History of Beyond Issues

To avoid with Beyond 3
** = solved mid-cycle*

A) Electronics Performance

1. * Poor USB hub performance in EVT
    - *Cause: 7-port HUB wasn't thoroughly tested in advance*
    - *Result: necessitated layout rework which delayed the launch schedule*
2. * Poor signal integrity over AOC
    - *Causes: Variable performance of linkbox and/or AOC, insufficient testing and gating criteria of linkbox and AOC at CM and LA factory, linkbox design shortcomings*
    - *Result: USB errors pile up --> chokes bandwidth --> various issues in the field, including: HMD tracking loss, controller tracking loss, eyetracking camera image tearing, eyetracking firmware fails to flash, and audio popping in connected audio devices. Lots of R&D time and effort put toward troubleshooting, then resolving with coordinated logistics and rollout of link booster*
    - *Solution: add drive booster circuitry to linkbox. Link booster accessory as hotfix*
3. Inconsistent AUX USB-C port performance
    - *Result: customers have varying degrees of success with identical hardware loadouts*
    - *Example 1: reports of Beyond Audio Strap buyers getting arbitrary L/R channel swaps during usage*
    - *Example 2: reports of Beyondex (BMR audio strap) buyers getting blackouts at high audio volume, while it works well for others.*
    - *Example 3: reports of "Matt hub" (small multi-port USB hub) buyers unable to run face tracking and audio simultaneously, while it works well for others.*
4. Tracking failure near bright lights
    - *Cause: lights, especially some LEDs, fully saturate the photodiodes at close proximity*
    - *Made worse by more transparent cover shells*
5. Tracking failure near high-EMI equipment, such as sim rigs with direct drive motors
    - *Result: customers must troubleshoot extensively with support, making for a rocky, delayed start to their Beyond experience*
    - *Solution: customer must purchase toroids and wrap their input cable through them, sacrificing cable length*
6. Messy/complex firmware rollouts during prototyping, testing, and production phases
    - *Cause: no distinguishing hardware and/or mainboard rev pollable via HID descriptors or firmware*
    - *Results: headsets ended up running incompatible firmware, sometimes bricking them or resulting in support tickets. Inelegant hotfixes have since been incorporated into utility software*
    - *Example 1: the transition from DVT-1 to DVT-2, where the FPGA flash chip size had been upgraded to 2MB, altering capability and creating a firmware compatibility gap. We had no deterministic way of distinguishing these mainboard revisions aside from physical disassembly and inspection*
    - *Example 2: utility must use "hacky" methods to identify HMD hardware capabilities. methods like: checking if the serial written to user flash starts with "BS2E" to identify 2 vs 2E, checking the PC's USB hub chain for connected ET camera device, or needing to poll fan RPM to identify fan v1 vs. v2*
7. * Intermittent controller tracking loss
    - *Cause: sync pins of the controller radios were not routed to the Tundra SIP. this feature was not properly communicated to us by Tundra Labs or Valve
    - *Result: the radios' cycling wireless frequencies sometimes overlapped, interfering with one another. this manifested as sporadic bouts of controller drifting. the R&D cycle and revisions here

were very expensive, as we scrapped thousands of fabbed mainboards and delayed production by many weeks to ensure this fix ended up with all BS2 owners

- *Solution: work out the fix in comms with Tundra Labs. route the sync pins and upgrade firmware of the controller radios, roll these changes out via a new mainboard run*

8. * Proximity sensor does not trigger for some face shapes
    - *Cause: our default proximity calibration does not have a detection range sufficient for some smaller noses. insufficient testing dataset*
    - *Result: affected users' displays stay darkened while wearing the HMD*
    - *Solution: added Proximity Sensor Offset feature to the utility app's advanced settings page*
9. Proximity sensor state does not proliferate to SteamVR
    - *Cause: Valve never answered us when we requested a way to accomplish this*
    - *Result: some features in VR misbehave or do not function, causing poor UX*
    - *Example 1: without prox state, the SteamVR dashboard only has head movement to determine user presence. if the user's head is too still e.g. while they are reading, the dashboard will suddenly recenter*
    - *Example 2: VRChat's AFK detection triggers an avatar animation to indicate that the user is away. Relies solely on the proximity sensor state*
10. * Electrostatic discharge anywhere near the AOC instantly causes issues
    - *Cause: insufficient grounding at the HMD's USB-C ports, insufficient ESD testing during early R&D + prototyping*
    - *Result: DP signal briefly corrupted, manifesting as "colorful/rainbow static"*
    - *Occasional result: entire HMD power cycles with strong enough discharge*
    - *Solution: reintroduce direct grounding path from USB-C ports (located on daughter flexes) to mainboard ground plane. Leveraged BS1-style grounding tapes to achieve this*

B) Design (Electronic and/or Mechanical)

1. Eyetracking modules are susceptible to sweat incursion, damage
    - *Cause: physical location and insufficient sealing*
    - *Common result: eyetracking protection mode (inverting display colors) fires until sweat dries. Camera USB device eventually ceases to populate*
    - *Occasional result: eyetracking camera chip overheats, melting the module's plastic housing*
    - *Partial fix: flood fill under the camera BGA. But surrounding SMD components still susceptible*
2. Eyetracking camera placement is compromised
    - *Result: software performance heavily limited and susceptible to strong performance variations due to differing eye shapes*
3. IPD adjustment is tedious, cumbersome
    - *Cause: the need to use and keep track of a small tool*
    - *Result: can't adjust both eyes at once. Difficult to adjust on the fly. Difficult to adjust while wearing HMD*
    - *Related problem: Due to tolerances of the very small IPD tools, they must be matched to compatible headsets*
4. Optical stack virtual image distance changes over time
    - *Cause: thermal expansion of lens plastics and optics housing as display heat spreads and accumulates. Insufficient thermals performance*
    - *Result: user visual comfort is unstable. Degrades over the course of a VR session in some cases, improves over the session in others. can result in ocular migraines, ultimately leading to RMA or product return*
5. Optics: high sensitivity to eye position, especially eye relief
    - *Result: users often feel their eyelashes must be touching the lens for good visuals. More fiddling required before enjoying VR. overall compromised UX*
6. Lens fogging at session start

- *Cause: eyebox traps the warmer, more humid air from the user's face and eyes against the cooler optical lens. Factors include low eye relief, surface temperature differences, and lack of ventilation*
- *Some users find issue D4 to be an effective means of fogging mitigation, as it ultimately warms the entire optics assembly during standby*

7. No fine adjustments between facial interface and HMD: eye relief, tilt, or yaw
    - *Results: users must compromise comfort and/or UX to achieve sufficient optical alignment. Customer may introduce light leakage by adding spacer magnets behind the cushion magnets, request a revised custom cushion from us, or purchase a third-party facial interface*
8. Audio strap: speakers fall off
    - *Cause: design does not securely attach the speaker modules. design does not sufficiently restrict speaker modules' rotation*
    - *Results: speaker modules are found detached during unboxing. Customers must be extra careful when donning, lest speakers catch on their head or ears and fall off. Customers cannot confidently place audio strap on a table without speakers detaching. Customers must frequently re-attach the speaker modules by hand. Overall degraded UX and brand image*
9. Audio strap: difficult to don/doff
    - *Causes - don: speaker modules' rotation is not restricted enough, making them catch on the user's head or ears, **unless** the user intentionally stowed the speakers beforehand. Speaker modules pop off (issue B8). No springs in the arms-->user must re-tighten during each don*
    - *Causes - doff: no springs in the arms-->user must first turn the knob to loosen. Plastic "fingers" catch on long hair. Speaker modules' head pressure drags hair up with them, **unless** the user intentionally stowed the speakers before doffing*
    - *Result: overall UX friction, added user frustration and product dissatisfaction*
10. Audio strap: public perception of audio quality
    - *Cause: users know or learn our speakers come from a $30 pair of headphones. Some are accustomed to/spoiled by the comfort and generous aural sweet spot of competing HMDs' BMR offerings*
    - *Result: compromised value proposition of the audio strap. Degraded brand perception*
11. Soft strap: tightness adjustment problems
    - *Cause: design requires two hands to adjust. Variations in plastics tolerances*
    - *Result: some straps do not retain their tightness, and grow loose over time. General user inconvenience, degraded brand perception*
    - *Occasional result: Some soft straps fail fully and cannot be tightened at all, resulting in a support ticket, RMA, and additional wait time before the user can interact with the core product*
12. Top strap setup is cumbersome
    - *Cause: top strap design is an afterthought. Design debt from Beyond 1*
    - *Results: velcro hooks damage the soft strap fabric, as well as the fabric of the top strap itself. Application of the velcro "short strap" is non-intuitive, and many users throw it away before they realize they need it-->poorer UX. Top strap does not integrate well with the audio strap, and slides around freely along its arms*
13. Eyetracking modules: accumulation of obstructive debris
    - *Cause: the eyetracking camera is situated within a rectangular cavity, where it is difficult to clean*
    - *Result: dust and debris like skin flakes accumulate in the camera cavity over time, degrading eyetracking performance. if user attempts to clean, they must use a tool with a narrow tip, and be extremely careful to avoid damaging the exposed camera lens*
14. Connector play at HMD input port causes disconnects, data integrity issues
    - *Cause: for BS1, identified as poor mating strength at the input flex's board-to-board connector. for BS2, it has not been root caused*
    - *Result: for BS1, sudden blackouts and HMD restarts when the cable/connector is jostled. for BS2, poor performance of tracking, controller tracking, and/or peripherals at the aux USB-C port*
    - *Partial solution: BS2 introduced a more robust and secure B2B connector. Field reports indicate it did not fully resolve issues involving connector play at the input port. Reports also corroborate that fixing the connector play alleviates the aforementioned results*

15. AOC connector sometimes difficult to insert
    - *Cause: excessive space in the input port cavity, lack of guiding geometry*
    - *Result: connecting the HMD feels less intuitive, irksome. Especially if attempting to connect/reconnect the cable while donning it*
16. Hardware IPD and software IPD are decoupled
    - *Cause: no internal components for reading/determining the hardware IPD or reporting it to software*
    - *Result: compromised UX, where user must be sure to set IPD at both interfaces. user cannot know the hardware IPD while wearing the HMD*
    - *Caveat: many users report being more satisfied with the visual experience when hw/sw IPD are intentionally mismatched*
17. Color shifting/loss of blue channel near FOV edges
    - *Cause: combination of chief ray angle, display pixel pitch, and lack of micro lens array*
    - *Result: user perceives light from the blue **subpixels** passing through the red subpixel **filters** because of the angle of light transmission at the FOV extremes. All colors appear distorted in an unnatural way. Also presents as a "blue/yellow chromatic abberation"*
18. "Pinched" distortion effect along FOV edge of all lenses
    - *Cause: molding gate of lens plastics and lens stress from mold separation*
    - *Result: visually observable distortion effect localized around a single point somewhere along the FOV edge. Cannot be calibrated away*
19. Display edges observable while in VR
    - *Cause: BS2 display aperture is larger than the display width/height*
    - *Result: FOV edge shape feels unnatural, not fully rounded. Degree of perceivability is subjective to user eye relief and physical IPD settings*
20. HMD does not have an action button
    - *Result: Flight and racing sim users do not have a frictionless path to controlling their PC desktop from within VR, which is often necessary during simulator setup*
21. User injury during strap arm egress
    - *Cause: sharp plastic points and edges near strap attachment knobs*
    - *Result: User's finger can scrape against that sharp plastic as the strap arm is detached, sometimes drawing blood*
22. Eyetracking modules: plastic camera bezel encroaches the camera FOV
    - *Result: plastic bezel is illuminated by the neighboring infrared LEDs, rendering as bright white anomalies along the camera feed edges*
23. Nits to eye + motion blur performance regarded as unsatisfactory
    - *Cause: our 3000 nit displays must make liberal use of black frame insertion, sacrificing perceived brightness to reduce the observable image persistence of the panels. The pancake optical stack further reduces nits to eye*
    - *Result: many customers return Beyond 2 or openly mark it as a compromised VR experience because of the need to run the visuals so dim*
24. Electric shock to user eyelid through the eyetracking module
    - *Cause: **this has not been properly root caused. Attempts to reproduce in LA have all been unsuccessful***
    - *Result: users fear for their health and the safety of using our device. Support ticket, RMA, sometimes refund, share publicly. Degraded brand image*

C) Manufacturing

1. * Excessive debris incursion on displays
    - *Cause: poor storage habits and clean room performance at CM*
    - *Result: large "dead pixel" count apparent in VR*
    - *Solution: CM uses kapton tape to remove particles from display surface prior to optics assembly*
2. Poor lens alignment/tilt within optical assmebly

- *Causes: inconsistent rotation of the lens --> sometimes plastics gate is orientated against the lens alignment datum --> offsets the lens tilt. poor tilt control during active lens alignment*
- *Results: compromised optical distortion performance that cannot be addressed with software calibration. Inconsistent VID/image sharpness across the FOV (internally dubbed "blur" for simplicity). The latter phenomenon is observable only by individuals with a certain biological vision trait, and thus frequently slipped through our LA factory QC processes. Support tickets and RMAs*
- *Partial solution: identify team members who could observe the blur phenomenon. organize the "blur busters" event to have affected customers review suspected optics in LA. instruct CM to consistently align the lens rotation with consideration of the gate position.*
- *Deeper root cause analysis was anticipated, but ultimately deemed unnecessary when the aforementioned approach dramatically reduced the number of blurry units*

3. Drastically inconsistent lens glare performance across optics
   - *Cause: **no root cause analysis has been performed***
   - *Results: more headsets failing QC, lowering of our glare performance bar in QC, more users having a poor visual experience and sharing that publicly. Support tickets, RMAs, and returns*
4. Frames of custom cushions are fragile after molding
   - *Causes: frame design too thin, materials choices, materials chemical reactions*
   - *Results: delayed production, factory crew must spend extra time checking for frame breaks, cushion remakes-->extra materials consumed, some customers still receive cushions with broken frames, some cushion frames break quickly in the field-->support ticket, RMA*
5. Cushion magnets fall out of their frames
   - *Causes: frame design does not mechanically capture magnets, inconsistent glue application at CM*
   - *Results: factory staff must test each frame's magnets, set aside failures, spend time gluing magnets back in. Cushion magnets fall out in the field, giving a degraded brand image and causing inconvenience for customer-->support ticket, RMA*
6. Lens insert magnets fall out of their frames (CONANT)
   - *Causes: same as causes for issue C5*
   - *Result: lens insert magnets fall out in the field, giving a degraded brand image and causing inconvenience for customer-->support ticket, RMA*
7. Lens insert lenses come unglued from their frames (CONANT)
   - *Causes: our frame design does not mechanically capture the lenses, inconsistent glue application at CM*
   - *Result: lens insert lenses come loose in the field, giving a degraded brand image and causing inconvenience for customer-->support ticket, RMA*
8. Lens insert frames crack in the field
   - *Causes: CM's glue weakens our frame plastics material, frame plastics too thin*
   - *Result: degraded brand image and inconvenience for customer-->support ticket, RMA*
9. Audio strap: plastic assembly splits at the underside "fingers"
   - *Cause: glue failure as housing flexes repeatedly over time. Inconsistent gluing at CM*
   - *Result: degraded brand image as users and influencers share. Strap pinches user's hair. Support tickets, RMA*
10. Audio strap: velcro hook layer separates from plastic
    - *Cause: insufficient adhesive performance*
    - *Result: degraded brand image, support ticket, RMA*
11. Excessive debris incursion in optical stack
    - *Cause: poor storage habits and clean room performance at CM*
    - *Result: more optics fail QC*
    - *Partial solution: development and introduction of the in-optic inspection station at CM. Establishment of new gating criteria at CM. Moves QC failures away from LA + after HMD assembly, over to CM + before HMD assembly*
12. * Tracking calibration (calibot) throughput bottlenecks

- *Causes: poor calibration space setup at CM during BS2 production. tech debt from original calibot software*
- *Result: production slowed, CM assembly line lost staff during bottlenecks, production runs delayed*
- *Solutions: revisions to calibot software. Arguing with CM until they finally set up the room properly*

D) Comfort

1. Excessive heat and moisture buildup in the eyebox
   - *Causes: insufficient thermals performance. Added heat from eyetracking cameras, while running. Poor airflow with custom cushion.*
   - *Result: user less inclined to use Beyond, more likely to cut VR sessions short. Sometimes destructively modifies their HMD or cushion to achieve desired thermal comfort. Sensitive users may return the product*
2. Inconsistent fan noise profile
   - *Causes: fan OEM output—the fan model itself. Insufficient gating criteria at CM*
   - *Result: user irritation and frustration from distracting fan noise. Compromised microphone performance as the noise audibly presents to other players they speak to*
3. Fan noise proliferates to audio peripherals
   - *Cause: fan vibrations travel along the AOC*
   - *Result: noise proliferates into any rigid bodies in contact with the AOC, including headphones' headbands and/or the housing of headphones' speaker modules. Ultimately, the user hears an irritating whining noise through their headphones*
4. Excessive standby heat
   - *Causes: VXR chip continues running while displays are inactive. Tundra SIP positioned directly against cover shell front surface*
   - *Result: users alarmed and frustrated, contact support, less likely to use HMD, may RMA or return product*
   - *Partial solution: we introduced the VXR Sleep feature, which helps greatly. But at the cost of SteamVR failing to recognize the HMD at first boot, always requiring a SteamVR restart. On some systems, a manual SteamVR restart is necessary. VXR Sleep was ultimately relegated to opt-in, default off*
5. Custom cushions: uncomfortable or functionally insufficient geometry
   - *Looks like: cushion too thick, poor HMD tilt and/or yaw, various points of excess pressure*
   - *Causes: inconsistent face scan quality. Cushion processing stack has not seen iterations or improvements since Beyond 1. Variable user preference. Insufficient adjustability between facial interface and HMD (issue B7)*
   - *Result: customers must work with support to have replacement cushions made at our cost time and time again, each cushion with a new adjustment. Lots of trial and error. Poor and drawn-out end user experience deflates their enthusiasm. Expensive as shipping costs and CS time adds up*
6. Custom cushions: geometry collides with outer corners of users' eyes
   - *Cause: cushion eyebox is not wide enough to support high-IPD individuals. Cushion geometry/toolpath near the outer eyebox edges cannot be modified with our existing software*
   - *Result: some customers unable to use custom cushion out of the box. May sometimes elect to destructively modify the cushion. May elect to return the core product*
7. All cushions: insufficient material offerings
   - *Looks like: some users have physically averse reactions to silicone, like skin irritation and development of rashes. Some simply do not like the feeling and/or inabsorbent nature of silicone*
   - *Cause: all official cushion offerings are silicone*
   - *Result: poor out-of-box UX. Users may spend extra for third-party solutions or elect to build their own. Uncompromising customers simply do not buy from us, or learn of their sensitivities through us and elect to return the product*
8. Audio strap: ear soreness
   - *Cause: speakers must apply persistent force to ear cartilage for the best sound quality*

- *Result: sensitive users' ears become sore after using the audio strap for 30+ minutes*

9. Audio strap: foam looks and feels cheap
    - *Cause: material selection-->open-cell foam is widely perceived as cheap and fragile*
    - *Result: degraded value proposition of audio strap, degraded brand image. Open-cell foam is difficult to clean, high-friction on hair*