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FOREWORD FROM THE DIRECTOR GENERAL

Looking back on the founding year of the European Spallation Source ERIC (ESS), the organisation and our supporters around Europe made a strong statement with the successful start of construction and with the establishment of the governance for the future.

With strong support from our stakeholders, ESS completed the transition to an international organisation and became a European Research Infrastructure Consortium. The Member countries are now jointly responsible for building and operating the world’s leading research facility using neutrons for scientific research and industrial development.

The construction phase kicked-off following completion of the Technical Design Report in 2012. In 2013, we established collaborations with potential In-kind Partners and secured essential funding commitments from Member countries to begin construction in Lund, Sweden in 2014.

In 2015, there was a dramatic advance in facility construction with over 20% of the facility completed by the end of the year. We also built up the organisation, recruiting new directors for administration and science, while increasing staffing to over 350 employees.

We completed over 20 design reviews of technical systems and interfaces, while building and testing prototypes of key accelerator and target equipment.

The ESS is happening all over Europe. In-kind Partners responsible for the delivery of technical systems are already in the execution phase of their respective work packages. In 2015, a collaboration of institutions responsible for the delivery of the instrument programme was formed. By the end of the year, ESS signed a Memorandum of Understanding (MoU) with the United Kingdom’s Science and Technology Facilities Council for the delivery of two instruments, LOKI and FREIA.

In 2015, our organisation also conducted a comprehensive assessment of progress, the ESS Annual Review. Within the time frame this document is published, we will have already performed the Annual Review for 2016. These reviews focus the entire organisation and our Partners on key priorities for the year and on the delivery of the facility in line with expectations.

In this, our first annual Activity Report as an ERIC, are examples of our progress and pictures of the ESS people and Partners that are committed to making ESS a reality. Throughout this process we continue to embrace our core values of Excellence, Openness, Collaboration, and Sustainability.

I am proud of the progress we have made, and even more proud of the fact that we confront our many challenges together as a team.

James H. Yeck
ESS Director General

“I am proud of the progress we have made, and even more proud of the fact that we confront our many challenges together as a team.”
ABOUT ESS

NEUTRON BEAMS FOR SCIENCE
A USER FACILITY TO ENABLE SCIENCE

A New Facility
The European Spallation Source (ESS) is the ambitious story of a new facility being built on an established vision. Daily progress on the construction site and in the development of the technical components make it clear that ESS is, after 20 years in the making, becoming a reality.

The entire research infrastructure of ESS is committed to the goal of building and operating the world's leading facility for research using neutrons. The ESS will deliver a neutron peak brightness of at least 30 times greater than the current state-of-the-art. Generating neutron beams for science will add value to a state-of-the-art neutron instrument suite, a suite of neutron instruments to answer their specific scientific questions.

Neutron scattering encompasses a diverse range of experimental methods. Depending on how a neutron instrument is built, it can extract various kinds of information and answer different questions. The ESS organisation will collaborate with the international research community in order to ensure that the instrument suite meets the needs of science, enables the breakthroughs of tomorrow, and makes this the facility built by scientists, for scientists.

The ESS project’s foreseen milestones include: first on-site Accelerator installations in 2016, readiness of the Machine for beam on Target at the end of 2019, Machine installation for 2.0 GeV performance in 2022, the start of the user programme in 2023, and the completion of instrument construction in 2025.

Approved Instruments
A total of 16 instruments will be built during the construction phase to serve the neutron user community, with more instruments built during the operations phase. The ESS instrument suite will provide a 10–100-fold improvement over current performance, enabling scientists to utilise neutron methods to study real-world samples under real-world conditions.

The Neutron Scattering Systems (NSS) project at ESS is responsible for the development and coordination of state-of-the-art instrument concepts for ESS, in collaboration with international Partners. Almost 40 concepts were developed and evaluated. Of those, 16 concepts have now been selected and approved by the ESS Council for construction.

Collaboration
Even before the anticipated global-scale scientific impact can be realised during operations, ESS has a direct economic impact. The project generates economic growth and jobs, advances development, and fuels innovation potential in the Öresund region and across Europe. With the ESS being built as a collaborative project, the growth effect will be shared between the Host countries, Sweden and Denmark, and all of the ERIC Partners and collaborations Partners.

The realisation of ESS enables access to frontier technology, experienced technical and scientific staff, as well as unique production facilities and technologies, which would otherwise be unattainable.

The ESS will be an attractive and environmentally sustainable compound with research and laboratory buildings and office space designed to make an impact on the world stage.

THE ESS PROJECT
The European Spallation Source is one of the largest science infrastructure projects being built in Europe today. The ESS facility will be the world’s leading neutron source for the study of life and materials sciences, soft condensed matter, magnetic and electronic phenomena, energy, engineering materials and geo-sciences, archaeology, and heritage conservation and fundamental and particle physics. The ESS source will be a key instrument for addressing the grand challenges which society faces today by making it possible to access novel insights on matter at the molecular and atomic levels, as well as plant water-uptake strategies, plant water-uptake processes of relevance for agriculture, and much more.
The research needs of the neutron science community will play a role in addressing and solving some of the grand challenges that society faces today. Research will have impacts on areas such as: energy, materials and life sciences, magnetics and electronics, fundamental physics, and cultural heritage.

Scientific Impact
To meet the challenges of our age and uncover the fundamental secrets of nature, we are increasingly dependent on the properties and behaviour of matter at the atomic and molecular level. The number of required techniques to probe matter is also increasing to keep up with the growing demands of society as well as the new matter complexities being uncovered and designed. Progress depends on the clarity provided by continually advancing techniques, and methods that constitute this unique scientific tool kit using neutrons to study nature.

Neutrons have wavelengths and energies that are at least 30 times greater than any other neutron source in the world, providing a quality of vision of the inner working of matter that will be at least that much greater. The uniquely long-pulse time structure of ESS will enable measurements over a wider temporal and spatial dynamic range, providing distinct advantages over present neutron instrumentation. Thus, ESS is a truly novel facility with the capability to transform the way we use neutrons.

Soft Matter
The ESS facility will surpass the limits of current neutron to better understand soft matter substances known as polymers and colloids, which are the foundations of blossoming technologies such as pharmaceuticals, detergents, cosmetics, and batteries that impact our everyday lives.

Chemistry of Materials
Society needs better catalysts, improved construction materials, more efficient energy materials, and more effective pharmaceuticals. The ESS facility will enable better exploration of material complexity, the issues associated with predicting behaviours, and the challenges of measuring both structure and dynamics as a function of time.

The ESS user community will make breakthroughs in materials chemistry by looking at materials in operando in catalytic converters, batteries and fuel cells. Research at ESS will track the evolution of dynamics, atomic structure, and important changes in microstructure in action for the first time. This record of materials chemistry in realistic conditions with unmatched clarity will allow progress in material design and development.

Novel Quantum States
Novel quantum states in magnetic and electronic materials are new and exciting scientific frontiers. They challenge our understanding of the states of matter, and will be at the core of future functional devices that will furnish our households, offices, and factories.

Understanding the magnetic order and excitations of these novel phases is uniquely accessible by neutrons. Here the magnetic order is either short-ranged or exhibits very long periodicity, making it challenging for resonant X-ray magnetic scattering methods. At ESS, all relevant energy and length scales required to understand such materials will be measured simultaneously for the first time.

Life Science
The untapped potential of neutron sources will significantly impact life science research. The use of neutrons for studying biological systems is growing, and ESS will edge closer to the level where neutron experiments can be made in a timely manner without the concern of radiation damage.

The ESS facility will enable investigations of rare biological samples in small quantities, both crystallised and in solution. Unlike X-rays, the non-invasive properties of neutrons leave the sample undamaged, enabling single-sample, time-resolved investigations. The brightness of ESS will allow the throughput and enable more comprehensive systematic parameter analyses, which are in high demand from the pharmaceutical industry. The ESS will unleash the unique investigative power of neutrons on the chemistry of life.

Current trends in biomedical research reveal a need to understand greater complexity. The higher neutron brightness of the ESS will allow better examination of the structure and dynamics of complex macromolecules in dilute concentrations.

The ESS facility will modernise neutron research methods, opening up new possibilities for studying smaller, more complex samples and recording of processes under real-world conditions in a wide range of scientific fields.
Mission
To design, build, and operate the world’s leading research facility using neutrons for science and innovation.

Excellence
We provide the world’s leading neutron science facility and world-class support for the science community. We advance the use of neutrons in science and technology by supporting and developing instrumentation and tools for the highest quality application of neutrons in research. We always aim for scientific, technical, and operational excellence in the safest environment.

OUR MISSION
AND
CORE
VALUES

Collaboration
We are an integral member of European society and we engage with the scientific and industrial communities to help build and operate ESS. In our everyday work and all our interactions, we seek to build and maintain relationships that create a shared sense of ownership among our stakeholders. Internally and externally we are committed to act and speak with one voice, as one ESS.

Openness
We perform our work in an open and transparent manner. In this way we build trust with our partners, our stakeholders, and with each other. We are willing to collectively and directly address challenges, and celebrate success. We demonstrate on all levels, internally and externally, that we stand for what we say in the way we act.

Sustainability
We act and make decisions with a long-term perspective and strive to safely and responsibly use natural, human, and monetary resources. We take the full life cycle of ESS into account, and view sustainability from environmental, social, and economic perspectives.

A EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM (ERIC)

The European Spallation Source (ESS) is the first ERIC established in Scandinavia and the 11th in Europe. The designation grants the ESS legal status in all of the Member countries, enabling them to participate in the governance and directly contribute to the financing of ESS.

Founding Members and Observers
The Founding Members are the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Italy, Norway, Poland, Sweden, Switzerland and the United Kingdom, Belgium, the Netherlands and Spain, joined as Founding Observer countries and plan to become Members in the near future.

The European Spallation Source ERIC is governed by statutes adopted by its Member countries, which concern governance and operational guidelines, membership, funding, and contribution to the organisation, as well as the rights and obligations of the Members. The ESS organisation has adopted its own procurement rules, based on transparency, non-discrimination, and competition.

Appointed Leadership
The Director General of the European Spallation Source ERIC is James H. Yeck and the Chair of the European Spallation Source ERIC Council is Professor Lars Börjesson.

Committees
The committees established by the ERIC Council serve as advisors to the Council. These include the Administration and Finance Committee (AFC), Scientific Advisory Committee (SAC) and Technical Advisory Committee (TAC), In-kind Review Committee (IKRC), Committee on Employment Conditions (EECC), Environmental Safety & Health Advisory Committee (ESHAC). Conventional Facilities Advisory Committee (CFAC) and the Annual Review.

The Transition to ERIC
The European Spallation Source ESS AB was set up as a limited liability company in 2010, and the staff of ESS Scandinavia were transferred from the University of Lund their initial hub of operations. To build and develop ESS, many of the critical skills needed to be imported through In-kind Contributions (IKC) from participating institutes and companies in the Member countries. To establish a legal framework for this, the European Spallation Source ESS AB has completed a transfer of assets, obligations, and personnel to the European Spallation Source ERIC on 1 October 2015. The ESS AB will be dissolved after 2015.

A European Research Infrastructure Consortium (ERIC) is a type of legal entity created by the European Commission for governing international research facilities. On 8 September ESS officially became an ERIC. The European Commission’s Director-General for Research and Innovation, Robert-Jan Smits handed over the official grant of the ERIC from the Commission to ESS during a ceremony on the construction site.

“The European Spallation Source is one of the most impressive European Research Infrastructures and has obtained the prestigious ERIC status,” said Smits. “The timely completion of ESS enables Europe to maintain its position as the leader in neutron-based research and provides a multidisciplinary centre for innovation and competitiveness.”

The new facility will be the world’s leading facility for research using neutrons and one of the highest priority research infrastructure projects in Europe. The EU has approved projects for the ESS under its Horizon 2020 programme for more than €20 million, including the project BrightnESS project up of 18 European institutes and universities from 11 countries and spans over 36 months.
ORGANISATIONAL GROWTH

The construction of the material research facility ESS is not the only thing progressing rapidly at the construction site on the outskirts of Lund. In order to realise the world’s leading facility for research using neutrons, ESS staff has grown at a steady pace and attracting talent from all over the world.

Growing Staff

Earlier in the year, ESS celebrated the hiring of its 300th employee and the 40th nationality represented by ESS staff members. ESS has come a long way from the time when the Swedish government established the ESS-Scandinavia Secretariat in 2007, with only seven employees. By the end of 2015, ESS reached a total of 353 staff representing 46 countries. This development with a growing number of employees means that there is a lot of in-house competence which is further enhanced through external collaborations with partners.

The ESS project evolved rapidly following the 2009 decision to build the facility in Lund, and continues to expand. ESS added a third of its workforce in 2014, growing by 111 employees. Altogether ESS will have approximately 500 employees when the material research facility delivers the first neutrons by the end of the decade. In an effort to find the best talent, ESS strives to recruit employees from all over the world.

New Management at ESS

The past year saw significant changes for ESS management. Agneta Nestenborg took charge of the ESS Project Support & Administration Directorate on 1 September. Her job is to ensure that the strategic planning, development, and implementation of processes and procedures are on-schedule for the ramp-up to cold commissioning at the end of 2019.

As the former Head of Project Sponsors Nuclear Operations at the Swedish energy utility, Vattenfall, she comes to ESS with experience in R&D, management, operations and governance across a wide range of industries that include science, construction, consulting, nuclear technology and others.

Agneta’s experience and extensive network within the Swedish industry and authority communities will be very valuable for the organisation as it transitions into the ERIC, facing a variety of challenges and opportunities.

YOUNG PROFESSIONALS

The ESS is also very proud of their continuing commitment to developing young professionals, with the Spanish Junior Professional Programme. Fifteen young graduates from Spain have gained valuable work experience as trainees, holding positions within different divisions, and making important contributions to the ESS project. Most participants have chosen to extend their trainee programme for an additional half year, with three staying even longer and becoming ESS employees.

An important addition at the end of 2015 was the naming of Andreas Schreyer as the new Director for Science at ESS. Schreyer, a career neutron scientist and former Director at HZG’s Institute for Materials Research, Schreyer has long been active in the ESS collaboration in his role spearheading the German contribution to the project. His management experience at large scale neutron and synchrotron facilities and his strong history and interest in supporting collaboration on instruments make Andreas an asset for the ESS Executive Management Team.

A Comprehensive Assessment

The review covered nine core project areas – from technical and scientific, to managerial and financial – and took in the analysis and recommendations of more than 30 external experts. The overall evaluation by the 2015 committee was positive, describing ESS as a “rolling machine that will reach its target.”

“The project is ballistic. It went from the initial phase of defining itself, to now it’s in execution.” - Marzio Nessi

The committee singled out the rapid personnel growth, and the “impressive” development of the project’s unique In-kind model. They also highlighted the resilience of the ESS technical design and the aggressive schedule. An action plan was developed to address the recommendations made by the committee.

ESS Technically Sound

Technical obstacles did not figure prominently in the recommendations, and the committee made the observation that there were no “showstoppers” in this area. As the first facility installations on the schedule, progress on Accelerator systems was placed in the spotlight. Expediting the formal design review process and strengthening the on-site technical review of in-kind work packages were highlighted as key recommendations for moving collaborations forward.

“I have had the benefit of working in many different areas. I hope to make good use of everything I’ve done, as the new Administration Director for ESS.” - Agneta Nestenborg

ANNUAL REVIEW

The 2nd Annual ESS Project Review took place over 4 days in April and provided a deep look to measure how progress on the technical and managerial aspects of the project match up to the commendable pace of the civil construction. The two must be closely coordinated to avoid delays.

The year 2016 will see the reach of the ESS project extend deeply into the Partner countries, with returns in the form of component optimisation, development, and installation on the Accelerator. This will be achieved through the implementation of the ERIC, facing a variety of challenges and opportunities.

The earned value of the ESS project is being tracked using 20,000 individual activity parameters, and reveals, among other things, that the project was about 11% complete relative to its estimated 2025 closeout cost by the time of the review. The next two years will see a sharp rise in completion of these activities, and this number is expected to rise to around 90%. Additionally, it is anticipated that more than half of all In-kind Agreements – 120 Technical Annexes totalling around €400 M – will be signed by the end of 2015.

The general impression from the Review was:

• Very positive, impressive progress.
• ESS is now a rolling machine, which will reach its target.

• ESS is defining how to deal with In-kind. A very impressive progress in this area.
• Schedule is very tight, but not impossible.
• More than 100 people have joined ESS in 12 months.
• Technical problems are finding solutions.
• We are seeing an increase in the amount of detail to deal with.
• Operation begins to be an integral part of the overall project.

RECOMMENDATIONS

The results of the 2nd Annual Project Review singled out impressive development and found no “major technical problems.”

The nine sub-committees emphasised the need to firm up the high-level integration between the project areas, while at the same time defining the mechanisms for operational-level integration.

The committee recommended constructive actions including: aggressive personnel recruitment and training in engineering areas, using cross-functional personnel, and further clarification and leveraging of the In-kind model.
The European Spallation Source (ESS) is a multi-disciplinary research centre based on the world’s most powerful neutron source. ESS will give give scientists new possibilities in a broad range of research, from life science and engineering materials, to heritage conservation to magnetism. ESS is a pan-European project, with Sweden and Denmark serving as host countries. The main research facility is being built in Lund, Sweden, and the Data Management and Software Centre (DMSC) is located in Copenhagen, Denmark.

**The Target is the Neutron Source**

When the accelerated protons hit the rotating tungsten target wheel, spallation occurs and neutrons are scattered from the tungsten nucleus. The more neutrons produced and collected in the target, the "brighter" the neutron source. The neutrons are directed through moderators and neutron guides to the scientific instruments where they are used for experiments. The target monolith consists of the target wheel, moderators, a cooling system, and shielding, and weighs approximately 3,000 tonnes.

**Total Building Area 65,000 m²**

The ESS facility will be approximately 650 metres in total length. The target building will be 125 metres long, and about 30 metres high. The 537-meter-long accelerator tunnel is built underground and will be covered with soil.

**Concrete:** 50,000 m³
**Rebar:** 6,000 tonnes
**Pipes:** 60 km
**Cables:** 2,000 km
**Total Volume:** 400,000 m³

**Steel and Concrete Piling to Avoid Movements**

The heavy target building and experimental halls are resting on a total of 6,600 piles of different types, in order to avoid unwanted movements in the structure.

**Unique Capabilities of ESS**

ESS will have 22 tailor-made instruments located in three experimental halls. Neutrons are excellent for probing materials at the atomic and molecular level – everything from motors and medicine, to plastics and proteins. The neutrons hit the sample and detectors register the neutron scattering, giving precise information about the material’s structure and dynamics.
CONSTRUCTION

MOVING FORWARD
Building the Accelerator Tunnel
The finished 537-meter-long Accelerator tunnel will come and go from sight quickly, as it will be buried under five to six meters of earth. Completion of the vault is anticipated for early 2016, with backfill and topfill already underway. The tunnel walls have been completed, extending from the Front End Building to the Target Station beam dump. Interior work has also been ongoing for several months, including interior painting and floor polishing.

The large Klystron Gallery Building is being built in stages. It runs alongside the tunnel for most of the tunnel’s length and the two are connected by 27 two-storey concrete "stubs." Construction of large areas of the Gallery Building, including the four-storey 'cold box' section, have progressed to interior and roofing works. Mechanical, electrical and plumbing (MEP) works will begin in the tunnel and the gallery in spring 2016. That’s an important shift in the type of work being done on a large portion of the site infrastructure.

CONSTRUCTION PROGRESS

ESS Site Development
The ESS civil construction project broke ground in 2014 as one of the largest research infrastructure projects in Europe. There has been much progress with the Accelerator tunnel nearing completion, and the complex foundation work for the Target station well advanced. The completion of these works will make way for focus to shift onto technical installations.

Conventional Facilities Activities
Conventional Facilities (CF) at the European Spallation Source refers to the spaces required to house research equipment, machines, instruments, and people. CF are also responsible for the mechanical and electrical services necessary for the proper functioning of the facility.

The overall goal of the CF project is to deliver the physical space for a research facility in a sustainable way, on-budget, on-schedule, and with the proper function and quality. Over the last two years, the work in CF has been marked by the following major activities:

- The licensing process,
- Building design,
- Procurement of the construction contract,
- Site investigations,
- Construction works, and
- Development of the energy concept.

Construction Update
The physical change of the ESS construction site over the last 12 months has been dramatic. The flat brown landscape of earthworks and concrete reinforcement has morphed to a buzzing, three-dimensional hive that now includes a power and drainage installation, interior finishing and roofing, and the continual work of foundation piling, concrete casting, and new excavation.

By the end of 2015, nearly 14,000 cubic meters of concrete have been put in place for the Accelerator tunnel alone. More than 4,000 concrete, steel core, or bored piles have been sunk for the Target station and Experimental Halls foundations. Construction on almost half of the buildings has commenced and the base slab of the tunnel is almost complete. The project’s on-site workforce grows rapidly, having nearly tripled in the last 12 months. There are now approximately 340 on-site workers representing 15 nationalities, including nearly 200 construction workers, among others from companies based in the UK, Sweden, Poland, Estonia, and Lithuania.

“It’s always uplifting to see how fast progress of the construction site is going.”

James H. Yeck
Director General of ESS, James H. Yeck puts strong emphasis on the development of the construction work. By the end of 2015, the ESS project had reached more than 20% completion. “What is more difficult to see is the momentum across the project as a whole,” he went on to say.

“This is absolute progress and it’s apparent that the pace is picking up. That energises us here in Lund and our Partners working across Europe.”

The project’s critical path dictates early focus on the Accelerator tunnel and adjacent areas. This is followed closely by the Target area, including buildings, installation tunnels, and the demanding monolith and hot cell foundations. Very critical will be the bunker interface between the Target and the Experimental Halls. The Experimental Halls, the instrument Beamline Galleries, and then the laboratory and campus buildings will be the last structures to complete.
Construction Partner Skanska and its sub-contractors have worked at a steady pace casting the tunnel’s base slab and erecting the walls and vaults section-by-section to complete the roughly 700 m of the main and auxiliary tunnels. The total length of the main Accelerator tunnel will be 537 m.

**Early Access for Installations**
The Conventional Facilities Division will work closely with the Accelerator Division to make some buildings and facilities available for early access. “The Accelerator Division will have partial access to their buildings in autumn 2016,” said Kent Hedin, Head of the ESS Conventional Facilities Division. “We are on track, and looking forward to the handover so the Accelerator teams can begin their installations and begin to build the Accelerator.”

Full access to the Linac tunnel and Front End Building is expected in spring of 2017. This includes the infrastructure, electrical, and otherwise, that are required to begin installation work. The primary electrical substation building, H05, will be the first to be completed.

**Morale is High**
The successful completion of several milestones in a row, all on time, has instilled the project with an optimistic and cooperative environment.

“There is a good work culture of helping each other, where no one is left to solve problems by themselves.” – Magnus Jakobsson

**Progress Based on Collaboration**
The collaboration agreement between the two companies is a multiple stage contract which provides flexibility and control for each phase of the complex construction project. Separate agreements will be settled for each stage with a specific scope and target cost.

The second phase of the agreement, worth 1.2 B SEK, was contracted in May 2015. This contract covers installations in a number of buildings, substations and transformers, ground works including piling, landscape works, and concrete works on the Target station and Experimental Halls. The contract with Skanska also focuses on detailed planning and preparations for the civil works construction, and developing the organisation, common goals, and working methods for a successful joint delivery of the full project.

**Collaboration with Skanska**
ESS and Skanska signed a collaboration agreement for the entire project in February 2014. The collaboration is divided into several stages and separate agreements will be settled for each stage with a specific scope and target cost.

The successful installation of the first ESS buildings being near completion, work is ramping up on the Target area. Construction there has included the challenging and time-consuming steel core and concrete piling work. By the end of the year, approximately 63% of the 6,000 concrete piles and 44% of the 356 steel core piles were brought to the bedrock.

“We will start concrete work for the Target building foundation in the Monolith area in early 2016. That’s a major milestone for the project,” says Magnus Jakobsson, Construction Section Leader for the ESS Conventional Facilities Division who works on-site with Skanska.

**Target and Building Works**
The Target area has been excavated and building works will begin in early 2016. Plumbing, electrical, concrete, road works, operational planning and procurement are ongoing in anticipation of the first ESS buildings being completed. The primary electrical substation (H03) and the distribution substation (H04), serving the Central Utility Building (CUB), will be the first major permanent buildings to go up on site. The large Gallery Building (G02) will follow close behind. The Gallery Building runs nearly the length of the Accelerator and includes the Cold Box and Test Facility areas.

In November, site workers celebrated the successful installation of the first of 63 large-diameter bored piles for the Monolith foundation. These piles are each 16 metres across and require a special pile-driver that had to be shipped from the UK in October. Once drilled, the piles are cast in place using a special procedure. The first casting followed several years of design work to meet requirements for earthquake proofing. Twenty-three have been set. The first Target installations are scheduled for late 2017.

The CF and Target Divisions are working on documentation for The Swedish Radiation Safety Authority (SSM). Approval from SSM is key to maintaining the facility will be handled in 2017. The application process is carried out stepwise, aligned with the design and construction process of ESS. The ESS facility design will meet the highest standards of safety that are expected by its users and its personnel.

In July 2014, the SSM granted conditional approval for ESS, which allows construction to proceed. John Haines, ESS Interim Associate Director of Environment, Safety, Health & Quality is preparing the application to SSM for the license to install equipment in the Accelerator tunnel and other parts of the facility.
IN-KIND AND COLLABORATION PARTNERS

A WINNING TEAM
IN-KIND CONTRIBUTIONS

The success of the ESS mission relies in great parts on the expertise of its international Partners, a network across many disciplines and all the Member countries. Our Partners bring their knowledge, personnel, and experience to the construction in the in the form of In-kind Contributions (IKC), or non-cash contributions.

Coordinated Effort for a Common Goal

Building a state-of-the-art facility is challenging in many respects, even more so when being built from the ground up, on a Greenfield site. In order to successfully construct ESS in the required time frame, experts, scientists and engineers from all over Europe are mobilising their knowledge and experience. The coordination of such an effort can be challenging, but the rewards are tremendous as well. This collaboration of more than 40 institutions, working together in parallel with one goal, enable the power of European science to deliver an unprecedented facility in a relatively short time frame.

In order to make this effort work, a framework has been created and Partners have systematically matched their skills and expertise with the needs of the project. An IKC may cover technical components as well as personnel needed to perform testing, installation, and integration.

The In-kind Contribution Process

The ESS IKC process can be separated into three fundamental phases:

1. **Preparation**: managing expressions of interest and contracting with Partner institutions.
2. **Implementation**: tracking the delivery of the contracted solutions, services, materials etc.
3. **Conclusion**: IKC value creating process is approved, applied and the closest of a contribution is conducted.

In-kind Contributions may also include R&D work needed during the Construction Phase. Other products or services relevant for the completion of the ESS facility may be included as well, as long as it is a planned part of the construction project and agreed between ESS, the Partner institution and the Member country.

In addition to the advantage for the ESS project, there are also important benefits that the Member countries will realise as a result of their contributions. It allows Partner institutions to have focused networking possibilities with international Partners, and at the same increase local know-how. Working on a large-scale research infrastructure creates unique employment opportunities in the Member countries, contributes to national economic growth and fosters the growth region of regional economies in high-value technological and specialised industries. It also allows the Partner institutions direct access to ESS research into cutting-edge technologies.

Progress Securing In-kind Contributions

Work and activities relative to establishing In-kind Contributions have been ongoing since 2011 and are making tremendous progress. These contributions are expected to finance more than €645 million, or 35% of the total €1.843 billion (2013) construction costs.

Overall, ESS has identified a project scope with a potential value of €664 million, equal to 61% of the ESS technical work scope. The total current value of IKC work packages with Partners is €132 million, nearly half the estimated potential value. That value will continue to rise. The Partner facilities and ESS project teams continue to identify work that may be done by IKC Partners. There are important decisions still pending on the distribution of IKC relative to Neutron Scattering Systems, Instruments and Integrated Control Systems. This is expected to raise the total planned IKC close to the goal of 35% of the project value.

IKC from Start to Finish

The process of identifying an IKC Partner begins with the ESS project teams. They are responsible for defining the work in their respective projects that can potentially be done as an In-kind Contribution. The value for contributions must be based on the overall ESS budget and project budgets as defined in the cost book. After the work has been defined and a value determined, ESS solicits proposals from potential Partners in the Member countries.

Potential Partner institutions evaluate those in-kind packages and when they see a potential package that is of interest, they can respond with an Expression of Interest. This begins a discussion between the potential Partner and ESS to reach an agreement on the scope, schedule and cost. Each Agreement follows a pre-defined structure. The delivering party, in agreement with ESS, is wholly responsible for the contribution including the technical, financial, and commercial aspects. The In-kind Review Committee (IKRC) evaluates all In-kind Agreement proposals that are reached and signed, and decides to endorse them or not. Finally, the ESS Council approves all the IKRC-endorsed In-kind Agreements.

Once Agreements are in place, funding can be released to the Partner and work can begin. Once work does begin, the Partner and ESS project teams continuously monitor progress of the package and other related packages, going through several key milestones. When work is completed, the ESS staff creates a final report for the contribution. Based on the final evaluation, the Member country receives credit for the value of the In-kind Contribution according to the ESS Cost Book.

THE FIRST DELIVERED IKC

An Estonian Success Story

The University of Tartu designed, set up, and tested a set up for laser pump probe neutron scattering experiments as an Estonian IKC. The final delivery and acceptance test took place in 2015. The equipment will be used on time-of-flight spectrometers and small-angle neutron scattering (SANS) instruments. This opens up a wide range of possible applications in biophysics, including photo-induced functional processes, temperature jump experiments, and thermal unfolding.
IN-KIND AND COLLABORATION PARTNERS

ESS is working together with partners from all across Europe and the world. In-kind Collaboration Partners are indicated in bold.

Aarhus Universitet - AU
A.V. Shubnikov Institute of Crystallography Russian Academy of Sciences - IUCr
Australian Nuclear Science and Technology Organisation - ANSTO
Bilbao Bizkaia Kutxa - BBK
Brookhaven National Lab - BNL
Budker Institute of Nuclear Physics of SB RAS - INP SB RAS
Centre National de la Recherche Scientifique - CNRS
Chalmers Tekniska Högskola - CTH
Cockcroft Institute
Commissariat a l’Energie Atomique et aux Energies Alternatives - CEA
Consejo Superior De Investigaciones Científicas - CSIC
Consiglio Nazionale delle Ricerche - CNR
Consortio ESS Bilbao - ESS Bilbao
Consorzio Interuniversitario Risonanze Magnetiche di Mealo Proteine - CIRMMP
Danmarks Tekniske Universitet - DTU
Deutsches Elektronen-Synchrotron - DESY
Diamond Light Source
École Polytechnique Fédérale de Lausanne - EPFL
Elettra Sincrotrone Trieste S.c.p.a.
Eötvös Loránd Tudományegyház - ELTE
European Molecular Biology Laboratory - EMBL
European Organisation for Nuclear Research - CERN
European Synchrotron Radiation Facility - ESRF
European X-Ray Free-Electron Laser Facility GmbH - European XFEL
Extreme Light Infrastructure Delivery Consortium - ELI DC
Facility for Antiproton and Ion Research in Europe GmbH - FAIR
Forschungszentrum Jülich GmbH - FZJ
Goethe Universität Frankfurt Am Main
GSI Helmholtzzentrum für Schwerionenforschung GmbH - GSI
Helmholtz-Zentrum Berlin für Materialien und Energie GmbH - HZB
Helmoltz Zentrum Geesthacht - HZG
Hongik University, Seoul
Huddersfield University
Indiana University
Institut Laue-Langevin - ILL
Institute of Accelerator Technologies of Ankara University - IAT-AU
Institute of Applied Physics of the Russian Academy of Sciences - IAP RAS
Instituto de Tecnología Química y Biológica, Universidad Nova de Lisboa - ITQB NOVA
Institutt for Energiteknikk - IFE
Instruct Integrating Biology - Istruct
Instituut Fizyki Jądrowej Henryka Niewodniczańskiego Polskiej Akademii Nauk - IFJ PAN
Integrated Detector Electronics AS - IDEAS
ISIS Neutron Source Facility
Istituto Nazionale di Fisica Nucleare - INFN (Catania, Legnaro, Milano)
Japan Proton Accelerator Research Complex - J-PARC
Joint Institute for Nuclear Research - JINR
Karlsruher Institut für Technologie - KIT
Kobenhavns Universitet - KU
Kungliga Tekniska högskolan - KTH
Laboratoire Léon Brilloin - LLB
Laboratório De Instrumentação e Física Experimental de Partículas - LIP
Latvijas Universitāte - LU
Leibniz-Institut für Molekulare Pharmakologie - FMP
Linköpings Universitet
Lund University - LU
Magyar Tudományos Akadémia Atommagkutató Intézet - MTA Atomki
Magyar Tudományos Akadémia Energiaügyügyi Kutatóközpont - MTA EK
Magyar Tudományos Akadémia Wigner Fizikai Kutatóközpont - MTA Wigner
Masarykova Universita - MUNI
Mittuniversitetet - MiUN
Narodowe Centrum Badan Jądrowych - NCBJ
National Research Center Kurchatov Institute - NTI
Nederlands Kanker Instituut - NKI
Norges teknisk-naturvitenskapelige universitet - NTNU
Oak Ridge National Laboratory - ORNL
Oulu Yliopisto - OULU
Paul Sherrer Institut - PSI
Politechnika Warszawska
Politechnika Wrocławska
Polska Grupa Energetyczna - PGE
Roskilde Universitet
Science and Technology Facilities Council - STFC
Source Optimisée de Lumière d’Energie Intermédiaire du LURE - SOLEIL
Stanford University National Accelerator Laboratory - SLAC
Stockholms universitet
Tallinna Tehnikalukkool - TUT
Tartu Ülikool - UT
Teknologisk Institut - DTI
Thomas Jefferson National Accelerator Facility - Jefferson Lab
United Kingdom Atomic Energy Authority
Universidade da Coruña
Università degli Studi di Brescia
Université Laval
Universiteit Leiden
Universiteit Utrecht
Universität I Bergen
Universitetet i Oslo
University of Bath
University of Manchester
University of Patras - UPAT
Uppsala Universitet
Ústav technické a experimentální fyziky, České vysoké učení technické v Praze - ÚTEC
Vilniaus universitetas
Weizmann Institute of Science
Zürcher Hochschule für Angewandte Wissenschaft - ZHAW
ESS is actively using European Union and national grants to facilitate partnership building with the scientific community and In-kind Collaboration Partners. Grants help to maximise scientific impact and productivity, and increase resources during the construction phase and into operations.

Building Capacity

Last year, ESS put in place a grants policy which will facilitate its commitment to playing a role in the wider European infrastructure community and its approach to becoming a world-renowned facility for external neutron users. Central to the policy are the Open Innovation and Open Access paradigms, which allow knowledge to be shared with partner organisations. ESS has proven to be very successful in this approach using European Framework 7 and Horizon 2020 research grants as well as several national and regional grants. External funding is used to support, among others – collaborative technological advances on detector resolution and large area detectors using Boron-10 isotopes, the design of an advanced liquid hydrogen moderator, chemical deuterium for studying a range of advanced materials with neutron scattering, and data treatment software (capture, streaming, analysis). This support helps to build and extend capacity within the future ESS user base in Europe and also to support outreach activities for science, innovation and collaboration with industries during the construction phase of ESS.

Simply constructing the most powerful spallation neutron source will not, by itself, ensure maximum scientific or technological impact. The success in funded collaborative projects is enabling ESS to build and extend a broad network for the exchange of best practices and enhance mobility of staff and knowledge. Through several grants in which ESS has been participating since 2012, both as co-ordinator and as a partner, a smooth transition from the initial planning stages to the implementation stage and subsequent operation is being supported. The number of funding applications by ESS staff increased significantly over the past two years. With only three submissions recorded every year in 2012 and 2013, ESS grants participation increased to 14 submissions in 2014 and 22 in 2015. Currently, ESS proposals have shown a success rate of 30%, a significant achievement in 2015 relative to the general Horizon 2020 success rate of below 15%. ESS is now involved in the implementation of 14 grants (two are about to be closed) from the following funding agencies: European Commission, Tillväxtverket, Vinnova, and Vetenskapsrådet.

In order to further increase the number and quality of funding proposals, ESS is working on an additional support scheme for scientists which will allow them to insource professional review capacity of draft proposals as well as writing support. Furthermore, ESS is creating modular proposal text blocks which can be used as starting points by the scientists and tailored to individual needs. This will help to reduce the time-burden of writing proposals (e.g. 'not reinventing the wheel') as well as increase consistency between proposals relative to the ESS overall policies on topics such as intellectual property, safety & security, project management structure and project impact.

Horizon 2020 implements the Innovation Union, a Europe 2020 initiative to create an innovation-friendly environment to tackle societal challenges, based on scientific excellence, by coupling research and innovation.

BrightnESS is a 3-year EU-funded project within the European Commission’s Horizon 2020 Research and Innovation programme under the INFRADEN-3 call. It’s a partnership of 18 European institutes and universities from 11 countries with a total budget of €20 million. BrightnESS helps to ensure that key challenges during the construction phase of the ESS are met, so that ESS can deliver high impact scientific and technological knowledge to its academic and industry user communities.

The overall aim of the project is to support the construction of the ESS in key technical areas, I&K and project management. The grant provides resources to help move ESS from its planning phase to the implementation phase, as well as to keep physical construction of the site and development and delivery of vital equipment and components by its In-Kind Partner institutes aligned.

BrightnESS key deliverables are to ensure that (A) the knowledge and skills of European companies and institutes are best deployed in form of In-Kind Contributions to ESS for its construction and operation, (B) technology transfer both to and from the ESS to European institutions and companies is optimised and (C) maximum technical performance is obtained from the ESS Target, Moderators and Detectors.

ESS is currently defining the metrics through which to measure its own contribution toward increased scientific knowledge and technological solutions for societal challenges. Part of the ESS is a partner in the strategic project called SINE2020 – world class Science and Innovation with Neutrons in Europe for 2020. This €12 million European grant is focussed on broadening the academic and industrial user base of neutron science in Europe. It is being coordinated by the Institut Laue Langevin neutron source in Grenoble and implemented with 17 partners.

SINE2020 will expand the innovation potential of neutron scattering at large-scale facilities by developing new and improved services for academic and industry users through a holistic approach, including outreach and education, samples, instrumentation, and software. Furthermore, the project will also prepare Europe for the unique opportunities that the ESS, as an ESFRI Roadmap facility, will bring to the different communities through the creation of synergies and complementary solutions. SINE2020 is also instrumental in creating the foundations for a significant increase in direct facility-industry collaborations.

EU supports the neutron science community: SINE2020 funded through Horizon 2020

BrightnESS and SINE2020 are two strategic European Union funded projects for ESS, which bring together major European research infrastructures of the present and the future, world-class national facilities and several smaller national facilities. Collectively, they offer high quality services and an efficient research environment for almost 9,000 scientists in Europe – by far the biggest user community of its kind in the world.

Building a research infrastructure and synergies for highest scientific impact on the ESS

The project also measures the effects of the ESS collaboration on participation by ‘Low research-performing countries’ (LRPCs) in neutrons research, which is an indicator for strengthening of the overall European Research Area. Lastly, BrightnESS monitors capacity building and research infrastructure human capital development by measuring research staffing at institutions in existing as well as prospective ESS Member countries.

Through these activities, BrightnESS provides a vital support framework for ESS so that Europe can deliver upon its Smart Growth strategy toward a more resource efficient and competitive economy.
OUTREACH ACTIVITIES

ESS outreach activities are a vital part of communication with our partners and potential industry users. The construction site is one source of those activities, and this kind of frequent contact with collaborators and future users ensures their continued support and commitment.

Partner Days
ESS Partner and Industry Days are unique events organised in cooperation with ESS Partners which provide overview information about ESS in general, in addition to in-depth updates on the status of each project. These events provide an occasion to connect to and interact with the local industry and scientific community in the respective ESS Partner country, with the aim to identify potential collaboration opportunities. Furthermore, the Partners already contributing to ESS have a chance to present their work.

Interacting with Collaborators
Organising these numerous outreach and networking activities every year helps ESS interact with its various target groups, that include prominent members from academia like university groups, research labs, and institutes; stakeholders from governmental ministries and funding agencies; and industrial suppliers and future industrial users.

ESS welcomed more than 2,200 visitors in 2015. Most visited the construction site to see the progress either by taking a guided walking tour, a bus tour, or for a viewing from the site offices. All activities were organised in close collaboration between ESS and Skanska.

Distinguished Guests
ESS values the presence and input of high-level guests, such as the Swedish, Danish, and Lithuanian Ministers of Research, EU Commissioner Carlos Moedas, European Commission Director General Robert-Jan Smits, and Bill Stirling, Director General of the Institut Laue-Langevin.

Partners and Stakeholders
Swedish Minister for Higher Education and Research Helene Hellmark Knutsson visited the ESS several times in 2015. On her first visit, she discussed the transition from a Swedish Aktiebolag (limited company) to a European Research Infrastructure Consortium (ERIC). The Research Minister was also given an overview of the ongoing construction and the progress of the project as a whole. The ESS-sponsored Science Symposia harvested input from a wide range of scientific disciplines and expands the neutron user base. The symposium resulted in reports which help feed into the ESS science strategy. Conferences and workshops organised by our Partners may include the participation of ESS speakers at lectures on ESS, neutron and material science, research infrastructure and procurements, and how to do business with ESS. All of these events have expanded the interest in our project in the Partner countries and even potential new Partner countries. This helps to grow the stakeholder base for potential resources.

On 8 September, the ESS marked an important milestone. On that day, the organisation became a European Research Infrastructure Consortium (ERIC), a type of legal entity created by the European Commission for governing international research facilities. The European Commission Director General for Research and Innovation, Robert-Jan Smits visited the construction site and handed over the official “plate” of the ESS ERIC to the Commission to ESS.

The year ended with a visit from Carlos Moedas, EU Commissioner for Research, Innovation, and Science to discuss the various opportunities and challenges a collaborative project such as ESS brings with it. His visit was a clear sign of the support and encouragement ESS has received from the European Commission and important stakeholders across Europe.

"My meetings with your staff have confirmed the enthusiasm that exists here and at ILL for deepened cooperation between our two organisations." - Bill Stirling, Director General of the Institut Laue-Langevin.
THE MACHINE

THE NEUTRON SOURCE
THE ACCELERATOR

ESS is an accelerator-driven neutron spallation source. The linear Accelerator, or Linac, is thus a critical component. The role of the Accelerator is straightforward. It creates protons at the ion source, accelerates them to an appropriate energy, and steers them onto the Target to create neutrons via the spallation process for use by a suite of research instruments. Building the ESS Accelerator requires the expertise of more than 25 Partner institutions executing 17 Work Packages across Europe.

ESS Accelerator requires the expertise of more than 25 Partner institutions executing 17 Work Packages across Europe.

The Most Advanced Linac
The ESS Accelerator is the most powerful linear proton Accelerator ever built by a factor of five. It will also be the first Linac to use spoked cavity technology for the acceleration of protons.

Pushing Accelerator Technology to its Limits
In the final and major stages of acceleration before contact with the Target, the proton beam energy of the ESS Accelerator will reach 2.0 GeV. France’s national Atomic and Alternative Energies Commission, CEA, is guiding the design, production, and testing of the superconducting radio-frequency cryomodules that make this possible. One of the largest of these Work Packages includes nearly half the length of the linear Accelerator five institutions in four European countries, and 20 percent of the Accelerator construction budget. This is Accelerator Systems Work Package 5 (WP05).

Working in close collaboration with one another, the members of WP05 have the responsibility to produce nine medium-beta and 21 high-beta superconducting radio-frequency (SRF) elliptical cryomodules for installation in the ESS Accelerator tunnel. Once installed in-line the cryomodules will run 256 meters and provide nearly 90 percent of the beam acceleration. First installations are scheduled for September 2016.

The work is distributed as in-kind Contributions (IKCs) to ESS from the national institutes on behalf of France, Italy, and the UK. The prototypes for both cryomodule types, high-beta and medium-beta, are being fully developed and tested by CEA Saclay and IPNO (Institut de Physique Nucléaire d’Orsay). IRFU – the French National Institute for Research on the Fundamental Laws of the Universe – will provide all cryomodule components except the cavities, and will include the final assembly of the full cryomodule units in a clean room. LAGA (Laboratorio Acceleratori e Superconduttività applicata di ESS) in Italy will provide the medium-beta cavities of the series, with Daresbury Laboratory in the UK providing the high-beta cavities. Finally, ESS will perform the crucial radio frequency (RF) power tests of the cryomodules before installation.

Collaborative Production of 120 Cavities
Once performance and quality specifications are achieved by the cavity and cryomodule prototypes, series production of the cavities will move to INFN-LASA and Daresbury, who will contract with private companies for fabrication. LAGA will produce the 36 medium-beta cavities and Daresbury the 84 high-beta cavities, and these labs will perform the acceptance testing, including radio frequency (RF) tests in cryogenic conditions.

The elliptical part of the Linac provides the bulk of the beam energy available for neutron production, and is the part that will qualify the ESS Accelerator as the most powerful proton source in the world when ready. Work Package 05 is the key to the success of ESS, says Head of the Accelerator Division, Matt Lindroos.

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DEVELOPMENT OF RF SYSTEMS

The Radio Frequency (RF) system for the ESS Linac is defined as the system that converts alternating-current (AC) line power to RF power. The Accelerator division saw many collaborations come together and received its first In-kind deliverable, a vacuum systems test facility from Daresbury.

**Low-Level Radio Frequency control system (LLRF), delivered by ESS and Lund University.** This laboratory will be used to test Accelerator components in the months and years to come. More specifically, the LLRF will be used to regulate the superconducting radio frequency (SRF) spoke cavities, and the cryomodules that contain them. The LLRF control generates an input signal to the RF amplifier that sets the unique phase and amplitude for each cavity. Set in series, the 26 spoke cavities work together with the LLRF to accelerate the ESS proton beam to progressively higher speeds.

**Spoke Cavities Prototypes**
This novel design will introduce spoke cavity technology to a linear proton Accelerator for the first time in history, making the ESS Accelerator more efficient and flexible.

IPN-Orsay’s (IPNO) Accelerator Division is developing this technology as part of and In-kind Contribution to ESS of nearly €20 million. IPNO is a division of CNRS, the French National Centre for Scientific Research, which has long been a key partner in the ESS Accelerator project.

The French lab will design, produce and deliver the Accelerator’s 13 spoke cavity cryomodules. These cryomodules, each of which will contain two spoke cavities, two power couplers, and be fitted with a custom designed ESS Cold Tuning System, will run end-to-end, constituting around 56 meters of the roughly 600-meter-long ESS Linac.

Validation of Tests
The test performed in June, in conjunction with similar tests performed in January, February, and March, has provided the final validation that the spoke cavity prototypes designed by IPN-Orsay and manufactured by two different vendors—Zanon in Italy and SQMS in France—are ready to move into production. More than this, the June test confirmed that the lab’s new chemical surface treatment of the niobium cavity’s metallic surface allows ESS over larger margins on measures of both quality and acceleration speed—an added assurance that the technology will perform as it is designed to do in the months and years to come.

**A First for Linac Design**
The use of spoke cavity technology to accelerate protons has been achieved in laboratories, but the ESS Linac will be the first to integrate it on a large scale. The technology makes it possible that the Accelerator will enter into its superconducting stage at a lower energy than any existing Linac, with 97% of the proton beam acceleration speed achieved in a superconducting environment. The next step for IPNO-Orsay is to integrate the RF power coupler with the cavity and confirm that they will function as a unit at high RF power. Following that, the assembly will be tested at the FREIA Laboratory.

A spoke cavity is a metal enclosure—like a barrel, though a barrel of a very particular shape—into which a powerful radio frequency electromagnetic wave is introduced at the very precise frequency of 352.21 MHz. The shape, temperature, and material composition of the cavity, along with other factors, ensure that the RF waves will propel the protons from one cavity to the next at ever-increasing speeds.

"The spoke is very interesting just because the structure itself is mechanically very stiff," explained Sébastien Bousson, Director of the Accelerator Division at IPNO-Orsay who is responsible for this technology's contribution to the ESS Accelerator. "It means the cavity is not affected by a lot of things that can cause troubles in its operation—vibrations, the variation of the pressure of the helium bath—that can affect the behaviour of the cavity and the capability to accelerate. The second advantage is that it can reach a very high accelerating gradient that with standard cavity geometries you cannot reach."

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THE TARGET

The neutrons that scientists need to study materials and molecules are produced in the Target Station. It is here that the spallation process takes place when protons from the accelerator hit the Target, a 3-tonne helium-cooled tungsten wheel. The design of the Target has a direct impact on the number of neutrons that can be generated, and is therefore of utmost importance for the future scientific capabilities of ESS.

Producing Neutrons
Spallation is the process for producing neutrons by means of a particle accelerator and a heavy metal target. Protons derived from hydrogen gas are drawn through a linear accelerator to a velocity just below the speed of light, at which point they collide with the nuclei of the target metal, tungsten. The collision of protons and the nuclei of the target metal, tungsten, throws off, or scatters, a collection of high-energy neutrons, which, once moderated, are delivered to the instruments through beam ports radiating from the Target station.

The Target station is where the neutron beams are produced for experiments. The fast, high-energy neutrons, which are released in the spallation process, are slowed down to energies that are suitable for different types of experiments, and then delivered to the instruments through beam ports leading to neutron guides.

In the Target station, fast, high-energy neutrons are released by spallation from the Target consisting of neutron-rich material, the heavy metal tungsten, when a high-energy beam of protons from the accelerator impinges on it. The neutrons, which are travelling at 10 percent of the speed of light, are then slowed down to roughly the speed of sound, using moderators and reflectors, to provide intense pulses of neutrons at velocities and energies that are useful for experiments. Once moderated, the neutrons are delivered to the instruments through beam ports radiating from the Target station.

Key features of the Target station are the Target, the neutron moderator, pre-moderator and reflector system, the beam-extraction system, and the shielding. The Target station also incorporates a powerful helium-based cooling system able to dissipate the heat generated by the powerful 5 MW proton beam hitting the Target. Radioactive isotopes and radiation is generated by the spallation process and by general activation of components. The Target will therefore be surrounded by steel shielding in the form of the cylindrical, 3,000-tonne Target station, monolith to prevent unwanted ionising radiation from escaping.

In 2015 the Target system completed the final design and prototyping stages and transitioned over to production activities. Major design choices, including the moderator, reflector concept, and neutron beam extraction configuration were settled.

System Optimisation in Spain
Spain was one of the first countries to send a Letter of Intent committing to ESS, and in November 2014 ESS-Bilbao was chosen as the In-kind Partner for the ESS Target system, including the novel rotating tungsten Target wheel, the Target shaft assembly, the drive motor and support bearing, being optimised, prototyped, tested, and ultimately will be delivered by ESS-Bilbao in Spain.

The Tungsten Wheel Concept
The Target wheel will measure 2.5 meters in diameter, is estimated to weigh 3 tonnes, and is divided into 36 radial sectors. The heart of the Target station is the roughly 7,000 tungsten bricks set into the sectors of the wheel. “The ESS Target wheel will feature a novel design of the rotating tungsten Target making it possible to distribute the heat over a larger volume than what is irradiated by the proton beam at one moment,” explained Ulf Odén, ESS’s lead engineer for the Target wheel. “Together with the helium coolant, this design can produce a Target with a long lifetime of approximately five years.”

Fernando Sordo, lead engineer of the Target wheel at ESS-Bilbao and his team are currently in the process of modifying the Target system proposal to achieve a design that can be manufactured more easily. “Focusing on design efficiency now will make it easier to meet the challenge of manufacturing and testing later,” said Sordo. The current ESS-Bilbao proposal has specifically modified the geometric arrangement of the tungsten bricks such that protons will not cross the Target without a spallation interaction.
THE TARGET SYSTEMS

The ESS facility’s centre of gravity is the 3,000-tonne Target Station monolith: the high density, high-energy interface between the linear proton Accelerator and scientific instruments. The Target baseline design was developed after the site decision in 2009.

Target Partner Collaborations

“We have had a great start to the collaboration with ESS-Bilbao,” noted John Haines, former Head of the Target Division. “They started fast. They hosted the Target wheel, shaft, and drive unit kick-off meeting at the end of January, and have already submitted a modified design proposal for the Target wheel, that is much easier to manufacture and is more robust.”

Haines went on to say “Working with ESS-Bilbao gives us access to the experience and capabilities of the Spanish nuclear industry. Beyond that, ESS-Bilbao has a focus just like our own, namely, making ESS a reality. Their dedication to the project is very valuable to us.”

Neutron Technologies in Spain

ESS-Bilbao is an internationally renowned strategic center for neutron technologies that leads the Spanish In-kinda Contributions to ESS. The work performed will in turn foster collaborations between Spanish academia and industry, as suppliers will be hired to manufacture and test the designs, which will fuel the Spanish national innovation potential by building capacity and supporting job growth.

“The building the highest powered spallation target in the world will position the Spanish engineering industry in the field of Neutron Science.”

Jose Luis Martinez, Executive Director of ESS-Bilbao

The Target Station Monolith

The tungsten Target and moderator-reflector are surrounded by a radiation shielding system of 3,000 tonnes of steel in order to contain the extreme level of highly penetrating gamma and fast neutron radiation created in the Target and its vicinity. The beam extraction system provides intense slow neutron beams through beam tubes going across the target shielding. At the surface of the shielding, the neutrons are delivered to be used at the neutron scattering instruments. The proton beam window separates the high vacuum in the Accelerator from the inert helium gas. All of these systems sit inside a large vessel. Together they form the Target station monolith, a large cylinder 8 m high and 6 m across.

Target Wheel

A rotating tungsten wheel is the baseline option for the Target, which distributes the irradiation over a large volume of Target material. Tungsten is a rare metal of high density that is commonly used at existing spallation sources. What is unique to the ESS application is the high power of the ESS Accelerator. This energy, which manifests in the tungsten as heat, must be dissipated rapidly and efficiently. To this end, the Target wheel rotation is timed such that each of its 36 sectors receives a single pulse from the beam per revolution.

Modulators

The ESS Target Station will contain two liquid-hydrogen moderators with a volume of approximately one litre each, partially surrounded by water pre-modulators of comparable volume. The moderators are placed inside an inner reflector of about half a cubic metre of beryllium. These components will be kept at their desired operational temperature by dedicated cooling systems which will not emit significant after-heat.

Beam Extraction

The beam-extraction system will consist of more than 40 beam tubes arranged in four sectors with about 60° horizontal angular spread. Each beam tube will be equipped with a beam shutter within the Target monolith to assure that the residual radiation escaping through the closed beam line when the Target station is not in operation is reduced to safe working levels at the wall of the Target monolith. This monolith will be surrounded by a combination of integrated and individual radiation shielding for each beam line, which guarantees safe working access to the areas outside of these shielding structures all the time, including during full power operation.

Target Handling and Fluid Systems

Providing adequate cooling for the Target at the 5 MW power level of ESS requires distributing the heat over a much larger volume than the few litres instantaneously irradiated by the proton beam. In addition, the amount of radioactivity created in the spallation process must be safely contained both in normal operation and in the case of accidents.

Containment of Radioactivity

The Target monolith will provide two barrier layers of containment against the escape of volatile and airborne radioactive materials, both at normal operation and in case of incidents, and will be continuously vented and filtered.

The Cooling System

When the 5 MW proton beam hits the Target wheel, the Helium circuit cycles the heat up through the shaft and away from the Target, then returns it at a lower temperature, similar to how a radiator functions in an automobile. The Target Helium Cooling System will keep the temperature below 500°C both in the structural material of the wheel and on the surface of the spallation material. Keeping the tungsten surface temperature below 500°C will avoid oxidation of the tungsten in the event that air infiltrates the Target Vessel. Oxidation of the spallation material is the main driver for contamination of the Target System and in turn the radiological threat to workers and public. The Nuclear Physics Institute of the Czech Republic (UJF) has committed to deliver the Target Helium Cooling System for ESS.

OPTIMISED FOR BRIGHTNESS

The “Pancake” Moderator becomes a “Butterfly”

The Target division conducted test that preliminarily validated the physics behind the “flat” moderator which has been developed for the ESS and for this pulse. The measurements appear to give preliminary empirical confirmation that ESS’s optimisation of its 2013 baseline moderator design will improve the performance for those instruments at ESS able to exploit this brightness by about 2.5-3 times. The new design is a major step forward in neutron moderator design, and has large implications for neutron science at ESS.

The optimised design established in 2014, which became known as the “pancake” moderator, was developed in a series of iterations over the last two years. It is referred to as “2-dimensional” because the vertical dimension is flattened to a slim 3 cm, from the original 30 cm. The result is a “flat” moderator that releases more neutrons in an evenly distributed pattern across a smaller area than the earlier design. Aside from the possibility of more efficient neutron extraction, the new geometry of the ESS moderator will require smaller beamline penetrations—an additional factor behind the increased brightness for the facility.

Over the last several months the concept underwent further design optimisation by Target division engineers and physicists, in close consultation with ESS instrument scientists, resulting in the 2016 baseline design. Due to the innovative shape of the para-hydrogen moderator, the Neutronics group experimentally confirmed the effectiveness of the design, by indirectly using the existing moderator at J-PARC.

Ferenc Mezei, ESS Technical Coordinator Ferenc Mezei emphasised that this increase in brightness goes to the heart of the ESS mission. “An experiment that can be done at ESS in one day can also be done at the other neutron sources in a bit longer time, but still can be done. What can be done at ESS in one week or two weeks cannot be done anywhere else. This is where the new science is.”

Impact on Instrument Performance

The new design is expected to raise instrument performance at ESS relative to other spallation sources. The moderator optimisation will not benefit every instrument at ESS to the same degree, though it will result in increased flux across a wide range of instrument classes and experiment types. Work continues on neutron extraction techniques and instrument beam guides that will also help determine to what degree the instruments are able to exploit the additional flux. For those instruments better served by a volume moderator, the ESS design includes a second, 6 cm high moderator situated beneath the Target wheel.

Ferenc Mezei, spiritus rector of the pancake moderator

“When the new Head of the ESS Target division Eric Pitcher, "Our pancake has become a butterfly.”

Since it was impractical in terms of both cost and time to perform a full mock-up of the butterfly moderator, the Neutronics group experimentally confirmed the effectiveness of the design, by indirectly using the existing moderator at J-PARC.
THE INTEGRATED CONTROL SYSTEM (ICS)

The Integrated Control System (ICS) covers the whole ESS machine and facility. A unified approach keeps the costs of development, maintenance, and support relatively low. ESS selected a standardised controls framework, the Experimental Physics and Industrial Control System (EPICS).

EPICS

The selection of EPICS is based on best practices and experience from similar facilities using platform standardisation, control system development, and device integration and commissioning. The controls framework was originally developed jointly by Argonne and Los Alamos National Laboratories in the U.S. The components of ICS include the control system core, the control boxes, the database management system, and the human-machine interface.

Control boxes are servers that control a collection of equipment (e.g., a radio frequency cavity). ICS will include many control boxes, each of which can be assigned to one supplier, such as an internal team, a collaborating institute, or a commercial vendor. This approach facilitates a clear division of responsibilities and makes integration much easier.

The central data management system is called ‘BLED’ (Beam Line Element Database), which is a set of databases, tools, and services used to store, manage, and access data. The set of tools that accesses BLED will be tailored to the needs of different categories of users, such as staff physicists, engineers, and operators, external partner laboratories, and visiting experimental instrument users.

The control system core is a set of systems and tools that make it possible for the control system to provide required data, information, and services to engineers, operators, physicists, and the facility itself. The core components are the timing system that makes possible clock synchronisation across the facility, the machine protection system (MPS) that helps avoid damage to the machine’s equipment due to beam losses, the personnel protection system (PPS) that prevents harm due to radiological risks, and a set of control system services that help with maintenance and operations. An estimated 1.5 million control points will be needed to ensure that complex machine and corresponding equipment work in synchronisation.

NEW DIVISION LEADERSHIP LEADS TO RESTRUCTURING

The ICS division gained new leadership this summer with the appointment of Henri Carling as Head of Division. Additionally, seven new team members have been hired this year. Considering ICS was one of the smaller divisions at ESS, this was a significant expansion.

Henri Carling, Head of ICS Division

Furthermore, the division went through some restructuring, including its Work Package configuration, and ICS- and kind activities were developed. The operational model for the division was defined and communicated, which will help overall understanding of responsibility, mandate, and prioritisation in the project. A comprehensive replanning and coordination effort also progressed. In particular, the ICS software budget, currently more than 40% of the ICS budget, is being intensively scrutinised.

INTEGRATION OF SCIENTIFIC, SIMPLIFIED, SMARTER

ESS abides by its commitment to create sustainable science in the interest of society with minimal environmental impact. The sustainability goals for ESS have impacted design, construction, and planning, and will come to bear on preparations for how the facility will serve the research community from 2023 onward.

Recent work during the ESS Construction Phase has resulted in notable gains for the project’s Responsibility commitment, which refers to responsible energy management.

“ESS has reduced its needs quite a bit with respect to the initial goals for electricity use. That’s a winning case, because what you don’t use in power means less power lost. There’s also less energy to recover.” — Rainer Gunsing

Path to Sustainability

Green Priorities for Big Energy Systems

An important investment ESS has made over the last few years is research into Multi-Beam Inductive Output Tubes (MB-IOT), a type of power-efficient Radio Frequency (RF) source for the Linac. The MB-IOTs are projected to deliver typical power savings of 2 to 3 MW of the 19 MW of power required to drive the Accelerator.

MB-IOTs as klystrons—another type of RF source that will power the Linac—use powerful radio waves to push the proton beam to increasing speeds as it shoots toward the Target.

The power required to run the linear proton Accelerator (Linac) at ESS will account for greater than half of the facility’s roughly 270 GWt annual energy needs. Increasing the efficiency of energy consumption for the Linac and its component systems is an important goal of the ESS Accelerator Division and its partners, including the French national organisations CEA and CNRS, who are working on the efficient superconducting Linac.

“An important piece of this puzzle is to reduce the beam losses, which we can do by designing smart, technical solutions,” said Mats Lindroos, Head of the Accelerator Division. “We are also developing the software, the control algorithms, to make these devices smarter.”

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THE PATH TO DISCOVERY
The development of ESS is driven by science and the requirements of research to put a foundation in place for tomorrow’s scientific community. The scientists and engineers at ESS and its Partners are working together to ensure a world leading facility.

The Neutron Toolkit
Neutron scattering can be applied to a range of scientific questions, spanning the realms of physics, chemistry, geology, biology, materials science, and beyond. With a neutron tool kit, it is possible to probe the structure and dynamics of materials over a wide range of length- and time-scales. Neutron scattering encompasses a diverse range of experimental methods. Depending on how a neutron instrument is built, it can extract different kinds of information and answer different questions.

The neutrons that scientists at ESS will use to study materials at the molecular level are produced by a process known as spallation. That process takes place when protons from the Accelerator hit the Target, a 3-tonne thick lead-coated concrete wall. That source of neutrons aims to have the highest peak and time-averaged brightness of any source of neutrons in the world when it is built. Today, ESS scientists and Partners from all over Europe are working hard to develop instruments that can harness the potential of this state-of-the-art instrument.

Schreyer Named New Science Director
As a key addition to the ESS management in 2015 was the naming of Andreas Schreyer as the new ESS Director for Science. The major goal for Schreyer and the entire ESS management team during the coming year will be to deliver a firm schedule to the ESS Council for the engineering design, construction, and commissioning of the first 16 instruments to be built at ESS.

"I’ve been involved with the ESS project from the outside so far, and I’ve seen it grow and seen very good work and very important decisions on the instrument suite being taken," Schreyer added. "We’re actually now in a state where we know what we want to build and what the instrument suite is supposed to be."

In October 2015 the European Spallation Source ERIC Council endorsed the initial 16-instrument suite that is the result of years of joint efforts within the neutron community. The general plan for sequencing these instruments was discussed with the SAC in September prior to being endorsed by the Council.

The instruments in this series will be the core tools of the ESS user program and expected to enter use by 2023. They will bring unprecedented capabilities to scientists studying matter with neutrons. Importantly, the ESS user community defined the suite of instruments to address the needs of that community.

"By the end of the 2016 we should be able to make a concise proposal that is aligned with our In-kind Partners as to how we do it and which instruments should be finished and by when," said Schreyer.

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Defining instruments
A key achievement of 2015 was the Neutron Scattering Systems’ (NSS) efforts to define the ESS suite of 16 instruments. These instruments are being built in a massive collaboration with Partners from all the Members countries. This milestone has driven discussions with In-kind Partners to defining their contributions to ESS.

In 2013, ESS began a process of selecting instruments based on proposals. These proposals were then developed into concrete plans for instruments that were presented to the Scientific Advisory Committee (SAC). Several instrument proposals were merged together. According to Schreyer, despite being long, it was an important process to go through because it helped involve all the Partners from Europe, which is needed to make the ESS In-kind model work.

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Support infrastructure
ESS is also taking shape as a user facility. The first successful ESS user experiment done in collaboration with researchers from the Lund University demonstrates the importance of neutrons to the life sciences, and shows the way forward for ESS.

The team studied protein carbohydrate binding interactions of a domain (carbohydrate binding module CBM) of a bacterial enzyme. Analysis of these samples with X-Rays and Neutrons makes it possible to better understand the basis of these interactions which have broad application in biotechnology applications, such as biofuel production and biore-

Detectors
In addition to instruments, ESS teams and Partners are working hard to develop the support infrastructure and technologies necessary to operate the instruments. Detector technology will play an important role in future instruments and ESS has been leading the way along with Partners at the The Institut Laue-Langevin and Linköping University demonstrating and building new materials for the next generation of detectors.

ESS Instruments

The table presents an overview of the approved instruments and the corresponding lead partner institutes. There are four different instrument classes with eight different use areas.

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<thead>
<tr>
<th>Instrument Class</th>
<th>Instrument</th>
<th>Lead Partner(s)</th>
<th>Icons</th>
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<tbody>
<tr>
<td>Large Scale Structures</td>
<td>ESS ODIN Multi-Purpose Imaging</td>
<td>TUM (DE) + PSI (CH)</td>
<td>![Icons legend](Image 550x750)</td>
</tr>
<tr>
<td>Diffraction</td>
<td>MIRACLES Backscattering Spectrometer</td>
<td>ESS Bilbao (ES)</td>
<td></td>
</tr>
<tr>
<td>Spectroscopy</td>
<td>T-REX Bispectral Direct Geometry Spectrometer</td>
<td>FZI (DE)</td>
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<tr>
<td>Support infrastructure</td>
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supported infrastructure and technologies of European and other institutions. The ESS In-kind model is a massive challenge and a great asset," said Kennedy. "As a Greenlandic site with no history of neutron scattering in the area, the only way to build ESS is to have the best of the neutron scattering community help us."

Kennedy and the NSS team have been busy defining the tasks between In-kind Partners and ESS. Their immediate goal is to secure signed in-kind Commitments from the Partners.
Europe’s Next Flagship Engineering DiffraCtometer
Developing instruments to make use of the unique brightness of ESS and the pulsed structure of the beam is a key challenge. A collaboration between Czech and German labs has resulted in the design of a novel diffractometer. This new instrument aims to be an important tool in European efforts to create 21st Century materials.

“BEER will have the greatest impact by enabling the use of structural materials that are incredibly important for transportation and energy.”
— Dr. Michael Preuss

The Beamline for European Engineering Materials Research (BEER) is the realisation of Dr. Petr Lukáš’ research group at the Nuclear Physics Institute (FZJ) and the Institute of Physics in the Czech Republic, and Prof. Andreas Schreyer’s research group – together with an innovative chopper design by Dr. Reinhard Kömpfner – at Helmholtz-Zentrum Geesthacht (HZG) in Germany. The concept evolved from two separate proposals previously under development for ESS: the Complex-Environment Engineering DiffraCtometer (CCEED) from the Czech labs, and the Structured Pulse Engineering DiffraCtometer (SPEED) from the German laboratory. It was not long before CCEED and SPEED became BEER.

The design of BEER’s enables simultaneous obtain Small Angle Neutron Scattering (SANS) and neutron imaging measurements, while working as a diffractometer. This solution provides nanoscale data for kinetic processes, and detects sample inhomogeneity during structural transformations.

“When we realised the two former instrument concepts could actually be merged into a single concept from which both groups could profit” explained Schreyer. “It became clear we could deliver an instrument concept able to combine the possibilities of worldwide existing instruments with novel concepts for an engineering diffractometer.”

Neutron diffraction obtains a pattern of the atomic structure of a material. It is used for characterising materials stress, textures, and deformation. The aim with BEER is to allow more flexibility in sample analysis and increase the usable beam intensity by at least one order of magnitude more than existing neutron diffractometers. That gives more possibilities to investigate samples in situ, but also in operando, or in operation, such as batteries while they are in use. The advances BEER offers to researchers have broad implications for society and industry. Dr. Michael Preuss is professor of metallurgy at the University of Manchester chaired the panel for Materials and Engineering Diffraction. He said materials such as advanced engineering steel, and super-alloys like titanium alloy, are at the limit of what we can do with them. BEER will have the greatest impact by enabling the use of structural materials that are incredibly important for transportation and energy,” said Preuss. “These materials are needed for aircraft engines, power stations, nuclear reactors, deep hole drilling of oil wells and more.”

Engineering materials are critical in technology breakthroughs that improve our modern standard of living. Magnesium and aluminium alloys make possible lightweight, fuel-efficient vehicles and aircraft wings. Titanium alloys mean better consumer electronics. Shape memory alloys (SMA) are essential for the development of device sensors and super elastic, nickel-free biomedical components.

Fruity processes. They can also be used for probe design that can recognize specific sugars in a complex sample.

The organization and management of the partnership for the experiment is a preview of the large-scale user program that ESS will become over the next decade. It is also helping to spread the word in life sciences circles that ESS is already supporting user’s research in life sciences and biology.

The Copenhagen Campus – The ESS Data Management Software Centre

The ESS Data Management Software Centre is an integral part of the ESS Science Directorate, located in Copenhagen with nearly 20 people employed. Mark Hagen, Head of the Centre’s Division, leads the work. He previously worked on the construction of both ISIS in the UK, and the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory in Tennessee, USA.

“WE are completely focused towards supporting the scientific research programme of ESS,” stated Hagen. “In the near term we are very much focused on enabling the instruments to operate.”

The team there is developing control, data reduction, and initial data analysis software. In the longer term they are dedicated to ensuring that the data analysis and modelling software is able to extract the maximum amount of scientific information from the experimental data.

Britain’s Science and Technology Facilities Council is lead Partner for two instruments. The ESS critical milestone to define the 16-instrument projectscope has catalysed discussions with In-kind Partners to agree on their contributions to ESS.

The UK Takes the First Step

A Memorandum of Understanding (MoU) was signed between ESS and the UK’s Science & Technology Facilities Council (STFC) in the autumn of 2015. That means that the STFC’s ISIS neutron science facility will become the lead Partner for the ESS instruments FREIA and Loki.

The ISIS neutron science facility at the UK’s Rutherford Appleton Laboratory has become a world-leading centre for research with neutrons in the physical and life sciences for nearly three decades. As Europe’s only pulsed spallation source it serves as the foundation for ESS, also a pulsed spallation neutron source. The facility’s Director, Robert McGreevy, is a member of the ESS Instrument Collaboration Board (ICB) and signed the first instrument MoU.

“TOLiK and FREIA are good for us, we know how to do these things and we have a user community who are interested in using them, and in using all of the instruments at ESS.”

Robert McGreevy and Dimitri Argyriou signing the first instrument MoU

This is great news for the project. This Partner has a strong tradition of excellence in neutron scattering and instrument building, which is needed to ensure success with ESS.”

“We are completely focused towards supporting the scientific research programme of ESS.”
— Mark Hagen, Head of the Centre’s Division

The ISIS facility at Rutherford Appleton Laboratory. Robert McGreevy and Dimitri Argyriou signing the first instrument MoU.

FREIA and Loki were developed and proposed by instrument scientists at ESS. Both instruments, combined with the high flux and unique pulse structure of the ESS neutron source, are expected to have a major impact across a wide range of materials and life science studies.

Loki

The instrument Loki was one of the first-selected for ESS and is expected to be a world-leading small-angle neutron scattering (SANS) instrument when construction is complete. Small angle neutron scattering is a technique that is applied across a spectrum of scientific disciplines, with users from chemistry, physics, biology, materials science, engineering, and geoscience. Loki is designed primarily with the needs of the soft matter, biophysics, and materials science communities in mind, and the trend in all of these fields is towards complexity and heterogeneity.

“The means that we can move forward and actually start to build it, ” said ESS Instrument Scientist Andrew Jackson, lead proposer and lead scientist for Loki. “The next step is, we start on the detailed design work, and they (ISIS) have an engineer ready to go” Loki is currently undergoing preliminary engineering design.

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— Gérard Argirou, Former Director for Science at ESS

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IKON

The semi-annual IKON meetings on in-kind contributions focus on neutron instrumentation, technologies and science that ESS will engage in. IKON8 and IKON9 took place in the UK and Lund, respectively with over 100 people from the ESS Partners.

The Director of ESS, Robert McGreevy, greeted the assembly with a whirlwind of information. They were also briefed on significant recent developments. The ca.150 participants, travelled from all parts of the globe. They were also briefed on significant recent developments in ESS Partner countries, Germany, Switzerland, and the UK.

The overall impression of the meeting was that the instrument collaboration teams have found their Partners, and taken off. Argyriou said he expected the discussion on aligning instruments with Partners to continue. That include finalising the resource configuration; signing Agreements for all 16 instruments as well as bringing ODIN to Phase 2, where it will join LoKI and NMX and moving the next wave of instruments into Phase 1, Engineering Design.

The 8th meeting in February covered a lot of ground concerning progress made on instrument engineering and design. The instruments LoKI and NMX received a lot of attention, as did the development and optimisation of their associated technologies. The ca.150 participants, travelled from all parts of the globe. They were also briefed on significant recent developments in ESS Partner countries, Germany, Switzerland, and the UK.

WORLD-CLASS DETECTORS

EU support through the BrightnESS project is delivering critical results for the development of such detectors at the European Spallation Source. One such development, in collaboration with Partners, is a Boron-based detector called a Multi-Blade Detector.

The Intensity Frontier: Developing World-Class Detectors Using Boron

The first attempts to use Boron-10 for neutron detection were made in the 1930s. Due to the high neutron flux expected at ESS and the economics of the Helium-3 crisis, Boron is experiencing a comeback for detector applications.

The project takes as its point of departure the use of Boron-10 as the detector’s converter rather than the standard Helium-3 gas used for most neutron detector applications worldwide. ESS researcher in neutron detection Francesco Piscitelli, is the lead developer of the Multi-Blade technology and was a part of the original team at ILL. Piscitelli has completed the design and assembly of a demonstrator model of the Multi-Blade that is being pre-tested at Lund University and fully tested on beamlines at the Budapest Neutron Centre (BNC), a facility operated jointly by Hungary’s Centre for Energy Research and the Wigner Centre.

We established that we needed to reach a neutron count rate factor of 300 greater than state-of-the-art,” said Richard Hall-Wilton, Deputy Head of Instrument Technologies and Detector Group Leader at ESS. “We hope to be able to achieve this by 2017.”

Other neutron facilities in both Europe and the US are cooperating with ESS and keeping a close eye on the development of the Multi-Blade Detector.

“Neutrons are not easy to detect, and Mother Nature has given us only a few ways. You need to transform a neutral particle, a neutron, into a charged particle, because we can only detect particles that are charged.” — Francesco Piscitelli
DATA MANAGEMENT AND SOFTWARE CENTER (DMSC)

From the moment the first neutrons produced by the European Spallation Source register their existence on a detector, the raw experiment data will flow from Lund, Sweden, to Copenhagen, Denmark, and then onto the ESS scientific user community throughout Europe.

The Experiment Data
The ESS, Data Management and Software Centre is an integrated part of the design and construction of the ESS instrument suite and a key driver in the development of the facility’s user program. Constructing and operating this comprehensive data workflow is the core function of the DMSC.

The Data Management and Software Centre is the Division of the ESS Science Directorate that is responsible for providing the scientific software for the ESS neutron beam instruments. Its scope of work ranges from instrument control and data acquisition software to data analysis, modelling, and simulation. In order to do this, the DMSC will be working in close collaboration with various groups from the ESS Partner countries to develop this all important software suite.

“DMSC is an integral part of the ESS Science Directorate. Our work is completely focused towards supporting the scientific research programme of ESS.” Mark Hagen, Head of DMSC

Data Management
An experiment or sequence of experiments results in a large number of documents, simulation results, measurements, analysis results, and scientific papers. All of this has to be stored in a structured way so it is easily accessed. Eventually all these data are going to be organised in a data management system that will be developed and hosted at the DMSC.

The data management system will be based on both disk and tape to ensure permanent storage for all data and fast access to frequently-used data. The high-performance cluster also hosted at the DMSC will be directly interfaced to ensure that data can be accessed with the highest bandwidth during reduction and analysis.

FROM LUND TO COPENHAGEN, AND BACK AGAIN
This is a typical data flow for a neutron scattering experiment. Each numbered element corresponds to a key area of scope within the DMSC.

1. **Experiment Control**: The team of users configure the components of the instrument and sample environment using an experiment control system that interfaces with the neutron instrument components through the ESS EPICS network;

2. **Stream**: Data are taken in the event mode whereby the individual detector counts are tagged with useful experimental metadata to create a dataset. The list of events and metadata are aggregated in software and broadcast over a network in a continuous stream of data that external software systems can utilise;

3. **Reduce**: The raw data are transformed and corrected from the base unit of measurement to the unit of measurement that can be visualised. Each dataset is tagged with useful experimental metadata to create a dataset. The list of events and metadata are aggregated in software and broadcast over a network in a continuous stream of data that external software systems can utilise;

4. **Visualise**: The representation to the beamline users of a scientifically meaningful display of the corrected data, and finally;

5. **Analyse**: A scientific model is generated in order to scientifically interpret the experimental data.

The performance gain of ESS will enable experiments on more challenging samples in an adequate (extreme) environment. Support laboratories and facilities are being established at ESS which will assist the success of user experiments.

Facilitating Successful Experiments
For an efficient and successful use of beam time, many samples will have to be prepared and conditioned on site using a combination of data using The technical support required prior to, during, and after a user visit is related to a specific experiment. For this, mechanical workshops and technical capabilities are required close to the instruments, to prepare items in a timely manner. The necessary lab facilities in the controlled areas will provide the possibility to condition the samples promptly before the experiment. Such facilities include sample handling, preparation, and storage. Temporary storage of samples in adequate conditions will be provided.

“It is an added value to have scientific support labs here in Lund, to offer an expert workflow for future ESS users,” says Prof. Arno Hiess, Head of the ESS Scientific Activities Division. ESS plans to provide access to a number of on- and off-site labs that will serve to facilitate users throughout the life cycle of their sample—its preparation, testing environment, handling, and disposal. “We will be able to follow up or provide expert support, we can keep bench and beam time allocation efficient,” explains Hiess. “We are here to enable the user through our experience, our knowledge of the role carbohydrates play in our immune systems. Dr. Zöe Fisher, a deuteration and crystallisation specialist at ESS, became involved when the group started looking at the possibilities of using neutrons for this experiment.

Neutrons have the power to discern the exact locations of protons in large molecular complexes, information that is key to understanding molecular functional mechanisms in biology. However, in order to obtain this information, samples often have to be deuterated and crystallized, which poses some challenges. In order to facilitate life science studies at ESS, a biocrystallisation support lab is being established as able to produce large crystals (1.6 mm3 in volume) that were then zapped with X-rays at MAX-lab and bombarded with neutrons on the BIODIFF instrument. The combination of these two methods gives a scale advantage.”

SUPPORT LABS AND FACILITIES

The ESS Biocrystallisation Lab already serves to provide services for users in need of assistance with biological samples to be analysed at existing neutron and X-ray sources. The ESS lab has established close ties to Lund University and collaborates with Lund Protein Production Platform at Lund University and collaborates with Lund Protein Production Platform (LPP), which provides a range of complimentary services to produce, purify, and analyse protein samples that will be used in spectroscopy and diffraction experiments.

Working together, these facilities are establishing an efficient administrative and scientific workflow that will be essential to making the best use of precious ESS beam time once the facility is commissioned.

Photograph (left) of a large, single crystal of X-2 L110F in complex with XXXG mounted in a quartz capillary undergoing H/D exchange (dimensions: 1.6 x 2 x 2 mm3). This image indicates a successful protein-crystallisation nucleation effect. Image credit: Mythili Reddy.

FIRST LAB SUCCESSES
The first successful user experiment at ESS began in the autumn of 2015 in collaboration with researchers from the Lund University. A team of researchers led by Prof. Mats Olhén studied protein-carbohydrate binding as part of a larger effort to expand knowledge of the role carbohydrates play in our immune systems. Dr. Zöe Fisher, a deuteration and crystallisation specialist at ESS, became involved when the group started looking at the possibilities of using neutrons for this experiment.

Neutrons have the power to discern the exact locations of protons in large molecular complexes, information that is key to understanding molecular functional mechanisms in biology. However, in order to obtain this information, samples often have to be deuterated and crystallized, which poses some challenges. In order to facilitate life science studies at ESS, a biocrystallisation support lab is being established as able to produce large crystals (1.6 mm3 in volume) that were then zapped with X-rays at MAX-lab and bombarded with neutrons on the BIODIFF instrument at the FRM II facility in Munich. The combination of these two high-resolution diffraction experiments in a very precise 3D model of the protein structure.

Photograph (right) of a single, large crystal of X-2 L110F in complex with XXXG mounted in a quartz capillary undergoing H/D exchange (dimensions: 1.6 x 2 x 2 mm3). This image indicates a successful protein-crystallisation nucleation effect. Image credit: Mythili Reddy.

The ESS Biocrystallisation Lab already serves to provide services for users in need of assistance with biological samples to be analysed at existing neutron and X-ray sources. The ESS lab has established close ties to Lund University and collaborates with Lund Protein Production Platform (LPP), which provides a range of complimentary services to produce, purify, and analyse protein samples that will be used in spectroscopy and diffraction experiments.

Working together, these facilities are establishing an efficient administrative and scientific workflow that will be essential to making the best use of precious ESS beam time once the facility is commissioned.
IN CHARGE AT ESS
GOVERNANCE

The European Spallation Source ERIC Council is the governing body of the European Spallation Source ERIC. The Council is made of representatives from the Member countries. It appoints the Director General and Chairperson, and approves the budget and technical scope of the facility.

The European Spallation Source ERIC Council

The European Spallation Source ERIC Council is bound by the Statutes ratified by the ERIC Member countries. The constituting European Spallation Source ERIC Council Meeting was held July 2-3, 2015, where the leadership was appointed, the Council Rules of Procedure were adopted, and the Terms of Reference for all advisory committees were adopted by the Council. James H. Yeck was appointed the Director General of European Spallation Source ERIC and Prof. Lars Börjesson was appointed the Chair of the European Spallation Source ERIC. In October 2015, Prof. Dr. Caterina Petrillo was unanimously elected as the governing body’s Vice Chair. The European Commission’s establishment of ESS as an ERIC occurred on August 31, 2015, and the transition of ESS from a Swedish limited partnership to an ERIC was completed as of October 1, 2015.

ESS Committees

The ESS project is supported by a number of independent advisory committees. Recommendations by each committee advances ESS along the critical path to completion. The committees consist of delegates representing the Member countries or experts which evaluate and advise the progress of the ESS.

ORGANISATION

The organisational chart of the ESS including the ERIC Council, the related advisory committees and the project directorates.
### ESS GOVERNANCE COMMITTEES

<table>
<thead>
<tr>
<th>Country</th>
<th>Chair</th>
<th>Vice Chair</th>
<th>ESS Council</th>
<th>Administration and Finance Committee (AFC)</th>
<th>In-kind Review Committee (IKRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>Laurent Gys</td>
<td>Christian Legrain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Petr Lukáš</td>
<td>Petr Ventukova</td>
<td>Petr Šittner</td>
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<tr>
<td>Denmark</td>
<td>Robert Feidenhansen</td>
<td>Morten Scharff</td>
<td>Søren Schmidt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>Touo Raim</td>
<td>Pritt Tammi</td>
<td>Haisi Kunig</td>
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<tr>
<td>France</td>
<td>Patricia Roussel-Chomaz</td>
<td>Bertrand Franet</td>
<td>Bernhard Laune</td>
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<tr>
<td>Germany</td>
<td>Sebastian Schmidt</td>
<td>Oda Koppier</td>
<td>Ulrich Breuer</td>
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<tr>
<td>Hungary</td>
<td>Laszlo Rosta</td>
<td>Orosiya Sárdi</td>
<td>Daniel Csánavy</td>
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<tr>
<td>Italy</td>
<td>Salvatore La Rosa</td>
<td>Ileana Gimirallo</td>
<td>Paolo Michelato</td>
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<tr>
<td>The Netherlands</td>
<td>Louis Vertegaal</td>
<td>Nico Kos</td>
<td>Guy Luijkx</td>
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<td></td>
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<tr>
<td>Norway</td>
<td>Bjørn Jacobsen</td>
<td>Bjørn Jacobsen</td>
<td>Bjørn C. Hauback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>Mateusz Gaczynski</td>
<td>Michał Rybinski</td>
<td>Adam Maź</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>Inmaculada C. Figueroa Rojas</td>
<td>Inmaculada C. Figueroa Rojas</td>
<td>Frederico J. Mompean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>David Edwardsson</td>
<td>Maud Bergkvist</td>
<td>Ulf Karlsson</td>
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<tr>
<td>Switzerland</td>
<td>Martin Kier</td>
<td>Patricia Soom</td>
<td>Peter Allembach</td>
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</tr>
<tr>
<td>United Kingdom</td>
<td>Neil Pratt</td>
<td>Maggie Collick</td>
<td>Uisch Steigenberger</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ESS ADVISORY COMMITTEES

**Scientific Advisory Committee (SAC)**
- **Chair**: Andreas Meyer
- **Co-Chair**: Sylvia McLean
- Other members: Vladimir Schovsky, Markus Braden, Björn Brummerstedt Iversen, Fabio Bruni, Arnaud Desmedt, Bernhard Frick, Kenneth W. Herwig, Björn Grönvall, Herve Jobic, Klaus Stefan Kirch, Jörg F. Löfler, Thomas Lundquist, Carmen Mijangos, Kristine Niss, Catharina Rappas, Toby Pennig, Roger Pyun, Helena Van Swygenhoven, Regine van Rijswijck, Wojciech Zajac

**Technical Advisory Committee (TAC)**
- **Chair**: Philippe LeBrun
- **Co-Chair**: John Galambos
- **Co-Chair**: Alberto Faccio

**Environment, Safety & Health Committee (ES&HC)**
- **Chair**: Paul Berkins
- **Representatives**: Enrico Carminati, Doris Ferkel-Wirth, Marek Jurek, Frank Komegay, Göran Larsson, Martin Luthander, Kelly Mahoney, Thomas Peterson

**Committee on Employment Conditions**
- **Chair**: Lars Börjesson
- **Provisional**: José Luis Martinez, Patrice Roussel-Chomaz

**Conventional Facilities Advisory Committee (CFAC)**
- **Chair**: Martin Faller
- **Representatives**: Olof Elvén, Carsten Jarlov, Sven Landelius, Peter Lundhuk, Gyanthe Saltrop, Tim Watson, Bo Smith, Katarina Bjelke

The ESS management can participate ex-officio.

---

**ESS AB Board**
- **Chair**: Lars Börjesson
- **Vice-Chair**: Bo Smith

**ESS AB Board Members**
- **Danish Members**: Hans Müller Pedersen, Katarina Bjelke, Lars Börjesson, Per Eriksson, Lena Gustafsson
- **Swedish Members**: Sven Landelius, Kim Gougaard, Karina Olofsson, Lars Börjesson, Lena Gustafsson
- **Employee Representative**: Mikael Polade

**Executive Management Team (EMT)**
- **Director General & CEO**: James H. Veck
- **Technical Director**: Andreas Schreyer
- **Director for Project Support & Administration**: Roland Ganzhry
- **Associate Director of Environment, Safety & Health and Quality Assurance**: Agneta Nielsen
- **Head of Conventional Facilities Division**: John Haines
- **Head of Communications & External Relations Division**: Kent Hedin
- **Head of Conventional Facilities Division**: Allen Weeks
- **Strategic Project Advisor**: Pia Kinhult
Translation of “Årsredovisning 31 August – 31 December 2015”:

Annual report
31 August – 31 December 2015

European Spallation Source ERIC
Org.nr. 768200-0018

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Contingent liabilities and pledged assets 69
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European Spallation Source ERIC is a consortium with the purpose of designing, constructing and operating the next generation neutron source. ESS is a European research infrastructure that will be used to conduct research on various materials and will have significant long-term impact on the competitiveness of Swedish research and industry. The site is under construction outside Lund and is scheduled to be completed in 2019. The user programme for researchers is planned to start in 2023 and the facility should be fully operational by 2025. The project is one of the largest and most high-priority research infrastructure projects in Europe.

European Spallation Source ERIC includes the facility, which is under construction outside Lund, Sweden, and the Data Management and Software Centre (DMSC) in Copenhagen, Denmark. The international focus can be seen throughout the organisation. The staff now includes employees from nearly 50 different nations.

European Spallation Source ERIC has 11 member countries: Sweden, Denmark, Germany, France, Italy, Switzerland, Norway, Poland, Hungary, Czech Republic and Estonia. A number of countries are observers until the respective national decision-making processes regarding membership are completed. Observers are currently the UK, Spain, Belgium and the Netherlands.

Joint cooperation is ongoing with partners from all over Europe and also from other parts of the world. European Spallation Source ERIC counts as an example of large international co-operation where exchange knowledge, personnel and experience, which in many cases are distributed directly to the project through in-kind contributions. In-kind contributions are expected to finance about 35 percent of the total estimated construction cost of 1.863 billion EUR (2013 prices).

When ESS user programme starts in 2023, it is estimated that two to three researchers and guests annually conducting experiments in the facility. Most users will be from European universities and institutes as well as industry.

Construction Project

The construction project, led by the Conventional Facilities Division, operates the work according to the schedule for the entire ESS project. The focus for the organisation is the project schedule in order to be able to complete the project on time and within the agreed budget.

At the time of the transition to the European Spallation Source ERIC 15% of the entire ESS project was already completed.

During spring the work started with the extensive land and piling works for the target station. 30% of just over 600 piles which are to prevent the heavy impact on the target building if affected by extreme forces, was completed at the end of September.

On May 28th, ESS AB signed an agreement with Skanska to build the second phase of the research facility. The contract including installations in a number of buildings, substations, transformers and land work and piling was taken over by the European Spallation Source ERIC in the asset transfer. Work on the accelerator tunnel has continued rapidly. In early October, the entire basement, and 50% of the walls and the ceiling of the tunnel were completed. Several adjacent buildings, including the Klystron gallery (2D2) and switchgear with several support buildings, were also progressing.

In-kind Contributions

The ESS project is based on extensive collaboration with research institutions within the partner countries. The majority of the instruments, the target station and the accelerator are delivered by contractors. In-kind contributions have been made by the partner countries. The majority of the instruments has been made in collaboration with partner institutions across Europe. More than 100 partners are now actively involved in the ESS project.

In 2015 ESS became an ERIC and it was a prerequisite for many of the in-kind partners to be able to sign the contracts. After the transition, several in-kind contracts were signed and are ongoing.

Risks and Uncertainties

Each potential event that could affect its overall objectives poses a risk. Risk identification and risk analysis is a part of the daily work at ESS. These aims are to contribute to the effective management of risks, by providing greater insight about the consequences with a certain risk involved, and with what probabilities could happen. Structured risk analysis enabling comparisons, and facilitates risk communication.

The risks are assessed from two different perspectives:

- Risks Related to Construction
- Risks Related to Radiation

Health and accident risks are assessed for all activities performed and also covers the management of radiation safety when ESS is running. It includes the management of risks related to accidents during the construction phase. Processes and rules for the ESS construction has been established in cooperation with our contractors.

Risks Related to the Quality and Function

Risks that could potentially degrade the quality and function of technical structures, systems, operations, and of great importance for ESS. To manage these risks ESS has during the year refined the existing processes for construction work and developed new technology systems. Processes and a quality management system has also been implemented.

ESS activities are financed by all member countries through contribution.

The remaining financing risks during the construction phase is of reaching one hundred percent cost coverage through commitment and being able to establish a bridge financing solution in order to secure the project. The first risk is dealt with in the ongoing negotiations with the countries that have shown strong interest to participate in ESS and the other dealt with the member countries. In 2015 it has been about moving forward some of the cash contributions and in the long term it is about using the future contributions as security to establish a temporary bridge financing to cover the identified gaps between the received on the one hand and on the other hand the cash to access.

Significant Events During the Year

The European Commission’s decision, which took effect from 31 August 2015, to establish the European Spallation Source as an ERIC means that the activities carried out so far within the framework of the ESS AB were transferred to the ERIC. The ESS project officially transitioned to the European Spallation Source ERIC October 1, 2015.

Development of the Company’s Financial Performance and Position

The net result amounted to -271 982 KSEK. The result includes costs for staff and consultant, and administrative and technical infrastructure during the construction phase.

Shareholders’ equity amounted to 67 183 KSEK. During the financial year, the European Spallation Source ERIC received contributions from member countries amounting to 339 165 KSEK.

Investments

After the acquisition from ESS AB the investments in construction in progress amounts to 278 113 KSEK.

Financing and Liquidity

European Spallation Source ERIC has during the fiscal year 2015 received contributions from member countries by 339 165 KSEK. More information about received contributions, see Note 16. Cash and cash equivalents amounted to 386 062 KSEK.

Significant Events After the end of the Year

The Swedish Parliament has decided after the closing date in accordance with Prop. 2015/16: 77 that the European Spallation Source ERIC shall be exempted from excise duties, including energy tax on electric power when the consortium for its own operations, makes substantial purchases of excise goods on which excise duty is included in the price. The same also applies to substantial consumption of electric power in its own operations, for which the consortium is liable for tax.

In January 2016 it was announced that James H. Yerk, Director General at the European Spallation Source ERIC, will leave his post after the process of finding a replacement is ongoing.
### INCOME STATEMENT

<table>
<thead>
<tr>
<th>KSEK</th>
<th>Note</th>
<th>2015-08-31–2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net turnover</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

#### Gross profit

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Administration expenses</td>
<td>–</td>
<td>–50 966</td>
</tr>
<tr>
<td>Research and development expenses</td>
<td>–</td>
<td>–219 212</td>
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<tr>
<td>Other operating income</td>
<td>4</td>
<td>7 674</td>
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<tr>
<td>Other operating expenses</td>
<td>5</td>
<td>–9 465</td>
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</tbody>
</table>

#### Operating profit

<p>| | | |</p>
<table>
<thead>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Financial income</td>
<td>8</td>
<td>4</td>
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<tr>
<td>Financial expenses</td>
<td>9</td>
<td>–39</td>
</tr>
</tbody>
</table>

#### Profit before tax

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Tax</td>
<td>–</td>
<td>–271 982</td>
</tr>
</tbody>
</table>

#### NET RESULT

|                          |       | –271 982             |

### BALANCE SHEET

<table>
<thead>
<tr>
<th>KSEK</th>
<th>Note</th>
<th>2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS PROFIT</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

#### Non-current assets

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible fixed assets</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Equipment, tools, and installation</td>
<td>11</td>
<td>8 217</td>
</tr>
<tr>
<td>Construction in progress</td>
<td>12</td>
<td>756 096</td>
</tr>
</tbody>
</table>

#### Total non-current assets

|                          |       | 766 313    |

#### Current assets

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Short term receivables</td>
<td>13</td>
<td>80 955</td>
</tr>
<tr>
<td>Prepaid expenses and accrued income</td>
<td>14</td>
<td>18 495</td>
</tr>
<tr>
<td>Cash and bank</td>
<td>17</td>
<td>386 062</td>
</tr>
</tbody>
</table>

#### Total current assets

|                          |       | 483 522    |

#### EQUITY AND LIABILITIES

#### Equity

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Capital contribution</td>
<td>16</td>
<td>339 165</td>
</tr>
<tr>
<td>Net result</td>
<td>–</td>
<td>–271 982</td>
</tr>
</tbody>
</table>

#### Total equity

|                          |       | 67 183     |

### CASHFLOW

<table>
<thead>
<tr>
<th>KSEK</th>
<th>Note</th>
<th>2015-08-31–2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating activities</td>
<td>–</td>
<td>–271 982</td>
</tr>
<tr>
<td>Adjustments for non-cash items</td>
<td>–</td>
<td>656</td>
</tr>
<tr>
<td>Cash flow from operating activities before changes in working capital</td>
<td>–</td>
<td>–271 326</td>
</tr>
<tr>
<td>Cash flow from changes in working capital</td>
<td>–</td>
<td>–99 669</td>
</tr>
<tr>
<td>Increases (+)/decreases (-) in operating receivables</td>
<td>–</td>
<td>1 180 652</td>
</tr>
<tr>
<td>Increases (+)/decreases (-) in operating liabilities</td>
<td>–</td>
<td>809 866</td>
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</tbody>
</table>

#### Investing activities

<table>
<thead>
<tr>
<th></th>
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<th>–8 873</th>
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</thead>
<tbody>
<tr>
<td>Acquisition of tangible assets</td>
<td>11</td>
<td>–756 096</td>
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#### Financing activities

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>–</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash contribution</td>
<td>–</td>
<td>–99 669</td>
</tr>
</tbody>
</table>

#### Cash flow for the year

|                          |       | 386 062     |

### CONTINGENT LIABILITIES AND PLEDGED ASSETS

<table>
<thead>
<tr>
<th>KSEK</th>
<th>Note</th>
<th>2015-12-31</th>
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</thead>
<tbody>
<tr>
<td>Contingent liabilities</td>
<td>–</td>
<td>None</td>
</tr>
<tr>
<td>Pledged assets</td>
<td>–</td>
<td>None</td>
</tr>
</tbody>
</table>

### EQUITY

<table>
<thead>
<tr>
<th>KSEK</th>
<th>Cash contribution</th>
<th>Net result</th>
<th>Total equity</th>
</tr>
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<tbody>
<tr>
<td>Opening balance 2015-08-31</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Contributions</td>
<td>339 165</td>
<td>–271 982</td>
<td>339 165</td>
</tr>
<tr>
<td>Balance as of 2015-12-31</td>
<td>339 165</td>
<td>–271 982</td>
<td>67 183</td>
</tr>
</tbody>
</table>
The following depreciation schedules are applied:

<table>
<thead>
<tr>
<th>Asset Type</th>
<th>Useful Life (Years)</th>
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<tbody>
<tr>
<td>IT equipment</td>
<td>3-5 years</td>
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<tr>
<td>Machinery and equipment</td>
<td>5-7 years</td>
</tr>
</tbody>
</table>

Impairments

The recorded value of the assets at balance date is reconciled for any indication of impairment. If any such indication exists, the asset’s recoverable amount is the higher of value in use and net realisable value. Impairment loss is recognised if the recoverable amount is less than the balance value. When calculating the value in use, future cash flows at a pre-tax rate are discounted to reflect the market’s assessment of risk-free interest and risk associated with the specific asset. An asset that is dependent on other assets is not considered to generate any independent cash flows. Such assets are instead attributed to the smallest cash-generating unit where the independent cash flows can be determined.

An impairment loss is reversed if there has been a change in the estimates used to determine the recoverable amount. A reversal is made only to the extent that the assets’ balanced amount does not exceed the amount that would have been determined after depreciation, if no impairment loss had been recognised.

ESS operates without profit in accordance with the requirements of the EU regulation relating to ERIC. Financing the future operation of the facility is planned to be achieved through contributions that ensure full cost recovery. This means that the assessment of external and internal indicators related to impairment review according to K3 regulations for ESS ERIC, is taking into account ESS ERIC’s specific conditions. This specific application complies in all material respects with the principles and methods as expressed in the “UTKast till redovisnings- talaende från FÅR Nadselverkningar i kommunala företag som omfattas av kommunalagens självkostnadsprincip” which thus is applied similarly for ESS ERIC.

Debtors Receivables are receivable and liabilities are recognised without discount, except in cases where they are not entirely due for payment within 12 months after the end of the period during which the employees perform the related services.

Tax

The tax consists of current tax and deferred tax. Taxes are recognised in the income statement except where the underlying transaction is recorded directly against equity, whereby the associated tax effect is recognised in equity. Current tax is tax to be paid or received for the current year. This includes adjustment of current tax with taxes from prior years. Deferred tax is calculated using the liability method for temporary differences between the book and the tax value of the assets and the liabilities. The amounts are calculated based on how the temporary differences are expected to be settled and by applying the tax rates and tax rules adopted or announced at the balance sheet date. Temporary differences do not take into account the differences relating to investments in subsidiaries and associates, which are not expected to be taxable in the foreseeable future. Unused reserves are reported including deferred tax liabilities. Deferred tax assets for deductible temporary differences and loss carry forwards are only recognised to the extent that it is probable that these will entail lower tax payments in the future.

Contributions

European Spallation Source ERIC is partly financed with cash and partly with In-kind contributions (non-financial contributions) from the member countries.

Cash Contributions

Received contributions from members are recognised in equity in the balance sheet. See capital contributions in Note 16.

In-kind Contributions

The process for approving In-kind Contributions are during the construction period performed by the Committee (In-kind Review Committee). The Committee reviews underlying agreements and recommends them to the ESS Council, with delegates from the member countries, for final approval. After approval it is required in order for the In-kind contributions to be recorded, finally documented agreements between the parties regarding the value of completed deliveries and signed contribution documents from the contributors.

The In-kind Contribution during the preconstruction phase was included in the transfer of ESS AB to the European Spallation Source ERIC. These In-kind Contributions have not been booked since the process for reviewing and approving values, completed delivery, and agreements for these grants in ESS AB were completed when they were transferred from ESS AB to the European Spallation Source ERIC. The process to review and approve these values will continue in European Spallation Source ERIC.
NOTE 3: EMPLOYEES, STAFF COSTS, AND FEES TO THE AUDITORS

<table>
<thead>
<tr>
<th>AVERAGE NUMBER OF EMPLOYEES</th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWEDEN</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>220</td>
</tr>
<tr>
<td>Women</td>
<td>112</td>
</tr>
<tr>
<td>Total</td>
<td>332</td>
</tr>
<tr>
<td>DENMARK</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>12</td>
</tr>
<tr>
<td>Women</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
</tr>
<tr>
<td>TOTAL</td>
<td>346</td>
</tr>
</tbody>
</table>

GENDER DISTRIBUTION IN THE MANAGEMENT 2015-12-31

| Management directors and Director General | 4 |
| Where of women                            | 25% |

SALARIES, OTHER REMUNERATION AND SOCIAL COSTS, KSEK 2015-08-31 – 2015-12-31

<table>
<thead>
<tr>
<th></th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>60 602</td>
</tr>
<tr>
<td>Denmark</td>
<td>3 859</td>
</tr>
<tr>
<td>TOTAL</td>
<td>64 461</td>
</tr>
<tr>
<td>Social costs</td>
<td>17 448</td>
</tr>
<tr>
<td>Pension costs</td>
<td>3 023</td>
</tr>
<tr>
<td>TOTAL SOCIAL COSTS</td>
<td>20 471</td>
</tr>
</tbody>
</table>

Salaries and other remunerations includes:
- to Director General: 606
- to Management directors: 1 325

ALLOWANCES TO MANAGEMENT DIRECTORS 2015, KSEK

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director General</td>
<td></td>
</tr>
<tr>
<td>Management Directors (3 pers)</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>2 450</td>
</tr>
</tbody>
</table>

Incentive Scheme
European Spallation Source ERIC has no incentive scheme.

Severance Pay to Senior Executives
Director General and senior executives employment agreements have from 1 October 2015 been transferred from ESS AB to European Spallation Source ERIC, and there are no severance payments.

FEES AND REMUNERATION TO AUDITORS, KSEK 2015-08-31 – 2015-12-31

<table>
<thead>
<tr>
<th></th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audit assignments</td>
<td>301</td>
</tr>
<tr>
<td>Other assignments</td>
<td>19</td>
</tr>
<tr>
<td>TOTAL</td>
<td>320</td>
</tr>
</tbody>
</table>

NOTE 4: OTHER INCOME

<table>
<thead>
<tr>
<th></th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate gain on receivables/liabilities of operations</td>
<td>4 191</td>
</tr>
<tr>
<td>Contributions for EU-Grants</td>
<td>3 404</td>
</tr>
<tr>
<td>Other income</td>
<td>76</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7 674</td>
</tr>
</tbody>
</table>

NOTE 5: LEASING FEES WITH RESPECT TO OPERATIONAL LEASES

All leasing agreements have been taken over from ESS AB from 1 October 2015.

<table>
<thead>
<tr>
<th></th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum leasing fees</td>
<td>2 626</td>
</tr>
<tr>
<td>Variable fees</td>
<td>212</td>
</tr>
<tr>
<td>TOTAL LEASING COSTS</td>
<td>2 838</td>
</tr>
<tr>
<td>Contractual future minimum leasing fees relating to non-retractable contracts which become due for payment:</td>
<td></td>
</tr>
<tr>
<td>Within one year</td>
<td>11 352</td>
</tr>
<tr>
<td>Between two and five years</td>
<td>5 811</td>
</tr>
<tr>
<td>TOTAL</td>
<td>17 163</td>
</tr>
</tbody>
</table>

NOTE 6: OTHER EXPENSES

<table>
<thead>
<tr>
<th></th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate losses on receivables/liabilities of operations</td>
<td>-9 374</td>
</tr>
<tr>
<td>Other expenses</td>
<td>-91</td>
</tr>
<tr>
<td>TOTAL</td>
<td>-9 465</td>
</tr>
</tbody>
</table>
NOTE 7: DEPRECIATIONS

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depreciation according to plan by asset:</td>
</tr>
<tr>
<td></td>
<td>Equipment, tools, and installation</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depreciation according to plan by function:</td>
</tr>
<tr>
<td></td>
<td>Administration expenses</td>
</tr>
<tr>
<td></td>
<td>Research and development costs</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
</tr>
</tbody>
</table>

NOTE 11: EQUIPMENT, TOOLS AND INSTALLATION

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accumulated cost of acquisitions:</td>
</tr>
<tr>
<td></td>
<td>Beginning of the financial year</td>
</tr>
<tr>
<td></td>
<td>Acquisitions</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accumulated depreciation according to plan:</td>
</tr>
<tr>
<td></td>
<td>Beginning of the financial year</td>
</tr>
<tr>
<td></td>
<td>Depreciation according to plan</td>
</tr>
<tr>
<td>Net value in balance sheet 31 Dec 2015</td>
<td>8 217</td>
</tr>
</tbody>
</table>

All equipment has been transferred to European Spallation Source ERIC from ESS AB according to agreement dated 1 October 2015.

NOTE 12: CONSTRUCTION IN PROGRESS

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accumulated cost of acquisitions:</td>
</tr>
<tr>
<td></td>
<td>Beginning of the financial year</td>
</tr>
<tr>
<td></td>
<td>Acquisitions</td>
</tr>
<tr>
<td>Net value in balance sheet 31 Dec 2015</td>
<td>756 096</td>
</tr>
</tbody>
</table>

NOTE 13: SHORT TERM RECEIVABLES

<table>
<thead>
<tr>
<th>KSEK</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VAT receivables</td>
<td>73 873</td>
</tr>
<tr>
<td>Other tax receivables</td>
<td>4 852</td>
</tr>
<tr>
<td>Other</td>
<td>2 240</td>
</tr>
<tr>
<td>TOTAL</td>
<td>80 965</td>
</tr>
</tbody>
</table>

VAT receivables remain in the balance sheet per closing date in anticipation of the Parliamentary decision under Prop. 2015/16: 77 concerning exemption from indirect taxes.

NOTE 10: TAX ON INCOME FOR THE YEAR

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-08-31 – 2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current tax</td>
</tr>
<tr>
<td></td>
<td>Deferred tax</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
</tr>
</tbody>
</table>

European Spallation Source ERIC has currently costs generating tax losses. Uncertainty about the possibilities and the timeframe to take advantage of these is the reason for not accounting for deferred taxes.

NOTE 14: PREPAID EXPENSES AND ACCRUED INCOME

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepaid rental costs</td>
<td>3 750</td>
</tr>
<tr>
<td>Prepaid insurance</td>
<td>9 665</td>
</tr>
<tr>
<td>Accrued income EU-project</td>
<td>4 407</td>
</tr>
<tr>
<td>Other</td>
<td>673</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18 495</td>
</tr>
</tbody>
</table>
The Council of European Spallation Source ERIC will decide upon the adoption of the financial statement and Annual report.

Director General certify that, based on my best knowledge, belief and understanding, the Annual Report is prepared in accordance with applicable accounting rules, the information provided is in accordance with the facts, and nothing of significance that could affect the image of the company as a result of the Annual Report, is omitted.

Lund 2016-04-30

James H. Yeck
Director General

Our audit report was submitted 2016-KPMG AB
Kent Lindén
Authorised Public Accountant

The European Spallation Source ERIC's mission is to design, build and operate the world's leading research facility using neutrons for science and innovation. This report is produced by The European Spallation Source ERIC with support from BrightnESS, a project funded by the European Union Framework Programme for Research and Innovation Horizon2020, under grant agreement 676548.

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NOTE 15: FINANCIAL INSTRUMENTS AND FINANCIAL RISK MANAGEMENT

Finance Policy
In view of the phase in which ESS currently operates, no financial instruments are at present being used to hedge flows or the Balance Sheet.

Liquidity Risks and Interest Rate Risks
Cash surplus are placed in bank accounts or other equivalent.

Credit Risks
Credit risks are considered limited, as the company's receivables consist of minor amounts.

Exchange Rate Risks
Exposure to exchange rate changes has been low and the exchange rate earnings that occurred during the year relates to exchange rate differences on account payables and bank balances mainly in EUR.

NOTE 16: CAPITAL CONTRIBUTIONS

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estonia</td>
<td>5 230</td>
</tr>
<tr>
<td>Denmark</td>
<td>172 971</td>
</tr>
<tr>
<td>Switzerland</td>
<td>20 897</td>
</tr>
<tr>
<td>Norway</td>
<td>106 935</td>
</tr>
<tr>
<td>Czech republic</td>
<td>28 952</td>
</tr>
<tr>
<td>Hungary</td>
<td>4 650</td>
</tr>
<tr>
<td>TOTAL</td>
<td>339 165</td>
</tr>
</tbody>
</table>

NOTE 17: OTHER LIABILITIES

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liabilities to ESS AB according to transfer agreement</td>
<td>865 613</td>
</tr>
<tr>
<td>Other</td>
<td>11 762</td>
</tr>
<tr>
<td>TOTAL</td>
<td>877 375</td>
</tr>
</tbody>
</table>

According to shareholders meeting in ESS AB, 2016-03-18, the company's purchase price claim on the European Spallation Source ERIC will be distributed to the shareholders, Sweden, and Denmark. The liabilities to ESS AB will be converted to contribution to European Spallation Source ERIC, Prop 2015/16 1.

NOTE 18: ACCRUED EXPENSES AND DEFERRED INCOME

<table>
<thead>
<tr>
<th>KSEK</th>
<th>2015-12-31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accrued vacation salary</td>
<td>17 209</td>
</tr>
<tr>
<td>Employee taxes and social costs</td>
<td>6 726</td>
</tr>
<tr>
<td>Accrued salary tax</td>
<td>2 801</td>
</tr>
<tr>
<td>Accrued payments for EU- projects</td>
<td>48 309</td>
</tr>
<tr>
<td>Accrued construction- and consultancy fees</td>
<td>32 192</td>
</tr>
<tr>
<td>Accrued expenses CEA</td>
<td>10 286</td>
</tr>
<tr>
<td>Other accrued expenses and deferred income</td>
<td>10 386</td>
</tr>
<tr>
<td>TOTAL</td>
<td>124 389</td>
</tr>
</tbody>
</table>

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