ALOHA PROOF MODULE MAKAHA TEST REPORT
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Purpose: This test is intended to provide assurance that the ALOHA Cabled Observatory (ACO) design provides a high-quality data transport link from the observatory node to the shore station over the HAW-4 cable. It will also show that the cable power is adequate for operation of the observatory.

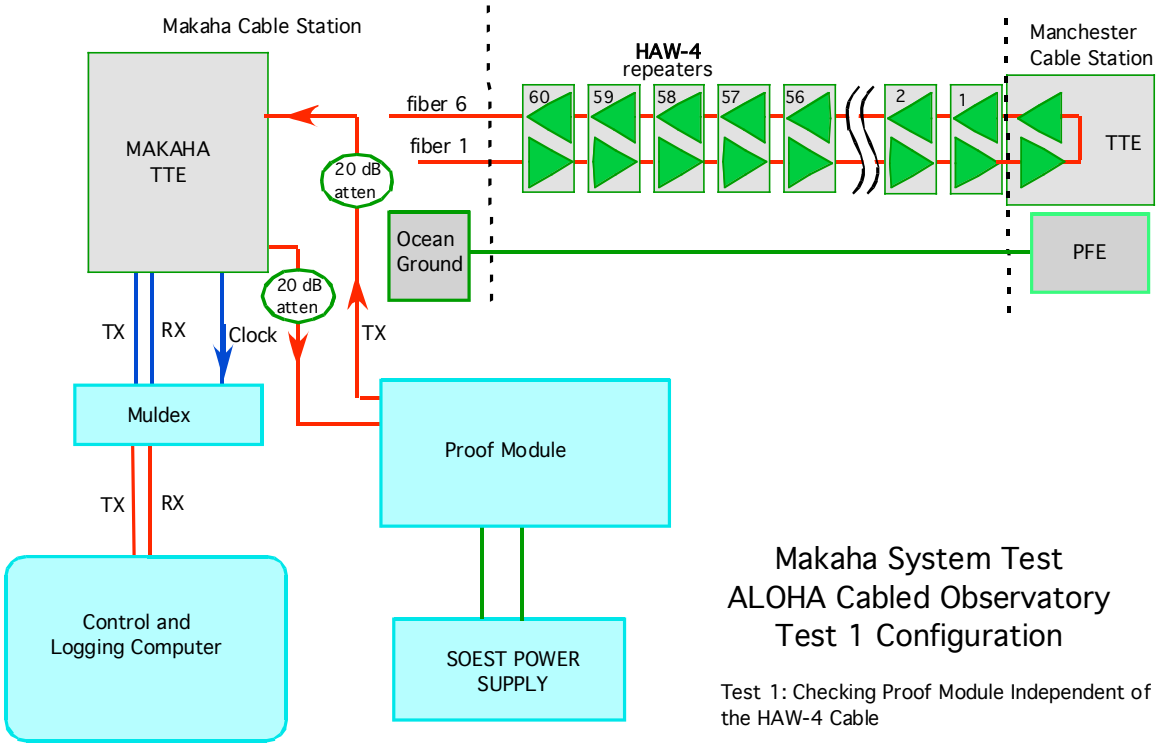
Procedure: The ACO Proof Module electronics are brought to the Makaha Cable Station and connected to the HAW-4 fibers, and the power system is connected in series to the HAW-4 system between the cable and the ocean ground. The cable is powered from the Manchester, California cable station, and data are sent from the Proof Module over the cable to Manchester and looped back to Makaha for evaluation.

Summary results: The ACO Proof Module system proved to be flawless in operation during this test. When powered from California, 4,262 km away, about 6100 V source voltage was required. Since these systems can provide up to 8 kV without stress to the system, almost 2 kV are available for observatory power if an observatory is installed at that distance from the power source, and more for shorter cable lengths. Data transmission was without errors over the wet portion of the system, verifying that the data transport link could operate reliably over cable lengths of more than 8,000 km.

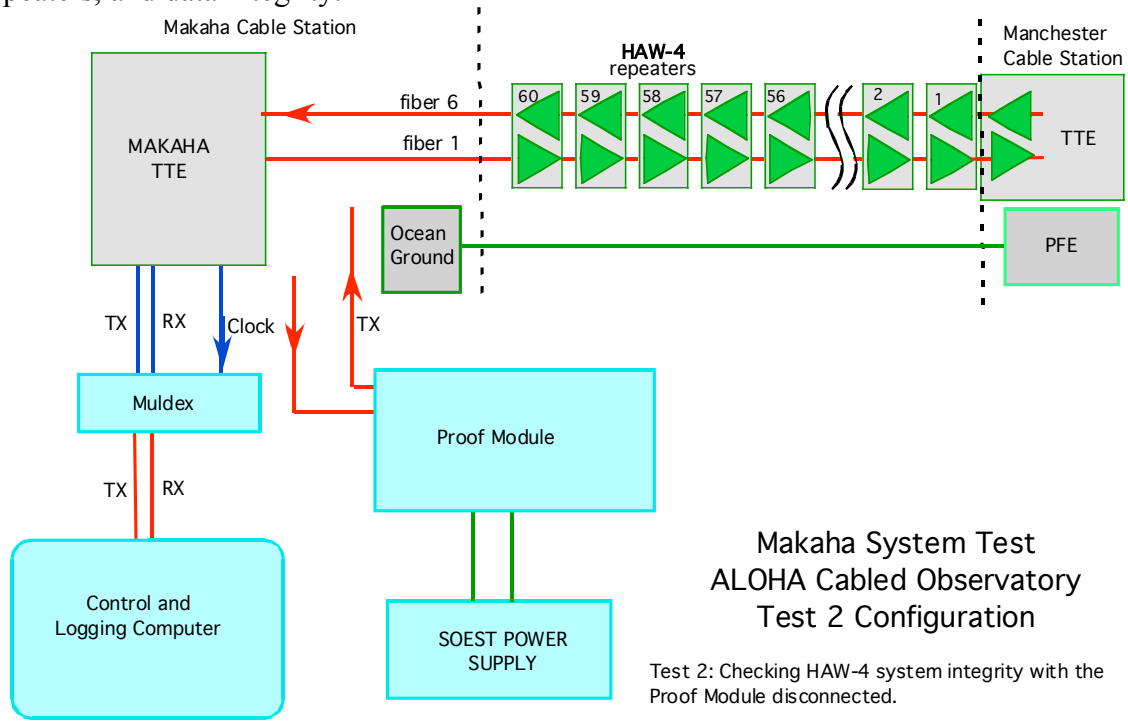
The one remaining test prior to emplacement will be accomplished within two weeks, with the Proof Module and cable termination installed in the ocean below Makai Pier, Oahu. The purpose of this test will be to operate the system with the mission power supply and to insure that the system operates nominally in the ocean.

Tests accomplished:

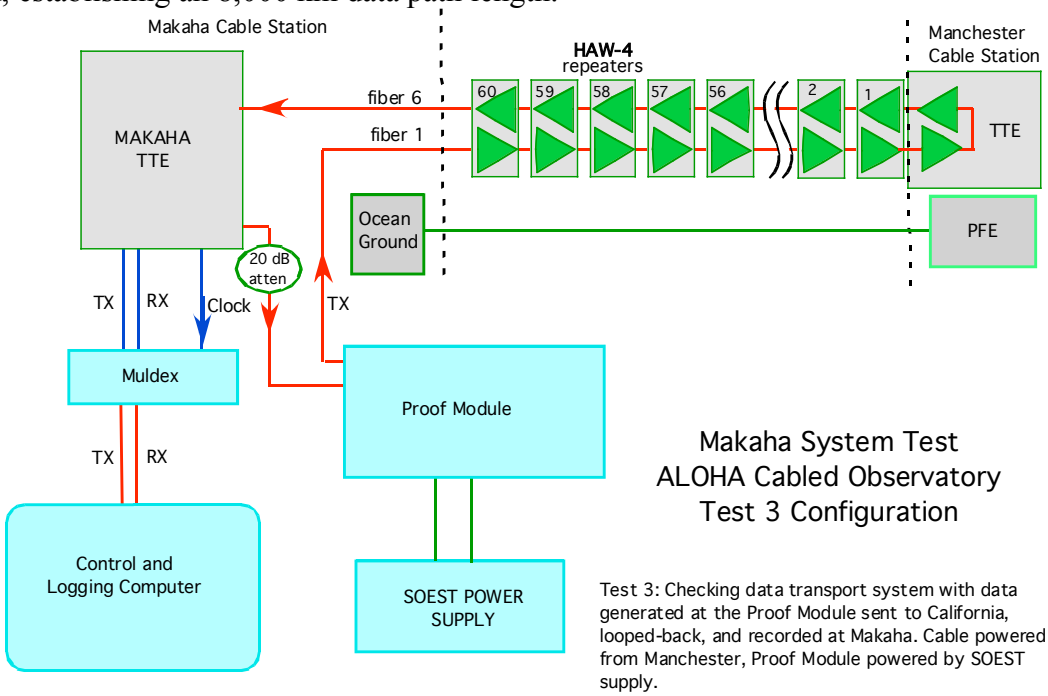
1) Supply power to the Proof Module directly from a local power source, with data recorded by the logging computer to insure that the isolated system is operating properly.



2) Power-up the HAW-4 cable from Manchester and evaluate the HAW-4 system, repeaters, and data integrity.



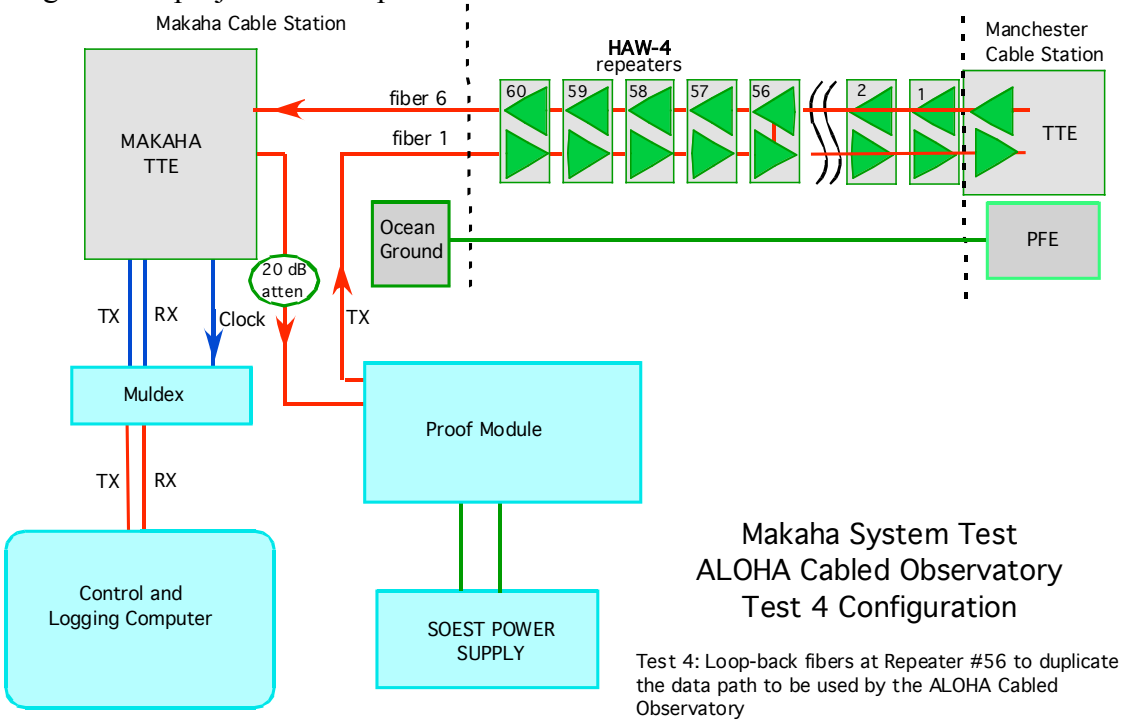
3) Connect fibers 1 and 6 (primary fiber pair) to the Proof Module and loop back these fibers at Manchester so that data and commands travel from Makaha to Manchester and back, establishing an 8,000 km data path length.



Makaha System Test
ALOHA Cabled Observatory
Test 3 Configuration

Test 3: Checking data transport system with data generated at the Proof Module sent to California, looped-back, and recorded at Makaha. Cable powered from Manchester, Proof Module powered by SOEST supply.

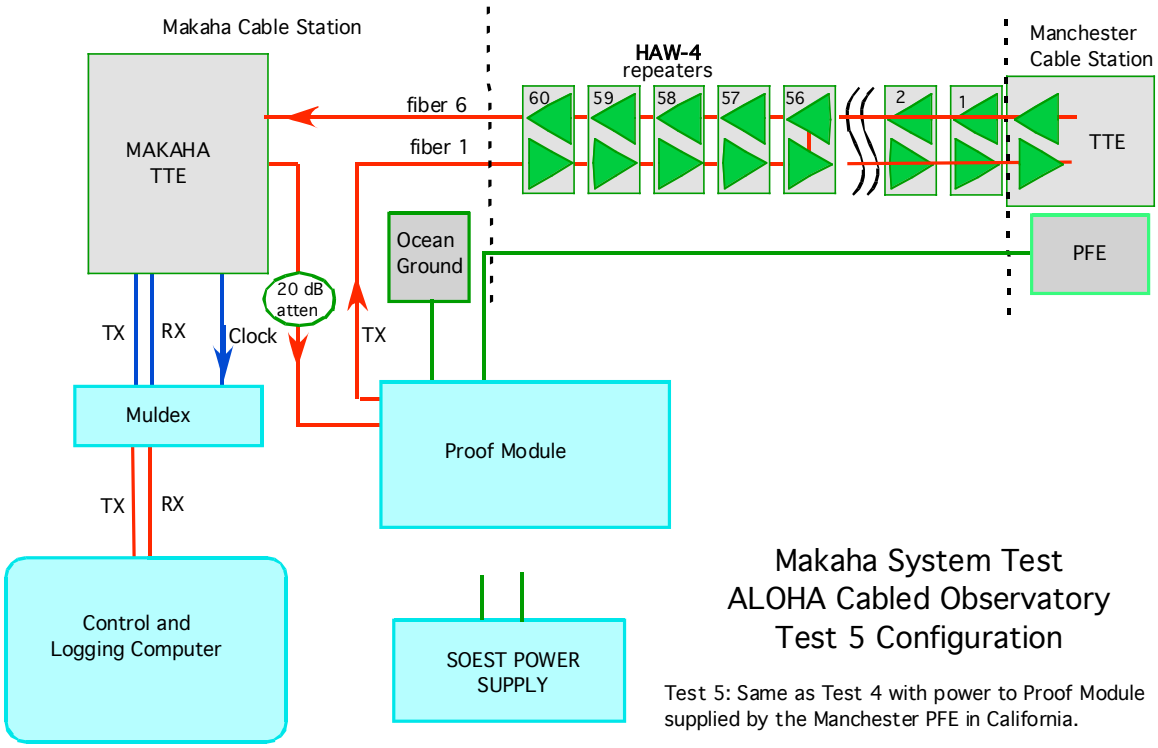
4) Loop-back fibers 1 and 6 at repeater 56, north of Station ALOHA, to simulate the length of the projected cable path.



Makaha System Test
ALOHA Cabled Observatory
Test 4 Configuration

Test 4: Loop-back fibers at Repeater #56 to duplicate the data path to be used by the ALOHA Cabled Observatory

5) Use the cable power supplied from Manchester to power the Proof Module and evaluate.



6) Cycle the cable power at Manchester and evaluate how the Proof Module reacts to the power cycle.

Comments:

Data recording: Data were recorded at 96,000 samples per second on two channels. Three modes of data were available: 1) hydrophone: The hydrophone is recorded on both channels, one channel with no filtering, and one with a 10 Hz high-pass filter to allow rapid amplifier and filter settling necessary for rapid settling of filters during emplacement and for improved dynamic range for acoustic data. 2) Pseudo-random noise: A noise generator in the Proof Module injects white noise into the 24-bit data word of channel A, and the compliment of the value into channel B. Summing the output of both channels should yield a value of zero if no errors are present. 3) Ramp: A counter injects a ramp into channel A with a change of one DU at every sample, and places the compliment into channel B. The resulting signal will be a rising ramp in one channel and a decreasing ramp in the other. The ramp repeats every 175 seconds. As with the random noise, the sum of the values in each channel should be zero when there are no errors. In addition, any offsets in the progress of the ramps indicate loss of data.

Engineering data included in the data stream include temperatures of various points in the package, and voltages and currents. A Digiquartz pressure sensor is also included, but its data were not evaluated in this test.

Data are stored continuously in 2-minute files with both channels stored at full-rate. Each file is nominally 87 MB in length. The file is divided into records of 4096 data values per record with a header including time code at the front of each record. One second of data consists of 23.44 records per channel. The Proof Module does not contain a clock, as all data are streamed to the shore station where the clock signal is added. Files are closed and a new file opened at the boundary of even minutes. If, for some reason, data are not being recorded when an even minute boundary passes, the open file will continue to grow in size until the next even minute boundary is crossed. Thus, file size provides another indication of error.

ANALYSIS

Analysis of the data was accomplished using mainly software developed by James Jolly at SOEST. When in the hydrophone mode is being used, the only data quality statistic is length of file. In the random noise and ramp mode, the XOR statistic provides indication of errors, and, in the ramp mode, both XOR and breaks in the ramp sequence indicate errors. Each file was evaluated for XOR errors, ramp errors, and file length. In addition, several of the interesting files were plotted in both time and frequency domain.

All files were copied to a back-up disk and the error-checking software was run on each data file. At the start of each record the program detects which type of data (random noise, ramp, or hydrophone) was recorded, and performs the analysis accordingly. When the data type changes within the record from either the ramp or random noise to hydrophone, the software interprets the hydrophone data as being in error. These "errors" are ignored.

Errors were detected only at times when known setup problems existed in the cable station or test equipment, or when errors were forced by attenuation of the optical signal being sent out the HAW-4 cable. No errors were found that could not be explained, and no errors can be attributed to any wet plant sources or to the Proof Module itself.

ALOHA Cabled Observatory
MAKAHA Cable Station Proof Module System Tests

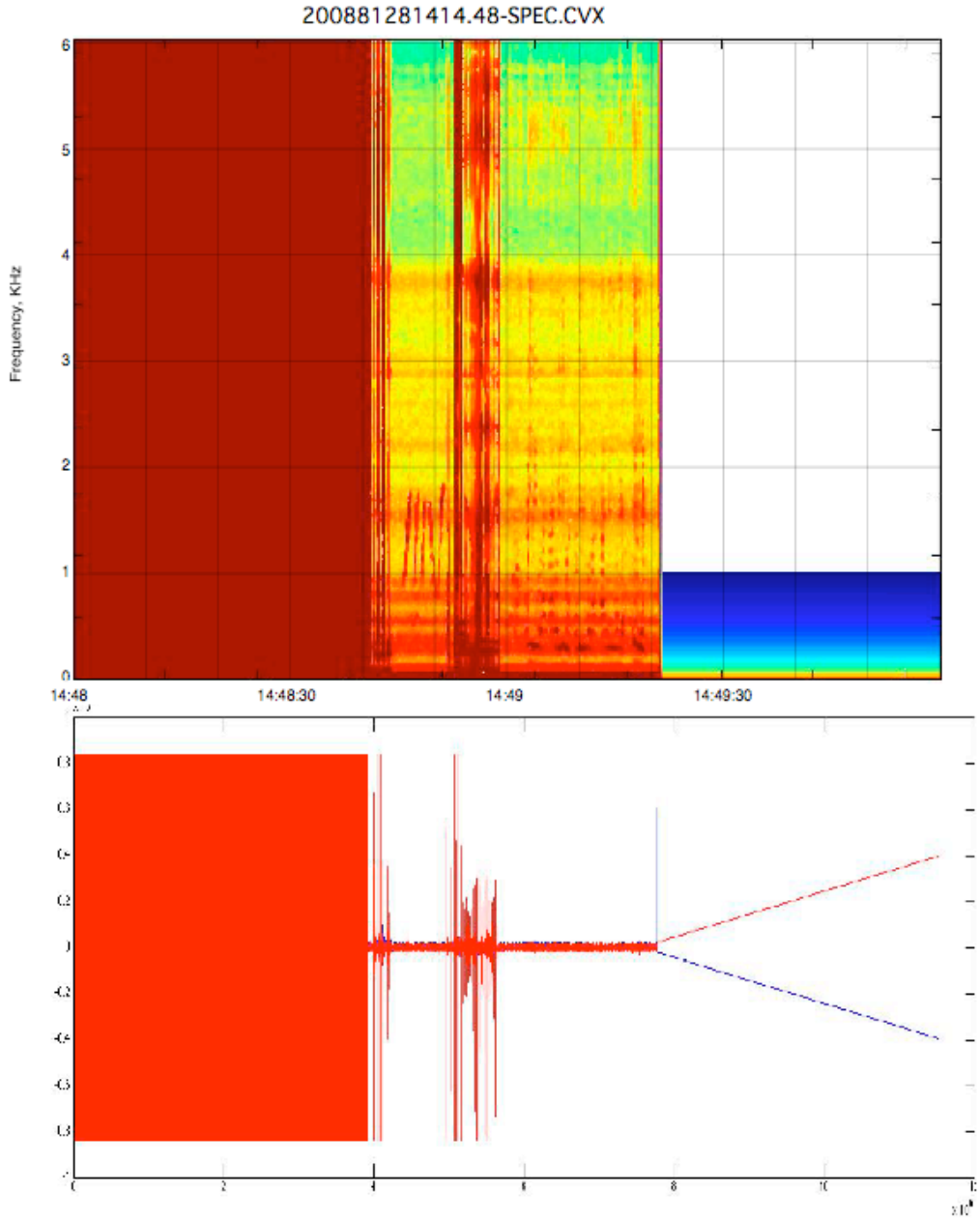
	Personnel:	Mark Tremblay, consulting engineer, Norm Gholson, SAIC (contracted by NSF)	
			Alexander Shor, Program Manager, NSF, James Jolly, UH Engineer, David Harris, UH Engineer, Fred Duennebier, Chief Scientist
	HST	Data file of interest	event
12/14/06	9:00:00		Arrive at cable station, unload
			drive from UH took~ 1hr 10 min
	10:00:00		**TEST 1**: Power HAW-4 from Manchester Cable Station, Manchester notes 6126 KV at 1.6021 A
	11:00:00		Mark notes that fiber 6 is showing a large number of errors.
	11:15:00		**TEST 2:** Proof Module attached to system using fibers 1 and 6, into the HAW-4 TTE, with power to the Proof Module supplied by SOEST power supply. No optical signal observed.
	12:30:00		Problem isolated to bad viconix-ST fiber jumper. Replaced by station spare.
		2006-12-14--12.42.HYD	first data file (audio)
	12:46:00	2006-12-14--12.46.HYD	break in data, change to random noise
		2006-12-14--12.54.HYD	break in data, many apparent errors, change to audio
		2006-12-14--12.58.HYD	long break in data - ~ 20 minutes analyzing problem, bad optical jumper
	1:20:00		All systems operating with Proof Module not connected to TTE.
		2006-12-14--13.20.HYD	Fiber 6 problem seems improved by re-seating a board in the Makaha TTE.
	1:30:00	2006-12-14--13.30.HYD good hydrophone	
	1:49:00	2006-12-14--13.48.HYD good hydrophone 13:48:40-49:24	
	2:00:00	2006-12-14--14.02.HYD	Attach Proof Module fibers to Makaha TTE. Still see fiiber 6 errors.
			begin long break - ~45 minutes,
	2:15:00		Mark determines problem with fiber 6 likely at Manchester Cable Station.
	2:30:00		Manchester replaces board in TTE as indicated by diagnostics. Fiber 6 problem gone.
	2:40:00		Manchester loops-back fibers 1 and 6 in station
	2:45:00		**TEST 3:** begin data integrity test with fiber 1-6 loop-back in Manchester. Data sent from Proof Module to Manchester and back for recording in ALOHA computer. **** these data actually looped back at Makaha by mistake - see 4:00:00 ****
	2:46:00		begin file 2006.12.14.14.46, Pseudo-random noise
	2:48:00	2006-12-14--14.48.HYD	**record 40 sec in each data mode**
		2006-12-14--14.48.pdf	**Analysis Figure**
	2:50:00	2006-12-14--14.50.HYD	begin recording in ramp mode
	3:10:00	2006-12-14--15.10.HYD	begin recording in pseudo-random noise mode
	3:30:00	2006-12-14--15.30.HYD	begin recording in **hydrophone mode**, making occasional noises
	3:30:48	2006-12-14--15.32.HYD	"more money". bangs, whale sounds, keys, whistle
	3:34:10	2006-12-14--15.34.HYD	'MORE MONEY"
	3:37:17	2006-12-14--15.36.HYD	Shor, whistle
	3:40:10	2006-12-14--15.40.HYD	whale sounds, banging on Proof Module frame
	3:50:00	2006-12-14--15.48.HYD	file 13:48 : last file of **hydrophone mode**, back to random noise
	4:00:00	2006-12-14--15.58.HYD	data off. No errors were observed during this test.
	4:00:00		Norm Gholson requests that Manchester break the loop to be sure data stops flowing. IT DOESN'T! Mark discovers wrong optical connection - the data were looped back in the Makaha TTE, not in the Manchester TTE!
	4:10:00		unable to get data transmission to Manchester. Discovered that 18 dB of optical attenuation were still at the output of the Proof Module laser. Attenuator removed. Data flows.
	4:24:00	2006-12-14--16.24.HYD	Now configured with loopback through Manchester. Data back on, random noise mode
	4:26:00	2006-12-14--16.26.HYD	**Manchester removes loop-back. Data flow stops as expected. NO ERRORS SEEN IN TEST SOFTWARE, but file length is short, Data started flowing again before 16:28 file re-start time.**
	4:26:00		files 16:26 - 16:34 pseudo-random noise mode
		2006-12-14--16.36.HYD	fiels 16:36 - 16:44 ramp mode data
		2006-12-14--16.46.HYD	files 16:46 - 16:54 **hydrophone** data mode
	5:00:00		we don't have a working SALT to configure the repeater configurations, so Mark Tremblay has devised codes for changing configurations using the printer port from the SOEST control computer.
	5:11:00	2006-12-14--17.10.HYD	**Test 4:** after a few unsuccessful tries, the fiber 1-6 loop-back commands are executed by repeater #56, the repeater just beyond Station ALOHA.
		2006-12-14--17.10.HYD	this file is long, and next file is missing as loop-back is reconfigured.
	5:14:00		begin test file 2006.12.14.17.14.HYD with Pseudo-random noise data
	5:18:00		Manchester loop-back is disconnected with no effect, as expected.
	5:24:00	2006-12-14--17.24.HYD	change to ramp at 17:24:40
	5:34:00	2006-12-14--17.34.HYD	change to **hydrophon**e
	5:44:00	2006-12-14--17.44.HYD	change back to ramp
	5:46:00	2006-12-14--17.46.HYD	remove repeater #56 loop-back - data stop
		2006-12-14--17.46.HYD	this file is long, and next file is missing as loop-back is reconfigured.
	5:48:55		RECONNECT LOOPBACK AT REPEATER #56
		2006-12-14--17.46.pdf	**Analysis Figure**
	DEPART STATION FOR THE NIGHT LEAVING THE SYSTEM OPERATING with loop-back at repeater 56		

Test Narrative: Day 1

12/15/06	Personnel	file of interest	Same as above w/o Dave Harris (sick)
	HST		EVENT
	8:30:00		Arrive at station, ~ 1 hr drive
	8:34:00		Observe that system has run with no recorded errors overnight. File being written is 2006-12-15-08.34.HYD
			Check control functions - all operating
	8:52:00	2006-12-15--08.52.HYD	Change to pseudo-random noise
	8:53:00	2006-12-15--08.52.HYD	Change to **hydrophone**
	9:00:00	2006-12-15--09.00.HYD	**shut-down cable power** at Manchester to switch Proof Module power from local power supply to get power from HAW-4 itself.
	10:40:00		**Test 5:** HAW-4 power back on from Manchester: 6160 V at 1.6 A
		2006-12-15--10.48.HYD	problem noted with logging computer. Screen locking up and in wrong resolution. Power re-start doesn't help. Resolution manually change to correct resolution, and all is well again.
	10:50:05	2006-12-15--10.50.HYD	switch to pseudo-random noise
	11:00:14	2006-12-15--11.00.HYD	switch to ramp
	11:05:00	2006-12-15--11.05.HYD	unplug transmit fiber from TTE to install variable optical attenuator. Will attenuate outgoing optical signal until errors are observed.
	11:06:00		begin attenuating signal
	11:09:00	2006-12-15--11.08.HYD	errors noticed with optical attenuation roughly 24 dB. Calibration is suspect because attenuator not operating properly.
	11:10:00	2006-12-15--11.10.HYD 2006-12-15--11.12.HYD	lots of errors
		2006-12-15--11.12.pdf	Analysis Figure
	11:15:07	2006-12-15--11.14.HYD	switch to pseudo-random noise mode - clean signal
	11:16:20	2006-12-15--11.16.HYD	increased attenuation - getting errors
	11:18:00		lower attenuation
	11:18:35	2006-12-15--11.18.HYD	switch to **hydrophone** note errors as "clicks"
	11:19:50		increase attenuation - note "snaps" in data
	11:20:20	2006-12-15--11.20.pdf	Analysis Figure claps, transmission noise "snaps"
	11:22:00		reduce attenuation
	11:26:50	2006-12-15--11.26.HYD	**Test 6:** power-down cable for power cycle test. Data stops
	11:29:30	2006-12-15--11.26.HYD	ramp cable power back up
	11:30:38	2006-12-15--11.26.HYD	data back up
		2006-12-15--11.26.pdf	Analysis Figure
	11:31:48	2006-12-15--11.26.HYD	switch to randomnoise
	11:32:37	2006-12-15--11.32.HYD	swich to ramp
	11:36:00	2006-12-15--11.36.HYD	begin power-down
	11:37:24		errors followed by end-of-data
	11:40:00		begin disconnecting and cleaning up
	12:45:00		depart cable station

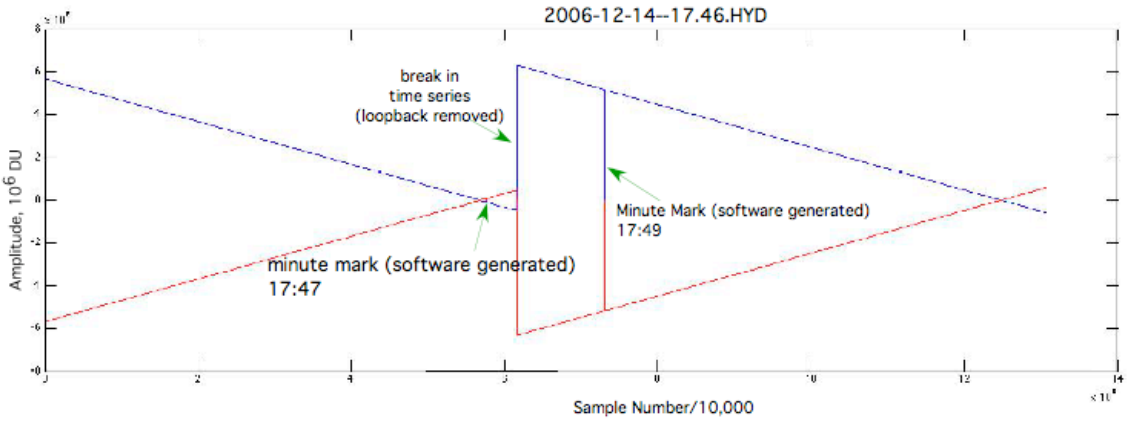
Test Narrative, Day 2:

Analysis Figures:



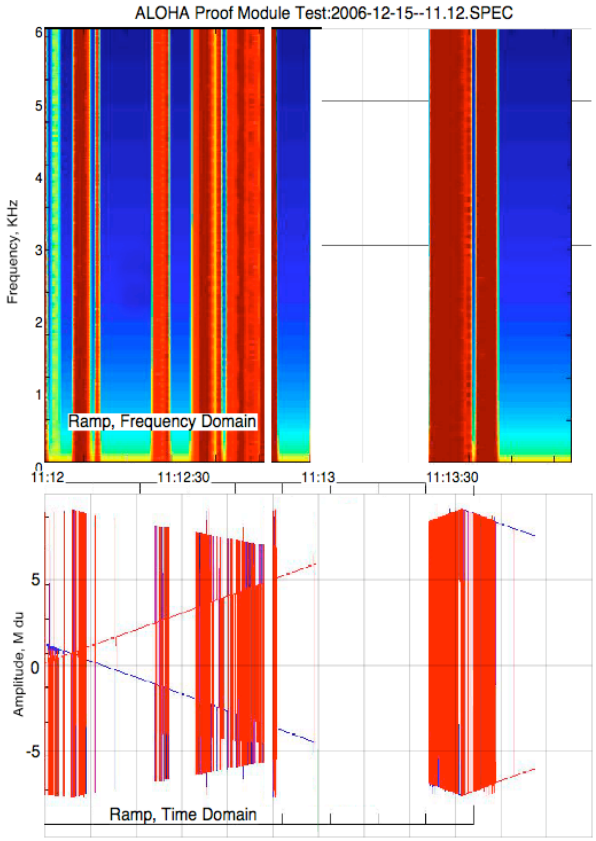
2006-12-14--14.48.pdf

This file shows the frequency domain (top) and time domain (bottom) for the two-minute period beginning at 14:48 HST on December 14, 2006. All three date modes, random noise, hydrophone, and ramp, were recorded for approximately 40s each respectively. Both channels are displayed in the time domain figure, but both channels are visible only in the ramp mode. The noise in the hydrophone data is caused by machine noises in the cable station and by intentional tapping on the Proof Module frame. The White area in the ramp section in the frequency domain is below the color pallet used; the low levels at high frequency are present, but small.



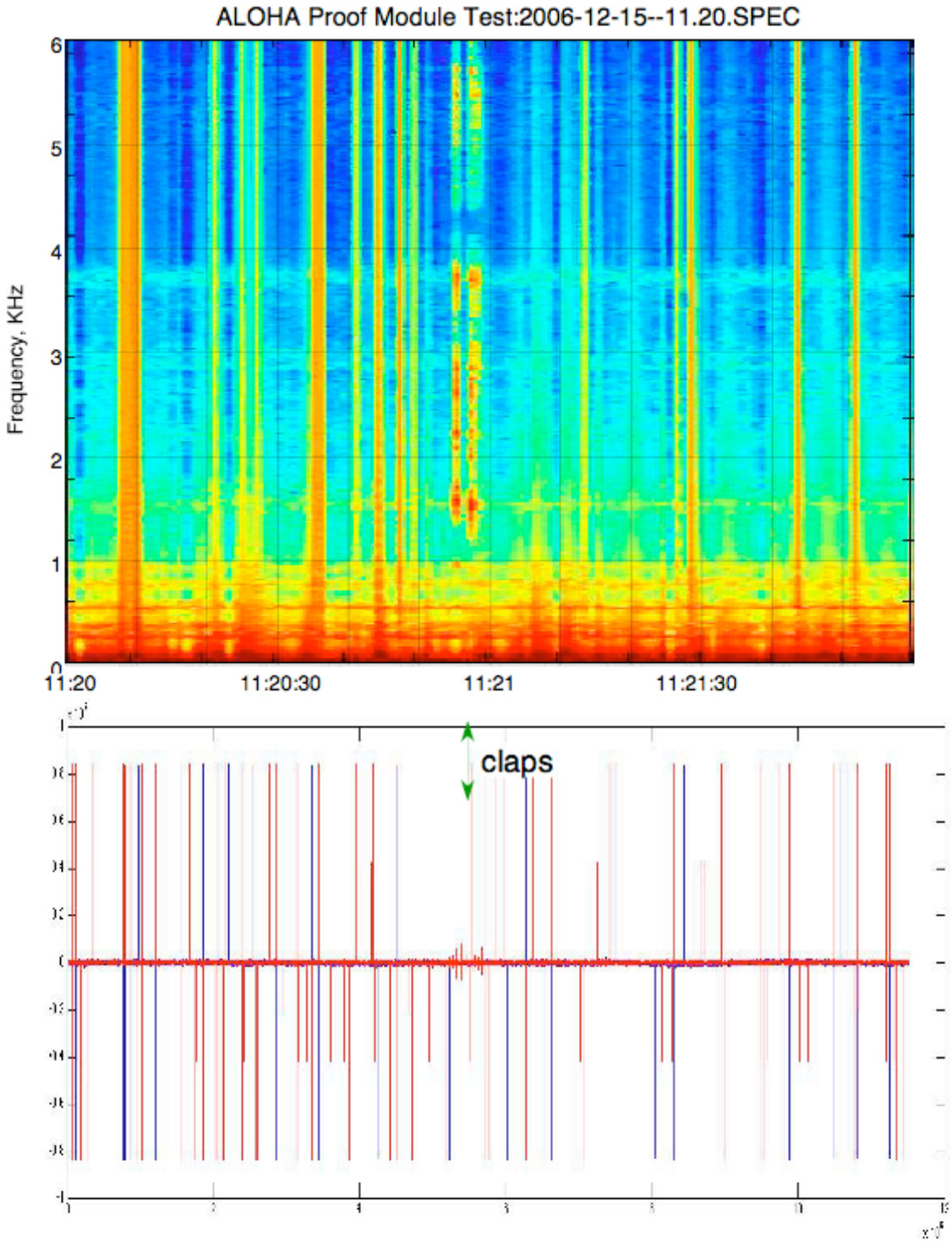
2006-12-14--17.46.pdf

This figure shows a file of ramp data taken when there was an intentional break in the data transmission while the Proof Module was still generating data. The plot-generation software replaces the data with zeros whenever a minute mark is detected.



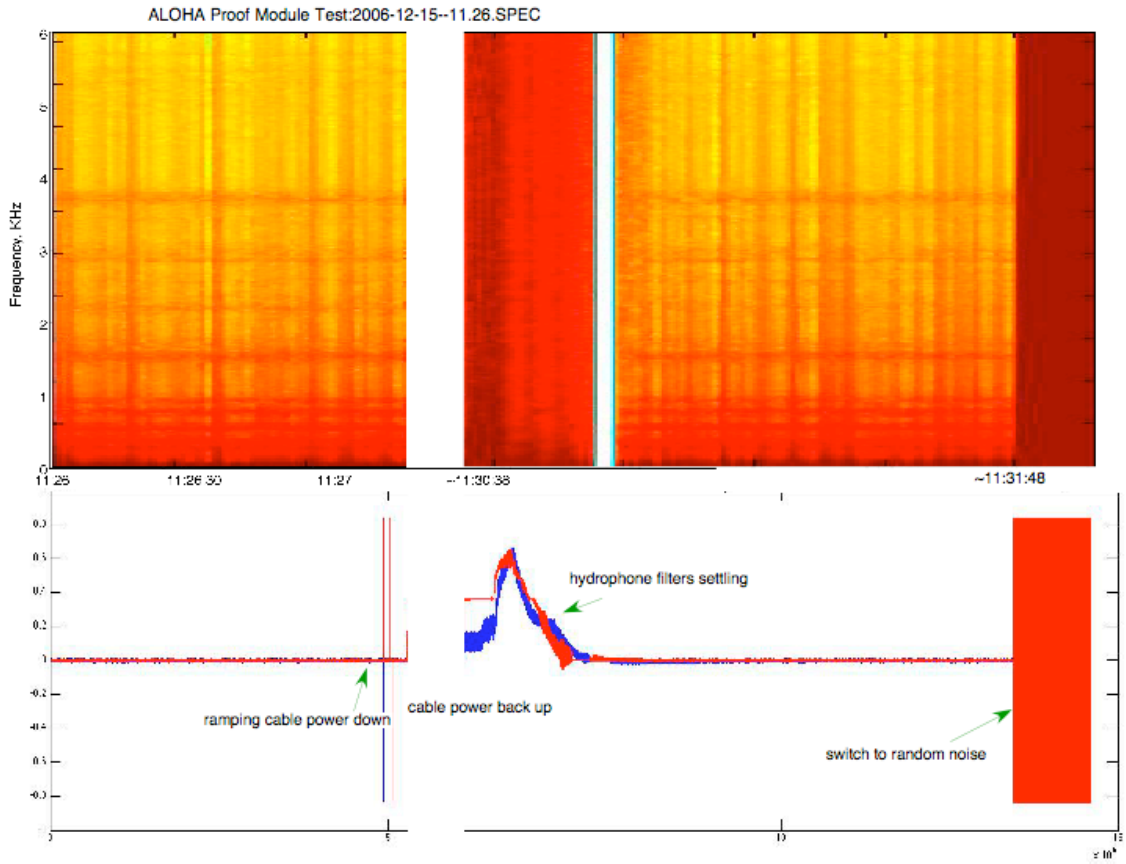
2006-12-15--11.12.pdf

At this time, attenuation of the optical Proof Module signal had been added to intentionally induce errors. This ramp displays a large number of errors and data gaps. The data gaps have been filled with white space to show where they occur.



2006-12-15--11.20.pdf

At this time, attenuation of the optical Proof Module signal had been added to intentionally induce errors. This hydrophone data displays sharp full-scale "clicks" when errors are present. The claps near the center were generated by clapping hands for comparison with the transmission errors.



2006-12-15--11.26.pdf

Test 6: The cable power at Manchester was cycles, removing power to the wet plant and to the Proof Module. The hydrophone data recorded show the effects of the power re-start as distortions in the signal as filters and amplifiers settle over a period of about 15 seconds.

Acknowledgements:

The cooperation, hospitality, and aid provided by AT&T, particularly the Makaha and Manchester Cable Station personnel made this test possible, and it is greatly appreciated.

Suggestions and oversight provided by Norm Gholson added significantly to the quality and completeness of this test.

Preparation for and execution of this test was funded by a grant from the National Science Foundation, and the participation of Alexander Shor , the program manager for the project, is particularly appreciated, and will aid significantly in establishing the credibility of the results.