

ASSIGNMENT DESCRIPTION

Title of tender	Borehole Measurements Feasibility phase Einstein Telescope EMR
Document number	P2.1_042_V1.0

1. Introduction

Introduction project Einstein Telescope

The Einstein Telescope will be an advanced observatory for gravitational waves. The border region of the Netherlands, Belgium and Germany is in the picture as a possible location. This is because of its tranquility, stable soil, and strong ecosystem of knowledge institutions and high-tech companies.

Researchers, companies and governments in the Netherlands, Belgium and Germany are jointly exploring the possibilities. The ultimate goal is to build the Einstein Telescope in the Meuse-Rhine Euroregion. For more info see <https://www.einsteintelelescope.nl/en/>.

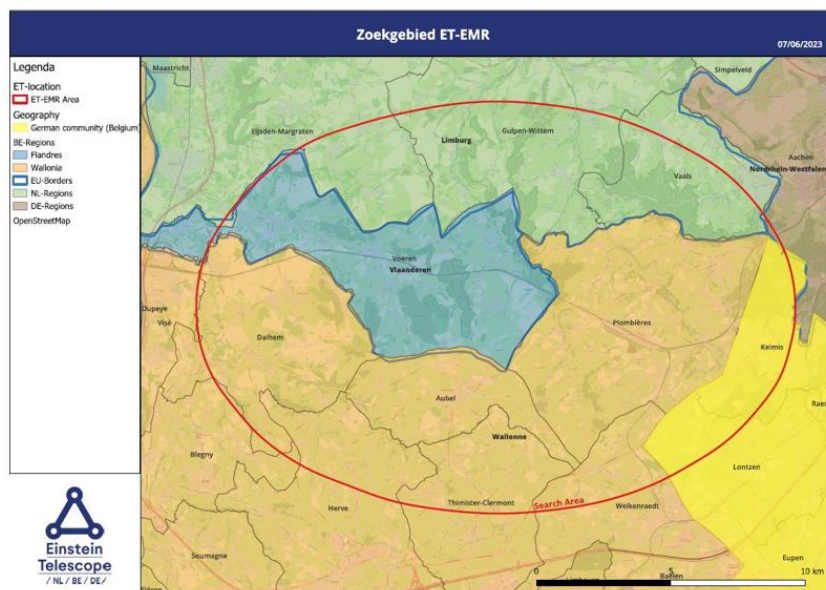
Project office ET

The Project Office ET, based in Maastricht, is carrying out a feasibility study, resulting in a contribution to the bid book, on the basis of which a final choice of location for the Einstein Telescope will be made. This phase includes activities within various disciplines (project management, contract management, technical management, environmental management, project control). The management of the project office is conducted jointly by the delegated principal on behalf of the Province of Limburg and the director of Nikhef.

Planned drilling

In the period Q4-2023 to Q2-2024, 10 borings are planned in the search area. Of these borings, the approximate location is known. Based on the results of the first set of borings, a second set of up to 10 borings is planned in the search area in the period Q3-2024 to Q3-2025.

The measurements to be taken will be definitively determined during the respective drilling. It is expected that the measurements requested in this tender should be carried out in 5 to 15 boreholes during the said period.



Boreholes

Depths 1st set of boreholes

- 8 boreholes depth = 250 m
- 1 borehole ~ 350 m
- 1 borehole ~300 m

The 2nd set of boreholes will be comparable.

Safety

The contractor is responsible for the safety, health and resulting certification of its company and its employees. The employer must take the necessary measures according to the European Agency for Safety and Health at Work and the local safety and health regulations.

Equipment

All materials and equipment used shall be regularly tested and inspected and maintained in good condition in accordance with safety regulations. Bolts of packers should be in good condition and are able to carry the weight and friction stresses while pulling up.

All probes and sensors must be calibrated and the relevant calibrations have to be submitted to the client on site (on request). In addition, copies of the probe characteristics and calibrations must be provided for documentation purposes. Calibrations must be attached to the measurement report for documentation purposes.

General info / requirements

Requirements	
Maximum fluid pressure	50 Bar
Maximum temperature in borehole	35 degrees Celcius
Power supply	Available infrastructure to be provided by contractor, drillcrew onsite for support. So a generator and a drill rig are normally on-site. So we advise you to cooperate with the drill company.
Water supply	Clear clean water supply Volume = 1000 liter. Tubes, couplings, please contact the drilling company on site.
RIH/POOH-system	A RIH/POOH system non dependable on the drill-crew is advised. If not feasible please contact the chief of the drill-crew and the client since this has implications for their crew planning and our costs.
Core and logging results	These define the test intervals
Crew	• Crew has at least one year experience in performing these tests; • Crewmembers have a background in geohydrology and/or geomechanical engineering and/or geology or geophysics. • Crewmembers are able to solve technical issues on site. • Crewmembers have fully understanding what they are measuring and can address mistakes immediately, e.g. when measuring the

	wrong interval and be able to calculate the actual measured interval. • Crewmembers are able to check with quick calculations whether measurements are realistic.
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Geology

Sandstones, siltstones, mudstones, limestones and dolomites occur in the working area. The different rock rock units have different brightnesses, which were determined at different outcrops (Table). It is possible that two rock units with strong contrast follow each other. Due to the geological situation, not all lithologies are likely to be encountered at the different drilling locations.

Lithology	remarks
Shales, siltites, not well cemented sandstone	Performed test have shown high permeability values
Limestone	Very likely to be karstified
Dolomite/Limestone	Very likely to be karstified
Sandstone, small limestone layers	Parts might be quartzitic
Shales	
Limestone	

Inclination: vertical

Borehole diameter: ~100 mm (as geological conditions may require different diameters, because the boreholes might be telescoped so the measuring system must be adaptable to borehole diameters up to 178 mm).

Tests provided by Client

The Client will provide results of measurements that will be carried out just before the hydrotests:

- Optical televiewer scan;
- Acoustic televiewer scan;
- 3-component magnetometer log;
- Natural Gamma Log;
- Spectral Gamma Log;
- Gamma-Gamma Log (for density determination);
- Full-Wave velocity Log (p- and s-wave velocities);
- Inflow/outflow measurements, including temperature and conductivity;
- Formation resistivity log.

2. Assignment

The assignment consists of:

- Services (2.1)

2.1. Services

As the wells are scientific exploratory wells, a high quality and resolution of the data obtained is expected. The tests are expected to yield the following findings be gained:

- Hydrogeological parameters (permeability, transmissivity, hydraulic storage properties)
- Stress field tensor (σ_h , σ_H , direction of principal stresses).

The planned test campaign will consist of hydraulic tests, including pumping and slug/pulse tests (both injection and extraction), as well as hydraulic fracturing (HF) and/or hydraulic pre-existing fractures (HTPF). The tests are carried out in the uncased well (prior to the completion of the borehole).

2.1.1. Hydraulic pump and slug/pulse tests

Service	Hydraulic pump and slug/pulse tests	
Description	Due to the uncertainties of the geological conditions, it is imperative to provide test interpretations and preliminary test results on site or on request, including the possibility of a short-term adjustment of the test sequence. The hydraulic campaign for each well comprises 10 to 15 pump and slug/pulse tests at 5 to 20 m intervals. The client expects and takes into account the advice of the Contractor's experts regarding the test locations, the length of the interval and the sequence of the tests. And the tests will be performed after the borehole logging visual et cetera is done. The intervals will be selected based on the logged data, the cores and maybe events during drilling. The required system for the hydraulic test campaign includes: • At least one double packer system with separate control valve for inflating/deflating of each packer. • It must be possible to test in a single packer configuration as well. • flexible interval length between 5 and 20 m • The monitoring system must allow for continuous data (available online) of pressures and temperatures in every interval: i.e. below the lower packer, in every interval between the between packers and at two positions above the upper packer. Pressures up to 50 bar can be expected. Monitoring of the packer pressures is not required, but is favoured. An online transmission frequency of at least 1 Hz is required. For checking the raw data must be transferable during the test run or shortly afterwards. • An in-hole pump	
Planning	Q4-2023 – Q3-2025 (the contractor will be informed 2-4 weeks before the planned measuring operation; mobilisation must be possible within 48 hours).	
Permits and access	All basic permits necessary for the execution of the work (e.g. access to property, access) shall be obtained by the Client. The client shall ensure free access to the borehole. All boreholes are accessible by a 4 x 4 vehicle.	
Requirements	1	1st set of borehole tests: Survey distance in borehole • 8 boreholes: 180~220 m • 1 borehole Henri-Chapelle : 320 m

		1 borehole 160 m Vijlenerbos Diameter: can differ depending the location and depth: PQ, SQ HQ 8 to 10 tests per borehole 2nd set of boreholes will be comparable.
	2	Constante pumping rate pump tests : Max drop = 100 m by Q= 0,01 to 1 m³/h Puls slug tests: Like extracting or adding value, see constant pumping rate test
	3	Equipment: The hydraulic tests shall be carried out with a straddle packer system that is suitable for borehole depths of 250 m. The equipment shall allow for testing in a single packer configuration. In the double (or higher) configuration, all packers can be separately inflated with a test interval with a flexible length between 5 and 20 m. A perforated filter segment located above the lower packer allows inflow/outflow to/from the interval. Continuous downhole pressure monitoring is required below, within and at two points above the test interval: one pressure observation point is inside and one outside the boom, inside and one outside the rod above the upper packer. As far as redundancy is concerned an additional pressure recording with an autonomous logger is required within the test interval. It is favored to record the packer pressures with pressure transducers at the surface. Continuous recordings of the borehole temperatures are required at the same locations, where the borehole pressures are observed. With the exception of the redundant interval pressure all data logging must take place online and must be carried out at the surface with an automatic data-acquiring system that makes a quick real time analyses possible on-site. A displacement-free valve must allow the hydraulic connection to the interval to be opened and closed. Maximum flow rates in combination with a 3" submersible pump integrated in the test pipelines must thereby be possible. Water extraction: 1. A submersible pump is required for the constant rate pumping/removal test. The pump must be integrated into the test pipe and meet the following minimum specifications: Flow rate 0.01 to 1 m³/h, head 100 m. 2. A suitable tool (swabbing tool) is required to discharge liquids from the test rod in order to initiate the flow from the reservoir, e.g. for a slug/pulse or withdrawal test. The swabbing tool must generate approximately 100 m of water column per lift. The downhole system shall include the following safety devices in case the system blocks in the borehole: 1. A separate downhole valve is required to release packer pressure at depth if the packers cannot be sufficiently drained by opening the packer lines at the surface, e.g. when the water level in the borehole is low. It may be necessary for the packer filling fluid to contain antifreeze for packer operation in winter. It is not allowed to deposit such chemicals in the borehole. 2. A safety connection in combination with a suitable adapter is required if the downhole system is blocked after the packer pressure has been released using safety measure no. 1 in the borehole. The safety connection must allow the recovery of the cables and lines, the submersible pump and the test hose. The adapter shall allow connection to drilling / suitable rods so that POOH is possible with the maximum pulling force of the drilling rig / drilling / suitable rod. The minimum requirements for the surface equipment system shall include a flowboard with electronic flow meters covering a flow range between 0.1 and 100 l/min and water temperature measurements. It is preferred that the packer pressures are measured with pressure transducers. In addition, it is necessary to measure the barometric pressure variations and the ambient temperature. All measurements shall be recorded in the central automated data acquisition system, which shall be operated in a secure location (trailer or office container) where the real-time test data

		is recorded and analyzed to allow control of the tests and timely adjustments to the test configuration required to improve test quality and optimize test time. The recorded data must be automatically backed up within regular time intervals (at least every 15 minutes). Minimal requirements equipment, hydraulic testing: • Packer configuration: Min. one double-packer system (multiple-packer configurations can be useful); • Range test intervals: 5-20m; • Packer: Inflatable, each packer individually, minimal 1 m sealing length, differential pressure min. 50 bar, Operating liquid: water; • Shut in Valve: Hydraulically controlled valve for opening and closing of the test interval; • Filter: Sand filter screen, filter screen size 1'500 mm / 500 mm; Openings 0.5 mm (0.02"); • Safety connection/connection: Salvage of the material, SIT, cables/lines, submersible pump and experimental rods; adapter for adapter must be able to be connected to the drilling be able to be connected to suitable hoists; • Submersible pump: Integrated in the pipe string for hydraulic tests, for further specifications see Table 3 (additional equipment for periodic pumping tests is favored), Approximately 100m water column per stroke; • Swabbing tool / Test rods for the hydraulic tests: Certified, waterproof, tensile strength up to 28 ton (T); • Sensor measurements: Pressure and temperature in the borehole at 4 different locations (below/inside/2x above the interval), including redundant pressure monitoring of the interval Accuracy: min +/- 0.01 %FS, resolution < 0.001 %FS; • In hole system: Tensile strength up to 12 (To.); • "Flow board" for monitoring and control of the experiments: Various flow meters that have a flow range between 0.1 and 100 l/min. cover. Water temperature measurement; • Packer pressure control panel (not mandatory but favored): Packer pressure measurement and recording for both Packer. Pressure vessel for constant packer pressure; • Automatic Data acquisition system: Recording rate at least 1 Hz, possibility of possibility of increasing recording rates to at least 10 Hz is favoured, real-time data plots, automatic backup data storage; • Monitoring of the barometric pressure: High-resolution sensor for atmospheric pressure. Measurements recorded with the automatic data recorded measurements. Minimum spec: range 800 - 1200 hPa Accuracy 0.02%FS, resolution 0.002%FS; Ambient temperature monitoring: High-resolution atmospheric temperature sensor. Measurements recorded with the automatic data recorded measurements. Minimum spec: range -30 - 50°C, accuracy +/- 0.15 °C at 0 °C, Resolution 1.5E-03 °C.	
To be delivered	1	Presentation, explanation on site: Graphs, based on preliminary (analytic calculated) analyses and RAW-data	
	2	Report: • Detailed description of the instruments and testing methods, and field experience. • Plots of graphs that show the results in a comprehensive manner. Mentioning geological conditions at measured depths in the graphs.	

2.1.2. Hydraulic fracking tests

Service	Hydraulic fracking tests	
Description	The hydraulic fracking tests will be carried out after the hydraulic tests. The positions and sequences for the tests will be determined in cooperation with the Client and are based on the results of the hydraulic tests in combination with the available logging protocols. As this is a scientific test campaign, the AG is relying on the expert advice of the Contractor regarding the test procedures, the number of tests and the tested borehole section and the section of the borehole to be tested with a flexible interval length. The required system for the hydraulic fracking tests shall include: • A double packer system; the use of a wireline system in combination with a hydraulically stiff test system is mandatory. • Flexible interval lengths up to 10 m. • The monitoring system must allow continuous data (available online) of the pressures in the interval between packers. A back-up system in the borehole for these measurements is recommended, but not necessary, if the system ensures an error-free collection of data. Monitoring of packer pressures is not required but is favored. A data frequency of at least 10 Hz is required. The raw data must be transferable during or shortly after the test. • Oriented impression packer system to measure the angle and direction of incidence of all induced fractures.	
Planning	Q4-2023 – Q3-2025 (the contractor will be informed 2-4 weeks before the planned measuring operation; mobilisation must be possible within 48 hours).	
Permits and access	All basic permits necessary for the execution of the work (e.g. access to property, access) shall be obtained by the Client. The client shall ensure free access to the borehole. All boreholes are accessible by a 4 x 4 vehicle.	
Requirements	1	1st set of borehole tests: Survey distance in borehole • 8 boreholes: 180~220 m • 1 borehole Henri-Chapelle : 320 m • 1 borehole 160 m Vijlenerbos Estimated amount of test per borehole HF/HTPF impression packer test: 8-10 tests 2nd set of boreholes will be comparable.
	2	Equipment: The equipment required for the hydraulic fracking tests consists of a straddle packer configuration suitable for wells up to 250 m deep. The use of a hydraulically stiff wireline system is preferred. Due to the geological conditions, the length of the test interval can be extended up to 10 m. The pressure within the interval is measured using a downhole pressure transducer with a minimum accuracy of 0.05 MPa and a minimum sample rate of 10 Hz. In addition, a surface pressure transducer with an accuracy of 0.05 MPa and a flow meter with a minimum accuracy of 0.1 l/min and a suitable measuring range are required. Measuring the outflow from the system in real time while depressurizing the interval or packers is considered the preferred option. Monitoring the packer pressure is also preferred. All

		monitored data requires a digital data acquisition system that allows real-time data storage and visualisation with a minimum sampling rate of 10 Hz. On the surface, an electrically driven multi-piston pump with sufficient power for the hydrogeological conditions is required to ensure a constant flow rate (minimum range of possible constant flow rates from 1 to 10 l/min). Upon completion of a test cycle, an oriented footprint packer test of the tested section is required, including a printout of the footprint on an enveloping plastic sheet.
To be delivered	1	Presentation, explanation on site: Graphs, based on preliminary (analytic calculated) analyses and RAW-data
	2	Report: - Detailed description of the instruments and testing methods, and field experience. - Plots of graphs that show the results in a comprehensive manner. Mentioning geological conditions at measured depths in the graphs.