

# Directional Steel Shot Drilling for High Temperature Geothermal Wells

Projectnumber: DEI124068, Date of this report: 8 April 2026

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## Summary of project and the parties involved

### Starting point

Geothermal energy can play a much greater role as a sustainable contribution to the global energy mix. This is stated in a recent report (2023) by the International Renewable Energy Agency (IRENA) and the International Geothermal Association (IGA).

Canopus progressed the development of directional steel shot drilling (DSSD) technology for the development of low-cost geothermal reservoirs through a HER+ grant. Current DSSD technology can drill horizontally or with a curve up to reservoir temperatures of around 85°C (3000m TVD), limited by the operating threshold of conventional electronics.

Since a successful field trial, there has been significant market interest for advanced DSSD technology allowing for accurate well trajectory adjustments at greater depths. Higher temperature operations necessitate advanced techniques, which require different functionalities and modes of operation. A straight-forward component replacement isn't feasible.

Canopus aims to meet this demand with high-temperature (175°C) DSSD technology for geothermal projects, enabling faster and deeper drilling into hot reservoirs.

### Project objective

The project focuses on developing a high-temperature electronic architecture and complementary mechanical construction to achieve precise directional control. The precise directional control will be employed for an advanced magnetic ranging system enabling accurate well interception at larger depth. Traditional magnetic ranging tools require specialized equipment and wireline runs, relying on cumbersome surface communication and data interpretation at surface. Our novel system utilizes the 6-axis magnetometer existing in the downhole DSSD tool for autonomous directional adjustments by autonomous data interpretation as part of the tool logic.

The system has the potential to achieve remarkable precision to ensure successful well interception. The high precision is realized by a combination of fast and precise directional changes, a unique feature of the DSSD system, and fast and precise updating of the interception target location in a closed-loop downhole procedure. The true innovation is the system's ability to autonomously adapt target coordinates during drilling in combination with fast response and steering, eliminating the need for wireline runs and surface communication, reducing costs and enhancing efficiency.

### Description of activities

Work activities include the development & testing of the downhole electronic system. A shallow pilot will demonstrate the ability for well tracking and intersection:

Work Package 1&2) Development & manufacturing (Canopus): Design of the architecture for the steering sub and system development. An embodiment of the high-T electronic architecture will be developed as well as the actuator, particle sensors, wiring and the drilling fluid flow passages.

**Developments in the reporting period:** Canopus engaged, a technology company with extensive expertise in mechanical engineering, to support the embodiment of the steering sub.

Canopus built their flow loop at their site in Delft. This allows the testing of the functionality of the steering sub and electronics at our own location. The temperature will be ambient, and the pressure will not match the actual down hole conditions. But the impact of temperature (increased noise) can be simulated.

Canopus also did other preparatory work.

**Work executed:**

- Building of the flow loop.
- Assessment of development and supply companies for HT electronics. Assessment of additional downhole tool supply companies (telemetry, MWD).
- Review of existing downhole systems (with ext. Partner). Preparation of fluid dynamic and mechanical modelling for HT upgrade. Defining design considerations of the HT sub.
- Selection of HT electric components (e.g. robust motor). Contracting of selected supply partner in March 2026.

Work Package 3) Testing (TNO RCSG): Testing of the high-T steering sub prototype to deliver the steering action for the operational windows of pressure, flow rate, particle concentration and drill string RPM.

**Work executed:**

- Preparation of testing with TNO.

**Main challenge:**

- Availability of personnel

Work Package 4) Development of steering sub interface to steer autonomously to relevant directional target sources (Canopus & TNO RCSG): Relevant directional objectives may come from pre-programmed spatial coordinates, localized magnetic beacons or geological properties.

**Work executed**

- Assessment of current magnetic ranging systems.
- Concept development of DSSD integrated ranging device.

Work Package 5) Shallow Pilot (Canopus): By drilling two shallow laterals, the steering capability and well intersection of a high-T DSSD-assembly can be tested at low cost while disturbing the electronics with high-T noise

Work Package 6) Developing next steps and reporting (Canopus): Planning phase for follow-up after the DEI+ pilot, where a deep field test/demonstration is planned.

**Expected outcome**

DSSD technology revolutionizes geothermal energy by enabling the creation of highly productive multi-lateral structures that were previously uneconomical for geothermal plays. By replacing fossil fuel-based heating solutions, DSSD significantly reduces CO<sub>2</sub> emissions. By extending its capabilities the DSSD tool will reach deeper resources and a wider range of geothermal plays where the need for multi-lateral structures is even higher to address challenges of low productivity due to low permeability. Moreover, the capability extension towards deep closed-loop well construction will open a new market for DSSD technology and enable more cost-effective construction of advanced geothermal systems.

This project will deliver advanced 175°C temperature rating DSSD technology allowing for accurate well trajectory adjustments. Additionally, it includes a plan for subsequent development, with the next step being the demonstration of high-temperature DSSD technology in deep field tests.

Following successful tests in shallow wells several have indicated that they are eager to implement this innovative technology in deeper, more challenging formations, leveraging Canopus' directional drilling capability expertise.

*The project is being executed with a subsidy from Topsector Energie from the Ministry of Internal Affairs ("Binnenlandse Zaken en Koninkrijksrelaties"), on the basis of the following scheme: "Regeling nationale EZK-en LNV-subsidies", which is being executed by Netherlands Enterprise Agency ("Rijksdienst voor Ondernemend Nederland")*