RESEARCH BLOCK II • TECHNICAL CONCEPT REPORT

High-SPL Acoustic Projection and Tactile Resonance

Low-profile integration study for a 72 V, high-power e-mobility airframe: electrical architecture, acoustic modelling, environmental hardening, and verification planning

Design objective. Evaluate whether a concealed acoustic and tactile subsystem can be integrated into the companion 5 kW hardtail concept without materially increasing the external profile, compromising battery safety, or obscuring service access.

Concept boundary: The supplied report is a capability study, not a construction release. “Stealth” is used only to describe visually integrated packaging; it does not replace vehicle classification, hearing protection, public-noise limits, or required road equipment.

72 V / 84 V NOMINAL / FULL-CHARGE BATTERY BUS	**500 W** DELIVERED-AUDIO COMPARISON BASIS
< 80 Hz INITIAL TACTILE-BAND TARGET	**CONCEPT** NO ACOUSTIC, THERMAL, OR ROAD-TEST EVIDENCE

DESIGN BASIS • Visual, analytical, and engineering-consistency revision • June 2026

1.0 Executive summary

1.1 Capability objective

Research Block I established a low-profile 5 kW hardtail platform with a 72 V dual-source energy system. This block evaluates an additional acoustic subsystem that divides output into localized structural vibration and directional airborne sound while keeping the visible hardware inside the frame envelope.

The revised architecture retains the source report's three core ideas: direct high-voltage Class D amplification, DSP-controlled band allocation, and a combination of tactile and high-efficiency acoustic transducers, but separates design targets from demonstrated results. No measured SPL, frame acceleration, insertion loss, thermal soak, water-ingress, or range data were supplied.

1.2 Critical consistency updates

Two source assumptions cannot be carried forward without correction. First, a 20-series lithium-ion system is 84.0 V at full charge; an amplifier described as accepting only up to 82 V is therefore not compatible with the stated battery. Second, the 73 mm bottom-bracket node is already occupied by the CYC motor and its mounting hardware, so a tactile transducer cannot be assumed to bolt directly to that shell.

Table 1. Design requirements, calculation basis, and release status

Requirement	Design basis	Revised target / status	Evidence required for release
External profile	Hardware concealed within frame and bag surfaces	Conceptually achievable; full-scale packaging unresolved	3D envelope model and physical mock-up
Battery interface	72 V nominal, 84 V full charge	Amplifier and protection hardware must tolerate full charge plus transients	Manufacturer limits, surge test, and load-bank test
Audio output	500 W delivered-audio comparison basis	Electrical and thermal values are calculated, not measured	Continuous load test at low and high battery voltage
Tactile output	Initial band below roughly 80 Hz	Candidate transducer identified; mount and frame response open	Accelerometer, strain, fastener, and fatigue testing
Airborne output	High-efficiency directional drivers	Driver bandwidth and midrange coverage unresolved	Impedance, sensitivity, distortion, and directivity measurements
Weather resistance	Acoustic fabric plus hydrophobic barrier	Plausible layer stack; insertion loss and pressure-spray performance unknown	Frequency sweep before/after spray and water-ingress inspection
EMI control	Audio electronics adjacent to a 5 kW FOC drive	Shielding, separation, filtering, and grounding required	Noise-floor and susceptibility tests under motor load
Operating boundary	High-output mobile acoustic system	Closed-course / stationary validation only until safety and legal review	Hearing, distraction, vehicle, and local-noise compliance review

Interpretation rule: Values labelled "calculated" are derived from the supplied report. Candidate product ratings remain procurement inputs and must be rechecked against current manufacturer documentation before design freeze.

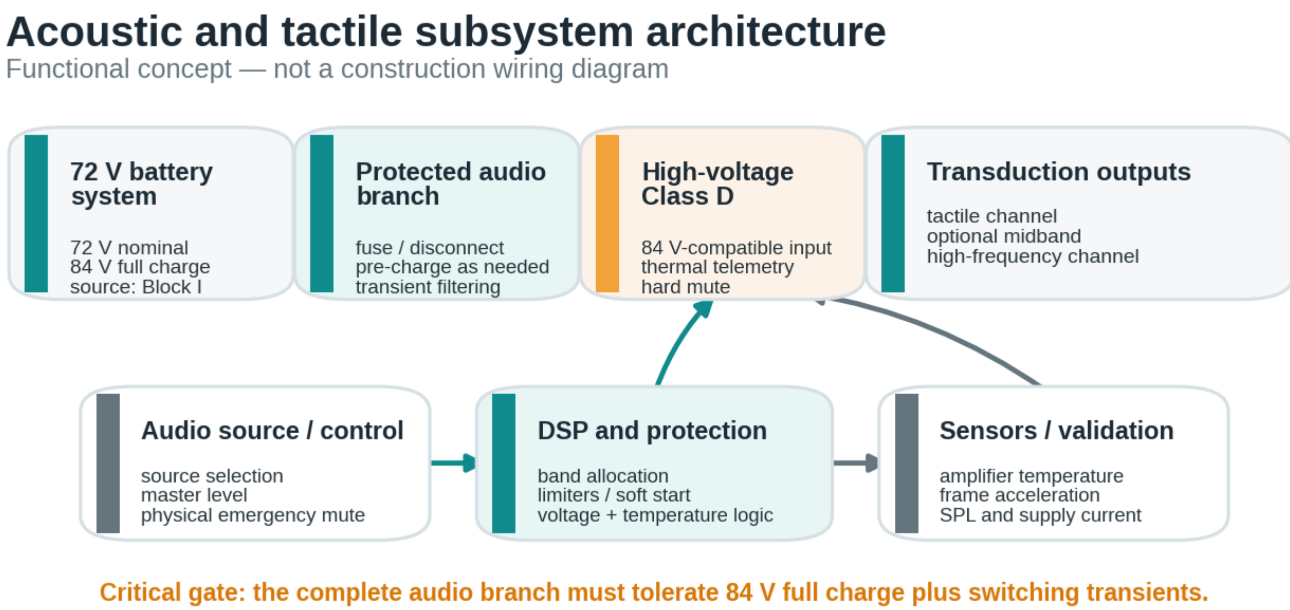

Figure 1. Functional architecture for the 72 V acoustic and tactile subsystem.

The diagram intentionally omits connector pinouts, pack-paralleling details, and component-specific wiring. It is an architecture view only.

2.0 Integration envelope and vehicle dynamics

2.1 Mass placement and packaging conflicts

Keeping the heaviest audio components low and near the center of the wheelbase reduces the height of the added mass and avoids loading the handlebars or a rear rack. That placement is directionally beneficial, but it does not prove high-speed stability. Steering geometry, tire condition, frame stiffness, rider posture, payload, and cable restraint remain dominant release factors.

The frame triangle is not empty space: Block I already assigns it to the secondary battery, discharge hardware, wiring, and service access. Audio hardware therefore requires a shared-volume study rather than an assumption that the existing frame bag will absorb every additional component.

Table 2. Packaging conflicts and required resolution

Interface	Conflict introduced by the audio concept	Required design response	Release check
Bottom-bracket region	Motor plates, chainring, cranks, and torque-reaction hardware already occupy the preferred tactile node	Develop an external cradle or adjacent downtube coupling plate; avoid loading motor fasteners	Full crank rotation, chain clearance, ground clearance, and structural inspection
Frame triangle	Secondary battery and balancer already consume the principal concealed volume	Create a dimensioned 3D packing model with service zones and thermal partitions	Mock-up with final connectors, bend radii, drainage, and battery removal path
Forward acoustic aperture	Directional output requires an opening in an otherwise weather-resistant bag	Use a replaceable acoustic window with drainage and a defined insertion-loss budget	Spray test, frequency sweep, seam inspection, and visual match
Amplifier heat	Conversion losses occur close to high-energy lithium-ion cells	Thermally isolate the amplifier, provide conduction paths, and monitor temperature	Worst-case thermal soak at low speed and high ambient temperature
Controls and mute	A concealed system can make fault recognition and rapid shutdown difficult	Provide a tactile hard mute and clear fault indication independent of the phone interface	Gloved-operation and single-fault shutdown test
Cable routing	Power, motor phases, brakes, and steering movement compete for limited routes	Separate power and signal paths; preserve full steering and suspension movement	Lock-to-lock steering, compression, abrasion, and pinch-point inspection

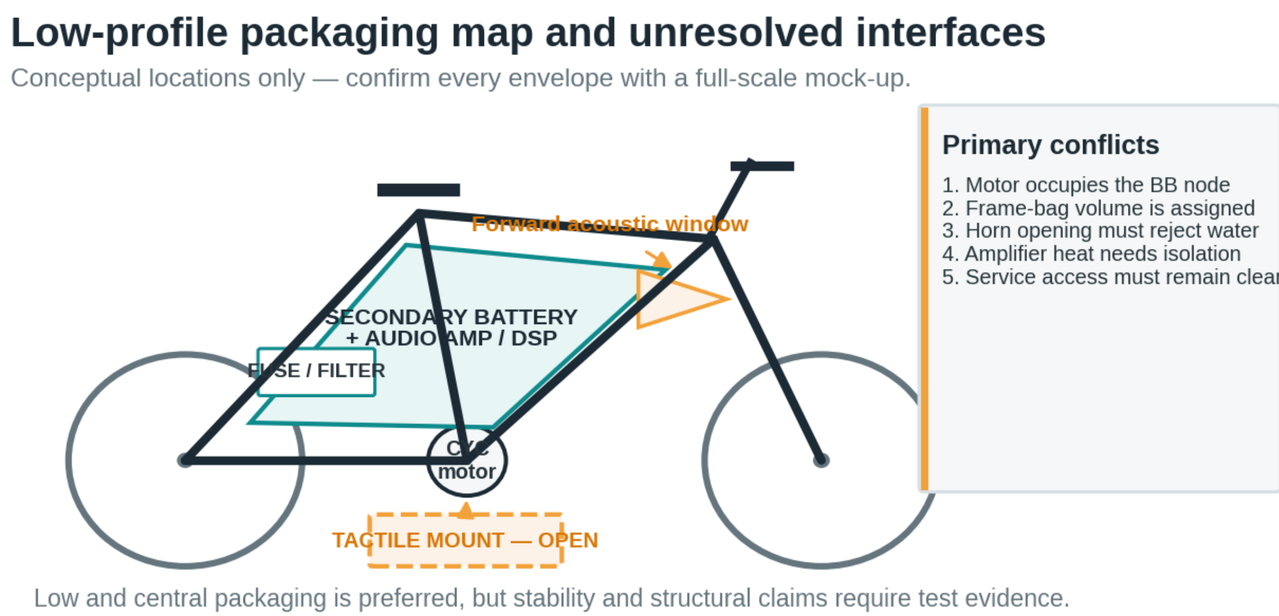

Figure 2. Conceptual packaging map showing shared frame-bag volume and the unresolved tactile-mount interface.

2.2 Aerodynamic boundary and speed sensitivity

Internalizing the system inside the frame triangle should create less frontal-area penalty than handlebar pods or rack-mounted enclosures. It will not make the vehicle aerodynamically identical to an unmodified bicycle: the bag thickness, seams, acoustic windows, and cable exits still change surface flow.

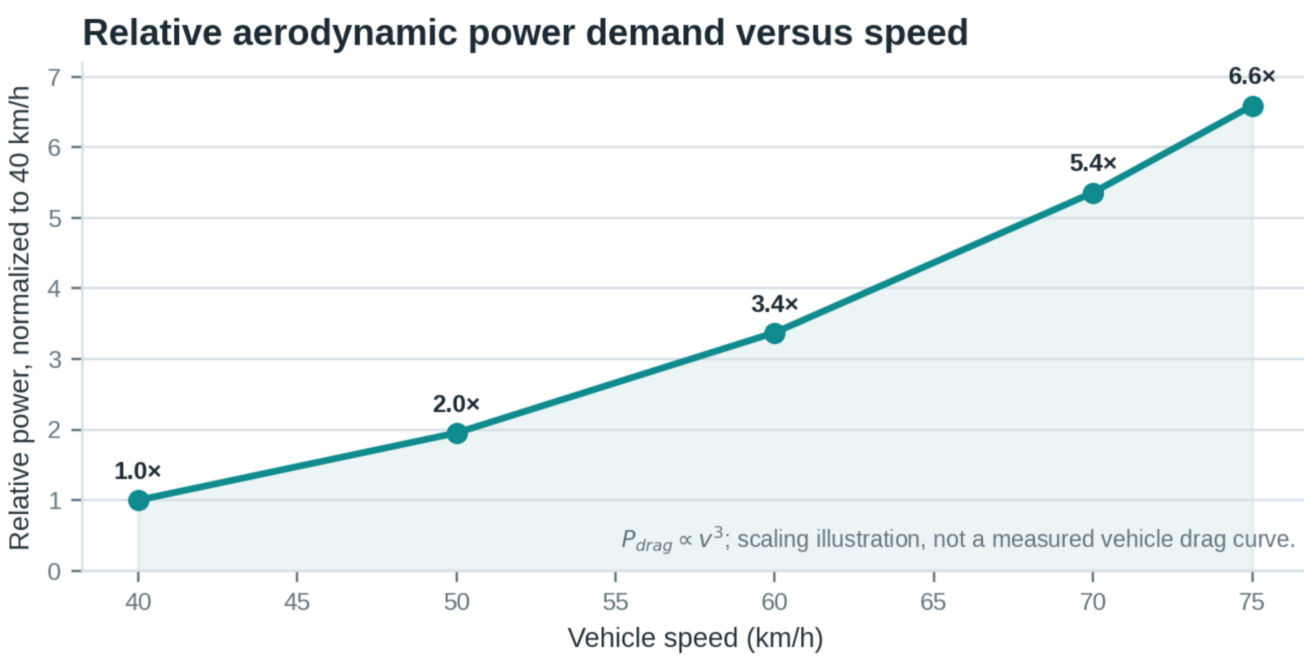

Figure 3. Relative aerodynamic power scaling, normalized to 40 km/h.

The curve illustrates the cubic speed relationship only. It is not a coast-down result and does not include rolling resistance, drivetrain losses, wind, rider posture, or actual drag area.

3.0 Electrical power architecture

3.1 Full-charge voltage compatibility and branch protection

A 72 V-class lithium-ion pack is normally a 20-series system: approximately 72 V nominal and 84.0 V at full charge. Every amplifier, filter capacitor, switch, connector, fuse, and suppression device on the audio branch must be selected for the full-charge voltage and expected transients, not the nominal label alone.

Critical design gate: A candidate specified for 48-82 V input is not compatible with an 84.0 V full-charge pack. Select hardware with adequate continuous and absolute-maximum margin, or redesign the battery operating window with coordinated BMS, charger, motor-controller, and range consequences. Do not rely on nominal voltage naming.

Table 3. Electrical calculation basis and preliminary design values

Parameter	Value used	Calculation / implication	Status
Battery bus	72 V nominal / 84 V full charge	All audio-branch devices require full-charge and transient margin	Hard requirement
Delivered audio output	500 W	Common comparison point for the two architectures	Design basis
Class D efficiency	90%	Input power ≈ 556 W at 500 W output	Assumption to verify
72-to-12 V converter efficiency	80%	Input power ≈ 694 W when combined with 90% amplifier efficiency	Comparison assumption
12 V branch current	46.3 A	500 W ÷ (0.90 × 12 V)	Calculated
72 V source current with buck	9.65 A	500 W ÷ (0.90 × 0.80 × 72 V)	Calculated
Direct 72 V source current	7.72 A	500 W ÷ (0.90 × 72 V)	Calculated
Estimated conversion heat	194 W buck architecture / 56 W direct architecture	Input power minus 500 W output; cable loss excluded	Calculated
Protection sizing	To be determined from measured continuous and peak current	Dedicated fuse, disconnect, cable ampacity, voltage drop, and pre-charge review	Open

3.2 Direct high-voltage Class D comparison

Direct high-voltage amplification removes the high-current 12 V branch and the associated converter loss. It does not eliminate thermal management: at 500 W delivered output, a 90% efficient amplifier still rejects roughly 56 W, and music transients can demand additional current and capacitor headroom.

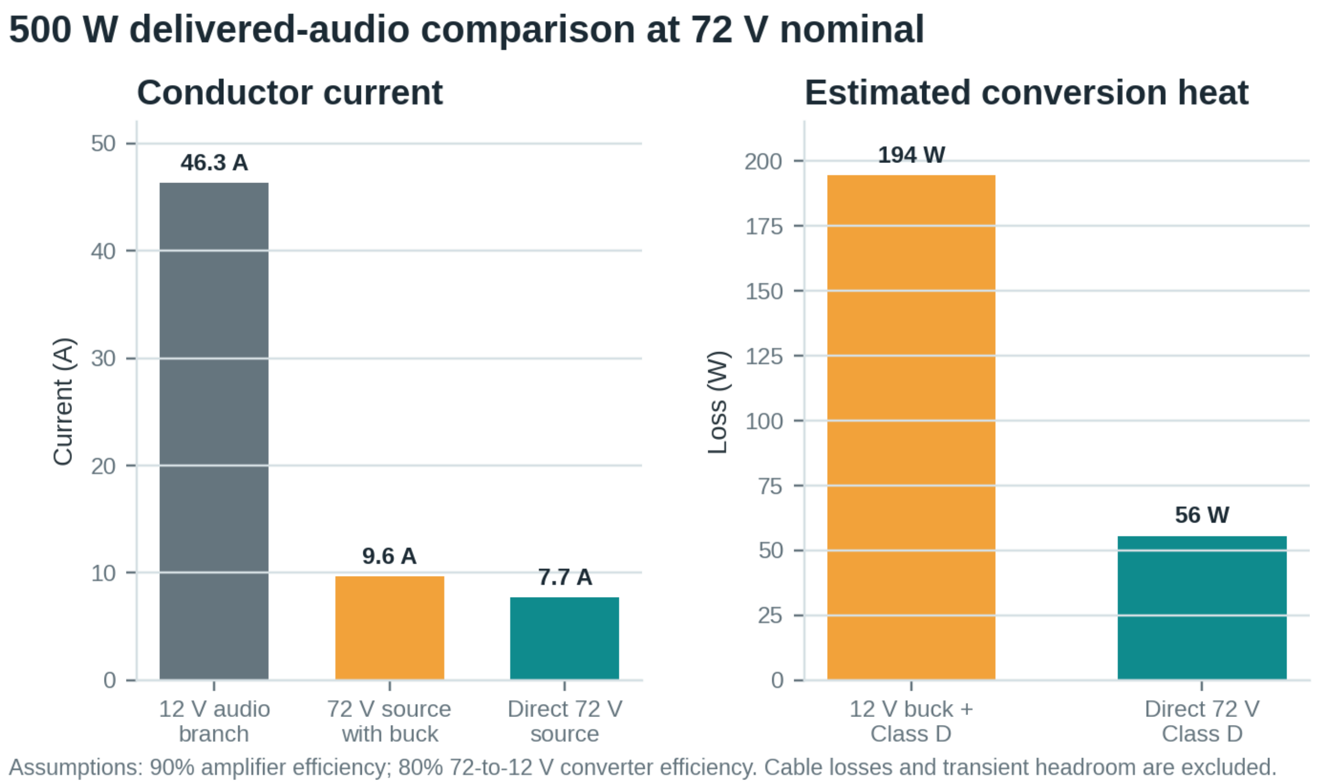

Figure 4. Updated current and heat comparison for a 500 W delivered-audio load.

This replaces the original chart with an efficiency-consistent comparison. Conductor gauge must be selected from current, route length, bundling, insulation temperature, allowable voltage drop, and fuse coordination.

4.0 DSP, crossover, and protection logic

4.1 Frequency allocation must follow measured driver limits

The source concept assigns content below 80 Hz to the tactile transducer and sends higher frequencies to compact horn-loaded drivers. That split is a useful architectural starting point, but 80 Hz is not a safe default high-pass frequency for a tweeter or small compression driver. The actual high-frequency crossover must follow the driver’s impedance, diaphragm excursion, waveguide loading, distortion, and manufacturer limits.

DSP, crossover, and protection signal flow

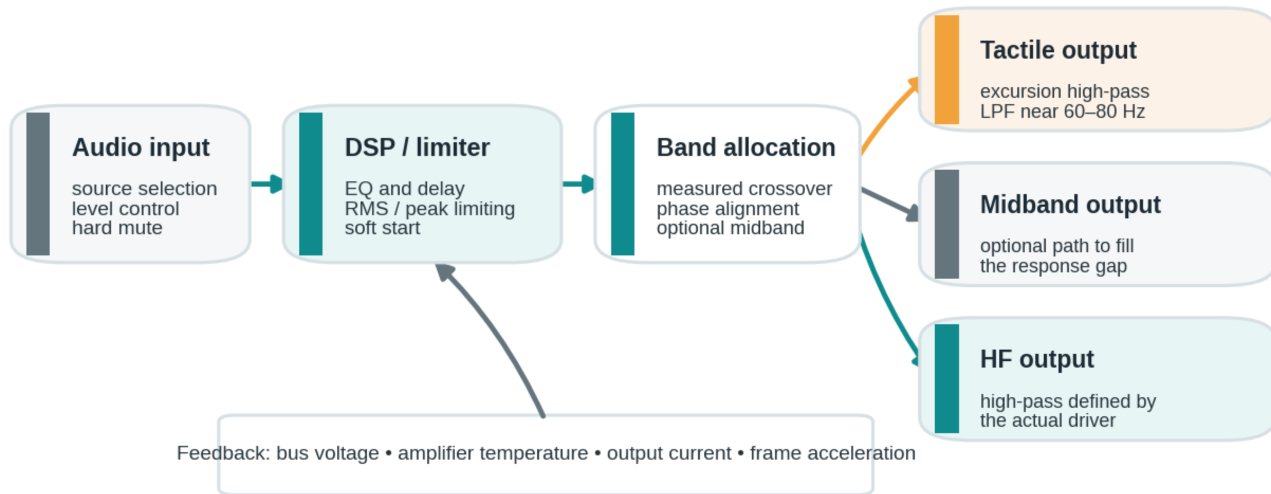

Figure 5. DSP signal flow with an optional midband path and independent protection for each output band.

Table 4. Initial DSP functions and commissioning sequence

Function	Initial configuration	Purpose	Commissioning evidence
Tactile high-pass	Approximately 20-25 Hz, then tune by excursion and frame response	Prevents wasted subsonic motion and mechanical overtravel	Current, displacement proxy, accelerometer, and listening test
Tactile low-pass	Initial study range 60-80 Hz	Confines low-frequency energy to the haptic path	Frame acceleration and crossover summation sweep
High-frequency high-pass	Set from the actual driver and waveguide; not assumed to be 80 Hz	Protects the diaphragm and limits distortion	Impedance, distortion, thermal, and manufacturer data review
Optional midband channel	Add if the selected high-frequency driver cannot cover speech and music fundamentals	Closes the likely response gap between tactile and tweeter bands	Full-system frequency response and intelligibility test
RMS / peak limiter	Calibrated from measured amplifier gain and driver voltage limits	Protects voice coils and controls hearing risk	Oscilloscope, load, thermal, and SPL verification
Soft start / mute	Muted power-up, fault mute, and physical emergency mute	Prevents pops and enables immediate shutdown	Power-cycle, communication-loss, and single-fault tests
Thermal / voltage derating	Reduce output as amplifier temperature rises or bus approaches limits	Preserves headroom and battery safety	Thermal soak and low-voltage / high-voltage test matrix

5.0 Tactile low-frequency subsystem

5.1 The frame as a mechanical resonator

A tactile transducer can create strong local vibration without the enclosure volume required by an airborne subwoofer. The bicycle frame then becomes part of the mechanical transfer path. This is best understood as haptic feedback, not as guaranteed “seismic” sound projection. Response will be dominated by mount stiffness, frame modes, component mass, tire contact, rider coupling, and structural damping.

The bottom-bracket region remains attractive because it is stiff and low, but the companion motor installation occupies the same zone. The revised report therefore treats the Rockford Fosgate IBeam IB-200 as a packaging candidate rather than a released selection.

Table 5. Updated tactile-transducer comparison

Candidate	Continuous / peak rating	Claimed response	Integration attributes	Revised status
Clark Synthesis TST429 Platinum	135 W RMS	5-800 Hz	High-output circular unit; neodymium magnet; larger package	Evaluate where maximum output justifies mass and volume
Rockford Fosgate IBeam IB-200	100 W RMS / 250 W peak	20-800 Hz	Slim rectangular form is favourable for frame-adjacent mounting	Preferred packaging candidate; mount and current availability must be verified
Dayton Audio BST-1	50 W RMS	20-200 Hz	Compact circular unit; useful lower-power reference	Bench-reference candidate, not automatically underpowered without measurement
AuraSound AST-2B-4	50 W RMS	20-80 Hz	Compact circular unit with a narrow low-frequency claim	Bench-reference candidate for efficient tactile-only operation

Ratings and bandwidths above reproduce the values in the supplied table; confirm current datasheets, impedance, mounting requirements, and continuous thermal limits before purchase.

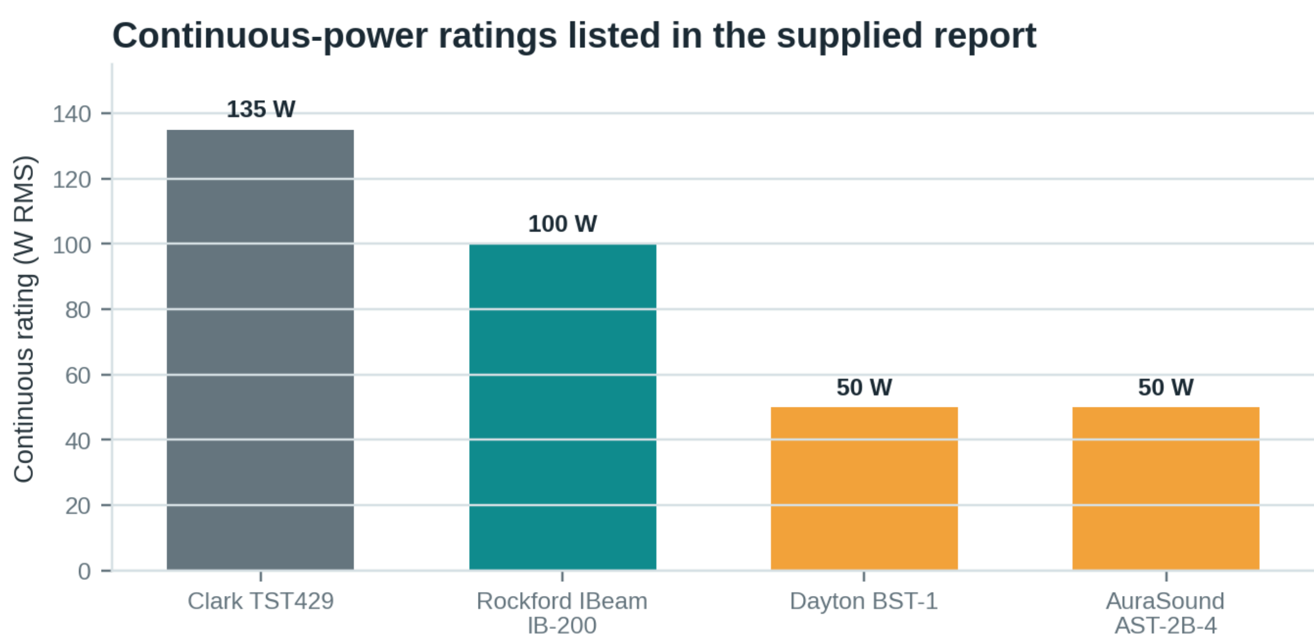

Figure 6. Continuous-power ratings from the original transducer table, redrawn in the report style.

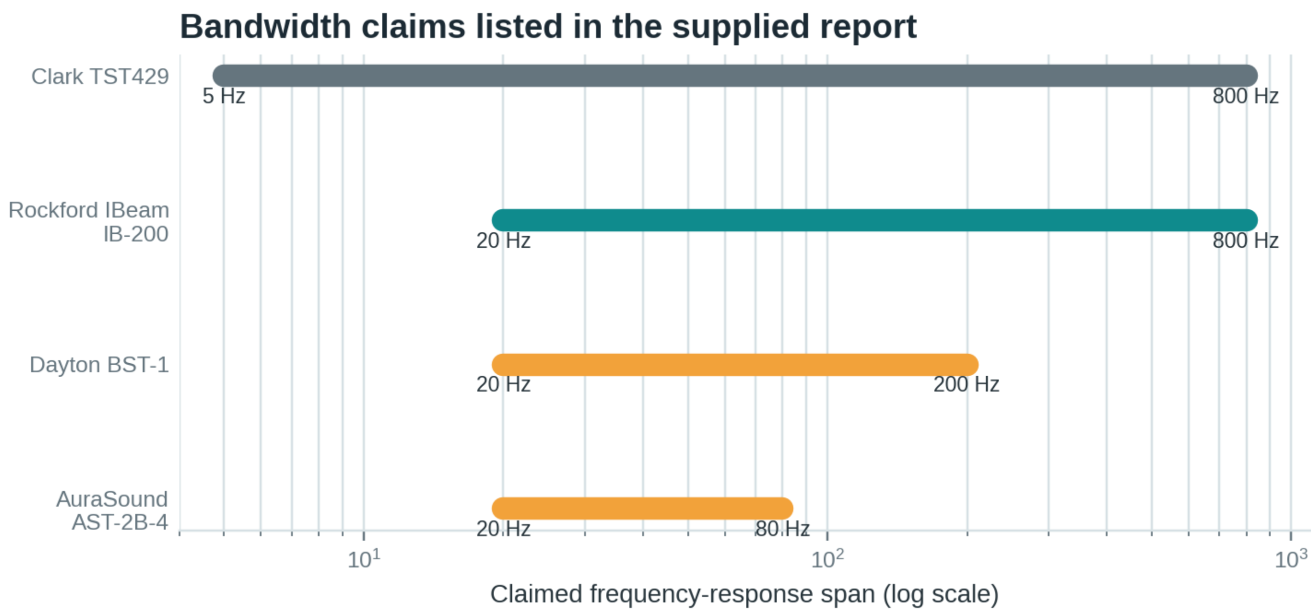

Figure 7. Claimed tactile-transducer bandwidths on a logarithmic frequency axis.

5.2 Mounting and structural release checks

The transducer mount must transfer vibration without becoming a fatigue initiator, loosening the motor interface, restricting crank rotation, or creating unsafe rider exposure. Adhesive-only attachment is not an acceptable release basis for a high-energy, high-vibration component.

Table 6. Tactile mounting and structural validation plan

Verification area	Method	Provisional pass criterion
Static clearance	Full-scale mock-up with final motor, cranks, chainring, cables, and bag	No contact through crank rotation, frame flex, steering, or expected ground-clearance envelope
Attachment load path	Mechanical drawing, fastener analysis, and instrumented bench excitation	No reliance on thin unsupported tube walls; positive retention and defined load spread
Frame strain	Strain gauges or comparable measurement near the mount during stepped excitation	No permanent deformation; dynamic strain remains below engineering-approved limit
Fastener retention	Witness marks, prevailing-torque hardware, and repeated vibration cycles	No measurable movement, loosening, fretting, or thread damage
Modal response	Accelerometers at mount, frame, saddle, and handlebar during frequency sweep	Usable tactile output without uncontrolled resonant peaks or objectionable control vibration
Rider exposure	Measure saddle, pedal, and handlebar acceleration at each operating mode	Output limited to a documented, tolerable envelope; no impairment of steering or braking
Thermal behaviour	Operate at maximum continuous test signal while monitoring coil and nearby surfaces	Temperatures remain within verified component and material limits
Post-test inspection	Dye-penetrant or appropriate visual inspection at critical joints and mount surfaces	No cracking, coating damage, fretting, or progressive movement

6.0 High-frequency projection

6.1 Sensitivity, directivity, and the missing-midband risk

High-sensitivity drivers can produce useful acoustic output with substantially less electrical power than low-sensitivity full-range cones. A waveguide also concentrates energy into a defined angle rather than distributing it uniformly. Those advantages do not remove the need for bandwidth coverage: a compact super-tweeter may not reproduce the speech and music midband that lies between the tactile channel and the high-frequency channel.

The DS18 PRO-TWN5 named in the source report should therefore remain a candidate pending confirmation of its actual continuous rating, impedance, sensitivity, minimum crossover, and polar response. A dedicated midrange transducer may be required.

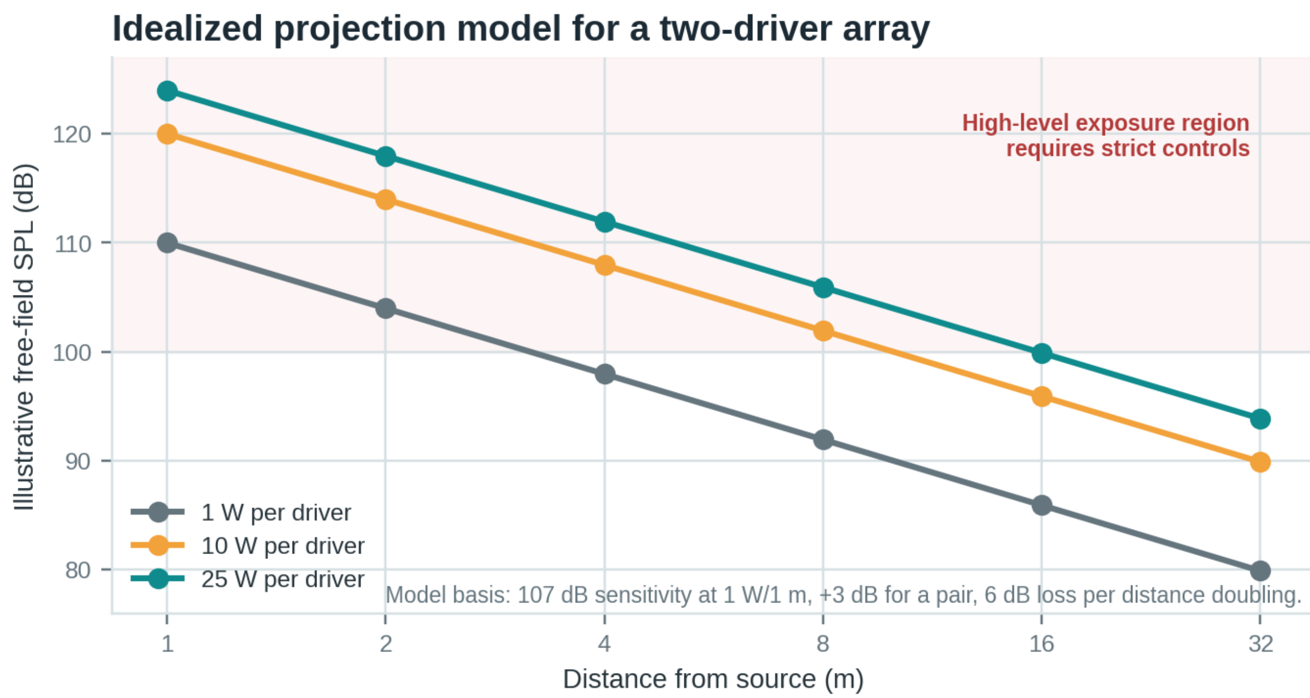

Figure 8. Idealized free-field SPL-versus-distance model for a two-driver high-sensitivity array.

Table 7. Projection-model assumptions and limitations

Model element	Value / rule	Interpretation
Sensitivity basis	107 dB SPL at 1 W / 1 m per driver	Source-document target; must be confirmed for the exact driver and waveguide
Two-driver summation	+3 dB	Assumes non-coherent equal sources; actual placement and phase can increase or decrease summation
Power cases	1 W, 10 W, and 25 W per driver	Illustrative electrical inputs, not released operating levels
Distance loss	20 log10(distance), equivalent to 6 dB per doubling	Ideal free-field spreading only
Excluded effects	Wind, ground reflection, vehicle motion, horn directivity, compression, distortion, and background noise	Measured results may differ materially in either direction
Release measurement	Calibrated SPL, frequency response, directivity, and distortion at multiple distances	Required before any claim of range, intelligibility, or safe operating level

Hearing and public-safety gate: High SPL can cause permanent hearing damage, mask traffic cues, distract the rider, and disturb other people. Commissioning requires calibrated level limits, a physical mute, stationary or closed-course testing, hearing protection, and a review of applicable vehicle and noise rules.

7.0 Concealment and environmental protection

7.1 Acoustic windows are controlled leaks

Dense laminated frame-bag fabric is not acoustically transparent. A forward-facing driver therefore requires a deliberate opening. The revised layer stack uses an outer abrasion and visual layer, acoustic fabric, a hydrophobic membrane, a spacer and drain cavity, and the waveguide. Each layer can attenuate or reflect sound, so “unhindered” transmission is not a valid design assumption.

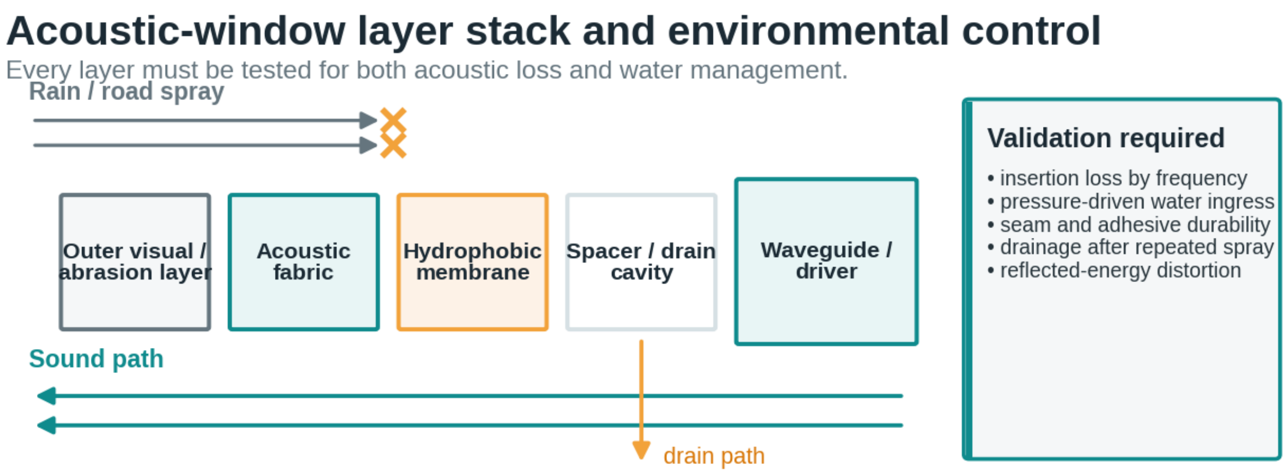

Figure 9. Acoustic-window stack showing outward sound transmission, water rejection, and drainage.

Table 8. Acoustic-window materials, risks, and verification

Layer / feature	Primary function	Dominant risk	Validation
Outer visual and abrasion layer	Maintains the bag appearance and protects the edge of the cut-out	Fraying, flutter, blockage, or added acoustic loss	Abrasion cycles, visual inspection, and swept response
Acoustic fabric such as FR701	Provides a visually uniform porous surface	Frequency-dependent attenuation and moisture retention	Insertion-loss sweep dry and wet
Hydrophobic acoustic membrane	Limits liquid-water penetration while passing pressure fluctuations	Pressure-driven leakage, clogging, adhesive failure, and high-frequency loss	Directed spray, pressure pulse, drying, and post-test acoustic sweep
Spacer and drain cavity	Prevents the membrane from contacting the waveguide and gives water an exit	Standing water, capillary traps, or resonant cavity effects	Drain-time test and inspection after repeated spray
Waveguide seal and fasteners	Controls the acoustic path and restrains the driver	Air leaks, rattles, loose hardware, and galvanic contact	Leak check, vibration test, torque marks, and corrosion review
Cable gland and service access	Routes power and signal while allowing maintenance	Wicking, pinch damage, and loss of sealing after service	Repeated service cycles followed by spray and insulation checks

8.0 Electromagnetic interference and signal integrity

8.1 Separate switching energy from low-level audio

The FOC motor controller and its phase conductors produce rapidly changing voltage and current. Audio inputs, wireless modules, and DSP clocks can convert that energy into audible whine, resets, or unstable control. The response is a system-level zoning strategy rather than a single generic “noise filter.”

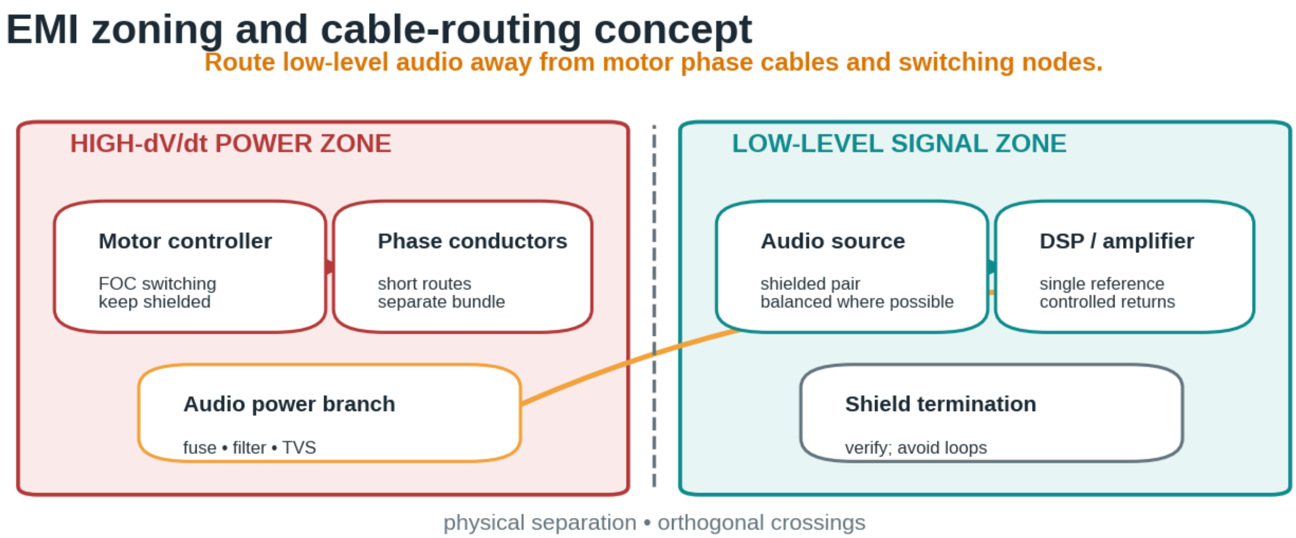

Figure 10. EMI zoning concept with physical separation, filtered power, and controlled shield termination.

Table 9. EMI control matrix

Control	Implementation intent	Failure mode addressed	Verification
Dedicated audio branch	Fuse close to the source; suitable LC or common-mode filtering; transient suppression selected for 84 V operation	Conducted switching noise and voltage spikes entering the amplifier	Oscilloscope capture and audio-noise measurement at idle, acceleration, and field weakening
Cable separation	Route audio and control cables away from motor phases and controller switching nodes; cross at right angles where necessary	Inductive and capacitive coupling into low-level signals	Incremental routing test while monitoring noise floor
Shielded / balanced signal	Use differential signalling where supported and maintain shield continuity	Common-mode pickup and radiated interference	Injected-noise and motor-load susceptibility test
Ground topology	Define a single power reference and avoid unintended current through signal shields	Ground-loop hum and shared-impedance coupling	Ground-current measurement and alternate-termination comparison
Enclosure and mounting	Bond or isolate conductive parts intentionally; avoid floating shields and galvanic paths	Radiated emissions, intermittent contact, and corrosion	Continuity, insulation, corrosion, and vibration checks
Power decoupling	Place low-ESR bulk and ceramic capacitance close to amplifier inputs within manufacturer limits	Local voltage collapse during bass transients	Supply ripple and brownout testing at minimum battery voltage
Fault handling	Mute on communication loss, overtemperature, under-voltage, and over-voltage	Loud transients, uncontrolled output, or repeated resets	Single-fault insertion and recovery test

9.0 Energy and range implications

9.1 Continuous acoustic output is a material traction-energy load

The source report states that full acoustic output draws 5.5 A from the 72 V battery, equivalent to approximately 396 W. It also states that this increases total electrical draw by 50% while riding at 40 km/h. Taken together, those statements imply a propulsion draw of about 792 W at that operating point.

Using the 2.52-2.88 kWh energy envelope from the companion platform, the resulting model predicts a one-third range reduction at continuous full audio output. This is consistent with the source narrative, but it remains an ideal energy calculation rather than a road test.

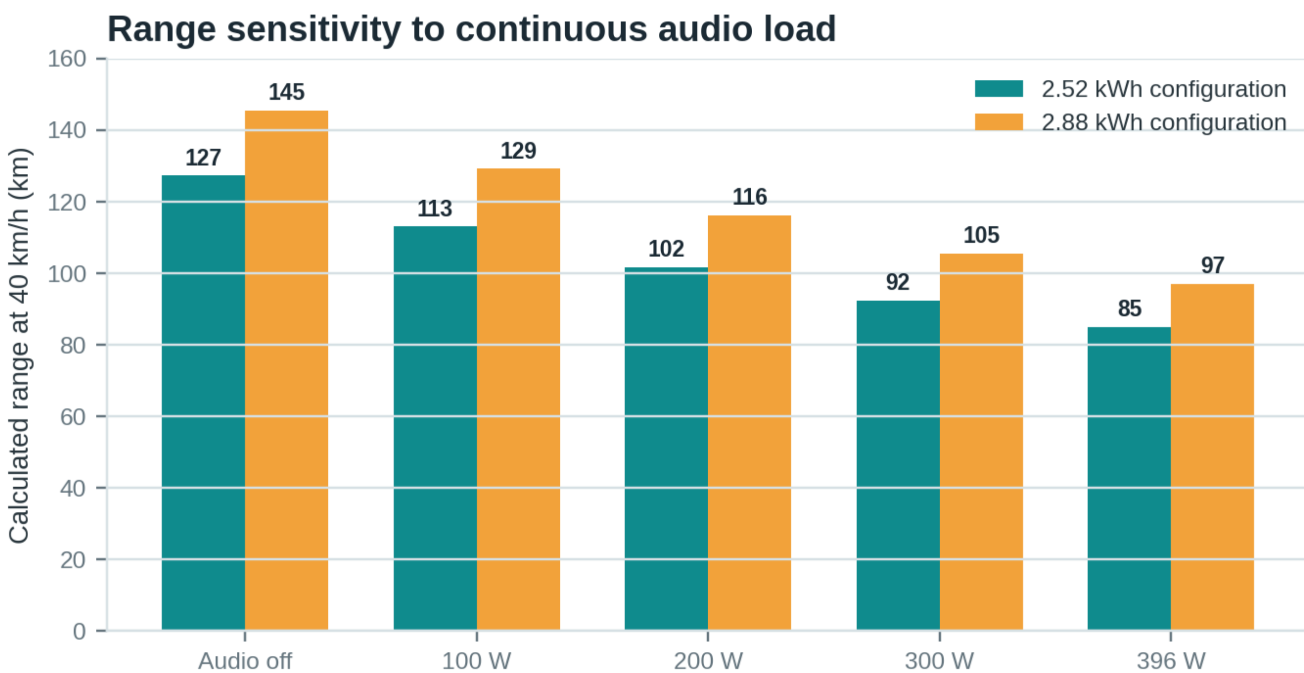

Figure 11. Calculated range at 40 km/h as continuous audio load rises from zero to 396 W.

Table 10. Energy-budget calculation at 40 km/h

Parameter	Audio off	Full audio	Interpretation
Battery energy envelope	2.52-2.88 kWh	2.52-2.88 kWh	Nominal pack-energy range from the companion concept
Propulsion electrical draw	792 W inferred	792 W inferred	Derived from the source statement that 396 W audio adds 50% to total draw
Audio electrical draw	0 W	396 W (5.5 A × 72 V)	Continuous full-output source value
Total electrical draw	792 W	1,188 W	Propulsion plus audio
Energy use at 40 km/h	19.8 Wh/km	29.7 Wh/km	Total power divided by speed
Calculated range: 2.52 kWh	127 km	85 km	Excludes reserve and all unmodelled losses
Calculated range: 2.88 kWh	145 km	97 km	Excludes reserve and all unmodelled losses
Range change	Baseline	-33%	Matches the mathematical consequence of a 50% rise in continuous power

Actual range will vary with speed, wind, terrain, rider posture, tires, drivetrain efficiency, battery temperature, voltage sag, state-of-charge reserve, acoustic duty cycle, and amplifier efficiency.

10.0 Verification, safety, and release gates

The acoustic subsystem should be commissioned as a staged laboratory and closed-course program. Each stage must preserve a rapid shutdown path and should proceed only after the preceding electrical, structural, and environmental checks pass.

Table 11. Integrated verification plan

Verification area	Method	Provisional pass criterion
Input-voltage margin	Operate at minimum, nominal, and full-charge voltage; apply representative switching transients within a controlled test setup	No component exceeds verified voltage rating; no latch-up, reset, or insulation breakdown
Branch protection	Short-circuit and overload coordination review with current-limited source before pack connection	Fuse and disconnect clear faults without damaging wiring or creating sustained arcing
Continuous thermal load	Load-bank and acoustic testing at worst-case ambient with battery thermally isolated	Amplifier, connectors, conductors, and adjacent battery surfaces remain within verified limits
Acoustic response	Calibrated frequency, distortion, directivity, and SPL sweeps in a controlled area	Defined response achieved without exceeding driver, hearing, or community-noise limits
Tactile structure	Instrumented frequency and endurance sweeps with frame strain and fastener checks	No cracking, fretting, loosening, unsafe control vibration, or progressive change
Weather resistance	Repeated spray, drainage, drying, and post-exposure insulation / acoustic tests	No liquid reaches energized parts or cells; acceptable insertion loss and full recovery after drying
EMI and control integrity	Operate motor through speed and load envelope while monitoring audio, DSP, wireless link, and faults	No audible whine above the defined noise floor, resets, false commands, or lost mute function
Vehicle dynamics	Incremental low-speed closed-course testing with added mass secured and audio initially disabled	No steering restriction, oscillation, brake interference, cable movement, or component migration
Human factors	Gloved mute operation, fault indication, rider-cue masking, and exposure review	Immediate mute is intuitive; output settings do not impair awareness or exceed approved exposure
Post-test inspection	Documented inspection after each test block	No hidden thermal damage, water retention, cracked mounts, abraded cables, or loose hardware

Public-operation gate: Do not use a high-output acoustic mode on public roads until the vehicle, electrical system, sound levels, rider-distraction controls, and local legal requirements have been independently reviewed. The safest default is muted output while moving.

11.0 Procurement and design-freeze checklist

The source document names plausible components, but several selections are not electrically or acoustically closed. Procurement should follow the requirements in the final column rather than the product name alone.

Table 12. Candidate hardware and pre-purchase checks

Subsystem	Candidate in source report	Design-freeze requirement	Current decision
High-voltage amplification	SoundExtreme EV30011 / EV30041 family	Continuous input and absolute maximum must exceed 84 V with transient margin; verify output power, impedance, cooling, protection, and isolation	HOLD: 82 V claim conflicts with 84 V full charge
DSP / crossover	Integrated amplifier DSP	Independent band filters, calibrated RMS / peak limiters, soft start, hard mute, telemetry, and configuration retention	VERIFY capability and failure behaviour
Primary tactile candidate	Rockford Fosgate IBeam IB-200	Current datasheet, impedance, RMS limit, physical dimensions, mounting load path, and availability	PACKAGING STUDY required
Alternative tactile candidate	Clark Synthesis TST429 Platinum	Mass, dimensions, current draw, mount stiffness, and benefit over lower-power candidates	BENCH COMPARE
Reference tactile units	Dayton BST-1 / AuraSound AST-2B-4	Use as measured references rather than rejecting by power rating alone	OPTIONAL test articles
High-frequency driver	DS18 PRO-TWN5	Confirm whether it is a tweeter or compression driver, its safe crossover, sensitivity, impedance, directivity, and continuous rating	HOLD: midband coverage unresolved
Possible midband driver	Not specified	Weather-tolerant, compact, high-sensitivity unit covering the gap between tactile and HF paths	REQUIREMENT open
Acoustic window	X-Pac bag, FR701 fabric, hydrophobic screen	Obtain material samples; measure insertion loss, spray resistance, drainage, seam durability, and colour match	PROTOTYPE coupon first
Electrical protection	Not fully specified	84 V-rated fuse, service disconnect, pre-charge where required, transient suppression, insulated enclosure, and strain relief	MANDATORY before pack connection
EMI materials	Shielded twisted-pair and power filter	Voltage/current-rated components, controlled shield termination, cable separation, and documented ground plan	BENCH VALIDATE
Instrumentation	Not specified	Bus voltage/current, amplifier temperature, frame acceleration, calibrated SPL, and fault logging	ADD to prototype
Safety controls	Not specified beyond DSP	Physical mute, power-state indication, default-muted start, exposure presets, and fault-latched shutdown	MANDATORY

12.0 Conclusion

The acoustic concept is feasible at the subsystem level: direct high-voltage amplification can reduce conversion loss and eliminate a high-current 12 V branch; tactile transduction can create strong localized vibration without a subwoofer enclosure; and high-sensitivity directional drivers can project sound efficiently. The supplied report nevertheless overstates several unverified effects and leaves critical interfaces open.

Three gates dominate the next revision. The amplifier must be compatible with the 84 V full-charge state, the tactile mount must coexist with the CYC motor and survive structural testing, and the acoustic driver set must cover the midband without an unsafe crossover assumption. Environmental insertion loss, EMI, thermal behaviour, rider exposure, and range must then be measured. Until those gates close, the system remains a documented concept rather than a released build.

Document basis: supplied Research Block II narrative and tactile-transducer table, with energy-envelope values carried forward from the companion Research Block I concept. All product selections require current manufacturer verification.