

# A Linux-based Surface controller for the **Ice-Tethered Profiler** and Other Applications

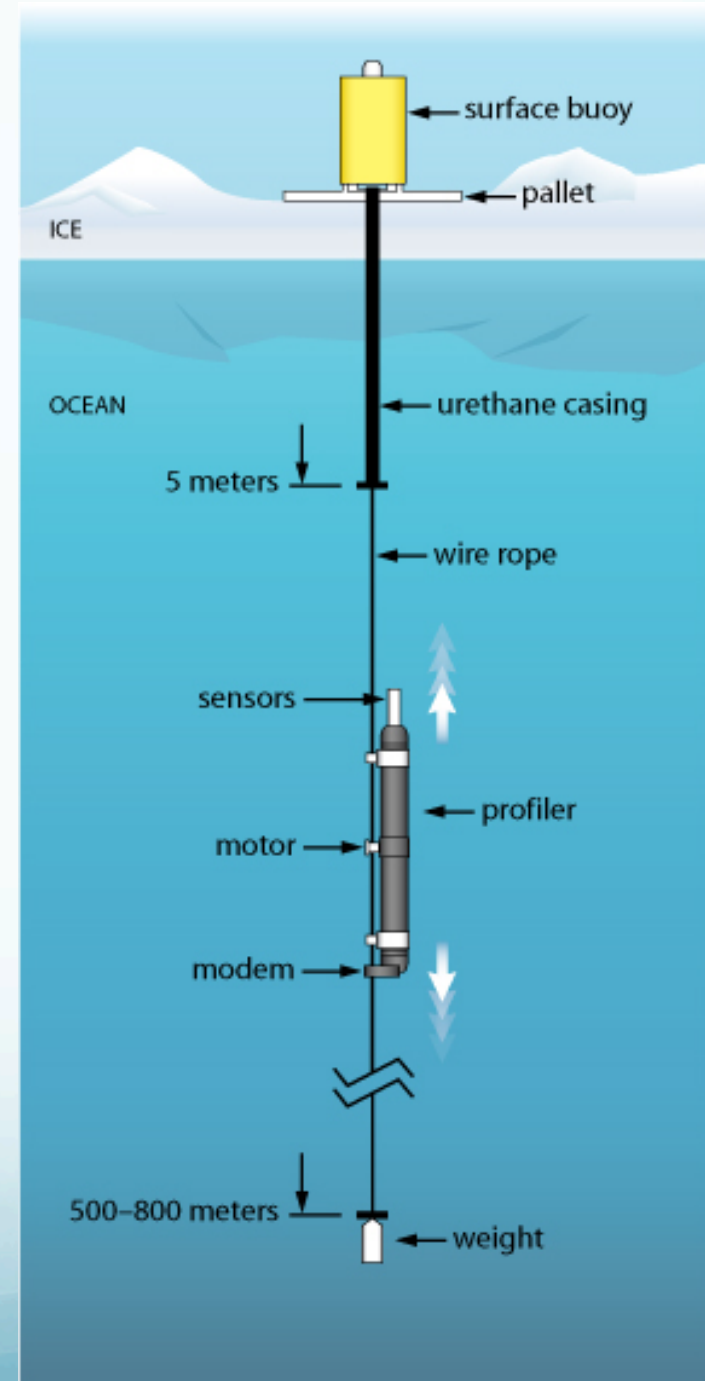
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Polar Technology Conference  
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# ITP Background

- Surface Buoy
- Urethane Casing
- Wire Rope & Weight
- Profiler
  - Sensors
  - Controller
  - Motor
  - Inductive Modem

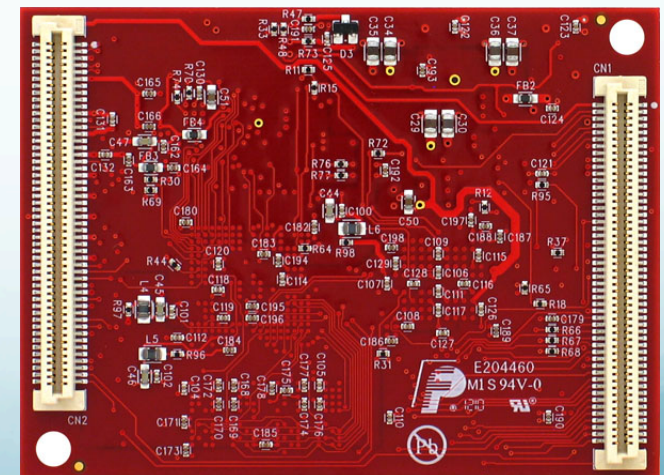
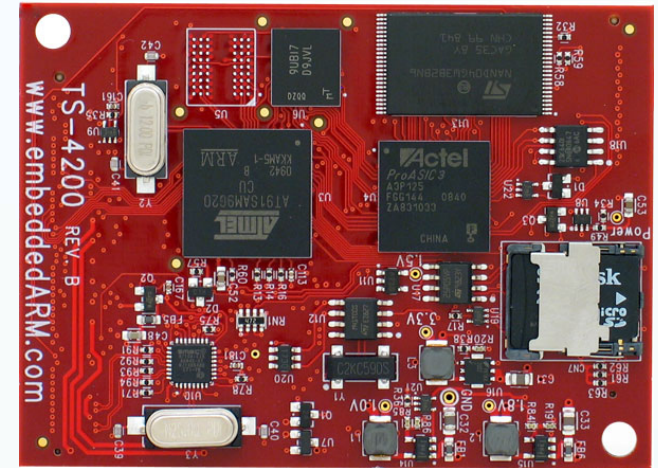


# Why a new controller?

- More Instruments = More Data
  - More Battery Drain
  - More Iridium Costs
  - Compression would help
- Flexibility
  - Code maintenance
  - Adding features
- Functionality
  - Surface instruments?
  - USB Camera?
- New Logger Platform
  - Going forward at WHOI
  - Swiss Army Knife

# The Hardware: TS-4200

- 400MHz ARM9 CPU 64MB DDR-RAM (128MB Optional)
- 256MB SLC XNAND Drive
- 1 MicroSD Card Slot (Delkin Ind. Grade)
- 1.2K LUT Actel Low-power FPGA
- 2 USB Host, 1 USB Device Ports
- 10/100 Ethernet Port (Magnetics Req.)
- Up to 6 UARTs (1 Auto-485 capable) (7?)
- 1 SPI, 1 I2C, 1 I2S, 4 ADC
- Up to 78 GPIO/DIO
- Watchdog Timer
- Real Time Clock and Temp. Sensor
- Fanless Operation from -40 °C to 85 °C
- Credit Card Sized (55mm x 75mm)
- Very Low Power (75mA at 5V, 375mW)
- Boots Linux 2.6 in less than 3 seconds
- Unbrickable, Boots from SD or Flash

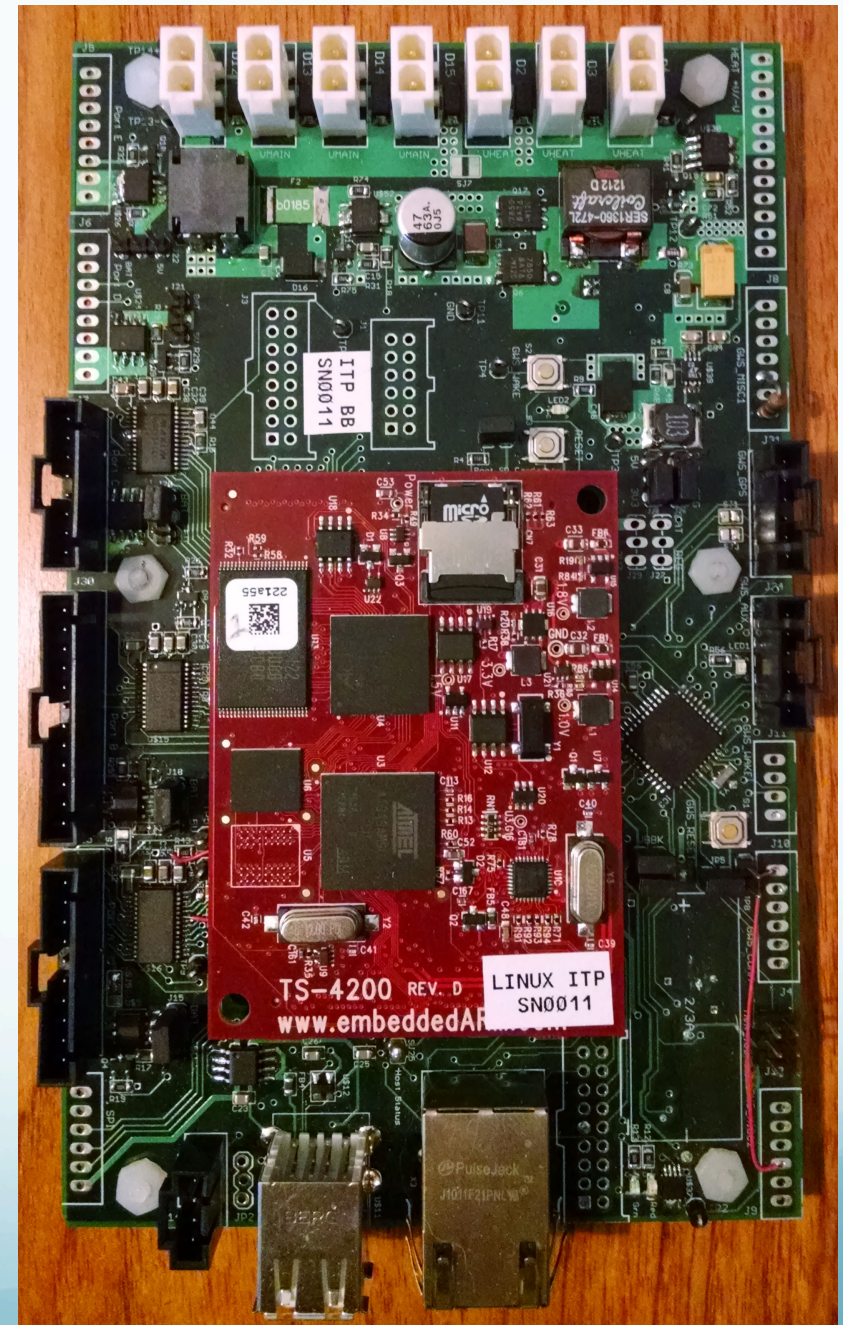


# Development

- Started with stock TS-4200 image from TS
  - Boots Linux 2.6.36.2 from either a MicroSD card or on-board XNAND drive
- Modified kernel source to break out CPU UARTs as needed
  - 1- 9wire RS-232 port
  - 1- 5wire RTS/CTS flow control RS-232 port
  - 4- 3wire RS-232 port
  - Console RS-232 port port
- Removed unnecessary startup software (Apache, etc.)
- Fast boot in less than 3 seconds
- Full boot in about 17 seconds now
- Custom startup script
  - Starts 3 main processes in the background
  - User can still log-in and poke around without interrupting the normal operation of the system
- Inter-Process communication protocol with UDP
  - Control, Iridium, IMM and expansion port loggers

# 4 x 6.5" Baseboard with TS-4200

- Serial Ports
- Power/ Power Options
- Heat
- USB
- Ethernet
- SPI/I2C
- GPIO
- Supervisor
- GPS
- Aux. Supervisor port
- Micro SD
- XNAND
- RTC Battery



# Power Specifications

- Power, measured at main battery,  $v_{in} = 10.0V$ 
  - .20 mW Low power sleep (may be less next rev.)
  - 275 mW Supervisor with GPS
  - 347 mW Linux idle with Supervisor (no GPS)
  - 436 mW Linux idle with Supervisor and GPS
  - 1.9W Linux with Iridium idle
  - ~4W Linux with Iridium transmitting
  - \*Note: USB and Ethernet disabled for ITP

# Data Transfer Strategy

- Original surface package data transfer approach
- Take advantage of multi-tasking
  - Retrieve files inductively from Profiler below
  - Compress data files
  - Put files in Iridium queue
  - Control, Iridium and IMM processes run in parallel
  - Only run Iridium process until queue is empty
  - Any new data files after queue is empty go home at next epoch



# Iridium Transfer

- Home grown “FTP” style protocol, very little overhead
- Establish RUDICS connection to shore server
- “Gateway” software spawns off transfer protocol process which allows for multiple buoys to call in at same time
- RCWD, FPUT, FGET, QUIT
- Send 2k packets with packet count and checksum, AACK and NACK
- “Two in the air” concept
- Write to tmp file, keep track of packets received
- Allows file restart in middle of file
- With multi-packet file sizes we regularly see ~320 bytes/sec. transfer rates
- Protocol in use prior to RUDICS for more than 10 years
- If RUDICS down call main server 56K modem
- If main server down call backup server 56K modem
- Data can be rsynced between two servers
- If forced to call backup modems, use system-id-based, staggered call schedule

# Power Saving Strategies

- Use low power supervisor chip for GPS logging instead of waking Linux for that task at desired GPS fix spacing
- Supervisor retains the last 48 GPS fixes, GPS log retrieved from supervisor when Linux awoken by Profiler or backup schedule
- Data compression saves power (and money)
  - Analyzed 2400 ACM and CTD files from ITPSYS80
  - ACM files were on average 65% of original size (80.5kB avg. orig. size)
  - CTD files were on average 75% of original size, (27.5kB avg. orig. size)
- Multi-tasking saves power, don't wake Linux just for Iridium transfer, do it in parallel with inductive transfer, turn modem off when the outbound queue is empty
- Future compression based power saving plan.
  - Linux controller for Profiler
  - Compression below saves IMM time, extends battery life for both

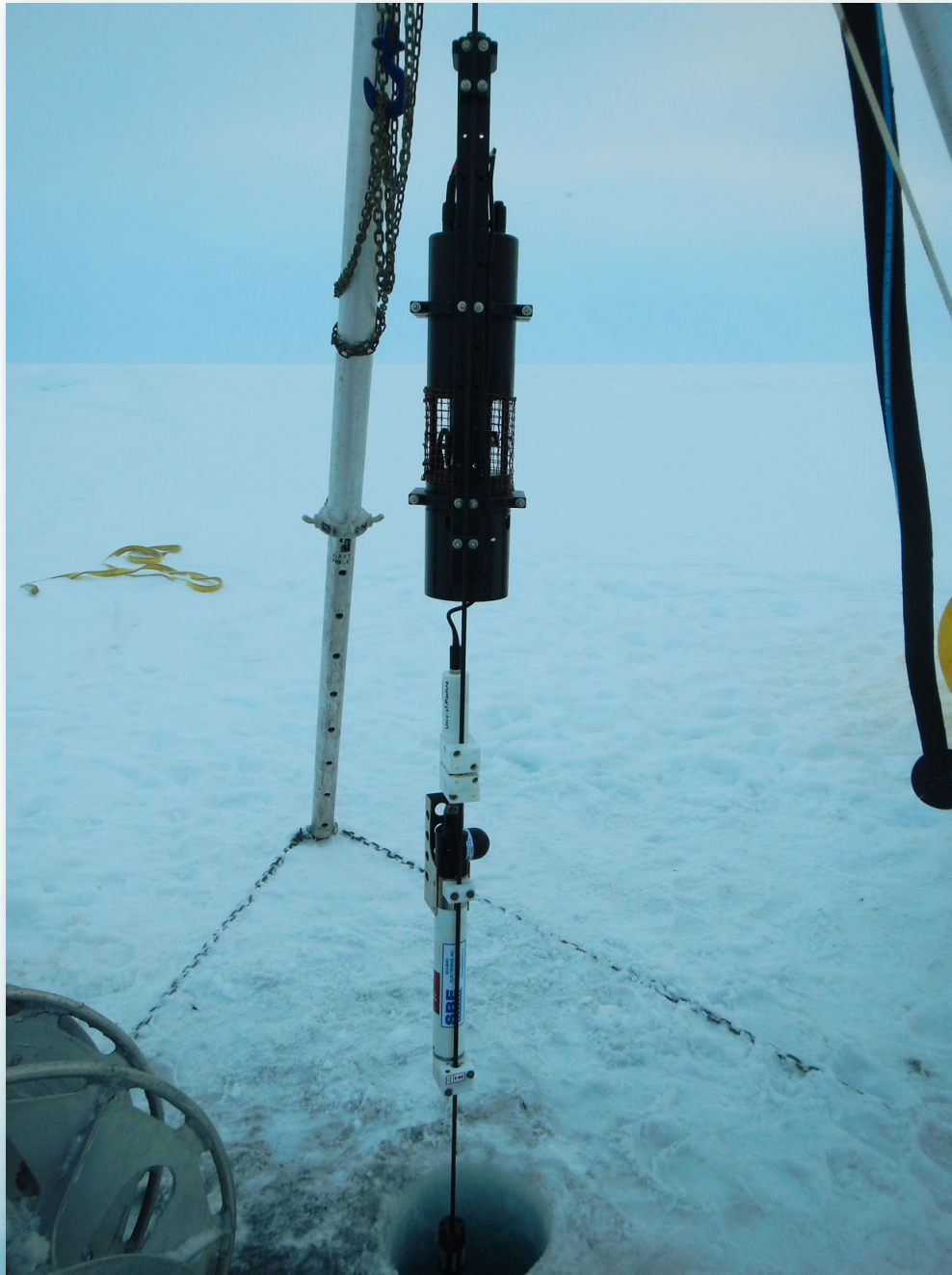
# Development/Deployment Issues

- How low can you go!
  - bootstrapping
  - brown out detection
  - vBack odyssey, -55°C testing
  - measuring vBack
- Wake button reaction time in cold up North
  - Over aggressive software debounce
- Software Install
  - Disk image
  - XNAND
- Wake on character (future rev.)

# BGOS October 2014













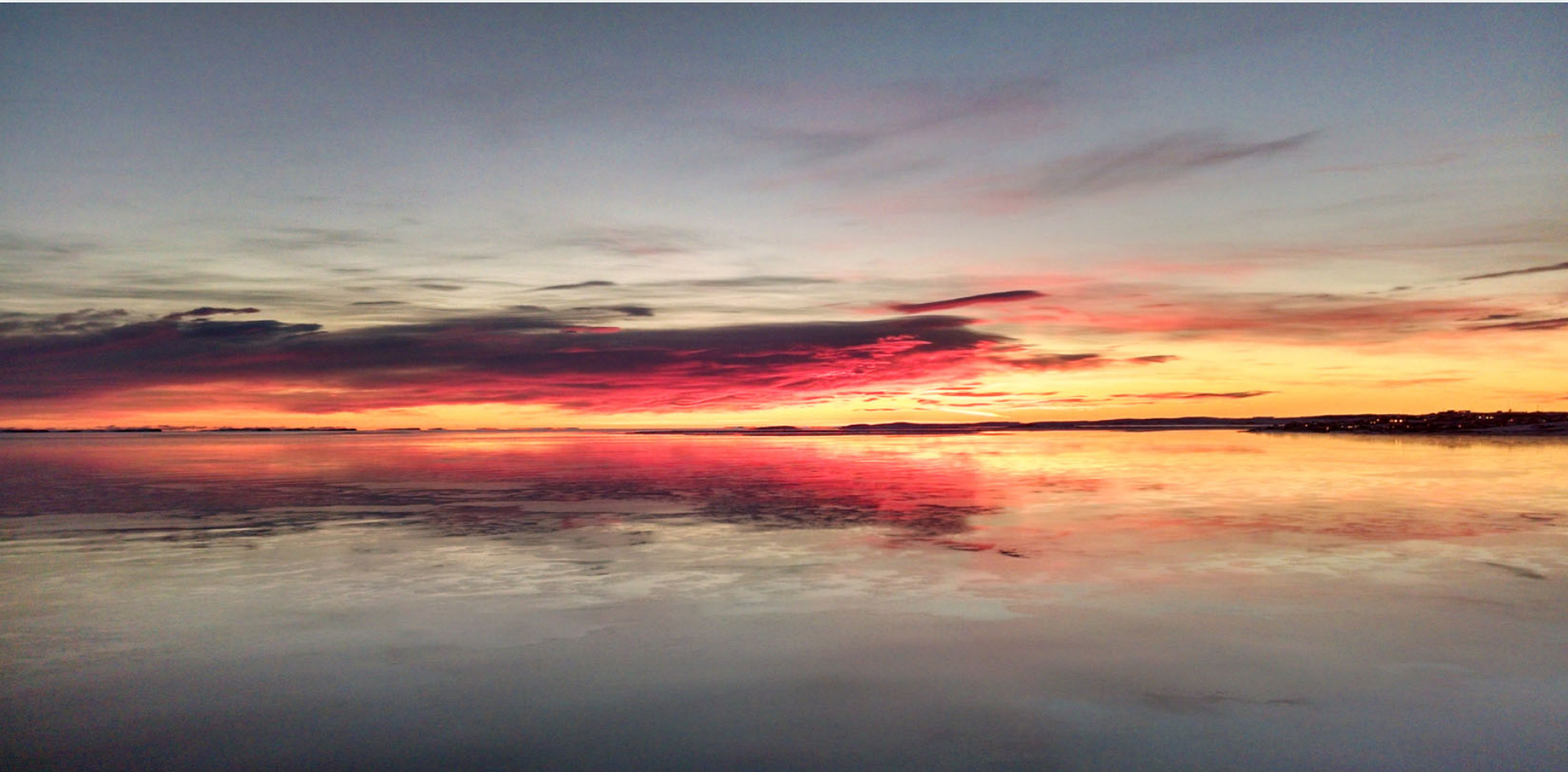












Sunrise  
Kugluktuk, Nunavut, Canada

# Thank you.

Presented by

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