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International Fusion Energy Cooperation: ITER as a Case Study in Science and Diplomacy

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THE goal of developing a clean, limitless source of energy has long been an elusive pursuit for energy scientists. Yet it did not become an object of potential diplomatic endeavor until the end of the Cold War, when the diffusion of conflict made scientific partnerships and joint projects between the United States and the former Soviet Union conceivable. President Ronald Reagan sent the following message to Congress on March 22, 1982: "[I]t is becoming increasingly important that we all reach beyond our borders to form partnerships in research enterprises. There are areas of science, such as high energy physics and fusion research, where the cost of the next generation of facilities will be so high that international collaboration among…nations may become a necessity. We welcome opportunities to explore with other nations the sharing of the high costs of modern scientific facilities."

At the Geneva Superpower Summit in November 1985, following discussions with President François Mitterrand of France and Prime Minister Margaret Thatcher of the United Kingdom, General Secretary Mikhail Gorbachev of the

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former Soviet Union proposed to President Reagan an international project aimed at developing fusion energy for peaceful purposes. Upon his return from Geneva, President Reagan told the American people: "[A]s a potential way of dealing with the energy needs of the world of the future, we have…advocated international cooperation to explore the feasibility of developing fusion energy."

Immediately following the standoff over nuclear disarmament at the Reykjavik Summit in October 1986, a proposal to implement the concept of a fusion experimental research facility, to be known as ITER, was made. (ITER was originally an acronym for International Thermonuclear Experimental Reactor.) This led to the 1988 start of collective design efforts known as the ITER Conceptual Design Activities. Almost two decades later, the ITER Organization was established, with construction beginning in Cadarache, France, supported by seven international partners: China, the European Union, India, Japan, the Russian Federation, South Korea, and the United States.

The road towards the construction of ITER, and the establishment of the ITER Organization, the international organization charged with its construction and operation, makes a fascinating case study in the intersection of science and diplomacy for large-scale, capital-intensive international projects. This article is about the negotiations that took place between the conclusion of the Conceptual Design Activities and the final signing of the ITER Agreement in November 2006. It traces the key legal and political challenges confronted by the United States during those negotiations. Precedents and lessons are drawn for future negotiations to establish other large-scale international joint projects, whether in science or other fields.

The Dream of Fusion

Fusion has long been an important dream. The concrete vision that led to the ITER negotiations was to construct a large-scale magnetic confinement fusion research device that would generate energy by fusing hydrogen isotopes — deuterium and tritium — into helium and an energetic neutron in a "burning plasma," in much the same way that the sun generates its energy from fusing hydrogen into helium. The nominal success-criterion for ITER would be production of output fusion energy ten times the energy injected into the plasma. Successful operation of the test reactor could lead to larger ratios, perhaps as high as twenty, and a fusion power plant would have an operational ratio around thirty.

A practical fusion power plant would have inputs of the abundant elements deuterium (from water) and lithium. The process would start by fusion of deuterium and tritium hydrogen isotopes at very high temperatures, sufficient for overcoming the Coulomb barrier, to release helium and an energetic neutron. The latter would strike a "blanket," providing heat and transmuting lithium into helium and tritium. Tritium would be cycled back into the plasma for further fusion reactions. The heat of the blanket would be used to generate steam for generation

of electricity. The helium created in the various steps of the fusion process would be released and eventually escape the earth's gravity.

The Beginning of International Negotiations

While the vision was a powerfully unifying one, the road to an international agreement was relatively long and contentious, with difficult political moments in the relationship among the four founding parties, the former Soviet Union, the United States, the European Community (to become the European Union), and Japan. The first major obstacle came quickly: the initial ITER design (with a circular cross section for magnetic confinement as compared to the "D"-shaped cross section for ITER that leads to more stable operation) escalated significantly in cost to the point where the United States decided to discontinue involvement after six years, leaving during the Engineering Design Activity phase in July of 1998. (The United States would ultimately rejoin the effort in 2003.)

In addition to design and cost, there was no agreement on a legal and policy structure that would be appropriate for creating and sustaining an international facility and experiment. New approaches were needed for a form of agreement and organization that would allow partners with diverse political and legal systems to work together on a science experiment of this magnitude.

In the meantime, the United States' own scientific work on fusion continued through a legal mandate in 2001 to develop a burning plasma experiment. Domestic developments led the United States back in the direction of ITER. The House of Representatives passed the Securing America's Future Energy Act of 2001 on August 1, 2001, requiring that the Office of Science within the U.S. Department of Energy (DOE) take a number of actions to explore a burning plasma experiment.

The Office of Science commissioned a study in the fall of 2001 and a workshop in Snowmass, Colorado in the summer of 2002 "…for the critical scientific and technological examination of the proposed burning plasma experimental designs and to provide crucial community input and endorsement to the planning activities undertaken by the Fusion Energy Sciences Advisory Committee (FESAC)."[1] The Snowmass workshop proved to be the turning point for the U.S. fusion program, ending with a near-unanimous endorsement for moving ahead with burning plasmas and providing technical assessments of a range of facility design approaches. Later, a sub-panel of FESAC supported this perspective, using the technical assessments from Snowmass to develop its prioritization of approaches to burning plasma studies. The full FESAC unanimously supported entry of the United States into the ITER negotiations in September 2002.

The National Research Council of the U.S. National Academies addressed questions about the importance of a burning plasma experiment for fusion energy and the scientific and technical readiness to undertake such an experiment. The National Research Council endorsed the ITER effort as a necessary next step in the

U.S. fusion energy research program in a preliminary report issued in December 2002.[2]

These reviews informed President George W. Bush's decision to re-engage the United States in ITER talks. He announced on January 30, 2003:

"The results of ITER will advance the effort to produce clean, safe, renewable, and commercially available energy by the middle of this century. Commercialization of fusion has the potential to dramatically improve America's energy security while significantly reducing air pollution and emissions of greenhouse gases…. We welcome the opportunity to work with our [ITER] partners to make fusion energy a reality. The importance of ITER has also been recognized by the U.S. House and Senate, which are considering the Energy Bill containing language authorizing U.S. participation in ITER."

The three remaining ITER parties welcomed the renewed U.S. interest. By June 10, 2003, the U.S. Department of State granted approval for the United States to negotiate an agreement for ITER, with DOE as the lead negotiator. On June 18, 2003, the United States applied for admission to the ITER negotiations. That year, China and South Korea also expressed interest. (At the end of 2005, India joined, bringing the total number of ITER members to seven.)

Soon after the United States rejoined the international effort in 2003, another major obstacle appeared: a significant controversy emerged among the partners about where ITER would be built. In August and September, the United States conducted site visits to the three potential ITER sites proposed at the time: in France, Spain, and Japan. Soon thereafter the European Union chose the French site (Cadarache) over the Spanish site, reducing the choice to two possibilities. Through an extensive site review process, the United States chose the Japanese site of Rokkasho-mura for ITER as the one that best satisfied the needs of access, construction, and operation.

In December of that year, Energy Secretary Spencer Abraham hosted a Ministerial Meeting to take a collective decision on the ITER site. The meeting produced a deadlock with Russia, China, and the EU supporting the Cadarache, France site, while the United States, South Korea, and Japan supported the Rokkasho-mura, Japan site.

With the site issue unresolved, the parties nonetheless continued to negotiate the ITER Agreement. The United States hoped the EU and Japan could work out a solution to the site stalemate, with the commitment that the United States would support whichever site they agreed to. The key step forward was to change from an EU *vs*. Japan contest to a host *vs*. non-host competition, where concrete values could be placed on being either a host or a non-host. The discussions between the EU and Japan ultimately led to the so-called Broader Approach agreement. Under this agreement, Japan agreed to withdraw its bid to host ITER, and the EU agreed to procure a certain amount of ITER materials through Japan, support additional Japanese staff at ITER, and support the nomination of a qualified Japanese

candidate to be the first ITER Director-General. In June 2005, with the Broader Approach in place, the six parties agreed to the Japanese candidate for Director-General and to build ITER in Cadarache, France.

Key Legal and Political Hurdles to an Agreement

Financial Obligations, Liability, Withdrawal, and Dispute Settlement

With the formal entry of the United States, China, and South Korea in 2003 and the resolution of the site issue in 2005, the stage was set for productive negotiations concerning the remaining arrangements. Some issues such as the preamble, the purposes of the organization, the final clauses on amendments, and accession, were addressed relatively easily. However, one of the key legal and political issues was what form the parties' funding commitments would take. This was complicated by the significant uncertainty surrounding the total cost of ITER and the need to decide, as a political matter, how to apportion each party's share, considering the impossibility of coming up with precise cost figures that could be accounted for in multiple currencies for a project that would take years to construct and would operate for decades.

Additionally, while it is very difficult for any government to make firm legal pledges to fund an uncertain amount of money over many decades, it was necessary that each party have a high level of confidence that each of the other parties would remain committed financially. Furthermore, given the magnitude and unprecedented nature of the project, liability was a significant concern. To address these issues, the parties had long and difficult discussions about the nature of the withdrawal provisions and dispute settlement provisions. Not surprisingly, the host party (the EU), which naturally ran the biggest risk if others defaulted or if liability arose, pushed for far-reaching, clear, legally binding funding commitments in all of the following areas: fixed contributions; individual member liability for any liability of the organization not covered by existing resources plus insurance; withdrawal provisions that would require parties to maintain their full financial contributions notwithstanding withdrawal; and mandatory, legally binding dispute settlement provisions. Other parties preferred more flexibility in these areas, although individual positions differed on almost all points, with each party interested in formulations that were most acceptable and familiar to its domestic system.

The United States grappled with what form (treaty or executive agreement) an agreement of this type should take. Normally, agreements with fixed funding commitments that legally bind the United States cannot be concluded as executive agreements, i.e., international agreements that the executive branch undertakes independently, without congressional involvement. But treaties require the advice

and consent of two-thirds of the Senate and that has proven a fatal hurdle to dozens of agreements and indefinitely postponed the United States' ability to join many more (e.g., the Vienna Convention on the Law of Treaties submitted to the Senate in 1971, the Convention Against all Forms of Discrimination Against Women submitted in 1980, and the American Convention on Human Rights submitted in 1978). U.S. negotiators thus initially sought to negotiate funding commitments that would include the explicit caveat "subject to the availability of appropriated funds," though they recognized that such a caveat posed a threat to the stability that all desired, including the United States itself.

As noted above, the EU called for very clear, legally binding funding commitments; they urged the United States to pursue a treaty if needed. However, the U.S. delegation remained concerned that a treaty could take years to get approved. The United States also considered the EU's proposed liability, withdrawal, and dispute settlement provisions unacceptable. If the agreement contained the provisions on those topics proposed by the EU and needed to be submitted to the Senate for advice and consent, it would likely be rejected as entailing too much risk and too little ability to meaningfully withdraw.

A breakthrough came in 2005 when, as part of a broader package of energy legislation known as the Energy Policy Act, Congress explicitly authorized U.S. participation in ITER in accordance with certain requirements. Also, in this act's Section 972, it specified that no federal funds could be expended on ITER until the final agreement was submitted to Congress and 120 days elapsed thereafter. This latter provision, coupled with the specific provisions authorizing U.S. participation in the agreement, meant that the agreement would now be concluded as a congressional-executive agreement. Congress would now review the agreement whether or not it was submitted to the Senate for advice and consent. If Congress did not object and instead funded participation, it would amount to an implicit congressional blessing. The congressional authorization provided the U.S. negotiators with additional flexibility. The United States was now willing and able to drop its insistence that the financial obligations portion of the agreement be explicitly made "subject to the availability of appropriated funds," providing compromises could be worked out on other, related issues. The United States still, however, opposed the strong formulations the EU favored for withdrawal, liability, and dispute settlement and insisted that alternatives be negotiated.

Ultimately, this entire set of issues was handled as a package, and a compromise was reached. The agreement would contain a formulation describing the commitments that would not have caveats based on the availability of funding. Rather than providing that the members "shall" make certain contributions, however, it provided that the resources of the organization "shall be" as referred to in separate documents laying out financial contributions and in-kind contributions. The document laying out financial contributions provided estimates for the costs associated with different phases and the assigned percentage shares of those

estimates to each of the parties. The agreement further provided that these amounts (and in-kind contributions) could be updated in the future by unanimous consent of the ITER Council. Given this unusual formulation (commitments to separate documents outside the agreement), the estimates contained in those documents, and the ability to change them over time, lawyers may debate whether or not the agreement contains firm, legally binding financial obligations. In any event, the parties all undertook the commitments in the separate documents in good faith, relying on others to abide by them.

The compromise for the withdrawal provision provided that parties other than the host party could withdraw after a period of ten years (i.e., the anticipated construction period) and that in any case withdrawal would not affect the withdrawing party's agreed share of the construction costs. Furthermore, if withdrawal took place during the operational phase, a party would contribute its agreed share of the cost of decommissioning the ITER facilities. Thus, withdrawal would have zero impact on constructions contributions financially, but the party would not be responsible for its full financial contributions, as the EU originally wished.

The liability article specified, as the United States wished, that "Membership in the ITER Organization shall not result in liability for Members for acts, omissions, or obligations of the ITER Organization." As a compromise with the EU, however, all parties were ultimately able to agree that the article would also specify that should compensation costs for damages arising from non-contractual liability exceed the amounts available to the organization in the annual budget for operations and/or insurance, the members "shall consult, through the Council, so that the ITER Organization can compensate…by seeking to increase the overall budget by unanimous decision of the Council in accordance with Article 6(8)." Thus there is an obligation to consult and to seek to reach agreement to raise additional funds, but not a commitment in advance to undefined liability amounts.

Finally, with respect to dispute settlement, the United States kept out legally binding dispute settlement (in part because it entailed uncertain legal results that Congress would likely find objectionable), but all agreed that any party could request mediation and that, in such a case, a mediation meeting would be convened within thirty days. Furthermore, the agreement specifies that the parties may of course submit the dispute to any other agreed form of dispute settlement, i.e., there can be legally binding dispute settlement to which both parties explicitly agree.

The Voting Structure

The ITER Agreement provides that the council will have a wide range of responsibilities, including final approval of the staff and any changes to the overall cost sharing. There were early debates about whether these matters all needed to

be decided by consensus or could be voted and, if they could be voted, whether or not votes would be weighted by contribution. In December 2005, after many difficult negotiating sessions, the United States suggested that heads of delegations and a lawyer work out the voting issue. The resulting agreement was to weight the votes by contribution and designate certain matters for decision by the council as ones that would require unanimity. In addition, the parties agreed that consensus would always be sought and, where there was a need to resort to voting, no decision could be taken if either the majority of members (four out of seven) or members providing over fifty percent of the contributions were against. These issues were finally agreed to at a "sidebar" meeting of heads of delegation in February 2006.

Privileges and Immunities

Another issue for the United States related to the provision of privileges and immunities for the organization and its staff. The basic dilemma that, while the parties were all ready to include fairly standard language in the agreement about the organization and its staff having privileges and immunities appropriate to their functions, some parties wanted to spell out, in a separate side agreement, specific privileges and immunities that were different from those that some other parties thought appropriate. Specifically, it quickly became clear for U.S. negotiators that most parties were prepared to convey privileges and immunities to the staff of the organization that went beyond what the United States would be able to provide by simple designation of the ITER Organization as an international organization for purposes of the U.S. International Organizations Immunities Act (IOIA).

Over many months, the United States attempted to negotiate provisions in a side agreement that were either consistent with the authorities in the IOIA or that provided for separate treatment for the United States. In the end it was impossible for the other parties to accept either an agreement that was fully capable of being implemented consistent with existing U.S. law, or provisions detailing separate obligations for the United States. Fortunately, at the eleventh hour, the positive political will in senior levels of each of the parties and the shared desire to reach an agreement prevailed. The negotiators were essentially instructed to make it work. This led to a softening of the issue of separate treatment: rather than provide for provisions specifically addressing the United States in the agreement, the other parties would conclude the agreement on privileges and immunities without any mention of the United States. The United States, for its part, would specify in a separate political declaration that it would implement the privileges and immunities in the ITER Agreement consistent with the IOIA.

Innovative Solutions, Remaining Challenges

Innovative solutions were found to some of the agreement's most contentious challenges. By placing financial commitments in a separate document, and providing that the council could adjust them by consensus over time, the negotiators facilitated an agreement. They found the right balance between stability for members and the organization concerning withdrawal, liability, and dispute settlement. Additional solutions provided flexibility for members whose governments were likely to balk at open-ended, uncertain commitments, or commitments from which one could never withdraw. For the United States, the ability to conclude the agreement consistent with U.S. law (including the IOIA) without entering into any open-ended, uncertain financial or other liabilities—in combination with the provisions in the Energy Policy Act of 2005—provided the avenue necessary to reconcile the U.S. positions with the other parties and conclude the agreement. Conclusion of the ITER Agreement as a congressional-executive agreement is an important precedent for similar future projects.

The ITER Agreement was initialed by the heads of delegation in Brussels on May 24, 2006, with the final signing by all seven parties taking place in the Élysée Palace in Paris on November 21, 2006. On November 19, 2007, President Bush signed the Executive Order designating the ITER International Fusion Energy Organization a Public International Organization, allowing the United States to implement the privileges and immunities commitments undertaken during the negotiations.

One could have presumed the hard work was over. Alas, implementation of the agreement has not been without early challenges. For example, the initial selection of the key staff of the organization was made partly along political lines, with each member party submitting nominees for its assigned Deputy Director-General position to the ITER Organization leadership for their decision. Unfortunately, some members nominated only a single candidate, obviating any choice for the ITER Organization. There have since been questions about the competency of certain staff to carry out their assignments.

Further, there have been construction delays leading to very significant cost re-estimates. It was assumed that the ITER design was eighty percent completed before the organization was established. However, it was subsequently re-estimated to be closer to forty percent complete.[3] This led to the need for extensive redesign, delaying the ITER construction phase. As is understood widely in project management circles, delay means cost increases. The U.S. contribution (9.09 percent of the total ITER construction cost) was initially estimated to be $1.12 billion, but reexamination in the light of construction delay and uncertainty in design led to a revised estimate of $2.2 billion, which includes escalation and contingency estimates.

The international community must address and agree on common project management standards if there are to be future scientific instruments on the scale

of ITER or larger. The DOE's Office of Science, through its project management office, anticipated this issue by bringing together representatives from around the world to see if a global project management understanding could be crafted. In February 2005, the head of the project management office, Dan Lehman, convened a meeting of his counterparts from thirteen countries or international entities to compare cost elements for large-scale scientific construction projects. The meeting highlighted the difficulties associated with comparing construction costs among international partners because different countries or international entities often include different cost elements in estimating construction costs. For example, Australia, Belgium, France, the United Kingdom, and the United States include contingency and escalation (inflation) in cost estimates (Germany includes only escalation), while Canada, the European Commission, EURATOM, South Korea, Japan, and the Netherlands do not. These differences affect ITER because the European Union, Japan, and South Korea do not include contingency and escalation in their cost estimates, while the United States does. So when there is a schedule-slip or a design change, the parties have different estimates with regard to cost increases. Failure to recognize the basis for these differences by governments has led to ITER Council conflicts that are simply based on differing approaches to cost estimation. Diplomatic success will depend upon a "Rosetta Stone" for global project management, enabling every party to understand the actual costs of large-scale construction (Supplementary Table online).

Conclusion

A number of important "lessons learned" emerge from this recounting. One is common to most complex international agreement negotiations, but becomes even more important in the context of large-scale projects. Negotiators must expect the unexpected and maintain a flexible spirit and political goodwill when difficulties and mistrust arise. Without political will, trust, and flexibility, international agreements of this complexity and importance cannot be achieved. For example, if the other parties had insisted on provisions that would have required the United States to pursue a treaty domestically, there's a great likelihood that the treaty would still be sitting before the Senate awaiting advice and consent, and that the United States would not be at the table in Cadarache today. If the parties had insisted on uniform privileges and immunities provisions for all parties, rather than allowing the United States to implement the obligations consistent with existing law in the form of the International Organizations Immunities Act, the agreement would also have been much more difficult for the United States to achieve domestically. In general, participants in international project negotiations should expect that there will be significant cultural and other divides that will occasionally present seemingly insurmountable challenges that give rise to mistrust and "negotiation-

fatigue." Strong political will is the key to carrying on successfully in the face of these difficulties and achieving collective agreement.

Another more operational but no less important lesson for large-scale project endeavors is that, in addition to establishing sound construction cost estimates, cost containment *during* construction is crucial to keep projects on time and on budget. Construction delays always lead to cost increases. The vehicle for monitoring construction costs and schedules is as important as knowledge of the cost elements themselves. It is in this area that the greatest danger lies. Without an international standard for project management, unnecessary conflicts will arise based not on different priorities, but on the inability to understand each other's approach to cost containment. These issues—including agreement on a common international standard for project management—should be addressed in order to help ensure that future large-scale international scientific projects can be successful. SD

Endnotes

1. 2002 Fusion Summer Study Report, June 2003 (The Snowmass Workshop full report): Conference report on "Major Next Steps in Fusion," Snowmass, CO, July 8-19, 2002. http://fire.pppl.gov/snowmass02_report.pdf.
2. The National Research Council Burning Plasma Assessment Committee, interim report, December 2002. http://fire.pppl.gov/nrc02_int_rpt_122002.pdf.
3. N. Holtkamp, "The Status of the ITER Design." *Fusion Engineering and Design* 84, No. 2-6 (2009): 98-105.

Supplementary Materials

Table of Cost Elements Included in Large Scientific Project Construction Cost Estimates.
http://www.sciencediplomacy.org/cost-elements

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