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CESSAMag

CERN-EC Support for SESAME Magnets

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PROJECT FINAL REPORT

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For more information on CESSAMag, please see www.cern.ch/CESSAMag

CESSAMag stands for "CERN-EC Support for SESAME Magnets". It is a 4-year long FP7 project which aims at supporting the construction of the SESAME light source, the Middle East's first major international research center in the making.

Delivery Slip

	Name	Partner	Date
Authored by	Jean-Pierre Koutchouk, A. Milanese, M. Cerqueira Bastos, A. Szeberenyi	CERN	19/01/2017
Edited by	A. Szeberenyi	CERN	23/01/2017
Reviewed by	Jean-Pierre Koutchouk S. Stavrev D. Tommasini E. Tsesmelis R. Voss C. Lindberg Warakaulle	CERN	25/01/2017
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Name of the scientific representative of the project's coordinator Title and Organisation:	Jean-Pierre Koutchouk, Scientific Coordinator CESSAMag, CERN
Tel:	+41 22 76 73230
Fax:	+41 22 76 67564
Email:	Jean-Pierre.Koutchouk@cern.ch
Project website address:	http://cern.ch/cessamag

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I. PUBLISHABLE SUMMARY

1. EXECUTIVE SUMMARY

*FP7-CESSAMag is a **science diplomacy project** whereby CERN and the European Commission joined forces to give a technical and political boost to the SESAME light source project in the Middle East. The EC provided the funds for CERN to purchase the magnetic system of the 2.5 GeV storage ring and part of its powering scheme, while CERN provided its expert manpower for the design, procurement and testing. Special emphasis was put on knowledge transfer and collaboration with SESAME, and all actions strengthening the Euro-Mediterranean partnership. Key challenges faced by CERN were: the creation of a legal and political project framework for a complex and unprecedented project; balancing the provision of human resources with the demand by CERN's core programs; the search for external in-kind or financial support; and the maintenance of the highest possible quality and reliability of equipment at lower cost. These challenges were all resolved. The links created between CERN and SESAME remain solid. The science diplomacy impact of CESSAMag was communicated to general and scientific audiences, and received positive feedback at all levels.*

*Building upon the SESAME study, the design of the **magnets** was optimized and complemented with engineering studies. After assessment of the best offers by CERN and SESAME, the bulk of the orders were placed with experienced European companies. For magnets not on the critical path, CERN made a special effort to identify less experienced companies in the SESAME Member countries demonstrating potential and motivation. CERN benefitted from an in-kind contribution of Pakistan, offering the assembly of 50% of the sextupoles. A SESAME engineer was deeply involved in the design and building of a quadrupole and sextupole measuring bench at CERN. All magnets were successfully measured and tested at either ALBA or CERN and have excellent field quality and reproducibility, making them a reference for similar synchrotrons, without cost increase. All technical and design data are made available to SESAME.*

*Following a proposal by CERN experts, the initial SESAME plans for the **magnet powering** scheme were drastically modified. The new scheme, based on light source standards (PSI), allows individual powering of quadrupoles and simplified maintenance by plug-and-play modules. The optimization of the scheme allowed the inclusion of the spares and controls not foreseen in CESSAMag at no extra cost. The plans were approved by SESAME. CERN provided additional manpower and was supported by an intensive collaboration with SESAME engineers and two visiting engineers from Turkey and Iran. The power sources and control electronics were procured from Israel, Italy and Switzerland. The interfaces were designed and built by CERN and SESAME and the firmware by SESAME. Once assembled in racks, the powering scheme was thoroughly tested, passed the acceptance tests and was delivered to SESAME on time.*

*The final activity of CESSAMag was the **support to installation and commissioning**. The main support actions were the integration of the first SESAME cell at CERN in 2015, the creation of a survey network and the installation and alignment of the first cell in the SESAME tunnel, the hardware commissioning of all dipole magnets and of a sample of quadrupole magnets. In addition, a significant fraction of the powering scheme was tested and a power test was completed where, for the first time, the SESAME dipole chain was powered to its nominal 2.5 GeV setting for 6 hours. All tests, carried out in collaboration, gave satisfactory results with only minor corrections necessary. The goal of providing SESAME with full control of the equipment delivered by CERN was fulfilled and all technical and political objectives of the project were achieved or exceeded.*

2. PROJECT CONTEXT AND OBJECTIVES

2.1 CONTEXT

SESAME (**S**ynchrotron-light for **E**xperimental **S**cience and **A**pplications in the **M**iddle **E**ast) is the Middle East's first major international research center in the making. It is a cooperative venture by scientists and governments of the region set up on the model of CERN (European Organization for Nuclear Research) although it has very different scientific aims. It is being developed under the auspices of UNESCO (United Nations Educational, Scientific and Cultural Organization). The acronym "SESAME" was proposed to evoke memories of the culture of the region. SESAME opens the door to dialogue in the region based on a science for peace approach.

SESAME is a "third generation" light source; a particle accelerator-based facility which studies a range of different properties of matter by using electromagnetic radiation emitted by circulating electron beams. Experiments at SESAME will enable research in fields ranging from medicine and biology, through materials science, physics and chemistry to healthcare, the environment, agriculture and archaeology.

SESAME is an organisation driven by the scientific communities of its Members. The need for an international light-source in the Middle East was first recognised in the early 1980s by the Pakistani Nobel Laureate Abdus Salam, and was also felt by the Middle East Scientific Collaboration group, which grew from a meeting of Egyptian and Israeli scientists and politicians in 1995. The project was initiated with a proposal to relocate the soon-to-be-closed Berlin Synchrotron to the Middle East, although it was soon decided to equip SESAME with a completely new, and much more powerful main ring. The challenge for SESAME, given the difficult political context of the Middle East and its instability, has been to find capital funding and share the dedication and enthusiasm of the scientists with the political sphere.

The philosophy of CESSAMag was for CERN to join forces with the European Commission, and timely give a boost to the SESAME project, both technically and politically, by providing a key component of the storage ring.

2.2 PROJECT OBJECTIVES

CESSAMag's overall objective was to deliver the magnetic system and its powering scheme for SESAME's new main accelerator ring. The magnetic system is a key component of any light source in terms of complexity, performance and cost.

The project included 6 work packages: one dedicated to Management and Technical Coordination and 5 to technical work and support.

WP1: Project Management and Technical Coordination

Besides running the project and managing its technical aspects to ensure technical success, the initial key objective of this work package was to create the legal and administrative framework, including international cooperation agreements with SESAME and ALBA-CELLS for an unusual CERN contribution to an external project. Building solid collaborative links both with the SESAME management and SESAME scientific and technical staff was an instrumental requirement for success. WP1 was responsible for finding the needed manpower resources with the support of the CERN Director-General. As the EC funding did not cover the whole cost of the equipment, an important goal was to explore all strategies offering potential savings and search for external support, e.g. in-

kind contributions of manpower or manufacturing. WP1 was to give regular updates towards the CERN Director-General, the SESAME Council (where the coordinator was invited as a CERN delegate), the Technical Advisory Committee and the EC Project Officer. Other goals included promotion and initiatives on training, knowledge transfer, and participation of industry in SESAME countries and on the science diplomacy aspect.

WP2: Magnet design and engineering study

The first objective of WP2 was to start from the SESAME design studies of the magnets, complement them by 3D design of the magnet ends, optimize the quality and robustness and minimize costs. As a design in isolation could create integration issues, the integration aspect had to be considered as well. The second objective was to complement the engineering studies and prepare the documents and drawings necessary for the Call for Tender and the orders. Finally, the third objective was to define specifications: mechanical for industry and acceptance, and magnetic for the assessment by CERN of the prototypes, and for following the quality of the series fabrication. This work was to be carried out in close collaboration with SESAME, and the results to be approved by the SESAME Technical Director.

WP3: Magnet procurement

The primary objective of WP3 was to define the procurement strategy for each kind of magnet, depending on its complexity and criticality in the schedule. Indeed, to make the participation of inexperienced companies from the SESAME Member countries possible, an assessment of the criticality of magnets and magnet parts is required, as well as alternate plans in case of need. The second objective was to prepare the market survey, formal or based on experience, the call for tender, selection process and orders following the CERN rules and strategies, and associating the SESAME team. After this careful preparation, WP3's task was to launch the fabrication of the prototypes of the magnets and, in parallel, to proceed with the procurement, tests and acceptance of parts for the series production, to shorten the possible construction time and recover from delays occurring in the process. An additional goal was the knowledge transfer to the companies producing the magnets, with special focus on the less experienced companies.

WP4: Magnetic measurements

The objective of WP4 was to design and build at CERN a magnetic measurement bench for quadrupoles and sextupoles (to be shipped to SESAME originally), and define the measurement procedures for all magnets. It was foreseen to measure the combined function bending magnets at ALBA-CELLS, which has a specialized bench, after defining together the procedures and strategies, including shipments. Measurements were required as soon as prototypes or batches of a series of magnets were delivered, to allow for feedback on production. After precisely defining its goals, the task of WP4 was to carry out the measurements and provide feedback to WP3. Finally, all measurement data had to be stored in a database for use by SESAME operations.

WP5: Magnet power supplies: specifications and procurement

The original objective of WP5 was for SESAME, as a third-party in CESSAMag, to procure all power supplies with a light follow-up by CERN. Outside the CESSAMag framework, SESAME was to produce the controls and purchase spare parts. Following a proposal by CERN which was agreed by SESAME, the objectives drastically changed: the first one was to design an integrated powering scheme based on power sources, controllers, and unifying interfaces allowing the SESAME control

system to access power sources of various manufacturers in an identical manner. The second objective was an individual powering of each quadrupole, to give to SESAME the same flexibility as other modern light sources for matching insertion devices. The third objective was to build a highly modular system, with minimal time-to-repair by plug-and-play modules. The fourth objective was to provide the spare components. The final objective was to crucially involve SESAME engineers in all steps, design, purchasing, production, integration and final testing. This objective was essential to put SESAME in position to maintain the powering scheme, and to develop and upgrade it as needed in the future.

WP6: Support for magnet integration and commissioning

The objectives of this work package were to give appropriate support to SESAME to ensure all components delivered by CERN would perform as anticipated and to provide further assistance to SESAME upon request of its Technical Director. As such, CERN and SESAME were to prepare a plan for the provision of commissioning support and a final commissioning report summarizing this activity was to be produced as a result.

3. THE MAIN S&T RESULTS / FOREGROUNDS

The main results achieved and foreground generated follow closely the project objectives as defined at the beginning of the project and recalled in the previous section of this document. For convenience, they may be grouped under five headings:

- The magnetic ring of SESAME
- The magnet powering scheme
- The support to integration, installation and commissioning
- The knowledge transfer and training
- The management, technical coordination, communication and contribution of the project to science diplomacy

3.1 THE MAGNETIC RING OF SESAME

3.1.1 The magnet design and engineering study reports (WP2)

The first main results of CESSAMAg are the three design reports on the combined function bending magnets, on the quadrupole magnets (long and short), and on the sextupole magnets with their auxiliary corrector windings. Starting from initial studies carried out by SESAME, CERN revisited the subject in collaboration with SESAME to take them further following the CERN strategy for procurement of magnets. Indeed, CERN research accelerators are designed and built at forefront of technology. Hence magnets are not procured to magnetic specifications, which would be risky and expensive. CERN rather pushes the magnet studies to a stage where the mechanical specifications should be sufficient to reach the wanted magnetic performance. Other important aspects are included as well, such as the standardization of serviceable parts for all magnet types and manufacturers, a mechanical design allowing opening and closing the magnets without jeopardizing its mechanical accuracy. This strategy is complemented by a quality assurance plan, in which break points are defined in the fabrication process with provisions of actions, such as magnetic measurements at CERN on the prototype with provision of iterations on request from CERN, periodic control of the quality of series magnets to prevent trends, etc.

A full 3D analysis was carried out to finalize the geometry of the poles and the pole ends. Provisions were anticipated for the adjustment of the integrated strength and of the multipole content, should the measurement of the prototypes call for such trimmings before entering production. While the specifications for field quality were being elaborated, the design study opted for best quality following CERN practices for CERN magnets, at no additional cost. For quadrupoles and sextupoles that are less critical than the combined function bending magnets, a sufficient modularity of the design was included from the start, in view of the possible procurement of parts in SESAME Member countries, and separate assembly. The design reports summarize the requirements from SESAME, the design study, the engineering study and the technical drawings. The studies were presented to the SESAME TAC (Technical Advisory Committee) where they were fully endorsed. They followed a formal approval process at CERN and SESAME, and they are stored in a dedicated database accessible from CERN and SESAME and form the background for the technical specifications needed for tendering. They were also published as conference articles. Given the outstanding magnetic performance of the constructed magnets (see below), these reports can serve as reference for similar light sources to be constructed.

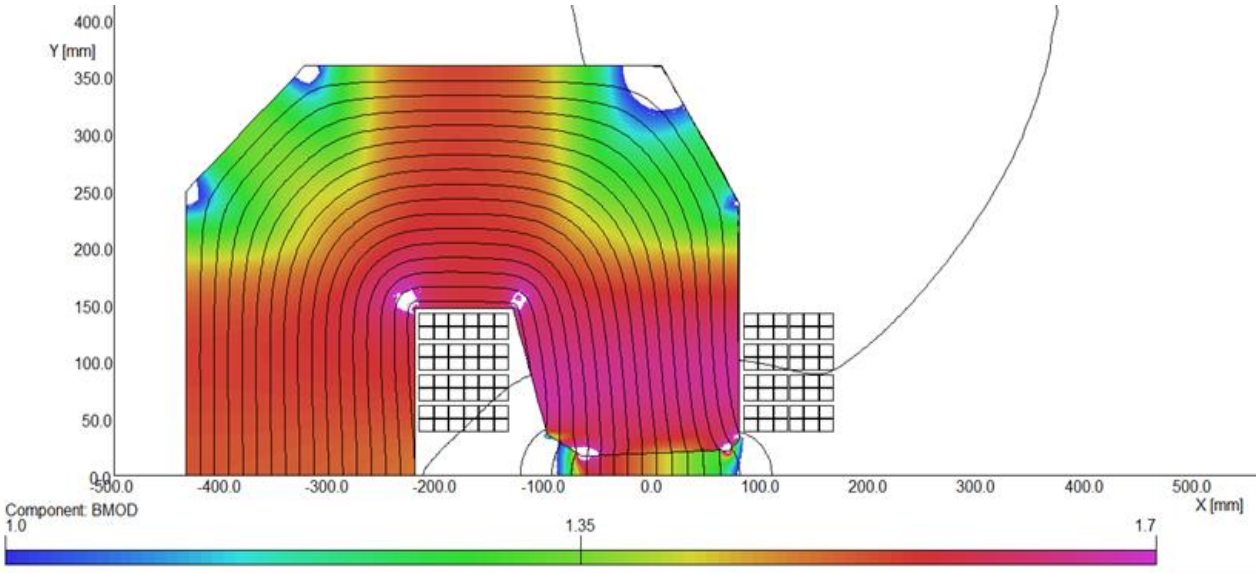

Figure 1: Magnetic flux density distribution in the dipole at nominal energy.

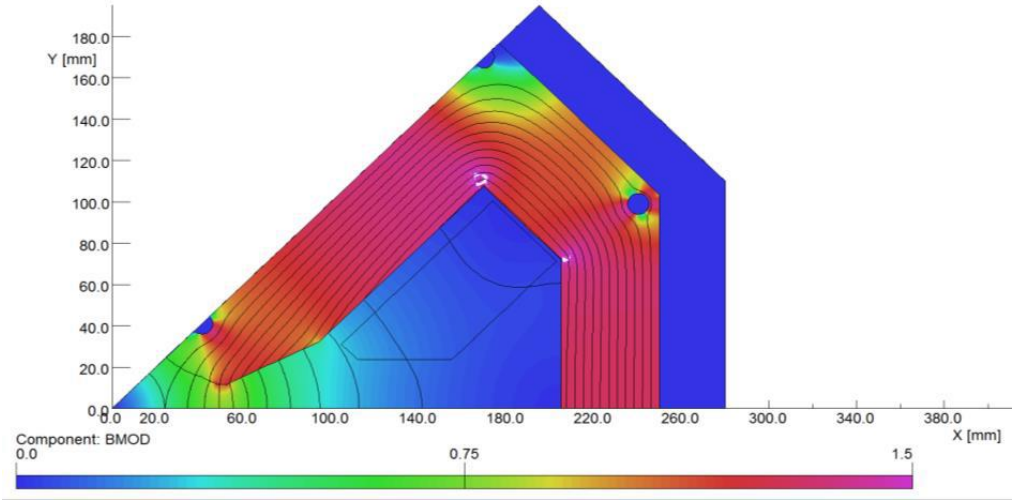

Figure 2: Magnetic flux density in the QF quadrupole at nominal energy.

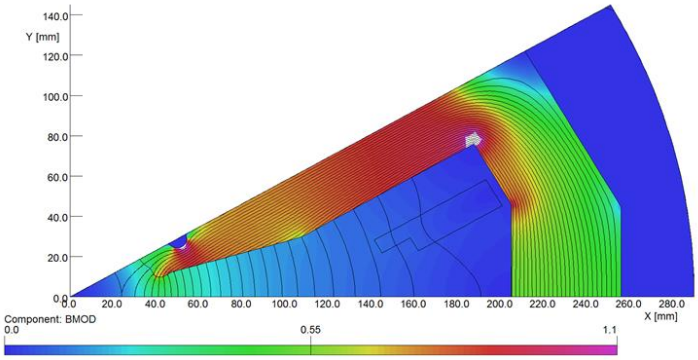

Figure 3: Magnetic flux density distribution in the SD sextupole at nominal energy.

A fourth report, published as a SESAME report and prepared in collaboration with SESAME, defines the requirements on magnetic quality (field integral, multipoles) and mechanical accuracy (deviation between magnetic and mechanical axes, tilt etc.) based on the requested final performance of the storage ring. It uses beam optics and dynamics, and studies the sensitivity to magnetic or alignment imperfections. It shows in general a comfortable margin between machine performance requirements and the magnet quality that can be achieved without an impact on the cost.

3.1.2 The magnet production, measurements, tests and delivery (WP3 & WP4)

A key result of CESSAMag, and the most spectacular one is the string of magnets forming the storage ring.

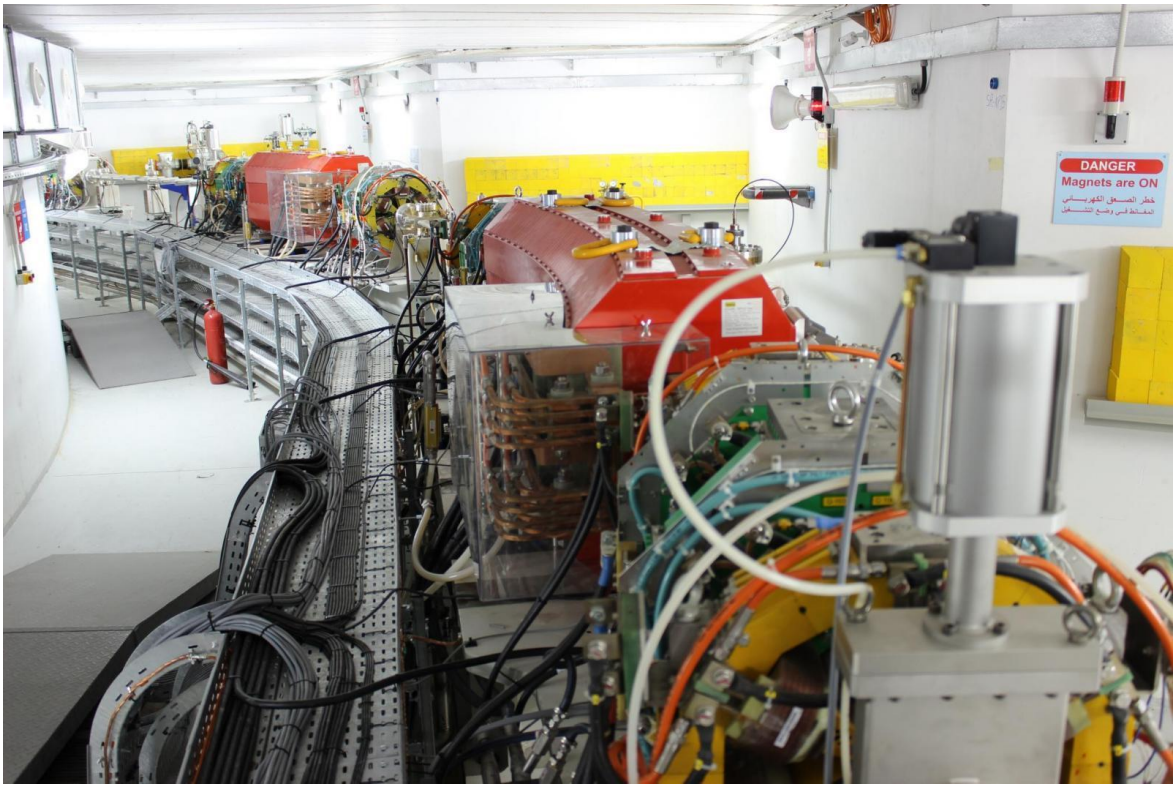

Figure 4: Two SESAME cells spaced by a straight section; red: the bending magnets, green: the quadrupoles green and yellow: the combined sextupoles/correctors. Each of the 16 cells is made of one bending magnet, 4 quadrupoles and 4 sextupole/correctors arranged in double-bend-achromat.

The storage ring magnetic structure is composed of

- 16 combined function bending magnets (dipole + quadrupole),
- 64 quadrupoles of two types: 32 long focusing quadrupoles, and 32 short defocusing quadrupoles,
- 64 sextupole/correctors.

Figure 5: dipole (TESLA, UK), quadrupole (Elytt, Spain, SONMEZ, Turkey); sextupole (CNE, Cyprus, HMC3, Pakistan, SEF, France)

Each series of magnets is complemented by at least one spare magnet and spare parts for magnets repair should this be necessary in the future.

The total weight of the magnets delivered is in excess of one hundred tons, and the cost of the magnets represents 80% of the EC grant.

To ensure minimized magnetic differences between magnets, CERN separately procured the steel laminations for the yokes. A tight quality assurance plan had been set up to ensure well-controlled characteristics, especially the permeability. These parts, together with other smaller parts that CERN foresees to have standardized on all magnets, were later distributed to the magnet manufacturers of the quadrupoles and sextupoles.

After the magnet technical documents had been generated from the design studies, calls for tender were organized for each kind of magnet. CERN made special effort to identify companies in the countries of SESAME Members without former experience in accelerator components but demonstrating motivation and potential, taking into account the possibility of procuring parts in some companies and assembling the magnets in other companies. The tendering process followed standard CERN practices, with the participation of SESAME. A Specification Committee was held to comment on the details of the tendering documents, including the plans for quality assurance. The Invitations to Tender or Price Enquiries were issued by the CERN Purchasing Office. The bids were opened in a selection committee with participation of SESAME. Finally, the contracts were adjudicated considering the economic and technical content of the offers, while finalizing the global strategy:

- The contract for the combined function bending magnets as a whole was not split, as this magnet is complex. It was thus adjudicated to an experienced company TESLA, UK, which had already produced similar magnets.
- The contract for the quadrupole was split into two: SONMEZ, Turkey produced the magnet coils; this company manufacturing electrical transformers had no previous experience with magnet coils but had the will to acquire it. ELYTT, Spain, was selected to produce the quadrupoles with the SONMEZ coils, after their acceptance at CERN.
- The contract of the sextupole/correctors was split into three main contracts and ancillary ones: The experienced SEF company in France produced the coils. CERN procured all other parts from various companies. After all components were accepted by CERN, they were shipped to two companies for assembly. 50% was shipped to CNE, Cyprus that specialized in metrology

and had no previous experience of the precision assembly of magnets but was motivated to learn and get this expertise. The other 50% was shipped to HMC3 in Pakistan. This latter contribution was a donation to CERN by the Pakistan delegates to the SESAME Council. This Pakistani company, originally specializing in heavy mechanical work, wanted to acquire and demonstrate competence in precision assembly of accelerator magnets. This action was part of the vision to contribute to a future upgrade of the SESAME injectors and to create tighter links with CERN.

Some delays with respect to the CESSAMag schedule were experienced in placing contracts, due to challenging legal peculiarities of this project, but the magnets were eventually delivered on time.

Figure 6: Production of sextupoles in Pakistan Right: Set of sextupoles produced by HMC3 Left: Sextupoles leaving from Taxila (HMC3) to port of Karachi

For each kind of magnet, the fabrication strategy included the production of a prototype to be delivered either to ALBA-CELLS in case of the bending magnet or to CERN in case of the quadrupoles and sextupoles. The goal was to magnetically measure these prototypes built according to mechanical specifications by the companies. For that purpose, CESSAMag benefited from a measuring bench suitable for combined function bending magnets in ALBA-CELLS, Spain, which acted as a subcontractor in CESSAMag. The ALBA-CELLS facility had to be adapted, and the measurement and acceptance procedure was defined in collaboration with CERN. **For the quadrupoles and sextupoles, a measuring bench was constructed at CERN**, mainly by a young SESAME engineer under supervision of a CERN expert. The bench, its software and the measurements were to be done by this SESAME engineer to acquire competence in magnet technology.

The bending magnet and sextupole magnet prototypes were immediately of outstanding quality. Although already within specification, the quadrupole prototype needed one iteration more to reach highest quality. The series production followed, including magnetic measurements for all magnets by either ALBA-CELLS or CERN and acceptance on the fly.

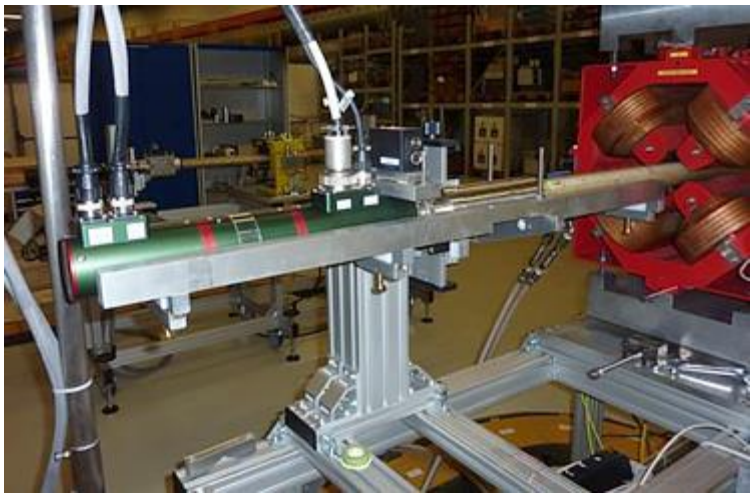

Figure 7: SESAME magnet measuring bench for quadrupoles and sextupoles

The measured field quality of all magnet types is excellent, making them a reference for similar synchrotrons. This was achieved at no additional cost, but with a careful follow-up in the industry and the rigorous application of quality procedures. Industry in SESAME Members (Cyprus, Pakistan and Turkey) provided a significant contribution at best quality standards.

All measurements and documents are collected in a database accessible to SESAME for future use.

3.2 THE MAGNET POWERING SCHEME (WP5)

This major contribution of CESSAMag has seen a complete change of plans as compared to the initial SESAME choices in Annex 1. Rather than procuring power supplies adapted to each kind of magnets, which would have had different controls, a new concept was proposed by CERN, with the following objectives:

i) fulfil the SESAME requirements while opening prospects for increased flexibility of the storage ring optics without additional cost,
ii) use commercial equipment, whenever possible,
iii) minimize the time-to-repair by standardization of components and cheaper spare part policy,
iv) give preference to control strategies already used in advanced light sources,
v) have the customized electronics designed at CERN by SESAME staff, to maximize the transfer of knowledge and allow SESAME to maintain the system with maximum efficiency.

The proposed strategy is comprised of the individual powering of the quadrupoles, which was not initially foreseen. This is of particular relevance as it provides enough flexibility for optical compensation of insertion device effects and for simple beam/based alignment. In terms of power supplies, the proposed strategy follows the present trend in accelerator applications of buying voltage sources from different manufacturers (multiple orders), buying the DCCTs separately and using a single standardized control system for all power supplies. Integration of all systems is done in-house (in this case at CERN before shipping it to SESAME).

With this strategy SESAME has full control over the performance of the current loop and benefits from the standardization of the control electronics with clear gains on maintenance and spare management.

In this strategy, the control electronics is of utmost importance, in particular the requirements for synchronization, digital control of the magnet current and integration into the EPICS control infrastructure. A controller solution based on an existing system from the Paul Scherrer Institute (PSI) in Switzerland, used in other light sources, was chosen.

As for the power supplies, the dipole magnet power supply is the only custom made product purchased from industry on the basis of a detailed technical specification that is prepared by SESAME in direct collaboration with CERN. The quadrupole power supplies are compact and easily replaceable commercial off-the-shelf devices. The same approach was followed for the sextupole power supplies. The orbit corrector and skew quadrupole power supplies are based on a solution from the PSI light source, Switzerland, and are fully integrated with the control electronics.

This proposal was scrutinized by the SESAME engineers and by an external review committee convened by CERN and attended by light source experts, where it was acknowledged as a significant improvement. A technical specification report was produced for the SESAME management and the proposal presented at the SESAME Technical Advisory Committee, where it was highly recommended. It was finally approved by the SESAME management.

The significantly increased workload for CERN was volunteered by the Power Supply Group and approved by the CERN management, with the understanding of significant participation of the SESAME staff. In addition, advantage was taken of the SESAME Council meeting for a call of manpower support to SESAME Members. Iran and Turkey responded positively.

The standard tendering, selection and placement of contracts were done and procurement of the parts started rapidly. In parallel, prototypes of electronic modules were designed and developed by CERN and SESAME. Test beds for the evaluation of the power supplies and the control electronics were prepared.

This period was marked by an intensive collaboration between the SESAME and CERN teams. The CERN team was further reinforced by one engineer from Turkey (TAEK, 1 year) and one from Iran (ILSF, 7 months). The collaboration was facilitated by the IAEA financial support to the SESAME staff and to the visit of the Turkish engineer to CERN.

The bulk of the power supplies were ordered in Israel (TDK Lambda), the dipole power supply in Italy (EEI) and the corrector power supplies and part of the controls in Switzerland (PSI light source). The production was closely followed by the CESSAMag team. Delivery was on schedule, except for the dipole power supply that needed further visits and a second iteration to pass its Factory Acceptance test. The development of the interface electronics and control chassis was shared between CERN and SESAME teams.

The control strategy for the CESSAMag power supplies is based on a unique controller for all power supplies and a high precision current measurement device to control the current. The specification and implementation of the controller software, timing system and gateway were fully performed by SESAME experts. The high precision current measurement transducers (DCCTs) were purchased in the Netherlands. The CESSAMag team developed and built the electronic interface between the PSI control hardware and the power converters. The firmware was developed by the SESAME team, who also designed the racks and integrated them at CERN. The hardware and firmware development work involved frequent interactions and visits with PSI light source engineers.

Once integrated in racks, a full system test and acceptance were performed at CERN for each power supply and for each rack, including the control electronics and the generation of waveforms,

complemented by performance and synchronization tests. All tests fulfilled the SESAME requirements, and the powering scheme was shipped to Jordan.

Figure 8: CERN-SESAME power supplies team at CERN, with one visiting engineer from TAEK, Turkey.

Figure 9: The SESAME power supplies ready for shipment at CERN (dipole power supply on the left, quadrupole, sextupole and corrector powering racks on the right)

3.3 THE SUPPORT TO INTEGRATION, INSTALLATION AND COMMISSIONING (WP6)

The Work Package of CERN support for magnet integration and commissioning (WP6) has followed the needs and requests expressed by SESAME, in order to guarantee the best coherence between CERN and SESAME contributions in this delicate phase of the project.

The support extended over a period of one year with several dimensions:

- the integration of the first SESAME cell at CERN by a CERN-SESAME team,

Figure 10: SESAME engineers at the integration test at CERN

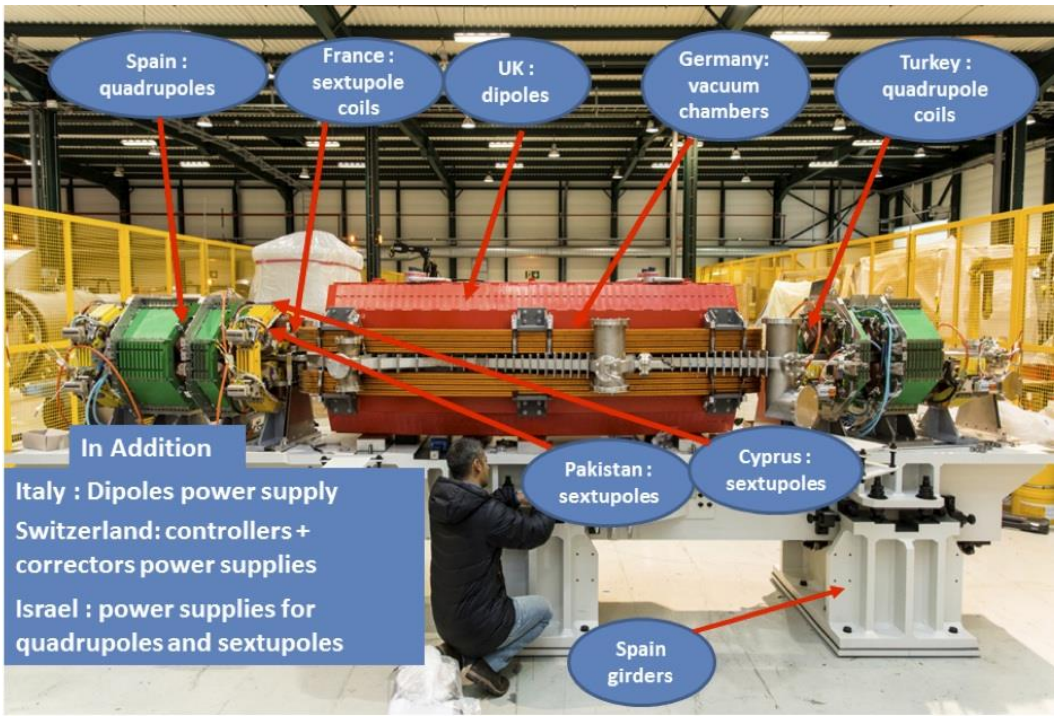

Figure 11: The integration test: first of the 16 cells of the SESAME storage ring (with the country contributions)

- the creation of a survey network in the SESAME tunnel, while training a SESAME surveyor,
- the installation of the first cell (girder and magnets) in the SESAME tunnel and its alignment with respect to the survey network,

- the hardware commissioning of all dipole magnets and a sample of quadrupole magnets, etc.

Figure 12: Thermal check of connections at full power

- the tests of the powering scheme for the dipoles, four quadrupole circuits, one sextupole chain and some correctors.
- a power test, involving the powering of the dipole chain at nominal excitation (2.5 GeV) for 6 hours.
- a range of contributions in installation, alignment, identification and solution of minor issues.

3.4 THE KNOWLEDGE TRANSFER AND TRAINING

Besides the production of a key component of the light source described above, the training and knowledge transfer dimensions foreseen in the CESSAMag objectives were considered as having a key potential impact. Rather than being treated as separate activities, aspects of training and knowledge transfer have been deeply included in CESSAMag design, construction and testing activities, with the final goal of producing a high quality magnetic system for the SESAME storage ring, fully serviceable and upgradable by the SESAME staff.

It became rapidly evident that the SESAME staff had the appropriate competence, and would take advantage of the experience and expertise of CERN. Hence training is more correctly understood as transfer of technical experience in collaborations and, importantly, transfer of best practices, especially for commissioning.

While the initial plan was directed to the SESAME staff, two additional targets came in naturally during the project:

- Knowledge transfer to companies in the SESAME Member countries without former experience in accelerator technologies who had expressed interest and contracted with CERN.
- Training of staff of other laboratories of SESAME Member countries coming to CERN to help, following the extension of scope of the magnet powering scheme with a very large increase of the CERN workload.

Indeed, after agreement of the SESAME directorate, CERN took the responsibility for procuring some important equipment parts in the industry of SESAME Members, by splitting orders for quadrupoles, sextupoles and power supplies and organizing and supervising the assemblies of the complete systems. This gave rise to knowledge transfer to these companies (Cyprus, Pakistan, and Turkey) who had no former experience in accelerator components and their requirements, with the exception of an experienced company in Israel. This strategy was possible due to the availability of

alternative solutions at CERN, thereby mitigating the potential risks. With the exception of one attempt that could not be implemented for administrative and political reasons (Iran), all other attempts turned out to be significant successes in a win-win collaboration.

Figure 13: Knowledge transfer to industry in CESSAMag. Left: first sextupoles from CNE, Cyprus. Right: sextupole before painting by HMC3, Pakistan. Below: quadrupole coils from SONMEZ, Turkey

A dimension not foreseen in the Grant Agreement and successfully implemented was the participation of two young engineers from Institutes in SESAME Members (Turkey, Iran) in the CESSAMag work and their training at CERN. These engineers were sent by their delegates to the SESAME Council after a call for support by the CERN coordinator. They were rapidly integrated; e.g. the most experienced took occasionally the role of secretary of the project meetings.

In the course of the discussions between CERN and the EC, i.e. before the decision on the CESSAMag project, CERN had started the training of one Pakistani engineer and one scientist in relation with the SESAME project.

Altogether, the duration of training received by the SESAME staff, the engineers from SESAME Members travelling to CERN and the companies from the SESAME Members amounted to about 90 person months. The CERN personnel effort in training and knowledge transfer is 16 person months.

Beyond the quantitative assessment, the quality of contacts was excellent and created tight links between CERN and SESAME staff, as well as with the staff of participating institutes and companies. This collaboration brought to CERN additional fruitful experience in working with partners from other regions and with different working approaches. Combined with a science for peace goal, it

inspired particular dedication in the CERN staff involved and allowed mobilizing the required human resources, in spite of the additional workload. One should note the importance of the IAEA funding for training, instrumental to allow mobility of the SESAME staff, allowing CESSAMag to concentrate its funds on producing the full magnetic system

3.5 THE MANAGEMENT, TECHNICAL COORDINATION, COMMUNICATION AND CONTRIBUTION TO SCIENCE DIPLOMACY (WP1)

An important result achieved by all work packages is the **reduction of the cost** that allowed providing a more powerful and complete magnetic system while reducing the financial share SESAME was due to contribute to CESSAMag. This was achieved by a combination of factors. The initial one was a detailed magnet design and procurement strategy minimizing costs while ensuring highest quality. Globally, after the economic crisis in Europe, the market costs for magnets was somewhat lower than the costs assumed in the CESSAMag proposal, which were based on the average costs paid by CERN for similar equipment a few years before. The procurement office of CERN proactively negotiated, including offering an advanced payment to compensate for the scarcity and cost of bank loans to more modest companies. The in-kind contribution of Pakistan and the procurement of parts in companies of the SESAME Member countries without former experience allowed savings in material costs significantly larger than the increase in manpower cost for knowledge transfer and quality assurance. All ancillary expenditures were minimized. Unfortunately the sudden change of exchange rate between the EUR (EC grant) and the CHF (CERN working currency) at the beginning of 2015 reduced the savings by a factor of two to about 10%. Nevertheless, CESSAMag could better cover the cost of a much improved powering scheme putting SESAME at the same level as the most recent light sources.

Another important result is the **enhanced networking** inside and outside the ERA. This was much facilitated by the invitation made by SESAME to the CESSAMag coordinator to participate in the SESAME Council as a delegate of CERN, by the invitations made by the SESAME Technical Advisory Committee to CESSAMag experts to present their proposals and progress, and by the Commission inviting the coordinator to several workshops or meetings, one in the European Parliament. A first unplanned result is the improved networking of CERN with a number of European light source laboratories, e.g. SOLEIL (France), ALBA-CELLS (Spain), PSI (Switzerland), and ESRF (France), stimulated by the common support to SESAME but going beyond it (e.g. loan of magnets). The links between the CERN and the SESAME Organizations have been strengthened since CESSAMag with the active support of the CERN Director-General Prof. R. Heuer. Despite a common concept and former CERN Directors-General chairing the SESAME Council, the links had been more limited previously; the two laboratories being at very different states, one small in the making, the other large and mature, and acting in totally different scientific fields and political contexts. Beyond SESAME, the networking enabled trust-building and identifying common interests with institutes or organizations in some countries of SESAME Members. This has already stimulated actions beyond CESSAMag by other actors: training, summer students, etc.

Communication has been an active and sensitive field with the results that the CESSAMag and the SESAME projects are now well known in the accelerator community and beyond. The challenge was to concentrate on CESSAMag, without interfering with the SESAME communication. Indeed SESAME is in the totally different and complex context of the Middle East. Whenever situating CESSAMag in the SESAME context, agreement of SESAME was sought and obtained for written communication, or SESAME official communication was used. The electronic journal “Accelerating News”, born as the newsletter of FP7 EuCARD, then further expanded to other EU- funded

accelerator research projects, including CESSAMag, now reaches the whole accelerator community worldwide. Frequent accounts on the progress of CESSAMag were featured in this journal. We could observe how the presence of CERN as an international scientific laboratory and a model of science diplomacy, and of the European Commission as a major political body stimulates the interest of journalists for SESAME. This is probably the most specific result of the science diplomacy aspect of CESSAMag. Several interviews were given via public channels, including articles, talks, documentaries, etc.

With respect to **science diplomacy**, CERN has promoted the CESSAMag approach and achievements through its broader stakeholder relations work, including via the International Relations Office of the Director-General (now a Sector since 2016). The project coordinator was a member of the DG Office. This has allowed discussions on SESAME and SESAME support at the highest levels with CERN partners, like US DoE officials, the European Commission via the CERN-EC MoU, etc. An important result is to have convinced at the outset the Commission of the importance of SESAME and of the value of scientific endeavours that can be labelled science diplomacy. This result was underlined by Commissioner C. Moedas himself when he visited CERN (Figure 14) and when introducing the SESAME Council meeting in May 2016. Another example was the invitation of the project coordinator to an international debate on science diplomacy in Berlin by the Bosch Stiftung.

Figure 14: The EC delegation led by Commissioner C. Moedas with members of the CESSAMag team and the CERN DG (2015)

4. POTENTIAL IMPACT, DISSEMINATION, EXPLOITATION OF RESULTS

The potential impact already observed follows closely the expectations anticipated in the Annex 1:

4.1 IMPACT ON THE SESAME STORAGE RING MAGNETIC SYSTEM

The magnetic system, together with its powering scheme, was delivered on schedule, and installed properly by the SESAME team after a joint exercise on the first machine cell (out of 16). As a result, SESAME remains on schedule for this key component of the storage ring.

The powering scheme proposed by CERN, not planned in the Annex 1, has significant potential impact: SESAME becomes upgradable thanks to the optical flexibility introduced by the individual powering of the quadrupoles. This flexibility allows the installation of properly matched insertions to produce light beams with different characteristics compared to the light produced in dipoles, as is done in most other recent light sources. It might be used to refine the optics in view of a minimization of the emittance. The introduction of families of sextupoles opens the door to chromaticity control to higher orders, which would become necessary if the focusing is increased. The introduced modularity of the power sources, combined with the provision of spares, will optimize the machine availability by allowing SESAME to maintain the power scheme by the exchange of modules, without time-consuming external maintenance. Finally, the selection of the latest version of the control modules developed by PSI for its own projects and used in other sources allows SESAME to get integrated in this circle and benefit from the accumulated expertise.

4.2 IMPACT ON THE SESAME STORAGE RING

The significant workload taken off the shoulders of the small SESAME technical team has already contributed to the present state of the SESAME project, which enters commissioning phase. On the request of the SESAME Technical Director, an integration test of a full cell was carried out in collaboration with CERN, using the CERN infrastructure. The SESAME engineer in charge of integration concluded that its successful outcome would not have been possible without the human and technical infrastructure existing at CERN.

4.3 IMPACT ON THE SESAME LABORATORY AND STAFF

The excellent relationship rapidly established between CESSAMag and the SESAME Management has created an atmosphere of trust and mutual care between the laboratories.

The tight relationships between CERN and the SESAME engineers, and their association with the CESSAMag project, especially for the development of the powering scheme, have had several impacts:

- The knowledge transfer of CERN expertise in handling large projects, especially the follow-up of fabrication in industry to reach maximized quality and reliability at minimized costs.
- It allowed several SESAME engineers and technicians to experience the life at CERN in its dimension of large scientific laboratory open to a very large number of external users from all nationalities. This is a future goal for SESAME.
- It contributed to the stabilization of an outstanding expert within the SESAME staff until the end of its project.

However, it could not prevent another SESAME engineer trained at CERN to leave SESAME soon after training. This illustrates the complexity of the task in a global competitive world and the need of SESAME support over a sufficient time, now implemented by the European Commission.

4.4 IMPACT ON THE SESAME ORGANIZATION

As expected, the joint action between CERN and the European Commission, providing funds, the appropriate technology and engineering support, and the expertise in running large scientific projects had an important symbolic impact: it created confidence that the project, after a difficult period without capital funding, would reach completion. At the SESAME Council meeting in December 2016, the President of Council and the Chairman of the SESAME Advisory Committee both underlined that SESAME would not be where it stands without the boost created by CESSAMag.

4.5 IMPACT ON INTERNATIONAL COOPERATION

This impact can be seen, or may be expected, across several levels such as the CERN Organization as a component of the European Research Area, at the levels of the ERA itself and of SESAME and international cooperation, often with a science diplomacy dimension:

- The international cooperation agreement (ICA) signed between ALBA-CELLS and CERN by their respective Directors offered a framework for the participation of ALBA-CELLS in CESSAMag that was more ambitious than it would have been had they participated as a subcontractor in the project. The goal of this ICA was to cement a long-term collaboration between two important actors of the ERA.
- The Protocol to the ICA signed by the CERN and SESAME Directors, specifying the framework for CESSAMag, created new links between the two Organizations' managements. The successful CESSAMag activities, mutual visits, and the proximity between two former CERN Directors-General serving as Presidents of the SESAME Council have likely contributed to the agreement by Professor Rolf Heuer to become the next President of the SESAME Council from May 2017.

Figure 15: ICA signed between CERN and SESAME
(Image credit: CERN)

- The CESSAMag venture shared between CERN and the EC further enhanced relations. During the SESAME Council meeting hosted by the Commission in April 2016, Carlos Moedas, Commissioner for Research, Science and Innovation underlined the role of CESSAMag/CERN as an example of catalyzer of a reflection leading to the implementation of a structure that embraces three pillars of science diplomacy defined by the Commission. Furthermore, the European Union, recognizing the value of SESAME in Euro Mediterranean cooperation, became an active Observer in the SESAME Council as of 2015, and has taken the initiative to consolidate the competence and sustainability of SESAME.

- The participation of Pakistan in CESSAMag, sending engineers and scientists for training and collaboration at CERN and providing an important in-kind contribution, has added a further dimension to its links with CERN. This collaboration demonstrated the excellence of HMC3 in Pakistan for the assembly of magnets, while the previous Pakistani contributions in CERN experiments involved heavy mechanical parts. These contributions were discussed both in the SESAME Council and in the CERN-Pakistan Committee, which facilitated Pakistan becoming an Associate Member of CERN.
- Turkey's in-kind contribution of manpower to CESSAMag was interlinked with the discussions of Turkey becoming an Associate Members of CERN.
- The contribution of Cyprus to the production of the sextupoles magnets was also interlinked with the discussions of Cyprus becoming an Associate Member in the pre-stage to CERN Membership.
- Iran's in-kind contribution of manpower to CESSAMag triggered ILSF, Iran, to recently propose cooperation between CERN and ILSF. This suggestion is currently being considered by the CERN International Relations Sector.
- Finally, the support of IAEA for visits of SESAME staff to CERN, as well as CERN visits to SESAME to assist in commissioning, has led to discussions between the IAEA and CERN concerning possible collaboration in areas of common interest.

4.6 IMPACT ON EUROPEAN INDUSTRY

The EC grant was primarily dedicated to the procurement of equipment, and only a minor fraction to training actions. This was made possible by IAEA's financial support of SESAME training and by CERN's expert visits in support of SESAME commissioning. The cost of the CERN personnel was entirely borne by CERN.

Some 85% of the 5 M€ grant was spent in industry in the European Union (Austria, Cyprus, France, Italy, The Netherland, Spain, UK); with Cyprus being a SESAME Member as well. A proactive market survey had allowed the identification of a firm without accelerator experience, but with the potential expertise to contribute at a very competitive cost provided appropriate knowledge transfer was provided. 12% was spent in Switzerland, an FP7 associated country, for an outstanding product used in several light sources world-wide. 10% was spent in two other FP7 associated countries (Israel, Turkey), who are also Members of SESAME. In the latter case (Turkey), similarly to Cyprus, a significant knowledge transfer was provided. The total exceeds 100% of the EC grant, being the contribution of SESAME.

Beyond the financial impact, the CERN strategy involves break points, visits and interactions during the prototyping and fabrication processes, to reach the highest standards at the contracted price. This interaction proves to be highly effective on both sides, improving both competences and products.

4.7 IMPACT ON SCIENCE AND SOCIETY

The impact of CESSAMag on science and society is mostly indirect, through its support to SESAME, which will significantly impact science in the Middle East, and provide an object of pride for society more broadly.

Yet, some impacts on science and society are specific to CESSAMag:

- The involvement of local industry in the SESAME Members has demonstrated the potential of companies without accelerator experience to produce high-precision advanced accelerator

components provided appropriate knowledge transfer is given. This was initially judged not possible or at least risky by the SESAME management, so CERN took full responsibility. This experiment was underpinned by the CERN technical platform, allowing the provisions of "plan B"s that turned out unnecessary.

- The gratuity of the CERN-EC support to SESAME via CESSAMag is likely to be seen as trustful cooperation around the Mediterranean Sea.
- The CERN-EC support to SESAME via CESSAMag illustrates the importance of Europe in supporting intellectual activities, beyond its more classical financial and humanitarian support.

4.8 DISSEMINATION ACTIVITIES AND EXPLOITATION OF RESULTS

This section is closely linked to the section on impact. For coherence, it reproduces some of its material.

Communication and dissemination between CERN and SESAME

Since the first CERN visit of the SESAME Director in July 2010 and the signature of the 2010 Protocol for CERN-SESAME collaboration, the links between CERN and SESAME have become tighter, including between the technical teams, who have met on several occasions at CERN or SESAME. During the course of the project, the CESSAMag Project Coordinator has participated in the SESAME Council as a delegate of CERN, and thus provided progress reports to the SESAME Council at least twice a year. CESSAMag experts also regularly presented recent developments to the SESAME Technical Advisory Committee. With the frequent visits of SESAME staff members (especially in WP5: Power supplies) to CERN the direct personal communication was reinforced as well. These visits not only gave the opportunity to the SESAME experts to meet and exchange with accelerator experts all around the world but also to experience the CERN culture of diversity and peaceful collaboration.

Global dissemination to the scientific accelerator community

The results of the project have been distributed on several occasions to the scientific accelerator community, including European light source laboratories and a wider accelerator physics community. 3 articles related to CESSAMag results – co-authored by SESAME experts- were presented at the prominent IPAC conferences in 2014 and 2016. A main progress-reporting platform was the Accelerating News online quarterly newsletter, which is a popular newsletter of the accelerator community, and read by industrial experts too. CESSAMag was featured in this newsletter on more than 6 occasions with articles on topics varying from technical information to science diplomacy. Full-length articles were also published to mark key achievements (e.g. the completion of a full cell) by the CERN Courier whose audience goes far beyond the accelerator community.

Whenever situating CESSAMag in the SESAME context, agreement of SESAME was sought and obtained for written communication, or SESAME official communication was used.

Communication and dissemination between CERN and the European Commission

In addition to the standard periodic reporting, the CESSAMag Project Coordinator has kept the EC Officer informed of significant project progress. This common venture has further reinforced relations between CERN and the EC and the summary of project progress became part of the biannual CERN-EC MoU meetings. In 2015, CERN also organized an in-depth visit for Commissioner Carlos Moedas

and his team to view some of the magnets during their test at CERN, before being shipped to SESAME. The CESSAMag project received spotlight from the EC associated media, including Horizon-magazine.eu, Government edition of the Pan European Networks.

Dissemination to policy-making bodies

The Project Coordinator has been interviewed by several media channels addressing policy making bodies. He has also been invited to present the project to the European Parliament, attracting the attention of the MEPs to science diplomacy. Another example was the invitation of the project coordinator in an international debate on science diplomacy in Berlin by the Bosch Stiftung. During the SESAME Council meeting hosted by the Commission in April 2016, Commissioner Carlos Moedas underlined the role of CESSAMag as a catalyzer of a reflection leading to the implementation of a structure embracing three pillars of science diplomacy. With respect to science diplomacy, CERN has promoted the CESSAMag approach and achievements through its broader stakeholder relations work, including via the International Relations Office of the Director-General (now a Sector since 2016). The project coordinator was a member of the DG Office. This has allowed discussions on SESAME and SESAME support at the highest levels with CERN partners, like US DoE officials, the European Commission via the CERN-EC MoU, etc.

Beyond the CESSAMag project, a major diplomatic event will be organized by SESAME, with capacity-building support from CERN, in May 2017 for the official inauguration of the light source. This event will undoubtedly attract a significant number of high-level policy-making actors.

Dissemination to society

Naturally, SESAME attracts the attention of popular media and society. This interest has been materialized by the various interview and guest article invitations that the Project Coordinator has received during the course of the project. Popular media coverage included visit and shootings of BBC UK and an interview by BBC Arabic. To build on the existing interest, in 2015, CERN joined the International Year of Light celebrations with two projects, the High Luminosity LHC and the CESSAMag project. On this occasion, Prof. Rolf Heuer, CERN Director-General, published a popular article in the Huffington Post that has seen numerous re-tweets, references and attracted a lot of media inquiries both to CERN press office and SESAME. The project has also delivered a comprehensive document on CERN-EC-SESAME Communication on Science for Peace in the Middle-East (D1.4) the purpose of which is to summarize the science diplomacy aspect of the project. It will be further distributed via various channels to the scientific community, civil society and to the media. This communication has been approved by all involved partners and to be used as is.

Management of intellectual property

The principles for dissemination, access and use of knowledge generated through the CESSAMag project (Foreground) have fully complied with the Rules for participation in FP7 and for the dissemination of research results, adopted by the European Council and Parliament in December 2006. Due to the sensitivity of the project and its context, agreement of SESAME was sought and obtained for written communication, or SESAME official communication was used.

Access to the Foreground generated by CESSAMag and to the related CERN Background have thus been fully granted to the SESAME Organization, with the understanding that acknowledgement of the CERN and EC contributions will be made when needed.

II. USE AND DISSEMINATION OF FOREGROUND

SECTION A: DISSEMINATION MEASURES (PUBLIC)

A1: List of scientific (proceedings) publications										
No	**Title**	**Main author**	**Title of the periodical or the series**	**Number, date or frequency**	**Publisher**	**Place of publication**	**Year of publication**	**Relevant pages**	**Permanent identifiers[1] (if available)**	**Is/Will open access[2] provided to this publication?**
1	Magnetic measurements of SESAME storage ring dipoles at ALBA	A. Milanese, J Marcos	Proceedings of IPAC 2016	n/a	IPAC	Busan, Korea	2016	-	Link	Yes
2	Design of the main magnets of the SESAME storage ring	A. Milanese, E. Huttel, M. Shehab	Proceedings of IPAC 2014	n/a	IPAC	Dresden, Germany	2014	-	Link	Yes
3	Multipole and alignment error limits for the SESAME storage ring magnets	A. Milanese, E. Huttel	Proceedings of IPAC 2016	n/a	IPAC	Dresden, Germany	2014	-	Link	yes

[1] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[2] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

A2: List of dissemination activities							
No	**Type of activities[3]**	**Lead author (institute)**	**Title**	**Date/Period**	**Place**	**Type of audience[4]**	**Countries addressed**
Link	Article	J-P Koutchouk, L. Lapdatescu	FP7 CESSAMag: building industrial relations with SESAME members	July 2016	Geneva, Switzerland	Scientific community	International
Link	Conference session	CERN/SESAME communications	SESAME –a scientific source of light for the Middle East and neighbouring regions	July 2016	Manchester, UK	Civil Society, Scientific community, Medias	International
Link	Article	J Toes, L. Lapadatescu	FP7 CESSAMag and science diplomacy	April 2016	Geneva, Switzerland	Scientific community	International
Link	Article	J. Gillies	Last main ring components leave CERN for SESAME	February 2016	Geneva, Switzerland	Scientific community	International
Link	Article	H. Jarlett	Historic moment as SESAME begins storage ring installation	February 2016	Geneva, Switzerland	Scientific community	International
Link	Article and video	SESAME communications	Installation of SESAME's storage ring begins	February 2016	Amman, Jordan	Civil Society, Scientific community, Medias	International
Link	Conference session	SESAME communications	SESAME: A Scientific Source of Light in the Middle East	February 2016	Washington DC, USA	Civil Society, Scientific community, Medias	International
Link	Article	A. Silver	Opening SESAME: Middle East research center approaches completion	February 2016	Washington DC, USA	Civil Society, Scientific community, Medias	International
Link	Article	CERN Courier	Interactions & Crossroads, SESAME charts shared cultural future for the Middle East	January 2016	Geneva, Switzerland	Scientific community	International

[3] Dissemination activities: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[4] Type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

Link	Article	C. Llewellyn Smith	Open SESAME: A powerful Light Attracts middle Eastern Scientists (World Policy Journal)	December 2015	Amman, Jordan	Civil Society, Scientific community, Medias	International
Link	Article	M. Bastos	Shipment of SESAME Magnet Power Supplies	November 2015	Geneva, Switzerland	Scientific community	International
Link	Article	Euractiv.com	Commission lauds Jordan for bringing Middle East scientists together	October 2015	Brussels, Belgium	Civil Society, Scientific community, Medias	International
Link	Presentation	G. Kamel	Science shines light in the Middle East	October 2015	Geneva, Switzerland	Civil Society, Scientific community, Medias	International
Link	Article	C. Llewellyn Smith	SESAME for science and peace (Nature Photonics)	August 2015	Amman, Jordan	Civil Society, Scientific community, Medias	International
Link	Article	C. Llewellyn Smith, Z. Sayers	SESAME: a bright hope for the Middle East. CERN Courier	July 2015	Geneva, Switzerland	Civil Society, Scientific community, Medias	International
Link	Article	EPS news	SESAME moves towards commissioning	June 2015	Internet	Civil Society, Scientific community, Medias	International
Link	Article	A. Milanese	Bending magnet for SESAME storage ring	April 2015	Geneva, Switzerland	Scientific community	International
Link	Article	Horizon2020 Projects	Moedas visits “powerful example” of collaboration	April 2015	Brussels, Belgium	Civil Society, Scientific community, Medias	International
Link	Article	A. Szeberenyi	EU Commissionner Carlos Moedas visits SESAME	April 2015	Geneva, Switzerland	Scientific community	International
Link	Article	B. Deighton	Middle East particle accelerator shows positive power of science – Dr Jean-Pierre Koutchouk. Horizon	April 2015	Brussels, Belgium	Civil Society, Scientific community, Medias	International
Link	Article	A. Szeberenyi	SESAME passes an important milestone at CERN, CERN Courier	April 2015	Geneva, Switzerland	Scientific community	International

Link	Article	A. Szeberenyi	First SESAME cell complete	April 2015	Brussels, Belgium	Civil Society, Scientific community, Medias	International
Link	Article	A. Szeberenyi	SESAME passes an important milestone at CERN, PhysOrg	April 2015	Geneva, Switzerland	Scientific community	International
Link	Article	SESAME communications	One cell of SESAME storage ring assembled	April 2015	Amman, Jordan	Civil Society, Scientific community, Medias	International
Link	Article	E. Kelly	Open Sesame: scientists to get access to new Middle East synchrotron	April 2015	Brussels, Belgium	Civil Society, Scientific community, Medias	International
Link	Article	R. Heuer	The SESAME Laboratory: Celebrating the Power of Light	March 2015	Internet	Civil Society, Medias	International
Link	Article	J-P Koutchouk	Science supporting dialogue	February 2015	Brussels, Belgium	Civil Society, Scientific community, Medias	International
Link	Article	S. Stavrev	EU Commissioner for research, science and innovation visits CERN	January 2015	Geneva, Switzerland,	Scientific community	International
Link	Article	M. Bastos	Powering strategy of SESAME magnets	December 2014	Geneva, Switzerland	Scientific community	International
Link	Article	CERN	SESAME boosts electrons to 800 MeV	October 2014	Geneva, Switzerland	Civil Society, Scientific community	International
Link	Article	A. Milanese	First industry magnet for SESAME storage ring. Milanese	September 2014	Geneva, Switzerland	Scientific community	International
Link	Article	C. Llewellyn Smith	Viewpoint: A shining light in the Middle East	August 2014	Geneva, Switzerland	Civil Society, Scientific community	International
Link	Article	C. Sutton	Accelerating progress on SESAME	June 2014	Geneva, Switzerland	Civil Society, Scientific community	International
Link	Article	A. Milanese	First pre-series sextupole for the SESAME storage ring	April 2014	Geneva, Switzerland	Scientific community	International
Link	Press release	CERN	EC and CERN support major research facility in Middle East	April 2014	Geneva, Switzerland	Civil Society, Scientific community, Medias	International

Link	Article	e-EPS	SESAME Council Meeting held in Jordan	December 2013	Internet	Scientific community	International
Link	Other	A. Milanese	Coupling field maps of combined function bending magnets to linear optics for the SESAME storage ring	November 2013	Geneva, Switzerland	Scientific community	International
Link	Press release	UNESCO	European Commission contributes 5 million euros to the SESAME synchrotron light source in the Middle East	June 2013	Paris, France	Civil Society, Scientific community, Medias	International
Link	Press release	CERN	European Commission and CERN support major research facility in the Middle East	May 2013	Geneva, Switzerland	Civil Society, Scientific community, Medias	International
Link	Presentation	C. Llewellyn Smith	SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East) a dream coming true	May 2013	Geneva, Switzerland	Civil Society, Scientific community	International
Link	Press release	EC	Questions and answers on SESAME	May 2013	Brussels, Belgium	Civil Society, Scientific community, Medias	International

SECTION B: EXPLOITABLE FOREGROUND (PUBLIC)

LIST OF APPLICATIONS FOR PATENTS

There are no patents, registered trademarks, designs associated to the project.

EXPLOITABLE FOREGROUND

B2: Exploitable foreground									
Foreground Number	Type of Exploitable Foreground[5]	Description of exploitable foreground	Confidential (yes, no)	Foreseen embargo date	Exploitable product(s) or measure(s)	Sector(s) of application[6]	Timetable for commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
1	GAK	Design reports of SESAME magnets	no	N/A	Deliverable reports D2.1, D2.2 and D2.3	C27, M72.1	Short term	-	CERN & SESAME
2	GAK	SESAME magnets	no	N/A	Accelerator magnets	M72.1	Short term	-	CERN & SESAME
3	GAK	SESAME magnetic measurement bench	no	N/A	Measuring bench	C26.5.1, C27, M72.1	Short term	-	CERN & SESAME
4	GAK	Procurement of some magnets or components in SESAME Members industry	no	N/A	Knowledge transfer	Euro-Mediterranean cooperation	Medium term	-	CERN
5	GAK	Design of the SESAME magnet powering scheme	no	N/A	Design of a modern magnet power scheme for a light source	C27, M72.1	Short term	-	CERN &SESAME
6	GAK	Collaborative implementation of the SESAME magnet powering scheme	no	N/A	Powering scheme	M72.1	Short term	-	CERN &SESAME
7	GAK	Support to integration and commissioning	no	N/A	Support on-site, Knowledge transfer	M72.1	Short term	-	CERN &SESAME

[5] Type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[6] Type of sector (NACE nomenclature): http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

8	GAK	Knowledge transfer and training on accelerator projects	no	N/A	Effective training	Euro-Mediterranean cooperation	Short term	-	CERN &SESAME; HMC3, Pakistan; TAEK, Turkey, ILSF, Iran; CNE technologies; Cyprus; SONMEZ, Turkey
9	EUP	International collaboration agreements between CERN and SESAME	yes	N/A	International networking	Euro-Mediterranean cooperation	Short and Medium term	-	CERN &SESAME
10	EUP	International collaboration agreement between CERN and ALBA-CELLS	yes	N/A	European networking	ERA	Short term	-	CERN &ALBA-CELLS
11	EUP	Implementation agreement with PAEK, Pakistan	yes	N/A	International networking	International cooperation	Short term	-	CERN, PAEK, HMC3, Institute of Physics, Pakistan
12	EUP	Implementation agreement with TAEK, Turkey	yes	N/A	International networking	International cooperation	Short term	-	CERN, TAEK, Turkey
13	EUP	Implementation agreement with ILSF, Iran	yes	N/A	International networking	International cooperation	Short term	-	CERN, ILSF, Iran
14	EUP	Informal collaboration with IAEA	yes	N/A	International networking	International cooperation	Short term	-	CERN, IAEA
15	EUP	CERN-EC-SESAME Communication on Science for Peace in the Middle East and science diplomacy aspect	no	N/A	Articles and political impact	Euro-Mediterranean cooperation	Short and medium term	-	CERN, EC, SESAME

Foreground no.	Its purpose	How the foreground might be exploited, when and by whom	IPR exploitable measures taken or intended	Further research necessary, if any	Potential/expected impact (quantify where possible)
1	Document the conceptual and engineering design of the magnets of the SESAME light source	Already exploited by SESAME, can be exploited by future light source projects as a reference	open	none	Key impact on SESAME; potential impact on light source projects in less developed countries
2	Produce the magnets for the SESAME light source	Already exploited for SESAME, already a request received for a review of another light source project	open	none	Key impact on SESAME equipment and schedule; potential impact on light source projects in less developed countries
3	Magnetic tests of accelerator magnets	Already exploited for SESAME, will be exploited in the future by CERN	open	none	Key impact on SESAME; potential impact on light source projects in less developed countries
4	Demonstrate the possibility of procuring technical equipment to high quality standards in industry of SESAME Members, with the potential of creating a financial return	Already exploited for the construction of the SESAME light source in Cyprus, Pakistan and Turkey companies; should initiate further actions by SESAME	open	none	Key impact on the perception of what is feasible in SESAME members; industry; important potential commercial impact on the companies
5	Document the conceptual and engineering design of the magnet powering scheme for the SESAME light source	Already exploited by SESAME, can be exploited by future light source projects as a reference	open	Comprehensive testing with beams may lead to some modifications	Key impact on SESAME; potential impact on light source projects in less developed countries
6	Collaborative production of the equipment for the magnet powering scheme	Already exploited by SESAME, can be exploited by future light source projects as a reference	open	Comprehensive testing with beams may lead to some modifications	Key impact on SESAME equipment and schedule; potential impact on light source projects in less developed countries
7	Ensure that the equipment delivered by CESSAMag is operational; give support to SESAME commissioning	Already exploited by SESAME	open	On request of SESAME in the framework of the CERN-SESAME-Jordan international cooperation agreement	Important impact on SESAME

8	Transfer of knowledge to the SESAME staff, to inexperienced companies in countries of SESAME Members and to visitors at CERN delegated by laboratories in SESAME Member countries	Already exploited	open	On request of SESAME in the framework of the CERN-SESAME-Jordan international cooperation agreement	Acknowledged as a key impact by SESAME staff and visitors; potential commercial impact in the companies trained.
9	Create a legal framework of collaboration between CERN and SESAME	Exploited	none	Depending on future collaborations between CERN and SESAME	Key impact; allowed the exceptional contribution of CERN to an external project Science for peace component
10	Create a legal framework of collaboration between CERN and ALBA-CELLS	Exploited	none	none	Important impact; facilitated the technical contribution of ALBA-CELLS to CESSAMag and opens a framework for other topics
11	Allow a tight collaboration between CERN and Pakistan and a donation by Pakistan without interference with SESAME strategies	Exploited	none	none	Key impact; allowed significant savings for CESSAMag; allowed, combined with training, the development of a competence in accelerator magnets in Pakistan which aims at creating an accelerator center; had a possible impact on the decision by Pakistan to become an associate member of CERN; Science diplomacy component
12	Give voluntary support to the CERN team in charge of the magnet powering scheme	Exploited	none	none	Important impact on the CERN workload, and on knowledge transfer; ; had a possible impact on the decision by Turkey to become an associate member of CERN; Science diplomacy component

13	Give voluntary support to the CERN team in charge of the magnet powering scheme	Exploited	none	none	Important impact on the CERN workload, and on knowledge transfer; ; triggered a proposal by ILSF, Iran, to sign a cooperation agreement with CERN in view of training and expert advice for a future Iranian light source. Science for peace component
14	Give financial support to training of the SESAME staff in the framework of CESSAMag and to the CERN staff carrying out the support to commissioning	Exploited	none	none	Triggered a proposal by IAEA to sign a cooperation agreement with CERN for combined support of SESAME and for other common goals beyond SESAME
15	Acknowledge and publicize the science diplomacy dimension of the completed CESSAMag project	The article serves as basis for further official communication on this topic. Distributed to policy makers.	open	none	The actions summarized by this document had a major impact that continues on the short and medium term: the joint CERN-EC action allowed SESAME to take off; the further actions by EU, to become an Observer member and to offer financial support for key targeted actions are very promising

ANNEX I LIST OF ACRONYMS

ALBA or ALBA-CELLS	Spanish synchrotron radiation facility, Barcelona
CNE	Company: Center of Technology CNE Technology, Cyprus
DCCT	Direct-current current transformer
EEI	Company: Equipaggiamenti Elettronici Industriali, Vivenza, Italy
ELYTT	Company: ELYTT Energy, Madrid, Spain
EPICS	Experimental Physics and Industrial Control System
ERA	European Research Area
ESRF	European Synchrotron Radiation Facility, Grenoble, France
GeV	Giga electron Volt: unit of energy for electrons
HMC3	Company: Heavy Metal Complex III, Taxila, Pakistan
IAEA	International Atomic Energy Agency, Vienna, Austria
ICA	International Cooperation Agreement
ILSF	Iranian Light Source Facility, Tehran, Iran
IPAC	International Particle Accelerator Conference
MoU	Memorandum of Understanding
PSI	Paul Scherrer Institute
SEF	Company: Societe d'Etudes et de Fabrication pour la recherche et l'industrie, Toulouse, France
SESAME TAC	SESAME Technical Advisory Committee
SOLEIL	Synchrotron SOLEIL, Gif-sur-Yvette, France
SONMEZ	Company: Sonmez transformer company, Gebze, Turkey
TAEK	Turkish Atomic Energy Commission
TDK Lambda	Company: manufacturing of power supplies, with a branch in Israel
TESLA	Company: TESLA Enginnering LTD Group, Storrington, UK
UNESCO	United Nations Educational, Scientific and Cultural Organization
US DoE	Department of Energy, USA