DUMAND II Specifications

Hawaii DUMAND Center

The following specifications of DUMAND II are those that have best been determined as of the date above. Some are still subject to change or refinement, so the user is cautioned to always refer to the latest dated version. This is not intended as a complete specification of every element of the experiment, but as system specification with emphasis upon interfaces between elements being produced in various locations. An ASCII version of this document can be found in UHHEPG::[DUMAND]SPECS.TXT.

Contents

I Construction Schedule (See DUMAND II Gantt Chart for schedule details.)

- o Lay cable and Junction Box in Summer 1992
- o First 3 strings installed Fall 1992.
- o Full array in late 1993.

II Array Geometry

- o 9 strings, 24 optical modules per string, 10 m spacing, 40 m octagon side, 100 m tare height.
- o coordinate system defined from center of active part of array, physicist coordinates: X East, Y North, Z up. String numbering clockwise, number 1 at 22.5 degrees E of N, number 9 in center. Optical Module numbering from top down, 1 – 24 (top optical module at Z = +115.0 m., bottom OM at Z = –115.0 m)
- o string placement precision goal, 2 m; string relative location measurement and monitoring to <10 cm.
- o outrigger responder locations +/– 300 m; 30 m precision of placement; survey precision to geodetic system, 1 mr. Transponders to be conneted to JBEM for power and signals.
- o one String Controller housing per string, at string center, Z = 0 m.
- o 3 calibration modules each on strings 1, 3, 5, 7, and 9; Z = –90., –20., +50. m.
- o 1 environmental monitor located at top of center string (9), and 1 located near Junction Box.
- o 5 hydrophones per string, located at Z = +120, +55, –10, –65, and –145 m. Connected independantly to individual links to the SC, with digitzation at SC.
- o anchor package and redundant battery powered acoustic transponding releases at bottom of each string (Z = –215 m).
- o junction box to shore cable located at X = 150 m (Y = 0, Z = –215).
- o array located at 156^{o} 19' W, 19^{o}44' N, depth 4760 m.

III Optical Module Specifications

A) Overall Design and Performance Goals

- all modules to be interchangeable (Hamamatsu or Philips) in system.
- broad beam sensitivity goal: greater than 0.025 PE/quanta/m^2 at peak spectral sensitivity, in forward direction.
- data output to be fiber optic signal absent for output ON, width variable.
- output to be held ON if noise rate exceeds programmable level for more than a programmable time interval (nominally 100 counts in 10 microseconds). Output to remain in ON state for minimum of 1 second, or until rate drops below 10^6 counts per second.
- second pulse for JOM, if first pulse exceeds predetermined remotely reprogrammable threshold. First pulse time-over-threshold, second integrating charge for all pulses. Delay between leading edges of pulses to be fixed 100 ns.
- EOM will output one charge integrating pulse. Pulse to be linear for first several PE, then rolling over to logarithmic response for added dynamic range. Saturation yet to be determined.
- amplitude induced time slewing may be corrected in software.
- special care for startup transient protection and turn on into safe state.
- PMT dark noise rate at 0.1PE and rated sensitivity to be less than 30k counts/sec.

B) Electronics, Monitoring and Control

- high voltage to be programmable and readable to 12 V, 0 to 3kV (256 steps).
- discriminator threshold to be settable and readable to 1mV, 5 to 250mV (256 steps).
- noise rate to be read locally, resolution of 1kHz, integrated over 1 sec, 16 bits (0 to 64M counts/sec).
- all local supply voltages and some (TBD) currents to be monitored.

- o temperatures to be monitored at 1–3 most temperature sensitive locations (mainly for use in laboratory testing).
- o unit to report leak condition.
- o command language protocols similar to SPS, see separate specification for details.
- o OM–CM link employs 300 baud 74HC943 modem.
- o program to default to preset conditions if no communications within 10 min after power on. default program to keep noise rate below 100kHz, integrating over 10 min. (Details of default program TBD).
- o computer must be remotely reprogrammable.
- o microprocessor to be 68000 series, CMOS.
- o total OM power consumption not to exceed 10 W at 48 VDC.
- o optical fiber data out, 1300 nm multimode, about –10 dbm at connector, exact value TBD.
- o 2 electrical contacts, 48 V DC pwr with superposed C&C data.

C) Mechanical, Optical

- o maximal spectral response over 350 to 490 nm band
- o all modules packaged in Benthos 17" O.D. (or equivalent) housings.
- o optical coupling to be installed in forward hemisphere region between PMT and housing. (Shinetsu KE1051).
- o units to be packaged for PMT facing downwards.
- o special care to be taken to prevent light emission from base of PMT HV.
- o JOM to be magnetically shielded, internal to housing.
- o magnetic field effects to be examined for EOM.

D) Testing, Assembly

- o module design to be examined for reliability.

- o group characterization of angular and spectral response to be made from sample units.
- o sample optical interfaces to be measured with spectrophotometer, losses not to exceed 20 % total absorption, between 350 nm and 480 nm.
- o individual measurement of forward direction broad beam 420 nm +/- 20 nm absolute sensitivity, time jitter at 1 PE light level, noise rate above 1PE, measurements in air at 0 to 4 degrees C on fully assembled module.
- o tests to be made for light output from each module (flasher check).
- o test procedure to include mechanical and electrical stress, burn in, to achieve failure rate less than 2.5% per year.
- o units to be delivered to HDC tested and calibrated, in housing.
- o acrylic hardhat design as in SPS, modified for new cable size.
- o hardhats to be installed and string integration to be done at HDC.

IV String Controller

A) Fast Data Digitization and Multiplexing (similar in spirit to SPS, but new chip, more compact design, common FIFO output stack, 2 words per hit, more time resolution, less power, higher reliability, ancillary data in rollover word)

- o SC to digitize OM pulses to 1 ns least count (1024MHz clock).
- o One digitizer chip per SC, total to be able to handle 24 OMs, 3 CMs, 5 HMs, and C&C.
- o 17 bit word output from the digitizer: 5 bits address, 10 bits time, 1 bit up/down, 1 bit stack overflow flag. Words combined in pairs to form 40 bit words. Output words sent to sshore using Gazelle "Hot-Rod" chip set, or equivalent. Digitizer to add 4 parity (error check) bits.
- o SC clock roll over every 1.0 microseconds (10 time bits). Shore clock roll over every 16.384 milliseconds (24 time bits).
- o Two level data buffering: fast data buffering adequate for 5 hits at 1 GHz, flushed a 3 ns per word; second buffer for 100 words loaded at 167MHz, flushed at 40 ns per word.
- o rate to shore 625MBd: with 40 bit words (4B/5B encoded) that yields one word/ 80 ns. Encoding and serialization to be handled by Hot-Rod chip.
- o one fast data channel to shore at 1550 nm, C&C on same fiber from shore at 1300 nm.
- o null words to be transmitted every 1024 data words; time to be transmitted without FIFO delay.
- o rollover word to carry all slow data in 8 bits: C&C (1), NB (1), and hydrophone data (6).
- o power consumption goal: less than 100 W for all fast electronics per string.

B) SC Command, Control and Clock (SPS based redesign, parallel instead of party line OM communications, new clock control circuit, new communications circuit for shore c^3 link)

- o 68000 based CMOS GESPAC computer at SC to communicate with shore and OMs.
- o default ROM based bootstrap program.

- o non–volatile memory for storage of latest operating parameters.
- o communicate with and control power for 24 modules, EM, and up to 3 CMs; monitor individual module supply currents.
- o hydrophone digitizer board in SC backplane.
- o string communications to be in parallel at 300 bd for each module, transmission and reception to be possibly simultaneous on all channels. (Full parallelism).
- o communication path to shore via fast data line.
- o ancillary SC environment monitoring: temperatures, currents and voltages at up to 32 locations (locations TBD).
- o SC fast data section connected to command system (same G64 bus) for control of the digitizers and of the clock.
- o 3–axis accelerometer and compass, digitized and passed to shore through c&c network.

C) Power (basically as in SPS)

- o supply 48 VDC for OMs regulated, 2 supplies 5A each.
- o other supplies, specifications TBD (need fast circuit designs).
- o input power from shore at 350VDC, with voltage regulation at JB.
- o special care to be taken to avoid low voltage latching.

D) Packaging (basically as in SPS, but larger diameter tube)

- o housing to be 8.5" ID, 7075–T651 Al, standard oceanographic tube. Length TBD (about 2 m).
- o string optical and electrical penetrators on top end.
- o shore power, fast data and C&C optical connections on bottom end.
- o test, transport and deployment jig to be incorporated into string transport van design. provision must be made for cooling during tests.
- o mechanical contacts to be electrically isolated.
- o housing to be triply corrosion coated, zinc anode protected.

- o all connectors and housing to be pressure tested to 6km depth equivalent (cycling and durations TBD).
- o representative connector test samples to be tested and dissected for examination.

V Laser Calibrators (similar to SPS, but no dork, include backup laser)

- o fifteen units, six in first batch to be installed.
- o monitor outputs to be identical to OMs.
- o command structure same as OMs, plus additional firing commands.
- o ability to support $\geq$5 pulses per second for $\geq$1000 seconds, $\geq$10% duty cycle.
- o expected lifetime of greater than 2 x 10^7 pulses.
- o output amplitude variable by 100x under remote control, 8 steps.
- o spectral output centered in 420 +/- 20 nm band.
- o light pulse to be adequate to produce 10 PE in a module in nearest neighbor strings and down 4 modules.
- o light output pulse to be isotropic to 10% (achievable?).
- o power consumption not to exceed 20 W at 48 VDC.

VI Environmental Monitor Units and Acoustics. (similar to SPS with addition of pinger, major changes in instrument package, additior of junction box package with TV and transponders)

A) Ocean located hardware:

- monitoring to include pressure (1/5000), temperature (0.01°C), ocean current (vector direction, 0.05 to 100. cm/sec), tilt (0.05 deg), heading (2°). [sound velocity needed to 10^{-3} or better.]

- One Neal Brown or equivalent unit in string 9, communicating with hydrophone digitizer in SC. No controls, only can be turned ON and OFF by EM computer. Pinger will also be under EM CPU control.

- One EM to be deployed with the junction box, and connected to one of the spare fibers. This EM requires ocean current monitoring (Neal Brown unit), 3 hydropohnes, lights and TV. Low light TV, with pan, tilt, and zoom, to face toward other strings or toward ROV while making connections. EM at J Box to communicate to shore via 1550 nm link, using TAXI chip multiplexor. C&C link to be same as for an SC, with EM appearing essentially as an 10th string.

- 5 hydrophones/string with 50kHz bandwidth (100k samples/sec). controllable from shore via SC. Hydrophone modules to link directly with SC for digitization at the SC. Only control will be ON and OFF by SC computer.

- acoustic calibrations, gains, and dynamic range to be adequate to permit operation down to ocean thermal noise leve.

- 4 responder units (plus one on-line spare) to be transported to the site with the junction box. These to be wired through the JB to the JBEM for power, control and communications. They are to produce chirped pulses (15-20 KHz) upon shore command. To be moored at 300 m radius from array center at compass points, buoyed up 10 m off bottom with fared flotation.

A) Environmental Monitoring Computer and associated hardware on Shore

- accept request for position survey from control computer.

- accept up to 100k samples/sec from 5 hydrophones x 9 strings directly from trigger card, plus 3 from JBEM and 4 from responders.

- record return times of acoustic pulses from various transponders and responders.

- o independent VME based computer for receiving EM signals from strings (via TP card and VME bus).
- o calculations of sound velocity.
- o monitor ocean currents, tilts, etc. and generate alarm upon preset conditions, notifying control computer.
- o separate stripping of TV, frame grabbing.
- o carry out search for unusual acoustic pulses, study deep ocean HF noise (TBD).

VII String; Transport Container (string mechanical design essentially unchanged, more fibers and wires, new transport plan, need float and anchor packages)

- o floatation package at string top, Z = 130 m, to include buoyancy (about 1000 lb) to provide verticality. 2 strobes, 2 radio beacons, radar reflector, and high visibility marker to be attached for recovery operations. minimum use of metals desirable. package to be streamlined to minimize drag to ocean current.

- o string harness to consist of parallel riser cables (24 inch spacing), with both optical and electrical connections to OMs and other modules. Each string harness to include 5 shielded twisted pairs for hydrophone signals.

- o string fibers: 1300nm multimode, 62.5μm core, 125μm cladding, $<$1db/km loss.

- o riser cable to have 27 triplets of power/C&C data wires, voltage regulation factor of $>$9, and optical fiber.

- o independant structural riser cable to have min of 5,000 lb breaking strain.

- o cable bending radius to be less than 0.5 m.

- o sufficient string anchor mass to take net string buoyancy to −3000 lb.

- o long life (5 year) battery powered acoustic transponder to be located adjacent to anchor. functions to include passive response, and anchor release plus cable guillotine upon coded acoustic command (emergency string recovery without robot). To be attached to SC for trickle charge power, and for acoustic data transmission during deployment.

- o mechanical lanyard for robot activated detachment of anchor package (no umbilical cable loss).

- o umbilical cable for connecting string to junction box, to consist of power (2 wires, 350 VDC, 2 A) and one single mode fiber (fast data to shore, C&C to SC). Bending radius $<$30 cm, cable to be non-buoyant.

- o umbilical cable reel and connector storage located about 2 m above bottom, designed for interface with Sea Cliff, ATV and other ROVs.

- o transport van to utilize modified (refrigerated) 40' shipping and deployment container. container to serve for integration and testing environment.

VIII Junction Box (new design)

- optically totally passive.
- 12 string connection ports, submarine and robot accessible, allowing for removal of string with all other ports occupied. 1 optical connector per string, plus one power connector (2 wire).
- optical connectors to be single-mode deep ocean robot mateable/demateable. dummies to be in place upon deployment.
- electrical connector same, 350 VDC, 5 A sustained.
- optical pass-throughs for 10 high speed data links to shore.
- electrical fanout: DC at 350 V passed through J Box, with voltage regulation and overcurrent breakers at the J Box.
- voltage regulation circuit to be redundant and ocean replaceable.
- junction box to weigh less than 2000 lb in air, <500 lb in water.
- shore cable mechanical termination to withstand 10,000 lb sustained load. strain relief to handle bottom setdown without excess bending of shore cable.
- design to guarantee setdown in proper orientation.
- long life battery powered acoustic transponder to be buoyed 10 m above J box with JBEM, below lift point.
- modified environmental (JBEM) package with current velocity sensors, pan, tilt and zoom TV, lights, pinger, and 3 hydrophones to be in place. JBEM attached to spare port, at deployment and able to monitor J Box setdown.
- 5 wet mateable, 4-pin connectors for hardwired transponder net. connected to JBEM for power and signal processing.

IX Shore Cable (design based upon SPS and other projects)

- 12 single mode fibers, optimized for 1300 and 1550 nm transmission bands. individual loss less than 12 db over whole length.
- 5.5 kW delivered power at 350 V DC.
- 2 mm, 2 layer armoring; 2 mm min insulation thickness.
- 40 km design length, minimum number of splices. cable to be fabricated in greater than 8 km sections. splices to be made prior to deployment.
- cable series resistance to be 66 – 90 Ω, capacitance about 37.6 ∓F, insulation dielectric constant 2.28, nominal 36 km length.
- refer to manufacturing specification for details of construction and testing.

X Trigger Processor and Data Filtering (new design for receiver/trigger processor/memory buffer card, remainder mostly off the shelf, much new software)

A) time and frequency standards (off the shelf)

- o all frequencies derived from 1MHZ and 1/sec output from master clock. Absolute time from GPS satellite receiver.
- o times to be referred to UTC to 1 microsecond accuracy.
- o time format to be in years, days, sec, microsec.
- o clock to have battery backup for > 1 day capability.

B) trigger processor

- o design goal: first level to <1000 triggers/second, second level to <10 triggers/second. If unachieveable, third level trigger to be implemented.
- o 1 trigger processor/memory card per incoming data channel (9).
- o incoming fiber to connect directly to receiver and time correction circuit, to convert free running SC clock time to UTC.
- o special outputs from optical receiver for slow EM data, hydrophones, and C&C data.
- o 32 bit architecture throughout.
- o first level trigger upon T3, T2, or any CM.
- o second level trigger TE upon pe sum exceeding programmable threshold (about 30 PE in 1μsec), combinations of T3 and T2 from strings (TA). SN and nuclearite signals to be implemented in DSPs.
- o trigger unit to inform harvesting computer of time of trigger and location of trigger in memory buffer.
- o 1 μsec resolution absolute time latch for trigger finding time.
- o sufficient memory on card for 10 ms of data.
- o on-card scalers for all singles rates (including null and rollover), second scaler at higher threshold, trigger rates, overflow conditions, errors, and special words.
- o special register for OM status, indicating OMs in ON condition for more than fixed time interval (indicative of bioluminescent event).

- OM in ON state to generate trigger to next level (for finding slow massive particles)
- debug outputs.
- adequate spares and documentation so that (almost) any collaborator can perform online service.

XI Command Link

- outgoing link, shore to SCs, at 1300 nm, 9600 bd.
- return data multiplexed on fast data stream, 9600 bd.
- separate computer for control, interfaced to array and data harvesting computer(s).
- control OMs, CMs, EMs, and SCs, monitor health continuously.
- communicate with EM shore computer.
- perform on-line calibrations of time and sensitivity.
- computer will run VMS, FORTRAN based code.
- interface to outside, and via fast data link to collaborators.
- fast data distribution of first pass fitted events on line at rate not to exceed 1/sec.
- online 3D event display to be available.

XII Data Protocols

- o data to be available to remote collaborators on-line via computer network.
- o ZEBRA structure adopted.
- o provision for ancillary data recording, such as clock health, power supply status, laboratory conditions, alarms.
- o read scalers and ancillary data once per second (or longer), insert data in record stream.
- o data harvesting computer carries out first pass analysis on-line, writes to storage medium. storage less than 10 events/sec.
- o all C&C logged, including operator comments.
- o data to be recorded on 8mm videotape.
- o possibility of back-end data reduction computer, in particular when all 9 string are installed, TBD.
- o all recorded data also passed to control computer.

XIII Deployment, Survey, and Repair Operations

- o all ship navigation to be done relative to active microwave transponders at 3 surveyed locations on Big Island (plus 1 possible location on Haleakala). system to have resolution and absolute accuracy of 1 m or better. GPS backup and cross referencing to be available.

- o temporary (+/- 1 km) outrigger transponder network drop and survey via ship to be carried out after J box installation, with goal of 1 m absolute position determination of 5 transponders (cruciform net plus J box).

- o 4 wired-in responders (+/- 300 m) to be installed with connections made by submarine or ROV at time of string deployment.

- o need fast data link from shore station to ships to transmit slow scan video and acoustic data.

- o deployment of 3 strings (numbers 9, 2 and 3 in that order) to take place as soon as possible after J box placement and cable integrity verification.

- o string position monitoring during deployment to be done via battery powered acoustic units on each string bottom, with data reception on ship board. position required to 1 m relative to net.

- o string placement to employ ship guidance only (no active thruster package).

- o connection to take place within one week after string placement. string recovery vessel to stand by.

- o strings to be tested immediately after connection. if problems they may be retrieved immediately. allow ship schedule for 1 week turn around for 1 retry.

- o plan must allow for 1 week weather delays.

- o second group of (6) string placements and connections after 6 months to 1 year.

- o long term schedule one service operation per year, with replacement of 1 string, and recycling of up to 2 strings on a 1 week turnaround.

XIV Array Power Supply (at Shore Station)

- max power output 30 VA, 2 kV DC, 15 A.
- input power 3 phase, 480 V, 60 Hz AC.
- output regulation to 10 V.
- output ripple <3% .
- manually settable overcurrent and overvoltage trip.
- remote as well as local control of output current and voltage, analog acceptable.
- programmable ramp up and ramp down.
- remote as well as local control of reset, startup and shutdown.
- panic shutdown mode, remotely activated as well as local initiation (for use with enabling interlock). interlock condition available for remote reading.
- remotely readable outputs for supply output voltage and current (analog acceptable).
- remote readout of health and alarm conditions, such as high temperature, desirable.
- output floating, positive terminal nearer ground.
- air cooling.
- backup supply required, cold spare available via manual switch.

XV Shore Station Laboratory (in new lab building at NELH)

category DUMAND space requirements

L 1) DC supply and UPS room (12 ft x 12 ft)
L 2) electronics room (12 ft x 25.5 ft)
O 3) control room (13 ft x 26 ft)
O 4) system manager's office (12 ft x 13 ft)
O 5) physicist's office (12 ft x 13 ft)
O 6) electronics/test equipment/supplies storage room (13 ft x 12 ft)
O 7+8) offices for first year (12 ft x 12 ft)

Other Space (common with others, only access needed):

coffee/snack area
conference room
xerox, FAX
reception
exhibit area(?)
electronics shop for test and repair

AC Power: DC cable power supply, 30 KW, 3 phase, 480 V, on UPS
computers and other electronics, 10 KW, all 110 V, also on UPS

Notes on needs of DUMAND area:

1) DC Supply room needs to receive shore end of cable to array. Need protected cable trench from end of slant drilled pipe. Lethal voltages, will require special safety precautions. Fibers exiting the cable must be lead to the electronics room so desireable to have adjacent, and with door into electonics room. Needs to be air conditioned. Small window from electronics room or control room would be desireable. Should have halon fire protection. Need forklift outside access outside installation and replacement. Ground bus from electronics room here too. Am as yet uncertain about connection to seawater ground, but probably it will go in same conduit as E–O cable. Battery packs for UPS may be on other (existing power room) side of wall. Will need breakers and such in power room.

2) Electronics Room is needed to contain noisey electronics racks in area adjacent to main control area (3). This room should have doors opening into control room, and have a window into control room (so one can see alert and monitor lights). The crate cooling fans are very noisey, so sound deadening is needed. Needs min 2 x 15A and 2 x 20A circuits for computers, electronics, and bulk storeage devices. All on UPS. Allow for 5 electronics racks (triggers and data harvest, clocks, environ, control, comm). Should have overhead cable trays (12 inch). A/C for 10 KW. Air

should be to computer grade (particularly to filter out the salt). Halon system needed. Room should have installed independant ground via a heavy-guage exposed conducter, attached to earthed rod (could be overhead with cable tray).

3) Control Room will need space for four standard work tables with terminals, plus other peripheral devices, telephones, etc., and one larger (10 ft) work table for data analysis and drawings. Need space for some filing cabinets (3), book shelves (take 8 ft of wall space, floor to ceiling), and storage cabinets (2). Desirable to have restful ocean view for workers putting in long hours, but window shades will surely be needed for late afternoon sun. Will need cable pass from electronics room, and overhead cable trays (4 inch). Should have sound absorbing ceiling and perhaps floor covering. Neither 2) nor 3) need false flooring. A/C for 1 KW and 6 people. Should have blackboard (dustless), dimmable lights, and book shelves. Note that we plan high speed phone data link to this room or 3) for remote operation. Also, should have extension (less heavy) to ground bus, overhead.

4) System Manager's office, should be near the control room, ideally with a view into it. Window, A/C. Blackboard and book shelves.

5) Physicist's Office may be next further removed from control room. Window, A/C. Similar layout to 4).

6) Storeage room, should be in air conditioned area (electronics spares) and probably would most conveniently open onto control room, or the electronics room. No window needed. Needs shelves and cabinets.

General) plentiful AC outlets and telephone jacks. useful to have speakers in all DUMAND rooms for paging. there should be an integrated fire alarm system. bulletin boards in otherwise unused hallways are desireable.