF Ignition Plan being coordinated by Tom Bernat of LLNL. There is a steering committee representing all the ICF Labs: Tom Bernat of LLNL, Doug Wilson of LANL, Ray Leeper of SNL, Steve Obenschain of NRL, Wolf Seka of UR/LLE, and Ken Schultz of General Atomics. The plan is organized as a Work Breakdown Structure (WBS) with five major elements. The first four elements represent the physics challenges that must be addressed in order to achieve ignition with indirect drive targets in the NIF: Drive Energetics, Drive Symmetry, Shock Timing and Optimization, and Ignition Implosions. The fifth WBS element includes the tasks necessary to extend these activities to encompass ignition by direct drive in the NIF. Each WBS element is being planned in detail by literally dozens of scientists and engineers at the six ICF Laboratories, and the work planned will involve the coordinated effort of all six Labs. The Plan also includes experiments in all the Labs' facilities: NOVA, Omega, Nike, Z and Trident, as well as the expriments in the NIF itself. Each individual task within the WBS is being planned in some detail, including planned technical activities, personnel support needed, equipment costs, and supporting information such as facility requirements and target needs. The tasks are also being prioritized to provide the ICF Program Managers and the DOE with the information they need to effectively manage this large, complicated and important activity.

While the NIF Ignition Plan is still being developed, it is progressing nicely. Further, the plan will be a "living document," continuously being updated and improved as progress towards ignition in the NIF continues. The existence of the NIF Ignition Plan, developed by the ICF technical community, involving participation and responsibility of all six ICF Labs, and including cost, schedule, and priority information, bodes well for the ultimate success of the National Ignition Facility.

International Activites:

MAST - The Mega Amp Spherical Tokamak, Garry Voss, EURATOM/UKAEA Fusion Association, Culham Science Centre, Abingdon, Oxfordshire, U.K.

Theoretical studies in the 1970's and 1980's indicated that a tight aspect ratio tokamak should allow very high plasma beta (ratio of plasma to magnetic pressure). The aspect ratio (A) is the ratio of major to minor radii, and at very low values of A the plasma appears to be spherical. START (Small Tight Aspect Ratio Tokamak) was built at Culham in 1990 to investigate the tight aspect ratio concept and produced plasma currents up to 300 kA for pulse lengths of up to 40 msec at an aspect ratio down to 1.25. With the addition of a neutral beam injector loaned by the US DOE and ORNL, world record beta values were achieved. These and other very encouraging results led to the design and construction of MAST. The objectives of MAST are to explore the physics of the spherical tokamak in strongly heated sustained plasmas at MA current levels and with cross-sectional size comparable to existing medium-sized conventional aspect ratio tokamaks such as DIII-D (San Diego, U.S.A.) and ASDEX-Upgrade (Garching, Germany). MAST will thus provide both key information for the development of the spherical tokamak concept and important data (such as aspect ratio scaling) for the larger aspect ratio route. The MAST device and program have been designed to complement the similarly sized NSTX at Princeton (see June 1998 FED Newsletter). The main parameters (nominal) of START and MAST are shown in the table.

Parameter	START	MAST
Plasma current	260 kA	1-2 MA
Aspect ratio	≥ 1.25	≥ 1.3
Major radius	0.32 m	0.7 m
Minor radius	0.26 m	0.5 m
Elongation	≤ 3	≤ 2.5
Flat top pulse length	~40 msec.	≤ 5 sec
Additional heating power	≤ 1 MW	≤ 6.5 MW
TF Cu coils	Single turn	24 turns
TF rod current	≤ 500 kA	≤ 2.2 MA
Vessel diameter	2 m	4 m
Vessel height	2 m	4.4 m
Bakeout temp.	50 °C	200 °C
Solenoid flux swing	0.08 Vsec	1 Vsec

The main cylindrical stainless steel vessel not only provides the vacuum enclosure but also reacts the loads induced on the external toroidal field (TF) coils and the internal poloidal field (PF) coils. The vessel is stiffened by external webs which also serve to locate and support the 24 TF coil return limbs in 12 pairs. A 7 mm thick inconel tube provides a vacuum boundary around the center column and helps to support the end plates under vacuum and electromagnetic loads.

The five pairs of internal PF coils provide plasma shape and position control, correction of the solenoid fringing fields and form a divertor for plasma power and particle exhaust. Each coil is contained within a stainless steel can in order to maintain the high vacuum and is supported by internal structures designed to accommodate the differential thermal expansion arising during bakeout and to provide adjustment and flexibility to reposition the coil if required.

The design of the center rod and solenoid has been optimized to balance the stresses and thermal constraints in these two structures in order to achieve the low radial build required for operation at low aspect ratio. The center rod consists of 24 wedge shaped conductors formed by extrusion and subsequent drawing of silver bearing copper and each contains a single cooling water channel. Flared end sections containing a silver plated groove were then soldered to each end of the wedges. The conductors were individually wrapped with glass tape and assembled and aligned before being vacuum impregnated with epoxy resin to form a solid center rod. A novel slip plane was constructed onto the outer surface of the rod to allow strain isolation between the rod and the four layer solenoid. The solenoid was wound using half-hard high conductivity copper onto this slip plane and it was also vacuum impregnated with epoxy resin.

During a shot, the center rod expands axially by 2 mm and electromagnetic loads from the TF return limbs cause the center tube to extend by 1 mm. Also, during bakeout, a slow axial movement of up to 12 mm can be produced between the water cooled rod and the hot vessel. The movements are accommodated by the use of sliding joints to carry the 92 kA toroidal field current between the center rod and return limbs. These joints are based on a tongue and groove geometry with copper Feltmetal as the contact material. This consists of a felt of fine copper wires sintered to a copper foil which is silver plated. This gives a material which has a large number of contact points on one face while the other face can be soldered to the tongues at the ends of the return limbs. Stainless steel spring plates inserted between a pair of tongues provides the required contact pressure. Although this type of joint has previously been developed and demonstrated for use at cryogenic temperatures on the ALCATOR C-MOD machine at MIT. a further development program has been carried at Culham to optimize and demonstrate its suitability for MAST where the joints operate in air at up to 120 o C.

Additional heating comprises up to 5 MW of 70 keV deuterium beams provided by 2 injector systems on loan from Oak Ridge National Laboratory supplemented by up to 1.5 MW of 60 GHz ECRH heating.

Assembly of the machine is now complete and the vessel is under vacuum. Commissioning of the coil systems is currently in progress. For further information visit the MAST web site : www.fusion.org.uk/culham/mast.htm

This work is jointly funded by the U.K. Department of Trade and Industry and EURATOM. The loan of neutral beam injection equipment by Oak Ridge National Laboratory and the U.S. DOE and also advice from the ALCATOR Engineering group at MIT in connection with sliding joints are gratefully acknowledged.

International Fusion Research Activities of IAEA, Tom Dolan, Head Physics Section, IAEA, Vienna, Austria

The 17th IAEA Fusion Energy Conference was held October 19-24, 1998, in Yokohama, Japan. There were about 850 participants and observers, compared with about 600 at the previous conference in Montreal, Canada (1996). About 117 oral talks and 248 posters were presented. There were special oral and poster sessions on the ITER EDA, and a summary session in which the conference highlights were described. There were several new results of interest, including energy confinement times > 0.1 s measured in the Large Helical Device (LHD), which just began operation in Japan. The 18th IAEA Fusion Energy Conference will be held 4-10 October, 2000, in Sorrento, Italy.

The IAEA held the following Technical Committee Meetings in 1998:

* Fusion Power Plant Design (Culham, UK)

* Steady State Operation of Tokamaks (Hefei, China)

* Research Using Small Fusion Devices (Shonan Village, Japan)

* Spherical Tori (Tokyo University, Japan).

A research coordination meeting was held for the Coordinated Research Project (CRP) on "Engineering, Industrial and Environmental Applications of Plasma Physics and Fusion Technologies" (1996-1999), which involves twelve laboratories. The purpose of this CRP is to develop various applications and to promote international cooperation.

A new CRP on "Comparison of Compact Toroid Configurations" (1998-2002) will have its first meeting 14-17 December 1998 in Vienna, involving about 16 laboratories. The purpose of this CRP is to compare spherical tokamaks, spheromaks, field reversed configurations, and similar devices with regard to plasma stability and current sustainment.

The following IAEA meetings are planned for 1999:

(TCM = Technical Committee Meeting; RCM = Research Coordination Meeting)

Type	Title	Dates	Place	Scientific Secretary
IFRC	International Fusion Research Council	9-10 June 1999	Vienna	T. Dolan
TCM	First-Principle Based Transport Theory for Tokamaks	21-23 June 99	Kloster Seeon, Germany	T. Dolan
TCM	Data Acquisition and Management for Fusion	19-21 July 99	Lisbon, Portugal	U. Schneider
TCM	Energetic Particles in Magnetic Confinement Systems	Sep-99	Vienna?	U. Schneider
TCM	H-mode Physics	27-29 Sept. 99	Culham, U.K.	U. Schneider
RCM	Final Meeting on "Engineering, Industrial and Environmental Applications of Plasma Physics and Fusion Technology"	Fall 99	Vienna	U. Schneider
TCM	ECRH Physics and Technology for Fusion Devices	Oct. 99	Naka, Japan	T. Dolan
TCM	Research Using Small Fusion Devices	Oct. 99	Chengdu, China	U. Schneider
TCM	Steady State Operation of Tokamaks	Oct-Nov. 99	Kyushu, Japan	Dolan/Schneider

There are also some international activities organized by the International Energy Agency (OECD, Paris) which are not reported here.

Editor's Note

Starting in June 99, the FED newsletter will publish answers to questions posed by the readers. Iâll take your questions and seek out the answers from the authors of the articles, FED officers, and/or executive committee members. Please send or E-mail your questions to:

Dr. Laila A. El-Guebaly
Fusion Technology Institute
University of Wisconsin - Madison
1500 Engineering Drive - Rm 431
Madison, WI 53706 U.S.A.
E-mail: elguebaly@engr.wisc.edu

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