High-Resolution Seismic Refraction Tomography PDR

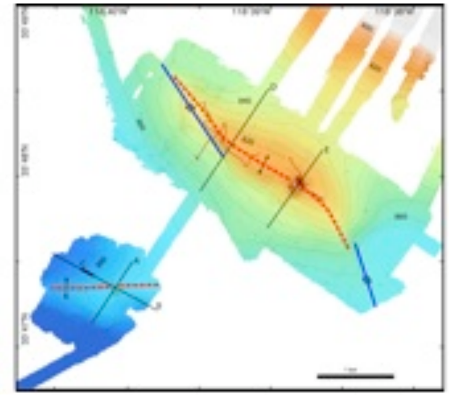
- Agenda
  - Introduction and Project Overview
  - Science Drivers and Requirements
  - Preliminary System Architecture and Design
  - Operational Scenario
  - Conclusions and Action Items

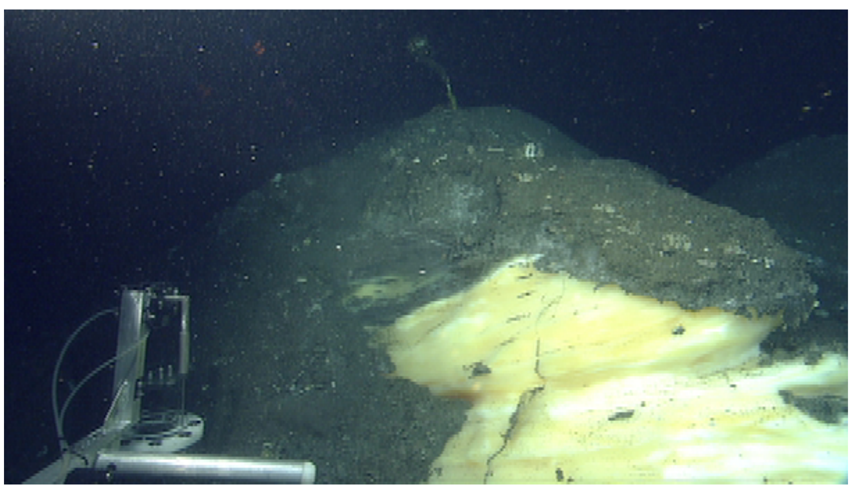
M B A R I

Motivation

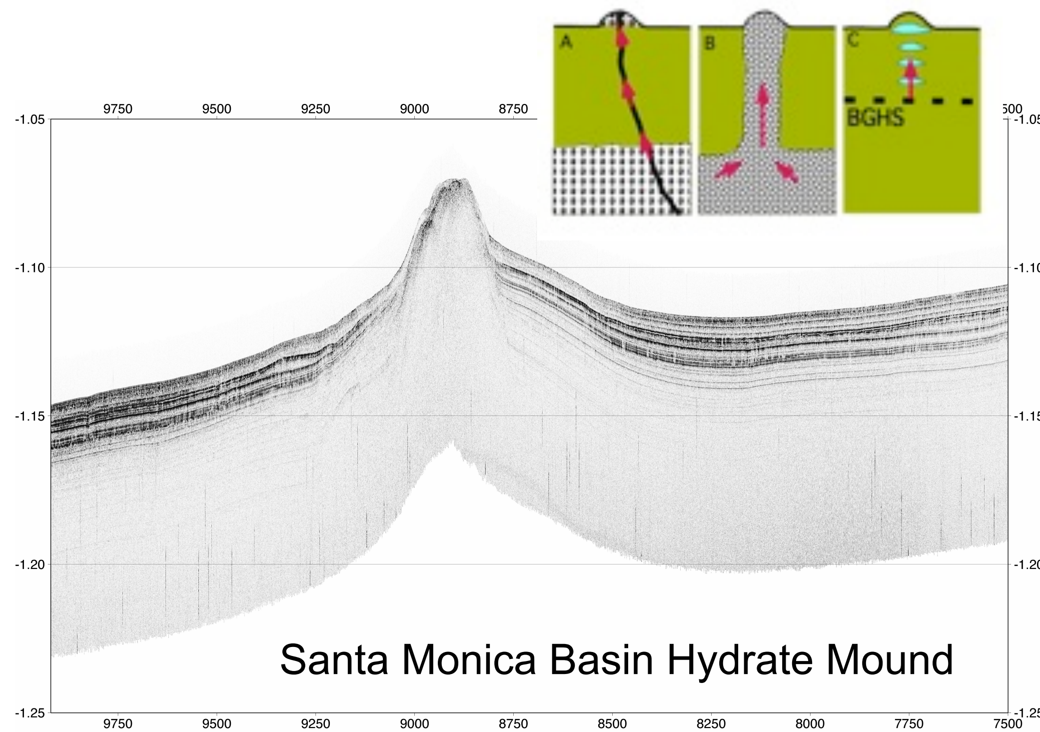
To image fine scale (<10 m) variations in compressional seismic velocity structure of the shallow (<200 m) seafloor subsurface.

The initial science application will be imaging the structure of hydrate deposits in continental margin sediments (e.g. Santa Monica Basin & Barkley Canyon).





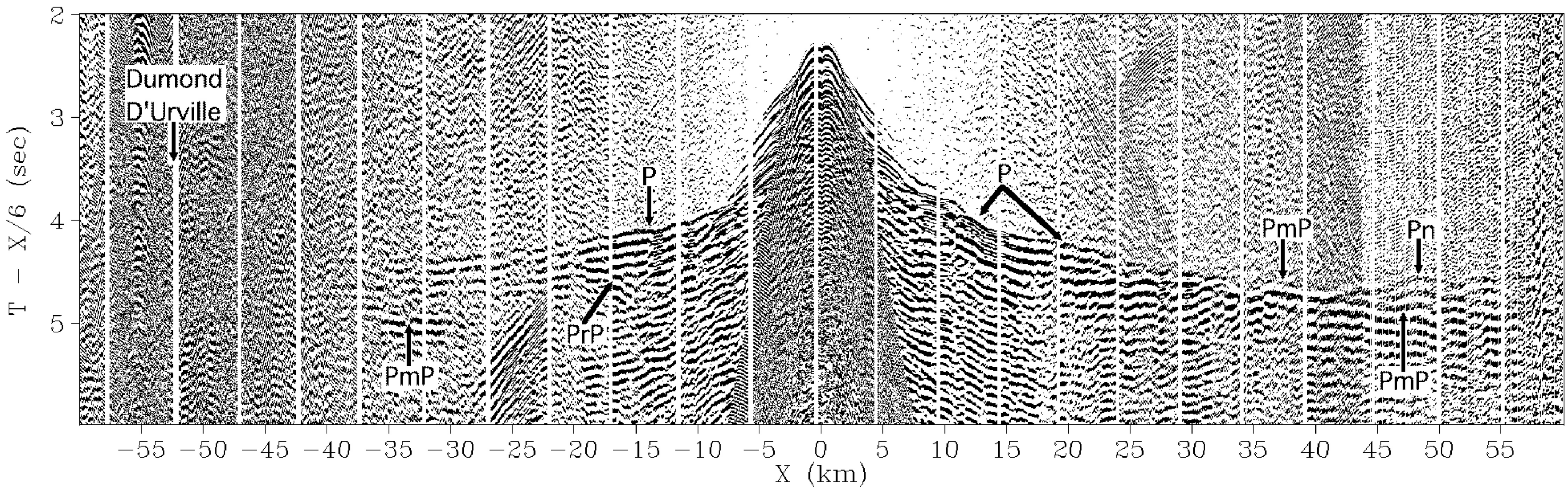
Barkley Canyon Hydrate Outcrop



Santa Monica Basin Hydrate Mound

Conventional Seismic Refraction

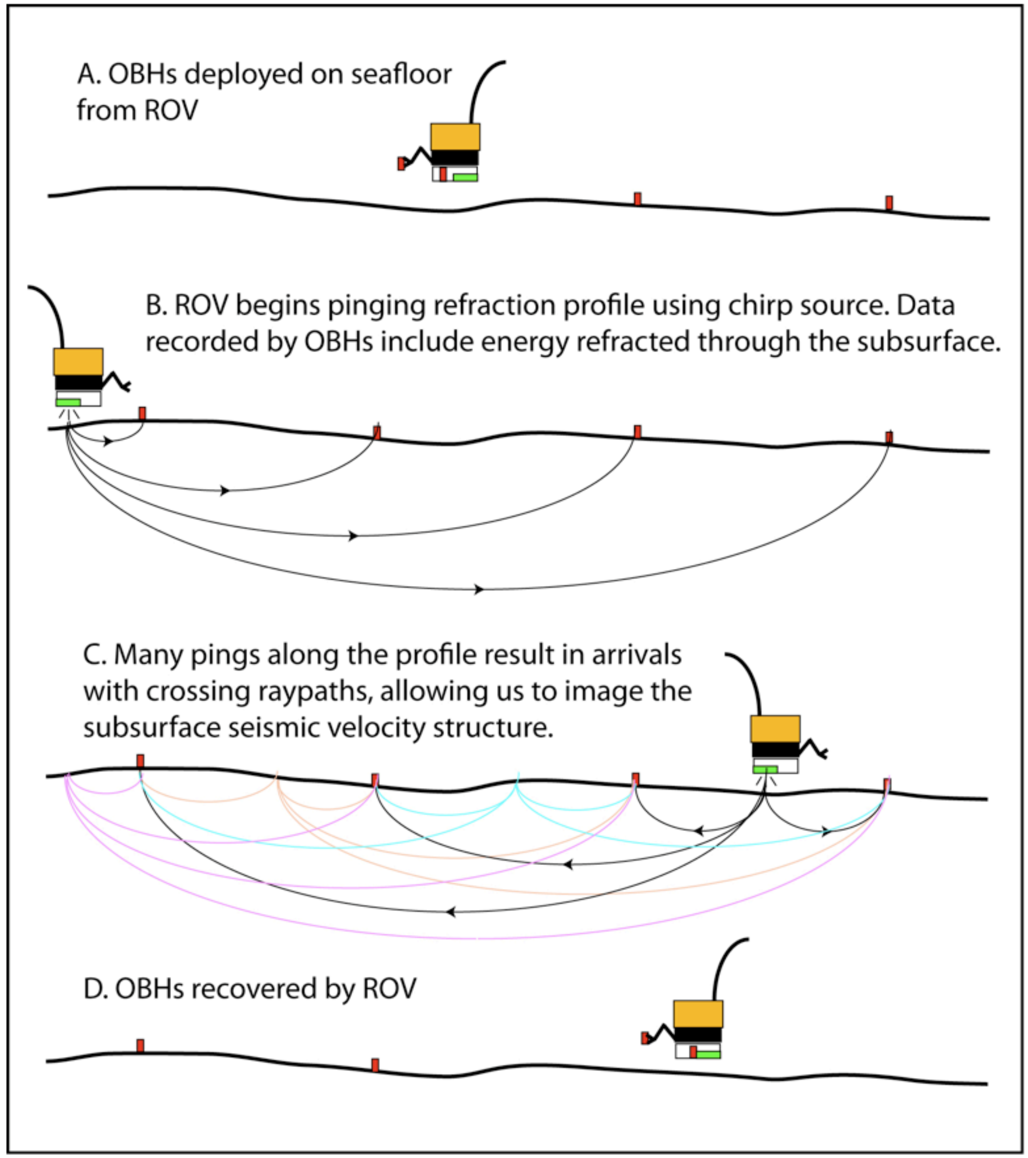
- Shallow towed sources (airguns, waterguns, sparkers)
- Ocean bottom hydrophones/seismometers
- Dominant frequencies 10-100 Hz
- Ranges up to 100 km
- Image crustal scale structure - resolution no better than 500 m.



High Resolution, On Bottom Seismic Refraction Tomography

Sources and receivers on or near bottom in deep ocean

- Shorter ranges allow higher frequency signal – can use sonar in 500 Hz – 10 kHz band
- Can use ROVs for deployment, recovery, and source
- Use swept frequency source (chirp) to deal with low signal (refracted arrivals low amplitude) and high noise (generated by ROV)



Project Timeline

- Year 1
  - Develop system – source + 2 receivers
  - Test system in Monterey Bay (on shelf and in upper Canyon) – 3 Pt. Lobos Days
- Year 2
  - Acquire suite of receivers
  - Conduct major experiment

MBARI

Requirements

Repeatable Chirp Acoustic Source

- 3000m depth rating
- 1-6 kHz sweep capability
- User-defined source signal
  - Signal editing capability
  - Allow changes during experiment
  - Maximum pulse duration >100 ms
  - Pulse intervals > 1 second
- Adaptable to ROVs from other institutions

MBARI

Requirements

Ocean-Bottom Acoustic Receiver

- 3000m depth rating
- Deployable by ROV
- Records full bandwidth of source wave
  - >15 kHz recording frequency
- Recording duration of 10 hours
- Capability to synchronize source and receiver times

MBARI

Requirements

- Timing accuracy
  - Accuracy shall be within the best possible time resolution of a refracted arrival
  - Finest useful timing accuracy for 1-6kHz sweep is +/-0.25 msec

M B A R I

System Design

Acoustic Source

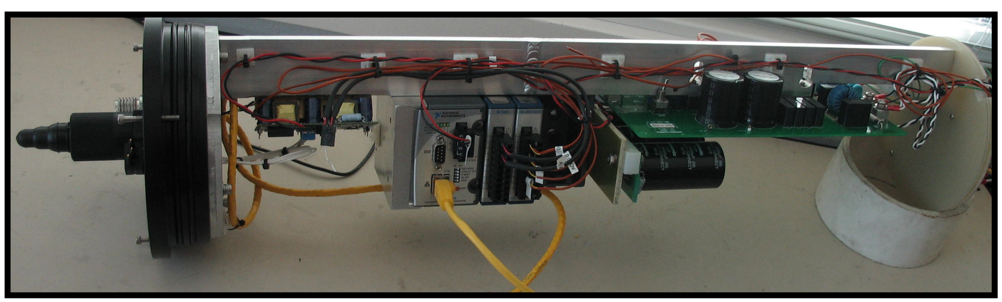
- EdgeTech DW-106 Subbottom Transducer
- 1-6 kHz full-spectrum chirp
- 200W amplifier
- Build housing
  - Depth rating
    - Year 1 – 300 m
    - Year 2 – 3000 m

MBARI

System Design

Acoustic Source Controller

- National Instruments cRIO real-time controller with integrated FPGA card
- Timing accuracy in microseconds
- Source signal defined using LabVIEW interface
- Re-use electronics chassis from Gene Massion



M B A R I

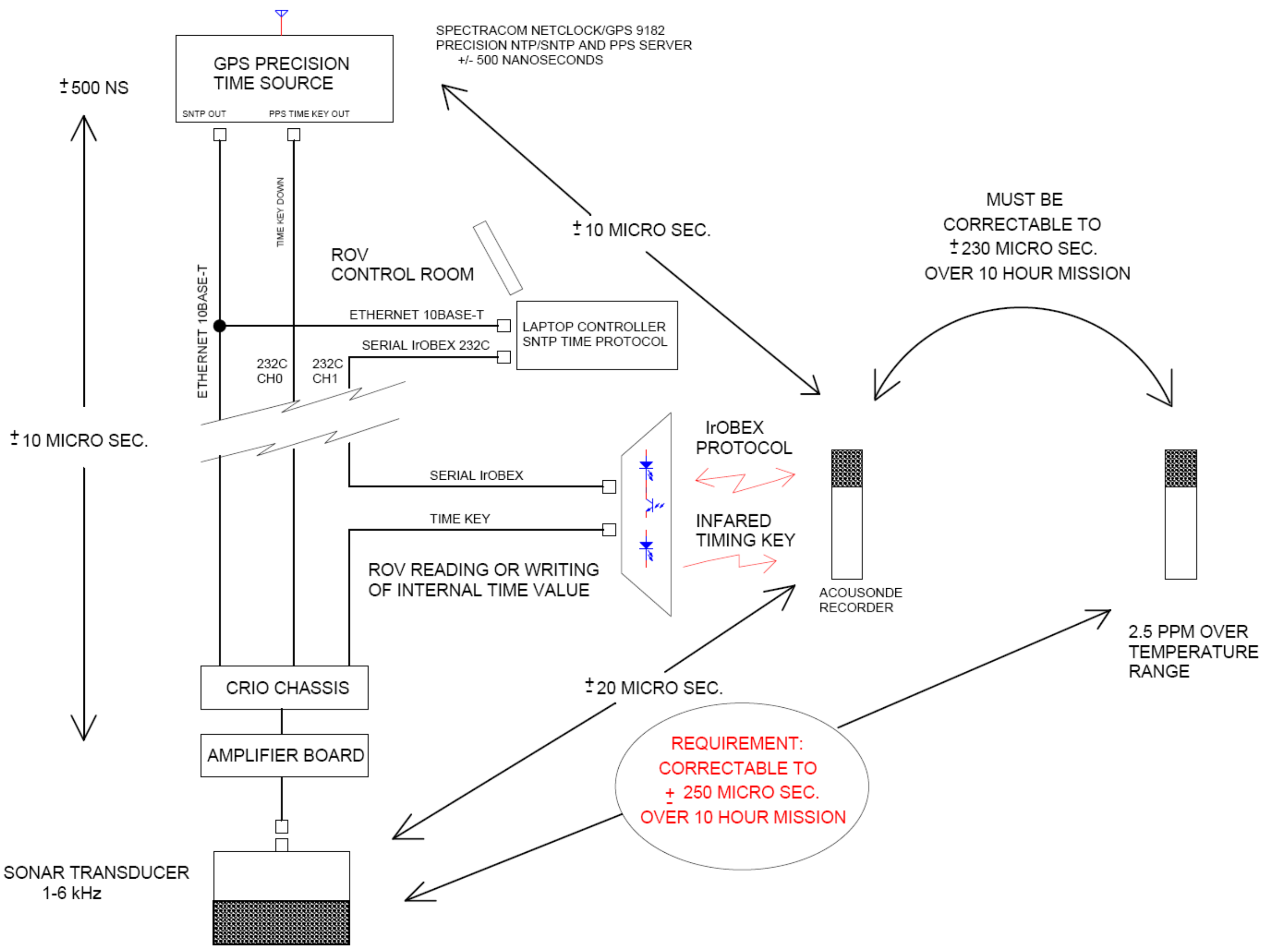
System Design

Ocean-Bottom Acoustic Receiver

- Acousonde acoustic recorder
- 3000 m rated
- Over 20 kHz recording frequency
- Over 24 hours duration
- IR set-up and synchronization
- Clock accuracy is an issue

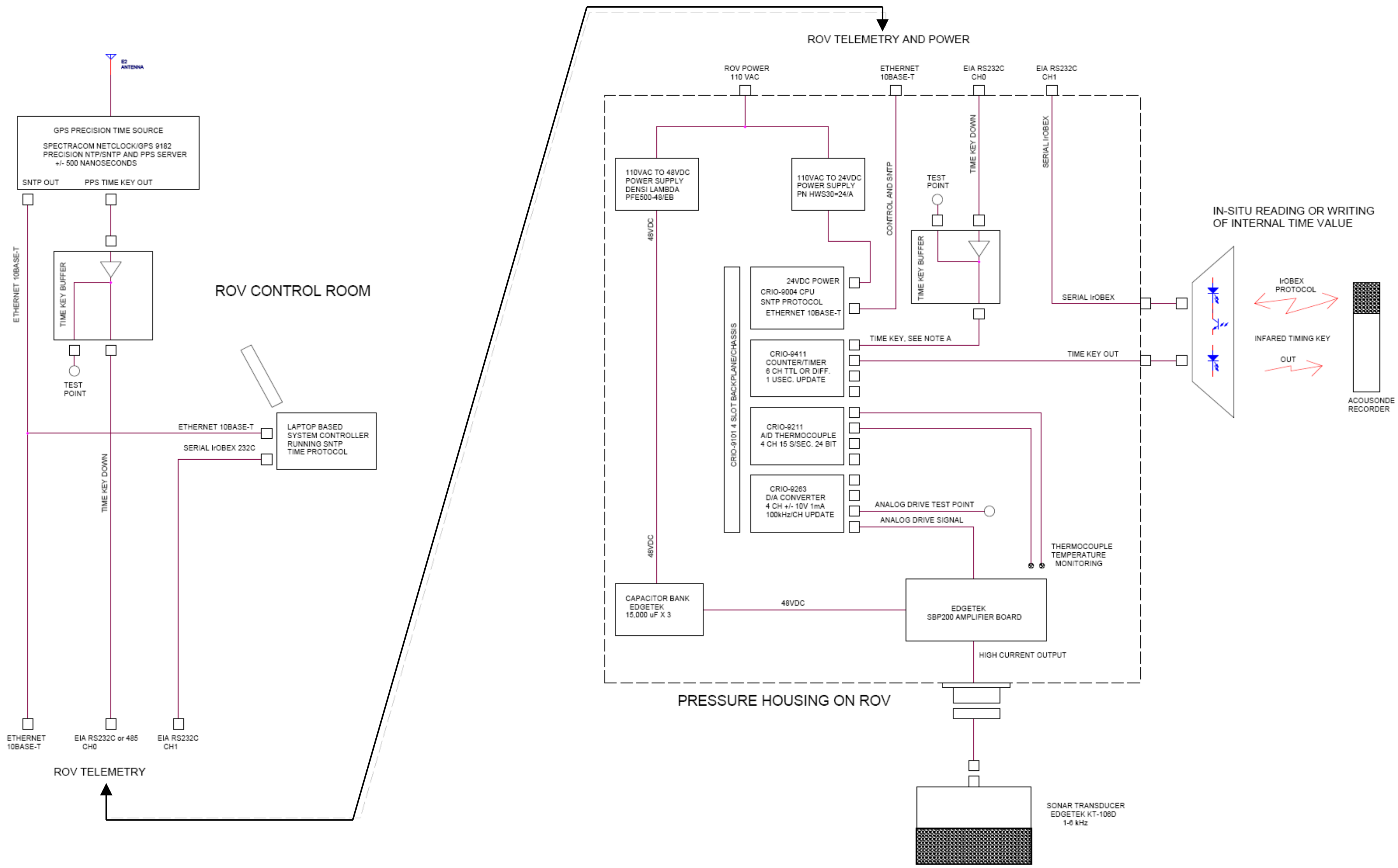
MBARI

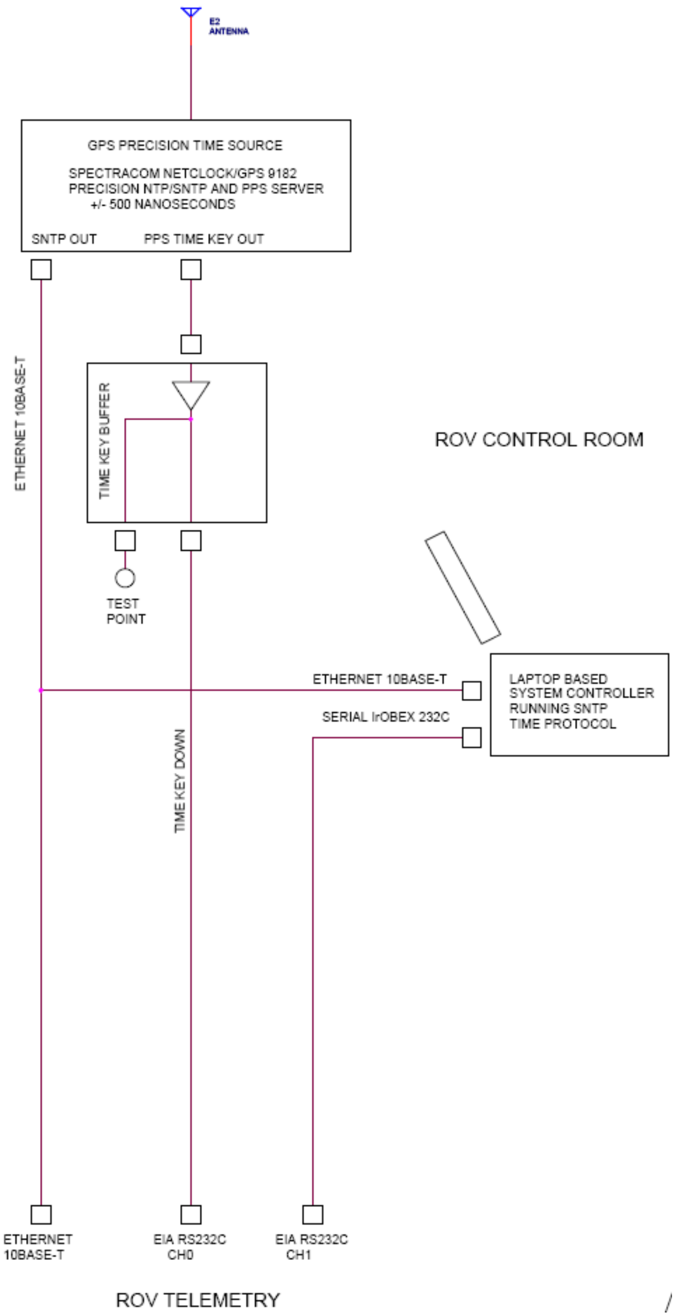
Timing Budget

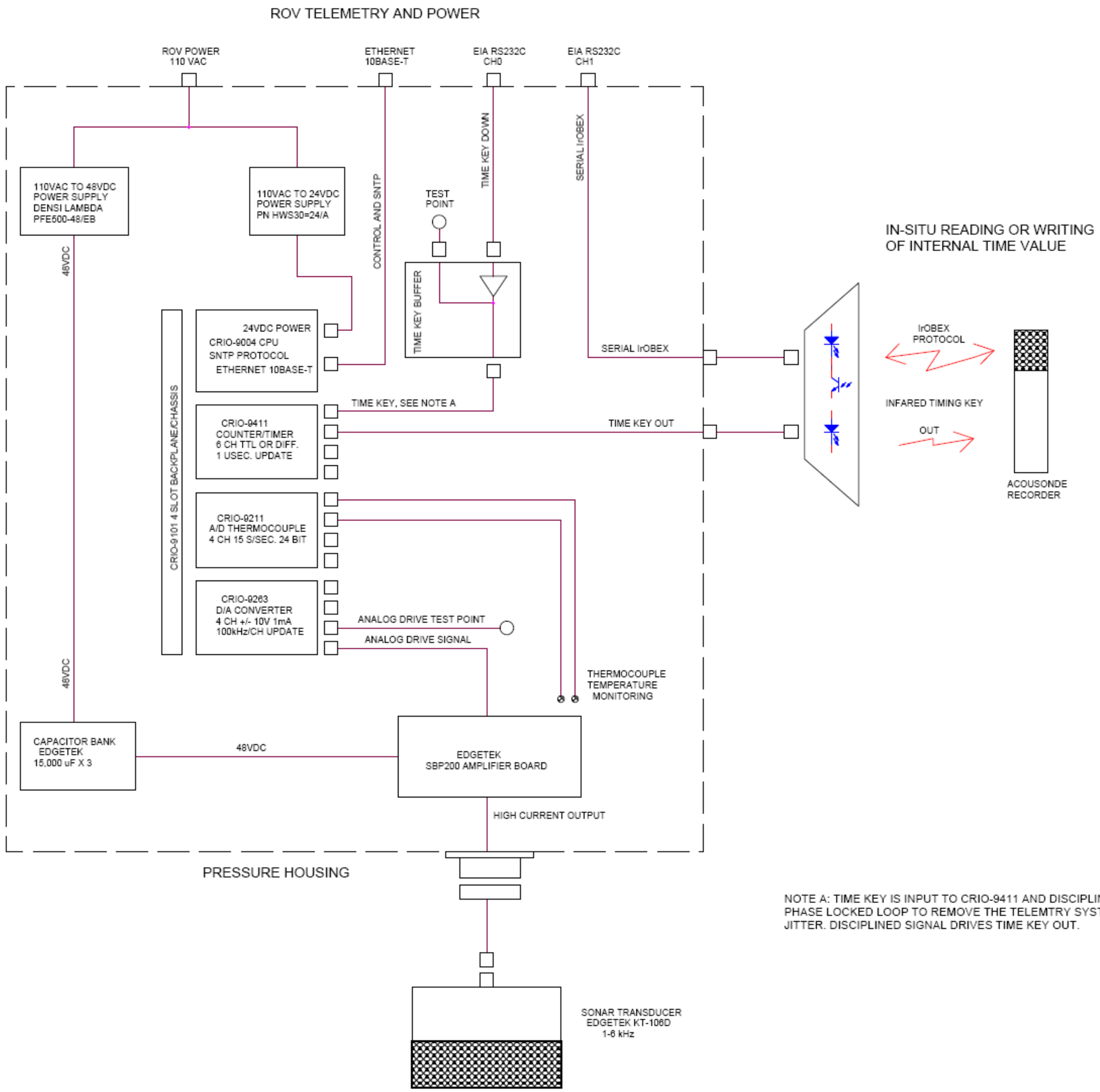


MBARI

System Design




E2 ANTENNA
GPS PRECISION TIME SOURCE
SPECTRACOM NETCLOCK/GPS 9182
PRECISION NTP/SNTP AND PPS SERVER
+/- 500 NANOSECONDS
SNTP OUT
PPS TIME KEY OUT
ETHERNET 10BASE-T
TIME KEY BUFFER
TEST POINT
ROV CONTROL ROOM
ETHERNET 10BASE-T
SERIAL IrOBEX 232C
LAPTOP BASED SYSTEM CONTROLLER RUNNING SNTP TIME PROTOCOL
TIME KEY DOWN
ETHERNET 10BASE-T
EIA RS232C CH0
EIA RS232C CH1
ROV TELEMETRY



NOTE A: TIME KEY IS INPUT TO CRIO-9411 AND DISCIPLINES A LOCAL PHASE LOCKED LOOP TO REMOVE THE TELEMTRY SYSTEM INDUCED JITTER. DISCIPLINED SIGNAL DRIVES TIME KEY OUT.

MBARI

Technical Issues

- Accuracy of Acousonde clock
  - Is drift correctable?
  - Addressed by cold room tests before at-sea tests
- Maximum range to observe refracted arrivals
  - determined by at-sea tests

Status and Plan

- Equipment ordered
  - Edgetech transducer – just arrived
  - 2 Acousondes – arrival early May
    - Will have board set for bench testing soon
- Test days
  - April 3 (reschedule), May 27, June 8

System Design

- Timing budget across the system
- Hardware architecture block diagrams
  - Precision GPS based time reference for synchronization
  - Precision time key from surface through ROV telemetry to subsurface sonar/timekeeping processor
  - National instruments cRIO chassis inherited from Gene Massion
    - D/A driver with 1 microsecond update rate
    - Timer/counter board with 1 microsecond resolution
  - Acoustic amplifier and 1-6 kHz source transducer from Edgetek
  - All hardware except time key buffers IR transducer are COTS.