

EISCAT_3D: Preparation for Production

EISCAT3D_PfP

Deliverable D4.1

First report on industry contracts

Work Package 4 – Procurement of Production-Ready Designs and Hardware

Leading Beneficiary: EISCAT Scientific Association

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Abstract

This report focusses on the progress of industry contracts for the procurement of production-ready designs and hardware of various sub-systems of the test sub-array. This test sub-array will be built and tested at the existing EISCAT site in Ramfjordmoen, Norway by the end of EISCAT3D_PfP project. This report discusses the progress of the procurement of the following sub-systems: first stage receiver unit (FSRU), antenna unit (AU), pulse and steering control unit (PSCU), time and frequency unit, status and control unit and cables, connectors and containers. Further, this report also includes information about the transmit unit (solid state power amplifier and power supply units) which will be delivered as an in-kind contribution from National Institute of Polar Research (NIPR), Japan.

Introduction

EISCAT Scientific Association (EISCAT) is a multi-national scientific research association that develops and maintains radar system infrastructures. EISCAT_3D is a monitoring instrument that will allow measurements of, among other things, the ionospheric plasma and will serve as the main instrument for many scientists in the field of atmospheric, ionospheric and space weather studies. With the commissioning of EISCAT_3D system, EISCAT will have a world-leading research radar infrastructure, using incoherent scattering technique to study the Earth's atmosphere.

EISCAT_3D aims to establish a system of distributed phased array radars that enable comprehensive three-dimensional vector observations of the atmosphere in the auroral zone above northern Europe. The use of new radar technologies, combined with the latest digital signal processing, will achieve ten times higher temporal and spatial resolution than obtained by present radars while simultaneously offering continuous measurement capabilities. The flexibility of the EISCAT_3D system will allow the study of atmospheric phenomena that are unreachable by the present systems. The EISCAT_3D project proposal is based on the results from design studies incorporating the latest ideas and advances in radio array technology, software radar techniques, and advances in available components and technologies. During EISCAT3D_PfP project, EISCAT will use expert services of a consulting firm to address several technical challenges during implementation and also to facilitate the procurement of necessary components and instruments from manufacturers for cost and energy-efficient construction of the EISCAT_3D test sub-array.

EISCAT3D_PfP project will enable smooth transition from preparatory phase to implementation by moving from individual prototype subsystems to manufacture-ready designs for immediate implementation in an industrial production environment. Further, this project also focusses on the operation of these subsystems as a single system with compatible interfaces and also without any internal interference. The above challenges will be addressed by implementing and testing a test sub-array, at EISCAT's Ramfjordmoen site, near Tromsø in Norway, using subsystems that are as close as possible to a final configuration.

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Description of EISCAT_3D Test Sub-array

During EISCAT3D_PfP project, an EISCAT_3D test sub-array system will be produced and tested at EISCAT's Ramfjordmoen facility in Norway. This hardware will be similar to the final sub-array configuration that will be deployed at the EISCAT_3D core site in the future. The total size of this test sub-array will be approximately 7m in diameter with an additional buffer for safety reasons. This test sub-array will transmit a maximum peak output power of 91 kW (500W per polarisation per antenna) in the frequency band around 233 MHz and with a maximum bandwidth of 5 MHz. Currently, Ramfjordmoen facility has transmit license in the band of 230.016-236.544 MHz with a peak transmit power of 2 MW. The receiver frequency band is 218-248 MHz. A top level block diagram of the different procurement objects/subsystems in the test sub-array is shown in Figure 1.

The test sub-array system consists of following sub-systems:

- **Antenna Unit (AU)**, made up of 91 inverted v-shaped crossed dipole antenna elements together with its meshed ground plane, mounted approximately 2.0m – 3.0m above the ground level. This unit also includes array structure and other supporting structure such as the mounting poles.
- **Transmit Unit (TU)** consists of a solid-state power amplifier (SSPA), transmit/receive (T/R) switch and a power supply unit. This unit will be supplied as an in-kind contribution from National Institute of Polar Research (NIPR), Japan. Hence, it is marked with dashed (--) line in Figure 1.
- **First Stage Receiver Unit (FSRU)** is made up of low noise amplifiers (LNAs), anti-aliasing filters, analog to digital converters (ADC) and a digital beamformer along with a control circuitry and application programming interface (API).
- **Pulse and Steering Control Unit (PSCU)** consists of a radar controller unit, an exciter, and an interface to the other sub-systems.
- **Time and Frequency Unit** consists of a White Rabbit (WR) master and slave sub-unit, time and frequency synchronisation sub-unit and clock generator sub-unit.
- **Status and Control Unit** is made up of input/output serial and parallel ports connected to a computer.

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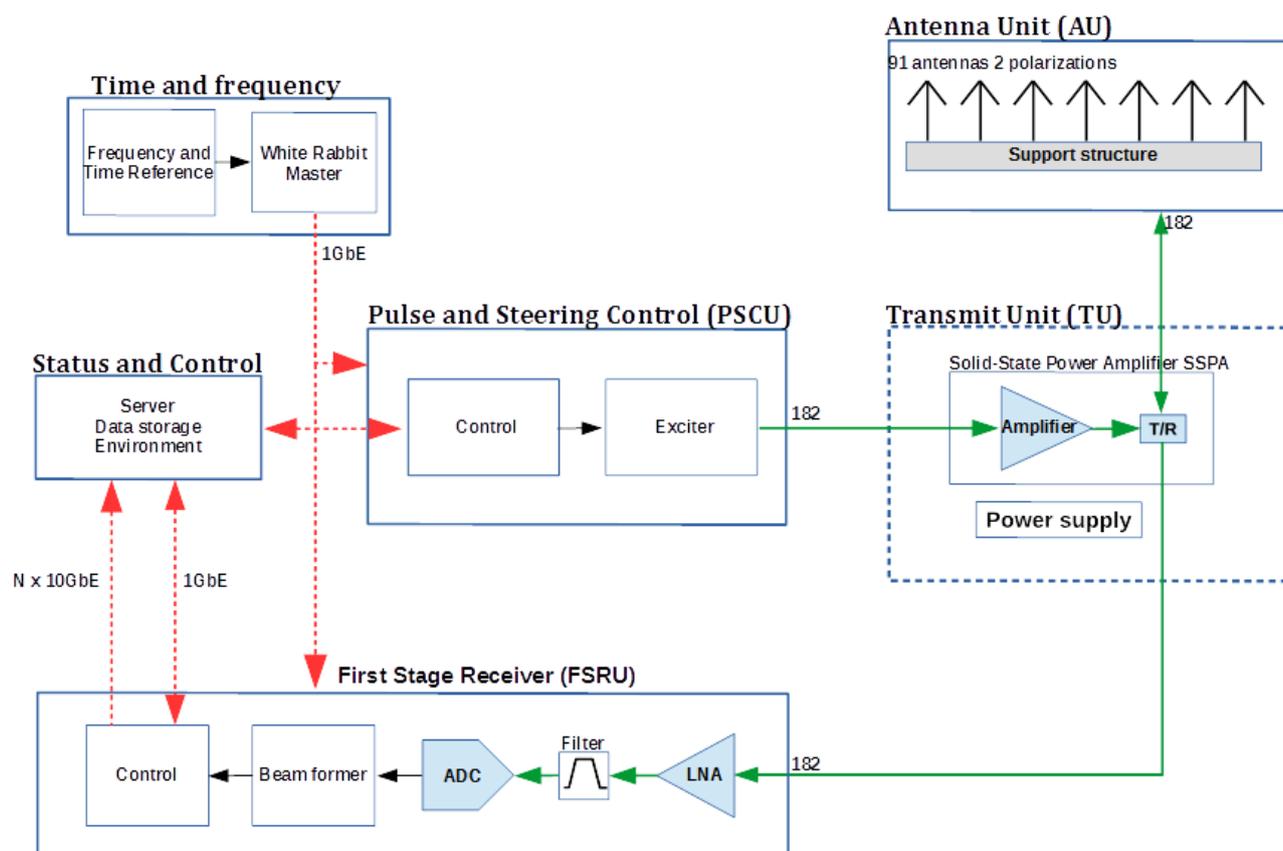


Figure 1: A top level block diagram of the different procurement objects/subsystems in EISCAT3D_PfP project.

EISCAT3D_PfP Test Sub-Array Procurement

A manufacturing consulting contractor, Consoden AB, was selected to assist EISCAT3D_PfP project in the procurement of production ready designs and hardware of various sub-systems. Consoden AB assisted the EISCAT3D_PfP project in developing the procurement strategy, preparing the necessary tendering documents and suggesting the tender evaluation procedure. Consoden suggested several different possible procurement strategies: procurement with open competition, procurement with closed competition and direct award of contract.

In this project, the procurement of critical subsystems such as FSRU, AU and PSCU are done via open competition by publishing the tender invitation on the EISCAT_3D public homepage and submitting the procurement documentation to all the tenderers that request it. Further, the tenderers were asked to fill out a requirement answer template as part of their response to the tender invitation. According to the procurement rules of EISCAT Scientific Association, any tender invitation must have at least 3 offers for full competition. The tender evaluation is done by considering the fulfilment

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of technical, cost and the delivery schedule requirements. The notification about the award of contract is published on the EISCAT's public homepage.

FSRU Procurement:

The FSRU subsystem contract has been awarded to National Instruments (NI), Sweden in October 2016 and the project formally started on November 8, 2016 via a Skype meeting. It is planned that most of status meetings in this project will occur electronically (via Business Skype). Further, a project community page was created by NI for all technical discussions and sharing the other project information. This NI community page is private and accessible to the FSRU project staff of NI and EISCAT.

As per the contract, NI will deliver a FSRU based on the not yet released NI/Ettus N350 USRP product, a high-channel-count, software defined radio (SDR) that comprises four NI/Ettus N310 devices and a central timing and synchronization module integrated into a 19-inch rackmount enclosure. The NI/Ettus N310/N350 USRP products will be customized and extended for the FSRU by developing the following major hardware and software components:

- A customized circuit card with radio frequency (RF) front ends
- A customized circuit card for the N310 with analog to digital converters (ADCs)
- Signal Processing Software
- Beamforming FPGA code
- EISCAT specific Subsystem Manager Interface

The FSRU procurement is divided into five phases and the description of each phase is shown below:

| Project Phase | Category | High-level Description of Work | Achievement Criteria |
|----------------------|---|--|--|
| Phase I | Define Requirements and Create Detailed Specification | NI and EISCAT will work together to finalize system requirements | System Requirements Specification available and approved |

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| | System Design | Design, define and document Subsystem Manager Interface | Subsystem Manager Interface description available and approved |
| | | Create System Design and Interface Description | Design Description (draft) and Interface Description available and approved |
| Phase II | RF Front End Module Development | Development of the customized RF Front End Module of the First Stage Receiver Unit | RF Front End Module available and tested (test report available) |
| | ADC Module Development | Development of the customized ADC Module of the First Stage Receiver Unit | ADC Module available and tested (test report available) |
| | Beamforming Functionality | Development of the beamforming FPGA code of the First Stage Receiver Unit | Beamforming functionality available and tested (test report available) |
| | Subsystem Manager Interface | Development of the Subsystem Manager Interface | Subsystem Manager Interface available and tested (test report available) |
| Phase III | System Verification and Testing | Verification and testing of the First Stage Receiver Unit at NI. | Successful System verification and test (test report available) |
| | Certification/Compliance Testing | NI will execute the necessary CE mark related compliance testing activities | Compliance test report |

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| Phase IV | On-site testing/Verification and delivery and acceptance | NI will deliver the First Stage Receiver Unit to EISCAT and work with EISCAT together on the on-site testing/verification of the First Stage Receiver Unit | Successful System verification/test Signed acceptance document |
| Phase V | Technical Support after the delivery / acceptance of the system (First Stage Receiver Unit) | NI will support EISCAT after the delivery of the system for a 3-month long evaluation period. | Evaluation period started |

The Phase I and Phase II of the FSRU procurement are currently underway. In Phase I, the system requirements are finalized and the Subsystem manager requirements are under discussion. In the coming weeks, a draft describing the Subsystem manager interface will be delivered to the EISCAT. In Phase II, two prototype designs (one from preparatory phase of the EISCAT_3D project and the other is the NI design) of the RF front end module, low noise amplifier (LNA), are developed and tested in NI lab. The measurement results are discussed and available on the NI-EISCAT community page. Further, the development of beamformer application programming interface (API) is underway and a document will be supplied to EISCAT after finalizing the requirements. The Phase III of this project will start upon completion of Phase I and II. The delivery of the FSRU subsystem is expected by the end of Phase IV of this project i.e., June 2017.

AU Procurement:

The AU subsystem contract has been awarded to the Huber + Suhner Ltd., United Kingdom, in December 2016 and a project kick-off meeting was held at EISCAT headquarters in Kiruna, Sweden. During this meeting, a brief project plan was presented. According to this project plan; internal project meetings will be done within the Huber + Suhner Ltd. project staff for every 2 weeks and status meetings (via WEBEX) with EISCAT staff will be done every month. Further, Huber + Suhner Ltd. has set up a project steering committee to review/decide/define the next steps and also, to address any major changes in the project. This steering committee will meet as when required to discuss the project and EISCAT will be informed about the meeting through meeting minutes.

As per the contract, Huber + Suhner Ltd. will deliver an AU comprised of the following parts:

- 91 Antenna Elements, each with two cables and connectors

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- Ground Plane
- Array Structure
- Mechanical Attachment Interfaces contains the following sub-parts:
 - Antenna Element to Array Structure
 - Ground Plane to Array Structure
 - Array Structure to foundation

The AU procurement will be executed in the following phases:

| Project Phase | Category | High-level Description of Work | Achievement Criteria |
|--------------------|---|---|---|
| Requirements Phase | Define Requirements and Create Detailed Specification | Huber+Suhner Ltd. and EISCAT will work together to finalize system requirements | Requirements Specification available and approved after review. |
| Design Phase | Design and Simulate the AU | Huber+Suhner Ltd. and EISCAT will work together to finalize system requirements | Final Design available and approved after review. |
| Test Phase | Verification and Testing of the AU Design and the first article | Verification and testing of the simulated design and the first article at Huber+Suhner Ltd. | Successful AU verification and test (test report available) |
| | Certification/ Compliance Testing | Huber+Suhner will execute the necessary compliance testing activities | Compliance test report |
| Production Phase | Production of 91 antenna elements and other parts after performing the production readiness review. | Huber+Suhner Ltd., will produce the antenna elements and other parts after successful first article inspection/testing. | Successful production of AU |

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| Acceptance Phase | Acceptance test will be performed before the delivery / acceptance of the AU | Huber+Suhner will deliver the AU to the EISCAT after successful acceptance test. | Signed acceptance document |
|------------------|--|--|----------------------------|

The requirements phase, design phase and test phase of this project are currently underway. A review meeting was held on January 26-27, 2017, at Huber+Suhner Ltd. premises in Herisau, Switzerland to finalize the requirements and to discuss some key design issues. The meeting was attended by EISCAT3D_PfP project staff and Huber+Suhner Ltd. representatives. Further, this meeting also discussed the administrative and commercial matters related to this project. This meeting marked the end of requirements phase in this project with a list of action items for finalizing the design of AU. The production phase will start after the successful testing of the first article and also, reviewing the production readiness. It is anticipated that the AU will be delivered to EISCAT by the end of May 2017 after the successful acceptance test.

PSCU Procurement:

PSCU contract is not yet awarded to any of the bidders because of the issues with the received proposals. Hence, a new procurement strategy will be adopted for timely procurement of this unit.

TU Procurement:

TU will be procured as in-kind contribution from NIPR, Japan through a contract with Mitsubishi, Japan. Under this in-kind contribution, SSPAs including T/R switch and the power supply units will be delivered to the EISCAT. As per the Mitsubishi contract with NIPR, EISCAT will receive 19 SSPAs and the required power supply units in April-May 2017. Further, a demonstrator SSPA will be tested at Mitsubishi Factory near Osaka, Japan in early March, 2017. The EISCAT3D_PfP project is responsible for the control interfaces for these units.

Time and Frequency Unit Procurement:

This unit will be an off-the-shelf device and the procurement will be done once the FSRU and PSCU units are tested.

Status and Control Unit Procurement:

This unit will not be procured because an existing server (personal computer) is planned to be used with the software developed by EISCAT staff.

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Cables, Connectors and Containers procurement:

The cables, connectors and containers are the off-the-shelf products. The procurement of these items will be done as per the EISCAT rules.

Conclusion

The vendor contracts for procurement of FSRU and AU are progressing as expected and hence, these units will be available on time at EISCAT's Ramfjordmoen site, near Tromsø in Norway. However, a new procurement strategy has to be adopted for the timely delivery of PSCU at the site and thus, leading to integration with other subsystems for implementing and testing of EISCAT_3D demonstrator test sub-array.

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