Avoid DAS-aster!

Issues to consider before your next DAS experiment

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AGU DAS Workshop, Dec. 2020

A Team Effort : *Dark Fiber and Distributed Acoustic Sensing*

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How to avoid a DAS-aster!

Some things we have learned since 2014

- This isn't a science talk (no new results) – triage of some challenges/complications we have encountered in the field. There is likely another talk on processing mistakes (many). Also not for the old hands at this …
- Sometimes you learn by screwing things up! We made mistakes (in the 6 experiments we have done) so you don't have to ☺
- This talk – a focus on dark fiber installations but many of the same issues exist to varying degrees for fit-for-purpose fiber networks.
- Contact any of us with questions/comments (community has lots to learn)

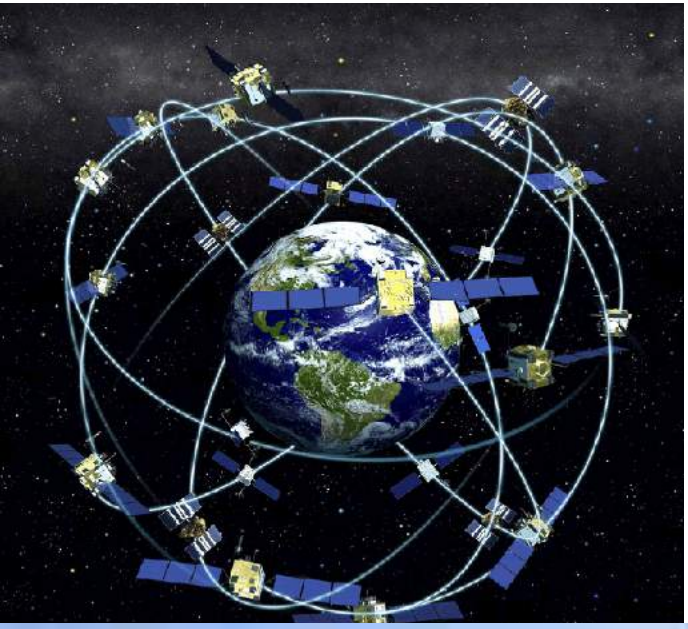
Know "when" you are : (keep track of time)

Know "where" you are : (determine array geometry)

Know "what" you are looking at : (coupling and fiber installation + physical safety)

Know "how" to manage the data! : (data transfer, storage, processing, archiving)

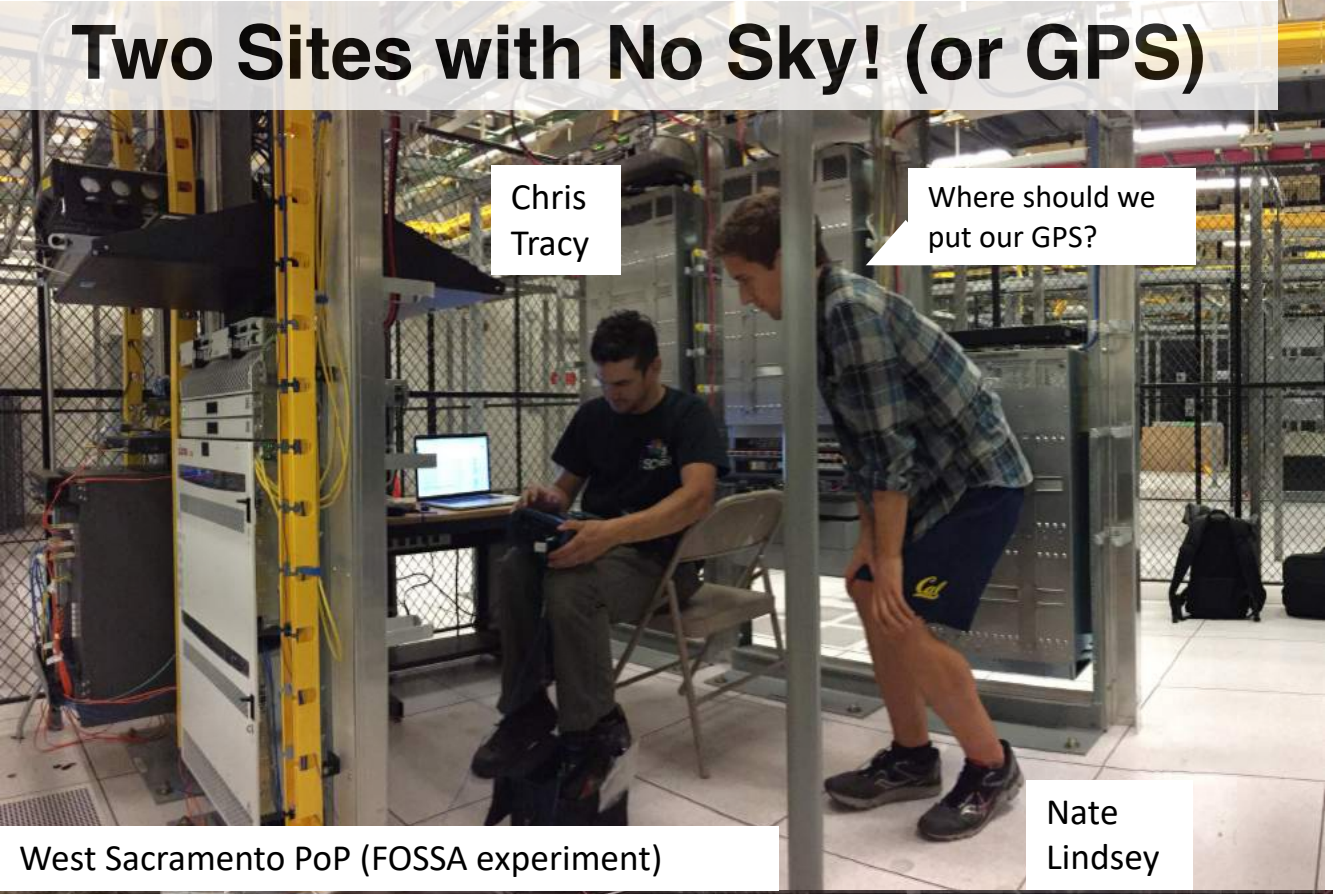
Know "when" you are:
keeping track of time



- Standard in seismology is to keep track of time using GPS
- For DAS, absolute time is important for
  - EQ arrivals (t0) and active sources which don't generate a TTL connected to your IU.
  - Coordination with external networks.
- To get GPS times you need … sky (or at least a window)
- When you don't have it, stuck with internal clock on DAS (often with large drift).

From Trimble

Two Sites with No Sky! (or GPS)



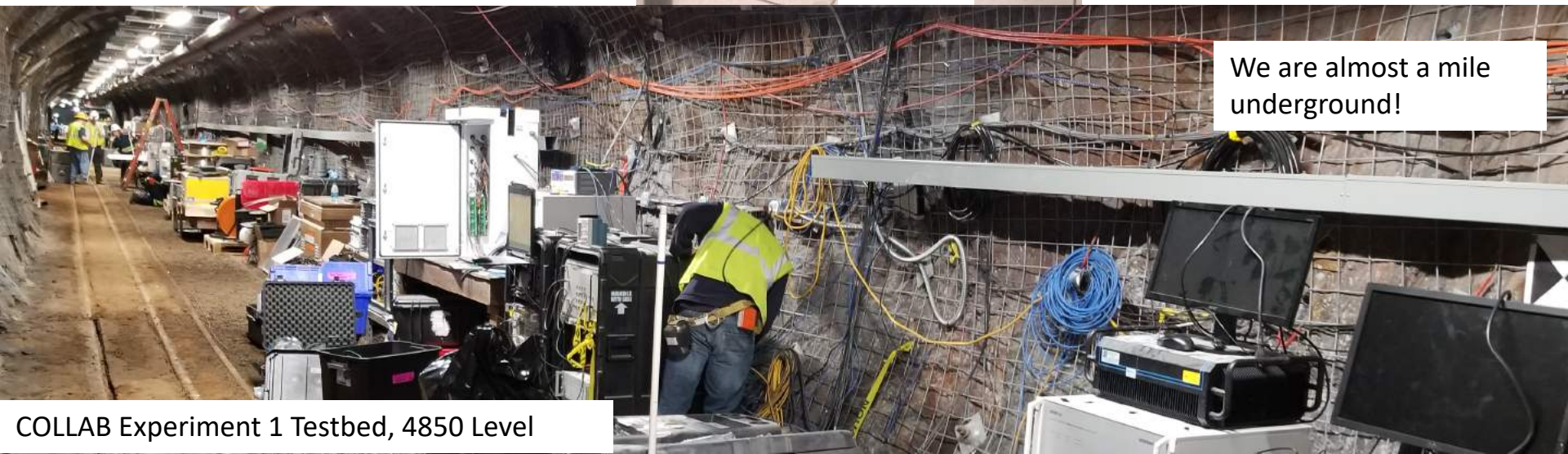
West Sacramento PoP (FOSSA experiment)

Two examples where GPS was tough to manage

1) Deep in the center of a giant Point-of-presence (PoP) for dark fiber acquisition [FOSSA DAS experiment].

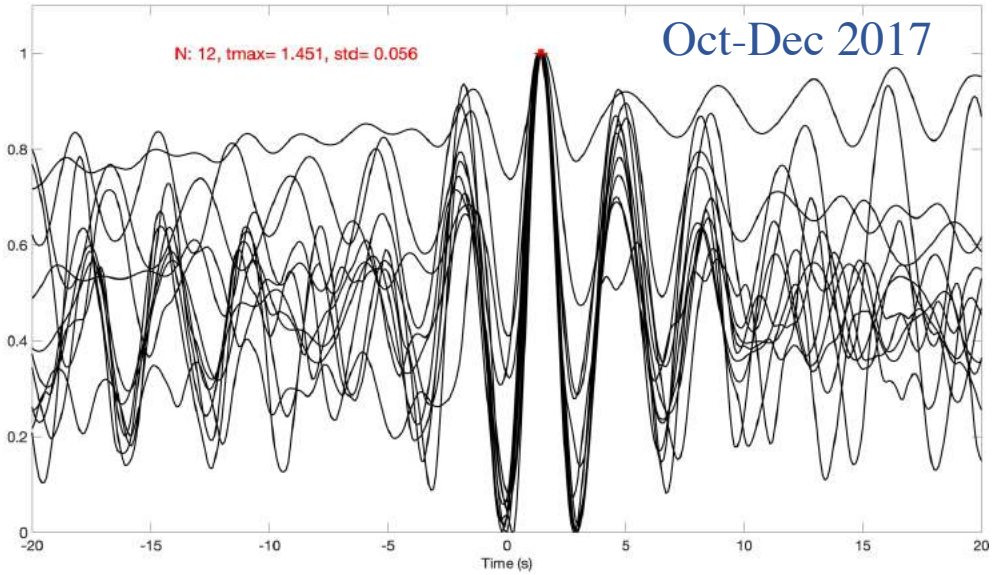
2) 4850 ft underground at the SURF facility (Homestake mine), Lead SD [COLLAB experiment]

Problems & solutions?

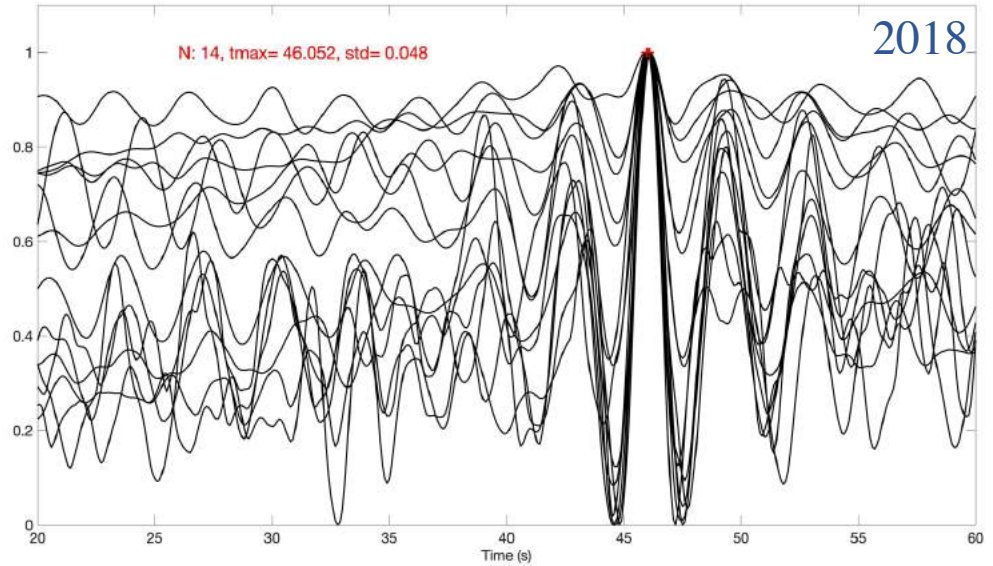


COLLAB Experiment 1 Testbed, 4850 Level

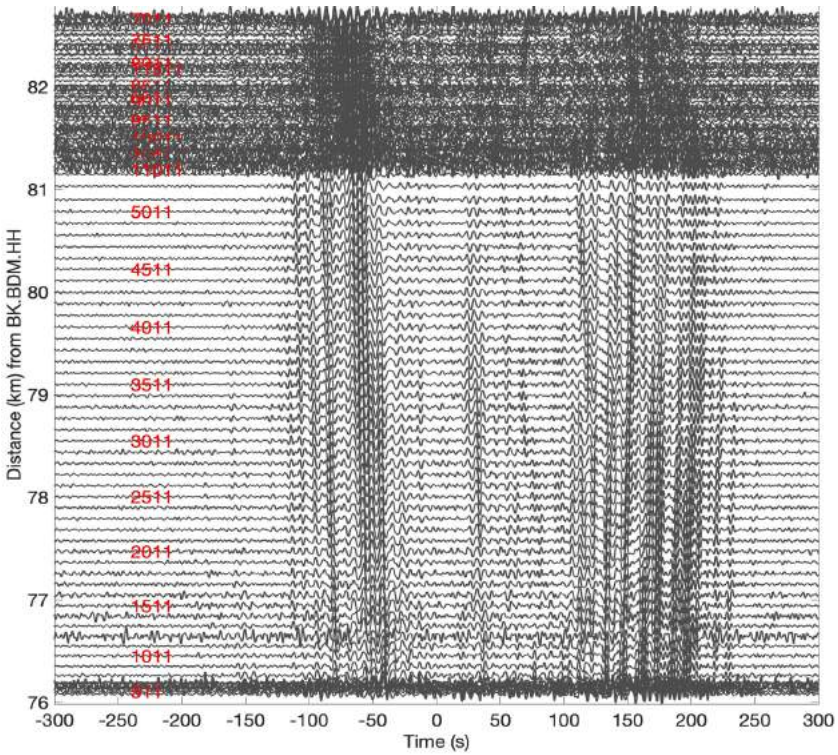
Impact of Bad Timing:
45s + of clock drift



[courtesy Avinash Nayak]

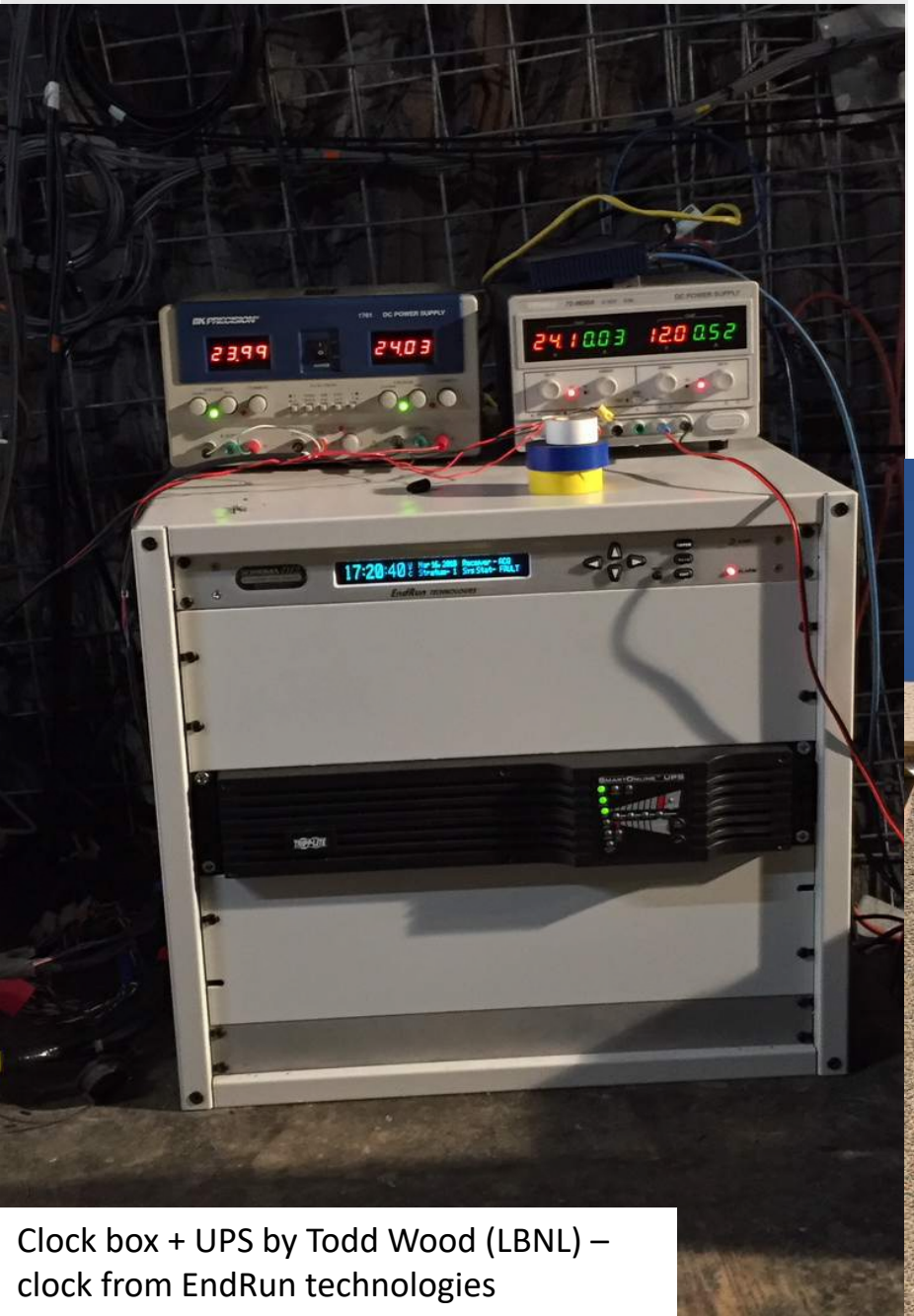


- Without GPS or a PPS synchronization pulse, systems fall back to either an internal clock or NTP (network time protocol).
- An internal clock can slip seconds/day depending on system.
- Example: FOSSA, estimated clock drift by x-correlation with GPS-timed inertial sensor (BDM) and computing symmetry.
- 45s + drift by 7 months, questions still about correction accuracy!

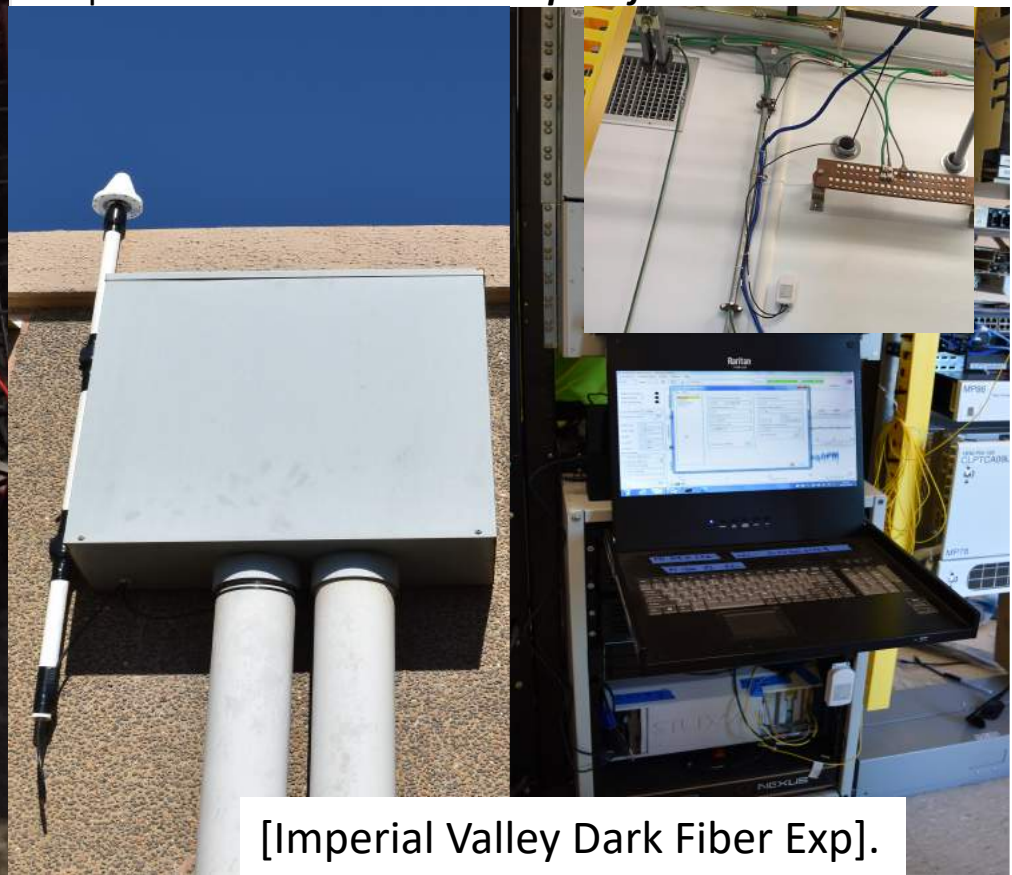


Solutions Which Helped

- For mine, ended up synchronizing DAS to ***rubidium atomic clock***. Clock synched on surface, instruments synched using either PPS (pulse-per-second) or precise time protocol (PTP) (but needed to synch clock sometimes!). Worked but talk to IU vendor ;)
- For next PoP deployment, found way to route GPS cables to feed-through point on wall and mounted external antenna
- More exotic solution (x-correlation referencing) also possible but not advisable – ***plan for time standards!***



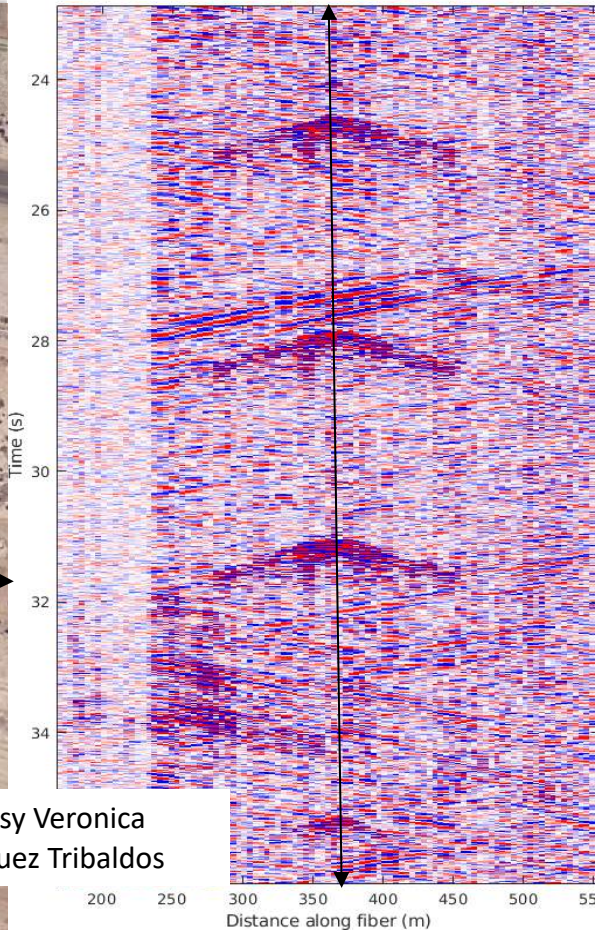
Clock box + UPS by Todd Wood (LBNL) – clock from EndRun technologies



[Imperial Valley Dark Fiber Exp].

Know *where* you are:
The joys of tap testing

- For dark fiber or pre-installed networks, we only have “weak” constraints on fiber location + lots of slack (telecom protocol)
- Vendor fiber KML files can be ***off by 10-100s of meters*** and can have 10-100s of m spooled in various locations (manhole, ILA runs).
- **Tap testing GPS locations is often the best way of determining location. Plan time for a reasonable number of locations!**
- Remember not to change settings on the IU during/after tap tests (can mangle channel #s) and **keep record of settings**.

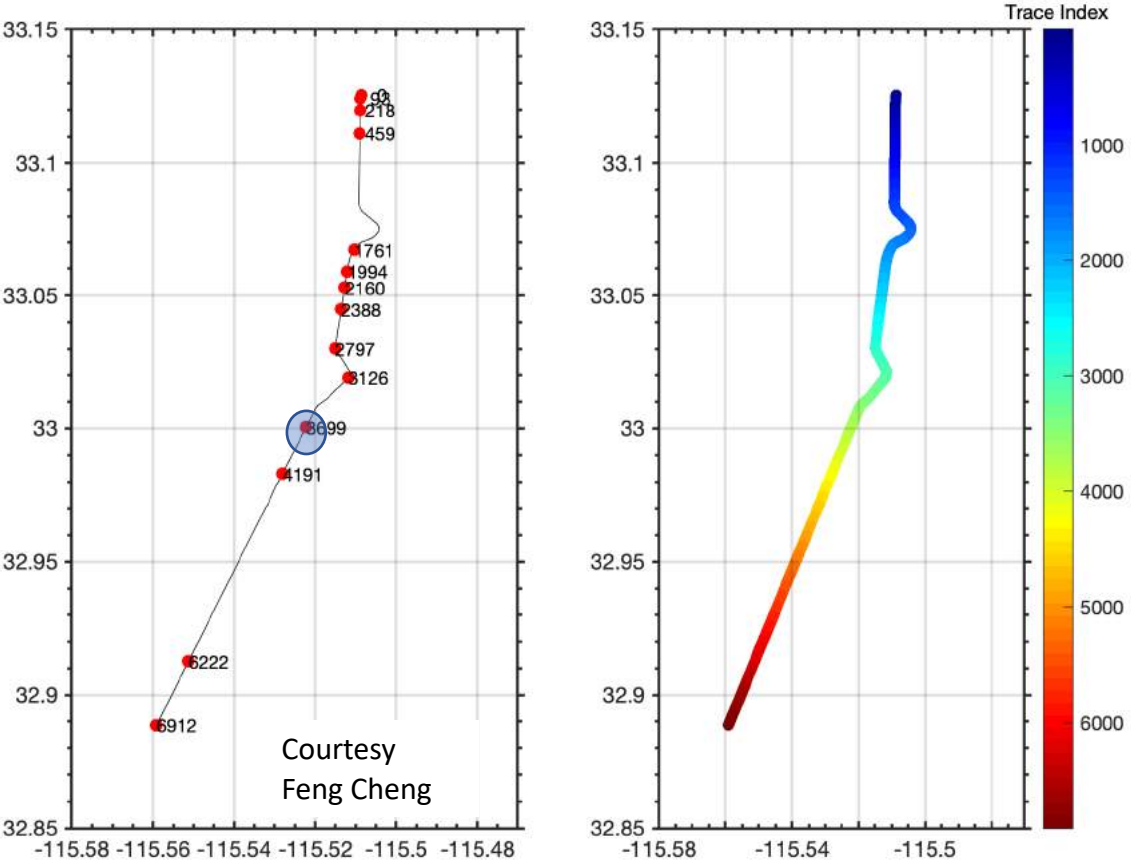


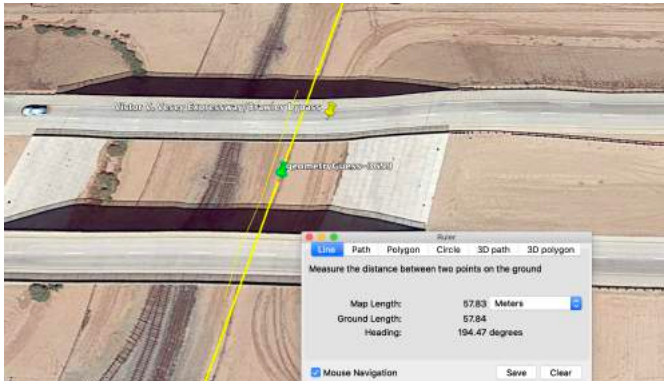
Courtesy Veronica Rodriguez Tribaldos

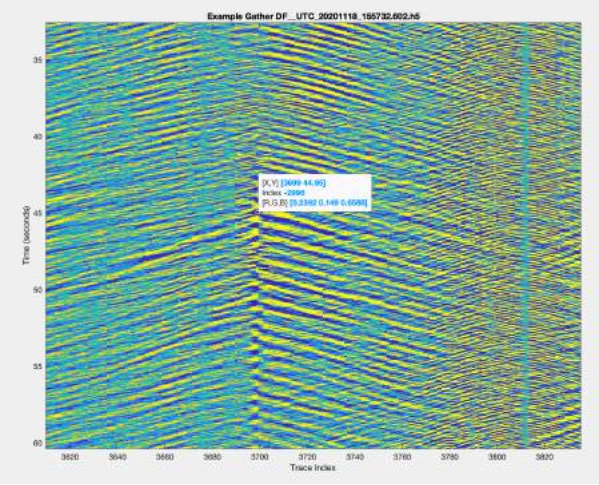
Todd Wood & Michelle Robertson ”on the road”

Know *where* you are:
The joys of tap testing

- If you don't have enough "taps" can sometimes in-fill with "natural" noise sources along the path (and fiber turns).
- Example below from current project in the Imperial Valley, CA, 28 km (~7000 channel) array, taps in North supplemented by natural sources in the South.
- But be forwarned – there are ***many*** anthropogenic noise sources. Particularly in urban areas, may be hard to ID the sources (supplement with manual taps) and harder yet to get +- 10 m accuracy.







Know *where* you are:

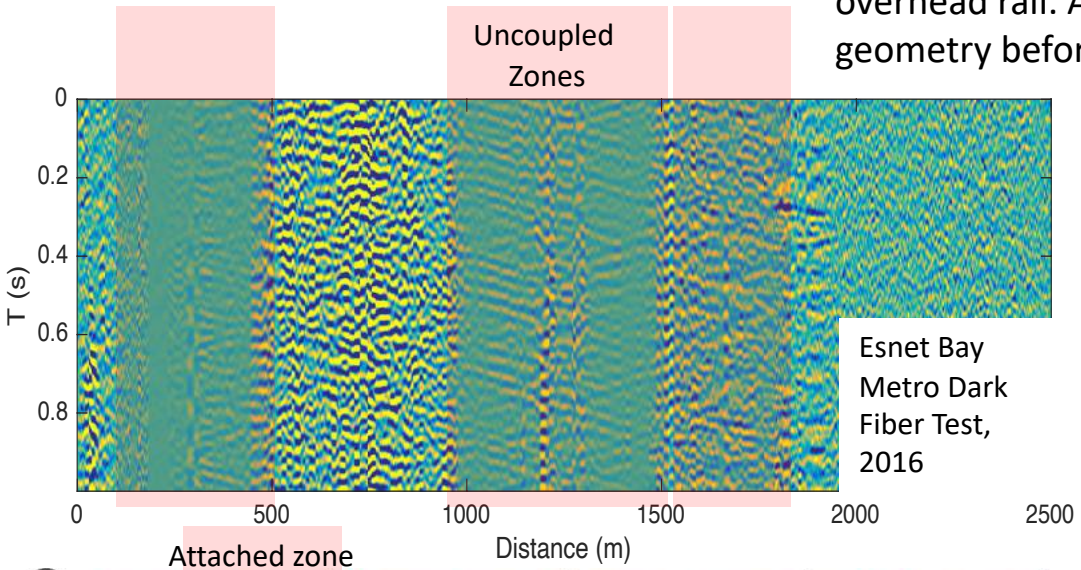
The joys of tap testing [fit-for-purpose network edition]

- For networks you install, many corners and short sections can be challenging.
- Typical gauge lengths (~10 m) spread taps over larger section – if runs are short, IDing channels at a corner can be complicated.
- Consider tap testing on both turn-arounds ***and*** long straight runs to help mitigate these issues. Also keep track of splices ….
- Remember that the tap test is only as good as your surveying (important for short runs).
- Geometry assignment has been a right of passage in our group – also error prone (can be on for one section, off for others).

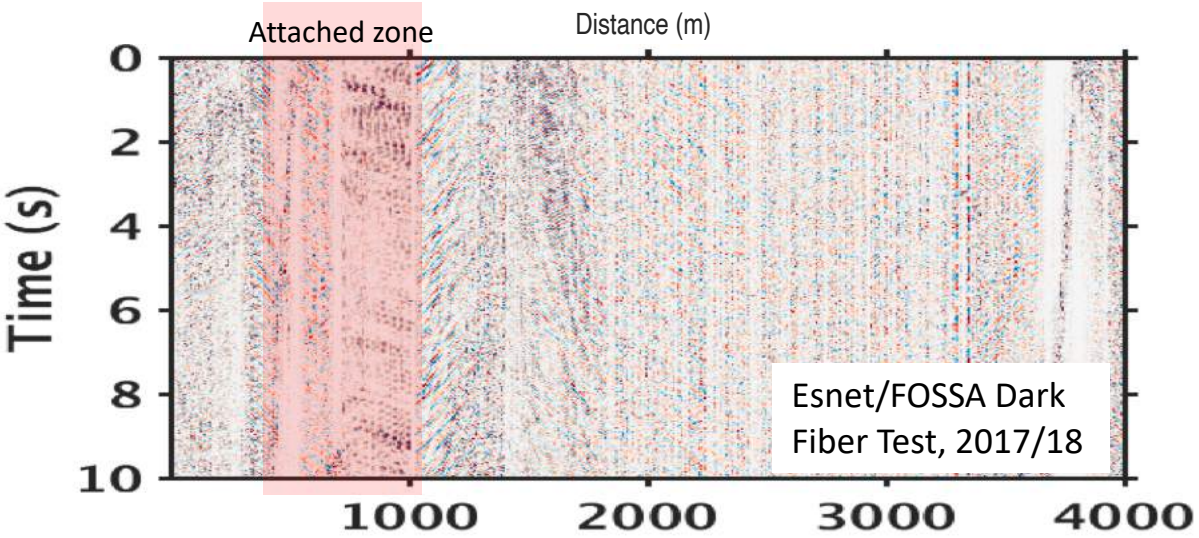
Fairbanks, AK
(Lindsey et al., 2017)

Know *what* you are looking at: Coupling and installation

- When exploiting fit-for-purpose arrays, we know how fiber is **coupled to soil/rock** etc.
- When using pre-existing networks (dark fiber, infrastructure components) need to know installation practice!
- Big issue is ”attached” fiber on utility poles, bridges, overhead rail. Attempt to determine the surface/subsurface geometry beforehand if possible (engineering drawings)

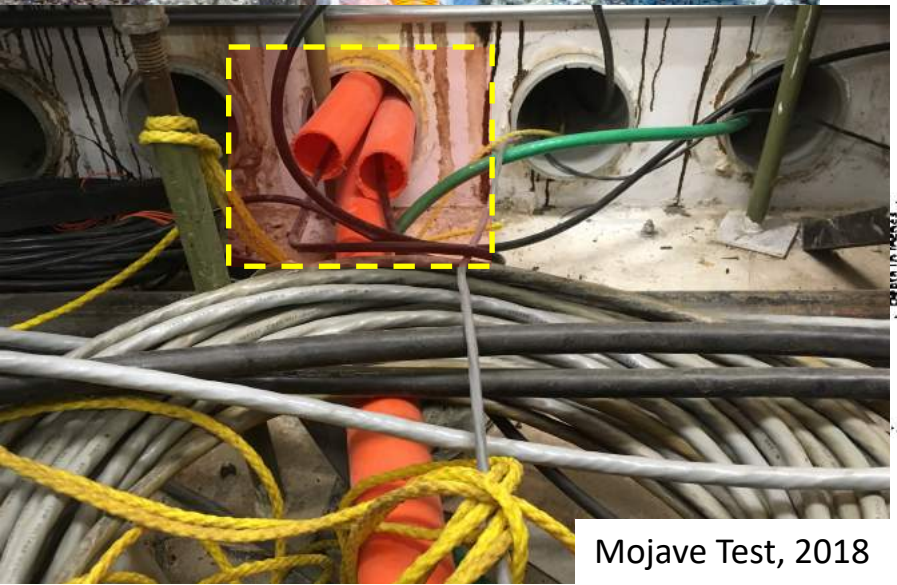


Esnet Bay Metro Dark Fiber Test, 2016



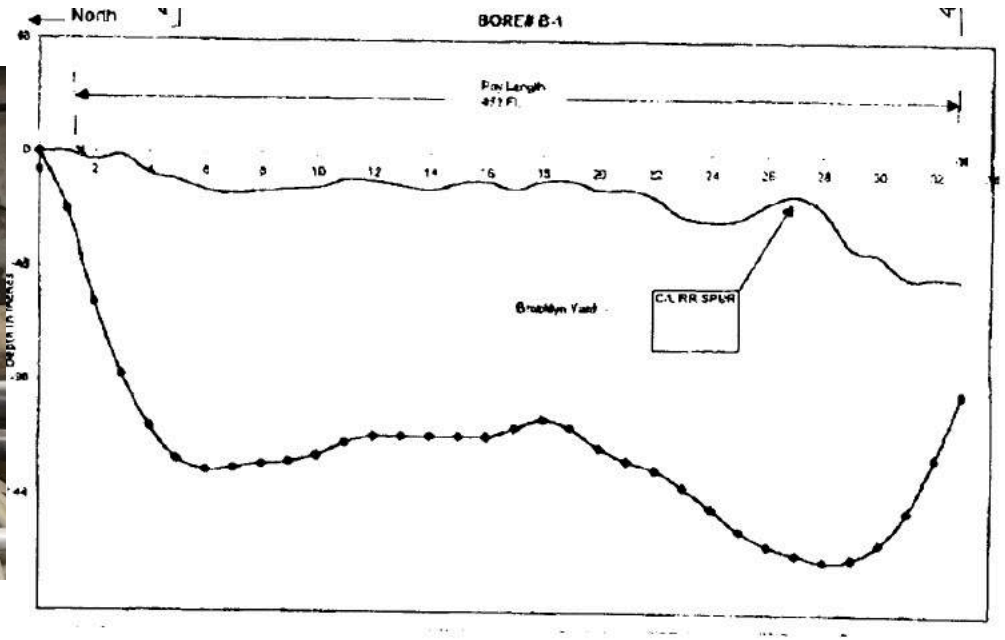
Esnet/FOSSA Dark Fiber Test, 2017/18

Know *what* you are looking at:
Coupling and installation



Mojave Test, 2018

- Even when fiber is known to be subsurface, coupling can be an issue.
- Worst case (from limited experience) are scenarios where fiber is in multiple layers of conduit and not heavily packed.
- Again – useful to have engineering drawings beforehand.
- If you know anyone involved in the fiber installation, they will know where the skeletons are buried …. (details not always in reports).



Know *what* you are looking at: Physical system safety

- If the IU is destroyed, you definitely aren't measuring anything of interest! (and IUs are pricey)
- In this case, individual broke into our instrumentation shack and incinerated everything inside.
- Would have been nice to have a thicker door, taller fence around site, and more monitoring (did record arson on game camera).
- Moral of the story, site security matters! (no system = no data).

What used to be a DTS

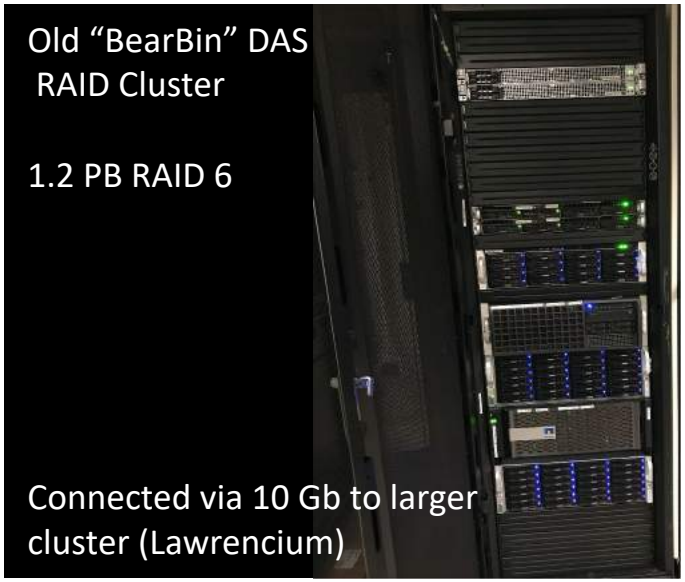
Before

After

Fairbanks, AK, Permafrost Test Facility

How do we manage data?

The Endless Struggle!



- Assuming you are generating beautiful data, what do you plan to do with it? Need to have a strategy for transferring, storing (short term), processing, and archiving this data volume. (“cradle to grave”)
- Remember, ballpark for a large dark fiber network could be up to 10-20 TB/week, multiply by long term deployment.
- Moving data from IU to home institution is often via ”sneaker net” except for cases where high-speed network connection is available. Local RAID array for longer term – lower bandwidth connection for QC.
- Need to get data to where processing is (cluster, cloud, supercomputer). Our solution is a centralized RAID system visible to institutional cluster.
- Our solution is not sustainable! Need path to smaller storage footprint (perhaps products/compression).

Remote Field System: Local RAID + Cell for QC

A couple of months of sneakernet operation

Max bandwith:
USPS sending boxes of 12TB drives

This dataset is ~300 TB raw with over 100 TB of working data versions.

Marco Voltolini

How do we manage data?

The Endless Struggle!

DAS IU :
22 km, 2 m DX, 500 hz ~8 TB/wk - continuously (FOSSA)

Option 1 :
Store everything in full resolution, forever
[drown in HDs!]
(also need grant $s)

0.4 PB/yr
(up to 3.2 PB/yr/IU)

50 x 8TB drives

~60K storage Server to use

Option 2 : Compression
Large scale compression**?**
Working on it…

Option 3 : Products
Start being selective – consider special purpose data products customized to application intent

Moral of the story:
Be clear-eyed at the beginning of a project about the ***amount*** of data you will collect, what storage will ***cost***, and what will ***happen*** to it at the end.

Lessons Learned:

Fingers crossed that you will avoid a DAS-aster!

Know ”when” you are

- Have a plan for timing on your DAS IU, consider clock/GPS fault tolerance.

Know “where” you are :

- Have a plan for mapping geometry, particularly for large networks.

Know “what” you are looking at :

- Gather as much data as possible on network installation.
- Think about the physical safety of your systems.

Know “how” to manage your data! :

- Consider the lifetime of your DAS data (more than a boilerplate DMP!). A plan for transfer from field – storage – processing - archiving.

Thanks for listening to our rambling!

Supported By

Dark Fiber project : LBNL LDRD

Lawrence Berkeley National Laboratory
Laboratory Directed Research & Development program
LDRD

Geothermal Technology Research Office : US DOE

[DoD : Strategic Environmental Research and Development Program]