4th Activity Report

EISCAT_3D

European Next Generation Incoherent Scatter Radar

Design Study

implemented as

Specific Support Action

Contract number:	011920
Project Co-ordinator:	EISCAT Scientific Association
Project website:	http://www.eiscat.se
Reporting period:	from 01/05/2008 to 30/04/2009

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Contents

A. ACTIVITY REPORT

1. Progress report

1.1 Summary of the activities and major achievements

Executive Summary

This is the fourth Annual Report of the EISCAT_3D Design Study. It covers the final year of the project.

The Design Study underwent a major project revision during the third reporting year. It included an expansion of the consortium and partially revisiting the tasks and resources needed for the different sub-parts.

The revised project plan was activated 1 May 2008 with a retroactive start date for the new partner, Swedish Institute of Space Physics, from January 2008.

The revised project plan, Annex I of the contract, is available on the project web site at:

www.eiscat.se/groups/EISCAT_3D_info/Annex_I_1May2008

The work for the final year was planned to be devoted to finalising outstanding chores, testing of design features using the small test array (referred to also as "Demonstrator"), wrapping up the project and producing the final reports.

Most of this could be performed as envisaged but due to unexpected delivery problems, the multiple beamforming technique could not be installed in the test array. Some tests needing this could therefore not be done before design study ended 30 April 2009. The test array has though been regularly used in single beam mode. EISCAT plans to implement the multiple beamforming feature later.

A major follow-on step to the design study was reached when the EISCAT_3D concept was included in the first major revision of the ESFRI Roadmap. The event was announced at the European Committee on Research Infrastructures (ECRI) meeting held in Versailles December 2008.

The ESFRI EISCAT_3D concept will involve a number of huge phased-array radar transmitters and receivers, each covering areas at least 300 m square, distributed across northern Scandinavia, and possibly beyond. The most probable arrangement will include three ultra-high-power transmitting/receiving arrays, one in Finland, Sweden, and Norway, and at least three other even larger receiving arrays between and around the active sites. The EISCAT_3D proposal was submitted by the Swedish ESFRI delegation.

The Design study objective differ from the ESFRI concept and recommends one active and four receive-only arrays (description on page 8).

This is the final report of the project and as such, it summarises the project as well as highlights some of what was done during the fourth reporting period.

End of project status

Project Management

WP1: 'Management of the Design Study' worked well over the project. The project revision finalised in May 2008 took much resources. This report (Deliverable D1.4) and the final report on the design study (Deliverable D1.5) are both being finalised after the end of the project period. The final report will focus mainly on the project as such, its findings and the foreseen follow-on activities.

System related tasks

Initial design goals

WP2: 'Evaluation of design performance goals' was completed as originally planned. The goals were summarised in Deliverable D2.1: EISCAT_3D Radar Performance Specification Document.

The Active Array (transmit-receive site)

Was considered by two Work Packages.

WP3: 'Evaluation of options for the active element', considered the overall concept but particularly the antenna element design. It was planned that WP3 would hand-over to WP6 a few months into the study the findings but it eventually overlapped somewhat. The work done in WP6: 'Active Element', focused on integrating the Antenna Element with transmitter technology. Both packages were mainly done at the Swedish Institute of Space Physics.

Renkwitz antennas test setup by IRF (WP6)

The Passive Array (receive-only sites)

Was considered mainly in WP4: 'Phased array receivers'. The Work Package included also the setup of a test array at the EISCAT Kiruna Site. The test array hardware was accounted in the project but paid by EISCAT. Its role in the project was to be used as a test bed for the different Work Packages and to validate critical design features. Due to technical problems, the test array could not get in a multiple beam operational test phase before the design study ended. Some design features could therefore only be validated in theory or in small scale workbench tests.

Control and Monitoring

Was done in in-house EISCAT in WP7: 'Distributed Control and Monitoring'. The work had two scopes, overall theory and direct implementation in the test array.

Data archive and distribution of data
Was mostly done by the Rutherford Appleton Laboratory group in WP8: 'Data archive and distribution.

Interferometry
Was done at the University of Tromsø in WP5: 'Interferometry'.

Signal Processing for the whole system
Was covered in WP9: 'Signal Processing'. Most Partners were directly involved in this package.

Networking and reference time and frequency
Was studied by EISCAT in WP12: 'Networking and reference time and frequency'.

New uses of Incoherent Scatter Radar technology
Was studied at the University of Tromsø in WP10: 'New techniques'.

Site locations
Early in the project, potential build sites were examined and its findings were then summarised in WP13: 'Enabling Procedures'. Some further work relating to acquiring land, etc. has thereafter been considered too. The work was done by EISCAT engineers.

Frequency allocation
The responsibility for acquiring the needed protected frequency allocation in Finland, Norway and Sweden resided with the Technical Project Leader, initially at EISCAT but since early 2008, at the Swedish Institute of Space Physics.

Technical documentation
The final technical documentation work started roughly six months before project end. It was initially planned to be done mainly using EISCAT resources but it was agreed to bring in the Rutherford team in WP11: 'Implementation Blueprint'. It finally became so that all editing and much of the writing was done by the Rutherford team alone.

The final technical report is Deliverable D11.1: EISCAT_3D Radar Final Design Study document.

Work Package specific details are expanded in later chapters.

The Design Study Recommended System

System features

Following extensive consultation with the scientific user community in 2004 and 2005, it was determined that only a multi-static phased array system could reach or approach the performance demanded by present and future users. Accordingly, the target system specified in the EISCAT_3D Performance Specification Document (PSD) comprises a central active (transmit-receive) site (the "core") and four receive-only sites, located on two approximately 250 km long baselines oriented N-S and E-W respectively. To achieve the desired performance, the proposed system design incorporates a number of innovative, ground-breaking concepts, e.g. direct-sampling receivers, digital time-delay beam-forming, multiple simultaneous beams from each receiving array, adaptive polarisation matching and Faraday rotation compensation, digital arbitrary-waveform transmitter exciter system, full interferometry and imaging capabilities and amplitude-domain data recording at full sampling rate

During the four-year study, all mission-critical technical concepts have been modelled, investigated by simulations, in critical cases also by full-scale tests, and found to be realisable. Array sizes, transmitter power levels and receiver noise performance required to reach the desired time and space resolutions have also been established. To reach the desired performance, the target system should have the following technical characteristics:

The core will comprise a 120-m diameter filled circular aperture array with ≈16 000 elements, laid out on an equilateral triangular grid, and a number (6…9) of smaller outlier receive-only arrays. The core will provide: a half-power beamwidth of ≈ 0.75^{o}, i.e. comparable to that of the EISCAT UHF system, a power-aperture product exceeding 100 GW m^2, i.e. an order of magnitude greater than that of the EISCAT VHF system, grating-lobe free pattern out to 40^{o} zenith angle and graceful degradation in case of single-point equipment failure. Each core array element will be made up from a radiator, a dual 300+300 watt linear RF power amplifier, a high performance direct-digitising receiver and support electronics. The recommended radiator is a crossed Yagi antenna with a minimum directivity of about 7 dBi.

Four filled 8 000-element receive-only arrays will be installed, two on each baseline at distances of respectively ≈110 and ≈250 km from the core. Their radiating elements will be 3- or 4-element X Yagis, essentially identical to those used in the core. The Yagis will be directed towards the core field-of-view and elevated to 45^{o}. Outlier arrays for interferometry will also be installed.

Advanced digital beam-forming systems will allow the generation of a large number of simultaneous beams from each array, thus eliminating the time/space ambiguity plaguing all present incoherent scatter systems and making true volumetric imaging of vector quantities possible for the first time.

The artist impression on page 35 shows what one such site might look like.

1.2 Consortium management activities

Consortium management effort of all contractors
Work Package 1: Management of the Design Study included the consortium management of the project. The deployed human effort was accounted in the Management Work Package (WP1).

Consortium management summary
The Consortium Agreement, activated 21 March 2005, regulated the consortium management handling. The day-to-day management of the project was done by the Co-ordinator, EISCAT. The co-ordinating tasks were handled in a separate Work Package, WP1: Management of the Design Study. The main overall vehicle for the project is the General Assembly, where each Partner has representation. The consortium agreement also includes a Steering Group that supports the Co-ordinator and the General Assembly. The Steering Group also functioned as the internal Project Review Panel.

The project underwent a major revision in the first half of 2008 and the revised project plan was finalised 1 May 2008.

The revision included the addition of a fifth partner, the Swedish Institute of Space Physics (IRF), and a redistribution of tasks. The overall project funding volume did not change.

The EISCAT Directorship changed 1 January 2009 and the new EISCAT Director, Dr. Esa Turunen, assumed responsibility for this project from that date.

General Assembly
The General Assembly held one e-mail conversation meeting during the reporting period.

The eighth General Assembly meeting of the project was held 22 December 2008
The meeting was held as e-mail conversation. Mr. Henrik Andersson, Co-ordinator/EISCAT Prof. Asgeir Brekke, UiT, Prof. Jerker Delsing, LTU, Dr. Lars Eliasson, IRF and Prof. Richard Harrison, RAL/STFC participated.

The General Assembly approved the distribution of the third prefinancing to the Partners and the redistribution of 4 man-months from EISCAT to RAL/STFC in Work Package 11.

Steering Group
The Steering Group had two physical meetings during the reporting period and a number of telephone conversations.

Eighth meeting: 17 September 2008, Swedish Institute of Space Physics (IRF)
The meeting was held after the All-hands meeting 16 – 17 September at the Institute. Present were Mr. Henrik Andersson, Co-ordinator/EISCAT, Prof. Tony van Eyken, Co-ordinator/EISCAT, Dr. Esa Turunen, Co-ordinator (Invited), Prof. Cesar La Hoz, UiT, Dr. Jonny Johansson, LTU, Dr. Ian McCrea, STFC-RAL, Mr. Markku Postila, EISCAT, Dr. Gudmund Wannberg, Technical Project Leader and Mr. Ingemar Wolf, IRF.

The Steering Group handled regular project related matters and discussed the resources needed for the final reporting of the project.

Ninth meeting: 14 January 2009, Conference centre at Stockholm/Arlanda Airport
Present were Mr. Henrik Andersson, Co-ordinator/EISCAT, Dr. Esa Turunen, Co-ordinator/EISCAT, Prof. Cesar La Hoz, UiT, Dr. Jonny Johansson, LTU, Dr. Ian McCrea, STFC-RAL, Mr. Markku Postila, EISCAT, Dr. Gudmund Wannberg, Technical Project Leader and Mr. Ingemar Wolf, IRF.

The Steering Group considered the layout and work needed to finalise the main final report, WP11's Deliverable D11.1: Implementation Blueprint. The various WP specific deliverables were also considered.

The Partners had also several telephone conversations during the reporting period where reports and technical details were discussed.

Project WEB site
Work Package 1: Management of the Design Study included the setup of a project web site at www.eiscat.se. The project has a restricted area where all internal project related documents are included. There is also a public area, accessible by everyone, for published material.

Final, after the project ended, Consortium actions
It is planned to have a final (ninth) General Assembly meeting to formally close the project after the final report has been approved.

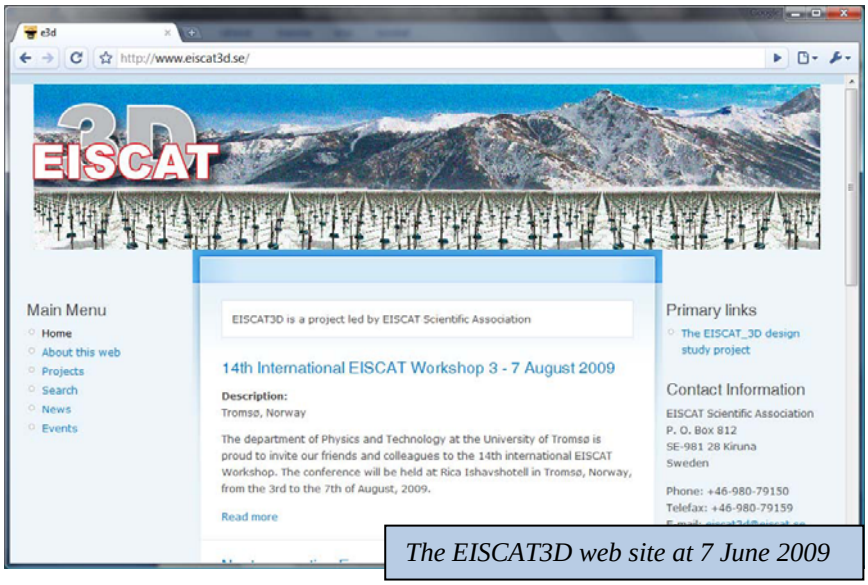
The Steering Group held its tenth and final meeting 27 May 2009.

About thirty people attended the organised User Meeting 28 - 29 May 2009. It was held at Ångströmlaboratoriet, Uppsala University, Sweden. Scientists and interested parties attended coming from several European countries, India, Japan and USA. The design study findings were summarised by the project team, scientific capabilities were presented and discussed and next steps were deliberated.

A dedicated EISCAT3D web site has been launched:

www.eiscat3d.se.

This web site is a follow-on to this project and will be the main vehicle for reporting the continued development of the EISCAT3D system.



The EISCAT3D web site at 7 June 2009

Management and general meetings (where all participants were invited)

Consortium management: See 1.3.1 Work Package 1: Management of the Design Study

All-Hands Meeting
The Swedish Institute of Space Physics organised a well attended All-Hands Meeting, 16 – 17 September 2008, at the Institute in Kiruna.

Totally 22 presentations were given and resulted in fruitful discussions.

Talk 1: Technical aspects of EISCAT_3D: review and current status: Gudmund Wannberg
Talk 2: Status of the Demonstrator array: Lars-Göran Vanhainen
Talk 3: Antenna simulations: Tore Lindgren
Talk 4: Receiver system for the Demonstrator array: Mikael Larsmark
Talk 5: Digital down-converters: Tarmo Laakso
Talk 6: Demonstrator data transfer frame count logic: Lars-Göran Vanhainen
Talk 7: Parallel/serial/parallel conversion (SERDES) logic: Peter Bergqvist
Talk 8: Demonstrator beam-formers: implementation in FPGA: Walter Puccio (given by Gudmund Wannberg)
Talk 9: "Channel boards" for the EI_3D/EI UHF interface: Markku Postila
Talk 10: EI_3D signal processing challenges: Magnus Lundberg
Talk 11: WP3: The active antenna array: simulations, test bed etc: Toralf Renkwitz
Talk 12: EI_3D RF power devices: test beds: Ingemar Wolf
Talk 13: WP5 progress and status: Vasil Belyey
Talk 14: WP10 progress and status: Rico Behlke (given by Cesar la Hoz)
Talk 15: WP8: Current status and future activities: Ian McCrea
Talk 16: WP8 internal design issues: Ivan Finch
Talk 17: WP8: Context and interfaces: Derek McKay
Talk 18: LTU summary: Jonny Johansson
Talk 19: UiT summary: Cesar la Hoz
Talk 20: IRF summary: Ingemar Wolf
Talk 21: EISCAT summary: Markku Postila
Talk 22: EISCAT_3D: Financial and administrative status: Henrik Andersson

Milestones or deliverable achievements scheduled for this reporting period

See 1.3.1 Work Package 1: Management of the Design Study

1.3 Other specific activities (Design Study/Construction activities)

1.3.1 Work Package 1: Management of the Design Study

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	3.42					3.42

Objectives (May 2008 project plan)
The Management Work Package runs throughout the Design Study and ensures a co-ordinated and concerted approach towards the project objectives. The Package also covers administrative and reporting tasks as well as provision for timely and appropriate distribution of funds between the partners and procurement of audit certificates by each of the Partners at regular intervals.

Overall Project summary

After the initial setup of the project in 2005 the project management entered into a routine mode. The substantive project revision in 2008 needed a large involvement by the project management. The slow start of the project resulted in extraordinary financial considerations which was finally solved mid-stage of the project. After the project revision, this Work Package was streamlined to mainly handle co-ordinating tasks.

One General Assembly meeting was held and the Co-ordinator participated in two physical Steering Group meetings.

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1.3.1.1 EISCAT

The tasks done have focused on co-ordinating activities. The tasks have mainly been done by the EISCAT Head of Administration, Mr. Andersson, with some assistance from other EISCAT staff.

Audit certificate costs for the third and fourth periods have been booked under this Work Package too.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D1.4	Annual Design Study Progress Report + Annual Financial accounting Report, including Audit Certificates (this document)		EISCAT	Month 48 + 1.5	Month 48 + 1.5
D1.5	Final Report of the EISCAT_3D Design Study		EISCAT	Month 48 + 1.5	Month 48 + 1.5

Major meetings and workshops organised under this activity during this reporting period

Date	Title/subject of meeting /workshop	Location	Number of attendees	Website address
17 Sep 2008	Eighth Steering Group Meeting	Kiruna, Sweden	9	project web site
22 Dec 2008	Eighth General Assembly Meeting	e-mail meeting	5	project web site
14 Jan 2009	Ninth Steering Group Meeting	Arlanda, Sweden	8	project web site

The Steering Group met the tenth and final time, 27 May 2009, which was after this project ended.

It is also planned to have a final General Assembly meeting to formally close the project after the final report has been approved.

1.3.2 Work Package 2: Evaluation of design performance goals

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months						0.00

Objectives (May 2008 project plan)
This Work Package includes a comprehensive review of current and future requirements, leading to a Specification Document describing the specific and detailed performance goals to be achieved.

Overall Project summary

The Work Package was basically completed during the first reporting period with the Performance Specification Document D2.1 that was published in 2005.

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Since the same persons who did this Work Package also were involved in WP13, the handover meeting did not need to physically take place.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
Month 36	Handover meeting WP2 to WP13		EISCAT	Month 36	Month 36

1.3.3 Work Package 3: Evaluation of options for the active element

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	0.00				4.41	4.41

Objectives (May 2008 project plan)
A major part of the cost of the new facility will be invested in the production of the high power transmission capability. The relative benefits, and consequences for the design of other subsystems, of adopting either a phased array (with the transmitter integral with, and distributed across, the antenna) or a multi-component transmitter (providing multiple feeds to support electronic beam steering with a conventional antenna) will be evaluated as part of this Work Package and used to identify the optimum solution in terms of scientific return, performance, ease of manufacture and commissioning, reliability, maintainability and cost.

Overall Project summary

The purpose of this Work Package was to consider how the active array would be constructed. The actual design considerations for the active array are under WP6. This Work Package was taken over from EISCAT by IRF in January 2008.

After an initial lack of staff resources, the situation improved when IRF took over the package and the Work Package has fulfilled its tasks devoted to it.

4th Reporting Period progress

1.3.3.1 EISCAT

EISCAT provided equipment and paid for some travel during this period.

1.3.3.5 IRF

The work has concentrated on the follow-on to the simulations and design work done by Mr. Toralf Renkwitz during the third reporting period. IRF staff made the mechanical design and a prototype of the antenna. IRF delivered also the D3.2 report.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D3.2	EISCAT_3D Radar Active Element Subsystem Report		IRF	3 Nov 2008	2 Feb 2009

1.3.4 Work Package 4: Phased array receivers

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	9.65		31.05			40.70

Objectives (May 2008 project plan)
A key element of the next generation radar is the ability to receive scattered radar power over a wide range of altitudes by employing an essentially unlimited number of simultaneous receiving beams, generated by sophisticated signal processing of the signals received at the individual antenna elements of two or more large phased arrays located at distances of the order of 100-300 km from the transmitter site. This work package includes all the design and development work to prepare construction blueprints for such arrays.

Overall Project summary

The Work Package was expanded in the May 2008 project revision and could thereafter better fulfil the needed design study work.

The Work Package has produced the expected results. It has been shown, but unfortunately not tested to the extent wanted, that the design concepts are feasible for a large receive-only array.

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1.3.4.1 EISCAT

The EISCAT design team has continued to be busy with the passive array system. Tasks have been spread over several people each contributing to the project. Various design features have been tested on the test array. Although these have been done partially by the Partner teams themselves, EISCAT engineers have co-ordinated and assisted in these tests.

1.3.4.3 LTU

Final work has been performed on the complete front-end system, with high focus on the timing and calibration system. Installations have been performed in the Kiruna based test array. This done, the LTU design team has focused mainly on testing of the time synchronization and system calibration, to the extent that has been possible to perform. Documentation and dissemination has been a large part of the work, with finalisation of deliverables as well as publications of scientific papers and thesises

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
Month 36	Report presenting algorithms and evaluations (using simulated data) for subspace tracking of polarization orientation in low-SNR applications, including evaluation of Bayesian estimators that utilize apriori orientation knowledge.		LTU	Month 36	Month 48

Month 36	Submission to IEEE Transactions on Signal Processing on the Estimation of 2x2 Complex Covariance Matrices in low-SNR Situations.		LTU	Month 36	Month 48
Month 40	Antenna array subsystem design finished		LTU	Month 40	Month 48
Month 41	Report extending the above derived technique to an adaptive fashion, i.e., sub- space tracking using a-priori orientation knowledge		LTU	Month 41	Month 48
Month 42	Report showing evaluations using real data containing electron density records from the EISCAT_3D deployment area.		LTU	Month 42	Cancelled (system unavailable)
Month 46	Successful validation of antenna subsystem using demonstrator sub-array		LTU	Month 46	Cancelled (system unavailable)
Month 46	Evaluation of the above mentioned techniques on real data containing electron density records from the EISCAT_3D deployment area.		LTU	Month 46	Cancelled (system unavailable)
D4.2	Receiver/Receiving Antenna Subsystem Report issued		LTU	1 April 2009	30 May 2009

1.3.5 Work Package 5: Interferometry

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months		10.04				10.04

Objectives (May 2008 project plan)
Studies of very fine scale plasma phenomena require the routine employment of interferometric techniques in order to resolve features whose spatial scales are less than the scales of the scattering volumes defined by range gating and the transmitter beam geometry, or the intersection geometry of transmit and receive beams. This Work Package includes studying interferometry-specific requirements for the receive systems and developing designs for the hardware and software required to make interferometric observations a routine component of the radar operation.

Overall Project summary

The Work Package has produced the expected result but the final validation of imaging algorithms could not be done because the Demonstrator array is not in its final configuration.

4th Reporting Period progress

1.3.5.2 UIT

UiT completed the final studies and prepared the final report during the reporting period.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D5.3	EISCAT_3D Radar Multidimensional Imaging Radar Data Visualisation Report		UIT	15 Jan 2009	12 March 2009
Month 47/47	Validation of imaging algorithms on demonstrator array		UIT	Month 46/47	Cancelled (system unavailable)

1.3.6 Work Package 6: Active Element

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	0.85				16.81	17.66

Objectives (May 2008 project plan)
This package covers the detailed design of the active component of the radar including generation, modulation and distribution of the RF signal, RF power generation, the transmitting antenna system, the control and monitoring systems and, if required, the necessary transmit receive switching and receiver protection.

Overall Project summary

The main effort of the Work Package was transferred from EISCAT to IRF in the beginning of 2008.

IRF took over the EISCAT started tasks related to long term testing of power amplifiers and have also designed and constructed a small active antenna array for validating the theoretical performance of the design.

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1.3.6.1 EISCAT

EISCAT has assisted the IRF staff with a few tasks.

1.3.6.5 IRF

IRF engineers have been involved in completing the power amplifier tests and particularly running it with extended pulsed full-power tests to verify device integrity. After the antenna design for the core was final, a few samples were ordered and was assembled and connected to a data logger for measuring purposes. The data has regularly been evaluated.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
Month 43	Active element topology design finalised. Sub-WPs defined and assigned		IRF	Month 43	Month 45
D6.1	Active Element Interim Report		IRF	15 Dec 2008	4 Feb 2009
Month 43	WP6 meeting		IRF	Month 43	Month 43
Month 46	D6.2 Radar Active Element Subsystem Design Document available in draft form for public comment.		IRF	Month 46	Month 46
D6.2	EISCAT_3D Radar Active Element Subsystem Design Document		IRF	1 April 2009	30 May 2009

1.3.7 Work Package 7: Distributed Control and Monitoring

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	2.01					2.01

Objectives (May 2008 project plan)
Both the global control and monitoring of the whole facility and the low-level control and monitoring of the thousands of distributed antenna elements within the individual arrays place large demands on the support systems and software. This work package includes an evaluation of existing concepts and strategies for managing real-time, geographically widespread systems and the design and validation of a flexible, expandable and (insofar as possible) future-proof control and monitoring system.

Overall Project summary

The Work Package was initially oversized and was reduced in May 2008 project revision.

The main emphasis was to consider EISCAT's current EROS (EISCAT Real-time Operating System) solution and to examine whether that part could be reused for at least the initial goals of the EISCAT_3D system. Since it was found that EROS could be used, much of the initial resources assigned to the Work Package became unneeded.

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1.3.7.1 EISCAT

Very early in the project, the assessment showed that EISCATs EROS system could do the necessary tasks after some additions. These were implemented during this reporting period. Also the two deliverables were finalised.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D7.1	Basic set of control and monitoring software primitives for the WP4 Demonstrator		EISCAT	5 Nov 2007	12 March 2009
D7.2	EISCAT_3D Radar Control and Monitoring Subsystem Report		EISCAT	5 Nov 2007	15 March 2009

1.3.8 Work Package 8: Data archive and distribution

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months		3.61		8.50		12.11

Objectives (May 2008 project plan)
Objectives: This work package covers several areas related to the efficient collection and distribution of large volumes of data across the geographically extended radar installations and between the instruments themselves and the user and consumer communities. The work package includes the design of the Data Distribution System and the Secure Data Archive, as well as the design of Data Visualisation and Data Assimilation tools to allow users and consumers to access and utilise the output of the new facility efficiently and effectively.

Overall Project summary

The Work Package total was slightly reduced in the 1 May 2008 revision and some tasks were transferred from RAL to UIT

The Work Package has shown that even with current off-the-shelf hardware, the performance requirements can be met, though not necessarily in an optimum way. The Work Package included also studies of various data visualization techniques. The Work Package became a joint project between RAL/STFC and UIT.

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1.3.8.2 UIT

UIT studied the raw and analysed data visualization and produced the final deliverable, D8.6 during the reporting period.

1.3.8.4 RAL/STFC

Work continued on confirming the detailed requirements for the data distribution and archive system. The science case was revisited and various options were assessed in terms of data implications. The topology of proposed data systems was set. Detailed design diagrams for central and remote sites were made. Discussions with potential data product vendors continued. The final deliverables were made.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
Month 36	Design documents for raw and analysed data archives and hardware system finalized (completion of task 5)	Task 5	RAL/STFC	Month 36	Month 36
D8.3	Complete low-level specification of data storage system, including system design, proposed technical solutions, identification of appropriate hardware and technology with specific manufacturer details and pricings		RAL/STFC	30 April 2008	10 Sept 2008

Month 41	Completed design for multi-data assimilation software (completion of task 8).	Task 8	RAL/STFC	Month 41	Month 41
D8.5	Specification of the access layer, with descriptions of data products being transferred into and out of the data system, the user functionality required to handle these, and the necessary interfaces with the sub-systems being designed in other work packages		RAL/STFC	2 Feb 2009	30 Jan 2009
Month 45	Access layer software design finalized (completion task 6)	Task 6	RAL/STFC	Month 45	Month 45
D8.4	Study of extensions to data system required to handle supporting instruments clustered around the EISCAT-3D radar. Specification of how such data could be combined with the radar data to produce value-added products, and use cases to illustrate the value of the combined data		RAL/STFC	30 Sep 2008	9 March 2009
Month 47	Completed designs for raw and analysed data visualisation systems (completion of task 7)	Task 7	RAL/STFC	Month 47	Month 47
D8.6	EISCAT_3D Completed design studies for raw and analysed data visualization		UIT	31 March 2009	24 May 2009

1.3.9 Work Package 9: Signal Processing

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	11.62		6.19		3.80	21.61

Objectives (May 2008 project plan)
The effective operation of the distributed components of the receiver, the post-set forming of multiple antenna beams with arbitrary polarisations, the automatic beam pointing checking and correction, the adaptive interference excision and the effective decoding of the transmitted radar modulations place heavy demands the hardware and software signal processing components. This Work Package includes a critical assessment of different signal processing strategies and topologies and the design and validation of a comprehensive, expandable set of hard- and software processing primitives.

Overall Project summary

With the joining of IRF, New competence was brought into the Work Package and resources were redistributed to accommodate IRF.

The Work Package did not manage to complete in time all the planned design work. That was not critical to the whole project since the theoretical work was done. Lacking are some final tests.

4th Reporting Period progress

1.3.9.1 EISCAT

Work continued on the digital down-converter units (DDCs), the receive system and related ancillary components. The work included also deliverable D9.1.

1.3.9.2 UIT

It was envisaged that UIT should enter this Work Package and bringing their skills into the Signal Processing but it was agreed that this could be done via their WP5, Interferometry work.

1.3.9.3 LTU

LTU considered adaptive polarisation techniques and the findings were described in deliverable D9.3.

1.3.9.5 IRF

The staff concentrated its effort initially to the design of a FPGA-based beam-former and the thereafter planned implementation and installation in the Demonstrator. Towards the end of the project, it was planned to run extended tests of pointing accuracy. Due to unexpected delays in the delivery of the FPGA test systems, this work could not be completed within the time constrains of the design study. IRF completed also deliverable D9.2.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D9.1	Basic set of processing primitives required for the operation of the WP4		EISCAT	3 Nov 2008	17 April 2009

	demonstrator				
D9.2	EISCAT_3D Radar Signal Processing Subsystem Report,		IRF	2 March 2009	5 June 2009
D9.3	Report presenting algorithms and evaluations (using simulated data) for subspace tracking and Bayesian estimation of polarisation orientation in low-SNR applications		LTU	2 March 2009	17 May 2009
D9.4	Manuscript on Estimation of 2x2 Complex Covariance Matrices in low-SNR Situations submitted to IEEE Transactions on Signal Processing		LTU	2 March 2009	17 May 2009
D9.5	Report extending the above-derived techniques to adaptive applications		LTU	2 March 2009	17 May 2009
Month 47	Evaluation of the subspace tracking and Bayesian polarisation estimation techniques, using real data from the Demonstrator and electron density records from the EISCAT_3D deployment area.		IRF	Month 47	Cancelled (system unavailable)

1.3.10 Work Package 10: New techniques

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months		6.61				6.61

Objectives (May 2008 project plan)
The unique capabilities of the proposed new incoherent scatter radar will make it possible to undertake continuous observations of different physical parameters in the polar upper atmosphere. Long and continuous time series of such parameters are of vital importance for understanding the climatic conditions in the upper parts of the atmosphere. This Work Package will exploit the use of such data for climatic studies. The application of such long time series for continuous correction for ionospheric disturbances in remote sensing polar orbiting satellite data and especially in Galileo, as well as GPS data, will be addressed. The application of such data in space weather studies and for the correction of SAR remote sensing data will also be investigated.

Overall Project summary

During a period, the Work Package was stopped because it had reached the man-effort budget total. After more resources had been assigned it was restarted but with a slightly modified objective. It produced three deliverables, D10.1 and D10.2 before it was stopped and then the final D10.6.

4th Reporting Period progress

1.3.10.2 UIT

The area of interest, Ionospheric signatures of Global Change was studied and concluded in deliverable D10.6.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D10.6	Feasibility Study report: Global Change studies implications for EISCAT_3D		UIT	1 Sept 2008	2 May 2009

1.3.11 Work Package 11: Implementation Blueprint

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	0.00			7.00		7.00

Objectives (May 2008 project plan)
The goal of the Design Study is to produce a complete specification and set of appropriately tested and costed design blueprints suitable to support a detailed procurement exercise as the initial task of a successor project which should construct and commission the new radar. This Work package will start towards the end of the overall study and co-ordinate the preparation of the final deliverable design documents across the other Work Package areas.

Overall Project summary

The main task for this Work Package was the final Design Study Document D11.1. Since EISCAT had difficulties in providing the needed staff resources, it was agreed to bring in the RAL/STFC team as writers and editor in charge.

The planned producing of blue-prints for a complete system was descoped to rather focus on fewer but important break-throughs in the design study.

4th Reporting Period progress

1.3.11.1 EISCAT

Although it was planned that this Work Package was to be done by EISCAT, the direct producing effort was done by RAL/STFC with support from all Partners and particularly the Technical Project Leader.

1.3.11.4 RAL/STFC

The staff have compiled material, added and expanded certain areas, and have produced schematics etc. The deliverable D11.1 was mainly done by the RAL/STFC staff.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D11.1	EISCAT_3D Radar Final Design Study document, due 15 April 2009		RAL/STFC	15 April 2009	8 June 2009

1.3.12 Work Package 12: Networking and reference time and frequency

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	6.53					6.53

Objectives (May 2008 project plan)
At each antenna array, high quality timing and frequency reference signals must be generated and distributed to all elements to achieve the stringent synchronisation (to better than 50 ps) required for the overall system to function as intended. Also, command data must be passed to each array element and the data streams from the receiving elements must be collected, concentrated, and routed onto a high-capacity backbone network. This work package covers the design of the time and frequency reference systems and the array-internal fibre-optic network topology and communication protocols.

Overall Project summary

The work needed for the Work Package was initially underestimated. Its total more than doubled in the May 2008 Project revision. The work was completed as planned.

4th Reporting Period progress

1.3.12.1 EISCAT

The tasks initiated in the previous reporting periods were completed and the design goals were verified to the extent possible. The two reports, D12.1 and D12.2, were delivered.

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
D12.1	EISCAT_3D Radar Time, Frequency and Synchronisation Subsystem Report		LTU	1 May 2007	9 Dec 2008
D12.2	EISCAT_3D Radar Array Networking / Communication Report		EISCAT	1 June 2007	6 April 2008

1.3.13 Work Package 13: Enabling Procedures

Contractors and deployed human effort

Participant number	**1**	**2**	**3**	**4**	**5**	
Participant short name	EISCAT	UIT	LTU	RAL/STFC	IRF	Total
Person-months	1.41				0.65	2.06

Objectives (May 2008 project plan)
This Work Package addresses issues related to the preparations for the next phase of the EISCAT_3D project in so far as they are relevant to the Design Study. As the Design Study progressed during the first intervals it became clear that some planning and preparation related to actual potential build sites would be required to illuminate the design study itself, particularly in the latter stages, as well as further preparatory work supporting the construction of the final reports.

Overall Project summary

This Work Package was included in the project with the May 2008 project revision. It had two main objectives, site locations (land), and frequency allocation. The second was moved from WP1, Project Management, into this Work Package.

Most of the site location work was done already in 2005 as preparatory work for WP2, Evaluation of design performance goals, whereas the frequency matters have been an ongoing activity.

The site location work was done by EISCAT staff and the frequency allocation duties were handled by the Technical Project Leader, from early 2008, at IRF.

The frequency allocations work could not be completed before the project ended. A preliminary agreement with the Norwegian authorities was concluded whereas the Finnish and Swedish authorities were not ready to commit yet.

The frequency allocation requirements will be discussed on Ministry level discussions between Sweden, Norway and Finland at a future Nordic Council of Ministers meeting probably later in 2009.

4th Reporting Period progress

1.3.13.1 EISCAT

The findings from 2005 and follow-on investigations were formulated in deliverables D13.1, D13.3 and D13.4.

1.3.13.5 IRF

The Technical Project Leader organised meetings with authorities in Norway, Finland and Sweden and attended forums in Europe. The finding have been summarised in deliverable D13.5 (only a status report).

Milestones or deliverable achievements scheduled for this reporting period

Deliverable/ Milestone No	Deliverable/Milestone Name	Workpackage /Subtask No	Lead Contractor(s)	Planned (in months)	Achieved (in months)
Month 38	Frequency spectrum negotiations completed; draft agreements and frequency allocations available		IRF	Month 38	Not achieved
Month 43	Drafts of D13.1-4 available		EISCAT	Month 43	Month 47
D13.1	Additional input materials related to the preparation of the Final Design Document		EISCAT	2 March 2009	16 April 2009
D13.2	Review of potential or actual funding sources, due 2 March 2009		EISCAT	2 March 2009	Cancelled (moved to D1.5)
D13.3	Review of steps necessary to procure use of realistic potential EISCAT_3D sites in northern Scandinavia		EISCAT	2 March 2009	16 April 2009
D13.4	Review of other issues affecting the possibility to move to the next stage of the project (e.g.: Preparation for build, Build, and Operations & Maintenance)		EISCAT	2 March 2009	3 April 2009
Month 48	Frequency allocation agreements opened for signing; firm frequency allocations made.		IRF	Month 48	Not achieved
D13.5	Agreements between EISCAT and the regulatory bodies in Sweden, Norway and Finland for protected frequency allocations in all three countries, valid from 2009 until at least 2020 with options for extension		IRF	30 April 2009	Report * 30 May 2009

* Since formally agreements with the regularly bodies could not be met before the project ended, D13.5 is rather a report of the work done and status at the end of the project.

2. List of deliverables

Consolidated list of all deliverables planned and/or achieved during the reporting period

Task number	Deliverable No **[sort order]**	Deliverable Name	Workpackage /SubTask No	Delivered by Contractor(s)	Planned (in months)	Achieved (in months)
WP1	**D1.4**	Annual Design Study Progress Report + Annual Financial accounting Report, including Audit Certificates (1)		EISCAT	Month 48 + 1.5	16 June 2009
WP1	**D1.5**	Final Report of the EISCAT_3D Design Study		EISCAT	Month 48 + 1.5	16 June 2009
WP3	**D3.2**	EISCAT_3D Radar Active Element Subsystem Report		IRF	3 Nov 2008	2 Feb 2009
WP4	**D4.2**	Receiver/Receiving Antenna Subsystem Report issued		LTU	1 April 2009	30 May 2009
WP5	**D5.3**	EISCAT_3D Radar Multidimensional Imaging Radar Data Visualisation Report		UIT	15 Jan 2009	12 March 2009
WP6	**D6.1**	Active Element Interim Report		IRF	15 Dec 2008	4 Feb 2009
WP6	**D6.2**	EISCAT_3D Radar Active Element Subsystem Design Document		IRF	1 April 2009	30 May 2009
WP7	**D7.1**	Basic set of control and monitoring software primitives for the WP4 Demonstrator		EISCAT	5 Nov 2007	12 March 2009
WP7	**D7.2**	EISCAT_3D Radar Control and Monitoring Subsystem Report		EISCAT	5 Nov 2007	15 March 2009
WP8	**D8.3**	Complete low-level specification of data storage system, including system design, proposed technical solutions, identification of appropriate hardware and technology with specific manufacturer details and pricings		RAL/STFC	30 April 2008	10 Sept 2008

WP8	**D8.4**	Study of extensions to data system required to handle supporting instruments clustered around the EISCAT-3D radar. Specification of how such data could be combined with the radar data to produce value-added products, and use cases to illustrate the value of the combined data		RAL/STFC	30 Sep 2008	9 March 2009
WP8	**D8.5**	Specification of the access layer, with descriptions of data products being transferred into and out of the data system, the user functionality required to handle these, and the necessary interfaces with the sub-systems being designed in other work packages		RAL/STFC	2 Feb 2009	30 Jan 2009
WP8	**D8.6**	EISCAT_3D Competed design studies for raw and analysed data visualization		UIT	31 March 2009	24 May 2009
WP9	**D9.1**	Basic set of processing primitives required for the operation of the WP4 demonstrator		EISCAT	3 Nov 2008	17 April 2009
WP9	**D9.2**	EISCAT_3D Radar Signal Processing Subsystem Report,		IRF	2 March 2009	5 June 2009
WP9	**D9.3**	Report presenting algorithms and evaluations (using simulated data) for subspace tracking and Bayesian estimation of polarisation orientation in low-SNR applications		LTU	2 March 2009	17 May 2009
WP9	**D9.4**	Manuscript on Estimation of 2x2 Complex Covariance Matrices in low-SNR Situations submitted to IEEE Transactions on Signal Processing		LTU	2 March 2009	17 May 2009
WP9	**D9.5**	Report extending the above-derived techniques to adaptive applications		LTU	2 March 2009	17 May 2009
WP10	**D10.6**	Feasibility Study report: Global Change studies implications for EISCAT_3D		UIT	1 Sept 2008	2 May 2009
WP11	**D11.1**	EISCAT_3D Radar Final Design Study document		RAL	15 April 2009	8 June 2009
WP12	**D12.1**	EISCAT_3D Radar Time, Frequency and Synchronisation		LTU	1 May 2007	9 Dec 2008

		Subsystem Report				
WP12	**D12.2**	EISCAT_3D Radar Array Networking / Communication Report		EISCAT	1 June 2007	6 April 2008
WP13	**D13.1**	Additional input materials related to the preparation of the Final Design Document		EISCAT	2 March 2009	16 April 2009
WP13	D13.2	Review of potential or actual funding sources, due 2 March 2009		EISCAT	2 March 2009	Cancelled (moved to D1.5)
WP13	**D13.3**	Review of steps necessary to procure use of realistic potential EISCAT_3D sites in northern Scandinavia		EISCAT	2 March 2009	16 April 2009
WP13	**D13.4**	Review of other issues affecting the possibility to move to the next stage of the project (e.g.: Preparation for build, Build, and Operations & Maintenance)		EISCAT	2 March 2009	3 April 2009
WP13	**D13.5**	Agreements between EISCAT and the regulatory bodies in Sweden, Norway and Finland for protected frequency allocations in all three countries, valid from 2009 until at least 2020 with options for extension		IRF	30 April 2009	Report 30 May 2009

(1) This document

Achieved Deliverables (in bold above) are collected in Annex 3.

3. Use and dissemination of knowledge

Fourth (P4) reporting period

Conference presentations resulting from the project

Date	Title/subject of meeting /workshop	Location	Website address
16 – 19 Sept 2008	ION GNSS 2008: A Picosecond Accuracy Timing System Based on L1-only GNSS Receivers for a Large Aperture Array Radar	Savannah, Georgia, USA	www.ion.org/meetings/gnss2008program.cfm
27 – 30 Oct 2008	International Symposium on Antennas and Propagation: Performance of a Yagi antenna during snowfall	Taipei, Taiwan	www.isap08.org
9 – 10 Dec 2008	Fifth European Conference on Research Infrastructures (ECRI): ESFRI Roadmap	Versailles, France	www.ecri2008.eu
19 – 24 April 2009	EGU General Assembly: EISCAT 3D - The Next Generation European Incoherent Scatter Radar System	Vienna, Austria	http://meetings.copernicus.org/egu2009/

Patentable discoveries resulting from the project
None

Publications resulting from the project
A complete list of publications is included in Deliverable D11.1:
www.eiscat.se/groups/EISCAT_3D_info/Deliverable_D11_1.pdf

Public Relations in connection with the project
In addition to presentations at formal conferences and workshops as already detailed, particularly the ESFRI roadmap inclusion was covered both in national and international TV, Radio and press coverage.

Web-based activities in connection with the project
All-year: The project web-site has been constantly updated and the follow-on, www.eiscat3d.se, was launched.

Other actions in connection with the project

Date	Title/subject of meeting /workshop	Location	Website address
27 – 28 May 2008	EISCAT Council meeting, review of EISCAT_3D project	Kiruna, Sweden	Internal meeting
2 – 3 Sept 2008	EISCAT Scientific Oversight Committee, presentation of EISCAT_3D project	Uppsala, Sweden	Internal meeting
30 – 31 Oct 2008	EISCAT Council meeting, review of EISCAT_3D project	Kunming, China	Internal meeting
26 – 27 March 2009	EISCAT Scientific Oversight Committee, presentation of EISCAT_3D project	Kühlungborn, Germany	Internal meeting

Caption: Artistic impression [angle-shot #3] of an EISCAT_3D multi-static phased array system

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