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International Scientific Cooperation

ITER - A Case of Study

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Abstract

In a world struggling with economic depression, pollution, global warming, over population and looking for a reliable and unlimited source of energy, science and scientific knowledge needs to be at the centre of every state policy. The focus of this work is not strictly on international law, but more in general on why and how international scientific projects are created and to find the best ways for politician, diplomats and non- scientists in general to provide researchers and scientists with tools and opportunity to do their job the best way possible.

In the first part I will describe the current state of “World Science” and how cooperation in science has developed, the problems it has encountered and possible solutions to these problems. I will describe one of the first international cooperation projects, the Manhattan Project, and then move on to more recent examples to describe the evolution of scientific cooperation in more recent times as well as underlining its importance, not only for scientific purposes, but also as a way to bring nations closer, thus offering a chance to improve relations and open possibilities for other type of agreements and cooperation opportunities. I will take into consideration the role of science in international diplomacy for both major and small nations and how they can use it to its most effectiveness.

I will then move on to describe modern international cooperation projects, especially the ISS, being the most expensive international project ever started, and ITER, probably the world´s best chance at finding a reliable and durable solution to the energy problem.

The ISS offers an interesting case of study as space cooperation could, in my opinion, be one of the key area where international cooperation can be

used most effectively. At the same time it provides a chance to build a framework which could then be used in other projects and scientific areas.

Another important point I will take into consideration is the evolution of cooperation in science within the European Union. What the EU is trying to accomplish both on a political level, with the European Union, and on the scientific level, with the European Research Area and the Framework Programmes, is of the uttermost importance, not only because it would unite a group of countries which have been at wars since the beginning of history, but because it could be the stepping stone in showing that grudges and past conflicts can be overcome for the greater good. Applying the project and framework the EU is using for ERA and Framework Programmes to other part of the world could be the first step in creating international scientific networks of nations, which would have the effect of reducing the number of parties joining international projects, thus improving coordination and simplifying governance.

In the last part I will take ITER as a case of study. I will concentrate on the creation of the project, thus analyzing the path that led to the signing of the agreement and the creation of the Domestic Agencies and the ITER Organisation. I will then focus on analyzing the reasons behind the problems the project has, from governance difficulties to funding issues, from agreements laws quandaries to design setbacks. I will try to provide possible solutions for most of these problems, to be applied both for the ITER project itself as well as for all future international scientific cooperation projects.

1.0 - History of International Scientific Cooperation

"*Fortunately science, like that nature to which it belongs, is neither limited by time nor by space. It belongs to the world, and is of no country and of no age. The more we know, the more we feel our ignorance; the more we feel how much remains unknown; and in philosophy, the sentiment of the Macedonian hero can never apply, — there are always new worlds to conquer.*"

Sir Humphry Davy, discourse delivered at the Royal Society (30 November 1825).

The foundations for the European scientific renaissance go beyond the 17th century England; they were created by scientists and scholar from all around the word. Algebra was introduced by a 9th-century Baghdad scholar, Musa al-Khwarizmi, following study of Indian number systems developed by Aryabhatta. China, in the same century, saw the first reference in a Taoist text to 'fire medicine', or gunpowder; Mesoamerican and Egyptian agriculturalists would read the stars to know when to cultivate their crops. With the rise of early scientific societies in the 17th century, scientific knowledge became more and more interconnected, linking researchers from Europe and beyond through travels, correspondence, and publications. For instance, when Henry Oldenburg edited the world's first scientific publication in 1665 it enjoyed a wide international readership and drew on ideas from Italy, Hungary and the Bermuda, amongst other regions (Royal Society 2011).

In recent time the importance and opportunities a globalized science can offer have become more and more clear and needed. In a world struggling with economic depression, pollution, global warming, overpopulation and looking for a source of energy capable of supporting the current needs, science and scientific knowledge is, will and need to be at the centre of every state policy. Scientific knowledge has improved many aspect of our lives; life expectancy has increased strikingly in the last 2 centuries, agricultural output has risen to meet the needs of an constantly increasingly population, new technology and energy sources have freed humanity of the most arduous labours. Internet and new communication technologies as well as computation and information handling, have allowed worldwide communication possibilities and unprecedented opportunities for scientific advances.

There are different reasons for cooperation; cooperation can enhance the impact of research and bring together a diversity of experience. Sometimes is a necessity in order to access funds, resources and data, and to ally with the most talented researchers.

The importance of science in the modern world goes beyond pure research objectives. Science is a common language, and its political neutrality has always been a mantra of the scientific community. This peculiarity has been used by scientists and governments to advance political commitment among nations, which is diplomacy through science.

Science diplomacy is the way to go if we want to find the solution to the problems afflicting our world and it is probably also the best solution with the potential to strengthen and improve relations between countries around the world, promote goodwill and advance the frontiers of knowledge. Science diplomacy can help spread the principles of science to governance, but in order to do this, governments need to improve the tools to allow this to be effective.

In the last 2 centuries science has become increasingly interconnected; as of today, less than 26% of papers are produced by only one institution and over 35% have authors from multiple nationalities (more details can be found in Chapter 3.0).

Science diplomacy means using scientific cooperation among nations to address common problems together, joining knowledge, expertise and funds. Diplomacy through science has been used for a long time by many countries around the world. One of the first example dates back to the 1931, with the creation of an international non-governmental organization, the International Council for Science (ICSU). This organization has as its main objective the international cooperation in the advancement of science, mobilizing resources and knowledge to develop scientific solutions to solve world most difficult challenges.

Another example of the early stages of international cooperation is the Manhattan projects; the United States were able to bring together scientists from different countries, resources and tools in order to develop something that put an end to WWII.

Even during the Cold War, an era marked by the Cuban Missile Crisis, proxy wars and the fear of a mutual assured destruction, science had played a significant role in keeping lines of communication open. People from both sides looked for ways to bridge differences and increase the chances for peace and resolution. In a 1985 address to the nation, days before meeting with Soviet leader Mikhail Gorbachev for the first time, President Ronald Reagan stated “We can find, as yet undiscovered, avenues where American and Soviet citizens can cooperate fruitfully for the benefit of mankind. In science and technology, we could launch new joint space ventures and establish joint medical research projects.”

Even though the scientific link established between USA and URSS may be the most well-known historical case of science diplomacy, it was just one of the many that started developing after the Second World War

Science played an important role in establishing interaction between states that would have not been possible otherwise. At a White House state dinner for Japanese Prime Minister Hayato Ikeda in 1961, President John Kennedy made U.S. diplomatic history by announcing the U.S.-Japan Committee on Science Cooperation, the first of its kind. This was done to repair "the broken dialog" between the two countries.

In 1972, year of Nixon's historic visit to China, they included science as one of the main areas for future cooperation; Today, U.S. science and technology (S&T) collaboration with China is one of America's largest cooperative programs, and productive relationships exist across multiple disciplines. While for many Americans today, China is seen more as a competitor than a partner in applying science to solve the broad challenges facing the world; the reality is that science cooperation has provided great benefits to both countries in areas ranging from climate change and environment to energy and food security, among others.

This way of interaction, which often involves non-governmental scientists and especially NGOs, has proven very important to establish connection to countries like Iran, Burma, North Korea; countries where the direct government-to-government relation would be hampered by political issues.

More recent examples show that the intersection between diplomacy and science goes well beyond the building of relationships between two countries and means more than just meeting some foreign policy objectives.

International cooperation has a wide range of possible modalities for collaboration, such as researcher exchanges, fellowships, cooperative projects, meetings, sharing access and costs of scientific instruments or facilities, participations in national programs, sponsorships, global scientific projects, exchange of experimental materials and exchanges of results of experiments and tests.

Big international scientific projects concerning world´s global problems, like global health programs, space research, experimental energy research like ITER, climate change studies, global security, pandemics and protection of natural resources require assistance and close interaction among scientists, organizations and countries from all around the world have seen a grow of interest in recent years. This being said, international scientific cooperation among industrialized countries is still dominated by informal cooperation between scientists, while cooperation with less-developed countries is more frequently managed through formal agreements and frameworks.

One of the most interesting points about international scientific programs is that they provide a systematic framework for supporting projects, in addition to the types of collaboration already in place. They allow closer and formal form of collaboration which can improve the work of scientists.

What the world could accomplish if it manages to work as one might be the only way to secure future generations a better future.

1.1 - Manhattan Project

'I am become Death, the shatterer of worlds'

- Bhagavad Gita (uttered by Robert Oppenheimer upon seeing the first ever nuclear mushroom cloud)

This quotation, taken from Robert Jungk's book on the Manhattan Project, exemplifies the feeling of the so called “father of the atomic bomb”, just after witnessing the results of what he and his colleagues worked so hard to achieve. The Manhattan Project was to become the largest secret project ever undertaken by the U.S. government, and the first project of this dimension that has involved scientists from numerous different countries, making it probably the first real international scientific project in history.

This chapter does not want to give a full and precise history of creation of the bomb; there are enough well written books about it. What I want to focus on is, first of all, the size and type of the projects and the scientists who work in it as well as the secrecy that surrounded the project till after the end of the war.

The creation of the Manhattan Project can be drove back to the warning letter, wrote to U.S. President Franklin D. Roosevelt by physicists Leó Szilárd and Eugene Wigner and signed by Albert Einstein (due to his higher status as scientists in the U.S. in 1939), about the potential development of an "extremely powerful bombs of a new type" by the German. The letter urged the President to take steps in fission and uranium research. The letter, written by the scientists, eventually managed to convince the U.S. government, which probably already saw the potential of such a powerful weapon, but it was not an easy task, until Roosevelt signed the Executive Order 8807, which created the Office of Scientific Research and Development (OSRD) to implement uranium and fission research.

Before the end of June 1940, there was no hope of obtaining any funding for an atomic project. But after the reports on the progress of atomic research in Britain, the American government became more and more interest in the project. Edward Teller, one of the most important scientists who worked at the projects, described the early days of the project as:

"'There is no mention of the futile efforts of the scientists in 1939 to awaken the interest of the military authorities in the atomic bomb. The reader does not learn about the dismay of scientists faced with the necessity of planned research. He does not find out about the indignation of engineers asked to believe in the theory and on such an airy basis to construct a plant."Szilard had the same opinion; in fact he believed that the project was delayed for at least one year by the shortcomings of the authorities and politics. [1]

Roosevelt proceeded to approve an atomic program on October 1941, and made contact with Prime Minister Winston Churchill, suggesting that they correspond on atomic matters. At the beginning the project was developed in different part of the U.S., Canada and UK, but, in 1942, Roosevelt and Churchill agreed to concentrate the work on the atom bomb in the US. Control of the project was transferred to a Military Policy Committee, formed by General Styer, Admiral Purnell, and General Leslie Groves, and only two professional investigators, Dr Vannevar Bush and Dr James Conant. On August of the same year the project was renamed "Development of substitute materials" or Manhattan Project (the Manhattan Project started in an office building in Manhattan, New York).

[1]Jungk, Robert, "Brighter Than a Thousand Suns: A Personal History of Atomic Scientists", Mariner Books, 1970pag 90

It was Oppenheimer which came to the conclusion that if the bomb was to be constructed and tested before the Germans (they still did not know that the Germans were not even close in developing an atom bomb; it was first discovered after the Alsos mission and after listening to the conversations of the best German scientists held in Farm Hall), there was a need to concentrate the effort and allows the scientists to work closer together. This would have the advantage to avoid duplication of proceedings. In addition to that, the creation of a place where theoretical and experimental physicists, mathematician, armament experts, engineers, biologists, specialists in radium chemistry and metallurgy and other technician could work together and exchange ideas about problem more that often interconnected was seen as be the best way to go. It was the 25 November 1942 when the Assistant Secretary of War, John McCloy, ordered the acquisition of Los Alamos where soon after began the construction of what would become the "centre of excellence" for the development of atom technology and at the end of the atom bomb.

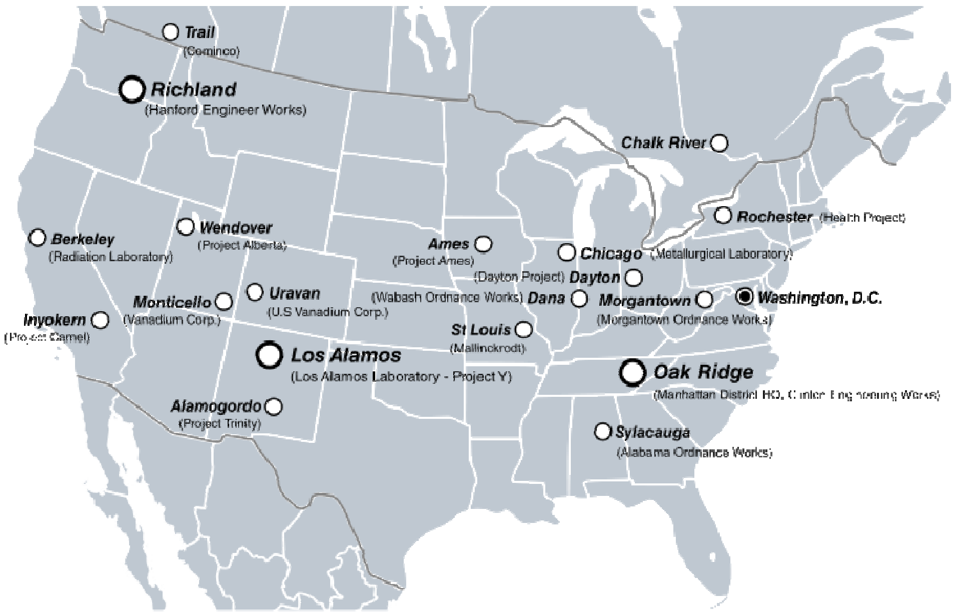

Fig.1 ***A selection of US and Canadian sites important to the Manhattan Project.***[2]

[2] http://en.wikipedia.org/wiki/File:Manhattan_Project_US_Canada_Map_2.svg

Even though after the 1942 Los Alamos became the most important centre for research, the Manhattan Project network of infrastructure was far more extensive.

As we can see in Fig.1, in the end the Manhattan Project included over 30 different research and production sites (there was a metallurgical Laboratory in the University of Chicago, the Headquarter were in Washington D.C. and so on) with the three most important locations being:

- Hanford, Washington, was the home to the B Reactor, the first full-scale plutonium production reactor in the world.
- Oak Ridge, Tennessee, where K-25, S-50, and Y-12 plants were built to separate the fissile isotope uranium-235 from natural uranium, which consists almost entirely of the isotope uranium-238.
- Los Alamos, New Mexico, which was the centre for the actual construction of the first atom bomb and were most of the scientists involved went to live after the 1942

Note that all these sites eventually became top research centres after the end of the war, and are still operating today.

In addition to giving the possibility for scientists to work together on the project from the same place, gathering most of the personnel in one place was also a security measure. Security measures were one of the most important factors during the bomb development.

The first efforts to establish a security perimeter around the atomic research projects occurred in 1939 when the scientists themselves attempted to institute a voluntary censorship on publications concerning uranium fission research. In 1942 things changed, as the Army took over security for the projects. This decision was taken due to the program rapid expansions which were involving tens of thousands of worker, scientists and engineers as well as firms and construction companies.

The nature of the Manhattan Project made it vulnerable to espionage and sabotage. The recruitment of so many individuals from different part of the U.S. and the world, no matter how efficient its clearance procedures where, made it a high risk job for the Army to keep it secret.

In addition to the thorough scrutiny all personnel were subject to, the army tried to erect invisible walls round each branch and department, so that no department anywhere knew what any other was doing. This so called compartmentalization was so tight that out of the 150.000 person who eventually worked for the project no more than a dozen were allowed an over-all view of the plan. Even though this compartmentalization proved to be highly efficient (no information ever reached the Germans, and the Russians were only told by Fuchs, a spy scientist working at Los Alamos), it was of great hindrance on the scientific level. This made most of the scientists to only pretend to observe the compartmentalization. After the war Szilard gave the following account of the matter to a committee of Congress: [3]

"These kinds of rules could not be obeyed if you wanted to obey them. But we did not want to obey them because we had to choose between obeying these rules and sabotaging or slowing down our work, and we used common sense in place of obeying rules. Hardly a week passed that somebody did not come to my office at Chicago from somewhere, wanting to convey a piece of information to which I was not entitled. They usually did not ask me to conceal the fact that I came into possession of this

[3]Jungk, Robert, "Brighter Than a Thousand Suns: A Personal History of Atomic Scientists", Mariner Books, 1970 pag.97

information. All they asked was that I conceal from the Army the fact that they were the persons who had given it to me."

Szilard had been the first, in former days, to advocate that secrecy - of course only to a reasonable extent- should be maintained about scientific data.

In addition to this, every person directly involved in the project could only receive or write correspondence through a thorough censorship commission. The most prominent scientists were provided with bodyguards. Special care was taken in observing those who were not regarded, for one of the other reason, as 100% reliable; especially during the early days of the projects scientists of European origin, even though they were the ones who devoted themselves with the greatest determination to the project, were often saw as "alien enemies" and covered in mistrusts. But it did not stop to that; in fact even Robert Oppenheimer, born and raised in the US, director of Los Alamos National Laboratory and General Advisory Committee of the Atomic Energy Commission (AEC), suffered a thorough investigation that led to the loss of the scientist's security clearance. This was due to the several Communist acquaintances dating back to 1930s as well as his opposition to the development of the hydrogen bomb. The McCarthy era anti-Communist drive and its inquisition to get rid of the "subversives", who had supposedly infiltrated the government, exacerbated the situation. In 1953 "Oppenheimer was accused of having associated with Communists in the past, of delaying the naming of Soviet agents, and of opposing the building of the hydrogen bomb". [4] In the end the Oppenheimer was found not guilty of treason, but his clearance was revoked due to "fundamental defects of character", and Communist associations "far beyond the tolerable limits of prudence and self-restraint

[4]American Physical Society, June 29, 1954: Oppenheimer's Security Clearance Revoked, June 2001 (Volume 10, number 6)

which are to be expected of one holding the high positions" he had held since 1942. [5]

Microphones were concealed in offices and homes, and everybody was told to keep silence about any details of the project, even with their closest relatives. The scientists and families drivers' licenses listed only numbers, not names. Photographs could not include anything that might identify the landscape of New Mexico. Counter intelligence activities were one of the most important responses to provide the secrecy needed by the project. The project remained classified for many years. In fact, it was so secret that Harry S. Truman, although vice president of the United States, was not made aware of its existence until after the death of Roosevelt in 1945. [6]

This compartmentalization, even though it was considered necessary to prevent information about the project to reach the public and therefore the enemies, hindered the development of the bomb; in fact the ignorance about the actual activities of the project prevented personnel to be genuinely interested in their work. When future Nobel Prize winner in physics Richard Feynman managed to obtain permission to tell certain people what was really going on and why what they were doing was so important, their work reached considerably higher standards. In fact, one of the strength of the project at the time was to have been able to create harmony and a deep sense of purpose. Men and women formed an international community with a sense for a common goal which was what made the project so successful; and this happened despite the harsh working condition, the secrecy, all the problems and the short time at disposal.

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[5] American Physical Society, June 29, 1954: Oppenheimer's Security Clearance Revoked, June 2001 (Volume 10, number 6)

[6] The Manhattan Project, United States History, http://www.u-s-history.com/pages/h1644.html

Even when it was clear that the Germans were not close to creating a bomb, scientists kept working hard on the project. As Jungk points out, the driving force was that:[7]

"If we don't now develop this weapon and demonstrate to the world, by public experiment, its appalling nature, sooner or later some other unscrupulous power will attempt, unobtrusively and in all secrecy, to manufacture it. It will be better for the future peace of the world if humanity at least knows where it stands."

Such was the attitude, for instance, of Niels Bohr in the confidential discussions which arose. But an even stronger argument for justifying further research went as follows:

"Humanity needs the new source of power which we have discovered and developed. All we have to do is to take care that in future it shall be used for peaceful purposes instead of for destruction."

What was really amazing about the project was the number of scientists and personnel involved and their nationalities. Even if it does not seem so by looking at the latest international projects like ITER, the ISS and similar, the Manhattan Project started and took place during one of the most difficult time in the history of the world, during the most cruel and disruptive war earth has ever seen; a time when mistrusts and hate for "enemy" nations were at its highest. Yet, if we consider the most important scientists who participated to the project we can see people from all over the world working together for a common goal.

It proves instructive to list a small number of scientists and technical personnel out of the tens of thousands who took part in the projects.

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[7]Jungk, Robert, "Brighter Than a Thousand Suns: A Personal History of Atomic Scientists", Mariner Books, 1970 pag 137

The core was of course formed by American researchers and scientists, coming from all top universities in the US.

Frank Biondi was an engineer who worked on a technique to separate Uranium 235; Arthur Compton, Nobel Prize in physics in 1927, who worked in the metallurgic department for the production of nuclear reactors to convert uranium into plutonium; Paul Emmet, chemists, who worked on the separation of U-235 from U-238; Richard Feunman, Nobel Prize in Physics in 1965, who worked on the theoretical section of the project; Ernest Lawrence, Nobel Prize in physics in 1939, who also worked to find a solution for the problem of separating U-235; Edwin McMillan, Nobel Prize in chemistry in 1951, who worked on implosions research; Philip Morrison, who worked as part of the scientists group who managed the project and later worked for SETI; Frank Oppenheimer, who conducted research on aspects of nuclear physics and uranium enrichment; Robert Oppenheimer the so called "father of the atomic bomb"; Glenn Seaborg, Nobel Prize in chemistry in 1951, who worked on plutonium extraction; Harold Clayton Urey, Nobel Prize in chemistry in 1934, who worked in uranium enrichment; John Hasbrouck van Vleck, Nobel Prize in physics in 1977, who confirmed the feasibility of the atom bomb.

But other scientists were working together with these and other American scientists: Luis Alvarez, Spanish, Nobel Prize for physics in 1968, who worked on the construction of detonators for the atomic bomb, Hans Albrecht Bethe, German, Nobel Prize for physics in 1967, who worked as part of the scientists group who managed the project; Felix Bloch, Swiss, Nobel Prize for physics in 1952; James Chadwick, British, Nobel Prize for physics in 1935; Enrico Fermi, Italian, Nobel Prize for physics in 1938, one of the most important scientists in the project; Otto Frisch, Austrian, who worked on the device used to make the bomb explode; Wu Jianxiong, Chinese, who to develop the process for separating uranium metal into the U-235 and U-238 isotopes by gaseous diffusion and known as the "First Lady of Physics" or the "Chinese Marie Curie"; Bruno Rossi, Italian, who headed the group at the Los Alamos Laboratory that carried out the RaLa Experiments; Mario Salvadori, Italian, a structural engineer; Emilio Segre, Italian, Nobel Prize for physics in 1959, who helped discover the element astatine and the isotope plutonium-239, which was later used to make the Fat man atomic bomb dropped on Nagasaki, as well as working at the Los Alamos National Laboratory as a group leader; Louis Slotin, Canadian, who died after accidentally beginning a fission reaction; Leo Szilard, Hungarian, who conceived the nuclear chain reaction in 1933, patented the idea of a nuclear reactor with Enrico Fermi, and in late 1939 wrote the letter that resulted in the Manhattan Project; Stanislaw Ulam, Polish, mathematician; John von Neumann, Hungarian, a pure and applied mathematician and polymath; Victor Weisskopf, Austrian, Group Leader of the Theoretical Division of the Manhattan Project at Los Alamos; Eugene Wigner, Hungarian, Nobel Prize in Physics in 1963, who led a team to design the production nuclear reactors that would convert uranium into weapons grade plutonium.

These were just a tiny part of the 125,000 or so employees at its peak.

All things considered, the Manhattan Project was one of the greatest successful stories in modern science and technology history. What those men achieved in just a couple of year, in spite of all odds, is a truly remarkable achievement. It should then not come as a surprise recent (i.e. during last 20 years) trend of “invoking” the creation of a new Manhattan Project for every problem affecting mankind. This means rounding up all the scientists and expert on a specific subject or matter, give them unlimited resource and expect results in a few years. While reasonable, some controversial issues should be accounted for. History should teach us about the past, so that we could at least try to avoid making the same mistakes or finding better solutions for the future. And there were a number of things that went wrong in the Manhattan project.

First of all the “overriding factor” or policy which permeated the project was secrecy. This meant that not only there were no public calls for such a project, but both the public and the Congress were purposefully excluded from the secret which meant that they were taken out of special discretionary funds that Roosevelt had at his disposal, a sort of black funds, with all the problems related. Secrecy also masked cost overruns which from the initial 400$ million grew to 2$ billion. The work was also secret and needed to be done quickly, which resulted in missed opportunities and policies founded on deeply incorrect assumptions. In addition to this the Manhattan Project itself was not a model for an orderly, democratic, unambiguously positive government science project. Also the amount of resources invested in the project meant diverting them from other projects. Moreover investing so much money from the beginning meant that calling off the work would be institutionally impossible, especially considering the very low external oversight or independent auditing, which is nowadays a requirement for spending public money. Last but not least at the end, instead of dismantling the infrastructure, it would have been more efficient to expand them for further use.

This said and taken into consideration, I still think that the “public calls” for a new Manhattan Project (which was in fact everything but a public call at the time) are not wrong. What we can learn from the Manhattan project is the idea that working together, pooling resources together thus avoiding duplication and sharing information is the only way we can afford the effort we face in the global challenges.

1.2 - Sabin and Chumakov

I now want to briefly write about an example of a powerful and successful cooperation which took place during the years of the Cold War and involved two scientists who were working on the same problem, at the same time but in two different and never so distant countries. In fact, despite strong political tensions, cooperation on healthcare and biomedical sciences has drawn praise for its ability to transcend politics and unite the two countries around a common cause. [8]

Most of us regard the Cold War as long past history, something from the past, but it actually took place not that far back in time. It was a period of dangerous antagonism between two countries who were fighting over anything and anybody. And during this period, 2 scientists, one American, one Russian, found a way to work together to accomplish something that would help millions of people. The objective was to find a vaccine for the polio, which epidemics where leaving thousands of children and adults mutilate or paralyzed.

This is when the two scientists formed an “alliance” in order to find a cure, a vaccine. In 1955 US virologist Salk was the first to bring a vaccine to the population, becoming immediately very famous. At the same time, his American colleague Sabin was still working on a better vaccine. Salk’s vaccine used “deactivated” polioviruses which were killed using formalin; Sabin instead wanted a vaccine which contained weakened active polioviruses, which would give life immunity and the possibility for immunize children to “spread” the immunity to other non-vaccinated children. In addition to this, Sabin’s vaccine could have been given using a sugar cube, while Salk’s needed a syringe.

[8] Rojansky, Matthew, Tabarovsky , Izabella, The Latent Power of Health Cooperation in U.S.-Russian Relations, AAAS Center for Science Diplomacy, 05.08.2013

In 1955 Sabin identified 3 types of poliovirus to use in his vaccine, but he did not have the possibility of proving that he was right. To demonstrate the validity of his vaccine he would have needed millions of test subjects, which, as most of the inhabitants had already been vaccinated, was impossible in the US.

At the same time polio was spreading in the URSS. In 1956 the 2 most important Russian virologists, Chumakov and Smorodintsev, met with same American scientist, Salk and Sabin among them. The encounter was "silently" approved, but both nations were on the lookout for anything suspicious. Chumakov and Sabin immediately liked each other. This brought to creating a strong bond. Sabin had the vaccine which could have helped saving millions of lives, Chumakov found the way to overcome bureaucratic obstacles.

The URSS was already using the Salk vaccine, but Chumakov was looking for something easier to distribute and cheaper in order to give it to the whole nation, but he couldn't get the approval of the politicians. Eventually, he found a way. The responsible of the health department of the Politburo was a friend of Chumakov, and he gave him clearance. Chumakov tested the vaccine on 10 million children by 1959.

The Sabin-Chumakov collaboration brought a new vaccine which was then chose to fight polio all over the world, even in the USA after 1962. Sabin in 1972 then donated his vaccine to the WHO in order to be used in third world countries as well.

The new vaccine originated from the collaboration of these 2 scientists reduced the number of cases from the 350.000 of 1988 to the 650 of 2011. [9]

[9] Vaughan C. Turekian, Norman P. Neureiter, Science and Diplomacy: The Past as Prologue, 3.9.2012

This story shows the potential a US-Russian health engagement could have; the two nations have unrivalled scientific resources and expertise which, if combined, could drive innovation and economic grown, and not just for US and Russia. This potential could go beyond health and biomedical science and reach all branches of science, but unlocking this latent potential requires strengthened leadership, resources, and strong institutional foundations. [10]

Recognizing the unique possibilities provided by the "healthcare diplomacy and cooperation" , in the years after the dissolution of URSS, Russia and USA established two bilateral commissions, which objective is to improve the cooperation in a variety of fields, such as economy, space, energy and S&T. The first one was created by Boris Yeltsin and Bill Clinton in 1993, which came to be known as the Gore-Chernomyrdin Commission after U.S. vice president Al Gore and Russian Prime Minister Viktor Chernomyrdin. The second one was established in 2009 by U.S. president Barack Obama and Russian president Dmitry Medvedev and it is called Bilateral Presidential Commission. The Mission Statement, identifies the objective of the commission as "identifying areas of cooperation and pursuing joint projects and actions that strengthen strategic stability, international security, economic well-being, and the development of ties between the Russian and American people [....] the foundation for the work of the commission is based on the core principles of friendship, cooperation, openness, and predictability, and we are resolved to address disagreements openly and honestly in a spirit of mutual respect and acknowledgement of each other's perspective." [11]

[10] Rojansky, Matthew, Tabarovsky , Izabella, The Latent Power of Health Cooperation in U.S.-Russian Relations, AAAS Center for Science Diplomacy, 05.08.2013

[11] U.S. Embassy Moscow Press Office, October 2009, http://moscow.usembassy.gov/obama-medvedev.html

These two commissions are helping managing US-Russian cooperation across many scientific fields. While certainly not perfect, this cooperation makes it important to maintain these initiatives alive and strong, turning ideas and projects into action. For this to happen cooperation between public and private sectors is critical, and the BPC possesses the necessary influence to make this happen.

2.0 - Evolution of International Scientific Cooperation in recent times and the birth of the biggest International Scientific Projects

Thomas Jefferson saw with his high perception that 'the brotherly spirit of science [...] unites into one family all of its votaries of whatever grade, and however widely dispersed through the different quarters of the globe'
This remark was made in Jefferson's letter accepting election as president of the American Philosophical Society

One of the most common images that come to mind when thinking of science and scientific practice is the one of the "lone, long-haired genius, mouldering in an attic or basement workshop [...] motivated by the flame burning within him";[12] this, even though it still applies in some cases, is an image belonging to the past. Science and its practice are increasingly expanding from a restricted national scope to an international one, from individuals to groups, from being restricted to a single discipline to interdisciplinary.

Some statistics can help us to understand how science collaboration has changed in recent times. From 1985 to 2007 the number of scientific articles published by a single author decreased by 45 percent; collaborative research now lies well above 50% of all research activities in many countries and research organizations;[13] the number of scientific articles published with domestic co-authorship increased by 136 percent, and those with international co-authorship increased by 409 percent. The same trend holds for patents. [14] For example the study on "'charged-particle multiplicities' measured with the ATLAS detector at the LHC in Geneva has been published in March 2010; 3222 researchers from 32 different

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[12] Price, D. de S. (1963). Little Science, Big Science. New York/London: Columbia University Press.pag. 3
[13]Wuchty, S., Jones, B.F., Uzzi, B. (2007) The increasing dominance of teams in the production of knowledge. Science, 316: 1036-1039.pag.1037
[14]Hormats, Robert D., Science Diplomacy and Twenty-First Century statecraft, 3.09.2012pag. 2

countries contributed to this study. 20 institutions from six different countries with thousands of scientists collaborated in sequencing the complete human genome in 13 years, as part of the Human Genome Project. This shows the power and the possibilities that can be gained from large scale international collaboration. [15]

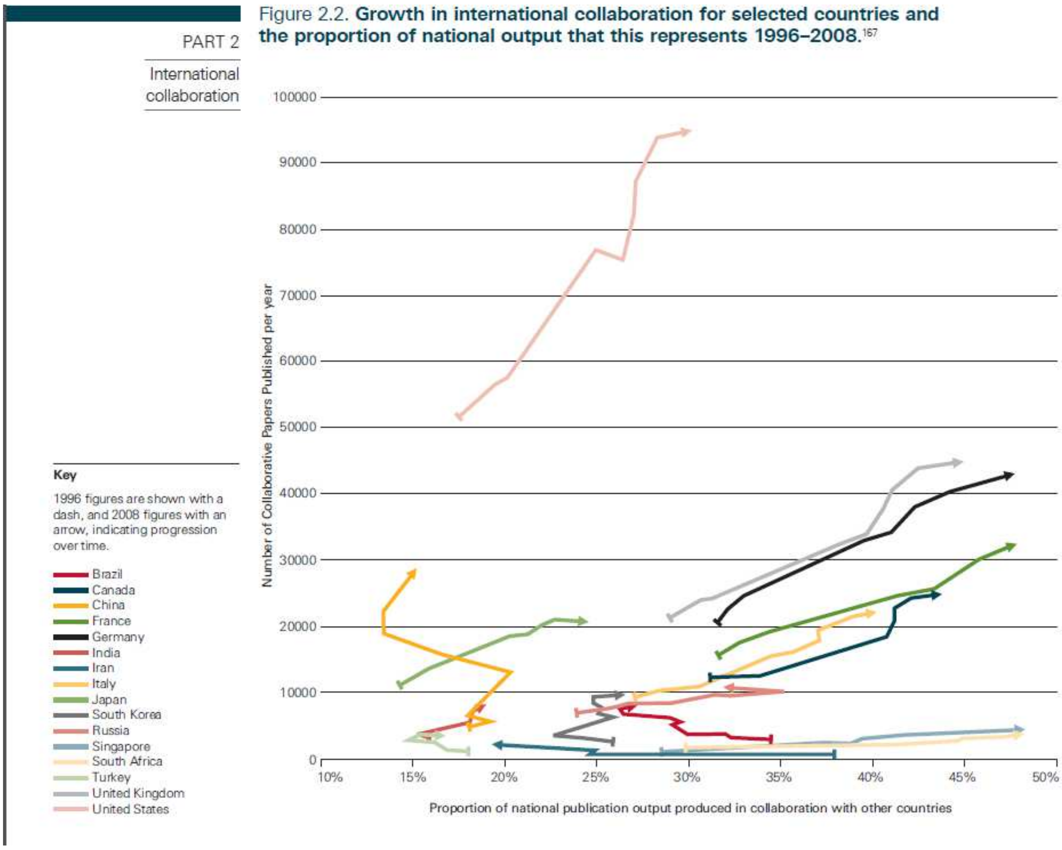

Fig.2: ***Growth in international cooperation***[16]

Collaboration in science takes advantages of expertise that exists around the globe. The increase in the level of international organization cooperation, international research collaboration and EU collaboration has been facilitated by a number of different factors in recent times.

The most obvious one is the rapid and unprecedented develop of technological advances. Thanks to E-Mails, Internet, data sharing, mobile

[15] The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 24

[16] "Knowledge, Networks and Nations" 59 pag 48

phones it is much easier for scientists to communicate and collaborate with colleagues beyond one's own country.

The development of the World Wide Web technology at CERN has changed international scientific cooperation in unquantifiable ways. E-Mails allows for instant communication and sharing of information, VOIP allows a free way to contact colleagues all over the word, especially from developing countries; Twitter helps to keep track of new and on-going projects, thus helping to share information to the whole "interested" community with a push of a button. An example were the rumours that the Higgs boson had been discovered; they started around 1st July 2012, one day before the announcement at Tevatron, and three days before the official announcement from CERN on 4th July. Data sharing allows fast and free access to documents anywhere, anytime; now one partner can send data and drafts from one side of the planet at the end of the working day to be continued by their colleague on the other side, on the same piece of work at the start of their day. [17]

Global collaboration, with the assistance of modern technology, needs no sleep. But as dramatic a change as the internet has brought, it is still not a bed of roses.

Many countries still lack the infrastructure to utilize internet to its best; just seven years ago, in 2006, less than 5% of Africans used the web compared with more than 50% among G8 countries. In addition to this the internet bandwidth is often limited, which may hinder the ability to communicate effectively. [18]

[17]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 65

[18]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 67

Moreover international research collaboration has become much more affordable. Yet despite the arrival of low-cost airlines and developments in communications technologies, it is still not cheap.

Apart from physical distance acting as a barrier for collaboration, scientists also need to bridge institutional differences, especially when working "big science" projects that involve many different institutions, each with its own rules, funding schemes, institutional frameworks, norms and values.

National borders separating researchers still makes collaboration less likely; researchers operating under different national systems will generally find it more difficult to align incentives, deal with property rights issues, university regulations, research assessment criteria, and – more generally – shared norms and values all render research projects easier to coordinate at national levels than at the international level.

Language is also an issue; even though most scientists speak English, by far the most dominant language in publishing results of research projects, complex and sensitive modes of communication are easier when researchers do speak the same language. [19]

This being said, the advantages of international cooperation still surpass the disadvantages; this has brought an increase in international cooperation, but with big differences from country to country.

The BRICS and the other rapidly growing scientific nations are collaborating less than most of their 'developed' counterparts; for example in the Netherlands and Denmark in the period from 2004 to 2008 half of the research published was the product of multinational authorship while China, Turkey, Taiwan, India, South Korea and Brazil produce over 70%

[19]Hoekman, J. (2012). Science in an age of globalisation : the geography of research collaboration and its effect on scientific publishing. Eindhoven: Technische Universiteit Eindhoven. ((Co-)promot.: Prof. Dr. K. Frenken& R.A. Boschma).pag 77

of their publications from national researchers alone[20]. Small nations and less developed countries are collaborating at a much higher rate. USA, Europe and Japan are demonstrating a growing propensity to collaborate with global partners, China, Turkey and Iran are proportionally decreasing their collaborations. Furthermore, ambitious scientific nations such as Saudi Arabia and South Africa are increasing their relative collaboration. [21]
But these differences are not that surprising. In China and India international collaborations are growing significantly but, at the same time, the row amount of publications is skyrocketing(see Chapter 3.0). In recent time these countries invested a lot in research and education, which means they are not close minded regarding cooperation with scientists outside their own country, just that these cannot keep pace with the even more increase in overall (national) publications. At the same time Europe, Japan and USA are increasing their international cooperation, mostly thanks to the improved performance and capacities of scientific research in "the rest of the world".
Research collaboration is beneficial in many different ways. For developed countries this allows them access to unique geographical resources as well as being able to draw on local knowledge and understanding. For developing countries international cooperation allows them to "catch up" with the latest development in their field; it offers scientists access to facilities, funding, equipment and networks which are often limited, badly maintained or obsolete in their country of origin. Scientists themselves benefit from cooperation also in citation terms, as for each international author of an article there is a related increase in the impact and the citations

[20]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 47
[21] The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 47

of that paper.[22]This, in turn, has a strong impact on the accessibility of further research funding.

There are many reasons and rationales for collaborative science. What it's clear is that the exploitation of scientific knowledge and the development of new technology are the prime source for economic competitiveness in the modern world, which is the main reason why cooperation has increased so outstandingly in recent time. The economic benefits and the bundling of resources and knowledge are key elements especially when the focus in on the "big science projects" which have also increased in numbers and quality. These "great challenges" require a scaling-up of research efforts if we want to alleviate global problems with global approaches.
Many projects scale and scope are way too great for one nation alone and in recent time we have seen many of these. For example the First Census of Marine Life is a global network of more than 2500 scientists from 80 different countries who engaged in a 10 year projects to answer the questions of what has, does and will live in the oceans. External factors contribute massively to the creation of international projects. In the case of global public health emergency, for which large scale global commitment and collaborative research are essential, the World Health Organisation (WHO) recently managed a project to study the cause, transmission and possible treatment of the SARS epidemic threat (Severe Acute Respiratory Syndrome). Energy is another important subject of international scientific cooperation; recent projects like the International Thermonuclear Experimental Reactor (ITER), or the proposed Desertec are trying to solve one of the most problematic issues the world is facing.

[22]Hoekman, J. (2012). Science in an age of globalisation : the geography of research collaboration and its effect on scientific publishing. Eindhoven: Technische Universiteit Eindhoven. ((Co-)promot.: prof.dr. K. Frenken& R.A. Boschma).pag 59

Space and basic research is probably the most "renowned" subject for international cooperation, mostly due to the high costs and relative "low immediate benefits" of this kind of research. Many projects have been started and proposed in recent time, such as the Large Hadron Collider (LHC), the Atacama Large Millimetre/sub-millimetre Array (ALMA), the European x-ray free electron laser (European XFEL), the Square Kilometre Array (SKA), the Hubble Space Telescope (HST) and the James Webb Space Telescope (JWST).

All these global challenges require collaborative approaches which need strong institution in order to reach the hoped results. Are the existing institutions up for the task?

'The central dilemma', remarked Jan Nilsson, former president of the Gothenburg University and the former secretary general of the World Physics Organization (IUPAP), 'is that the new problems we face do not fit well into the old organizations we created'[23]

Like Nilsson, many share the view that international science-based institutions are creaky, bureaucratic and inefficient, off the radars of young scientists, poorly coupled to the private sector, and leave out most developing countries.

The causes are manifold;

First, the politicization of the governance coupled with the institutional rigidity of existing government oriented institutions. This causes slow response times where contemporary researches need to be flexible, adaptive, decentralized and they need to help establishing the means for rapid contacts among scientists of different countries and sectors. As the Ukrainian cell biologist Yuri Gleba said: 'In the future world of rapid

[23]Nichols, Rodney W., UNESCO, US goals, and international institutions in science and technology: what works?, Technology in Society, Volume 25, Issue 3, August 2003, Pages 275–298pag 6

change, the real premium in organizational structures will be adaptability and flexibility. Institutional dinosaurs will have to evolve or expire'. [24]

Second, international projects supported by governments need to be continuously fruitful and steadily provide results and direct benefits in order to keep receiving political and economic support, a main problem especially for basic research which needs multiyear appropriations that governments often cannot and will not provide. This means an erratic support with tight funding, which constrains the scientists in providing mediocre but "fast" results delegitimizing the real "mission".

Finally an increasingly important aspect in the globalised science world is the reluctance and failure in attracting scientists and cooperation from developing countries. This is mostly connected to the "old" government based institution and their rigidity, while newer NGOs are effective in attracting new talents, thanks to their innovative and flexible frameworks.

In additions to these main problems there is also a lack or at least an inadequate collaboration with the private sector, which I will examine more deeply later on.

In order to improve this situation and make the most out of international projects and institutions these issues should be handled and if possible resolved.

First of all what international organizations need is a strong enough leadership and governance, to bring together highly professional staff, a flexible framework and economic funding overcoming partner nations own goals. This must be coupled with transparency of operations in order to avoid misunderstandings, sustain political will and earn steady funding. Second, clear agendas must be set with specific set of rules leaving no reasons to doubt the project goals.

[24]Nichols, Rodney W., UNESCO, US goals, and international institutions in science and technology: what works?, Technology in Society, Volume 25, Issue 3, August 2003, Pages 275–298pag 8

Last but not least, international organization should recruit the best people, pooling from developed and developing countries, with no restriction except the search for the best. And all this should be done in cooperation with private sector industrial R&D as only when firms, governments, and universities merge their capabilities and set common goals, global problems, such as food, water, and energy can be met.

2.1 - Role of International Scientific Cooperation in Diplomacy

'Ninety-five percent of the new science in the world is created in the countries comprising only one-fifth of the world's population. And much of that science neglects the problems that afflict most of the world's people."

- Kofi Annan in Science, March 7, 2003

As history has taught us, science and technology has been the backbone of innovations and the driving force that has brought us to the world we live in today. Despite its central role in creating the world, science has been only scarcely used as a tool of diplomacy. This has begun to change as it has become clear that the world order requires a coherent, non-political and comprehensive tool to bring countries together and especially to close the gap between developed and developing countries. Science diplomacy is not "new" but its importance has become deeper, broader and more visible than ever before. Many of the mayor global challenges science has to face in the 21st century require an adaptation of the tools, techniques and tactics of foreign policy and international diplomacy to adapt to the increasingly scientific and technical complexity.[25]

[25]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 62

Recent history provides many examples of how cooperation in science can bolster diplomatic relations. Through the Cold War scientific treaties and organizations were the conduit between nations; they offered a framework to enable collaboration and alternative channel of engagement with countries whose relations were difficult on just the political level. The use of science to ameliorate tensions between USA and URSS started in the late 50s, when experts from both sides where tasked to find a system acceptable for both nations to monitor and control nuclear armaments. The Treaty on the Non-Proliferation of Nuclear Weapons, entered into force in 1970, is an example. The critical point of this as similar treaties is that the interest of the nations involved to reach an agreement allowed the scientific discussions to proceed behind the political one. This was made possible by two factors; the subject was deeply scientific in nature, and the political interest of the governments was strong. The implications of modern global problems present opportunities for large scale cooperation among nations; science and technology is an international language that is understood by anyone, without any prejudice, not coloured by race or culture [26], and therefore has a fundamental and pervasive influence on international affairs. So the main question now is: how do science and technology influence international affairs? And how do international affair influence science?

These mutual effects are well described by Weiss (2005).

First of all let's have a look at the effects of science and technology on international relations:

- Scientific knowledge discovers and points out new (global) issues, such as climate change, stem cells, endangered species; this creates a

[26] Zewail, Ahmed H., "Science in Diplomacy", Cell, Volume 141, Issue 2, 204-207, 16 April 2010pp 204

need for new policies in international agendas and the need for new treaties, lessening the scope of international anarchy.

- Science and technology alters the meaning and significance of international security, blurring the boundaries between domestic and international issues. This is the case for example of the fight against terrorism, arms control and political changes in developing countries which constrains and dictates the foreign policy environment.
- Advances in science and technology through, for example, development of new weapons (ICBM), can change the pattern of the distribution of power among states, affecting bilateral and multilateral relations, reordering hierarchies of military power and economic power, creating or resolving international problems, creating new tools and arenas for international cooperation and competition.
- Advances in communication and information technology have changed the relation between typical governments processes - diplomacy, war, crisis management, administration - and private sectors ones - commerce, trade, finance, communication, research and innovation -, linking them and forcing states and diplomats to taking into consideration how these will be perceived by the public.
- Science and technology through the creation of new information technologies and worldwide communication through mass media have changed the approach and perception of global issues, norms, state interests, foreign policy and power relations. The mass media have reinforced the sense of common identity among geographically dispersed people stimulating a more conscious participation of the public in state decision, forcing governments to take into consideration public opinion.

- The capacity to manage and produce new technology and carry out technology innovation has changed the way to determine economic and political power, surpassing the one dictated by the pure military power, by affecting a wide range of political, economic, social and cultural variables.
- Altered the balance of importance in foreign policies between states on one hand and international organizations, NGOs, private firms and other non-state actors on the other. These are increasingly more important in opening channels of communication and cooperation with otherwise "impermeable" states (such as Iran, North Korea etc.)

Influence international relations have on science and technology can be summarized into the following points:

- Public opinion, mostly dictated by the topical and resonance of specific issues, for example climate change or OGM, affects the financing and level of importance of scientific and technological projects and their feasibility.
- Foreign policy and objectives directly affect agendas and budget allocation for national projects, in order for them to meet the current national needs.
- The state of political relations among states dictates how, where to and with whom scientists from one country can move to, enrol in, collaborate, communicate and meet with.
- International agreements determine the strength and state of intellectual propriety, a prerequisite for most innovations.
- Any changes in economic conditions or policies, regulations, income levels and distribution and cultural or religious preference affect the evolution of science and technology as they operate through mechanisms of economics, laws, politics and culture.

For a long time the fact that science-technology and international politics are pervasive has been ignored or restricted to specific topics, like WMD and terrorism. This has been changing; President Obama’s landmark speech to the Islamic world at Cairo’s Al-Azhar University in June 2009, identified science as a tool with which to strengthen relationships[27]:

"On science and technology, we will launch a new fund to support technological development in Muslim-majority countries, and to help transfer ideas to the marketplace so they can create more jobs. We'll open centres of scientific excellence in Africa, the Middle East and Southeast Asia, and appoint new science envoys to collaborate on programs that develop new sources of energy, create green jobs, digitize records, clean water, and grow new crops. Today I'm announcing a new global effort with the Organization of the Islamic Conference to eradicate polio. And we will also expand partnerships with Muslim communities to promote child and maternal health.

All these things must be done in partnership. Americans are ready to join with citizens and governments; community organizations, religious leaders, and businesses in Muslim communities around the world to help our people pursue a better life." [28]

This speech by President Barack Obama in Cairo describes the way to go in using science technology in diplomacy and reflect the potential of international collaboration in healing difficult political relations, or at least keep the channels of communication between countries with fractious relations open. According to the Department of State science and technology agreements “establish frameworks to facilitate the exchange of

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[27]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 62

[28]The White House, Office of the Press Secretary(Cairo, Egypt), REMARKS BY THE PRESIDENT ON A NEW BEGINNING, Cairo University, Cairo, Egypt, June 4, 2009

scientific results, provide for protection and allocation of intellectual property rights and benefit sharing, facilitate access for researchers, address taxation issues, and respond to the complex set of issues associated with economic development, domestic security and regional stability."

SESAME

One example of this bridge-building is the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), which has a target date for commissioning in late 2015. Modelled on CERN in Europe, SESAME is a partnership between Bahrain, Cyprus, Egypt, Israel, Iran, Jordan, Pakistan, the Palestinian Authority and Turkey. Synchrotrons are large and relatively expensive facilities, beyond the reach of most of the members' individual science budgets, so pooling regional resources is the obvious way to construct SESAME, which has the potential not only to build scientific capacity in the region but also to foster collaboration. [29]

MERC

Another important program, financed by the U.S. Agency for International Development, which supports cooperation in the Arab world, is the Middle East Regional Cooperation Program, aka MERC. This is a competitive research grant program with a focus on projects on agriculture, health, water and environment as well as trying to improve the difficult relation between Israel and its neighbour Arab nations. The program was established after the Camp David Accords in 1979 and broadened to include all Israel neighbouring Arab countries in 1993. It includes now

[29] Smith, Chris Llewellyn, Synchrotron Light and the Middle East, Bringing the Region's Scientific Communities Together through SESAME, Science and Diplomacy, AAAS Center for Science Diplomacy, 16.11.2012pag 2-6

institution from Egypt, Palestine, Jordan, Morocco, Lebanon, and Tunisia.[30] Even though it is sponsored by the US, most of the current active projects have no direct participation of USA partners, relying entirely on direct cooperation between Israelis, Palestinians, and other Arab partners. Despite the great improvements MERC's brought to the relations in the Middle East, and the successes of many of its projects, cooperative research between Israel and its neighbour is still affected by security issues and political insecurity. Still it is important to acknowledge and publicize the results and achievements of such a "brave" projects. "At a time when government outreach is more constrained, these scientific accomplishments, which travel across borders, will stand out and perhaps provide the groundwork for broader cooperation."[31]

I think that the EU must play a major role in developing science and technology in international diplomacy. Of course there are concerns, especially about the intellectual property right; most industrialized/advanced countries, including many within the EU, fear that involving developing countries could infringe innovations and new technologies without providing adequate compensation. Even though it may be true sometimes, the advantages in further developing and widening science and technology cooperation are far more than the possible disadvantages. History provides many examples of how scientific cooperation can bolster diplomatic ties and cultural exchange. This has been proved recently with the discovery of the Higgs particle at the CERN, an organization formed to build the foundations for European science after World War II by bringing together former adversaries. Besides strong partnerships within Europe, CERN also includes participation of scientists

[30] Mock, Kira E., The Middle East Regional Cooperation Program, AAAS Center for Science Diplomacy, 02.21.2013

[31] Mock, Kira E., The Middle East Regional Cooperation Program, AAAS Center for Science Diplomacy, 02.21.2013

from the United States and many other countries. CERN illustrates the importance of science and international research institutions in uniting nations to pursue a single noble goal. [32]

Another "European" example that comes to mind is the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, one of the oldest international research institutions. Along with CERN, the ICTP shows how important of a role international research institution can play in bridging the world's political and developmental divides by focusing on large-scale scientific challenges that require collaboration between countries.[33] The ICTP was founded in 1964 by Pakistani Nobel Laureate Abdus Salam and operates under a tripartite agreement between the Italian Government, United Nations Educational, Scientific and Cultural Organization (UNESCO), and International Atomic Energy Agency (IAEA). It is located near the Miramare Park, about 10 kilometres from the city of Trieste, Italy. The founders chose Trieste because of its great cultural diversity and because of its key location on the border between Western and Eastern Europe during the Cold War which provided it with strategic benefits being essentially the only place in the West where scientists from both sides of the Iron Curtain could meet and share their scientific results and knowledge of physics and mathematics.[34] Nowadays, ICTP still plays a major role in bringing young scientists from developing countries in contact with most advanced facilities and techniques in Physics and Mathematics.

[32]Quevedo, Fernando, The Importance of International Research Institutions for Science Diplomacy, Science and Diplomacy, AAAS Center for Science Diplomacy, 01.07.2013
[33]Quevedo, Fernando, The Importance of International Research Institutions for Science Diplomacy, Science and Diplomacy, AAAS Center for Science Diplomacy, 01.07.2013
[34]Quevedo, Fernando, The Importance of International Research Institutions for Science Diplomacy, Science and Diplomacy, AAAS Center for Science Diplomacy, 01.07.2013

CERN increasingly international impact thanks to its initiatives to expand to non-European countries and his search for non-member states scientists serves as a model for current and planned international experimental facilities such as the ILC (International Linear Collider), the ITER, the SKA (Square Kilometer Array) and ANDES (Agua Negra Deep Experiment Site).

Working thought the universal language of science, both have demonstrated the importance of a global approach to address the challenges of our time. But in order to make the best out of it, EU must improve its frameworks and relations to non-member countries in many ways which, at the same time, will foster EU itself.

First of all strengthening and widening science and technology cooperation with non-EU countries in a more systematic institutional framework integrating universities, governments initiatives, corporations and EU institutions would benefit dynamicity and competitiveness, which is what European firms and institutions need to access the best knowledge in the most efficient way.

In addition to this, as already one of the largest research and development spenders in the world, the EU is in a top position to guide and help scientific and technological progress around the world, especially considering the necessity to respond to global challenges.

Moreover, improving cooperation with non-EU countries may help Europe in facing the demographic decline which will have a serious impact on the availability of labour force in the future. It would also strengthen the values and principles European integration has been based on, which balance state sovereignty and supranational integration. Rather than on force, the EU is established on consensus and common interest among states. This makes the EU a unique political player building on its reputation as a civilian power, which gives it a unique chance to share and shape the human capital capacity building effort in the ‘demographic dividend’ economies through co-investment in S&T education and research.

2.2 - Science cooperation for non-proliferation efforts

After examining the role and importance of science and scientific cooperation in international diplomacy, I want to briefly focus on specific function science cooperation can have in international relations, i.e. its role in non-proliferation efforts.

I take as example a program, the Nunn-Lugar Cooperative Threat Reduction, a section of the U.S. Atomic Energy Act (AEA) of 1954and an international organization, the International Science and Technology Centre (ISTC). These three helped counter the spread of weapons of mass destruction, making the world safer.

The Nunn-Lugar Cooperative Threat Reduction is a program which provides funding and expertise to partner governments in the former Soviet Union to secure and eliminate weapon of mass destruction at the source. The reason behind this is quite simple: WMD proliferation and the diffusion of scientific knowledge are inextricably linked, as advances in engineering, biology and physic can enable the development of weapons. When the URSS dissolved, the risk of the proliferation of materials, weapons and especially scientists and knowledge from Russia was very high. Therefore, in November 1991, Senators Sam Nunn (D-GA) and Richard Lugar (R-IN) aimed to address the problem, especially the one about the immense Russian nuclear arsenal, by creating the Cooperative Threat Reduction Program which objectives were:

- Dismantle Former Soviet Union (FSU)'s Weapons of Mass Destruction (WMD) and associated infrastructure.
- Consolidate and secure FSU WMD and related technology and materials.
- Increase transparency and encourage higher standards of conduct in adherence to nuclear agreements and non-proliferation activity.
- Support defines and military cooperation with the objective of preventing proliferation.

At the beginning the program and funding applied to former URSS states, Russia, Ukraine, Belarus, and Kazakhstan in particular, but recently assistance has expanded to non-Soviet countries such as Iraq, Afghanistan, China, and African nations such as Djibouti, Kenya, South Africa and Uganda. [35] African and Middle East are of special importance due to the usually underrated (in comparison to nuclear weapons) risk of biological weapons; Africa "hosts" numerous deadly viruses, like Ebola, Dengue or Marburg, which Al Qaeda has made no secret of its desire to use. It is from Africa that the URSS, during the Cold War, got their original samples of viruses and bacteria for its biological weapon program. [36]

In 20 years the Nunn-Lugar program has deactivated more than 7,600 strategic nuclear warheads in the former Soviet Union, more than 2,300 nuclear-capable missiles and nearly 700 missile launchers. In addition approximately 820,000 rounds of chemical munitions have been destroyed and more than 2,247 metric tons of chemical weapons have been neutralized.[37] But the program is also helping cooperative research and transparency in the handling of dangerous pathogens as well as secure vulnerable facilities and building early warning systems.

[35]Bresolin, justin, Fact Sheet: The Nunn-Lugar Cooperative Threat Reduction Program, July 2013
[36]Lugar, Richard G., Science Cooperation Essential for Nonproliferation Efforts, 03.09.2012
[37]Lugar, Richard G., Science Cooperation Essential for Nonproliferation Efforts, 03.09.2012

In the year following the creation of the Nunn-Lugar program, another important organization with a similar objective was created, the International Science and Technology Centre (ISTC). The Funding Parties are Canada, the United States, the European Union, Japan, Norway and South Korea ; the objective is to engage weapons scientists, technicians, and engineers from the Commonwealth of Independent States (CIS), which include Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan, in peaceful, civilian science and technology activities. In the 20 years the ITSC has collaborated with more than 73.000 scientists in areas as disposal of weapons-grade plutonium, chemical weapons destruction, and nuclear material control and accounting. [38] In addition to this the organization "contributes to the solution of national or international technical problems in relation to the transition to market-based economies. This is achieved by supporting basic and applied research and technology development in the fields of environmental protection, energy production, and nuclear safety; and promoting the further integration of NIS scientists into the international scientific community"[39].

The last example is a specific section of the U.S. Atomic Energy Act, which shows how science cooperation for non-proliferation efforts can be implemented in a country politic to control and manage the nuclear technology. "The act 123 of the U.S. Atomic Energy Act (AEA) of 1954 establishes the conditions and outlines the process for major nuclear cooperation between the United States and other countries. In order for a country to enter into such an agreement with the United States, that country must commit to a set of nine non-proliferation criteria."[40]

[38] Lugar, Richard G., Science Cooperation Essential for Nonproliferation Efforts, 03.09.2012
[39] Bresolin, justin, Fact Sheet: The Nunn-Lugar Cooperative Threat Reduction Program, July 2013
[40] Kimball, Daryl, The U.S. Atomic Energy Act Section 123 At a Glance, March 2013

This few sketchedexamples are just a way to show how the scientific community has become indispensable in creating an effective response to global problems from finding new energy supplies to improve food production, from fighting viruses and diseases to containing proliferation of weapons of mass destruction.

2.3 - The case of small nations in international scientific cooperation

So far, we have analysed the influence of scientific cooperation in international diplomacy and vice-versa, by focussing mostly on consideration of the strategic interests of the larger advanced nations, like EU, Russia and USA. We will return to this issue later on. Here, I would like to briefly examine how small nations can use and be part of international scientific cooperation.

These "small nation", like for example Israel, Singapore and New Zealand, are rapidly growing interest in the role of science within international diplomacy and how they can benefit from it. [41]

Most of the "small countries" share the same fundamental problems. First of all, they do not possess the capabilities or capacities to undertake deep basic research alone. This is related to the challenges of where to apply their limited R&T funds. This affects the balance and funding distribution between research for enhanced economic growth and research for other possible public-good outcomes.

Another difficulty small nation’s encounter is that of the limited capacity to have diplomatic representation in other countries and international organizations. Even though "the combined economic output of the twenty small industrialized nations with a population of less than 20 million

[41] Peter D. Gluckman, Stephen L. Goldson, Alan S. Beedle, How a small Country can use Science Diplomacy, 05.24.2012

exceeds that of China (1.3 billion people), they are afforded little weight in international forums." [42] This works a bit differently for small countries that are part of the EU. For example they have no representation and voice in international decisions taken during G8, G20 or in the Carnegie Group, a group that brings together the science ministers and senior officials from the G8 nations and some others including the European Commission. This means that they have to give significant effort to projecting their capacities and capabilities alongside those of the larger nations in order to be part of projects they would otherwise have not access to or be able undertake alone.

At the same time their different geopolitical status, gives them some kind of advantages. Limited resources make science in "small nation" frequently acquire an international dimension, meaning that they can be catalysts for important multi-jurisdictional research and technological initiatives. This gives science and diplomacy in small nations an even greater role and impact than that played in larger nations, as it allows them to maintain a global profile.

Their size allows them to engage in a different way that the one of larger nations, with direct contact with stakeholders and the public, making them more flexible.

The main and best way for small nation to be part of the international scientific community is to focus on key areas of expertise, using them to build close and meaningful relationships with other nations, small and large. The case proposed by Peter D. Gluckman, Stephen L. Goldson and Alan S. Beedle is the one of New Zealand. Zealand has started to reconstruct its science and innovation system and decided to focus

[42] Peter D. Gluckman, Stephen L. Goldson, Alan S. Beedle, How a small Country can use Science Diplomacy, 05.24.2012

especially on its role as an environmental guardian in addition to focused research in key areas of expertise, such as agricultural, bio-security, and biomedical science.

This focused effort has allowed New Zealand, despite its size and limited resources, to play a significant role in specific international affair. An example they analyse is the creation of the GRA, the Global Research Alliance on Agricultural Greenhouse Gases, a 2009 initiative which has become a formal alliance of thirty-three countries with the aim of finding ways to grow more food without growing greenhouse gas emissions.

Another example to be briefly considered is Switzerland. It has around 8 million inhabitants (New Zealand has about 4.5 millions) and very few natural resources. As an export-oriented economy, Switzerland requires high innovation in technology as products have to compete in a global market place. This is achieved through the education and research system which contributes not only to knowledge production but ensures that innovation and manufacturing are tightly integrated, and by an increasingly effective science diplomacy, achieved through a network of so-called Swissnexes consulates like structure specialized in all aspects of public science diplomacy. After the decline of the watch industries caused by the cheap products coming from Asia, Switzerland focused on high end products and high value technology, especially in medical science, sustainable building and urban planning (an example is the Swiss Village in the world's first net zero city in Abu Dhabi, Masdar City). In addition to this Switzerland also is the host of CERN.

These two brief examples shows that small nations can and should pull more than their own weight in a global system focused on solving "big science" challenges of our century. "As science becomes more global in its presentation, it is vital that small advanced nations are integrated into the processes that link science to innovation, economic growth, and environmental protection. Indeed, it is argued that small nations can play a disproportionately valuable role." [43]

3.0 - The State of World Science and Globalization in the Scientific World

"*Knowledge belongs to humanity, and thus science knows no country and is the torch that illuminates the world. Science is the highest personification of a nation because that nation will remain the first which carries the furthest the works of thought and intelligence."*Louis Pasteur

As Louis Pasteur said, science is global enterprise in a shrinking world. The scientific world has changed a lot in the last 30 years. As seen before, when Gorbaciov allowed Sakharov to go to the U.S., things were much different; a part for a few exception, international projects were limited and cooperation among scientists from different nations were restricted and difficult.

In the last century international science cooperation has seen a dramatic growth as more and more scientists are conducting research and more money is being invested in R&T. A few numbers will described this situation and growth better than words.

The number of researchers in the world has grown from the 5.7 million of 2002 (with 1 million publications) to 7.1 million of 2007 (with 1.58 million publications). This 7 million researchers have access to over 1000 billion US$ in R&D funding, which is a 45% increase since 2002. This investment produced, in 2012, over 2.5 million research papers from 225 different

[43] Peter D. Gluckman, Stephen L. Goldson, Alan S. Beedle, How a small Country can use Science Diplomacy, 05.24.2012

countries, ranging from the 1 of Tuvalu and the 20 of Djibouti to the 537.308 of the US, 392.164 of China, 152.877 of the UK and the 85.027 of Italy. [44]

The expenditures on R&D have also grown; in 2011 US was spending more than 400 billion US$ in R&D, 2,7% of their GDP, Israel tops the list with an expenditure of 4,2% followed by South Korea with 3,7%, Japan (3.6%) and Sweden (3,3%). China spent almost 300 billion US$ reaching 2% of GDP while India and Brazil almost reached 1% of GPD. The European Commission has a formal target to spend 3% GDP on R&D across the Union.

The architecture is also changing, with the expansion of global networks and the growth of international organizations. Science is becoming more interlinked; researchers are increasingly mobile, looking to collaborate with the best colleagues in their field, to access resources and share ideas and facilities, seeking new knowledge to advance their field or to tackle specific problems. The portion of scientific papers produced with more than one international author has grown from 25% in 1996 to 35% in 2008. The USA keeps leading the world in research, producing 20% of the world's authorship of research. However, between 1996 and 2008 the US lost one-fifth of its share of the world's article authorship, Japan lost 22%, Russia 24%; UK, Germany and France also fell back in relative terms. [45]

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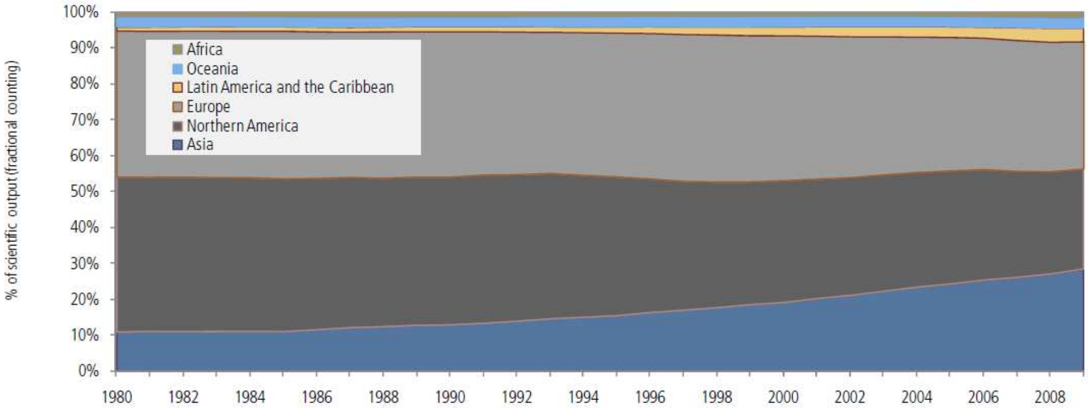
[44]SCImago. (2007). SJR — SCImago Journal & Country Rank. Retrieved November 24, 2013, from http://www.scimagojr.com

[45]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011, pag 10-20

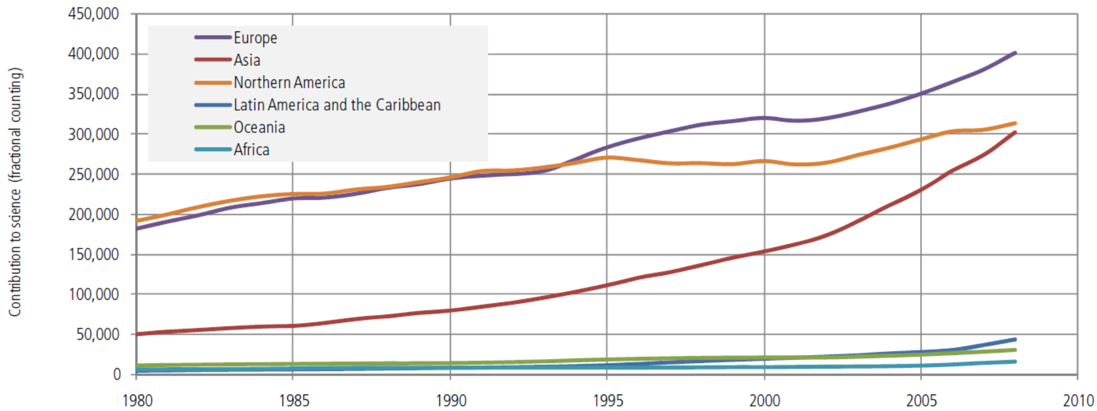


Contribution to world science by region, expressed as percentage, 1980–2009

Note: Major geographical regions are based on United Nations definitions; note that Northern America includes Bermuda, Canada, Greenland, Saint-Pierre-et-Miquelon, and the US.

Source: Calculated by Science-Metrix using the Web of Science (Thomson Reuters)

Fig.3: ***Changes in contribution to science as % among world regions[46]***



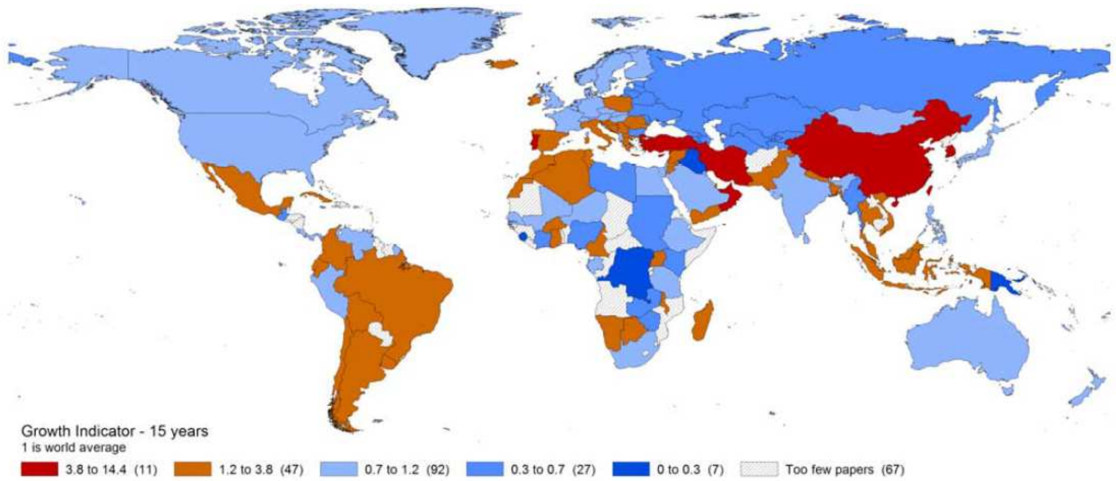
Contribution to world science by region, in number of papers, 1980–2008

Source: Calculated by Science-Metrix using the Web of Science (Thomson Reuters)

Fig.4: ***Changes in contribution to science in umber of papers among world regions [47]***

[46]Archambault, Eric, 30 Years in Science, Secular Movements in Knowledge Creation, Science-Matrix 2010, pag. 7

[47]Archambault, Eric, 30 Years in Science, Secular Movements in Knowledge Creation, Science-Matrix 2010, pag. 8



Growth mapped at the country level, 1995–2009 vs. 1980–1994

Source: Calculated by Science-Metrix using the Web of Science (Thomson Reuters)

Fig.5: ***Growthin numbers of papers per nation*** [48]

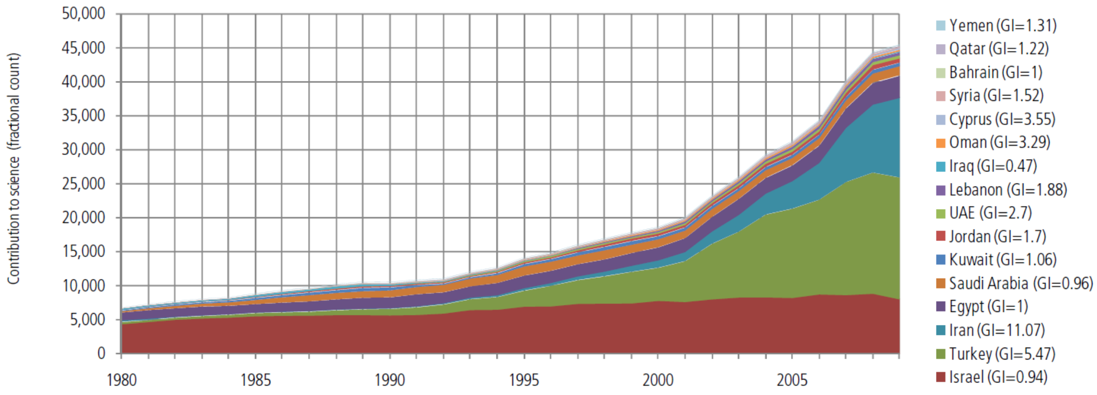
At the same time many Asian nations have increased their publication output. China's growth has been especially striking. Thanks to big investments in research and development as well as in education and universities, China has increased its publications to the extent that it is now the second highest producer of research output in the world. The rise in physics publication is an example of this growth: "In1986, a full decade after the wrenching experience of the Cultural Revolution, Chinese physicists published just four papers in Physical Review Letters. By 1996 the total had risen to28; by 2006 it had reached 202, about the same tally as Italy or Spain."[49]India has replaced Russia in the top ten and produces almost 2.5 million engineering graduates each year. South Korea, Singapore, Thailand, and Malaysia have all improved their standings.

In South America, Brazil is increasing spending in R&D, building on its natural and environmental resources. New commitments and investments to science have started to change the scene also in the Middle East. Qatar

[48]Archambault, Eric, 30 Years in Science, Secular Movements in Knowledge Creation, Science-Matrix 2010, pag. 9

[49] Day, Charles, Physics in China, Physics Today 63(3), 33 (2010); doi: 10.1063/1.3366238pag. 33

aims to spend 2.8% of its GDP on research by 2015. The United Arab Emirates is attempting to create the world's first fully sustainable city (Masdar Initiative), a city which will rely entirely on solar energy and other renewable energy sources, with a zero waste ecology. GE, BP, Shell, Mitsubishi and Rolls-Royce are among those who have joined as strategic partners.



Contribution of Middle East countries to world science, 1980–2009

Source: Calculated by Science-Metrix using the Web of Science (Thomson Reuters)

Fig.6: Growth of Middle East countries contribution to science [50]

Despite the impact of the global financial crisis and the priority given to healthcare and education, even less developed countries show signs of growth. Cambodia produced only seven articles in 1996, but increased this to 226 in 2012. Uganda went from 138 to over 1000, Colombia from 557 to 5776. [51]

Not only nations but also people are becoming more interconnected. Andre Geimwas awarded the Nobel Prize for Physics in 2010 together with Konstantin Novoselov. He obtained his PhD at the Russian Academy of Sciences in Chernogolovka, moved to the UK for post-doctoral positions at Nottingham and Bath, before moving to Copenhagen and Nijmegen, and

[50]Archambault, Eric, 30 Years in Science, Secular Movements in Knowledge Creation, Science-Matrix 2010, pag. 4

[51]SCImago. (2007). SJR — SCImago Journal & Country Rank. Retrieved November 24, 2013, from http://www.scimagojr.com

returning to the UK in 2001 to the University of Manchester. Now a Royal Society Research Professor, Professor Geim maintains links with colleagues in Russia, and is still a professor in the Netherlands. Venkatraman Ramakrishnan, 2009 Nobel Prize in Chemistry, was born in Tamil Nadu, India, undertook graduate degrees in the USA, and now works in Cambridge, England. [52]

This global wide increase in science cooperation has been helped also by the advent of the online availability of scientific journals and the birth of the Open Access movement. This brought a dramatic fall in the costs publishing scientific contents due to the "fall out" of the need of printed copies as well as increasingly vast online databases of research outputs. The ability to search for articles online, simply and rapidly, has changed the way to do science.

This "new way of doing science" by involving geographically disparate peoples, ideas, knowledge, and technologies has been made possible by the process of time and space compression called globalization. John Coatsworth defined globalization as what happens when the movement of persons, things or ideas among different regions accelerates. This “process” goes on from the eve of civilization but in the last decades the world is becoming smaller and smaller and connections have taken the form of a continuous, systematic, and self-reinforcing global exchange of knowledge. If, during the Italian Renaissance, scientists move from Rome to Florence to Venice and Milan now they are moving from New York to Shanghai to London and Tokyo.

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[52] The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 26

As already said, this process has been made possible by the technological advancements in ICTs and mobility and via the emergence of transnational institutional structures and globally operating organisations.

While the effects and products of globalisation are still not clearly defined, some people see it as a good thing, something that will sustain economic growth, raise living standards, and deepen interdependence. For Amartya Sen, a Nobel-Prize winning economist, globalisation "has enriched the world scientifically and culturally, and benefited many people economically as well". Others have different opinions; globalisation has been attacked by critics of free market economics, like the economists Joseph Stiglitz and Ha-Joon Chang, for perpetuating inequality in the world rather than reducing it.[53]

But globalisation is not the central aspect in this thesis. Globalisation in science has been for the most part a "gift" to humanity. Small entities, with limited resources and facilities, have now a chance to collaborate in international projects through overarching structures which create alignments between researchers at distant locations. It has brought together nations to accomplish tasks and projects which would have been impossible otherwise, like, for example, the cases of ITER, or the ISS and CERN discussed later on.

Before moving on to a deeper analysis of how and why nations and corporations cooperate, I want to point out a few points that summarize the current state of science in the globalized world.

- Cooperation is growing for many reasons; development in communication technology, cheaper travel costs, share costs and efforts and big scientific projects. In addition to this, scientists have

[53]R.C., When did globalisation start?, The Economist, Sep 23rd 2013, 9:00, http://www.economist.com/blogs/freeexchange/2013/09/economic-history-1

become more mobile in order to utilize equipment, resources, work with colleagues and institutions spread all over the world.

- Even though we saw that many "developing nations" are investing heavily in R&D, the traditional ‘scientific superpowers’ still rule the chart. US, EU and Japan all invest heavily in research and receive a substantial return in terms of performance, with large numbers of research articles, the lion’s share of citations on those articles, and successful translation, as seen through the rates of patent registration.[54]
- Science is still mostly based on bottom-up informal connections, but top-down initiatives are also helping scientists to organise themselves and shared knowledge.
- The strength of scientific centres of excellence keeps attracting most of the best scientists in the world.
- The interconnection of the subjects of global problems and challenges, such as climate change, water, food and energy security, population change, requires multinational funding, strategies and knowledge no single nation can provide alone. Therefore these challenges are being addressed via a number of different organisational mechanisms, intergovernmental or international bodies, through national systems, and by private individuals and corporations as well. These mechanism soften deploy novel and innovative forms of partnership.
- Interaction is simply necessary because of the increasing complexity and cost of scientific experiments. A single research team or even a single researcher is no longer capable of conducting them by themselves.

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[54]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 5

- Thanks to the way most international organisations are built, all nations, even the "small" ones and developing ones have a role in defining objectives and finding solutions for global challenges. This is need in order to be able to build infrastructures and frameworks able to meet the global and national needs in R&D
- People are more connecting thanks to formal and informal channels, virtual global networks and professional communities of shared interests. These networks span the globe. Motivated by the bottom-up exchange of scientific insight, knowledge and skills, they are changing the focus of science from the national to the global level.[55]

The question now is who and how the new big discoveries in the modern world will be financed. Issues for new discoveries are mostly found in the financing and developing phases, especially at the beginning, when new scientific concepts are applied to promising practical usages (but still purely hypothetical) and during the phase of testing before the products hits the commercial launch. These phases are very important but at the same time very expensive and laborious. In the past the laboratories of big corporations took care of these two phases, but in more recent times they favour "less risky" options, as new technologies need vast investments without any assurance to recover the capitals invested. In addition to this new technologies, like telecommunications and green technologies, are particular promising and important but at the same time very vulnerable to piracy and can be used by third parties do to the unclear and loose state of intellectual propriety laws.

The current state of the world economy gives us an opportunity to rebuild the system, making it more open, stable and resilient; more adapt to the needs of the new technologies discovery requirements. Bottom up

[55]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011pag 6

investments may be able to sustain the "long march" of technology discoveries from the laboratory to the open market. Partnerships between the public sector, universities and other governmental authorities will need to help out and in some cases substitute corporations and companies in R&D. One example is the development of the Siri "application", the personal assistance we can find in the new Apple smart phones. The projects was born from an initiative of the DARPA (the Defense Advanced Research Projects Agency), financed by the US government together with 22 different entities, among them the MIT (Massachusetts Institute of Technology), the Carnegie Mellon University and the Standford University, guided by SRI International, an American non-profit research institute which was founded as Stanford Research Institute. In 2010 Siri was bought by Apple after a 7 years development. Siri is more than a phone gadget. Its technology that allows AIs to understand, elaborate and answer a voice question could help us in many different fields. It is often the case that such opportunities are born when an idea is bind to the development of a new product. The Siri case shows us that the road from R&D to the market is rarely a straight line; most innovations require decades of work and huge investments before they can be used to create and sell new products. This means that at the moment many potentially revolutionary technologies are waiting to be developed, lacking financial resources. An example are the "personalized drugs", which target an individual specific problem, or the new generation micro-robots, small enough to travel through the human body.

During the last century most research and development was done in the laboratories of big companies. An example is the development of the strained silicon, the technology that has allowed the creation of the incredibly powerful processor we use today. It uses a layer of Germanium on the silicon to increase the space between atoms in the silicon, increasing efficiency and performance of electrical circuits. The idea originated at the Cornell University, in the late 80s, but the turnaround was made by the researchers of the AT&T Bell Laboratories who were looking for a better conductor for phone commutators. They invested a lot in the potential technology, without any certainties. In 1996 Gene Fitzgerald, head researcher at AT&T and later at MIT, founded Amberwave Technologies to sell strained silicon, but it took seven years and millions of dollars before Intel was able to launch the Pentium 4 "Prescott" processor, based on this technology. Another example is the large used of a XVII century technology, fracking, which become important and largely used only when first adopted by Stanolind Oil, as it took decades before this technology was able to help extract natural gas from reserve otherwise unreachable. The same can be said for the development of the 3D print, originated from an ink research by Siemens in the 50s. The road from idea to discovery is long and difficult, which makes it no surprise that companies are focusing more on product oriented investments which means that long base research is shrinking while short time research to improve products and services is growing. Private research investments in base research have been shrinking for the last 35 year, both in Europe, Americas and Asia. At the same time the rise of India and China as technological powers has added a new variable. These two countries could help research, but at the same time are threats for historical technology nations. China and India can invest billions in products and technologies deriving from research done in Europe, USA and Japan, seizing jobs and profits. No intellectual propriety law would be violated as usually patents expire before research results reach the market.

Missing private investors, industrialised nations need to rethink the process of base research, which will need an even greater governmental support. Governmental funding is just the first step, as governments need to help partnerships which bring together universities and NGOs. This approach is not new, but has often been under financed and restricted to small projects.

In order to improve cooperation governments need to create opportunities to help high risk research. Companies and universities need to find a way to develop strategic investments in technologies that can help them both, by creating opportunities for students, university researchers and professors to be in contact with partner in the industry to demonstrate the feasibility of the discoveries. Special fiscal treatments for universities working together with the industry should be applied. Offices for the technological transfer should focus more on the benefits for societies rather than their own university.

Europe is already making the first steps in the right directing with the creation and improving of the ERA, the European Research Area, which I will discuss later on. USA and ASIA may use the European experience to create their own "continental" ERAs, with the hope that sooner or later the geographical divisions will fade.

3.1 - Different Kinds of Cooperation

After analysing the situation in which science found itself at the dawn of 21st century, I now want to focus on the different kind of cooperation nations and corporations can engage in, the reasons and the problem behind them.

Science is a global enterprise and this means that its "use" will reflect the needs, the priorities, capacity and strength of countries and corporations. As we have seen in the last chapter differences in GDP investment in science and technology are striking. But another important difference is how research is funded and by which kind of structure is supported in the different nations. For example in Italy almost half of research is founded by the government while in Japan most of R&D investments come from business enterprises (78%). [56]The architecture through which science is created also differs between countries. In Germany research is developed by universities and at the same time also by Gesellschaften and Gemeinschaften, such as the Max-Planck and Fraunhofer Societies and the Helmholtz and Leibniz Associations, which are non-profit independent research organisations employing over 65.000 people in over 200 different institutes. In the United Kingdom most of research is run through universities labs. Russia and China significantly depend on their national academies which are the leading research organisations, like, for example, the Chinese Academy of Sciences, the world's most prolific publishing research organization, with over 50,000 papers in the period 2004 to 2008.[57]Specializes national laboratories run by the government as well as by private sector are the ordinary in the US. Two examples are the US

[56]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011 pag 36
[57]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011 pag 37

Department of Energy which employs over 30.000 scientists in 21 laboratories and the Agricultural Research Service which employs over 2,000 scientists in more than 100 laboratories.

These differences in the structure of science in the different nations add up to the different kind of cooperation nation around the world decide to adopt. Different models serve various reasons and objectives. After briefly explaining the most common characteristics of science and technology agreements I will list the most common cooperation structure among nations:

Common characteristics of science and technology agreements

Even if agreements differ in many ways, there are some common characteristics, first of all the purpose: "the parties of the agreement shall encourage, develop and facilitate cooperative activities in areas of common interest by carrying out and supporting scientific and technological research and development activities" [58] This can be achieved through different "form" of cooperation, ranging from exchange of scientists, information, materials and equipment to joint organisations. Even though the "ways" might differ, the principles on which S&T agreements are concluded are mostly shared. Nations willing to cooperate look to achieve a mutual benefit and shared advantages, a reciprocity in access to information, activities, equipment, know-how and an appropriate protection of intellectual propriety rights. Intellectual propriety rights are an important factor in scientific cooperation agreements and their issues are often clarified in specific annexes in order to secure a common implemented regulation for the utilization or propriety right created or furnished in the duration of the agreement. In addition to this S&T agreements specify the

[58]European Commission, Opening to the world: International cooperation in Science and Technology, Report of the ERA Expert Group, Directorate General for Research, 2008, EUR 23325 EN

form of the cooperative activities, the executive agents, the rules and dimension of funding collaborative activities. An appropriate organisational structure is also decided. Its role is to promote cooperative activities, reviewing, providing reports on the status of these activities and the effectiveness of the cooperation.

International treaties between states are subjected to the Vienna Convention on the Law of Treaties of 1969 and 1986, which in Art. 2 defines a treaty: "an international agreement concluded between States in written form and governed by international law, whether embodied in a single instrument or in two or more related instruments and whatever its particular designation" [59] "Treaties can be referred to by a number of different names: international conventions, international agreements, covenants, final acts, charters, memorandums of understandings (MOUs), protocols, pacts, accords, and constitutions for international organizations. Usually these different names have no legal significance in international law." [60](It differs under the U.S. law, but I will go in details about the difference in chapter 6.0 when writing about the ITER Agreement).

In the next section, I will discuss possible partnerships and parties for international treaties.

Bilateral agreements

This kind of agreement is the oldest and most common. It is an "agreement formed by an exchange of a promise in which the promise of one party is consideration supporting the promise of the other party". We can identify four "groups":

Bilateral agreements between industrialized countries: agreements between two industrialized countries are the most common especially considering

[59] Vienna Convention on the Law of Treaties 1969, art 2a
[60] Thomas Buergenthal, Sean D. Murphy, Public International Law in a Nutshell, West Group, 2002

both countries usually possess considerable capabilities in science and technology across a variety of sectors and activities and their objectives include the expanding of existing knowledge and improve reciprocal access to technology and scientists. For example the US has bilateral agreements with most of industrialized countries covering fundamental scientific inquiry in all disciplines.

Bilateral agreements between emerging economies: many of the same rationales apply as for the industrialized countries and cooperation will allow for engagement with common problems in areas such as the environment, health and energy issues.[61]

Bilateral agreements between developing countries: science and technology is no less important here for the bolstering of prosperity, security and stability than it is in other parts of the world, yet the potentials inherent in S&T remain far less exploited. Cooperation with developing countries in science and technology can help build capacities for better exploiting scientific progress.

Bilateral agreements between developed and non-developed countries: agreements between one developed and one developing/emerging countries has seen a steadily growth in the last decades. This kind of agreements allow emerging economies to access technology and resources developed by developed countries, while they access to new markets, specific resources available only in the partner country and scientific manpower.

Science and Technology bilateral agreements play an important role in forming an element of the architecture of EU relations with specific third countries. At the moment the EU has concluded several S&T agreements

[61]The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011, pag 54

with third countries, which can be grouped according to their geographical and geopolitical situation, like we just saw.

• Industrialized countries: Australia, Canada, Korea, US;

• Emerging economies: South Africa, Mexico and the BRIC countries Brazil, Russia, India, China;

• Target countries of the European Neighbourhood Policy (ENP): Egypt, Morocco, Tunisia and Ukraine;

• Mediterranean Partner Countries ('Mediterranean Partner Countries', 2008): Egypt, Morocco, Tunisia;

• Latin-American countries: Argentina, Chile.[62]

EU science and technology agreements with third countries are based on the article 170 of the EU treaty in conjunction with article 300.

Article 170 reads:

"In implementing the multiannual framework programme the Community may make provision for cooperation in Community research, technological development and demonstration with third countries or international organisations.

The detailed arrangements for such cooperation may be the subject of agreements between the Community and the third parties concerned, which shall be negotiated and concluded in accordance with Article 300."

The first paragraph of article 300 dictates:

"Where this Treaty provides for the conclusion of agreements between the Community and one or more States or international organisations, the

[62] European Commission, Opening to the world: International cooperation in Science and Technology, Report of the ERA Expert Group, Directorate General for Research, 2008, EUR 23325 EN, page 55

Commission shall make recommendations to the Council, which shall authorise the Commission to open the necessary negotiations. The Commission shall conduct these negotiations in consultation with special committees appointed by the Council to assist it in this task and within the framework of such directives as the Council may issue to it."

Article 170 and 300 clearly set a connection between science and technology agreements and the EU Research Technology & Development Framework Programme, which is the community main instrument for financing research. As declared in the two articles above all science and technology agreements are negotiated by the Commission after a Council authorization. After a consultation with the European Parliament the decision on the signature are adopted by the Council by a qualified majority on proposal of the Commission. [63]

Global Cooperation

This model of cooperation involves more state participation and work with top down policy approaches. It creates international sovra-organization, like for example WHO or UNESCO.

Science cooperation between nations and in one on a specific project

This kind of cooperation tends to create large-scale collaborative projects in particular technology areas and for particular needs. Examples are ITER (our case study), the Human Frontier Science Programmed (HFSP, Japan, Canada, France, Germany, Italy, Japan, Switzerland, the UK, the US and the EU representing the smaller states), the Intelligent Manufacturing Systems project (IMS, 140 public and private entities,73 companies and 61 universities from 21 countries), UNESCO and the UN Committee on Science and Technology for Development (UN-CSTD), the International

[63] European Commission, Opening to the world: International cooperation in Science and Technology, Report of the ERA Expert Group, Directorate General for Research, 2008, EUR 23325 EN, page 56

Council for Science (ICSU 141 countries). The main reason behind this kind of agreements is the large costs involved and therefore the need to share them by nation-states and sharing of facilities. Usually nation states had already invested substantial money for research into these areas and wish to improved and focus on them.

Regional collaboration

Collaboration is not driven solely by geographical proximity, but there are cases in which the best way to go is a "regional" cooperation, like in the European Union (EU), the African Union (AU), and the Association of South-east Asian Nations (ASEAN). Each of these Regional cooperation "groups" have common research strategies, and can help to co-ordinate scientific efforts within their regions and broader spheres of influence. Intra-regional collaboration is not, however, the dominant form of international co-operation.

North -north collaboration

The most typical form of cooperation still remains the one between old time safe partners, like the relation between US, Japan and Europe, in order for them to keep window open on new technological opportunities and expertise between similar developed countries, all with access to specialized technological expertise and large-scale infrastructures.

North-south collaboration

A new trend for Europe (and also for North America and Japan) comes from the increasing location of R&D activities in emerging economies especially due to the larger availability of scientific manpower. The rapidly growing markets of India, China and other emerging economies are the main target for these kinds of cooperation, which can help redirect funding to address critical problems of poor countries. A very successful example of this kind of cooperation is the creation of a network of centres of excellence focusing on issues related to tropical agriculture, sponsored by the Consultative Group of International Agricultural Research (CGIAR), which introduced new plant varieties and cultivation methods starting the "green revolution" in Asia and Latin America, which doubled global production of cereal crops between 1970 and 1990.[64]

South–south collaboration

This kind of cooperation has an increasing importance thanks to the growing economies of most "south" countries and their improved interests and funding for R&D. The South of the world must intensify co-operative efforts in order to reduce the huge gap between the North and the South in the production and utilization of scientific and technological knowledge. In order to do this regional and inter-regional efforts must be vigorously pursued with the objective of developing collaborative programmes in capacity building for scientific education and research, and to establish new regional alliances. Many developing countries, like for example Brazil, Argentina, China, Mexico and India have established research programmes which could assists other Developing nation to develop their local capacities in vitally important fields.[65]

India, Brazil and South Africa recently joined forces to promote South–South co-operation through the 'IBSA initiative'. With support from UNESCO and the Malaysian Government, the International Science, Technology and Innovation Centre for South–South Co-operation (ISTIC) was established in 2008. Based in Kuala Lumpur, aiming to be an

[64]Hassan, Mohamed H.A., Challenges, Opportunities and Strategies for South-South Co-operation in Science and Technology in the 21st Century, High-level Forum on South-South Co-operation in Science and Technology, Seoul, Korea — 14-17 February 2000

[65]Hassan, Mohamed H.A., Challenges, Opportunities and Strategies for South-South Co-operation in Science and Technology in the 21st Century, High-level Forum on South-South Co-operation in Science and Technology, Seoul, Korea — 14-17 February 2000

international platform for countries of the G77 and the OIC to collaborate on science, technology and innovation, and is already facilitating discussions in areas such as water, energy, health and agriculture.

Internationally collaborative research initiatives on specific global challenges

This kind of cooperation has encountered great appreciation in the last decades especially for its flexibility. For example the Generation IV International Forum (GIF) was setup by the US Government's office of Nuclear Energy, Science and Technology in 2000, and joined by eight other governments with the aim of identifying and developing a new generation of nuclear energy systems with enhanced safety and minimal waste. Minimize costs, share ideas and avoid duplication are the main reasons behind these kind of cooperation. Other major international initiatives include the Group on Earth Observation (GEO),a partnership of governments and international organizations which aims to develop global observation system to enable more effective responses to environmental

Location based initiatives

The importance of strong institutional infrastructure is recognized in countries with developing scientific ambitions. Therefore these countries compete to host such facilities as they can impact directly on the national science system. One example is the European Space Observatory (ESO)'s 'Very Large Telescope' which is located in the Atacama Desert in Chile. This structure draw European researchers and funding to the country and at the same time provides Chilean astronomers a top-notch facility. Chilean researchers are entitled to up to 10% of the total observing, which has made these researchers very popular as potential collaborative partners. This can explain the harsh competition to host the proposed Square Kilometre Array SKA, an international effort to build the world's largest radio telescope.

Diasporas Communities

A recent interesting article called "The Potential of Science Diasporas" on "Science diplomacy", pointed out the possibilities Diasporas community offer. A diaspora is a community of people settled in a new geographic location away from their homeland. It is not surprising that most of the diaspora-related initiative which have taken place started or have been supported by the US, where the story of technological and scientific innovation is strongly connected to the flow of immigration to the country. From the Manhattan Project's scientists to Sergey Brin, co-founder of Google, the US has always been the centre of attraction of scientists and engineers. In Silicon Valley alone, 44 percent of these engineering and technology ventures were founded by at least one immigrant and up until now, one-third of the 314 Nobel laureates while working in the United States were foreign-born. [66]

This has brought NGOs and the government itself to support the efforts of scientific diasporas communities. The most important and renowned example is NODES, Networks of Diasporas in Engineering and Science, which is a partnership between the State Department, the American Association for the Advancement of Science (AAAS), and the National Academy of Sciences and the National Academy of Engineering. NODES seeks to support diaspora knowledge networks by strengthening their links to professional societies, universities, NGOs, and government agencies at home and abroad in order to maximize the potential of their unique combination of expertise, networks and cultural understanding.

Students, scientists and engineers foreign born have a unique status which can help cooperation, recruitment and mentoring. The diminishing centrality of governments in international affairs has contributed to the

[66] Burns, William J., The Potential of Science Diasporas, Science and Diplomacy, AAAS, 12.09.2013

increasingly importance of nongovernmental organizations, civil society groups, and multinational corporations in addressing international relations, and diaspora communities can play a huge role in this regard.

All these different kind of agreements have common principles which are crucial for the success or failure of any given agreement.

Governance

Governance, transparency and accountability are crucial to international collaborative projects. The structure must allow projects to function on a high risk environment. Differences in national legislations and administrative regulations make the implementation of international projects more difficult. ITER, for example, has encountered some difficulties because its main Organisation and Council are responsible for the project, but most of the budget is held by individual countries' Domestic Agencies which are accountable only to their own authorities.

Flexibility

Global challenges are often interdependent and interrelated which makes the dynamic between these issues complex. Flexibility is required in order to work in an environment where both the public and the private sphere must use a coordinated effort to maximize coherence and minimize duplication. At the same time flexibility can strengthen research excellence and innovation by allowing a better access to diversified sources of knowledge, foreign knowledge, markets and S&T resources.

Multidisciplinary

International projects on global challenges require expertise from different areas, which therefore requires a multidisciplinary approach. For example the Intergovernmental Panel on Climate Change (IPCC) is a scientific intergovernmental body which brings together natural and social scientists. Researchers from all disciplines have a role to play in shaping future adaptation and mitigation policies, requiring the reconciliation of quite different methodologies and terminologies.

Funding and incentives

Incentive and funding structures and framework have an important role in the success or demise of international projects. Many are funded directly by Governments, philanthropists, industries or other actors, as pooling of resources also adds value. Most of today projects funding are granted through national institution which are then "required" to use the money to promote the national industries (ITER is an example). An addition problem is that often governments cannot provide long term financial support, especially for basic science projects, where the duration is long and the short term results are almost non -existent.

Involvement of industry

Science is not restricted to governments and universities. R&D activities in the developed world are more and more often funded by private enterprises. Companies use this business model to innovate through new technologies and knowledge, cooperating in order to solve their problems in innovative ways. This can have advantages also for the organisation itself, which can rely on more sources for funding, as well as for the companies which get access to new technologies. For example 38% of the industrial technology contracts at CERN have also brought innovative new products to market. [67] In any collaborative project, but particularly in those involving industry, reaching common understanding on intellectual property will be essential. Many global challenges will require substantial

[67]European Commission, Fusion and Industry together for the future, Directorate General for Research, Fusion Energy Research, 2009, pag 8

investment from and the creation of an appropriate incentive structure by government—but will rely on industry to carry out the work. Agreements should take into account the need for publicly funded research to be accountable, and the need to appropriately safeguard and reward innovation and creativity.

4.0 - International Space Cooperation

One field in which international scientific cooperation has seen a great development in the 20th century is international space cooperation. Manned space stations like the ISS, project of a lunar base or a human mission to Mars as well as scientific telescopes for finding habitable worlds in our galaxy are ambitions plans which will require international cooperation in order to be sustainable and affordable, especially with the shrinking budgets national space agencies, and especially NASA, have to deal with in the last decades. These partnerships must therefore be expanded to include the newly established space powers of emerging space nations and developing countries, which will provide bottom-up support structures and additional funding which will aid program continuity as well as increase public awareness of space activities. Especially the BRIC nations' economies may be able to reinvigorate their space efforts via public means provided by booming economies.

Monetary efficiency due to shared costs, political prestige and workforce stability are some of the mutual benefits that can arise from cooperative international space cooperation. However partnership in space sciences has always presented a political challenge. This is due to the fact that nations, like in other fields, struggle between the wish to be independent and the advantages of cooperation. Dependency and cooperation help to overcome asymmetries in scientific and technological know-how and economic constraints related to hardware development and missions costs. At the same time nations tries to minimize dependency in order to avoid sharing expertise and know how due to political reasons, security and economic implications.

The major problem in international space cooperation thus derives from political issues in technological competition. From the very beginning space cooperation has had a symbiotic element of foreign and security policies. Projects that have as target non-political and limited economic problems with a global scale are more likely to be dealt with through cooperation. The initial factor determined by technological capacity, economic situation and political views play an important role in defining if cooperation in specific projects is feasible or not. Political events are also defining when it comes down to international cooperation, like detente and the ending of the Cold War have enabled cooperation between the USA and the former USSR.

International space cooperation is regulated by the United Nations Treaties and Principles on space law, concluded by the Committee on the Peaceful Uses of Outer Space, the only international forum for the development of international space law. The forum has concluded five international treaties and five sets of legal principles in order to govern space related activities.

The five treaties are:

- The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty"), adopted by the General Assembly in its resolution 2222 (XXI), opened for signature on 27 January 1967, entered into force on 10 October 1967;

- The Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (the "Rescue Agreement"), adopted by the General Assembly in its resolution 2345 (XXII), opened for signature on 22 April 1968, entered into force on 3 December 1968;
- The Convention on International Liability for Damage Caused by Space Objects (the "Liability Convention"), adopted by the General Assembly in its resolution 2777 (XXVI), opened for signature on 29 March 1972, entered into force on 1 September 1972;
- The Convention on Registration of Objects Launched into Outer Space (the "Registration Convention"), adopted by the General Assembly in its resolution 3235 (XXIX), opened for signature on 14 January 1975, entered into force on 15 September 1976;
- The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the "Moon Agreement"), adopted by the General Assembly in its resolution 34/68, opened for signature on 18 December 1979, entered into force on 11 July 1984. [68]

The most important one is the "Outer Space treaty" which was opened for signature by the United States, the United Kingdom, and the Soviet Union on 27 January 1967 and now has 102 countries parties. It first defines that:

"The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind." (Art. 1)

[68] United Nations Office for Outer Space Affairs. "United Nations Treaties and Principles on Space Law.". Retrieved 16 February 2011.

It creates the basic legal framework of international space law by stating that

"States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the Moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international cooperation and understanding. " (Art 3)

The legal principles of all these 5 treaties are based on "non-appropriation of outer space by any one country, arms control, the freedom of exploration, liability for damage caused by space objects, the safety and rescue of spacecraft and astronauts, the prevention of harmful interference with space activities and the environment, the notification and registration of space activities, scientific investigation and the exploitation of natural resources in outer space and the settlement of disputes."[69] This means that outer space activities should and must be directed to enhancing the well-being of all countries and humankind in general.

In addition to these treaties, the OOSA also concluded five sets of legal principles, adopted by the UN General Assembly, which provide for the application of international law and promote cooperation in space activities. These are:

- The Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space (General Assembly resolution 1962 (XVIII) of 13 December 1963);
- The Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting (resolution 37/92 of 10 December 1982);

[69]United Nations Office for Outer Space Affairs. "United Nations Treaties and Principles on Space Law.". Retrieved 16 February 2011.

- The Principles Relating to Remote Sensing of the Earth from Outer Space (resolution 41/65 of 3 December 1986);
- The Principles Relevant to the Use of Nuclear Power Sources in Outer Space (resolution 47/68 of 14 December 1992);
- The Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries (resolution 51/122 of 13 December 1996)

Political actors in international space cooperation are represented by those individuals, states or organizations that can engage in cooperative outcomes. The most prominent are the nations and their national space agencies, communities of "space" scientists, international governmental organizations and international non-governmental organizations. The emergence of non-state actors allow for non-state processes of cooperation to influence and/or determine the extent to which cooperative outcomes are realized. Cooperation can therefore be either institutionalized or non-institutionalized. Institutionalized involve treaties, conventions, protocols that create a set of rules specified explicitly by multilateral legal instruments to regulate national actions on a given project. Space science is predominantly regulated by INGO committees, intergovernmental agreements (IGAs) and memorandum of understanding between national space agencies and the successes of INGOs especially is due to the strong scientific rationale brought by oriented epistemic communities thanks to the limitation or exclusion of politic and economic factors.[70]

In recent times many nations have passed national space legislation. The "Outer Space Treaty" requires parties to authorize and supervise national

[70]EligarSadeh, James P. Lester, Willy Z. Sadeh, Modeling international cooperation for space exploration, Space Policy, Volume 12, Issue 3, August 1996, Pages 207–223

space activities, including the activities of non-governmental entities such as commercial and non-profit organizations as well as incorporating the UN Charter and custom and practice of states in international law.

In addition to national laws, also commercial space activities, which has increased strikingly in the last decades, needs to be regulated, in a way that does not hinder investment but still ensuring they comply with international law. This could be resolved by extending the United Nations Convention on the Law of the Sea to outer space.[71] Commercial purposes also raise the question "whether space should continue to be legally defined as part of the “common heritage of man,” and therefore unavailable for national claims, or whether its legal definition should be changed to allow private property in space". [72]

Successful international cooperation in space programs requires solid, and continuous political and economic support, which requires all actors, but especially governments, not to seek to ensure minor advantages at every stage but to look at the "big picture". This requires space agencies to support international governmental agreements which have to provide a sustained economic support and help industry and space agencies to create and manage space project in an efficient way, especially trying to convey funds with minimum emphasis on national advantages and avoiding duplications. As we have seen, participation in complex and expensive programs undoubtedly allowed European nations and industry to make giant steps forward in space and connected technologies as well as experience in managing large international programs.

The creation of ESA, which we will discuss more deeply later on this chapter, was itself a significant exercise in international cooperation, being

[71] Wong, Kristina. "Rumsfeld still opposes Law of Sea Treaty." The Washington Times, June 14, 2012.
[72] Billings, L. (2006) To the Moon, Mars, and beyond: culture, law, and ethics in space-faring societies, Bulletin of Science, Technology & Society, 26(5), 430-437

the first multinational space agency and allowing European nations equalize or at least reduce the enormous differences in industrial capacity and knowhow of its members. The idea of an international space agency was discussed but unfortunately did not gather much support especially from international groups like ICSU, CEOS, IAF and COSPAR.

Unfortunately decisions on which space programs are to be implemented and funded still rely more on political decisions and selfish interests rather than on merits of the different programs. In addition to this, international space cooperation has focused on creating programs among established space powers rather than an integrated global effort. Therefore a lack of common focus and cooperation still remains, determined also by differences in budget cycles(EU has a four year renewal of Member States' commitments while US has an annual appropriation process), funding schemes and prohibitive technology transfer regulations (i.e. ITAR), which delays and affects the chance of creating and sustain truly global projects (ISS is an exception). [73] This has brought many problems over the year in many cooperation programs like, for example, the EO-ICWG.

4.1 - EO-ICWG

The EO-ICWG, the Earth Observation International Coordination Working Group, founded by USA, EU, Japan and Canada in 1986 is a striking example of a global project gone awry due to "unbridgeable" differences in decision making, power struggle and data policy.

IN 1986 USA, EU, Japan and Canada decided to create a framework to coordinate research and plans for Earth observation using the planned (later transformed in the ISS) Space Station Freedom. The idea behind EO-ICWG was to serve both institutional and earth system scientific

[73] M. Ansdell,P. Ehrenfreund, C. McKay, Stepping stones toward global space exploration, ActaAstronautica, Volume 68, Issues 11–12, June–July 2011, Pages 2098–2113

arrangement for data exchange. The idea was to coordinate research, data management, policy issues and instrument accessibility. This was the offs pringof the realization that earth observation is a global issue both in terms of science and applications. [74]

Cooperation in such a global and massive project involves functional arrangements to deal with technological and scientific resources through mechanisms for control of technology transfer and through intellectual property right provisions. Political arrangements address authority issues and decision making patterns, characterized by national and institutional responses framing the possibilities for cooperation.

The main principle of EO-ICWG was that each partner was to inform each other regularly and to share technical and scientific resources. This was done through a coordination of plans to maximize scientific, operational and applications benefits and determining of data policy and technical parameters for the exchange of information. National singular preferences were met by "making sure that the development of instruments and space borne means (i.e., spacecraft, launch vehicles, and data transmission) did not functionally depend on collaborative efforts. “Cooperation was to take place at the level of coordinating as effectively as possible a suite of nationally approved Earth observation missions", including "mission management principles, data policies, and terms of reference."[75]

The main point of discrepancy between NASA and ESA was the preference of NASA for multilateral agreements on terms of reference while ESA organizational and political constraint spoke against multilateral agreements. For ESA autonomy decision making within a specific

[74]Sadeh, Eligar, A failure of international space cooperation: the International Earth Observing System, Space Policy, Volume 18, Issue 2, May 2002, Pages 135–150

[75]Sadeh, Eligar, A failure of international space cooperation: the International Earth Observing System, Space Policy, Volume 18, Issue 2, May 2002, Pages 135–150

framework for participants was of paramount importance. Technology transfer were another point of issues, especially for NASA who was afraid of undermining "open skies", an international policy concept that calls for the liberalization of the rules and regulations of the international aviation industry—especially commercial aviation—in order to create a free-market environment for the airline industry. In addition to this, ESA wished to limit the scope of IEOS to "just science" did not fit NASA idea of IEOS. This was due to the ESA inability to negotiate and make agreements with foreign partners without memberships consent (art XIV of the convention establishing the European Space Agency)[76].This meant that NASA and ESA could not find consensus on how to coordinate IOES missions and framework, as "NASA preferred development of a multilateral MOU and Implementation Plan, whereas ESA resisted such efforts, preferring that the EO-ICWG at best remain an influential advisory group" in addition to the failure in finding an agreement in the data exchange policy. [77] The project was therefore shut down in 1996 and IEOS as a mission concept was never implemented.

The demise of a program like EO-ICWG which could have created a base framework for future international agreements has taught the international scientific community about the striking difficulties in managing international scientific programs. This experience tells us that the scientific community and the different nations still have a long way before being able to cooperate on a truly international level. One possibility to improve this could be a program using a common global research program with low security issues to prepare a framework which can be used in subsequent projects. This will allow stakeholder from different areas, both private and

[76]Convention for the establishment of the European Space Agency, (Ref. CSE/CS(73)19, rev. 7), Paris 30 May 1975.

[77]Sadeh, Eligar, A failure of international space cooperation: the International Earth Observing System, Space Policy, Volume 18, Issue 2, May 2002, Pages 135–150

governmental, and different cultures valuable practical experience from working together. Collaboration on low cost and smaller projects, like a worldwide CubeSat project, might prove helpful in creating a right framework as well ease cross cultural barriers, develop common working interfaces and foster standardization.

New coordination mechanisms and structures with a widened range of "space actors" with an emphasis on long term cooperation will be required to meet the needs of most space programs, which require the creation of common standards, methods and frameworks in order to be effective. Global cooperation on common goals also increases public awareness and engagement providing needed political support. Institutional arrangements should also be created or modified in order to meet the needs or such a wide array of different national legal systems. More enduring institutionalized framework, such as intergovernmental organizations, are required to sustain cooperation in long term scientific projects, like ITER, CERN or the ISS have proven.

Another crucial point is to allow epistemic scientific communities to be the decision makers in international projects. They are the best candidates to succeeding in bridging political differences among nations and intergovernmental organizations. This is the opposite of what is presently happening, where budget and the importance of national space agency are being reduced therefore limiting, if not cancelling, any decision power.

Political and economic factors regarding the cost/benefits of each nation in all future projects should be considered. At the moment most of the problems in international programs are linked to the nation’s direct benefits (for industry and state companies) and technological knowhow directly reflecting the amount of funding each nation invested in the project. Even thou it would be an unattainable hope to be able to completely separate from such factors, it is clear that long term viability of international projects requires a supranational structure with sufficient "power" to be able to provide answers for costs sharing and decision making authority. The demise of the Inter-Agency Consultative Group for Space Science (IACG), another promising framework, that NASA, ESA, Intercosmos and ISAS firstly created with the target of sending explorers to Halley's comet and then expanded to adopt solar-system exploration as the next subject, is another example of a lost opportunity. IACG was a remarkable example of international co-operation, but it did not meet NASA hopes and was therefore shut down.

International space cooperation offers a great opportunity to reach out to a larger group of nations and industries. This, as said before, will require a balanced approach to knowhow transfer methods which an organisation like ESA might help provide.

4.2 - ESA

The European Space Agency (ESA) is a unique organisation in that it represents the only institutionalized multinational space agency. [78] Established in 1975 from its predecessor, the European Space and Research Organization (ESRO) which was a purely scientific organization limited by its convention and financial resources from participating in space application programs, ESA has its headquartered in Paris, France, and has a staff of more than 2,000 with an annual budget of about €4.28 billion. Its origins trace through a lengthy process of institutional bargaining among European governments and their respective national space agencies.

[78] EligarSadeh, James P. Lester, Willy Z. Sadeh, Modeling international cooperation for space exploration, Space Policy, Volume 12, Issue 3, August 1996, Pages 207–223pag 213

The ESA Convention was signed in Paris on 30 May 1975 by the nine original Member States (Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom). It entered into force on 30 October 1980 with the deposit of the last instrument of ratification by France, in accordance with its Article XXI, 1[79].Since the entry into force of the ESA Convention in 1980, the founding members have been joined by Ireland the same year, Austria and Norway (1986), Finland (1995), Portugal (2000), Greece and Luxembourg (2005) and the Czech Republic (2008).[80]

The main reason behind the creation of ESA from ESRO hinged upon the limitations ESRO, along with European ambitions in developing autonomous capabilities in launching vehicles with the French Arianne project, planetary exploration probes, and meteorological and communications satellites. This led to the ratification of the ESA convention in 1980 by all member states.

ESA is not an agency or body of the European Union (even though it does have ties to it), and it includes Switzerland and Norway (non-EU countries) as members. ESA organisational structure is composed as follows:

1. Director General (DG) is the head of ESA's management, the Chief Executive Officer of the Agency and its legal representative, assisted by scientific, administrative and clerical staff in order to implement programmes, executes policy and reports to the Council.

2. The Council is a governing body of the European Space Agency, consists of representatives of each Member State and is headed by a

[79] Convention for the establishment of the European Space Agency, (Ref. CSE/CS(73)19, rev. 7), Paris 30 May 1975.
[80]www.ESA.int

Chairman, elected for 2 years and its role is to take decisions regarding ESA’s activity and policy.

Then there are 6 committees, devoted to the definition, management, running and control of mandatory activities, and 6 programme boards, devoted to the definition, to the management, to the running and to the control of the six optional programmes.

All member states are required by the ESA's convention to participate in mandatory scientific and technological research activities and contribute funds to that end.

The Science Program Committee composed of delegates of member states with competence in scientific matters take decisions about what the mandatory programs will be and provides common facilities (e.g. launchers, tracking, and operations). Mandatory programs are approved by a majority of all member states requiring a two-thirds majority in council to change decisions. This adds credibility and solidity to projects protecting them from unwanted changes.

Projects are identified and selected using the mechanism of the open call. ESA issues a call, with a descriptions of the scientific goals, size, cost of the mission, together with programmatic and implementation details, for proposals for new science missions. After this the different scientific advisories of ESA (like the Space Science Advisory Committee and the Science Programme Committee) assess the proposals and choose a couple of candidates which will then be put under a one-year feasibility study. The conclusions of all these feasibility studies are then presented to ESA’s scientific advisory committees and other scientists who make recommendations about which missions should proceed to preliminary design with two competitive industrial contracts. Results are presented, again in Paris to the various committees, and a final decision on which proposal will be selected for each mission is made.

Funding levels in ESA are approved by its sovereign legislative council while specific ESA spacecraft are funded by individual national space agencies. Funding are mandatory and gross national product based which helps ESA dealing with national political pressure, a central point for the effectiveness of its administration. This allows for mandatory programs to be driven by scientific merit first and only secondarily by political and industrial considerations.[81]

ESA's industrial policy has the objective to advances economic and technological interests. The key mechanism that governs ESA's industrial policy is based on the principle of just return which "is measured through an industrial return coefficient defined as the ratio of the proportion of all contracts placed by ESA in the space industry of a given member state to the budget that ESA spends on industrial projects as a whole. The return coefficient allows for an equitable sharing of economic and industrial resources." [82] This mechanism has had positive effect on political support for ESA activities and its framework which coordinates and balances the policy positions of various European national space programs, such as French autonomy concerns exemplified by the Arianne rocket and German preferences for cooperative missions with NASA.

4.3 - International Space Station

The International Space Station is, at the moment, the most expensive international project ever realized. The ISS is a massive object the area of a football field, travelling at about 27,600 km/h at about 400 km above earth.

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[81] EligarSadeh, James P. Lester, Willy Z. Sadeh, Modeling international cooperation for space exploration, Space Policy, Volume 12, Issue 3, August 1996, Pages 207–223

[82] EligarSadeh, James P. Lester, Willy Z. Sadeh, Modeling international cooperation for space exploration, Space Policy, Volume 12, Issue 3, August 1996, Pages 207–223

The story of its design, creation and implementation is a 30 year long one, which started in 1982, when NASA established a task force to create a conceptual design for the future Space Station Freedom, later renamed ISS. NASA, having in mind the failure of their previous project (Skylab), additionally decided that this one would be implemented through international cooperation; Japan, Canada and the EU were contacted in late 1982 and invited to participate in the project from the very beginning. They all accepted in 1985.

In 1984 Reagan stated: "Our next large target is to develop a new frontier based on the pioneer spirit. I command our nation to construct a permanent manned space station within ten years." This is considered the "official" start of the ISS construction. This led to a series of formal agreements between the station's original partners, Europe, Canada, Japan, and the United States. All three starting agreements, in the form of Memorandum of Understanding were signed in 1985. MoU record international "commitments", but in a form and with wording which expresses an intention that it is not to be binding as a matter of international law. A MoU is used whenever it is preferable to avoid the formalities of a treaty.

In 1988 the first Inter Governmental Agreement among the four countries was signed, with the concept that ISS would be utilized for space experiments in material and life sciences, utilizing features of space environment such as microgravity and high vacuum. In addition to this, ISS was designed to serve as an intermediate base for exploration to the moon and planets in the future or as a facility where malfunctioning satellites could be repaired. Both 1985 and 1988 agreements, like many other NASA cooperative agreements of the past, were characterized by an asymmetry in NASA's favour. They respected the usual NASA principles of cooperation with no exchange of funds, clean technology interfaces, control of critical path items, and decision-making authority in addition to clauses for withdrawal, the linkage of financial obligations to the respective national funding procedures, availability offends, and for possible station redesigns emanating from these impacts.

After the fall of the Soviet Union, with the space race therefore effectively over, participating countries struggling to maintain the necessary budget and thanks to the stabilization of Russia's economy and emerging democratic political system, Clinton, in 1993, decided to link ISS to aspects of US-Russian foreign policy. This brought NASA and the newly created Russian Space Agency to sign an agreement that was in fact a contract with the ultimate objective of building and operating a joint scientific research complex in space. This with the addition of US economic incentives for the Russian scientific elite also helped in containing the possible dispersion of know-how and technology from Russia to other third world countries, which was a great fear of the US foreign office. Russia, unlike its European and Japanese counterparts, emerged as an 'equal partner', in terms of its participation to the project.

This particular relation is expressed by the mixed Russian-US funded and Russian-built component module "Zarya", which in 1998 became the first ISS node launched into orbit. Major contributions from other ISS partners followed, including Russia’s Zvezda service module in 2000,NASA’s Destiny laboratory and Canada’s Canadarm2 in 2001, ESA’s Columbus laboratory and JAXA’s Kibo laboratory in 2008, and NASA’s Tranquillity module and ESA’s Cupola observation module in 2010. [83]

The ownership of modules, the station usage by participant nations, the contractual obligations, and the rights and responsibilities of each were

[83] M. Ansdell,P. Ehrenfreund, C. McKay, Stepping stones toward global space exploration, ActaAstronautica, Volume 68, Issues 11–12, June–July 2011, Pages 2098–2113

established in 1998 when the ISS partner (Canadian Space Agency [CSA], the European Space Agency [ESA], the Italian Space Agency [ASI], the Japan Aerospace Exploration Agency [JAXA], NASA, and Roscosmos) signed a series of Intergovernmental Agreements and Memoranda of Understanding amongst themselves. At the moment the main ISS modules are: Zarya, Unity, Zvezda, Destiny, Quest, Pirs, Harmony, Columbus, Kibo, Cupola, Rassvet and Leonardo.

Noteworthy in the project is its role as a foreign policy tool. In "Partnership – The Way of the Future for the International Space Station," Tara Miller wrote, “One reason Russia was asked to join the space station program dealt with financial problems. However, since the inclusion of the RSA into the partnership, the ISS has become a foreign policy tool. The ISS is used to help prevent the transfer of advanced engine technology from Russia to other countries. It is hoped Russia’s space program can be used in a constructive manner, to ensure that inter-continental missile technologies do not fall into the hands of warring states.”[84] And the ISS, build by a number of nations, some of whom were enemies not that long ago, has been a model of science diplomacy.

Most of nations acknowledge the importance of cooperation in addressing global challenges requiring multilateral solutions and the ability science has in creating partnerships among countries regardless of political traits. The idea of nations grouping up for large scale projects are now not only common but also very successful, if managed to be implemented. Many surmise that international scientific collaboration has intensified as of late

[84]TARA S. MILLER, CPPM, SHUTTLE CHAPTER," Partnership – The Way of the Future for the International Space Station", NPMA. Volume 16, Issue 5 – 2004

mostly because large research is too costly for single nations to undertake alone. While this may be true, there is more to it than just finance.[85]

The ISS is a unique laboratory which enables scientific research in unequalled environment. It has been inhabited by men and women for over a decade; as of today 211 individuals from 15 different countries visited and stayed on the ISS, without an on-board scuffle or major international incidents. This was only possible because they found a way in planning, organizing and personnel allocation viable with the different national priorities.

The benefits provided by this structure are manifold. It helps develop technology and study the impact of living in a gravity free environment which will help us build the foundation for future exploration of the solar system. It creates jobs for scientists and other highly qualified personnel. It is also the most complex and technically ambitious large-scale engineering project ever undertaken by a group of nations.

Expanding international cooperation by allowing as many nations as possible to be able to use the ISS facilities is essential for both technological advanced as well as for foreign policy advancements. This would mean adding nations like China, India, Brazil and others as partner and allowing scientists from emerging space nations to be integrated in future ISS related projects and experiments. This is mostly restricted due to the strong regulation such as ITAR, the International Traffic in Arms Regulations, which is a set of United States government regulations that dictate that information and material pertaining to defence and military related technologies may only be shared with U.S. persons unless authorization from the Department of State is received or a special

[85]Payett, Julie, ISS: Research and Diplomacy 350 Kilometers above the Earth, Lessons from the International Space Station, 12.10.2012

exemption is used. This has begun to change in more recent times as new export control reforms have recently been supported by the White House, as well as a restructure of the control lists and the harmonization of licensing policies.

The management of the station itself it mostly monitored by US and Russia, with their two main Mission Control Centres, one at the Johnson Space Centre in Houston, Texas, and one in Korolev, north of Moscow. The other partners also have their own control centres: in Tsukuba, Japan (for the KIBO Japanese laboratory complex), Munich, Germany (for the European-built Columbus laboratory), and Montreal, Canada (for robotics operations), but MCC-Houston is the primary centre for mission design, development, and integration. The official language of the station is English, but operations are conducted in both Russian and English. No passport or visa is required to board. [86]

What is the role of the ISS today? A part from the scientific and technological advances made possible during the construction and during the years of activity, we must recognize the role played by the ISS in history as a first of its kind and a formidable example of an effective foreign policy tool. This great example of peaceful cooperation, although unfortunately unusual for the human race, might encourage developing and emerging countries that cooperative large scientific projects are doable. We must reflect on the way the partners have found to achieve a long-term shared project that transcended domestic policies.

The ISS project taught the participant nations and the "spectators" that the objective of a mission must, first of all, be clear and goals should be clearly defined to enable partners to participate based on their objectives and

[86]Payett, Julie, ISS: Research and Diplomacy 350 Kilometers above the Earth, Lessons from the International Space Station, 12.10.2012

priorities. Formal frameworks are also essential for the functioning and plans should account for unforeseen events and possible withdrawal of participants, without jeopardizing the overall mission objective.[87]

[87] Payett, Julie, ISS: Research and Diplomacy 350 Kilometers above the Earth, Lessons from the International Space Station, 12.10.2012

5.0 - EU as a starting point and symbol for a new era in ISC

In this chapter I want to talk about the chance Europe has in becoming an example and set a precedent if it succeeds in creating a framework for cooperation, bringing together 27 Members states. If Europe through the European Research Area and similar projects would be able to create a stable, working and efficient framework for cooperation, the model could then be used for other "regions", for example to create a similar framework among the Asian countries or the African ones. It could then even be a starting point for a global framework for the development of science, by bringing together the different research areas created in various part of the world. It would be an extremely long, difficult and optimistic process, but chances are that it could also be the best option for mankind to solve the global problem that are and will affect us in the next centuries. And now Europe has a chance to be the one that started it.

The first steps are already there. After the terrible and destructive wars that have characterized the European continent for most of its history, we are now living the longest period of peace ever seen in this part of the world. The creation of the European Union was the first step in creating a common area. Now member states are closer than ever and the creation of the European Research Area, a series of scientific research programmes which utilise EU funds and the framework projects is bringing members states closer and closer together. The European Union is trying to reorient Europe's main rationale from one based on economic integration alone towards one based on the concept of a common society. The EU is trying to achieve this through encouraging cooperation, funding common projects, removing barriers for researcher’s movements, financing projects and infrastructures. But, even if Europe is moving forward on the right track, it is still very far from having an integrated approach to research at national and union level are integrated' (European Council 2000, I.A. 12). Cooperation is still highly influenced by geographical barriers; to overcome this problem there is a need to harmonize the different national research systems by aligning labour market regulations, diploma systems and property rights. Bringing members states closer together is not an easy task. People like Pierre Auger and Edoardo Amaldi --the founding fathers of CERN and of the first organizations concerned with cooperation in space, ESRO and ELDO-- or Denis de Rougemont, one of the early promoters of a federal Europe, believed into encouraging common projects in science and technology as a way to go to help political unification. Europe is the best field to try to go beyond the usual clashes and rivalry between nation-states and reach both political and economic unification. [88]

Scientific cooperation can prove helpful in this task. In the early years, it started in a framework of hostility and distrust, and only after the creation of the European Coal and Steel Community and after of the Common Market and EURATOM there was a "common ground for exchanges and cooperation that made it possible to overcome the obstacles left by the past and to re-establish bilateral links in the framework of multilateral European agreements and institutions." [89] Science, thanks to supranational objectives, universal status, common language, shares norms and equivalent experiments, has created a way to cooperate, even in time of tensions. Still, even though scientists consider themselves free from ideology and politic, technical elements in decision making can never be completely separated from the social, economic, political and cultural one. As Mc George Bundy said "You don't solve the problem of nuclear weapons and their relation to the world by saying, "Here is a nuclear core — that's scientific; here is a

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[88]Salomon, J.-J., Scientists and international relations: a European perspective, Technology in Society, Volume 23, Issue 3, August 2001, Pages 291–315

[89]Salomon, J.-J., Scientists and international relations: a European perspective, Technology in Society, Volume 23, Issue 3, August 2001, Pages 291–315

nuclear weapon, that's military; here is a treaty — that's political." These things all have to live with each other. There are elements that are indeed military or technological or diplomatic, but the process of effective judgment and action comes at a point where you cannot separate them out. It follows that it is also nonsense to talk about the political neutrality of scientists.[90]." Here lies the main difficult in creating a common framework, especially when the different entities, i.e. member states, all have their own national objectives. The problems encountered up until now are almost always political problems, especially when it comes down to applied research, which includes intellectual propriety rights and competitions problems. This is why the most successful initiatives today are the ones that involve basic research, rather than applied one.

An entity which can be used by the European politicians to achieve the goal of bringing together the different rationales of the member states are the so called "centres of excellence". They are shared facilities or entities that provide leadership, training, support and infrastructures to pursue the best results in specific fields. Key features of these centres are, amongst others, the presence of highly trained scientists, the capacity to integrate different fields for a specific purpose, stability of funding and operation conditions and being the benchmark in their specific field. Europe can use these entities to create a framework separated from national ones and thus more independent.

An important step that needs to be taken by the European Union is to improve its role and importance in international organizations. This is a prerequisite if Europe wants to be the symbol and the precursor for the creation of a regional and global framework for cooperation in science. At the moment Europe has a lot less influence and decision making power in

[90]Bundy M.The scientist and national policy. Address to the American Association for the Advancement of Science, 22 December 1962. Science 1963;139(March):805–9

international organizations as it should be expected. This is mostly because Europe still does not speak as one voice in international organizations meetings and decisions. For example, even though EU is financing many developing countries through its assistance programs and the 27 member states are the largest guarantors of the World Bank, the influence of EU is quite low. As in the World Bank, the EU has set up delegations with many international organizations, but only few with a full EU member status. So, in order for the EU to improve this status and thus achieve an open and successful ERA, it must reinforce the common delegation by stepping aside the different member states wishes and create a respected and globally recognized entity. In addition to this, this entity requires clear instruction before going to express EU position in international forums, by finding common ground among its members. Moreover the EU must maintain a high-profile presence through international visits and missions to be recognizes as a collective partner. Last but not least the EU must ensure its own capacity in science and technology research to be strong and that it has incentives to use in negotiations with others.

As far as management's standards are concerned, it is imperative that the different entities within Europe and at the global level as well are able to find on common managements standards in order to be able to address the many issues related to big science projects, such as ITER (the International Thermonuclear Experimental Reactor, currently being build; we will discuss this project later in Chapter 6.0). One of these difficulties is associated with comparing construction costs because different countries or international entities often include different cost elements in estimating construction costs.

This table, created by Daniel Lehman, director of the Office of Project Assessment in the U.S. Department of Energy's Office of Science, compares cost elements for large-scale scientific construction projects.

Country	Conceptual Costs	Materials and Subcontracts	Labor	Contigency	Escalation	Operating Costs	Development & Demonstration (D&D)	At what percent of final design is project baselined?
		Base Costs						
Australia		●	●	●	●			30 percent of Final Design
Belgium		●	●	●	●	●		Conceptual Design
Canada		●	●				●	When application is made to the relevant agency for approval
European Commission	●	●	●			●		
EURATOM*		●	●					30 percent of Final Design
Finland								
France	●	●	●	●	●	●	●	100 percent of Final Design
Germany	●	●	●		●			Conceptual Design
Republic of Korea		●	●	<10 percent				Conceptual Design
J-PARC**		●	●					100 percent of Final Design
Netherlands		●	●					Variable
United Kingdom		●	●	●	●			Variable
United States	●	●	●	●	●			30 percent of Final Design

● The country or entity includes this element in cost estimates

*European Atomic Energy Community **Japan Proton Accelerator Research Complex

The data in this table was collected from a U.S. Department of Energy meeting on February 7, 2005

Fig.7: ***Comparison of cost elements among nations*** [91]

It is clear that at the moment there are wide differences not only among nations from different countries but within the EU as well. "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,

[91]Daniel Lehman, U.S. Department of Energy's Office of Science, 7.2.2005

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." [92]

In addition to creating a common framework for the European Union's members, the EU should at the same time try to improve relations with its historical partners and especially with the US. This transatlantic relationship goes back to the beginning of the century and is a proven alliance based on common values, economical and institutional connections and a long story of cooperation in service of mutual interests. In a time when numerous new countries are investing and becoming relevant in S&T development, the partnership between Europe and the US must find new values and mutual interests in order to be able to bring benefits for both sides as well as providing a stabilizing factor and international framework for scientific cooperation. New actors, like NGOs, university and scientific associations need to step in to provide an acceptable way to deal with the shortcomings of purely governments supported projects, which, has we have seen before, are often hindered by political factors.

At the moment, most of the scientific cooperation between the EU and the US is driven by the desire of individuals, institutions and companies in common bottom up projects. Running parallel to these bottom-up scientific collaborations, the EU and the US are pursuing numerous official bilateral projects. Still, science and technology cooperation, are still not fully integrated in the transatlantic policy agenda which continues to be more focused on politics rather than science. Chances to cooperate are endless. One example, which has recently gained more importance and attention in the media, is about the plans to counter or reduce the effects and the damages cause by extreme storm events on the east coast of the US and

[92]Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

especially cities like New York, New Orleans, Miami and Norfolk. New York has been hit by a flood in august 2007, then by hurricane Irene in 2011 and Sandy in 2012. And the situation, due to climate change, will likely get worse. The Nederland is the world expert in dealing with see waters rising. It has in fact introduced multiple technical innovations for flood mitigations and storm water modelling which could be successfully transferred and adapted to deal with the problem the East Coast of the US is facing, especially in Louisiana and New York.

As I said, the political factor is by far the most problematic one, but not the only one. Another factor which is slowing and harshening international cooperation is the fragmented nature of the scientific landscape in both EU and US as well as the lack of a consensus about a specific strategy or roadmap to be followed in a scientific globalised world. Both the US and the EU have many (too many) actors in science and technology research. The Europe, as we have seen, is trying to create a more coherent reality through the European Research Area and similar projects. The US is still lacking a strong federal agency or institution capable of coordinating the plethora of academies, scientific associations, universities and research institution present. To improve this situation the EU must make ERA work while at the same time the US must find a way to create its own. For the time being it's up to universities and NGOs to play a critical role in creating a larger bottom up integrated network of networks, preferably by involving the traditional transatlantic institutions.

But as Cathleen Fisher has pointed: "U.S. and European leaders find it harder to agree on a common approach to both urgent, near-term crises and the grand challenges of our time. To many Americans, Europe seems increasingly unlikely to emerge any time soon as the strong and united partner that the United States seeks and requires. To Europeans, the United

States appears paralyzed by mounting debt and political dysfunction that threaten its long-term prosperity and hamper American efforts to exercise continued global leadership." [93]

5.1 –Framework Programmes

As we have seen in the last chapter, the European Union has the possibility to be the symbol and forerunner for a new era in international scientific cooperation. Although the EU is still far away to achieving this goal, some of its programs and projects may be the premise to something even bigger. I will now overview the most important ones, starting with the FP7.

The 7th Research Framework Programme (FP7) is part of the Framework Programmes for Research and Technological Development, also called Framework Programmes, which are funding programmes created by the EU to support ERA, the European Research Area, to be discussed in the next chapter. Until 2013 there has been seven Framework Programmes, with a time span of 5 years each. From Framework Programme 7 on, programmes will run for seven years. The eighth Framework Programme, called Horizon 2020, opened in 2014 and will run through 2020.

The budget allocated to the Framework Programmes has been steadily increasing from the 3.75 billion € of the first one (1984-1988) to the 50.50 billion € of the seventh one, in addition to the 2.7 billion € for Euratom over 5 years.

The FP7 bundles all research related initiatives concerning the EU under a common roof and has a key function in the developing and deepening of the European Research Area. Specifically, with the FP7 the EU wants to

[93]Fisher, Cathleen, The Invisible Pillar of Transatlantic Cooperation, Activating Untapped Science & Technology Assets, 03.11.2013, and Diplomacy, AAAS

reinforce science and technology cooperation with partners worldwide and especially with third world countries by reinforcing synergies between public authorities, industry, civil society, researchers and scientists to facilitate access to knowledge, resources, markets and infrastructures. It also aims to improve the mobility of scientists from and to Europe thus strengthening the capacity and position of European industry, university and research while, at the same time, offer an improved framework under which international research can be conducted.

FP7 is EU's main instrument for funding research in Europe, to respond to Europe's employments need and competitiveness. FP7 is made up of four main "blocks" which forms 4 specific programmes, each with its specific objectives. FP7 also has a fifth programme specific for nuclear research.

The structure of FP7 is[94]:

Cooperation - Collaborative research	•Health •Food, Agriculture and Biotechnology •Information and Communication Technologies •Nanosciences, Nanotechnologies, Materials and new Production Technologies •Energy •Environment (including climate change) •Transport (including Aeronautics) •Socio-economic sciences and Humanities •Security •Space
Ideas - European Research Council	•Frontier research actions
People - Human Potential, Marie Curie actions	•Initial training of researchers - Marie Curie Networks •Life-long training and career development - Individual fellowships •Industry-academia pathways and partnerships •International dimension - outgoing and incoming fellowships, •international cooperation scheme, reintegration grants

[94]EuropeanCommission, FP7, http://ec.europa.eu/research/fp7/understanding/fp7inbrief/what-is_en.html

	•Excellence Awards
Capacities - Research capacities	•Research infrastructures •Research for the benefit of SMEs •Regions of Knowledge •Research Potential •Science in Society •Support to the coherent development of research policies •Specific activities of international cooperation
Nuclear research and training	•Fusion energy - ITER •Nuclear fission and radiation protection
Joint Research Centre	•Direct actions in Euratom •Non-nuclear actions

Table 1 : FP7 Projects structure

Cooperation

The programme "Cooperation" supports international cooperation projects in the areas listed above. It supports common research initiatives carried out by different research bodies in transnational cooperation by supporting cooperation between nations, industry, universities in the EU and beyond.

The way to support cooperation objectives under the Cooperation body are four. The first one is collaborative research through European excellence. It aims to establish projects based on excellence in order to attract researchers and investments. This is done by stimulating collaborative projects and networks.

FP7 will also provide a framework to improve coordination, broadening and supporting financially ERA-NETs thus strengthening national and especially regional research programmes.

Another way is the use of Joint Technology Initiatives. These focuses on setting up long term public-private partnerships, where funding come from the private sector, national and European funding schemes, grants from the

Framework Programme and loans from the European Investment Bank. The selection for which Joint Technology Initiatives will be supported is based on Article 187 of the Treaty on the Functioning of the European Union ("The Community may set up joint undertakings or any other structure necessary for the efficient execution of Community research, technological development and demonstration programmes.") or on the Article 166 of the EC Treaty.

Last but not least, another way to implement and develop joint projects is through industry-led foras, called European Technology Platforms. These aim to develop "short to long-term research and innovation agendas and roadmaps for action at EU and national level to be supported by both private and public funding."[95] In particular their aim is to mobilize industry and other stakeholders within the EU to work together, sharing information and knowledge. ETP are independent organisations.

Ideas

The main objective of this programme is to reinforce creativity and dynamism in order to improve "Europe attractiveness" for the best researchers in the world. The main body of this programme is the European Research Council, an independent body that funds investigator-driven frontier research. The ERC Scientific Council is responsible for setting the ERC's scientific strategy including establishing the annual 'Ideas' Work Programme and calls for proposals, designing the peer review systems, identifying the peer review experts, and communicating with the scientific community. It works according to the principles of "scientific excellence,

[95] European Commission, CORDIS, http://cordis.europa.eu/technology-platforms/

autonomy, efficiency, transparency and accountability, and supports investigator-driven projects in 'frontier research'" [96].

People

This programme is entirely dedicated to human resources in research. Highly trained and qualified researchers are a necessary in order to advance science and technology innovation as well as an important factor in attracting investments and other partners. "People" aims therefore in strengthening in both quality and quantity the human potential available to European research by stimulating people to enter the profession of researcher, encouraging European scientists to stay in Europe while at the same time trying to attract researchers from all other the world to Europe.

The most popular and most important feature are the so called "Marie Curie Actions", which are a set of mobility research grant schemes funding pre- and post-doctoral researchers in Europe as well as experienced researchers. They are open to researchers of all ages and levels of experience, regardless of nationality.

Capacities

The "Capacities" programme aims to optimise the use and development of research infrastructures, while enhancing the innovative capacities of SMEs to benefit from research. It focuses especially on supporting access to existing research infrastructures, the construction of new ones and upgrading existing ones. The European Strategy Forum for Research Infrastructure (ESFRI) is the body for expert consultations on strategic issues related to research infrastructures. Supporting access to European infrastructures is also an important means for attracting researchers to

[96] European Commission, FP7, http://ec.europa.eu/research/fp7/understanding/fp7inbrief/what-is_en.html

Europe as well as developing or deepening cooperation with institutions in third countries. [97]

Capacities programme also focuses on "Specific Activities of International Cooperation" which supports regional dialogues between the Community and third countries.

Euratom

The European Atomic Energy Community (Euratom) is legally separated from the European community and therefore has its own Framework Programme. The FP7 Euratom programme covers both indirect and direct actions. The indirect action part of the program is managed by the Directorate General for Research and has 2 main core points:

- Fusion energy research, which aims to develop the knowledge needed for the construction and implementation of ITER as well as focusing on creating safe, sustainable and economically viable prototype. This includes the site preparation for ITER as well as its management, support, equipment and installation, R&D research and activities, construction and management of all related infrastructures and human resources education and training.
- Nuclear fission and radiation protection research which is funded through collaborative projects, networks of excellence and support actions.

The direct actions in nuclear energy are managed by the JRC, the Joint Research Centre. The JRC provides independent, custom driven, scientific and technical advice to the European Commission for the conception, development, implementation and monitoring of a wide range of EU policies. The budget the JRC has under FP7 is used to carry

[97] European Commission, Opening to the world: International cooperation in Science and Technology, Report of the ERA Expert Group, Directorate General for Research, 2008, EUR 23325 EN

out direct non-nuclear research. The main policies are therefore to support, inform and analyse specific EU policies, including the Lisbon agenda, which work towards the consolidation of a knowledge society with priorities for competitiveness and innovation and especially the European Research Area. In addition to this, JRC works toward an economically, environmentally and socially sustainable development. At the same time it contributes technological means for the detection and analysis of potential threats and the delivery of tools to improve the EU's prevention, monitoring and risk management capacities. [98]

Horizon 2020

As mentioned before, after FP7, the EU started a new framework programme, called Horizon 2020. This new research and innovation programme is the biggest EU research programme ever started. It will provide about €80 billion of funding over the 7 years long run (2014 to 2020)to support and encourage research in the European Research Area (ERA). In addition to these funding, also private and public national investment should be accounted for.

The main focus of Horizon 2020 relies on three key areas: excellent science, industrial leadership and societal challenges. The goal is to ensure that Europe is able to produce world-class science and technology to drive economic growth.

As the previous FPs, funding is divided into different categories. Apart the 3 main "pillars" that have been listed above, it also has 4 other areas; Spreading Excellence and widening participation, science with and for society, the European Institute of Innovation and Technology and Euratom.

[98]European Commission, CORDIS, Fusion Energy Research, http://cordis.europa.eu/fp7/euratom-fusion/home_en.html

Horizon 2020 Main Pillars

Excellent Science **(€ 24 billion)**	The objective of this first pillar is to "reinforce and extend the excellence of the Union's science base and to consolidate the European Research Area in order to make the Union's research and innovation system more competitive on a global scale." [99] It has 4 main area: • ERC (€ 13 billion) aims at providing funding for individual researchers and teams based on scientific excellence of the applications • Future and emerging technologies (€ 2.7 billion) aims at supporting collaborative research across disciplines on new and high-risk ideas and projects • Marie Skłodowska-Curie Actions (€6.1 billion), which aims at providing excellent and innovative research training as well as attractive opportunities through cross-border and cross-sector mobility of researchers. It is the main EU programme for doctoral training (it funds about 25 000 PhDs during the 7 years-run). It also co-funds national PhD programmes. • Research infrastructure (€ 2.5 billion), which aims at improving and developing Europe research infrastructure
Industrial Leadership **(€ 14 billion)**	This pillar focuses on improving "technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies." [100]It is managed by DG Enterprise and based on Europe 2020 and Innovation Union strategies. Its main areas are 3: • Leadership in enabling and industrial technologies, which provides support " for research, development and demonstration and, where appropriate, for standardisation and certification, on information and communications technology

[99] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/excellent-science
[100] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/industrial-leadership

	(ICT), nanotechnology, advanced materials, biotechnology, advanced manufacturing and processing and space." • Access to risk finance, which aims to help SMEs obtain funds for R&D and innovation, and develop an Union-level venture capital. COSME together with EIB and EIF will play an important role in implementing financial activities on behalf of and in partnership with the European Commission • Innovation in SMEs, which aims at providing both direct financial support and indirect support to SMEs to increase their innovation capacity.
Societal Challenges	This pillar addresses major concerns shared by citizens in Europe aiming at providing potential solutions for social and economic problems. Funding will focus on the following challenges: • Health, demographic change and wellbeing (€ 7.5 billion); • Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy (€ 3.8 billion); • Secure, clean and efficient energy (€ 5.9 billion); • Smart, green and integrated transport (€ 6.3 billion); • Climate action, environment, resource efficiency and raw materials (€ 3.1 billion); • Europe in a changing world - inclusive, innovative and reflective societies (€ 1.3 billion); • Secure societies - protecting freedom and security of Europe and its citizens (€ 1.7 billion); [101] • "Science with and for society" (€ 0.5 billion) and "Spreading excellence and widening participation" (€ 0.8 billion).

[101] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges

Other Areas funded within Horizon 2020

Spreading excellence and widening participation, which aims at creating and upgrading centres of excellence, improve national and regional research and innovation policies and providing researchers with better access to international networks	**Science with and for society**, which purpose is to improve effective cooperation between science and society in order to recruit new talent for science and to marry scientific excellence with social awareness and responsibility
European Institute of Innovation and Technology (EIT), which is working on "creating new environments where higher education, research, public administrations and business work together to produce disruptive innovation." [102]	**Euratom**, which focuses on both nuclear fission and radiation protection as well as on fusion research aiming at developing magnetic confinement fusion as an energy source, like ITER

Table 2: Horizon 2020 funding structure

In line with the Union's strategy for international cooperation in research and innovation as well as previous FPs, Horizon 2020 focuses on bringing together expert and researchers not only from all the EU members, but from all over the world. Not only does this provide sources of new ideas and expertise, it is also important to ensure that European researchers are able to collaborate worldwide with the best in the field.[103]

[102] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/european-institute-innovation-and-technology-eit

[103] European Commission, HORIZON 2020 in brief, The EU Framework Programmefor Research & Innovation, Directorate-General for Research and Innovation 2014

5.2 - European Research Area

The idea of a European Research Area, known as ERA, was firstly considered and analysed by Antonio Ruberti, a past Italian minister of Higher Education and former Rector of the University “La Sapienza” of Rome, in his book "Uno Spazio Europeo della Scienza", written in 1994 together with Michel André. It was formally launched after the initiation of the Lisbon Agenda in 2000. The Lisbon Strategy or Agenda was a plan devised to "make Europe, by 2010, the most competitive and the most dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion"[104]. Even though most of its goals were never reached, the idea was used to create the ERA. The main reason behind the plan were underlined by the Commission in the Papers, the white one on Growth, Competitiveness and Employment in 1993 and the green one on Innovation in 1995. The findings can be summarized in three main issues:

- Financial problem. Investments in research and development are lower than competitors
- Coordination. A better coordination of activity and programs within the EU is needed to improve the investments-results gap and avoid fragmentation and duplication
- Results. Transformation of technological discoveries into industrial products needs to be improved

In addition to the points listed above other important factors to be looked for are mobility for scientists and a re-focus on the modern world challenges such as climate change, energy and health.

[104] European Union Parliament Website Lisbon European Council 23 and 24 March Presidency Conclusion

The Commission plan with ERA is therefore that "research activities at national and Union level must be better integrated and coordinated to make them as efficient and innovative as possible"[105]. This can be achieved by creating an area where scientists, researchers, technology and knowledge can move freely while stimulating cooperation.

After some initial difficulties in carrying out the proposed objectives, in 2007, seven years after formally launching ERA, the Commission draws new ideas and redefined some other, which can be found in the Green Paper. The main points on which ERA is based are still very close to the original ones of 2000. The main concepts are the one of an "internal market" for free movement of scientists, technology and knowledge, an improved coordination of activities and programs at an European level and a framework for European funding for European states common initiatives. This should create organization capable of creating the right framework for private-public projects, thus allowing real sharing of knowledge, closing the gap between public research and companies/industry. In 2008 the Commission further underlined the importance of an "internal market" for research, dubbing it as the fifth freedom of knowledge after the four principles already present in the EU plans (free movement of people, goods, capital and services).

In order to reduce the fragmentation from a geographical prospective the EU, through ERA, is trying to align a variety of institutions and agencies and engage them in common research initiative all around Europe. The main issue still derives from the fragmentation created by the single nation states and their national policies which still defines most of the research funding schemes as well as the utilization of infrastructures and intellectual property regimes. At the same time the EU is also trying to reduce the

[105] Lisbon European Council, 23-24 March 200, Presidency Conclusions

inequalities in technological knowhow and investments between leading and lagging regions. This target is being engaged via two main tools. The first one is the Structural Funds and Cohesion Fund, which are financials tools to address regional disparities in terms of income, wealth and opportunities by funnelling most of their funding to Europe's poorer regions. The Structural Funds are made up of the European Regional Development Fund (ERDF) and the European Social Fund (ESF) and are one of the largest factors of the budget of the European Union. The second is through the Framework Programmes. They are particularly important in promoting networks for international scientific collaborations, especially since they are still relatively uncommon in caparison to the national ones. Hoekman in his "Science in an age of globalisation: the geography of research collaboration and its effect on scientific publishing" in fact pointed out that "FP funding is rather equally distributed across regions given their past scientific performance and that the impact of funding on subsequent publication output is highest for peripheral regions. The results suggest that FPs turn out to be more effective in establishing ties between poorly connected regions than in further strengthening existing ties between core regions. When doing the latter, FP funding is likely to substitute for other funding sources, which decreases the intended 'behavioural additionality' the FP projects aim to provide, since the impact of FP funding is the lowest for core regions."[106]

With ERA Europe has a great chance to augment the innovative potential of its member states and at the same time to play a major role in building a framework constituted by many different nations and people like it has ever be seen before. According to Art. 165 of the Nice Treaty of 2001, the Community and member states shall coordinate their research and

[106]Hoekman, J. (2012). Science in an age of globalisation : the geography of research collaboration and its effect on scientific publishing. Eindhoven: Technische Universiteit Eindhoven. ((Co-)promot.: prof.dr. K. Frenken& R.A. Boschma).

technological development activities’. This, even though it was present since the CREST mandate in 1974, it has been now made a crucial point in the agendas of the member states. The potential is there, but policy makers still need to find the best way to deal with how to make the best of it.

The first step that needs to be addressed is the identification of both one´s strengths and weaknesses as well as the ones of potential partners. At the same time it is necessary to point opportunities as well as threats and dangers and to find the best way to address the problem of competition versus cooperation. The EU has to main initiatives that can provide the data needed to take these decisions, the ERAWATCH, which provides information on European, national and regional research systems, policies, and programmes [107] and the Innovation Union Scoreboard which provides a comparative assessment of the research and innovation performance of the EU27 Member States and the relative strengths and weaknesses of their research and innovation systems [108].

This data and experience will then be used to find the best solution for partnerships, projects and joint activities within the ERA-Net scheme. There are a number of different issues that need to be considered when deciding the utilization of public funding for R&D projects. The business needs (innovation, value generation and international competitive advantage) should be balanced with those of the society (public sector renewal and production; international political relationships) and those of academia (scientific research and knowledge and international competition and cooperation). Additional considerations regarding the different types of scientific and technological activities, also need to be accounted for. ‘Big science’ decisions, for example, are governed by considerations of ‘indivisibility’ (the need to pool resources to tackle problems that are

[107] http://cordis.europa.eu/erawatch/
[108] http://ec.europa.eu/enterprise/policies/innovation/policy/innovation-scoreboard/index_en.htm

bigger than any one country could tackle alone); ‘excellence’ (the need to work with the best researchers in the world; and ‘global competition’ (the need for particular groups of countries to present a united front against other country groupings).[109]

It is therefore quite clear that to achieve a successful open ERA the Commission and the EU will require elements of multilateral and intra-regional cooperation. As Andris Piebalgs, the EU commissioner for Energy Policy, said on 10 January 2008: “‘If we take the right decisions now, Europe can lead the world to a new industrial revolution: the development of a low carbon economy’. This means that not only scientific and technological research must be ensured but also the development of better way to brings these discoveries to the market, in a way that can be effective and cheap for industrialised and for emerging economies.

[109] European Commission, Opening to the world: International cooperation in Science and Technology, Report of the ERA Expert Group, Directorate General for Research, 2008, EUR 23325 EN, pag 81

5.3 - Other European Union Organisations

European Research Agencies and Bodies

ERC - European Research Council	The idea for a European research agency for basic research was first considered during a meeting in 2001, following consideration about what the EU needed to implement the Lisbon Agenda. The ERC was formally launched in February 2007 as a component of the Framework Programme 7. The main reason behind ERC is to provide a new institution to implement funding based only on excellence and irrespective of nationality, gender or location. The ERC is made of two main governance structures; The Scientific Council (ScC), which consists of 22 European scientists, responsible for selecting the strategy and schemes to grant research founds and the ERC Executive Agency (ERCEA) which is responsible for supporting the peer review process and support the ScC in his operations. For the 7th Framework Programme the ERC budget was of €7.51 billion, supported by the EC and with contributions from states associated with the EU, but currently not members, the so called associated states, which (12 nations) together with the 27 forming the EU, also from the ERA.All funding grants given out by the ERC follow the two main principle on which the ERC was founded: the first is that research grant applications should be judged using the sole criterion of peer-reviewed excellence, independent of political, geographic, or economic considerations; the second ERC is to target frontier research by encouraging high-risk, high-reward proposals that may revolutionize science and potentially lead to innovation if successful. The ScC does not pre-select the frontiers but challenges applicants to identify and pursue them.[110]
REA - Research Executive Agency	The REA is a funding body created by the European Commission which purpose is to improve the efficiency and impact of research

[110] Simons, Kai, Featherstone, Carol, The European Research Council on the Brink, Cell, Volume 123, Issue 5, 2 December 2005, Pages 747–750

	programmes in Europe. Created in Brussels in 2008 by Commission decision, the REA is part of the ERA and the Europe 2020 program and Horizon 2020. Its management and administration structures include a Director, a responsible for Internal Audit, an ICS & legal affair responsible and three department: support, finance and administration. By the end of 2010 the REA was running almost half of the FP7 projects (about 4241) and has managed to reduce the time needs for grants as well as the payment time in different areas.
EASME - Executive Agency for Small and Medium-sized Enterprises	The EASME has replaced the EACI (Executive Agency for Competitiveness and Innovation) and manages a number of different EU programmes on behalf of the Commission. Among these we can find the COSME (Programme for the Competitiveness of Enterprises and SMEs), including the Enterprise Europe Network (EEN), the European IPR Helpdesk and Your Europe Business; Horizon 2020, with a special focus on the SME Instrument, the Energy Efficiency part of the “Secure, Clean and Efficient Energy“; the calls for proposals on Waste, Water Innovation and Sustainable Supply of Raw Material under the “Climate Action, Environment, Resource Efficiency and Raw Materials“;LIFE, the EU Programme for the Environment and Climate Action and others. The "mission" of EASME is to "help create a more competitive and resource-efficient European economy based on knowledge and innovation" by ensuring results and provide the Commission with valuable input for its policy tasks.
INEA - Innovation & Networks Executive Agency	INEA, the successor of the Trans-European Transport Network Executive Agency (TEN-T EA), officially started his activities on 1 January 2014 in order to implement a number of EU programmes, like the Connecting Europe Facility (CEF) and TEN-T and Marco Polo legacy programmes, and be a part of Horizon 2020 in areas such as smart, green, and integrated transport + Secure, clean and efficient energy. INEA's main objective is to increase the efficiency of the technical and financial management of the programmes it manages.

Table 3: European Research Agencies and Bodies

In addition to these main agencies and bodies, the European Union also has a number of Directorate General involved in specific area of research.

DGs involved in research

Agriculture and Rural Development	Climate Action
Communications Networks, Content and Technology (Connect)	Environment
Education and Culture	Enterprise and Industry
Energy	Mobility and Transport
Regional policy	Joint Research Centre

Table 4 : EU DGs involved in research

Furthermore there are a numbers of foras; two of the most important in the field of research are:

Other EU Foras

ESFRI - European Strategy Forum on Research infrastructure	ESFRI is an instrument created by the Commission in collaboration with Member States with the mission to support scientific integration in Europe and strengthen international outreach through a better use, development and management or research infrastructure. Research infrastructure are key components of the European Research Area both in advancing knowledge and in helping Europe compete in a globalized knowledge economy. One of the most important activities of ESFRI is the publication of the Roadmaps. The ESFRI Roadmap for Research Infrastructures, published in 2006 and updated in 2008 and 2010, identifies new RI meeting the needs of the European research communities. It is use to plan, implement and upgrade research infrastructures and help Member States in defining national budgets commitments. As part of ERA, ESFRI plays an important role in achieving the different targets proposed for EUROPE 2020 as many of the ESFRI Research Infrastructures are already providing an environment supporting research to address high priority areas and big scientific cooperation projects.

SFIC - Strategic Forum for International S&T Cooperation	Another strategic forum created to facilitate the development, implementation and monitoring of the international dimension of ERA is the Strategic Forum for International S&T Cooperation. Established in December 2008, it works as an advisory body to the Council of the EU and European Commission and it is composed of high-level representatives of the Member States and the European Commission. It's main focus is to increase coordination of international projects between Member States, Member States and the EU and third countries as well as sharing information and consultation between the partners to identify common priorities which could lead to coordinated or joint initiatives.

Table 5: EU Foras

5.4 - Fusion 4 Energy

Fusion for Energy (F4E) is the European Domestic Agency for ITER (see Chapter 6). It is a Joint Undertaking, which is similar to a common joint venture, i.e. "a business agreement in which the parties agree to develop, for a finite time, a new entity and new assets by contributing equity", with the difference that a European Joint Undertaking is a legal entity established under the Euratom Treaty. The term can be used to describe any activity proposed for the "efficient execution of Community research, technological development and demonstration programmes" [111]. The members of a Joint Undertaking are usually the European Commission and a number of non-profit industry-led organizations, SME's (Small and medium-sized enterprises), research organisations and universities.

The European Domestic Agency(DA) F4E has been created, together with the DA of the other participants, i.e. China, India, Japan, Korea, Russia, United States, to support the construction and operation of the International

[111] http://europa.eu/rapid/press-release_MEMO-07-191_en.htm

Experimental Thermonuclear Reactor (ITER) by providing the required in kind, cash and human resources. In addition to this the European DA has agreed to a "Broader Approach" project with Japan as well as to the construction and operation of DEMO (DEMOnstration Power Plant).

The F4E Joint Undertaking was created under the article 45 of the Euratom Treaty:

"Article 45

Undertakings of outstanding importance to the development of the nuclear industry in the Community may be constituted as Joint Enterprises within the meaning of this Treaty and in accordance with the provisions of the following Articles."

It was created by a decision of the Council of the European Union on 27 March 2007[112] for a period of 35 years, starting on 19 April 2007 (Article 1.1). Its headquarters are in Barcelona and the member of the organisation are: the Euratom, represented by the Commission, the Member States of Euratom and "third countries which have concluded a cooperation agreements with Euratom in the field of controlled nuclear fusion that associate their respective research programmes with the Euratom programmes and which have expressed their wish to become Members of the Joint Undertaking" (article 2). The Joint Undertaking is an "international body within the meaning of Article 151(1)(b) of Council Directive 2006/112/EC, and as an international organisation within the meaning of the second indent of Article 23(1)of Directive 92/12/EEC, of Article 22 point (c) of Directive2004/17/EC and of Article 15 point (c) of Directive2004/18/EC" (Article 1.4).

[112] "COUNCIL DECISION of 27 March 2007 establishing the European Joint Undertaking for ITER and the Development of Fusion Energy and conferring advantages upon it"Official Journal of the European Union L98: 50–72. Retrieved 30 June 2013.

Its tasks are defined in Article 1.2:

- Provide contribution to ITER
- Provide contribution to the Broader Approach Activities with Japan for the rapid realisation of fusion energy
- prepare and coordinate a programme of activities in preparation for the construction of a demonstration fusion reactor and related facilities including the International Fusion Materials Irradiation Facility (IFMIF)

More specifically the European DA will provide the components, equipment and equipment as well as supporting scientific and technological R&D in support of ITER construction. It will also provide the European financial contribution, arrange for the European staff available to ITER, manage procurements and oversee the preparation for the site and correlated activities. Regarding the Broader Approach project with Japan, F4E will also:

- Work on the production of the design and related activities of the International Fusion Materials Irradiation Facility (IFMIF -EVEDA)
- Work to upgrade JT60(Japan Torus), which is the flagship of Japan's magnetic fusion program, to JT-60SA by using niobium-titanium superconducting coils. This will help address key physics issues for ITER/DEMO
- Work designing and implementing DEMO through the International Fusion Energy Research Centre (IFERC) which implements three sub-projects at Rokkasho(Japan): DEMO Design and R&D Coordination Centre (DEMO Design, DEMO R&D), Computational Simulation Centre (CSC), ITER Remote Experimentation Centre (REC)

The F4E organisational structure is defined in articles 6 to 10 in the Annex of the Council Decision. The first of the governing bodies is the "Governing Board". The members of the governing board are represented by two members from each member of the Joint Undertaking, one of whom shall have scientific and/or technical expertise in the areas related to the activities of the Joint Undertaking. The Chairman is appointed for 2 years and the position can be renewed once. The activities and tasks appointed to the governing board are manifold and defined in Annex article 6.3 from point A to R. In general the Governing Board shall make recommendations and take decisions on any questions, matters or issues within the scope of the Joint Undertaking and in particular appointing the Director and Committee Members as well as adopting financial regulations, regulation for intellectual propriety rights, work programmes, rules for staff and budget.

The voting rights of the Governing Board are divided among all members, and distributed as illustrated in Table 1, and further discussed in the first Annex of the Council decision for the F4E:

Euratom	5	Italy	5
Austria	2	Latvia	2
Belgium	2	Lithuania	2
Bulgaria	1	Luxembourg	1
Cyprus	1	Malta	1
Czech Republic	2	Poland	3
Denmark	2	Portugal	2
Estonia	1	Romania	2
Finland	2	Slovakia	2
France	5	Slovenia	2
Greece	2	Sweden	2
Germany	5	Switzerland	2
Hungary	2	Spain	3
Ireland	2	The Netherlands	2
United Kingdom	5		

Table 6: Voting rights of the Governing Board of F4E

The second governing body of F4E is the Executive Committee. As stated in article 7, it is "composed of 13 members appointed by the Governing Board from among persons of recognised standing and professional experience in scientific, technical and financial matters relevant to the functions set out in this Article. One Member of the Executive Committee shall be Euratom." Half of the members are rotated every 2 years. The Chairman is appointed for 2 years and the position can be renewed once. The main function of the Executive Committee is to approve the award of contracts as delegated by the board as well as commenting and recommending on work programmes, resources estimates, annual budget and accounts drawn up by the Director.

The third governing body of F4E is the Director. As stated in Article 8 the director is the chief executive responsible for the day-to-day management of the Joint Undertaking and shall be its legal representative. It is appointed by the Governing Board among a "list of candidates proposed by the Commission following a call for expressions of interest published in the Official Journal of the European Union and in other periodicals or on Internet sites. The Director shall be appointed for a period of five years. After an evaluation of the Director's performance during this period by Euratom, and upon its proposal, the Governing Board may extend the term of office once for a further period of not more than five years." It is subject to the regulations of the European Communities and the Conditions of Employment of other servants of the European Communities, laid down by Regulation (EEC, Euratom, ECSC) No 259/68. Its main tasks are the preparation of work programmes, resources, budgets, annual activity reports as well as the implementation of controls in financial managements and internal affairs.

The scientific Programme Board is the fourth body of the governing structure of F4E. The members and the Chairman are appointed (Article 9) by the Governing Board. It advises the Governing Board and the director on the adoption and implementation of the project and work programmes. It also ensures coherence in the scientific and technical areas of the Joint Undertaking's activities with the overall European fusion programme.

In addition to these main bodies, the staff of the Joint Undertaking shall help the Director and the Governing Board in all F4E activities. F4E also has an advisory committee, called Audit Committee, which tasks are the examination and analysis of financial reporting, accounting, governance, internal control and risk management. The Audit Committee is composed of a Chairperson and four members appointed by the Governing Board on a proposition of the F4E Director. One member of the Committee is proposed by Euratom. All members are appointed for a period of two years.

The funding and resources needed by the Joint Undertaking are provided through four different channels, listed in Article 12; Euratom contributions through the Framework Programmes; Annual membership contributions from other Members; Voluntary contributions (e.g. for Broader Approach); Additional resources under terms agreed with Board. The annual membership contributions are calculated on the basis of the resources needed for administration and may not exceed 10% (estimated at €4-5 million per year) of the annual resources for administration.

The financial regulations used for the F4E Joint Undertaking are the same used in the JET. They define ceiling for award of contracts and the different procedures for the adoption of the annual budget, award of contracts etc.

The standard process used by Fusion 4 Energy to provide in-kind contribution of components has different steps. First of all, if there is research, development or any preparatory work to be done before a component may be produced, ITER may issue an “ITER task agreement” to anyone of the DAs in order for them to do the work requested. Then, the DA which received the request, will contract out the work to fusion laboratories or similar institutions, supporting the development (usually about 40% will be supported). If the development was successful (according to the specification in the ITA and satisfaction of ITER, the DA which carried out the work will receive a certain amount of ITER credit in recognition of the contribution. When the design is ready, the DA will close an agreement with ITER, called “procurement arrangement”, and initiate the procurement procedure to competitively bid for the work. The best offer in price/quality will be selected among the possible contractors.

When the component is delivered in accordance with the procurement arrangement specifications, the DA will be awarded a certain amount of ITER credit in recognition of the contribution.

6.0 - ITER

"*There will be a day when ITER will become largely energy self-sustaining; That will be one of those great moments in science - analogous to Fermi's achievement of nuclear fission on the 2nd of December 1942*"
Professor Steve Cowley, CEO of UK Atomic Energy Authority.

Nuclear fusion is the process occurring at the core of the sun, and resulting in an energy source able to release a tremendous amount of energy that we perceive as light and warmth. It results from the fusion of two hydrogen atoms (one proton and one electron) into a heavier helium atom (two protons, two electrons and two neutrons) due to the incredibly high temperatures present in the sun (of the order of 15.000.000° Celsius).

It can be artificially reproduced in a laboratory setting in a slightly different way (see Fig.8) but it requires temperatures even higher than those occurring in the sun. This means huge and expensive experimental apparatus, such as ITER. A major advantage of this process, is that it produces a new source of energy "clean" (at variance of the nuclear reaction) and essentially endless.

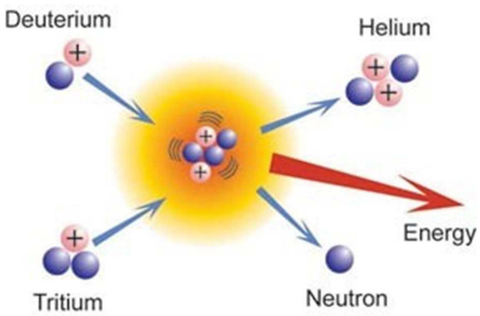

Fig.8: ***Fusion process*** [113]

[113] http://www.iter.org/sci/whatisfusion

ITER, Latin for "the way", stood in origin for International Thermonuclear Experimental Reactor. It will be the world's largest experimental tokamak nuclear fusion reactor. To be built near Cadarache in France, if successful, will be one of the most important milestones in the history of energy production technologies.

ITER objectives are manifold:

- Momentarily produce ten times more thermal energy from fusion heating than is supplied by auxiliary heating.
- Produce steady-state plasma with a Q value greater than 5.
- Maintain a fusion pulse for up to 480 seconds.
- Develop technologies and processes needed for a fusion power plant — including superconducting magnets and remote handling.
- Verify tritium breeding concepts.
- Refine neutron shield/heat conversion.[114]
- Achieve production of about500 MW(until now the Joint European Torus reactor produced 1.7 MW while the Tokomak fusion test reactors (TFTR) produced 10 MW.

Nuclear fusion is then a process "during which light atoms fuse to form heavier ones. During the fusion of elements with low atomic numbers substantial amounts of energy is released."[115] In the case of ITER the light elements which will be used to achieve nuclear fusion are deuterium and tritium, both isotopes of hydrogen. Deuterium can be extracted from sea water while tritium can be made from deuterium in contact with lithium (thus the idea is to "bred" it in the reactor walls).The two elements, once they overcome the electrostatic repulsion, come together to form a helium nucleus (an alpha particle), and a high-energy neutron. The most difficult

[114] "Why ITER?".The ITER Organization. Retrieved 13 September 2009./ http://en.wikipedia.org/wiki/ITER
[115] http://www.nuclearfiles.org/menu/key-issues/nuclear-weapons/basics/what-is-fusion.htm

part of fusion (apart reaching the necessary pressure-temperature) is the confinement of the plasma, where the reaction occurs. The major division in plasma containment technologies is between magnetic and inertial confinement. In magnetic confinement the plasma is kept together by the so called Lorenz force between currents in plasma itself and externally produced magnetic fields. The dimension of the plasma "ball" can range from 0.1 to 10 meters. The other type of confinement is achieved through inertia. This means there is "nothing" counteracting the expansion of the plasma, thus the confinement is simply the time it takes the plasma pressure to overcome the inertia of the particles. This is achieved by repeatedly "bombarding" a compressed fuel target ("pellet") with high energy lasers. The range of the plasma in this case ranges from 1 to 100 micrometres. Recently this kind of fusion process achieved, for the first time in history, the milestone of achieving fuel gains greater than 1. This has been achieved in February 2014 at the National Ignition Facility (NIF) of the Lawrence Livermore National Laboratory in the United States. This experiment used a small pellet of deuterium and tritium which was hit by 192 laser beams, concentrated in short duration impulses. Yet, self-sustaining fusion reaction are still far from being realized. The main problem at the moment is that we are still not able to avoid that ions and particles, once they reach the high fusion temperature, leave the plasma thus shutting down the reaction.

The ITER will use magnetic confinement with a torus shaped tokamak. The tokamak design was first presented to the public in 1968 by Russian researchers and achieved results far greater than any other magnetic confinement designs. At the moment the largest facility in operation using this design is the JET, the Joint European Torus, built in Oxfordshire, UK. Its purpose was to open the way for ITER and DEMO.

Why nuclear fusion? If achieved, nuclear fusion would be able to provide a source of energy with abundant resources and major environmental advantages. Deuterium can be find in common marine water; tritium can be bred using lithium, also quite common on the earth crust. Nuclear fusion does not emit harmful toxins into the atmosphere, like CO_2; it produces only helium, a gas that is already in abundance in the atmosphere and will not contribute to global warming. It also removes the 2 main problems linked to nuclear fission: nuclear waste and danger of fallout. No long-lived radioactive materials are produced. Radioactivity is produced by neutrons interacting with the reactor structure, but decays rapidly with the proper selection of low-activation materials. Regarding safety, nuclear fusion reaction is self-limiting as far as plasma pressure is concerned. There is no require for fast-acting emergency cooling systems as fusion power density and radioactive decay heat densities are moderate. Furthermore, with the development of appropriate materials, tailored to minimize induced radioactivity, the wastes from fusion power would not need to be isolated from the environment for more than one hundred years.[116]

Of course it can be argued that the money invested for fusion could be focused elsewhere, as for at least the next 30 to 50 years "nuclear fusion will neither tackle climate change nor guarantee the security of our energy supply" (Rebecca Harms, Green/EFA member of the European Parliament's Committee on Industry, Research and Energy). But this argument as such, it is not really a compelling one. Yes, the money spent on fusion development is a lot, but it is still very little compared to other less important costs supported by world nations. A more careful management of these strategic plans from the leaders of the world nations

[116]Shimomura, Y., The present status and future prospects of the ITER project, Science Direct, Journal of Nuclear Materials 329–333 (2004) 5–11

would then result into a higher available budget that can then be used for these important issues.

6.1 - History of the ITER

The pursuit for clean and limitless resource of energy has been the elusive pursuit of many scientists for a long time. The idea of designing and constructing an international financed experimental facility to develop fusion technology became something concrete only near the end of the Cold War, when the two at the time most powerful nations in both science and economy started to reopen dialogue. It was, for example, Ronald Reagan, the 40th President of the United States, who sent the Congress, on March 22 1985 a message underlining the importance of common projects.

“[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.”

Shortly after, during a Geneva Summit in 1985 with Mitterrand, Thatcher and Gorbachev, Reagan took a more defined position regarding common energy projects: : “[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.”

It was during this summit that the decision to start a project aimed at developing fusion energy for peaceful purposes first was made thus beginning the history of the creation of the ITER. It still took 22 year for the parties to find a common ground and sign the agreement which created the ITER organisation in 2007. During the following summit in Reykjavik in October 1986 the proposal for an experimental fusion facility called "International Thermonuclear Experimental Reactor" was made. Two years later the design phase began.

The story of the creation of the ITER agreement is a really fascinating case of study due to the intersection of science, politic and diplomacy in difficult time and for a scientific project where the four parties had a hard time to reach an agreement, especially because of the constantly increasing costs and the huge differences in the legal and policy rules for international projects. These early difficulties resulted in the United States leaving the project in 1998, only to re-join it in 2003, after 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)."[117] This ended with a near-unanimous endorsement for the importance of a burning plasma experiment for fusion energy thus the decision to move ahead with the ITER project. As President George W. Bush 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.

[117]Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

House and Senate, which are considering the Energy Bill containing language authorizing U.S. participation in ITER."[118]

The renewed interest of the United States in the project also had a positive effect on the interest of the latest three partners, China, South Korea and India, who followed the US and joined the project shortly after.

The next step was the choice of the site for the construction of the ITER. Russia, China, and the EU wanted ITER to be built in Cadarache, France, while US, South Korea, and Japan supported Rokkasho-mura, Japan as construction site. The final decision to build ITER in France was reached thanks 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.[119]

6.2 - The Agreement

Probably the most difficult diplomatic step in the creation of the ITER was the writing and signing of the agreement, which entered into force on 24, October 2007. [120] The agreement has been ratified by the People's Republic of China, EURATOM, the Republic of India, Japan, the Republic of Korea, the Russian Federation and the United States of America. European countries did not ratify the agreement singularly, but they did through EURATOM. For the EU the agreement has been concluded following a Council decision of 25 September 2006 which authorises the Commission to conclude it. The EU, acting on the basis of the Treaty establishing the

[118]Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

[119]Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

[120] Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project, IAEA 25 April 2007

European Atomic Energy Community, confirmed to the AIEA its adoption of the ITER Agreement to the IAEA on 5 February 2007. Its legal basis can be found in the Treaty establishing the European Atomic Energy Community, signed on the 25 March 1957, in articles 101, 124, 192. [121] This treaty, signed initially by the Governments of Belgium, Federal Republic of Germany, France, Italy, Luxembourg and the Netherlands has been consolidated in 2007 with the "Consolidated version of the Treaty establishing the European Atomic Energy Community".

There were many key points in the agreement for which was necessary to find a solution.

Type of Agreement

This was mostly a problem for the United States, i.e. what form the ITER agreement should use, either as a treaty or as an executive agreement.

Under the U.S. law, treaties have the following characteristics, which differ from the international law:

- treaties are equivalent in status to Federal legislation;
- a distinction is made between the terms treaty and agreement;
- the word treaty is reserved for an agreement that is made by and with the Advice and Consent of the Senate (Article II, section 2, clause 2 of the Constitution);
- agreements not submitted to the Senate are known as executive agreements; and
- regardless of whether an international agreement is called a convention, agreement, protocol, accord, etc., if it is submitted to the

[121] Treaty establishing the European Atomic Energy Community, 25 March 1957

Senate for advice and consent, it is considered a treaty under U.S. law.[122]

Therefore for the U.S. law the processes for negotiating and implementing treaties and agreement are different.

Treaty Making Process

- Secretary of State authorizes negotiation.
- U.S. representatives negotiate.
- Agree on terms, and upon authorization of Secretary of State, sign treaty.
- President submits treaty to Senate.
- Senate Foreign Relations Committee considers treaty and reports to Senate.
- Senate considers and approves by 2/3 majority. President proclaims entry into force.

Agreement Making Process

- Secretary of State authorizes negotiation.
- U.S. representatives negotiate.
- Agree on terms, and upon authorization of Secretary of State, sign agreement.
- Agreement enters into force.[123]

Executive agreements are one of the three mechanisms used by the United States to enter into binding international agreements. Sole executive agreements are made solely by the President of the United States and cannot go behind the President's constitutional powers. Congressional-

[122]International Legal Research Tutorial, Duke University School of Law and University of California, Berkeley, School of Lawhttps://law.duke.edu/ilrt/about.html
[123] International Legal Research Tutorial, Duke University School of Law and University of California, Berkeley, School of Lawhttps://law.duke.edu/ilrt/treaties_3.htm

executive agreements are made by the president and Congress. A majority of both houses makes it binding much like regular legislation after it is signed by the president. Treaties are formal written agreements specified by the Treaty Clause of the Constitution and they require the advice and consent of 2/3 of the Senate

Normally, agreements with fixed funding commitments cannot be concluded as executive agreement. The EU, especially as host partner and the one which was investing the most in the project, wanted a clear, legally binding funding commitment, which, because of the requirements seen before, could have taken years for the Senate to implement. In addition to this other parts of the agreement, like liability, withdrawal and provisions would have made the Senate reject it completely as too much of a risk.

The breakthrough came within a wider package of energy reforms, called the Energy Policy Act, in 2005. With the act the "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".[124]

This allowed the EU and the United States to find a compromise. The treaty would be concluded as a congressional-executive agreement while the withdrawal, liability and settlement disputes issues were resolved by adding 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

[124]Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

documents laying out financial contributions and in-kind contributions"[125] and that these amounts could be updated in future.

The signing of congressional-execute agreements instead of treaties for the U.S. is a relative common "procedure"; for example the NAFTA, the WTO's agreement as well as the bilateral FTAs have all been approved by majority vote of each house rather than by two-thirds vote of the Senate. [126] There are many reasons behind this decision. First of all it allows for more fast implementation and enforcement of agreements. "Moreover, securing the consent of two-thirds of the Senate to a treaty, along with the consent of both houses of Congress for implementing legislation, is a daunting task. By design, the Constitution’s supermajority requirement for treaties—among the highest bars imposed by the Constitution—allows ideological or regional minority interests in the Senate to frustrate the will of the majority." [127]This is mostly due to the frames set by the Constitutions, which do not respect the today situation. At that time it was expected that international agreements would be relatively rare and the number of seat in the Senate was 26, very different from the 100 seats the Senate has today. Last but not least, "the Senate typically takes up treaties only after they have been approved by its Committee on Foreign Relations. As a general rule, that committee will not act on a treaty if a minority of the committee objects and demands further time to consider the matter, resulting in an informal committee “hold.” The objection of a single Senator has prevented some treaties from ever being voted on by the committee (let alone the full Senate. Although the Senate has only rejected seven treaties in the past century, 45 treaties currently languish in the Senate, some of these dating

[125]Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

[126] Smith, Jane M., Shedd, Daniel T.,Murril, Brandon J., Why Certain Trade Agreements Are Approved as Congressional-Executive Agreements Rather Than Treaties, Congressional Research Service, April 15 2013

[127] Purvis, N., Paving the way for U.S. Climate Leadership, the case for executive agreements and climate protection authority, RFF DP 08-09, April 2008 pag 10

back to the 1940s".[128] This forced the Presidents to find alternatives to the treaty process, often keeping Congress in the dark.

Governance

The ITER Agreement has established the ITER Organisation (IO) which is responsible for all aspects of the ITER project, i.e. licensing procedure, hardware procurements (which is provided mostly through the DAs), the twenty-year operation period, and decommissioning.

Since the agreement was signed, the ITER organisation chart has changed quite a bit, trying to be more effective and providing a better framework.

The "top body" of the IO is the ITER Council, which has authority in appointing staff, amend regulations, budget and participation in the project of third parties. It meets twice a year. The Council is composed of four representative for each Member, has a Chair and a Vice-Chair, elected amongst the members and two advisory committees: the Science and Technology Advisory Committee, which advise the Council on science and technology issues that arise during the course of ITER construction and operation, and the Management Advisory Committee, which advises the Council on strategic management issues, budget allocations, application of privileges and immunities, and recommended administrative action to facilitate the work of the project.

The IO also appoints a member of the staff as Secretary, who shall perform his duties independently, solely to the interest of the Council, taking no instruction from any member. In addition to these bodies, there is an Internal Audit Service, a legal affair office, an office for the coordination between IO and DAs as well as eight Directorates, each covering a specific part of the project (general administration, management, plasma operation,

[128] Purvis, N., Paving the way for U.S. Climate Leadership, the case for executive agreements and climate protection authority, RFF DP 08-09, April 2008 pag 11

tokamak, plant system engineering, heating diagnostics and CODAC, building and site infrastructure, project control and assembly).

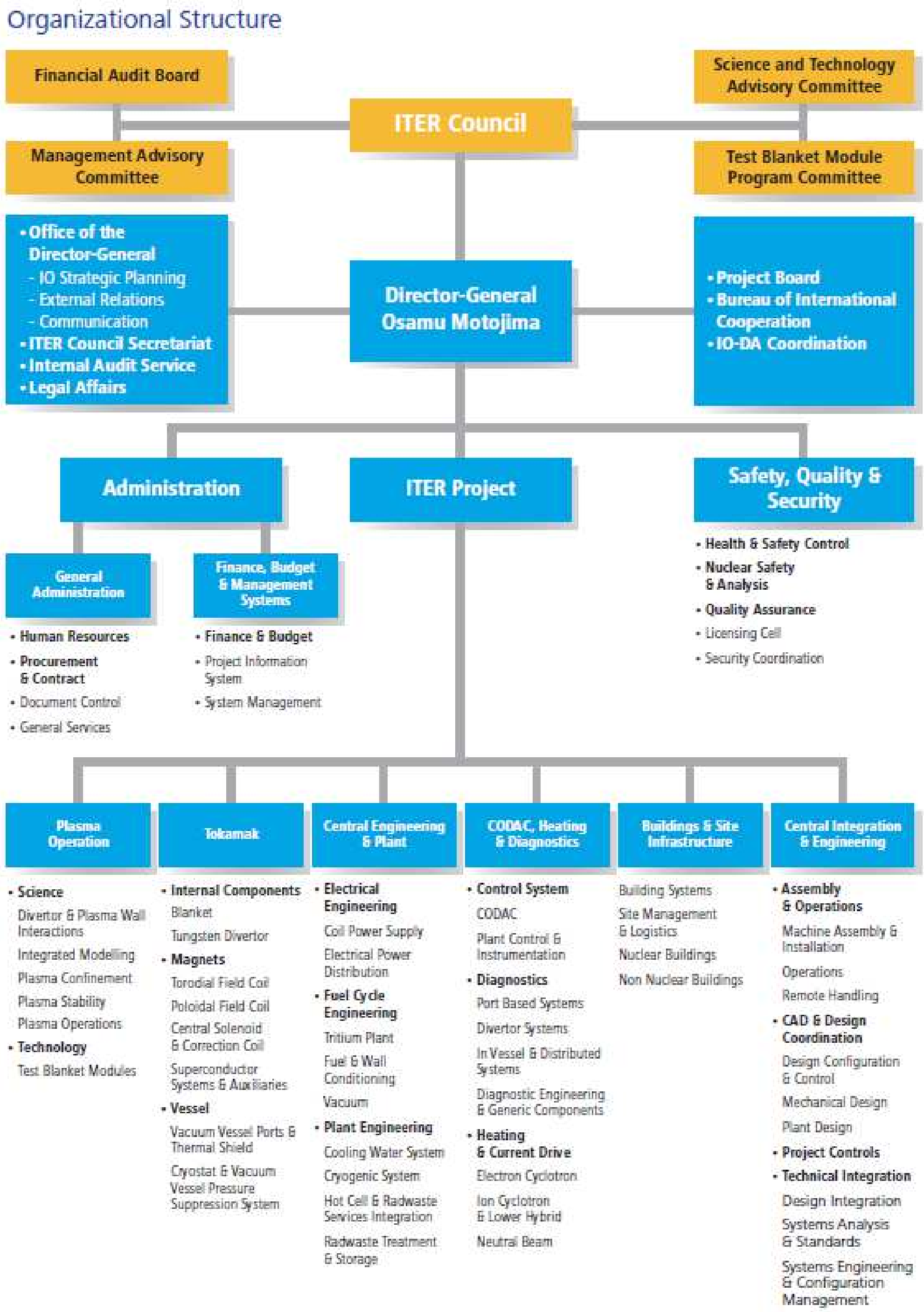

Fig.9: ***IO Organisational Structure*** [129]

[129] www.iter.org

In accordance with article 6 of the ITER Agreement, voting decisions adoption requires six or more votes in favour during the construction phase (out of 9, 1 for each member and 3 for EURATOM) and eleven of more during the operational phase (out of 20, 6 for EURATOM, 3 for Japan and US, 2 for the other members).

Funding

Another key issue was to decide what form funding commitments for the parties would take. This point was mostly problematic due to the continuous increase in costs and their uncertainty. In addition to this, it had also to be considered a way to account the shares in multiple currencies. The financial commitments were in the end placed in a separate document, allowing the council to adjust them by consensus over time.

ITER will be financed by the members of the organization, with different shares values for each phase. During the operation phase, the EU has responsibility for approximately 45.5 percent of construction costs, whereas China, India, Japan, Korea, the Russian Federation and the United States will contribute approximately 9.1 percent each. For the Operation Phase, which is planned to start in 2019, Europe will provide 34 percent, Japan and the United States 13 percent, and China, India, Korea, and Russia 10 percent.

The contribution for the projects will be provided by the members as "in-kind" contribution (90%) and as cash (10%).

To avoid the problem of dealing with multiple currencies, fluctuations and variable purchasing power the ITER organization uses a unique currency, developed specifically for this project, called ITER Units of Account (IUA or kIUA). For the construction phase, the members agreed to cap the expenditures to 4700 kIUA (in thousands), in accordance with the Baseline adopted in July 2010 by the ITER Council. For the Operational phase, which should start in 2019 and end in 2037, the per year estimated cost is 188 kIUA. For the Deactivation (2037-2042) and Decommissioning phases, the costs have been established in euro at EUR 281 million and EUR 530 million respectively (EUR in 2001 values).[130]The value estimates for the ITER costs during all phases have been defined in 2006, in a document called " Value Estimates for ITER Phases of Construction, Operation, Deactivation and Decommissioning and Form of Party Contributions".

The value estimated are detailed in Table 2

ITER Phases	**Value in kIUA or MEuros[131]**	**Form of Contributions[132] and References**
Construction Phase	**3577.7[133]kIUA Total**	
1. Direct Capital	3020.7	Mainly in-kind for hardware and assembly/ test of Tokamak components Cash mainly for installation/test of non-Tokamak components *References*: ITER EDA Doc. Series 24 and N-12ROM Attachment 5-2 on Procurement Allocation
2. Management and Support consisting of ITER Organization and staff (employees plus secondees) and infrastructure	477.0	Cash for employees, secondee allowance, infrastructure, etc. In-kind for secondees *Reference*: ITER EDA Doc. Series 24
3. R&D During Construction	80.0	Cash *Reference:* ITER EDA Doc. Series 24
Operation Phase	**188.0 kIUA per Year**	
1. Personnel	60.0	Cash for employees,etc. In-kind for secondees

[130] http://www.iter.org/faq

[131]OnekIUA equals one million US dollars (January 1989); Euro figures are at January 2001 values

[132]In kind contributions are measured in kIUA. Cash contributions are to be in Euros. To establish the kIUA value of cash contributions, the Euros shall be de-escalated to Euros (January 1989) using proven inflation rates, and then converted to millions of dollars (January 1989) to yield kIUA.

[133]Some of these values have been recalculated after approved changes in ITER designs. The actual construction phase value is capped at 4700 kIUA

		Reference: ITER EDA Doc. Series 24
2. Facility Operation (e.g. energy, fuel, maintenance, upgrades)	128.0	Cash and In-kind *Reference:* ITER EDA Doc. Series 24
Deactivation Phase	**281 MEurosTotal**	Cash *Reference*: NSSG-8 Decommissioning Input Appendix D
Decommissioning Phase	**530 MEuros Total**	Cash *Reference:* N-12 ROM Attachment 8 on Project Resource Mgmt. Regs

Table 7: Value estimates for ITER different phases

Further tables in the document provide more detailed values for each phase and member.

Construction Phase

Sharing of the estimated costs for the Construction Phase, expressed in both % of the sum of the contributions and in ITER units of value:

Host Party (EU),	45.46%	1626.23 kIUA
Each Non-Host Party	9.09%	325.245 kIUA
--		
All Parties	100.0%	3577.70 kIUA[134]

Table 8: Value estimates for ITER construction phase

(Note that this Contribution for Construction is that Contribution provided by each Party as its share of the agreed total estimated Construction Cost as contained in the Final Design Report of the ITER EDA and adjustments for split procurements.)

[134] This values has been updated to match the 4700 kIUA estimated after new ITER design

Operation Phase

Sharing of the estimated costs for the Operation Phase by the Parties, expressed both in % of the sum of contributions and in ITER units of value:

CN	10%	18.80 kIUA/year
EU	34%	63.92 kIUA/year
IN	10%	18.80 kIUA/year
JA	13%	24.44 kIUA/year
KO	10%	18.80 kIUA/year
RF	10%	18.80 kIUA/year
US	13%	24.44 kIUA/year

All Parties	100%	188.00 kIUA/year

Table 9: Value estimates for ITER operation phase

Deactivation Phase

Sharing of the estimated costs for Deactivation by the Parties, expressed both in % of the sum of contributions and in MEuros:

CN	10%	28.10 MEuros
EU	34%	95.54 MEuros
IN	10%	28.10 MEuros
JA	13%	36.53 MEuros
KO	10%	28.10 MEuros
RF	10%	28.10 MEuros
US	13%	36.53 MEuros
All Parties	100%	281.00 MEuros

Table 10: Value estimates for ITER deactivation phase

The sharing of estimated costs for Deactivation is proportionally the same as that for Operation because the Deactivation burden is determined by the outcome of the Operations period.

Decommissioning Phase

Sharing of the estimated costs for Decommissioning by the Parties, expressed both in % of the sum of contributions and in MEuros:

CN	10%	53.0 MEuros
EU	34%	180.2 MEuros
IN	10%	53.0 MEuros
JA	13%	68.9 MEuros
KO	10%	53.0 MEuros
RF	10%	53.0 MEuros
US	13%	68.9 MEuros
All Parties	100%	530.0 MEuros

Table 11: Value estimates for ITER decommissioning phase

Sharing of the estimated costs for Decommissioning is proportionally the same as that for Operation because the Decommissioning burden is determined by the outcome of the Operations period.

NOTE 1: 'Decommissioning' is understood to mean the actions dealing with the end-state of the ITER Facility following Operations with D-T fuels which will have activated the structure. It is for this reason that the Cost Sharing for Decommissioning is the same as that for Operation.

Should the ITER Facility be disassembled before it is activated, the costs of disassembly would be shared in proportion to the Cost Sharing for ITER Construction.

NOTE 2: The Parties will plan to provide their contributions to the costs of decommissioning by regular annual payments during the course of the ITER operations into a dedicated fund. In the case of a Party withdrawing from ITER after the start of operations, the Party is to contribute its share of the Decommissioning Fund to the extent that the decommissioning liability will have accrued by the date on which its withdrawal takes effect.

NOTE 3: The Host Party shall take responsibility for material increases in the costs of ITER construction resulting from any significant changes of regulations made by the competent authorities of the Host State after the date of the initial application for the license, except for those that result from changes in international regulatory standards that do not solely stem from Host Party regulations.

Providing "in-kind" contributions means that members do not report the actual costs, but they only provide their % of contribution, measured in kIUA only. The "organisational structure" for contribution is shown in the following image:

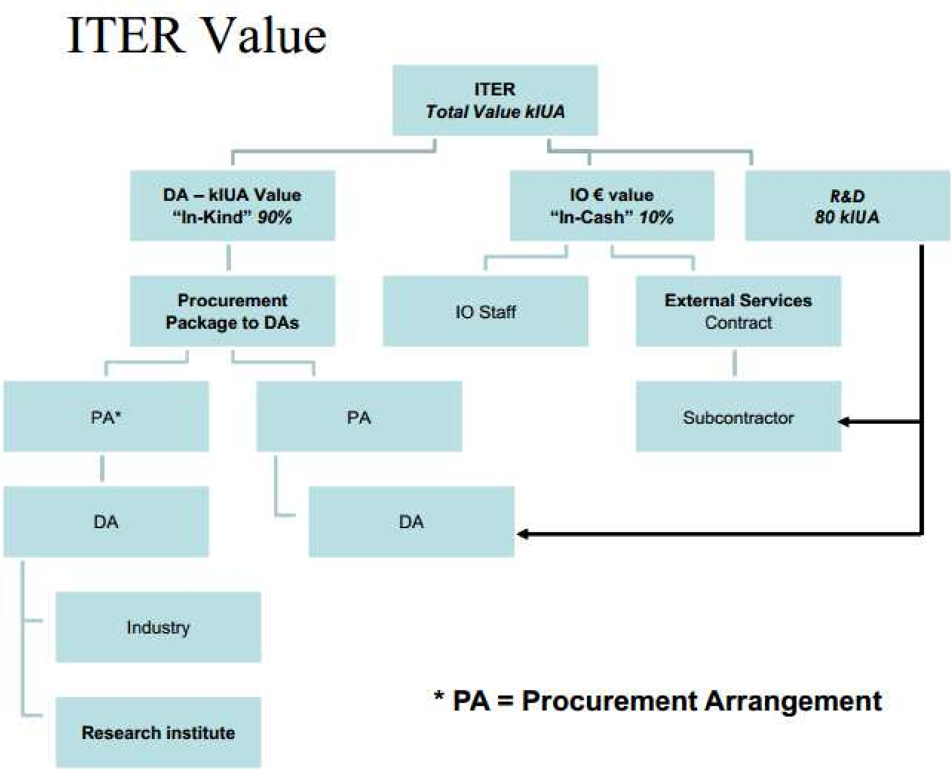

Fig.10: ***ITER Value and Procurement Arrangement Structure*** [135]

This kind of "division" is further complicated by the actual assigning of the provisions agreement. In fact, even single components or elements of the ITER will be provided by multiple members, each providing their own assigned % of a specific element. We will discuss the problems this signifies later.

The actual division of the provisions for each element is defined in a document, the "Common Understandings on Procurement Allocation" where a table (see under) provides "a comprehensive and technically satisfactory basis for assignment of fabrication responsibilities during the ITER construction by taking into account each Party's capabilities and priorities." [136]

[135] Final Report of Negotiations on ITER Joint Implementation, 1 April 2006
[136] Final Report of Negotiations on ITER Joint Implementation, 1 April 2006

Summary tables with specifics about procurement allocations and division of production of ITER components can be found in Annex I.

Procurement Arrangements are a unique ITER invention. Considering that often procurement of one component is shared among multiple DAs, there is a need for a clear management infrastructure, in order to assure quality control, regulatory requirements and risk management. Therefore any work under PAs must follow the ITER project infrastructure which is there to assure full and proper integration of all components as well as the French (as Host Partner) nuclear regulations. After receiving the PA, DAs can start the so called "call for tender".

All call for tenders must follow specific steps to assure quality, feasibility, technological requirement and proper integration with other components.

- First Step: Call for nomination, during which DAs nominates potential suppliers
- Second Step: Pre-qualification, during which it will be ensured that potential suppliers have the necessary resources, experience and technical requirements to provide the component.
- Third Step: Call for tender, during which IO specifies schedule, technical and commercial requirements and other details. After this the potential suppliers that qualified send their offers. After that a technical and financial evaluations follows to determine the best supplier. [137]

Liability

This was a significant concern, especially for the EU, which pushed for legally binding and clear commitments, while most other members

[137] 23

preferred more flexibility. Each party tried to find a solution which was the most acceptable and familiar to their own domestic system. In the end, as for many other issues, a compromised was reached, especially after US pressure. The liability article (Art. 15 of the Agreement) includes the phrase "Membership in the ITER Organisation shall not result in liability for Members for act, omissions, or obligations of the ITER Organisation". This means that, for example, if there were to be damaged suffered for example by Switzerland, which is not a member of the ITER Organisation, the members would be "free" from any liability, as the contractual limitation for third parties would be *Res inter alios acta, aliis nec nocet nec prodest.* There is indeed a article that 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.[138]

Withdrawal

Also for this aspect the EU came to an agreement, which was not exactly what it wished as major contributor. In fact the EU wished a full financial responsibility also in case of withdrawal, both for the construction as well as the operation costs. In the end, as per Article 26 of the Agreement, the members are able to withdraw after a period of 10 years; even if a party withdraws before the end of the construction phase, he is required to contribute to the construction costs, but not for the operation costs. If a

[138] Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

withdrawal takes place during the operation phase, the member is required to contribute to the decommissioning costs of ITER.

Dispute

Even though the US managed to keep out legally binding dispute settlements, in case of issues among the members in connection to the agreement, all parties agreed that the dispute should be settled through consultation, mediation or "other procedures to be agreed, such as arbitration" [139] (in case consultation or mediation was not successful), within 30 days with the aim of a fast and early solution. If the parties cannot find a proper solution by mediation, the chair of the council or another member of the council (if the chair represents one of the parties in dispute) will act as a mediator to attempt to resolve the dispute.

Privileges and Immunities

Privileges and immunities was another critical point, as most of the members were prepared to ratify the agreement giving the organisation itself and its staff way greater privileges than the ones the Unites States could by designating the ITER as an international organisation for purpose of the United States International Organisations Immunities Act (IOAI).

This created a problem as the other members would not accept provisions addressing the US specifically. In the end the solution was reached by concluding the agreement without specifically mentioning the US. For its part the US "would specify in a separate political declaration that it would implement the privileges and immunities in the ITER Agreement consistent with the IOIA." [140]

[139] ITER Agreement, Art. 25

[140] Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

The Art. 5 specify that the ITER has an international legal personality including the capacity to conclude contracts, agreements, institute legal proceedings, obtain licenses and acquire, hold and dispose of propriety.

Art. 12 clears the immunities and privileges of the staff and the ITER Organisation. It specifies that these are the ones required and necessary to exercise its functions and can be waived if such immunity would impede the course of justice.

Staff

The staff working for the IO is also a "melting-pot", where people from 25 different nationalities (2012 data) work together.

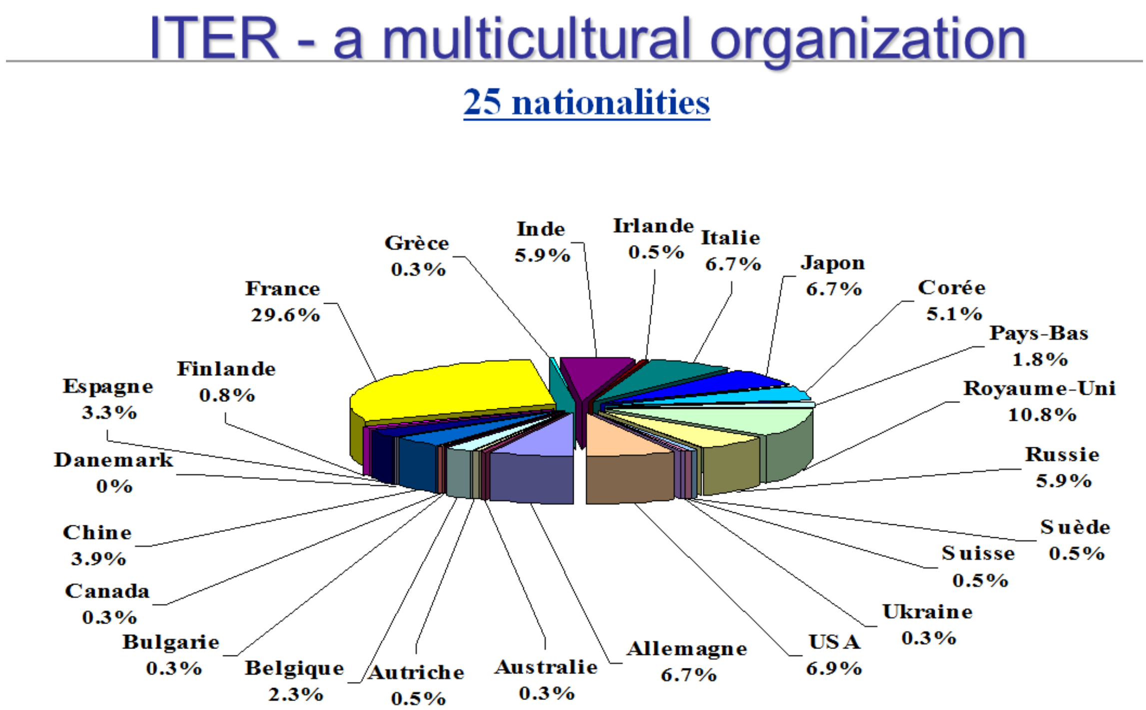

Fig.11: ***ITER personnel per country*** [141]

At the beginning of 2013 the IO employed 477 direct staff, which will be 565 at the end of the same year. [142]

[141] Dulon, Krista, Sharing the ITER Pie, ITER Newslinehttp://www.iter.org/newsline/96/1318

Staffing tables

Staff by Member	31/12/2011	31/12/2012
China	20	18
Euratom	304	312
India	29	30
Japan	35	35
Republic of Korea	26	30
Russian Federation	23	24
United States of America	34	28
Total	**471**	**477***

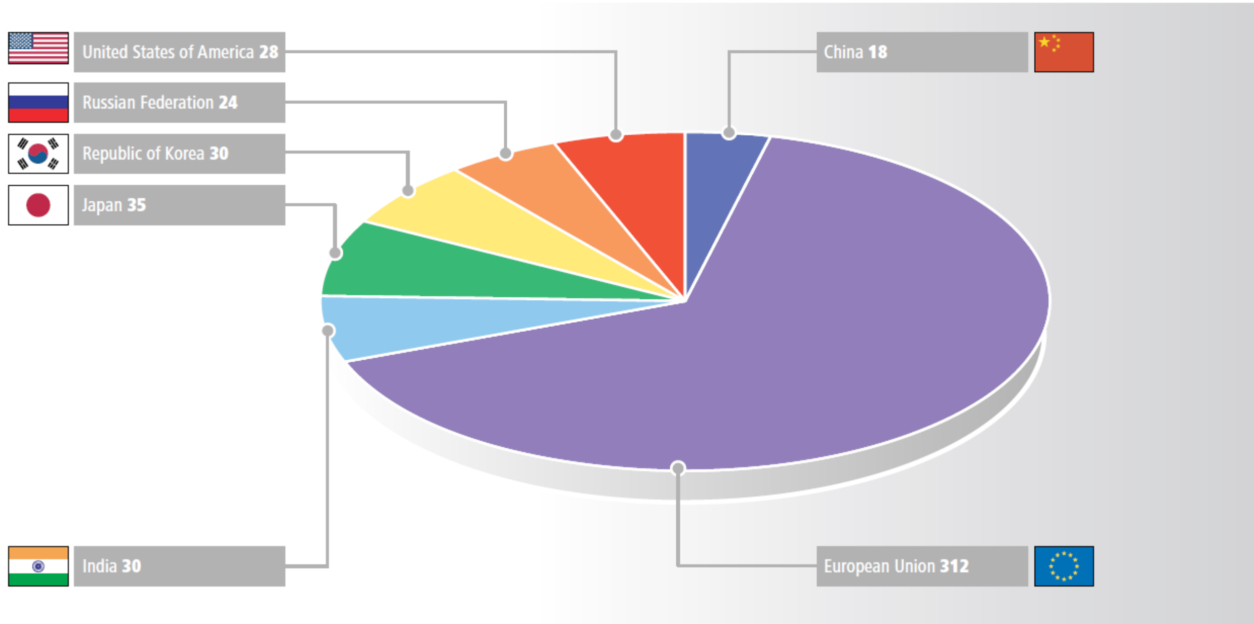

Fig.12: ***ITER staff members per Member State*** [143]

<u>Information and Intellectual Propriety Rights</u>

In ITER, as in all international projects, intellectual propriety is generated by different entities to achieve a common objective. Therefore a set of clear rules must be established in order to avoid the issues related to their utilization and propriety. These rules are incorporated in article 10 of the ITER Agreement and further detailed in the Annex on Information and Intellectual Property.

[142]Madia& Associates, LLC " 2013 ITER Management Assessment" Contrac-ITER/CT/13/4300000830) October 13, 2013pag 15

[143]Final Report of Negotiations on ITER Joint Implementation, 1 April 2006

First of all there is a difference between Information and Intellectual Property.

As per Article 1.2 of the Annex “Information shall mean published data, drawings, designs, computations, reports and other documents, documented data or methods of research and development, as well as the description of inventions and discoveries, whether or not protectable, which are not covered by the term Intellectual Property”

Article 1.3 of the Annex defines Intellectual Propriety: “Intellectual Property shall have the meaning defined in Article 2 of the Convention Establishing the World Intellectual Property Organization, done at Stockholm on July 14, 1967. For the purposes of this Annex, Intellectual Property may include confidential information such as know-how or trade secrets provided that they are unpublished, and in written or otherwise documented form, and :

a) Have been held in confidence by their owner,

b) Are not generally known or available to the public from other sources, and/or are not generally available to the public in printed publications and/or other readable documents,

c) Have not been made available by their owner to other parties without an obligation concerning confidentiality

d) Are not available to the receiving party without an obligation concerning confidentiality.”

Another important difference is explained in articles 1.4 and 1.5, i.e. the difference between “Background Intellectual Propriety (BIP)” and “Generated Intellectual Propriety (GIP)”. While the first includes Intellectual Propriety acquired, developed or produces before the entry into force of the ITER agreement (or outside the scope of it) and needed for carrying out the work, GIP is defined as all IP generated or throughout the life time of the contracts with the Agencies. It therefore includes IP rights (right resulting from industrial design, patent, copyrights and similar), similar forms of protection (i.e. *sui generis* right for databases), trade secrets and know-how as well as confidential material.

The general fundamental principles are listed in article 2 of the Annex, where, for example, it is stated that members shall support the widest possible dissemination of Generated Intellectual Propriety.

In Article 4 are listed the principles regarding IP generated or incorporated (except confidential information): by a Member, DA or Entity. It is stated that any Member acting through a Domestic Agency or Entity shall grant on an equal and non-discriminatory basis an irrevocable, nonexclusive, royalty free license to all other Members and ITER Organization as well as granting the right for sub-licensing it for the purpose of publicly sponsored fusion research and development program's. For use in other fields the member who generated the IP is encouraged to find a commercial agreement with the members which requested it. Regarding background IP the same general rules of access apply.

In case of Member incorporating Confidential information, they must ensure that the ITER Organisation has a non-exclusive, royalty-free license to use such background confidential information (BCI), while preserving confidentiality, and make its best efforts to grant a commercial license or supply the same component incorporating the BCI, with financial compensation, to other Members.

Articles 5 and 6 focus on IP produced by IO staff and researchers. In this case, for BIP and GIP, IO shall grant a non-exclusive, royalty-free license to Members, with the right of Members to sub-license within their respective territory.

In case of procurement with (for example) F4E, the contractor must grant access rights (licenses and user rights) to:

- F4E on a royalty-free basis, if the background is needed for the use of foreground or goods supplied under the contract;
- Any third party nominated by F4E for the purpose of implementing a contract with F4E, on fair and reasonable conditions;
- ITER IO or its members on a royalty-free or fee basis, depending on the nature of the background and the conditions for its use. It is worth mentioning that access to confidential background is subject to some restrictive conditions to safeguard the interests of the IP holder. [144]

In case of grants, the beneficiary must grant access to F4E:

Background**,** in the form of a license, with the right to grant sub-licenses and to use it for any purpose, under the following conditions:

- Royalty-free, *i)* when the owner of the background is a national fusion research organization of a member of F4E; *ii)* when the background has been generated or acquired under previous activities funded by Euratom
- Fair and reasonable conditions or royalty-free in any other case, specifically when the background has been generated outside Euratom-funded projects.

Generated**,** in the form of a royalty-free license, with the right to grant sub-licenses and to use it for any purposes.[145]

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[144]European IPR Helpdesk, Intellectual Property rules within the Fusion for Energy contractual framework, Fact Sheet November 2011pag 5

[145]European IPR Helpdesk, Intellectual Property rules within the Fusion for Energy contractual framework, Fact Sheet November 2011pag5

Ownership for Generated IP for procurement belongs to the Agency while for Grants belongs to the beneficiary generating it.

In general participants must ensure that generated IP is published or made publicly available as quickly as possible.

6.3 - ITER Problems and Possible way forward

Agreement

The difficulties in finding common grounds for an agreement among the members of the ITER projects have been pointed out in the last chapter. One of the most problematic factors that caused the delay in signing the agreement was that the number of members was increased during the negotiations and at different times; only EURATOM, Russian and Japan have been part of the project from the beginning without interruptions (USA was out from2000 to 2003) while China and Korea entered in 2003, India in 2005 and Canada was a member from 2001 and 2003. This signified that each time a member was admitted all the procurements packages had to be re-discussed.[146] Another issue was the location of where to build the ITER as well the novelty of the nature of cooperation.

It was also difficult to find a compromise due to the different levels of expertise on the required technologies. Moreover the complexity of the project organization was further increased because all members wanted to be part of every aspect of the projects, which has brought to the countless number of small procurements and division for each component.

Nevertheless, analysing the path that led to the signing of the agreement, we can propose some improvements that can be implemented in future agreements:

- The need for the international community to agree upon common international projects management standards. This is a must for future scientific project of a scale similar to ITER or even larger in order to

[146]Varandas, Carlos, Main aspects and lessons from the ITER project governance, NUKLEONIKA, 2012 pag. 136-146

avoid the need to find compromises when so many different nations with different "national standards" work together.

- Once a common framework to work on has been created, the project need to able to rely on a strong political will, trust and flexibility. Without these prerequisite no international project of this complexity can be achieved, as it must be expected that negotiations will have significant cultural, political and bureaucratic challenges due to the intrinsic differences each nation has.
- Another important aspect to be taken into consideration, before the beginning of every project, is to establish sound construction and operational cost estimates as well as a way to achieve cost containment during construction and operation. This is also to be achieved through an international standard for project management as, without one, different priorities and approaches will cause an inability to act and understand other partners.
- Moreover it is important to establish a feasible and achievable project schedule, as any delay will result in cost increases and insecurity, as we seen it happening in the ITER project. [147]

Liability

There are three parts to the liability problem:

1. Liability of the members DAs working directly with the IO,
2. Liability of suppliers regarding they contracts with DAs
3. Liability of the IO towards third parties and nations.

DAs enforce suppliers to take high levels of liability for the components they produce but it is not clear, from a legal point of view, if this liability

[147] Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

could be enforced if there is a problem or a failure once the components the supplier constructed reach the IO.

On the other side, stakeholders working for F4E have underlined that contract are bureaucratic and inefficient with very high quality requirements and very strict regulations regarding liability and IP, thus dissuading many possible suppliers from submitting bids.

The International Law Commission usually regulates liability for international organisation for objective and subjective acts, but the main issue for the ITER is not liability as an organisation towards nations or other international organisation, but between its members and suppliers. Moreover it does not usually involve illegal activities, but its focus is on the respect of funding deadlines for the Members as well as respect for technical and quality issues for suppliers. Therefore, in the case of ITER, we can point out that:

- The ITER Agreement reaches a compromise, which, among other things, frees the Members "for act, omissions, or obligations of the ITER Organisation". This compromise was reached in order to offer some protection to the members, but mostly to ease the joining of some member to the project which were opposed to an extension of liability to their nations. I think this is a point it can be agreed on, especially considering it created a distance between the organisation and the members which, at the same times, gives the organisation more independence.
- Regarding funding and withdrawal opportunities for Members, there should not, in my opinion, be the possibility of withdrawal without the obligation to fulfil the contribution to complete the project, even if these costs might increase, unless unjustified. This would make the actual

signing of an agreement more difficult but it would give the project financial stability, allowing it to put science first and money after.

- Regarding the supplier's liability, they should be subjected to complete liability if the item they provided does not fulfil the technological prerequisites, compatibility or fails, unless the failure can be attributed to an IO design failure. This is even more important in ITER, as the components for a single item may come from many different suppliers/countries and have to be assembled on site. Failure of one component would cause delays for the whole project and thus increasing costs. Precision and quality are key features of high end science projects and must therefore be assured in any way possible.
- Regarding liability for possible damage to third parties, the liability article of the ITER Agreement, as seen before, foresees an obligation to consult and to seek to reach agreement to raise additional funds, but not a commitment in advance to undefined liability amounts.[148] If we take a look at other International projects liability solutions, the terms are quite similar in liability claims in-between the IO and its members. For example in the ISS Intergovernmental Agreement (IGA, art. 16 and 17), created a cross-waiver of liability (cross-waiver stands for a set of promises made by parties to an agreement in which each of the parties pledges not to sue the other for damages caused by the other, except under specific circumstances). The objective is therefore to prevent claims by a Partner against the other Partners and their "related entities" for damages arising out of ISS-related activities. This means that a Partner shall not make any claims against another Partner or against its "related entities" if the person, entity or property causing the damage is involved in ISS-related activities and if the person, entity or property that suffered the damage suffered it by virtue of its involvement in ISS-

[148]Todd K. Harding, Melanie J. Khanna, Raymond L. Orbach, International Fusion Energy Cooperation, ITER as a Case Study in Science and Diplomacy, 03.09.2012

related activities. There are a few exceptions, i.e. claims between a Partner and its own “related entities”, claims made by a natural person, his/her estate or survivors for bodily injury, impairment of health, or death of such natural person or IP claims. This means that partner are more prone to cooperate to further the peaceful exploration and use of outer space through the ISS, without fear of legal claims that could arise out of the risks that are inherently present in such a collaboration. This kind of agreement should, in my opinion, used in future agreements as well, as it strengthen cooperation by reducing possible reasons for quarrels.

Cooperation

Cooperation in a big project, with many entities which need to work together, plays a very important role. Good cooperation between the IO and third parties, IO and the Das, between DAs themselves as well as between DAs and supplier is therefore a must.

The study “Potential for reorganization within the ITER project to improve cost-effectiveness” underlines how cooperation between agencies is complex, critical and often underdeveloped, making negotiations between ITER IO and the DAs to be drawn out and unproductive, creating delays for all parties involved. For example approximately 40 % of all business between F4E and ITER IO is subject to delays.[149] This is mostly due to the high level of bureaucracy, especially regarding PAs and specifications for components.

Regarding international cooperation the ITER Agreement allows the IO to “cooperate with other international organizations and institutions, non-

[149]European Parliament, Directorate General for Internal Policies, Policy Department D: Budgetary Affaairs, Potential for reorganization within the ITER project to improve cost-effectiveness, 12.04.2013, IP/D/ALL/FWC/2009-056, PE 49.674pag 57

Parties, and with organizations and institutions of non-Parties, and conclude agreements or arrangements with them to this effect" (Article 19).

For example in 2009 the Director-General of the ITER, Mr. Kaname Ikeda, and CERN Director-General, Robert Aymar, signed a cooperation agreement, to provide ITER with experience in technology but also in fields like finance, procurement, human resources and informatics using the experience of LHC, which was built in collaboration with over 10,000 scientists and engineers from over 100 countries, as well as hundreds of universities and laboratories.

The 2013 Management Assessment of MAT has found out that cooperation between the IO and the DAs has improved, with DAs often joining together to keep the project moving forward. The Unique ITER Team is playing a main role in improving communication, cooperation and interaction, but it also observed numerous examples where the communication between IO and DAs has been poor.

In order to improve cooperation in future projects, some action should be taken:

- A possible way to improve cooperation would be to create a body like the "Bureau" in F4E, which is specialized in providing support for communication and co-ordination between the Governing Board, F4E committees and F4E management. A similar body in the IO would most likely bring similar improvements, with the focus of improving the speed at which decisions are taken, which is the problem in most cases.
- Trust, confidence and effective cooperation among DAs and between IO and DAs is a must. This is not the case at the moment with the reasons being the excessive bureaucracy and mistrust caused by the perception that each member is trying to maximize their own interests and that of

their own nations companies involved. Cooperation between IO staff and DAs and their contractor is necessary to help contractors manage the difficult bureaucratic constrictions as well as working more effective and thus faster and at the same time reducing costs. A good idea the MAT management assessment proposed in its report is to rotate and exchange staff between IO and DAs in order to achieve a better understanding of the problems and necessities on both sides thus accomplishing a more effective level of cooperation. [150]

- Even though a lot can be done by changing the way the people in the project work together, the best way, in my opinion, would be an improvement at national and political level of the "attitude" towards the projects. Members of the ITER and of other projects as well tend to seek personal and national gains, trying to get the most out of the funding for the gain of their own nation or party. If this mentality could be switched to one which focuses on achieving the best results regardless of singular and personal gains, it would surely open up a lot more possibilities for cooperation, not only within the organisation itself, but also with third parties.

Staff

As seen in the previous chapter, the ITER staff has reached, at the end of 2013, 565 people employed from 25 different countries.

At the beginning of the project there was a critical lack of staff, especially people with the necessary technical and administrative skills which has caused delays and technical difficulties in implementing procurements agreements.

[150]Madia& Associates, LLC " 2013 ITER Management Assessment" Contrac-ITER/CT/13/4300000830) October 13, 2013 pag 12

This issue has been addressed by increasing the number of capable and motivated staff in both technical and administrative areas working for the IO. Still, the IO is still lacking the "critical mass" of personnel with large project management and industrial experience. At the same time several employees have been placed in positions for which they have limited qualifications. [151]

Another issue is the impossibility for the staff to help the schedule and the ITER Council approved baseline of activities, even if the suggestions could have improved them, due to the still too strict and inflexible organisational structure. This also means that the staff could not actively help in solving other issues, like reducing costs or risks to the DAs or improving schedule thus demotivating the staff due to the lack of involvement in the project they have. Another issue, very common in publicly funded projects, international or not, is the exaggerated number of manager in comparison to the rest of the staff. For example, the IO has 12 senior managers who manage 17 Division managers; these in turn supervise 42 other section manager. This can only leads in excessive bureaucracy and impasse in decision making. [152] Only considering these section and division managers, the ITER IO has a manager-to-staff ratio of 1 to 8 (this ratio is probably very distant from reality, but the annual reports of the IO do not show the actual figures of managing personnel to the working staff). This ratio is not too far from the global overage staff to supervisor ratio, but considering that the main issue for the IO is budget constraints, the first action which is usually taken to address this issue is to reduce the relative number of supervisors. For example at CERN the number of administrative and management staff been reduced by almost 24% since the start of the work

[151] Madia& Associates, LLC " 2013 ITER Management Assessment" Contrac-ITER/CT/13/4300000830) October 13, 2013 pag 4

[152] Madia& Associates, LLC " 2013 ITER Management Assessment" Contrac-ITER/CT/13/4300000830) October 13, 2013 pag 5-6

for LHC, in 1991. Scientists, engineers, technician and craftsperson make up 83% of the CERN staff, reflecting the Organisation's scientific vocation. Thus reducing the number of managers can produce benefits both in reducing bureaucracy, decision making speed and reducing costs. ITER must act now in order to be able to remain on track, which means reducing layers for a faster acting and decision making structure.

Taking into consideration these problems, we can formulate some improvements:

- Considering the complexity and difficulty of the project organisation, ITER needs to find personnel with great experience in managing large projects with an open mind regarding constructive confrontation and which understand the value of suggestions coming from their co-worker in finding immediate solution for problems, thus accelerating the project schedule.
- As Director General Motojima is coming to the end of this term, now would be the perfect time to make the necessary improvements in the IO staff thus addressing the problem of a schedule which is not achievable at the moment due to a lack of urgency and failure in taking important decisions. The new DG should be chosen for his ability and not for political reasons.
- Considering that in the end all organisations fail or succeed based on the people they engage, the IO must try to attract the most qualified and talented people available and removing underperforming staff. The aim should be to attract the world's most talented scientists and engineers by becoming a centre of excellence in the field of fusion energy, even

within the limitation of the international employment standards the IO is subject to. [153]

Procurements

Procurements for ITER are probably the most discussed and complicated aspect of the project. In order to satisfy the need of each Member to take part in every aspect of the project, the IO created the Procurement Arrangements so that each one of the members can provide a part of most of the components needed to construct the facility and operate it. The different parts are then assembled on site. This causes easy to predict issues. An example that highlights what this means can be seen in the procurement for vacuum vessel sectors. Most of the components will be built in Europe, and only a small part will be produced in India. Nonetheless both part are required to complete the part, so, even though Europe is responsible for the bigger part of the component, delays on the Indian part hold up progress on the European one, thus creating overall delays and increased costs, for the IO, F4E and the contractors. [154]

In addition to the problematic caused by the contractor in delivering the components (or their parts), there is also a problem on the "top" of the supply chain, i.e. the IO. Components coming from all around the world must fit together; in order to do this detailed designs and good organization are a must, as mistakes in either one will create very serious problem later, when the component must be assembled and utilized. The organization responsible for this is the Central Integration and Engineering (CIE). It has

[153] Madia& Associates, LLC " 2013 ITER Management Assessment" Contrac-ITER/CT/13/4300000830) October 13, 2013 pag 10-14

[154] European Parliament, Directorate General for Internal Policies, Policy Department D: Budgetary Affaairs, Potential for reorganization within the ITER project to improve cost-effectiveness, 12.04.2013, IP/D/ALL/FWC/2009-056, PE 49.674, pag 79

been noted that this organization is lacking the right people with the knowledge to do their job the way it should, being more focused on the process and bureaucracy rather than engineering aspects. If this organisation fails to deliver detailed designs and does not manage to make sure all components are up to the standards and can be integrated, the delays for the project will be great. Therefore the CIE should review and restructure the organisation in order to be more efficient and effective. [155]

The CERN also had a similar project when developing and constructing one of the most complex and key components of the LHC, the Magnetic Dipoles and especially the niobium-titanium coils that create the magnetic fields. The dipoles where designed at CERN, but the production of the 1232 diploes needed a big cooperation with the industry. To make sure that the specifications and designs were met, CERN constructed prototypes and then selected 3 companies which were assigned for the "mass" production, one in France, one in Germany and one in Italy. Scientists, engineers and physics form CERN then trained the personnel of these companies, which were then assigned the production of 30 diploes. After the 30, which gained the companies the experience needed, the rest of the diploes were ordered, with much lowers costs. In addition to the training, CERN itself also provided the contractors with the needed components to be assembled as well as the raw materials, in order to make sure the quality, uniformity and costs were up to the expectations. This direct and great involvement made sure that all diploes were identical and could be installed in any part of the tunnel, irrespective of where it was built. [156]

In addition to the technical issues and needs, procurements are a key area for cost reduction. This can be achieved by increasing interaction with

[155] Madia& Associates, LLC " 2013 ITER Management Assessment" Contrac-ITER/CT/13/4300000830) October 13, 2013, pag 10
[156] Gian Francesco Giudice, "Odissea nello Zeptospazio. un viaggio nella fisica dell'LHC", Springer 2012, pag 136-140

suppliers and augmenting competitiveness before finalizing the tender. Procurement procedure are furthermore constrained by delayed designed which prolong construction and by regulations that are ill-suited to reach cost-effectiveness, in particular for F4E which has to follow the EU Financial regulation, seen by many as not flexible and not adapt for this sort of contracts. The EU Financial Regulation is a document of reference for principles and procedures that govern the establishment and implementation of the EU budget and the control of the EU's finances. The document has been revised in 2010 and 2012 in order to modernise the regulations, with the aim to simplify administrative requirements, accountability, reduce delays in payments, add the possibility to implement multi annual work programs etc. Even though many of the new regulation are more focused on Europe 2020, bureaucracy reduction and similar improvements could help F4E in its relations with its partners and contractors. [157]

All in all, the main problems related to procurements can be summarized as follows

- Members trying to advantage their own national companies to detriment of the project
- High number of members each providing a small part of an equipment or component.
- IO design not delivered in time or with missing/incomplete specifications
- Increase in risk and costs and therefore producing delays due to the dissection of components production through many members
- IO little control on the call for tenders of the DAs

[157] European Parliament, Directorate General for Internal Policies, Policy Department D: Budgetary Affairs, Potential for reorganization within the ITER project to improve cost-effectiveness, 12.04.2013, IP/D/ALL/FWC/2009-056, PE 49.674, pag 68-72

Taking these issues into consideration, we can suggest some improvements that should be implemented in future similar projects:

- First of all, for future international scientific project that would like to use the in-kid and cash contribution framework developed by ITER, it will be more beneficial if the main and most important and complex components will be procured in cash, avoiding "separation" and focusing more on quality, while auxiliary components could still be procured through in-kind contributions.
- In addition to this, single components should be provided by a single member; this member should then be required to inform all other members of the technical developments and IP discovered during R&D and production of the component, so each can have advantages without the problematic of separated production, thus also avoiding duplication.
- A reorganisation at the "top of the chain", i.e. IO, is also needed. Designs and specification must be prepared timely, scientists and engineers involved in the project should take an active part in instructing and overlooking the production of the components in order to assure quality and reliability.
- As mentioned before in the agreement sub-chapter, much could be accomplished with a change in priority from the members. Instead of dividing the production based on contributions, the best way would be to utilise the best and more prepared industrial facilities and companies, regardless of location. This would not only reduce the time needed to build the components (utilising companies that already possess the best specific know-how, fully or partially) but it would also reduce costs and the risk deriving from components that do not fully respect the specifications. As "compensation", groups of scientists and engineers from nations lacking knowledge and technical capacities to produce the components in the first place, could be invited to assist and learn during

the production phase, in order for them to gather the know-how and bring it back to their nations.

Funding

Funding for the ITER is provided mostly through in-kind contribution which utilized an ad-hoc currency called kIUA and only a small part is provided in cash.

One of the main problems that affect ITER, as most big projects, is cost overruns. In 2001 the estimated cost for ITER was 5.900 million € (EURATOM contribution was at 945 million € in cash and 1.700 million € in in-kind contributions). In 2010 new estimated set the cost at 7.200 million € but EURATOM set a limit of 6.600 million € till 2020. The overrun caused a deficit for EURATOM in procurement agreement which cause a heat debate. [158] The almost 67% cost increase is mostly due to the finalization of the design, delay in construction due to increased design effort, the establishment of the DAs, fragmentation of the procurements, increases in global raw material costs, increased number of participants which caused a further separations of components procurements as well as heighten standards in French nuclear safety.

Costs overrun is even more problematic due to the limited flexibility provided by the strict budgetary discipline of EU and other member's states expenditures.

Another issue which has created difficulties regarding funding is that members states have often been slow with the payment of the direct annual membership fees.

[158] European Parliament, Directorate General for Internal Policies, Policy Department D: Budgetary Affairs, Potential for reorganization within the ITER project to improve cost-effectiveness, 12.04.2013, IP/D/ALL/FWC/2009-056, PE 49.674, pag 9

In addition to improvements on the member sides, we can suggest some general improvements to address cost overruns and funding problems:

- Better planning, establishing the requirements and features of the project before getting started. Considering that problems can come from different areas, the creation of a cross-departmental committee of project stakeholders, scientists, engineers, industry and other experts could be the first step in avoiding cost overruns.
- Better understanding of the systems and tools that will be used to design and develop the project can reduce wrong assumptions and design problems.
- Actively engage consultants from the industry to evaluate the projects in regards to industry production capabilities and to find the best candidates for the call for tenders.
- If needed, create a new schedule that must be adopted by all parties and must be fully transparent and made widely available to all interested parties, including Members and their government sponsors, in order to involve them more in the preparation process and thus bind them to their promised contributions.

Governance

Governance is one of the key aspects of the ITER project. This is due to the extremely complex and singular framework in which the construction of the ITER must take place, with the IO, the DAs and the different national companies providing the components. To achieve the overall goal of a successful construction of the ITER which respects the technical requirement needed for the success of the fusion test, within the agreed schedule and resources, adequate governance is required. Unfortunately both the issues encountered during the writing of the Agreement which created the structure and the focus on protecting national interests of the member countries create a need for a better governance and framework.

First of all, the ITER Agreement was structured to provide a number of advantages in terms of know-how and construction privileges for the members. This was done by "dividing" the responsibility of the projects among the IO and the seven Parties, creating a very intricate and challenging structure. In fact, the ITER structure deviates from other international projects where the responsibility and funds are controlled by the same authority. [159] This structure creates a high number and difficult interfaces between the IO and the DAs which is mostly problematic in the process of construction and assembling the thousands of components needed for the construction of the ITER as they come from seven different parts of the world. This problem is enhanced by the delays from the IO in providing the DAs with the drawings and specifications for components which, sometimes, caused the DAs to have to start production without the final designs and specs.

Another problem caused by the way the Agreement created the framework is that all serious decisions require unanimity to be approved, while consensus would have been sufficient, therefore giving diplomatic and political consideration great weight in comparison to technical factor, which, in an international scientific projects, should be the main and only focus. In addition to this, the Agreement, trying to avoid the IO to have to negotiate and monitor the production of components all around the globe, made it so the IO has no control over the DAs. These are important lessons to be learn as it clearly shows that "collaboration is most likely to succeed where there is a clear overriding need to collaborate, a compelling joint

[159] European Commission, Commission Staff Working Paper, Towards a robust management and governance of the ITER, Brussels, 9.11.2010, SEC 1386 Final, pag 4

interest in a successful outcome, and that - as far as possible - decisions are technically, rather than politically driven." [160]

These problems are all further plagued by the humongous bureaucracy that permeates the project in its whole. The reason behind international organisation projects is that they can achieve things otherwise impossible for single parties. But in order to be able to achieve its goals these organisation must use high efficient framework and effective business systems, empowering both scientists and staff by giving them freedom to act, open communication and disclosure. Most of these aspects are missing due to the inefficient and time consuming bureaucratic processes.

Taking into consideration the issues described above we can list a series of possible ways to improve the situation of the ITER governance;

- First of all, the DAs need to coordinate much closer with the IO, focusing on providing ITER with the best industrial capabilities and know-how they can, while at the same time cooperating more with other DAs when construction parts of the same components.
- DAs must also focus more on the ITER project itself rather than national interests; this should be helped by a stronger and more focused organisation. To be able to do this, the IO, within the limits of the Agreement and considering the existing constrains on resources availability, needs to exercise a much stronger authority in decision making on technical details and requirements when cooperating with the DAs. This can be achieved by improving the quality assurance and control mechanisms for all processes and procedures as well as improving effective monitoring and reports on the execution of projects related activities among the members.

[160] The Royal Society, Knowledge, Networks and Nations: Global Scientific collaboration in the 21st century, RS Policy document March 2011, pag 92

- In addition to this, the EU, as host Party and largest contributor by far, needs to exercise a strong and firm political leadership in order to be able to influence the other international partner in working more for the project and less for their own interests.
- Decision making processes should be faster, and this can be achieved by reducing bureaucracy and streamlining initiative, for example using experts who worked in other international projects to help improving and applying the best practices to ITER.
- The IO needs to develop a new and realists project schedule, avoiding the consistent schedule delays and funding problems the project now has, and made fully transparent and available to all members which, on their part, must then assume responsibility and accountability for the new project schedule deadlines. Similar problems affect the current mode of operation of the ITER Council, where the high bureaucracy causes the Council to take very long time to address issues or take decisions. It has been suggested by the MAT ITER Management Assessment that the Council should begin to operate as a "Board of directors", which would allow for a swifter decision making process. [161]
- Increasing accountability of project leaders personally for quality, progress and improvements should also contribute to the projects outcomes.
- Bureaucracy should also be reduced to simply decision making processes, communication and other aspects.
- The goal of the project should be the first and only objective while nationals and personal interests should be put aside.

[161]Madia & Associates, LLC " 2013 ITER Management Assessment" Contrac-ITER/CT/13/4300000830) October 13, 2013, pag 10-14

Final Notes

"When history looks at the 20th century, she will see science and technology as its theme; she will find in the monuments of Big Science—the huge rockets, the high-energy accelerators, the high-flux research reactors—symbols of our time just as surely as she finds in Notre Dame a symbol of the Middle Ages. ... We build our monuments in the name of scientific truth, they built theirs in the name of religious truth; we use our Big Science to add to our country's prestige, they used their churches for their cities' prestige; we build to placate what ex-President Eisenhower suggested could become a dominant scientific caste, they built to please the priests of Isis and Osiris."

Alvin M. Weinberg

In a world struggling with economic, social and environmental problems and political incompetence, science could and should play a major role in creating a better world. The focus of this work has not been strictly on international law, but more in general on the reasons and procedures international scientific projects are created and the best ways to make the most out of them. I concentrated more on providing ideas and solutions on how to manage and improve present and future cooperative projects. In fact the purpose of this thesis is to find the best way for politician, diplomats and non- scientists in general to provide researchers and scientists with tools and opportunity to do their job in the best way possible. In my opinion the optimal way is to create networks of international cooperation for science, thus concentrating and sharing funds, human resources and know-how from different nation for a common goal. It may sound obvious, but as we have seen we are not quite there yet.

At the beginning we have seen that science has always played a major role in shaping the world from the dawn of time. In the last centuries science kept evolving towards an international activity. The number of scientific authors from different countries per paper continues to grow as well as the percentage of paper written from scientists from developing/ third world countries. This trend will only rise as more and more projects are supported by cooperation between different organisations or nations. This has been helped by the spreading and availability of information and know-how; in fact, not only are publications increasing in number, but all of the knowledge created, thanks to the internet, is available to everybody everywhere. The web offers us a way to improve the collective long-term memory which is the basis for much of human progress, as well creating a short-term working memory for the rapid collaborative development of ideas, allowing instant global consultation and improvement of research paper. About the sharing of information I also made a point that sharing negative results of experiments would be a great improvement in scientific knowledge sharing; usually drug trials or experiment delivering negative results are not reported. If negative results would be published it could prevent useless duplications of effort, leading to acceleration of scientific progress and positive results may increase their credibility and usefulness if linked to negative results. Furthermore, the publication of well-documented failures allows for "negative results to be discussed, confirmed, or refuted by others, and in some cases might also reveal fundamental flaws in commonly used methods, drugs, or reagents".[162] For example, journals could refuse publishing of phase 3 trials if their earlier phase 1 results had not been reported, whether negative or not.[163] The launch of the Journal of Negative Results in Biomedicine (JNRBM) in 2002, "shows that “failure”

[162] Gabriella Anderson, HaikoSprott, and Bjorn R Olsen, Opinion: Publish Negative Results, The Scientists, January 15, 2013
[163]Kelly, Kevin, Speculations on the future of science, Edge, 4.6.06

is as important in science as in other aspects of life, and that scientific progress depends not only on the accomplishments of individuals but requires collaboration, teamwork, and open communication of all results—positive and negative".[164]

In Chapter 2.0 I analysed another side of science, i.e. its ability to bring closer together nations and scientists, despite political struggle and even wars. In my opinion, cooperation in science can be the solution, even though partial, to be able to unite people under one flag.

As we have seen the exploitation of scientific knowledge and the development of new technology are the prime source for economic competitiveness in the modern world, which is the main reason why cooperation has increased so outstandingly in recent time. There have been many example of science playing the "diplomatic role". The use of science to ameliorate tensions between USA and URSS started in the late 50s, but since then it has been used effectively many times in other geographical areas; we mentioned some examples like SESAME, MERC, Nunn-Lugar Cooperative Threat Reduction and many others. I also pointed out how cooperation in international scientific projects could help small nations, which generally do not possess the capabilities or capacities to undertake deep basic research alone, to pull more than their own weight in a global system focused on solving "big science" challenges of our century. Thanks to its universality, which goes beyond the geographical national boundaries, science provides a tool that can be used by nations not only to find common ground for scientific research but also to build "bridges" that can then be used to improve relations among countries as well as prepare the ground for other types of agreements.

[164] Gabriella Anderson, Haiko Sprott, and Bjorn R Olsen, Opinion: Publish Negative Results, The Scientists, January 15, 2013

After briefly analysing the state of world science in the age of globalisation and its different faces in chapter 3.0, I move on to a specific type of international cooperation, i.e. space cooperation. Space science, due to its difficult and demanding problems as well as expensiveness, offers a great opportunity for nations to work together. Manned space stations like the ISS, project of a lunar base or a human mission to Mars as well as scientific telescopes for finding habitable worlds in our galaxy are ambitions plans which could be achieved faster and easier if nations were to work together. In chapter 4.0 I take into consideration the ISS project; it has been the first "big space science" project to unite so many different nations and, even with all its difficulties and costs, it has worked. I point out that using this and other projects (also from different areas) experience we could create a framework for nations to develop and fund all future space projects.

In chapter 5.0 I focus on the EU and its FPs. What the EU is trying to accomplish both on a political, with the European Union, and scientific, with ERA and the FPS, is of the utter most importance, not only because it would unite a group of countries which have been at wars since the beginning of humanity, but because it can be the stepping stone in showing that grudges and past conflict can be overcome for the greater good. If Europe through the European Research Area and similar projects would be able to create a stable, working and efficient framework for cooperation, the model could then be used for other "regions", for example to create a similar framework among the Asian countries or the African ones. It could then even be a starting point for a global framework for the development of science, by bringing together the different research areas created in various part of the world. It would be an extremely long, difficult and optimistic process, but chances are that it could also be the best option for mankind to solve the global problem that are and will affect us in the next centuries. And now Europe has a chance to be the one that started it.

But, as we have seen, this can only be achieved if a set of rules, specific for scientific international endeavours, is drafted. The ISS agreement and especially the ITER agreement I analysed in this work can be taken as examples on the way to define a new set of rules. The problems encountered by both international projects should be taken into consideration to avoid repeating them.

One of the most important prerequisite for the creation of international scientific endeavours is to be able to keep politics and national interest out of science. As we have seen, the making of both ISS and ITER agreements had a number of problems and compromises that had to be solved. I proposed some changes and improvements that should be taken into consideration in the establishment of future scientific cooperation projects, probably the most important of them being the necessity for scientific projects to be able to have the means to achieve their objectives without having to be under restrain by the scientific unrelated wishes of the nations involved .

The road will not be easy, as proved by the ITER projects, but there is no other way, if we truly aim at building a better society. In order to do this, nations will have to work together for the sake of earth, its inhabitants and their future. Looking at the current situation, even though the number of international projects is increasing, it still might be a chimera. What is needed, in addition to capable, focused and eager scientists, is a strong leadership, capable of overcoming greed, insecurity, mistrust and selfishness, all too common in the current international projects.

In my opinion the best way to achieve this, is through the creation of inter-governmental organisations dedicated to science, with the economic and political autonomy necessary to perform at their best. What the EU is trying to achieve with ERA and the framework projects, should be improved and applied in the other continents as well, thus bringing together nations of geographical proximity. This should be accomplished by sovranational organisations conveying funding and the best scientists from all the member states and enabling them to pursue results without having to take independent national interests into the equation. These scientific organisations should then cooperate with each other, without the control or the boundaries deriving from science-unrelated factors. The creation of independent "Organisations for Science" for each continent would reduce the number of parties, thus simplifying governance. These organisations should then create one or more common centre of research for each field, where science is the main and only protagonist.

Annex I

Summary Table of Procurement Allocation

PACKAGE			kIUA	ALLOCATION	REMARKS
1.1 Magnet	ToroidalField Magnet Windings	1A	85.2	EU=100%	1A for 10TF (including 1 prototype) and 1B for 9TF (including 2.5 kIUA for fabrication verification)
		1B	82.3	JA=100%	
	Toroidal Field Magnet Structures	2A	51.4	EU=10%, JA=90%	Fabrication of whole structures by JA and Pre-compression ring (0.6 kIUA) by EU. Final assembly of 10 TF coil cases by EU (10%)
		2B	47.7	JA=100%	
	Magnet Supports	2C	22.85	CN=100%	
	Poloidal Field Magnet 1&6	3A	13.6	EU=50%, RF=50%	PF1 by RF and PF6 by EU
	Poloidal Field Magnet 2 to 5	3B	33.6	EU=100%	
	Correction Coils	3C	2.6	CN=100%	
	Central Solenoid Magnet	4A+4B	39.6	US=100%	
	Feeders	5A	26.15	CN=100%	
	Feeders Sensors	5B	18.05	FUND=100%	
	Toroidal Field Magnet Conductors	6A	215	EU=20%, JA=25%, RF=20%, CN=7%, KO=20%, US=8%	See Note-1
	Central Solenoid Magnet Conductors	6B	90	JA=100%	
	Poloidal Field Magnet Conductors	6C	74.25	EU=13%, RF=18%, CN=69%	
1.5 Vacuum Vessel	Main Vessel, including Blanket Manifold sand Hydraulic Connectors	1A	124.2	EU=80%, KO=20%	See Note-2
	Shielding	1B	37.3	IN=100%	

	Equatorial Ports	2A	24.5	RF=24%, KO=76%	See Note-2
	Upper Ports	2B	22.1		
	Lower Ports	2C	31.91		
1.6 Blanket System	Blanket First Wall	1A	87.0	EU=30%, JA=10%, RF=20%, CN=10%, KO=10%. US=20%	See Note-1
	Blanket Shield	1B	58.0	EU=10%, RF=20%, CN=40%, KO=10%, US=20%	
	Diagnostic First Wall		8.5	FUND=100%	
	Port Limiters	2	7.4	US=100%	,
	Blanket Module Connections	3	10.0	RF=100%	

28. **7 Divertor**	Cassette Integration	1	11.2	EU=100%	
	Outer Target	2A	28.5	JA=100%	See Note-1
	Inner Target	2B	20.2	EU=100%	
	Dome	2C	15.0	RF=100%	
	Plasma-Facing Component Tests	2D	8.0	RF=100%	
2.2 Machine Assembly	Assembly Operations	1	50.3	FUND=100%	See Note-3
	Assembly Tooling 3-11	2A	22.0	KO=100%	
	Assembly Tooling 1-2,12-13	2B	20.4	FUND=100%	See Note-3
2.4 Cryostat	Cryostat Factory	1A	60.0	IN=100%	
	Cryostat Assembly	1B	17.0		
2.7 Thermal Shield	Thermal Shield		28.8	KO=100%	
3.1 Vacuum Pumping&	Cryopumps	1	11.2	EU=88%, FUND=12%	

Fuelling					
	Roughing Pumps	2	6.7	US=88%, FUND=12%	
	Leak Detection	3	5.0	EU=88%, FUND=12%	
	Standard Comp.	4	5.3	US=88%, FUND=12%	
	Pellet Injector	5	5.0	US=88%, FUND=12%	
	Gas Injector Valve Boxes + Glow Discharge Cleaning Conditioning System	6	7.7	CN=88%, FUND=12%	
2.3 Remote Handling Equipment	Blanket Remote Handling Equipment	1	27.9	JA=100%	
	Divertor Remote Handling Equipment	2	12.0	EU=100%	
	Transfer Cask System	3	16.4	EU=50% CN=50%	
	Viewing/Metrology Systems	4	6.8	EU=100%	
	Neutral Beam Remote Handling Equipment	5	6.0	EU=100%	
	Hot Cell Maintenance Equipment	6	44.3	FUND=100%	
2.6 Cooling Water System	Blanket +Divertor	1A	33.7	US=100%	
	Vacuum Vessel and Neutral Beam	1B	27.4		
	Piping Outside Vault	1C	12.5	FUND=100%	See Note-3
	Heat Rejection and Component Cooling Water: Material and Transportation	2A’	38.5	IN=100%	
	Heat Rejection and Component Cooling Water: Engineering and On-site Assembly	2B’	36.2	FUND=100%	

3.2 Tritium Plant	Tokamak Exhaust Processing System	1	13.0	US=88%, FUND=12%	
	Storage & Delivery	2	14.5	KO=88%, FUND=12%	
	Hydrogen Isotopes Separation	3	6.2	EU=88%, FUND=12%	
	Atmosphere Detritiation	4	30.2	JA=50%, FUND=50%	
	Water Detritiation	5	14.5	EU=88%, FUND=12%	
	Tritium Analysis & Control	6	3.5	FUND=100%	
3.4 Cryoplant Cryo-distribution	Cryoplant	1	63.0	EU=50%, FUND=50%	
	Cryolines	2	17.6	IN=100%	
	Cryo distribution Components	3	16.2	IN=100%	
4.1 Pulsed Power Supply	High Voltage Substation Assembly	1A	6.0	EU=100%	
	High Voltage Substation Materials	1B	21.0	CN=100%	
	AC/DC Converters	2	82.2	CN=62%, KO=38%	
	Switch, Discharge Circuits	3	69.0	RF=100%	
4.1 Steady State Power Supply	Emergency	8A	5.7	EU=100%	
	Assembly	8B	14.3	EU=100%	
	Materials + Transportation	8C	20.0	EU=25%, US=75%	
6.2 Building	Concrete Buildings	1	323.5	EU=100%	
	Steel Frame Buildings	2	68.8	EU=100%	
6.3 Waste	Waste Treatment Storage	1	9.1	EU=100%	
6.4 Radiological Protection	Radiological Protection	1	4.2	EU=100%	
5.1 Ion Cyclotron Heating	Ion Cyclotron Antenna	1	4.5	EU=88%, FUND=12%	

& Current Drive					
	Main Transmission Line	2	4.8	US=88%, FUND=12%	
	Radio Frequency Power Sources	3	18.0	IN=100%	
	Power Supply	4	6.9	IN=100%	
5.2 Electron Cyclotron Heating & Current Drive	Equatorial Launcher	1A	7.3	JA=88%, FUND=12%	
	Upper Launcher	1B	8.9	EU=88%, FUND=12%	
	Transmission Line	2	17.9	US=88%, FUND=12%	
	Radio Frequency Power Sources	3	32.5	EU=31%, JA=31%, RF=31%, IN=8%	Startup system by IN
	Power Supply	4	13.9	EU=92%, IN=8%	Startup system by IN
5.3 Neutral Beam Heating &Current Drive	Assembly and Testing	1	3.8	EU=100%	
	Beam Source and High Voltage Bushing	2	9.5	EU=50%, JA=50%	
	Beamline Components	3	3.9	EU=50%, JA=50%	
	Pressure Vessel, Magnetic Shielding	4	11.9	EU=50%, JA=50%	
	Active Correction and Compensation Coils	5	6.1	EU=100%	
	Power Supply for Heating Neutral Beam	6	62.5	EU=38%, JA=62%	
	Diagnostic Neutral Beam	7	21.1	IN=100%	
5.5 Diagnostics	Magnetics	A	3.3	EU=25.0%, JA=14.2%, RF=13.5%, CN=3.3%, KO=3.3%, US=16%, IN=3.2%,	See Note-4

				FUND=21.5%	
	Neutron Systems	B	10.1		
	Optical Systems	C	25.7		
	Bolometry	D	6.7		
	Spectroscopic	E	22.5		
	Microwave	F	17.7		
	Operational Systems	G	11.0		
	Standard Diagn.	N	40.5		
4.5 Command Control and Data Acquisition and Communication	Control and Data Acquisition		50	FUND=100%	
Total			3020.7		EU~ 33%, JA~ 16% , RF ~ 8%, CN ~8%,KO ~ 8%, US ~ 8%, IN ~ 8%, FUND ~ 11%

Table 12: Summary table of procurement allocations

Note-1: The paragraph 5 of Common Understandings on Procurement Allocation should be applied.

Note-2: Proper integration should be obtained through a Prime/Sub Contractor or Consortium arrangement due to the importance of the safety classification of the components.

Note-3: These packages were originally allocated to Non-common. Due to the increase of the number of Parties, it is allocated to Fund.

Note-4: Details of sharing will have to be defined by the ITER Organization.

Images

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Glossary of acronyms and abbreviations

AAAS	American Association for the Advancement of Science
AIEA	European Atomic Energy Community
ASEAN	Association of Southeast Asian Nations
AU	African Union
BA	Broader Approach
BERD	Business enterprise expenditure on research and development
BIP	Background Intellectual Propriety
BPC	Bilateral PresidentialCommission
BRIC	A grouping acronym that refers to the countries of Brazil, Russia, India, and China that are deemed to all be at a similar stage of newly advanced economic development

CCS	Carbon captureandstorage
CEOS	Commettee on Earth Observation Satellites
CERN	The European Organisation for Nuclear Research
CGIAR	Consultative Group of International Agricultural Research
CIE	Central Integration and Engineering
CODAC	Control, Data Access and Communication ITER
COSME	Programme for the Competitiveness of Enterprises and SMEs
COSPAR	Committee on Space Research
CREST	Scientific and Technical Research Committee
CSC	Computational Simulation Centre
DA	Domestic Agency
DARPA	Defence Advanced Research Projects Agency
DAs	ITER Domestic Agencies
DEMO	DEMOnstration Power Plant
DFG	Deutsche Forschungsgemeinschaft (DFG; English: German Research Foundation)
EACI	Executive Agency for Competitiveness and Innovation
EASME	Executive Agency for Small and Medium-sized Enterprises
EC	European Commission
ECA	European Court of Auditors
ECSC	European Coal and Steel Community
EEN	Enterprise Europe Network
EFDA	European Fusion Development Agreement
EIARD	European Initiative for Agricultural Research for Development
ELDO	European Launcher Development Organisation
ENP	European Neighbourhood Policy
EO-ICWG	Earth Observation International Coordination Working Group
EP	European Parliament
ERA	European Research Area
ERC	Europe Research Council
ERCEA	ERC Executive Agency
ERDF	European Regional Development Fund
ESF	European Social Fund
ESF	European Science Foundation
ESO	European Space Observatory
ESRO	European Space and Research Organization
EU	European Union
EURATOM	European Atomic Energy Community
ExCo	F4E Executive Committee
F4E	Fusion for Energy
FESAC	Fusion Energy Sciences Advisory Committee
FP	European Commission’s Framework Programme

FP	Framework Programme
G20	Group of twenty finance ministers and central bank governors, established in 1999 to bring together systemically important industrialized and developing economies to discuss key issues in the global economy
G7	Group of seven of the world's leading industrialised nations, comprising Canada, the US, UK, France, Germany, Italy and Japan
G8	Group of eight which includes Russia in addition to the nations of G7, the leaders of which meet face-to-face at an annual summit
GB	Governing Board
GEO	Group on Earth Observation
GIF	Generation IV International Forum
GIP	Generated Intellectual Propriety
HFSP	Human Frontier Science Programmed
IAC	Internal Audit Capability
IAC	InterAcademy Council
IACG	Inter-Agency Consultative Group for Space Science
IAS	European Commission Internal Audit Service
IBSA initiative	IBSA Dialogue Forum (India, Brazil, South Africa)
ICSU	International Council for Science, formerly International Council of Scientific Unions
ICT	Information and communication technologies
IFMIF -EVEDA	International Fusion Materials Irradiation Facility
IGA	Inter governmental agreements
IGA	ISS Intergovernmental Agreement
IMS	Intelligent Manufacturing Systems project
INGO	International Non-governmental Organizations
IO	ITER Organisation
IOAI	United States International Organisations Immunities Act
IP	Intellectual Propriety
IPCC	Intergovernmental Panel on Climate Change
ISAS	Institute of Space and Astronautical Science
ISC	International Scientific Cooperation
ISS	International Space Station
ISTIC	International Science, Technology and Innovation Centre for South-South Cooperation (under the auspices of UNESCO)
ITAR	International Traffic in Arms Regulations
ITER	International Tokamak Experimental Reactor

IUA	ITER Units of Account
JET	Joint European Torus
JRC	Joint Research Centre
JT	Japan Torus
KAUST	King Adbullah University for Science and Technology, Saudi Arabia
LHC	Large Hadron Collider
LIFE	European Union's funding instrument for the environment.
MDGs	Millennium Development Goals – eight targets which range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015 –agreed to by all UN member countries
MIT	Massachusetts Institute of Technology
MOU	Memorandums of understandings
MRC	Medical Research Council
MS	EU Member States
NAFTA	North American Free Trade Agreement
NGOs	Non-governmental Organisations
NIF	National Ignition Facility
NODES	Networks of Diasporas in Engineering and Science
OECD	Organisation for Economic Co-operation and Development
OOSA	United Nations Office for Outer Space Affairs
R&D	Research and development
R4L Research4Life	the collective name for three public-private partnerships which seek to help achieve the UN's Millennium Development Goals by providing the developing world with access to critical scientific research
REA	Research Executive Agency
REC	ITER Remote Experimentation Centre
SBSTA	Subsidiary Body for Scientific and Technological Advice
ScC	ERC Scientific Council
SESAME	Synchroton-light for Experimental Science and Applications in the Middle East
SFIC	Strategic Forum for International S&T Cooperation
SKA	Square Kilometre Array
SME	Small and Medium Enterprises
TFTR	Tokomak fusion test reactors
TWAS	Academy of Sciences for the Developing World (formerly Third World Academy of Sciences)
UN-CSTD	United Nations Commission on Science and Technology for Development (CSTD)
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation

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