



# Ice Drilling Program

Dartmouth – University of Wisconsin - University of New Hampshire

DOCUMENT IDENTIFICATION	
Title:	<b>SCIENCE REQUIREMENTS: 700 Drill</b>
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DOCUMENT APPROVAL	
Science Community:	Osterberg, Kreutz, Kurbatov
IDP:	Albert

REVISION HISTORY (maintain last 3 versions)			
REV	DESCRIPTION	DATE	APPROVAL
1	Final Foro 700 requirements	3-30-2018	Kreutz, Osterberg, Kurbatov
2	Final 700 Drill requirements	5-11-2020	Kreutz, Osterberg, Kurbatov
3	Final 700 Drill requirements	1-10-2021	Kreutz, Osterberg, Kurbatov



## Science Requirements: 700 Drill

### *Background:*

The IDP Science Advisory Board identified in the IDP Long Range Science Plan 2015-2025 and later, a priority need to alter the surface equipment for the existing Intermediate Depth Drill in order to make a drilling operation that is less logistically intensive, to be used for alpine or polar ice coring at sites with limited logistics and with two months or less time on site. In continuing discussions, it became evident that a smaller diameter core would result in significant logistical savings. From discussions organized by IDP with iterative discussions between scientists, and IDP staff, the following are the science requirements for the 700 Drill:

### Scientific Requirements

1. **Target depths: from the surface to a potential maximum of 700 m depth**
2. **Ice core diameter: 70 mm initially, with potential future adaptation for 64 mm core.**
3. **Core length: 1 m**
4. **The drill should be operable in ice temperatures down to -25 C.**
5. **The surface equipment should be operable in ambient temperatures from -20 to +5 C .**
6. **All electrical connections and control boxes should be sealed to function well in environments with high levels of humidity, e.g. Antarctic Peninsula.**
7. **The anti-torque and motor sections should be compatible with use for a 64 mm core diameter, but the initial drill should have a barrel for a 70 mm core.**
8. **Air transport type: Bell 212 or similar helicopter and/or Twin Otter**
9. **Drilling fluid: drill should be compatible with existing fluids, e.g. Isopar K, Estisol 140**
10. **Maximum field project duration: 2 months on site with at least 40 days of production drilling. Target core recovery is 700 m within a single ~ 60-day field season.**
11. **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 ~1 m core segment, but the pieces must fit together and retaining stratigraphic order.**
12. **Absolute borehole depth measurement accuracy: 0.2% of depth**
13. **Field set-up time: the system should be able to be set up with no more than five persons with limited logistics (i.e. no heavy equipment), including surface infrastructure and any core handling/processing setup**



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14. Core processing equipment will be included with the drill system.
15. Core packaging materials (tubes, boxes, straps) and transportation materials (pallets, blankets) shall be provided by the logistics provider.
16. The core will be transported from the site in the same season it is drilled.
17. System should include the capability to bail fluid from the borehole
18. Borehole should accommodate logging instruments after ice coring is complete.
19. Drill system should be operable with either a generator or a renewable source. If the source is renewable, it should be light weight and portable, e.g. flexible or folding solar panels.
20. Borehole temperature ( $\pm 0.1$  C or better) and borehole inclination ( $\pm 0.5$  degrees or better) should be measured and recorded.
21. Desirable (but not mandatory): if it does not increase system weight or decrease portability, record the amperage and voltage of the drill motor as a function of time/depth, and record the borehole pressure near the bottom of the hole.
22. Replicate coring capability is desired.

## *Discussion:*

1. Drill sondes considered for the 700 m drill included the existing Foro sonde (98 mm core), or else adapting the Eclipse drill (81 mm core). Core quality for both should be comparable to the IDD core.
2. The drill, shelter, drilling fluid, generator, core boxes and core processing equipment will be most used when it requires the minimum logistics, and hence should be transportable using a reasonable number of twin otter flights. While 700 m is the maximum depth, there may be many instances where the drill would be used in shallower depths, and hence would need drilling fluid. It would be helpful for IDDO to identify the cargo requirements (weight and cube) for drilling to 400 m, drilling to 550 m, and drilling to 700 m, assuming that individual cases/piece size would fit into a twin otter.
3. The core diameter has the largest impact on the weight and cube of core shipment. For the Foro (98 mm) sonde, the ice core boxes alone for a 700 m project will likely fill more than 5 Twin Otter flights (example: 550 m of SPICE Core filled a 40 ft shipping container).
  - 700 m of a 98 mm diameter core (Foro) requires 140 boxes, 1,562 cubes
  - 700 m of 81 mm diameter core (Eclipse) requires 78 boxes, 870 cubes
4. Jay Johnson compiled the following information. The details below assume a 1-meter core per run. Some estimates for consideration:
  - SONDE - Two options: 1) Foro sonde, 98mm core, already designed OR 2) New Eclipse sonde, 81mm core, would need to source tubes/components
  - WINCH/TOWER/AUXILIARY SYSTEMS - IDDO would design a new winch, tower, core pullout table, and core processing and fluid handling systems, though this equipment would be based on other designs (IDDO, Danish designs), while incorporating newer/simpler technology and lighter materials wherever possible
  - TEAM SIZE - Two suggested options: 1) 24-hour operations, ideally 2 drillers/1 core



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handler per shift, so 6 people total OR 2) 12-hour operations, ideally 2 drillers/1 core handler and a 4th person with rotating days off, so 4 people total. Neither option includes a possible camp manager/cook position.

- DRILL SET UP TIME - 2 days
- DRILLING TIME - Two options: 1) 24-hour operations = ~23 drilling days, OR 2) 12-hour operations = ~46 drilling days. Both assume no days off, or possible rotating days off for 1 person each day.
- DRILL TEAR DOWN TIME - 2 days
- DRILL FLUID - Fluid choice unknown at this time. Will the holes need to remain open? If so and if we use Estisol, that will add complexity (i.e. weight, cubes, ventilation, etc.). Foro option = 126mm borehole, ~48 drums of fluid. Eclipse option = 112mm borehole, ~38 drums of fluid. Both options based on a 700m deep borehole, filled to 75 from surface, 25% loss rate, 201 L/drum.
- POWER - ~10kW generator (to be confirmed during design)
- SYSTEM WEIGHTS/CUBES - Total drilling equipment (not including fuel, fluid, generator) = ~5,000 lbs./~250 cu. for either system. The Foro sonde option (98mm) is only a few hundred lbs. heavier than the Eclipse sonde option (81mm). However, Foro-sized core = larger core/more ISC boxes/more fluid/more flights/etc. The biggest unknown is the eventual weight of shipping cases/crates. The wt/cu above includes an estimate for cases/crates.

\* We did think a bit about 2-meter cores per run, however that adds complexity/wt/cu (e.g. longer tent/tower/pullout table/core processing table, deeper slot/handrails)...basically larger everything. Since we believe the 1-meter option will work with your identified 60-day season, and since system size is a factor for remote location logistics, we feel a 1-meter core is the better option to consider. As always, please note that the numbers above are our estimates at this point. Final weight, durations, etc. are subject to change if/as we flesh out the design.

Note: These Science Requirements originally were created with a vision of a FORO 700 drill. Through a series of discussions in PY 2020, it became evident that a 64 mm core diameter would provide significant savings in logistics, provide sufficient core for an individual or small team drilling project, and is possible with stock tubing. The name of the Science Requirements was changed to “700 Drill” on 4/3/2020.

Discussions in late 2020 explored the idea of reducing the core diameter to 64 mm, which would further reduce logistics needed for core transport and drilling fluid, an important consideration for this drill system. Uncertainty about the fragility of a core that small led to the current acceptance of a 70 mm core diameter, with the provision that the drill design be able to be easily adapted to a 64 mm core in the future.