☐ Risk Review ☐ Design Review ☐ Milestone Review ☒ Technical Review ☐ _____

Overview			
Project Topic:	NAATOS Technical Review 20240611 CCG Sample Prep and Power Module Handoff		
Meeting Date:	20240611	Notes taken by:	Josh Bishop
Attachments:			

Attendance			
Attendee	Representing	Attendee	Representing
Josh Bishop	GHL, Product Development	Andrew Miller	GHL, Engineering & Software
Ryan Calderon	GHL, Engineering & Software	James Paolino	CCG
Chin Hei Ng	GHL, Engineering & Software	Rob Filipkowski	Odic

Meeting Minutes

Agenda

- Tech overview
- Configuration, calibration, and testing
- Lunch
- Troubleshooting and programming
- Pack-out and tour

Objectives

- Review first build of CCG design of Sample Prep and Power modules.
- Discuss design implementation with changes made and outstanding work needed.
- Get training on operation, configuration, and calibration.
- Troubleshoot (as needed); log hardware bugs for potential re-work and software bugs for firmware roll-out.
- Decide on whether and how many modules to bring back to GH Labs.

Notes

- Tech review – Sample prep module
  - Hall sensor on door closure affected by magnetic field hysteresis in 400-series pin
    - pin machined down to wall thickness on side of sensor
    - James suggests on a board re-spin to move sensor further away to middle of board to remove effect of pin and make sensing symmetrical to both pins
    - Hall effect sensor sensitivity is not adjustable in software
  - Motor
    - controller is integral to motor, takes PWM signal and reverse bit from main PCB to control
    - price can go down to <$4/motor at ~1000 from China

        - could consider smaller motor but James suggests secondary shaft to remove load from primary shaft
        - Running motor at 100% PWM, 100% power over 72 hours unattended caused catastrophic failure of motor
            - led to replacement of oil lubricant in bearing with automotive grease (brass filings in housing and bearing surface worn away)
            - suggestion to eventually pot flex cable connector (pulled contacts off board in failure)
            - motor mounts are on top housing to enable 1/2" end mill to machine in passes without dead-ends
        - space to increase size of bearing - in a perfect world, both modules would be 0.25" wider - especially helpful to move housing bolts out of sample prep bosses
    - Flex cable sees harmonics during shaking
        - added backing stiffener (same vinyl as used for button cover) and VHB btw cable and mounts on both ends
        - James suggests mechanical strain relief and connector stabilization on carriage end
    - Sample tube holder
        - is made of Delrin, which is good for mechanical properties (low friction on carriage rails) but bond at top can crack
        - Circular rather than oval cover for slot would improve manufacturability and obviate need for bond to remain aligned
        - analysis indicated lowest mass is best so current design minimizes
    - Assembly
        - stand bottom housing on back side next to top housing and connect cable and bond with VHB, then connect and mount motor
        - use cyanoacrylate Loctite because of connectors in NORYL (PPO) or Delrin
        - batteries mounted in holder then holder placed into base with connectors leading - ensure wires do not enter space for daughter board connector and gap to holder at top
        - as you are bringing top and bottom housing together, place door with hinge in place and then wiggle tube holder to ensure bearing is mounted in cam slot
    - Door
        - anodized aluminum was over-plated, so 5 or 10 thou was milled off face of hinges that pivot into base (can see "Sharpie anodization")
    - Batteries
        - needed rework as parallel pack (from series pack) due to miscommunication with board layout
        - connecterized by CCG
        - if unprotected cells go to 2.25V, then they cannot be charged again, but Rob's circuit is designed to protect against that state (under voltage protection on main board)
        - "fuel gauge" - how low can it drop before you can't run anymore, then recovery value before it'll let you run it again
        - LED indications for battery charging functionality not yet complete - planned availability in update later this week
    - manufacturability next steps
        - evaluated for parameters
        - redesign for reliability
        - DfM for injection molded
    - Feet
        - suction cup feet added to avoid walking at 100% motor operation (but spec is ~70%)
    - Scotch yoke
        - designed clearance btw tube holder and shafts (a little louder but better mechanically re: binding)
        - extra 0.25" would allow for lagging rails from above to avoid two datums - makes fit tighter and reduces acoustic noise
        - consider precise subassembly - but volume demands may drive mold to sufficient precision to not require separate higher precision subassembly
    - Board
        - Nordic microprocessor - dev kit connector requires opening housing to access on board

        - FFC for heating
        - BLDC controller in motor accepts PWM and has Hall effect sensors to report out speed (a bit noisy)
            - PID control for motor not enabled yet – James says may not be needed but Andy does not agree or accept that, especially as the motor already has the outputs built in - currently open-loop PWM (heat friction may change output but may be within spec) - but long-term will want to detect failures due to wear
            - motor may want larger capacitors on power line to smooth abrupt changes
        - LED driver probably over-spec'ed but makes advance notifications simple to implement (e.g., breathing)
    - Yield
        - Target was 15 - at 9 will try to get to 10
    - CAD
        - will be updated to "as-built"
- Tech review – Power module
    - Battery
        - needed rework as parallel pack (from series pack) due to miscommunication with board layout (same as Sample prep module)
        - connecterized by CCG
    - Feet
        - would change diameter in housing bore to grab feet better
        - Adding M2 screw to feet to fit better
    - Housing
        - easy to see change to plastic base
        - difficulty bonding magnets to hinged top so switched to 300-series carriers - James suggests switching to skin of material on bottom of hinged top to hold magnets from closures
        - NORYL can be molded (including with 1/32" thickness over heater board)
        - center pin was affecting Hall Effect sensor (in the same way as the door on the Sample Prep module) so was knocked out and replaced with non-magnetic 300-series pin
        - cutouts in bottom of top housing is to 1) allow room for components on board, 2) bring LEDs close to light pipes, and 3) keep bleed from LEDs away from optical sensor
    - Heater
        - driving heater board into underside of 1/32"-thick Test Device cut-out with nylon set screw (+ Loctite 945) - setting with ball end of Allen wrench to avoid overdriving
        - nylon screw can handle repeated heating (no creep or losing pre-load) - main board is handling load
        - module should be run several times to set load on nylon screw against main board bolted to top housing before calibrating heaters
        - comfortably go to 101 deg on valve heater (but not 102 - NORYL is not rated above boiling water)
        - same set-point on two modules can same rise time and steady-state temperature - potential for no calibration
        - highest sensitivity is nearest upstream end of test device where heater is closest to edge of module
        - add dots of thermal paste to heater board, press heater board into housing, remove heater board from housing, add copper to heater board and more dots of thermal paste to top of copper, assemble into housing
        - 2.5 thou of copper -> integrate directly into board? may increase cost of board unacceptably - also thermal paste likely dominates thermal conductivity of heat path so may not be worth it performance-wise
    - NORYL (PPO)
        - better materials for high temp applications but very inexpensive (and available in black) - Delrin a good option if we can reduce valve temp
        - prone to cracking - hairline cracks where hinge pins are press-fit (flood with low-viscosity adhesive to pot cracks)
        - better to avoid press-fits, especially given exposure of material to higher temps

        - Temperature limit at 101C, firmware safety parameters and logic in place to prevent overheating
    - Sensors
        - Hall Effect sensor is digital - noted effect of magnetic field hysteresis in adjacent pins above
        - optical sensor is analog - needs calibration by us relative to Test Device design
        - Optical sensor does not work with black surface (i.e. spacer material). Need to apply white/light color tape on spacer.
        - light pipe recessed (~15 thou) so that it doesn't get scratched by sliding Test Device in and out
    - Logging
        - log rate is currently 5 sec
        - current log capacity is 8 GB - stops writing when full
        - next rev -> nice to add wake from USB
            - probably need to use VBUS on USB connector, put to I/O interrupt pin
- Firmware - NAATOS Quick User Guide V1
    - Sleep mode - currently ~12 mA, so ~2 months on Sample Prep module and 1 month on Power module (Rob working on bringing down to microamps)
    - Rob needs to add description of Bootloader mode
    - Rob estimates PID for Sample Prep module next week
    - all heaters have overheat safety limits
    - config file - Rob suggests adding LED notification for config file in default
        - sample_rate (ms) - comm port output
        - logging_rate (s) - log file output
        - amp_zone_run_time (s) - needs to be renamed; heating time
        - valve_zone_run_time (s) - needs to be renamed; shaking time
        - low_power_threshold (%) - minimum battery charge needed to start run
        - recovery_power_threshold (%) - minimum battery charge needed to start run after low_power_threshold triggered (for this and previous, i.e., fuel gauge system, need to map % values to battery voltages)
        - heater_setpoint_1 (degC)
        - heater_setpoint_2 (degC)
        - heater_max_temp (degC)
        - min_run_zone_temp (degC)
        - min_run_zone_temp_en (bool) - whether min_run_zone_temp is engaged
        - alert_timeout_time_s (s)
        - ...
        - optical_distance (au) - analog parameter for optical sensor sensitivity (current default 800 is max)
        - Amp zone and valve zone run times need offset for RAMP TIME
            - need to test, assumed to be around 2 minutes each on 6.11.2024
- Feature List / Bug List
    - Power Module
        - Features Left:
            - Serial Data Streaming
            - Transition to sleep from a low power state
            - LED Fuel Gauge indication
            - Setting time/date via terminal or config file
            - Better low battery indication via LED
            - Add minimum wait time after valve complete before ending cycle.
            - Add sample invalid config time after cycle complete and sample not removed.
            - Add sample invalid red flashing LEDs after config time met.
        - Bugs:
            - USB issue when unplugging in the middle of specific USB stack operations. Currently caught by watchdog.
            - Unit will leave bootloader within 2-6 seconds due to the watchdog.

        - Normalize heater PID.
    - Sample Prep
        - Features Left:
            - Serial Data Streaming
            - Transition to sleep from a low power state
            - LED Fuel Gauge indication
            - Setting time/date via terminal or config file
            - Better low battery indication via LED
            - Possible PID for motor
            - Ramp to temp before starting cycle
            - Single button click to stop run
            - Add sample invalid config time after cycle complete and sample not removed.
            - Add sample invalid red flashing LEDs after config time met.
            - Add resettable PID integration config flag with specific value to reset at.
        - Bugs
            - USB issue when unplugging in the middle of specific USB stack operations. Currently caught by watchdog.
            - When pressing the button to leave File Mode, if the door is closed it will start a run.
            - Unit will leave bootloader within 2-6 seconds due to the watchdog.
            - Rename cycle config variables to match sample prep naming scheme
            - Normalize heater PID.
- Detailed list of modified components (before SG3):
    - VHB added to cable as strain relief near connectors on main and secondary PCAs: 3M 4930, ½" wide. There is one ~0.375" strip acting as a strain relief on the carriage (used as double side tape) and one ~1.25" strip on the main board (used as single side tape). We use a ~0.125" strip on the SD card to retain it as a precaution against the intense vibration (used as single side tape).
    - Battery pack holder modified from series to parallel.
    - Grease added to bearings: STP brand all-purpose grease (MSDS https://contentinfo.autozone.com/znetcs/msds/en/US/561696).
    - Rubber feet inserts modified the counterbore to 0.250 from 0.260, which will eliminate the need to stuff an m2x5 shcs into the rubber feet to achieve interference.
    - Leaf spring milled down TBD mm to accommodate Test Device thickness change not reflected in design of Power module slot height.
    - Magnet cover pin changes (incorporated into final CAD from CCG).
- PCA rework needed to make Power module main PCA functional (to be delivered by CCG).
- Testing
    - bug in code showed when I2C transaction to LEDs failed and restarted processor where init did not clear out subsystem states (so device kept running shaking forever with unlit LEDs and device had to be disassembled) - Rob was able to debug board in error state and make firmware fix
    - Andy and Chin started running tests on Sample Prep and Power modules, respectively, with LabView setups and thermocoupled Sample Prep tube or Test Devices
        - Power Module may have incorrect default valve temp
        - Power Module hall sensor repeat activation/deactivation can cause unknown state (flashing red/green LEDs)
        - Rob to check variable parameters, if in minutes or seconds for process time
            - valve zone heating process appears to be going for much longer than expected
    - Bootloading
        - run command ".\uploadImage.bat COM7"
        - put module in Bootloader mode
            - Power module - rock soft switch six times ending on zero
            - Sample Prep module - tap button three times

- see progress bar to 100% -> "Device programmed."
- device will have no LED indication, wait for STANDBY LED to show up again

Inputs / Outputs

- **Inputs:**
  - NAATOS Sample Prep and Power modules product and system requirements.
  - State transition diagrams and notification schemes.
  - Detailed designs for VCBB – CAD, PCB designs, firmware, etc.
  - Detailed design for Test Device – CAD, Interface Control Diagram (ICD).
  - PPT deck summarizing key VCBB test results and driving requirements.
  - A physical VCBB prototype provided to CCG for evaluation and testing.
- **Outputs:**
  - Delivery of first build of first design from CCG for NAATOS Sample Prep and Power modules.
  - Training of GHL staff by CCG/Odic on design, assembly, configuration, calibration, and use of both modules.
  - Initial data on temperature (and motor) operation collected by GHL staff.
  - Feature and bug lists for firmware (see notes above).
  - Detailed list of modified components (before SG3; see notes above)
  - Potential upgrades and re-work list for both modules (see decisions made below).
  - 8 Sample Prep modules and 9 Power modules handed off for transport back to Seattle with GHL staff.
    - Order for 5 more of each module from GHL to CCG.
    - CCG kept one of each module to support any troubleshooting needed by GHL.

Next Steps

Decisions Made

- Bring all available units of each build (8 Sample Prep and 9 Power modules) back to GHL in cases.
- Capture all other known issues (that cannot be addressed in firmware) and hold rework (until after SG3):
  - Sample Prep module – secondary PCA/cabling – first lifetime test used motor setpoint of 100% (operational motor set point is < 70%) and subsequently failed after 72 hours with multiple potential failures including bearing failure inside motor and in cam bearing, and delamination of cable contact at secondary PCA; connector delamination failure suggests additional structure support for shaking cable connector is needed in design.
  - Sample Prep module – motor drive system – first lifetime test used motor setpoint of 100% (operational motor set point is < 70%) and subsequently failed after 72 hours with multiple potential failures including bearing failure inside motor and in cam bearing, and delamination of cable contact at secondary PCA; bearing failures caused change to add grease to bearings (see outputs above), and suggests change to motor drive system that removes direct load on primary shaft to a secondary shaft.
  - Sample Prep module – hinged lid – over-plating of lid during anodization caused interference with lid and housing at closure, which suggests change to hinge width.
  - Sample Prep module – power switch – no battery disconnect hard switch.

- Both modules – magnetic lid closures – magnetic hysteresis causing Hall sensor to read lid state incorrectly, pins were cut down and/or replaced with non-magnetic material; suggests change to sensor location so that magnetic closure occurs under force from all magnets as designed.
- Both modules – housing footprint – arbitrary size constraint kept footprint to an absolute minimum but ~0.25" additional length would ease assembly (and servicing during development); examples are Scotch yoke rods installed through and in housing (SPM), battery cable sockets under battery packs (both), and assembly bolts through bosses (SPM).

- Apply formal Change Control processes per updated GHL Design and Development Lifecycle SOP going forward. SG3 to set baseline design of NAATOS TB V1 modular system for purposes of Change Control.
- Lifetime testing to be run before Feasibility Design Review (mid- to late-August 2024) on highest risk aspects of Sample Prep module (mounted motor driving Scotch yoke and primary PCA cabled to secondary PCA) and Power module (secondary PCA tensioned against NORYL housing by nylon screw in primary PCA and Test Device in slot above heaters and NORYL under leaf spring in magnetically closed lid).

Action Items

Description	Owner(s)	Target Date
CCG shipping out 2 Sample Prep and 1 Power module.	CCG	20240613
Additional 5 full units with spare parts (15-25 of all 4 PCBs, 5 FFC (with coating), 4 Battery pack with JST (2 each module – the lead length varies significantly between the designs, so we cannot use them interchangeably), 10 batteries.	CCG	20240708
Decide on location of lifetime tests for design aspects at highest risk of failure.	CCG/GHL	20240708
Add sticker to LAMINATES for power module RUN trigger light sensor properly.	Ryan Calderon	20240614
Look into power module OVERTEMP, right now a single value will change state. Might want to add multi-read to prevent noise induced false state change.	Ryan Calderon Chin Hei Ng	20240708
Test fluidics and wax valve performance in unmodified leaf spring vs. leaf spring milled down 0.3 mm to determine need for lid rework (before SG3) on all Power modules.	Chin Hei Ng Ben Sullivan Isabelle Sample	20240619
Power Module shows TEST COMPLETE after valve heating process. Should have configured delay time to wait for LFA flow through detection. Rob to make that logic change and add to config file.	Odic	ASAP
Power Module feedback control of motor speed is not enabled.	Odic	ASAP
TEST COMPLETE state holds infinitely; make TEST COMPLETE state for configurable time (2 hours) before entering TEST INVALID (indefinite).	Odic	ASAP
Add serial numbers to all devices. Utilize Nordic MAC address or make up. Need to add serial number to LOG files.	Odic	ASAP

File visit notes as Technical Review in GH Labs QMS.	Josh Bishop	20240621

Approval Signatures

Print Name	*Title*	*Signature*	*Date*
Carlos Gonzalez	Senior Director, Product Development	Carlos Gonzalez Carlos Gonzalez (Jul 17, 2024 15:46 PDT)	17/07/24
Jamie Purcell	Director, Diagnostics	Jamie Purcell Jamie Purcell (Jul 17, 2024 09:15 PDT)	17/07/24
Josh Bishop	Principal Scientist, Product Development	Joshua Bishop Joshua Bishop (Jul 17, 2024 10:52 PDT)	17/07/24
James Paolino	R&D Engineer, Project Manager	James Paolino James Paolino (Jul 22, 2024 08:30 EDT)	22/07/24

NAATOS Technical Review 20240611 CCG Sample Prep and Power Module Handoff

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