



Ice Drilling Program Office

Dartmouth – University of New Hampshire – Colorado School of Mines

DOCUMENT IDENTIFICATION	
Title:	SCIENCE REQUIREMENTS V2: Foro 3000 Drill
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DOCUMENT APPROVAL	
Science Community:	Eric Steig, T.J. Fudge, Ryan Bay, Robert Hawley
IDPO:	Mary Albert

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1	Final	April 20, 2017	T.J. Fudge, E. Steig, E. Brook
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Science Requirements: *Foro 3000 Drill*

Background:

The IDPO Science Advisory Board identified in the IDPO Long Range Science Plan 2016-2026 a need to investigate adaptation of an existing drill to minimize logistical requirements and time on site for deep ice coring. The first requirements were finalized on April 20, 2017. In consideration of replicate coring capability for the *Foro 3000*, from discussions organized by IDPO with iterative discussions between IDPO, scientists, and IDDO staff, the following are the updated science requirements for the *Foro 3000* drill:

Scientific Requirements

1. **Target depths: from the surface to 3,000 m depth**
2. **Ice core diameter: 98 mm +/- 3mm**
3. **Minimum core length: Core length per run should be designed to facilitate drilling to 3,000 m in three field seasons (assuming 40 drilling days each season with 24-hour operations).**
4. **The drill should be operable in ice temperatures from -53° C to 0°C.**
5. **The surface equipment should be operable in ambient temperatures from -40° to +5° C.**
6. **Transport type: prefer Hercules LC130 or ground traverse**
7. **Drill should be compatible with existing fluids Isopar K and Estisol 140; compatibility of other fluids would be vetted by the science community prior to use**
8. **Core quality requirements:**
 - a. **Core recovery over the entire borehole, as close as possible**
 - b. **Ice pieces to fit together snugly without any gaps**
 - c. **In non-brittle ice, the packed core should have no more than 12 pieces of ice per 10 m section of core**
 - d. **In brittle ice, there may be a lot of pieces in a single core segment, but the pieces must fit together, retaining stratigraphic order; more than 80% of the ice volume must be in pieces that each have a volume > 2 liters**
9. **Absolute borehole depth measurement accuracy: 0.4% of depth**
10. **Borehole inclination should be less than 6 degrees.**
11. **Drill design and electronics should be forward-compatible with a future replicate coring and deviation system capable of deploying a removable and oriented whipstock to preserve the full borehole logging record.**
12. **The drill will be a complete system which includes a drilling structure and ice-core processing equipment. The drill structure will be appropriate for moderate accumulation rate sites (<15 cm per year), recognizing that specific sites may require additional specifications. Additional logistical equipment is permissible for drill site set-up and tear-down, for example a tractor with 3,000 lb. fork capacity for moving**



equipment and bucket or snow blower for drill trench excavation and site maintenance.

Scientific Features desired but not required

- 1. Ability to break multiple 1-m sections during a drill run to reduce the need to cut brittle ice at the surface.**
- 2. Ability to measure inclination of borehole and azimuth of drilled cores**
- 3. Ability to replicate core with a removable or drillable whipstock. Deviation drilling would preferably occur on the uphill side of the borehole to allow passage of logging tools in the main borehole.**

Discussion:

1. This drill is part of a family of drills of similar design, including the Foro drill, the Intermediate Depth Drill (1800 m), and this Foro 3000 would be a version optimized for 3,000 m depths.
2. The maximum drilling duration of 3 years for 3,000m assumes 120 total drilling days (estimated 40 per season), and does not include site set up, drill installation, take out, etc.
3. It is desired that the Foro 3000 drill could be used at a different deep site using most if not all of the existing components, and without need for a major re-design.
4. For consideration for deeper drilling: Extending the winch capacity from 3,000 to 3,500 m will add an estimated 400 lbs to the system, of which 250 lbs. is for the extra cable. The winch drum would need to be 4" wider, going from 24" between flanges to 28", to hold the extra 500 m of cable. At 3,000 m depth there is 11.9 kN pulling force available for breaking the core and that drops to 11.1 kN at 3,500 m. This is currently limited by the breaking strength of the cable. For drilling to depths of ~ 3,500 m, only the winch and the cable would need to be changed for the Foro 3000.
5. For the logistical equipment needed on site, a tractor with forks capable of lifting 3000 lbs. is required for movement of pallets and drill fluid. A tractor with a bucket or snow blower attachment is needed for excavation of the drill trench and core storage area. The drill system could be installed and maintained with lesser equipment, however it will increase the setup and take down time and put people at a higher risk of injury. How ice core pallets are handled and loaded on aircraft, and in general how cargo is going to be loaded and off loaded from aircraft, may be a bigger determining factor on what size piece of equipment is required.
6. Core packaging materials (tubes, boxes, straps) and transportation materials (pallets, blankets) shall be provided by the logistics provider.