



*Next Generation Geophysical
Land & Shallow Water Acquisition Workshop*

23–25 Apr '24 • Muscat, Oman

Million Channel Crew Simulation

Kevin O'Connell & Cosmin Vasile

STRYDE

Table of Contents

- Landscape today
- Going Nodal
- Logistics
- Data Harvesting
- Data QC
- Data Management
- Crew Cost Analysis
- Conclusions

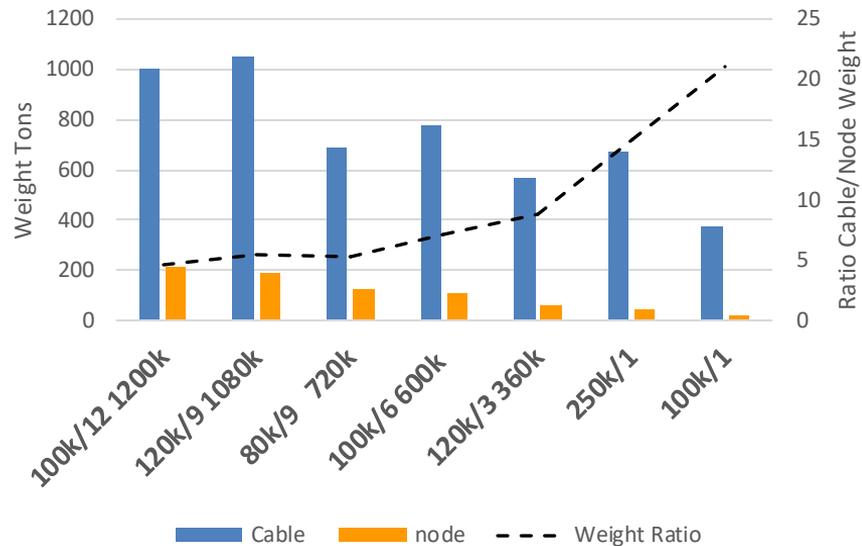
Landscape Today

- Super crews
 - 80k – 200k telemetry channels with digital single sensors or analog geophone inputs
 - Strings of geophones with 3, 6, 9 or 12 geophones
 - 600k – 1.2m geophones on the crew
- Typical receiver interval is 25m / line interval 100-200m
- Channel count trend is still upward
- Receiver/Source point & line intervals are decreasing

Landscape Today

- High channel count cable telemetry is reaching the limit of its technical and operational capability
- Operational inefficiency
 - System weight & volume
 - Large number of heavy trucks to roll spread
 - Large crew and camp size
- Technical downtime for cable systems accelerate as channel count grows
 - Cable cuts and connector wear
 - Weather - lightning/static/rain/storms
 - Battery

Weight Comparison - Number of Sensors



Going Nodal

- What if we replace each geophone on a crew with single sensor nodes?
- What are the implications on
 - Logistics
 - Data Harvesting
 - Data QC & Management
 - Crew Cost

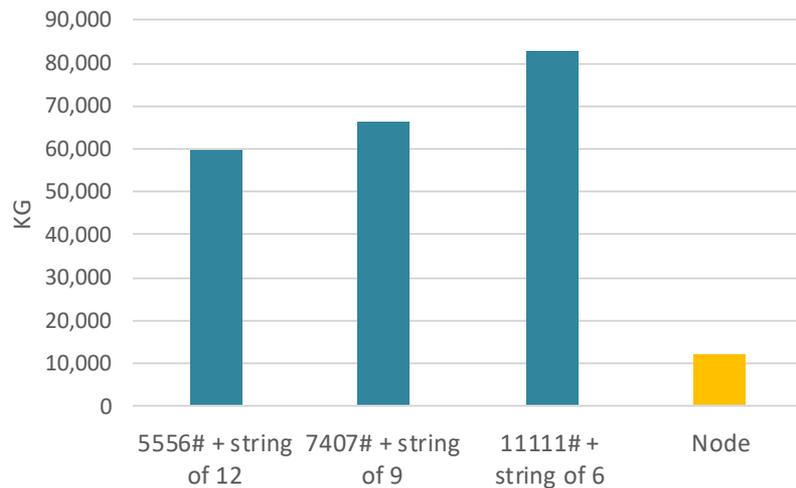


Node contains battery,
memory, gps, seismic sensor
150g

Logistics

- If we assume 15 day spread roll = 66667 sensors/day
 - Cost of cabled real-time telemetry is huge
 - 5-7 x ratio of equipment to move daily
 - Cable crews getting constrained by spread roll limitations

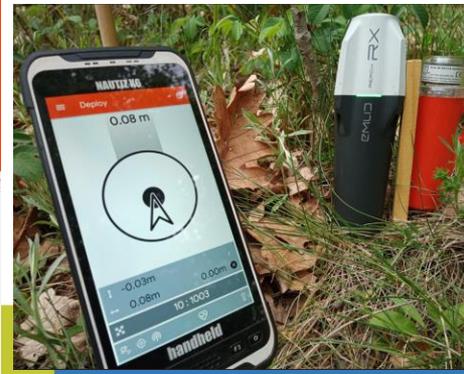
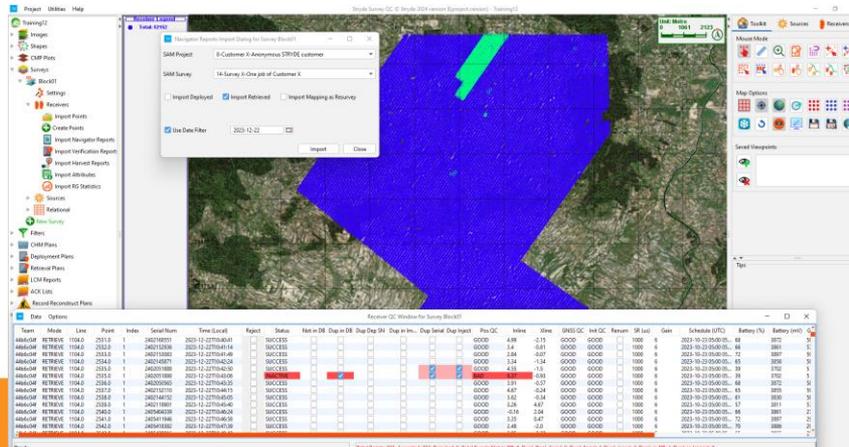
Weights to roll daily 66.7k sensors



Logistics

- Daily Spread Roll for Node
 - Line crew speeds dependent on receiver interval, by vehicle or foot
 - Short RI, typically 3-person layout team and 2-person retrieval team
 - Nodes buried for good coupling, reduce wind noise, vibe damage
 - Stake-less deployment with next-generation GNSS receivers
 - Deployment and retrieval QC management software

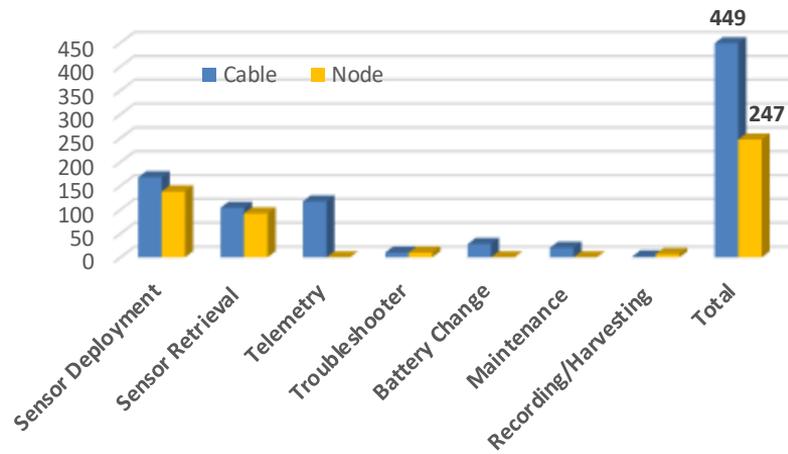
Terrain Deployment Time	RI	Seconds
Flat desert	8.33m	11
Flat desert	12.5m	13
Rocky desert with offsets	7.5m	15
Flat hard gravel	25m	16
Dunes	25m	25



Logistics

- Headcount to roll 67k sensors
 - 45% reduction in Rec Crew headcount vs cable system rolling 7407#, strings of 9

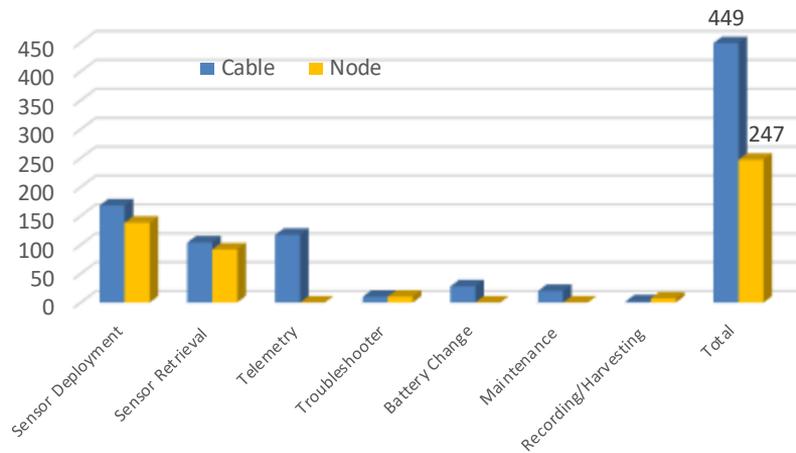
Recording Dept Headcount



Logistics

- Headcount
 - 45% reduction in Rec Crew headcount vs cable system rolling 7407#, strings of 9
- Vehicle fleet
 - Volume of cables + geophones is huge
 - Trucks are volume limited & not stressed on weight
 - Also need to rotate cable channels, geophones batteries from camp to line
 - Node crews will just use light vehicles

Recording Dept Headcount



67k sensor roll	Cable	Node
Light vehicles	4	17
Heavy vehicles	28	0



Logistics

- Summary
 - 45% reduction in recording crew size
 - 31% reduction in complete crew headcount
 - Significant reduction in vehicle fleet

- Less maintenance costs
- Large reduction in HSE risk & driving kms
- Reduction in water, fuel consumption and CO2 emissions

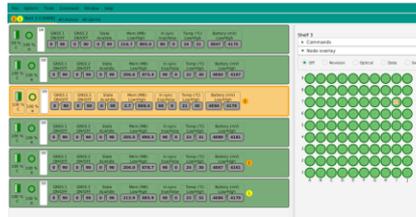


Department	Cable	Node
Camp (admin, catering etc)	45	31
Mech & Maintenance	31	23
QHSE	9	9
Vibroseis & Maintenance	183	183
Survey/Mapping	17	9
QC	8	8
Recording & Maintenance	449	247
Total	742	510

Does not include personnel rotation

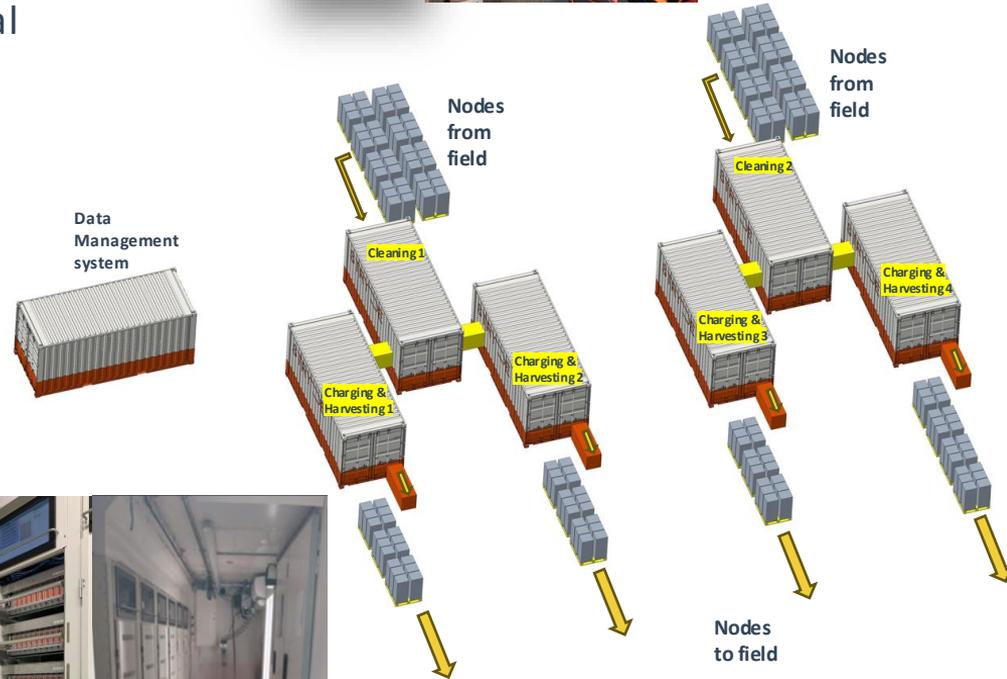
Data Harvesting

- 66.67k per day => $86400s/66667 \text{ node} = 1.3s/\text{node}!!$
- Key features needed for rapid turnaround of nodes
 - Ability to harvest and charge concurrently
 - Contactless charging and harvesting
 - > Extreme reliability on data harvesting and charging
 - Quick loading harvesting stations
 - Parallel process handling
- Bad nodes identified before harvesting is complete
- Automatically identify field errors (moved/replaced/missing nodes)



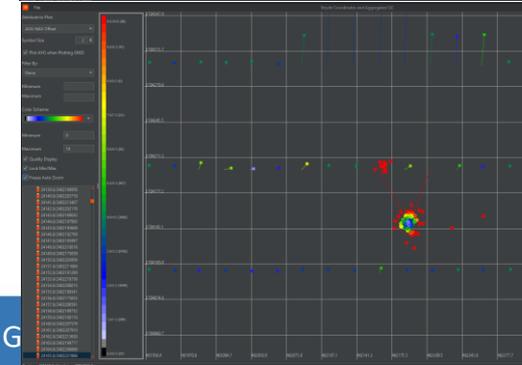
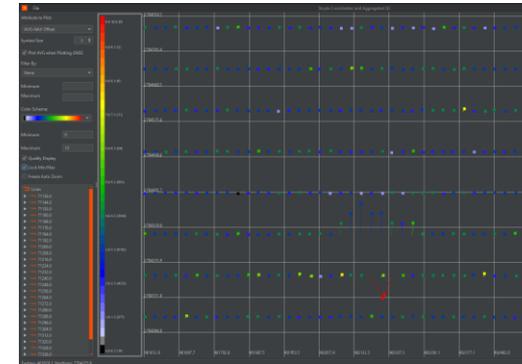
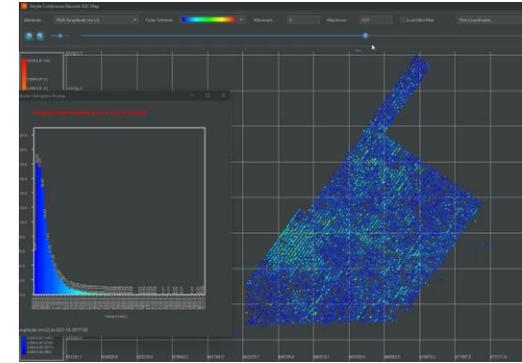
Data Harvesting

- Throughput efficiency and reliability is critical
- Seven 20' containers
- Single C/H 20' container = 3240 ports
- Cycle time depends on duration in the field
- 20k-32k nodes per C/H container per day
- Assisted lifting devices to ease workload
- Node tester included
- Fast redundant data transfer network
- Writing raw data to SSD raid disk



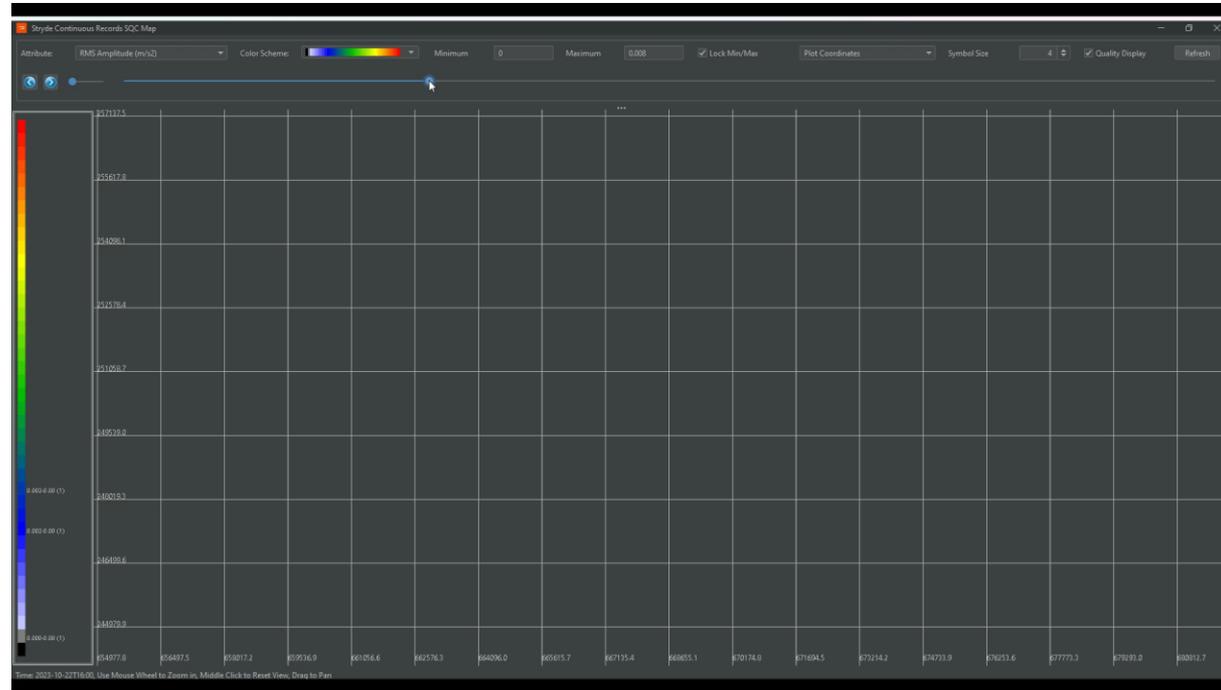
Data QC – Raw

- Due to data volumes (and possibly shooting technique), data QC needs to be statistical
- Attributes are read or calculated during harvesting
 - Hardware attributes – voltage, temp, tilt, clock accuracy, GNSS success rate, GNSS position
 - Seismic data attributes - RMS, dominant frequency, DC, clip, spike, zero crossing....
 - Test (shaker) – gain, resonance frequency
- Analytical decision on “good/bad node” made before harvesting is ended



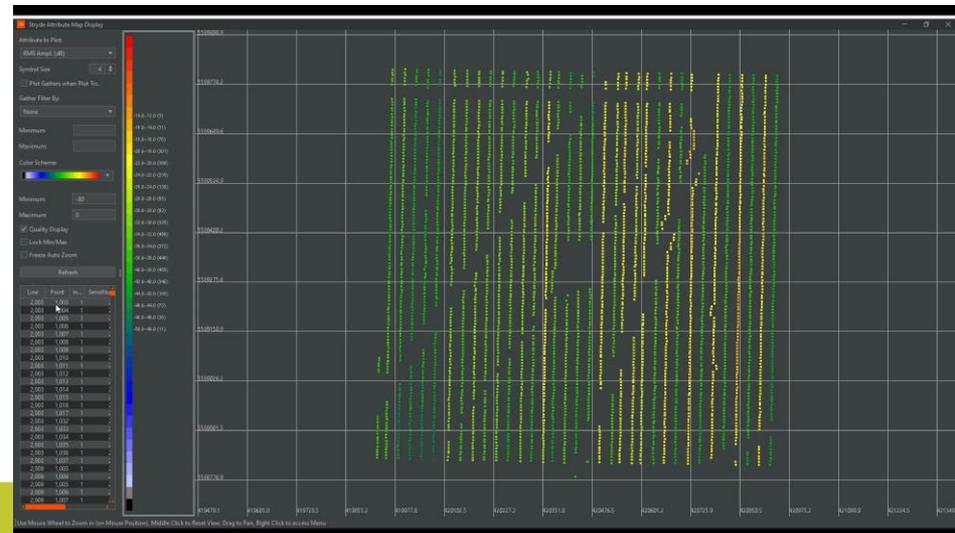
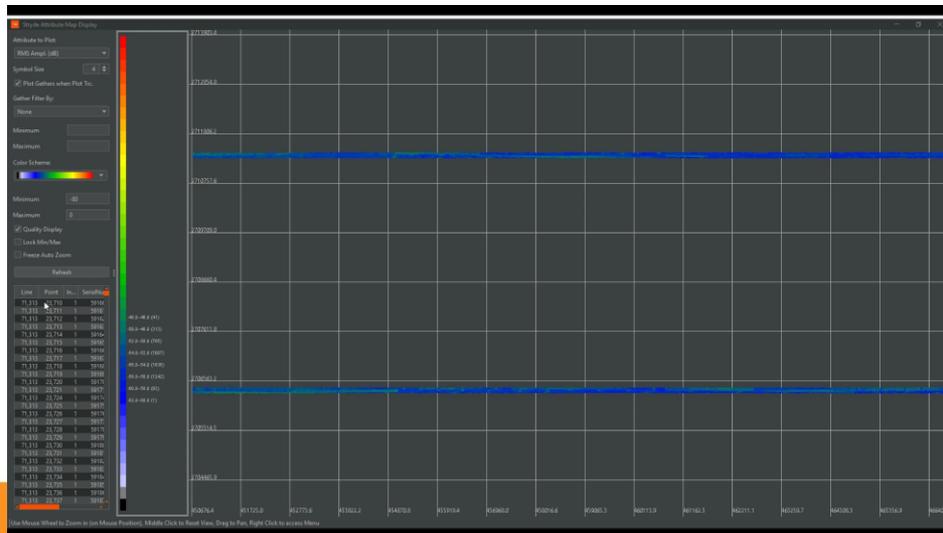
Data QC – Raw

- Attributes inserted into SEGD headers and saved to equipment database
- Attribute values can be read and displayed
- Timing interval of the attribute calculations determined by roll rate
- Bad traces highlighted to operator



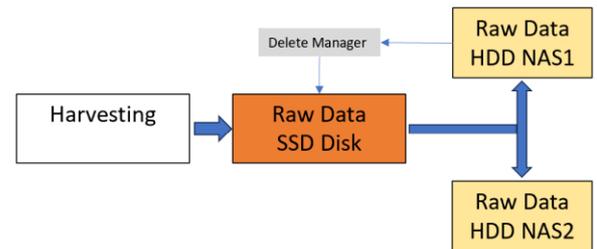
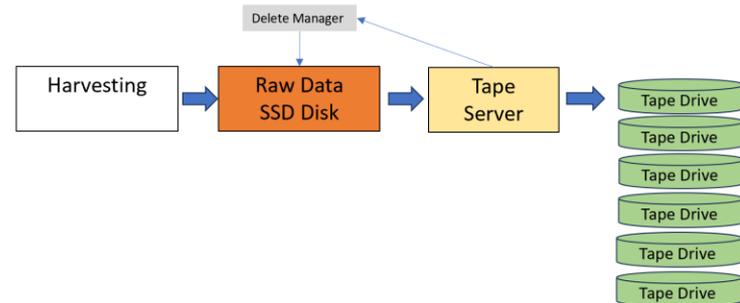
Data QC - Gathers

- When gathers are generated & trace attribute extraction done
- HW attributes (tilt, time sync accuracy etc)
- Seismic data attributes (RMS, dom frequency, dead, weak trace, etc)
- Attributes values can be read, filtered and displayed so that large number of gathers QC'ed quickly



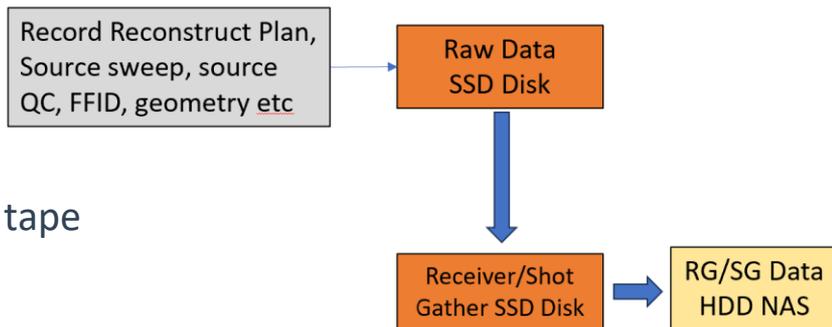
Data Management

- 67k nodes per day ~155TB (single copy)
- Not handling the data correctly will quickly stop the crew
- Optimal solution depends on whether data will be passed quickly to processing center (NAS) or stored for future processing (tape)
- Data format should be SEG-D R3 with headers fully populated
- Two copies. Tape writing slower than write to NAS
- If local processing center ready to receive data, then write two copies to NAS. One rotated to DP center, one remaining on crew until data confirmed read
- Delete Manager automatically deleting raw data once archived



Data Management

- Gathers written to SSD Raid Disk and copied to NAS or tape
- Data copying to media needs to be configurable & highly automated
- List of which files are NAS/Tape is generated and stored on the media and archived on disk for processing center use
- 10gbe network ports required to handle transfer speeds
- Raw data in 3-byte SEG D format and gathers are 4-byte SEG D
- Write-to-tape supporting latest 3592 JF tape drives & 50TB tapes

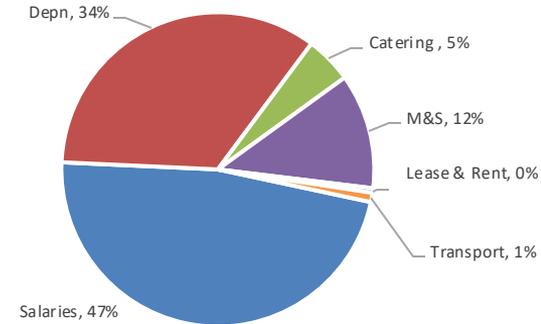


Crew Cost Analysis

- Mix of Capex and Opex
 - Equipment depreciation – acq system, vibes, vehicles, camp
 - Material & supplies – vibe, vehicles, acq system spare parts, fuel, water
 - Salaries / catering

- Acquisition system cost is not the whole equation
- Cable crews require more people, more vehicles & bigger camps

Total Crew Cost Breakdown

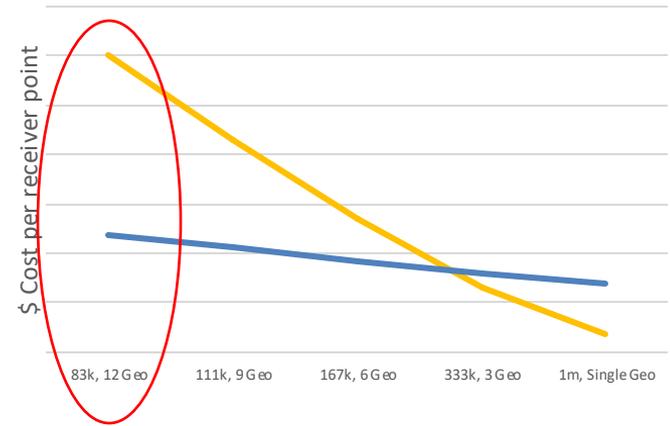


Crew Cost Analysis

- As you increase cable channel count, there is a point at which nodal acquisition will be cheaper per sq/km

Million geo vs million node but with different channel counts

Recording Capex



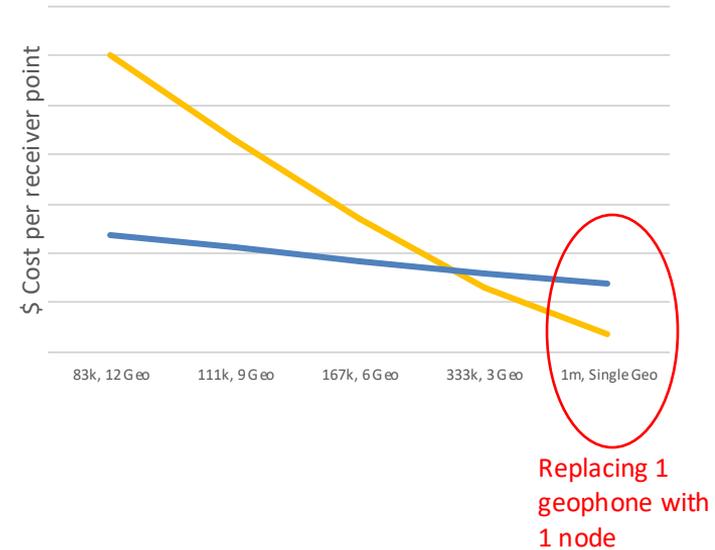
Replacing 12 geophones with 12 nodes

Crew Cost Analysis

- As you increase cable channel count, there is a point at which nodal acquisition will be cheaper per sq/km
- As you increase the telemetry channels then node cost is less than cable/geophone cost
- At what point does it make financial sense?

Million geo vs million node but with different telemetry channel counts

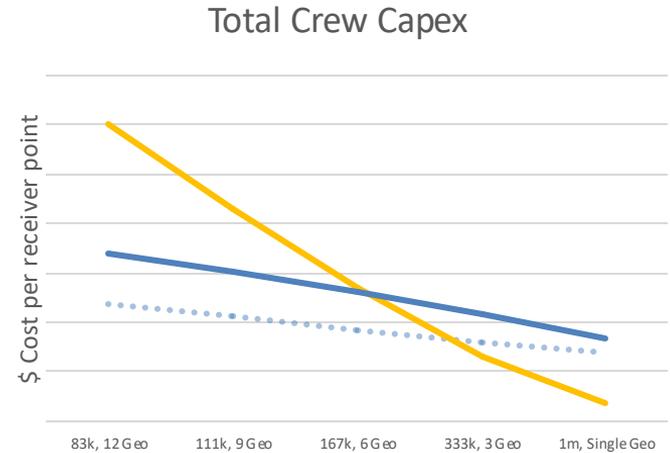
Recording Capex



Crew Cost Analysis

- As you increase cable channel count, there is a point at which nodal acquisition will be cheaper per sq/km
- As you increase the telemetry channels then node cost is less than cable/geophone cost
- At what point does it make financial sense?

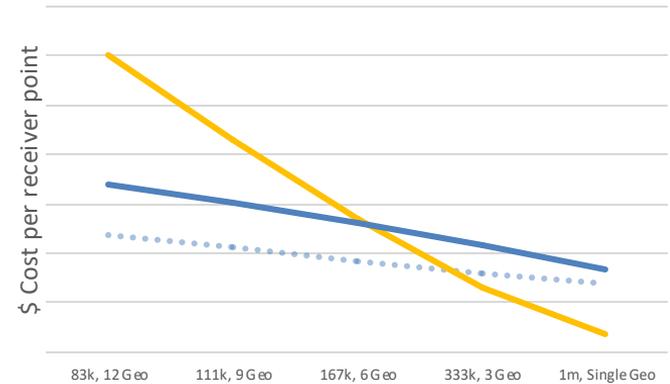
- Take into account total capex including the larger vehicle fleet and camp size then it lowers the threshold



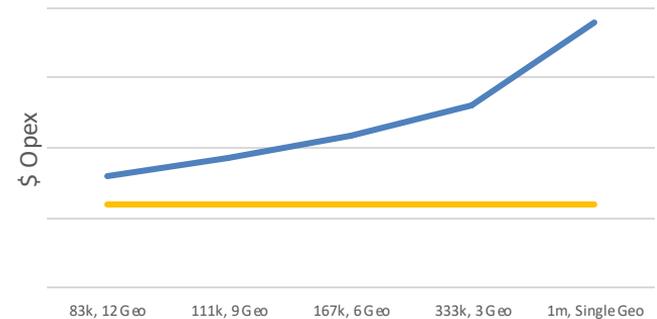
Crew Cost Analysis

- As you increase cable channel count, there is a point at which nodal acquisition will be cheaper per sq/km
- As you increase the telemetry channels then node cost is less than cable/geophone cost
- At what point does it make financial sense?
- Take into account total capex including the larger vehicle fleet and camp size then it lowers the threshold
- But opex savings (salaries, catering, M&S etc) are substantial with a node crew

Total Recording Capex



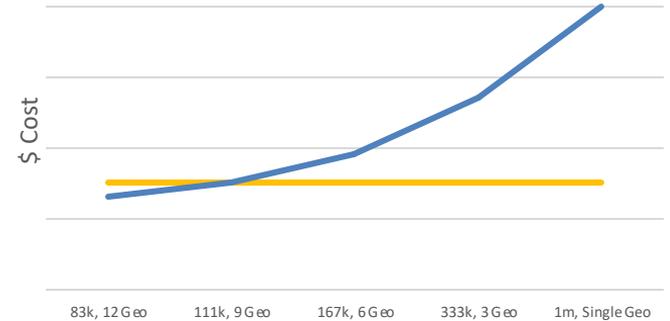
Crew Opex



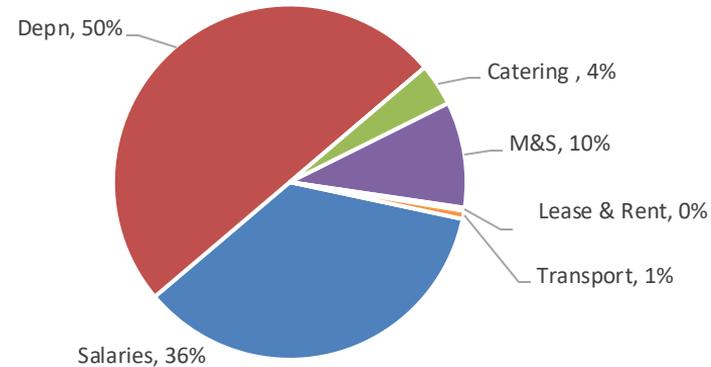
Crew Cost Analysis

- The combination of capex and opex costs shows the real picture of monthly crew cost
- This is 1:1 comparison
- In practice, it's common to use fewer single sensors to replace a geo array
- Technique like CS can lower the node count even further

Monthly Crew Cost



Total Crew Cost Breakdown



Crew Cost Analysis

- Further benefits of a node crew
 - Enable a faster spread roll – faster production opportunities
 - Mob/demob is much cheaper
 - Denser receivers allow sparser source to cut down on dozer costs
 - Reduces permitting effort

Conclusions

- Lightweight, low-cost nodes change the paradigm of operational logistics
- Large cable crews can be replaced with more efficient nodal systems (& increase trace density)
- Data harvesting throughput is achievable
- Data handling systems need to be robust and in place before survey start
- Node crews can roll more equipment per day, allowing opportunity to increase productivity sq/kms per month

- Opens opportunities for deployment automation
- Lowers field crew HSE profile and reduces environmental impact

Thank you