GEN1 Lessons Learned

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IceCube GEN2 Project Engineer

Upgrade Logistics Review
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Jeff Cherwinka – UW Physical Sciences Lab

- IceCube EHWD Sytem Engineer
  - Joined IceCube 2002
  - 6 trips to South Pole ~9+ months on ice
  - Lead Integration, Verification & Test for EHWD
  - Involved in shipment of EHWD to Pole and initial operation
- LZ Dark Matter Experiment Chief Engineer 2012 – Present
- IceCube GEN2 Project Engineer

IceCube Can Drill & Install every 48 hours

Demonstrated repeatable drilling & installation with repair and maintenance for 20 holes in a season. Achieving this rate required learning and we still remember

2003-4 Hose reel shipped to Pole and assembled

2004-5 **1**x Hole, Most of season spent assembling drill, then Drill & Install

- Heat Transfer limit -> higher nozzle velocity
- High Pressure pump motors overheating -> new motors
- 2x 12+ hour shifts, 18 drillers -> 3x 9 hour shifts 30 drillers + manager

2005-6 **8**x Holes, Major revisions to drill

- Air in fuel -> pressurized fuel system
- Hose failures -> Heat hose to -50 C or above during night

2006-7 **13**x Holes

- Firn drilling takes a lot of time -> Independent Firn Drill (IFD)

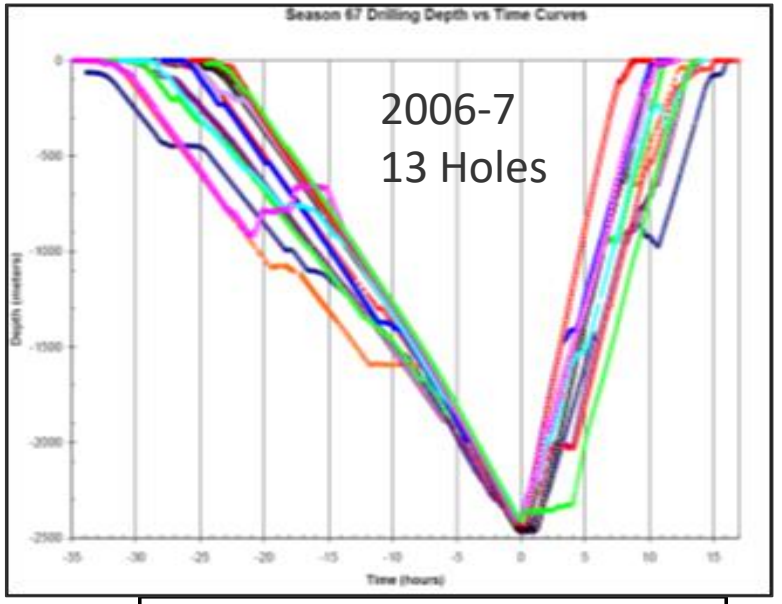
2007-8 **18**x Holes, Drilling limited by fuel availability

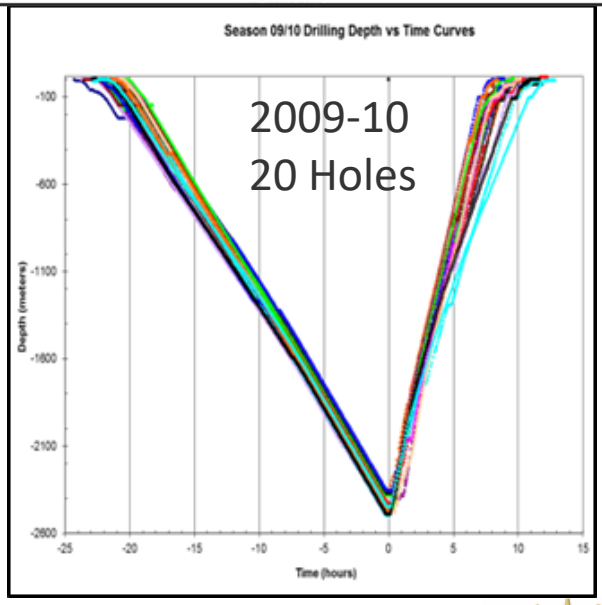
- Hole modeling & logging allows reduced lifetime and fuel savings
- Better management of rod well and idle heat usage for fuel savings

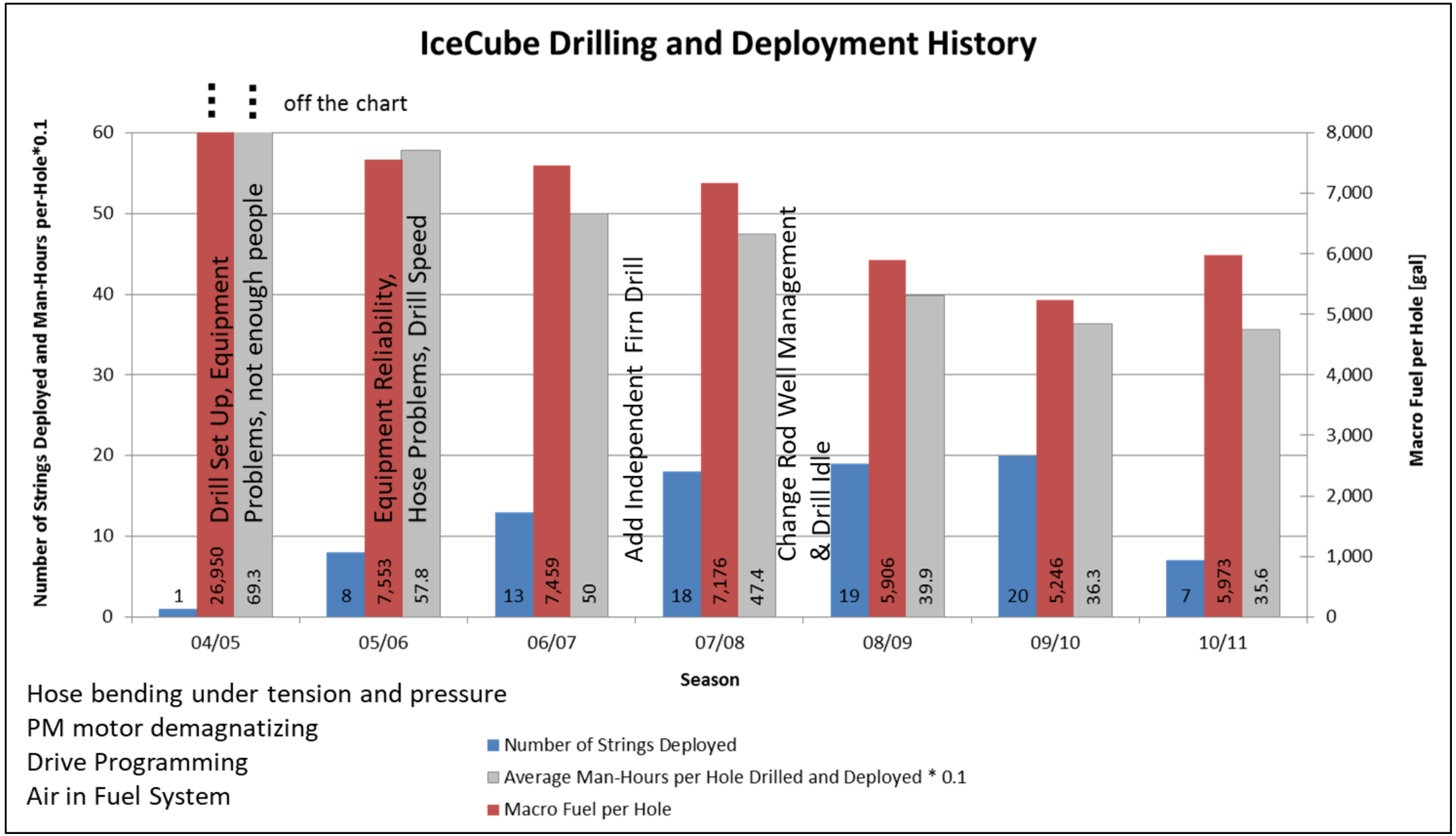
2008-9 **19**x Holes, Experienced crew & optimized equipment yield consistent holes

2009-10 **20**x Holes, And it's repeatable

2010-11 **7**x Holes Pack drill for storage and disposition to WISSARD







Hose bending under tension and pressure
PM motor demagnatizing
Drive Programming
Air in Fuel System

Other Lessons

- Water quality was not a criteria for EHWD. Water contamination from particulates, and bubbles from entrained air have proven to be issues and will be improved
- The northern hemisphere support group did help solve problems and improve solution implementation time. This was a dedicated person on shift in the north with a phone.
- Testing and training in the drill test bed at PSL helped avoid problems in the field and helped resolve them when they occurred. This facility has been retained and will continue to be used. All drillers and most installers get some training before heading to the ice.
- A meeting of all drillers before start of drilling to insure the equipment and people are ready proved to be helpful.
- Restarting the EHWD has shown we could have done better at documentation and archiving. The upgrade is working to improve this.
- Reliable snow machines are important for efficiency and safety.
- DOMs proved to be extremely reliable.

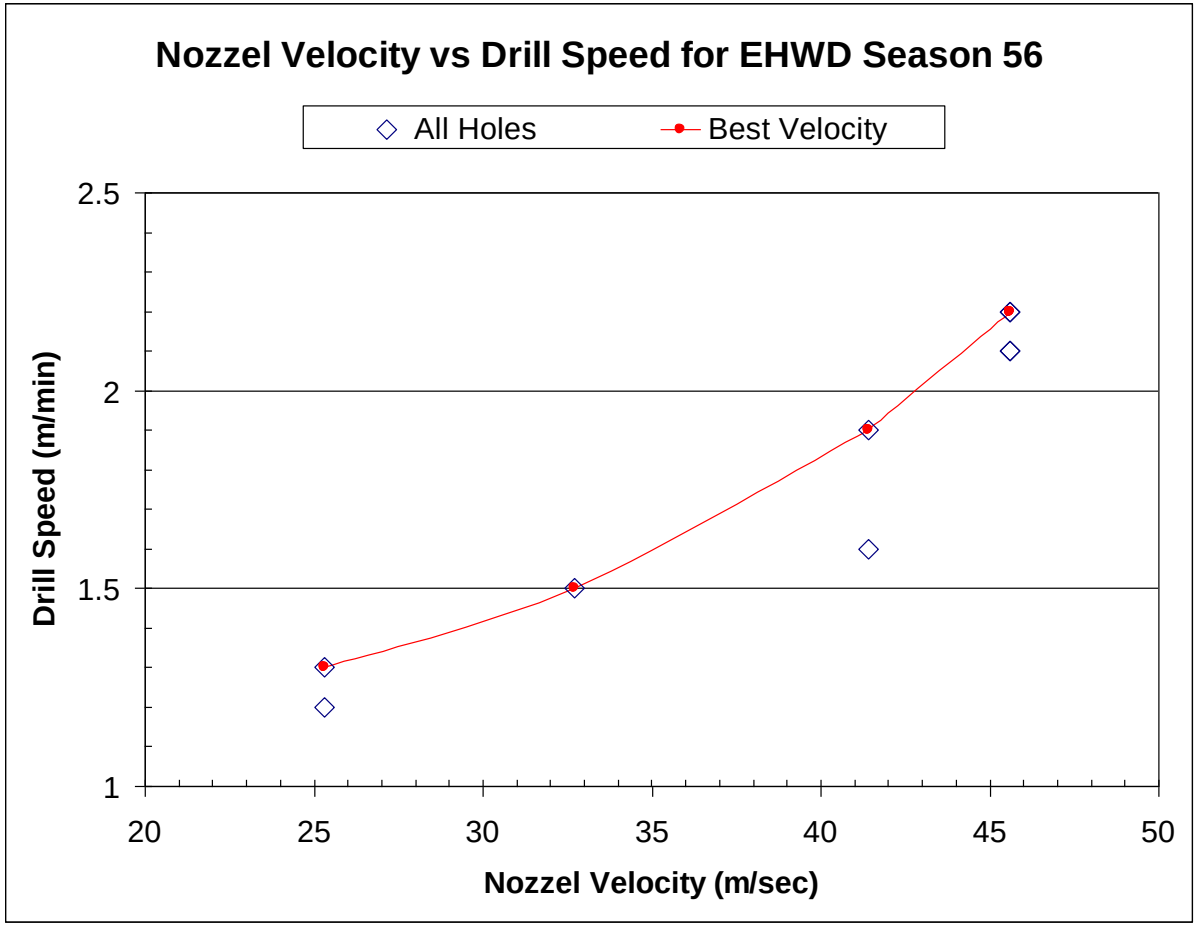
People are Key

- ❖Getting good people is important
- ❖Keeping Experienced people is even more important
- ❖ICU is fortunate to have many experienced people still available

  - Good Pay
  - Year Round Insurance
  - Summer Training
  - Treating people well

Making measurements allowed improvements

- While we attempted to model hole drilling with CFD we learned the most with experiments during drilling. Nozzle Velocity is key to maximum drill speed
- We also logged holes to verify and improve hole drilling and freeze back model
- ICU will study different reaming strategies and water quality impact on the hole ice
- We are thinking about other things that might be useful for GEN2 like freezeback pressure and it's mitigation



Logistics Experience

- The Logistic path to the South Pole is long and there are many serial steps. Every step had an issue at some point in the project. These are often out of the projects control
- Starting things into the Logistic path as early as possible yielded the best results
- Communicating with people as directly as possible helped eliminate and resolve problems
  - Air National Guard officers visited UW-PSL to look at cargo and talk about issues
  - RPSC also visited PSL and invited IceCube planners to their offices in Denver to work out details
  - IceCube had direct contacts at Port Hueneme to talk about arrival and shipment details
  - IceCube had direct contacts in Christchurch to talk about arrival and shipment details
- There were delays getting people to the South Pole… plan some float
- There were delays getting cargo to the South Pole… plan some float
- The project was completed successfully!

SUMMARY

- IceCube GEN1 drilling and deployment was not easy and it had a very difficult first year, but then continuous improvement led to consistent performance above expected installation rates.
- Most of the lessons learned have already been incorporated into improvements in the EHWD equipment and should benefit the ICU.
- The rest of the knowledge from those hard learned lessons is still in the hearts and minds of the many member of the ICU team that were involved in the original IceCube construction.