Monaco iter International Fusion Energy Days

November 23–25, 2010

MiFED 2010

Day 1

14:00–14:10
Welcome and Opening
Prof. Osamu Motojima
Director General of the ITER Organization

14:10–14:20
Academician Evgeny Velikhov
Chairman of the ITER Council

14:20–14:30
European Commission Representative

14:30–14:40
French Government Representative

14:40–14:50
H.S.H. Prince Albert II

14:50–16:35
Presentations by Representatives of the seven ITER Members on the theme

16:35–16:55
Coffee Break

16:55–18:10
Round table on future energy development

18:10–18:30
Free time / Press conference

18:30-20:30
Cocktail

Day 2

08:30–09:20
Introduction to the ITER Baseline
Prof. Osamu Motojima
Director General of the ITER Organization

09:30–09:55
Technologies of the Tokamak Core
G. Johnson

10:00–10:25
Assembly and Design Integration (Assembly, Remote Handling, CAD)
K. Blackler

10:00–10:25
Coffee Break

10:50–11:10
Facility Support System (Fuelling, Cryoplant, Electrical)
Y-H. Kim

11:15–11:35
Plasma Auxiliary Systems (H&CD, Diagnostics, Control)
D. Bora

11:40–12:00
Building Technology (Site Overview, Tokamak Complex, Hot Cell)
L. Schmieder

12:05–12:25
Fusion Technology Spin-offs
A. Maas

12:30–12:50
Burning Plasma Simulation
W. Ho Ulbergo

13:00–14:30
Lunch

14:30–15:15
The ITER Project Overall Procurement Strategy and Business Opportunities
F. Flament

15:15–17:00
Domestic Agency Procurement Processes and Implementation Status

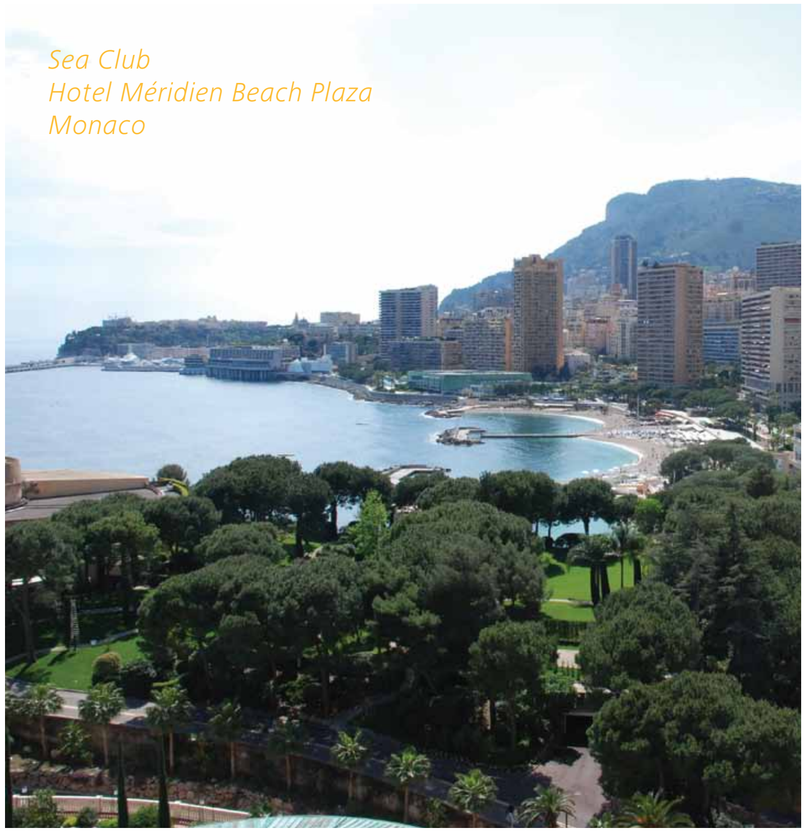
17:00–17:30
Coffee Break

17:30–18:00
Licensing of the ITER Facility and Technology Implications
C. Alejaldre

18:00–18:30
On-site Safety and Working Practices
T. Watson

Day 3

08:30–18:30
Oral sessions of ITER-IAEA Technical Meeting on Analysis of ITER Materials and Technologies



Sea Club
Hotel Méridien Beach Plaza
Monaco

The Little Kingdom by the Sea

The Principality of Monaco is the second smallest sovereign country in the world – the first one being the Vatican City. The size of Central Park in New York, its population barely exceeds 30,000 inhabitants, among whom less than 6,000 are Monégasques subjects.

This little kingdom by the sea, located 18 kilometres to the east of Nice, was established in the late 13th century. With the exception of a 25-year period during and after the French Revolution, it has always been ruled by the same family. This makes the Grimaldis of Monaco one of the oldest reigning dynasty in the world.

Despite its size, the Principality of Monaco enjoys the rights of a full-fledged independent state: it is a member of the United Nations with full voting rights; it exchanges ambassadors with some thirty capitals and mints its own euros.

In the constitutional monarchy of Monaco, it is the Prince who holds the executive power. Albert, born in 1958, the second child of Prince Rainier III and American-born Princess Grace, acceded to the throne in 2005.

Since Prince Albert I, who pioneered the then new science of oceanography, and founded the world-renowned Oceanographic Institute in Monaco in 1889, passion for science and the environment has been running in the Grimaldi family.

The Principality of Monaco's commitment to ITER is the most recent expression of this tradition.

Fall **2010**

Highlighting the First Monaco ITER International Fusion Energy Days

Special edition

iternewsline

A special publication by the ITER Organization for the first Monaco ITER International Fusion Energy Days.

PRINCIPAUTÉ DE MONACO
MINISTÈRE D'ÉTAT

IAEA
International Atomic Energy Agency

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china eu india japan korea russia usa

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Committed to Fusion as a Source of Renewable Energy

By signing an agreement with the ITER Organization in January 2008, the Government of the Principality of Monaco affirmed its commitment to the ambitious international research programme that ITER is. By doing so, Monaco has stated its position with regard to scientific research, sustainable development and renewable energies. The ITER project has one mission: to demonstrate the technical feasibility of nuclear fusion as a source of renewable energy, since the resources are plentiful and distributed across the entire planet.

The Principality of Monaco is deeply committed to this international project. This commitment has resulted in its funding various activities, amounting to 5.5 million Euros over a ten-year period. To coordinate and supervise the implementation of the activities under this agreement, a bipartite Coordinating Committee has been set up. It was officially established in Cadarache on 12th January 2010.

The agreement between the ITER Organization and Monaco provides for, among other things, the funding of post-doctoral research work. 5 post-doctoral students are to be selected every two years among candidates from the countries involved in the ITER project and from the Principality. On 11th February 2009, the Sovereign welcomed the first 2009-2010 "Prince Albert II of Monaco" group.

This agreement also makes provision for the annual organisation of an international conference in Monaco on ITER-related issues.

That is why I am delighted to welcome you to Monaco for the first ITER International Fusion Energy Days (MIIFED), which are being held in partnership with the International Atomic Energy Agency (IAEA).

I am convinced that these MIIFED days, open to a wide audience, to local economic players and political decision-makers, will not only highlight the importance of this programme for the future of the planet, but also the many opportunities it represents for them today. The IAEA is a key player in the event and has organised, in partnership with the ITER Organization, one of these scientific days on the following topic: "Analysis of ITER Technology and Materials".

The ITER International Fusion Energy Days will take place every three years.

I would like to express my grateful thanks to all the contributors who have supported us in this magnificent project. I hope you have an excellent stay in the Principality of Monaco and successful discussions.

H.E. Mr Michel Roger
Minister of State, Principality of Monaco,
President of the Monegasque Steering Committee for ITER

iter
china eu india japan korea russia usa

Fusion as Green Energy: From Dream to Reality

The potential of controlled thermonuclear fusion is enormous. The recent developments in the field leave no doubt that this energy source is destined to play an important role in sustainable future energy scenarios which have to overcome the environmental drawbacks of fossil fuels. The remaining steps to getting electricity into the grid from nuclear fusion reactors are an effort worth making.

On this path, the ITER project represents a milestone that the International Atomic Energy Agency (IAEA) has been supporting since its early days. The collaborative nature of ITER's work is reflected in bringing together – via its seven parties – more than half of the world's population to work on a single project, eventually for the benefit of our planet. The Monaco ITER International Fusion Energy Days (MIIFED) conference will strengthen collaboration and liaise with many additional Member States with a keen interest in fusion.

I would like to commend the Principality of Monaco for hosting the MIIFED. During the next few days, the two international bodies will hold their First Joint ITER-IAEA Technical Meeting on Analysis of ITER Materials and Technologies, which is a result of past collaboration. I would furthermore like to emphasize the importance of the support that the Principality of Monaco provides to the IAEA by hosting the IAEA Marine Environment Laboratories for the sake of delivering its programme to better understand and protect the marine environment.

On behalf of the IAEA, and as a great believer in nuclear fusion as a sustainable source of green energy in the future, I trust the conference will be successful in conveying to the media and the public, the scientists and the industries that fusion is an endeavor with enormous opportunities for all humankind.

Werner Burkart
Deputy Director General
Department of Nuclear Sciences and Applications

A Common Concern

The ITER Organization and the Principality of Monaco share a common concern for the future of energy and the preservation of our planet's resource. The Partnership Arrangement that was signed between the two parties on 16 January 2008 provides the ITER Organization with a strong support from the Principality in the form of a € 5.5 million contribution over a period of ten years.

Thanks to this generous donation, the ITER Organization can finance five two-years Postdoctoral Fellowships and organize, every other year in the Principality, an International Conference on fusion energy and ITER-related matters: the Monaco-ITER International Fusion Energy Days (MIIFED). The Principality is supporting ITER in two of the most essential aspects of scientific life: the training of the next generation of physicists and engineers and the sharing of knowledge and experience. What brings us together today is the first edition of MIIFED, jointly organized by the ITER Organization, the Principality of Monaco and the International Atomic Energy Agency (IAEA).

MIIFED offers an exceptional opportunity to explore and discuss what is at stake today in the energy world, and how fusion and ITER can help us meet the challenges of the coming decades. We are particularly honoured that His Serene Highness Prince Albert II of Monaco has accepted to deliver the keynote speech at the conference opening on 23 November. What is at stake with fusion and ITER is crucial for our future. Harnessing this new energy source and making it available for all the nations of this Earth is one of the greatest and most necessary ventures of our time.

Sharing this challenge and this excitement is what MIIFED is about.

Osamu Motojima
Director General of the ITER Organization

The Tokamak Machine

Feeders A

The 31 feeders are the lift-lines to the ITER magnet systems. They convey and regulate the cryogenic liquids to cool and control their temperature. They also connect the magnets to their power supply.

Toroidal Field Coils B

The 18 Toroidal Field (TF) magnets produce a magnetic field around the torus, whose primary function is to confine the plasma particles. The ITER TF coils are designed to have a total magnetic energy of 41 gigajoules and a maximum magnetic field of 11.8 tesla. The coils will weigh 6,540 tons total; besides the Vacuum Vessel, they are the biggest components of the ITER machine.

Poloidal Field Coils C

The six Poloidal Field (PF) magnets pinch the plasma away from the walls and contribute in this way to maintaining the plasma's shape and stability. Due to their size, the actual winding of five of the six PF coils will take place in a dedicated, 250-metre long building on the ITER site in Cadarache.

In-Vessel Coils D

The ITER In-Vessel Coil system is comprised of two systems: The Vertical Stability (VS) coils and the ELM coils. The Vertical Stability coils are two poloidal field coils located above and below the tokamak's mid-plane. They provide fast vertical stabilization of the plasma. The ELM coils, an array of 27 coils fixed to the wall of the Vacuum Vessel, provide resonant magnetic perturbations in order to control the plasma so that certain types of plasma instabilities are avoided.

Correction Coils E

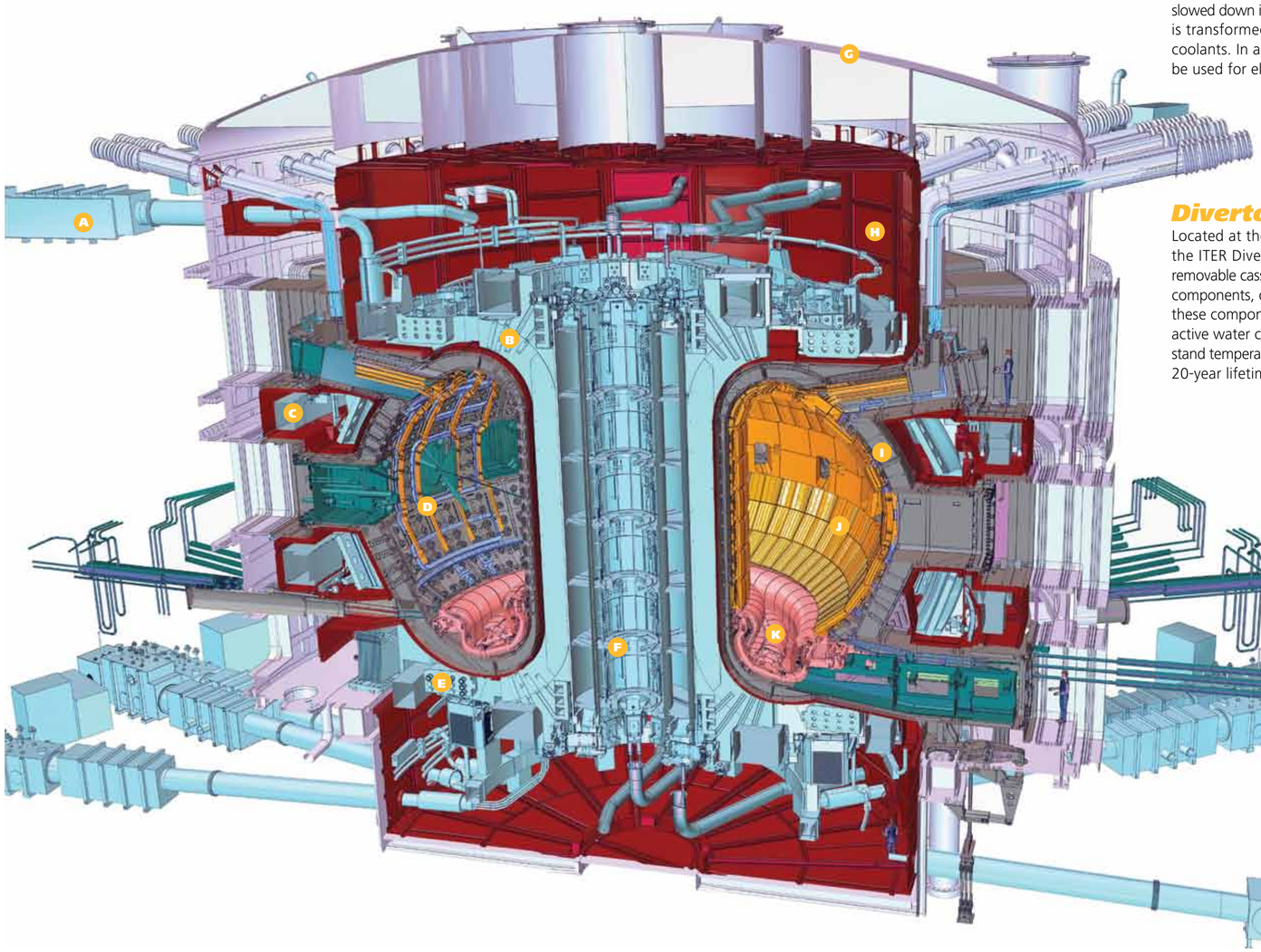
As their name suggests, the Correction Coils (CC) of the ITER Tokamak are designed to reduce the range of magnetic error fields created by imperfections in the location and geometry of the other coils used to confine, heat, and shape the plasma.

Central Solenoid F

The Central Solenoid - the backbone of the Magnet system - is essentially a large transformer. It contributes to the inductive flux that drives the plasma, to the shaping of the field lines in the Divertor region, and to vertical stability control. The Central Solenoid is made of six independent coil packs that use a Niobium-Tin (Nb3Sn) Cable-in-Conduit superconducting conductor.

Cryostat G

The Cryostat is a large, stainless steel structure surrounding the Magnets, providing a super-cool, vacuum environment. It is made up of two concentric walls connected by horizontal and vertical ribs. The space between the walls is filled with Helium gas at slightly above one atmosphere that acts as thermal barrier. The Cryostat is 31 metres tall and 36.5 metres wide.



Thermal Shield H

The Thermal Shield system is made of single-wall stainless steel panels with the cooling pipes welded to the panels. It is designed to minimize the heat loads transferred by thermal radiation and conduction from the warm components inside the tokamak to the components and structures that operate at 4.5K.

Vacuum Vessel I

The Vacuum Vessel is a hermetically-sealed steel container inside the Cryostat that houses the fusion reaction and acts as a first safety containment barrier. In its doughnut-shaped chamber, or torus, the plasma particles spiral around continuously without touching the walls. It will measure a little over 19 metres across by 11 metres high, and weigh in excess of 8,000 tons – more than the Eiffel Tower.

Blanket J

The Blanket covers the interior surfaces of the Vacuum Vessel, providing shielding to the Vessel and the superconducting Magnets from the heat and neutron fluxes of the fusion reaction. The neutrons are slowed down in the Blanket where their kinetic energy is transformed into heat and collected by the coolants. In a fusion power plant, this energy will be used for electrical power production.

Divertor K

Located at the very bottom of the Vacuum Vessel, the ITER Divertor is made up of 54 remotely-removable cassettes, each holding three plasma-facing components, or targets. The heat flux received by these components is extremely intense and requires active water cooling. They must be able to withstand temperatures of up to 3,000 C for the projected 20-year lifetime of the ITER machine.

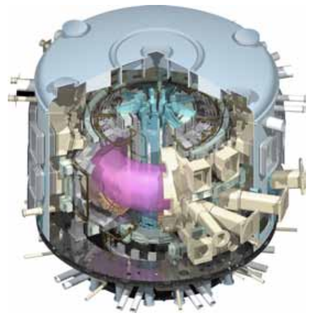
Q≥10 or What ITER Stands For

The goal of ITER is to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes. Scientists will therefore study plasmas in conditions similar to those expected in a electricity-generating fusion power plant.

ITER is designed to generate 500 MW of fusion power for extended periods of time, ten times more than the energy input needed to keep the plasma at the right temperature (Q=10). So far, the record energy turn out by fusion is 16 MW, produced by JET, the world's largest fusion experiment placed in Oxfordshire, UK. ITER will be twice the size of JET and it is aimed to be the first fusion experiment to produce net power. It will also test the key technologies, including the heating, control, diagnostic and remote maintenance that will be needed for a real fusion power station.

Operation of ITER will proceed in phases: a several-year "shakedown" period of operation in pure hydrogen, when the tokamak will remain accessible for operating staff for repairs, will be used to find the most promising physics regimes; this will be followed by operation in deuterium with a small amount of tritium to check shielding provisions, before launching increasingly frequent full operation with equal mixture of deuterium and tritium, at full fusion power.

Sabina Griffith
ITER Communications
Editor-in-Chief



The Hardhats Have Arrived

The initial preparation of the ITER site was carried out between 2006 and 2010 by Agence ITER France on behalf of the European Union, the Host Member, and France, the Host State. This significant and critical aspect of the project included the preparation of the 40-hectare ITER platform, provision of drainage and road networks up to the ITER platform, along with the construction of fences, water treatment facilities, and temporary offices.

For the permanent civil works and infrastructure required for the project, preliminary designs were developed in the period 2008 to early 2009. These were developed in-house with the support of Jacobs Engineering (UK) and Jacobs Nucleaire (France), and were used as the basis of the five Procurement Arrangements that define the scope of work to be carried out by the European Union as part of its in-kind contribution to the ITER project.

Construction of the permanent facilities has now commenced on-site under the management of Fusion for Energy (F4E), the European Domestic Agency for ITER. This agency, through its antenna based at the ITER site, is managing the detailed design and construction of all the ITER buildings and infrastructure. A series of contracts have been set up by F4E including those for the architect-engineering services, engineering and contract management support and safety inspection. In addition, construction contracts for the PF coil winding building, the Tokamak excavation and the future Headquarters building have been signed and construction works have commenced.

The construction activity now evident on the ITER site provides a visible measure of the significant progress of the project. Importantly, it provides a comprehensible and tangible indication to the Seven Members, as well as to the larger worldwide community, of the progress that has been made since the ITER site was selected in 2006.

2011 will see the completion of the PF coil winding building, the Tokamak excavation and the further preparation of the ITER platform ready for the main construction contracts which will commence in early 2012.

Timothy Watson
Head of the ITER Directorate for the Tokamak Complex

Fellowships

Become a Monaco fellow

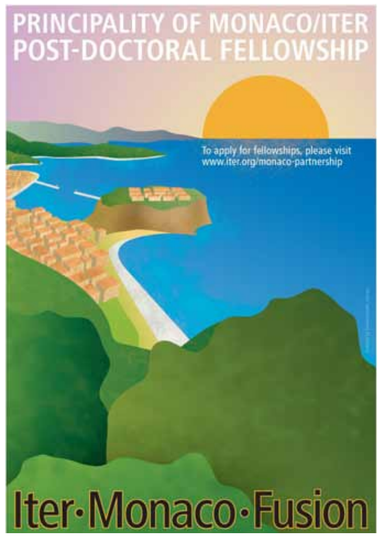
In January 2008, a Partnership Agreement was signed between the ITER Organization and the Principality of Monaco that set up five Postdoctoral Fellowships together with the establishment of an annual Conference on ITER related research. The Principality contributes 400,000 € for five Fellowships every two years over a ten year period, enabling five young scientists from the seven ITER Member countries or from the Principality of Monaco to be trained over two years in research areas related to the ITER project.

The Principality of Monaco is deeply committed to protecting the environment and to encourage sustainable development which is testified by the existence of the Prince Albert II of Monaco Foundation. As such it comes to no surprise that the Principality has expressed its interest in the ITER project as for the stakes it holds: "Needless to say, the challenge of protecting our environment and implementing measures to enable natural resources to be protected, extends far beyond the borders of each country", Prince Albert II writes on his website: "By definition, this is a common global challenge [...] This situation compels each one of us to take action if we want to protect the planet for future generations. Rest assured of my personal and unfailing commitment towards achieving this goal."

The principal motivation of the Research Fellowships is the development of excellence in research in fusion science and technology within the ITER framework. Brilliance and creativity, together with understanding of the relevance of your research interests to the ITER project are required.

In January 2009 the first five candidates arrived at ITER. In September this year, five new candidates were appointed to conduct research in fusion science and technology during the next two years under funding provided by the Partnership Agreement between ITER and the Principality of Monaco.

For full information go to: www.iter.org/Pages/Monaco2010.aspx



Our first fellows

Sophie Carpentier-Chouchana
Postdoctoral Researcher, Divertor and Plasma-Wall Interactions

"The ITER Monaco Postdoctoral Fellowship Program has given me the opportunity to join one of the most challenging scientific and technological projects of our time. My work in ITER has consisted in estimating what will be the wear of the 700 m2 beryllium first wall, which is a crucial question in estimating the lifetime of the tokamak internal components. Another part of my activities has been to assess how much of the precious fuel, the tritium, will be retained in the main wall during operation of the device and so to estimate how many shots will be possible before reaching the limit for the tritium-inventory allowed in ITER. Thus, the Monaco Postdoctoral Fellowship Program has given me the chance to work and make progress on critical aspects of the ITER project. From a personal point of view, it has meant a real opportunity for me to continue my personal adventure in fusion."

Matt Jewell
Postdoctoral Researcher Superconductor Systems and Auxiliaries Section

"My time at ITER has been an extraordinary opportunity for me to see these advanced superconducting materials—of which I was an active participant in the R&D for several years—now being put to use in the world's largest set of superconducting magnets. It has been both personally and professionally rewarding to interact with the teams at IO and across the DAs, and I will remember for my entire career the lessons I have learned here."

Junghee Kim
Postdoctoral Researcher Divertor Systems

"Working at ITER is a dream for many young researchers in Fusion Science and Technology. Therefore, the fact that I am now working on this project is indeed a personal honour. In ITER, I can meet people from many fields, and it has made me realize that the world is wider than I thought. Before joining ITER, I thought I should just concentrate on 'my' field; however, that is not the right way to grow as a professional because a big project such as this one is accomplished by all of us. The greatest reward of my time in ITER is that my professional insight has been continuously developed. I will work towards fulfilling my dream for making the fusion reactor with more insight and a wealth of experiences."

Evgeny Veshchev
Postdoctoral Researcher Port Based Systems

"ITER is a great ambitious project uniting creative ambitious professionals from all over the world. It is a real honour to work on ITER and I am very proud of it. I would like to express my sincerest gratitude to Monaco/ITER program for this opportunity to join this fascinating project and highly dedicated team."

Axel Winter
Postdoctoral Researcher Plasma Operations

"The Monaco Postdoctoral Fellowship gave me the unique opportunity to work for one of the most complex and fascinating science projects of our time in an environment that brings together scientists and engineers from all the ITER partners. My work on the Plasma Control System for ITER has enabled me to work closely together with many colleagues from different ITER departments, but also from other fusion devices around the world, which has been a highly rewarding experience. "

Construction and Manufacturing

Moving from design to hardware

The ITER project is moving from paper to reality, from design to hardware. As of today, 46 Procurement Arrangements have been signed, representing approximately 60 % of the total procurement value of the ITER project. Another 13 PAs are scheduled to be signed by the end of the year.

The most impressive progress is made in the area of conductor fabrication. Strand production for ITER's impressive Toroidal Field (TF) Coils has been launched in China, Japan, Korea, Russia, Europe and the US, together more than 100 tons (more than 21.000 km) of strands have been manufactured and registered in the Conductor Database.

760 meters of Copper dummy cable for the TF Coils have been produced in Japan, Korea and Russia, Japan and Korea have also produced first superconducting cable lengths. The commissioning of the winding machines is in progress in Japan as well as the welding trials for the coil cases, in Europe the call-for-tender for the winding package is underway and a contract for the qualification of the case welds has recently been signed.

A Message from Mr. OH Byung-Wook

President & CEO of Hyundai Heavy Industries

I would like to welcome all of you to the Monaco ITER International Fusion Energy Days! All of us, as mankind, have put significant effort into a more convenient and better way of life, and, as a result, major gains have been made along the way.

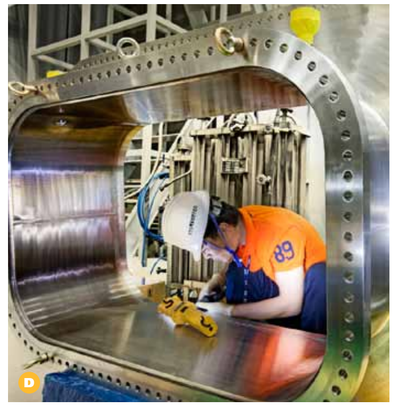
Currently though, we face some large problems; such as global warming, air pollution by carbon emission, and a shortage of energy, etc. However, I am sure that one of the best ways to solve these problems is with the development of fusion energy.

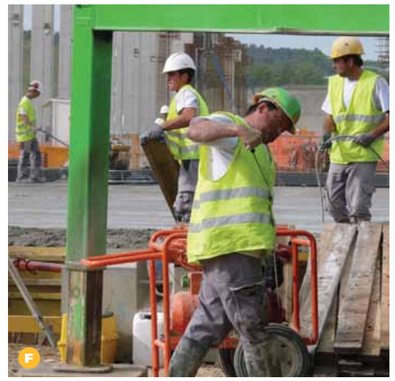
This conference is to discuss the development and improvement of fusion technology. It is significant that so many eminent scholars and experts have gathered together to address the best paths to a solution that will help to save our planet from the perils that lie ahead.

I am honored to be here with you today at this significant event. We, Hyundai Heavy Industries, manufactured and supplied the vacuum vessel and cryostat for the special project of KSTAR in 2007. KSTAR (Korea Superconducting Tokamak Advanced Research) is a prototype research project for ITER. Earlier this year, we began work on the fabricating of two of the nine sectors of vacuum vessel and ports for ITER.

I'd like to take this opportunity to express our sincere commitment to the larger ITER project and to the successful completion of our current undertaking.

Thank you very much.





A International collaboration is the key to the success of ITER. *Photo: Peter Ginter*

B The hardhats have arrived on the construction site. *Photo: ITER Organization*

C The placement of the concrete columns for the Poloidal Field Coil Winding Facility with the tokamak pit in the background. *Photo: ITER Organization*

D Prototypes of the port structures being manufactured in Korea. *Photo: Peter Ginter*

E An artistic impression of what ITER will look like. The large orange building in the centre is the Tokamak hall, the long building on the right is the winding facility for the Poloidal Field Coils. *Photo: ITER Organization*

F Construction of the ITER facilities started in summer 2010. *Photo: Agence ITER France*