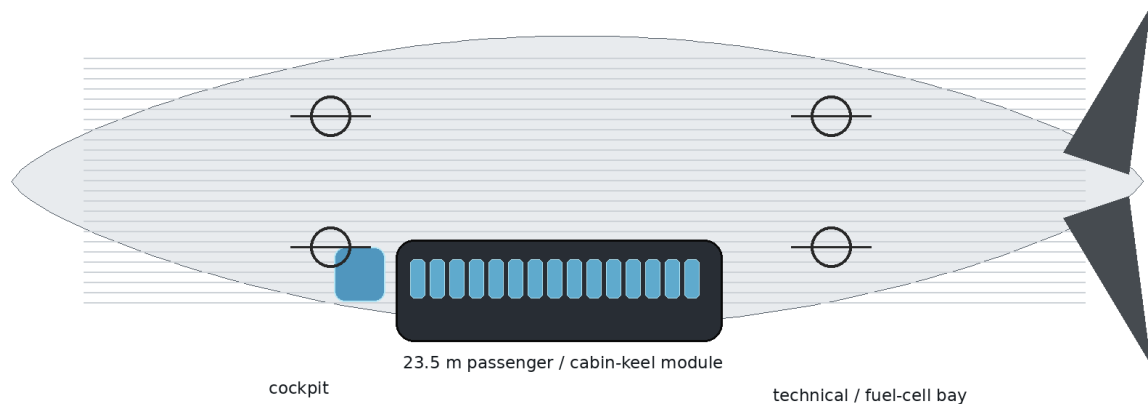


H120-He60

Integrated Product Definition & Multidisciplinary Design Iterations

Version 0.3 — Pre-PDR Design-Convergence Candidate

H120-He60 v0.3 - conceptual side view



120 m overall | 25 m max diameter | mirror-look lightweight envelope | semi-rigid keel

Concept owner / author: Chris Oesterreich

Date: 20 September 2026

Scope: 60-passenger semi-rigid hydrogen-electric helium airship

Status: preliminary engineering definition — not type certified and not construction release data

1. Executive design baseline

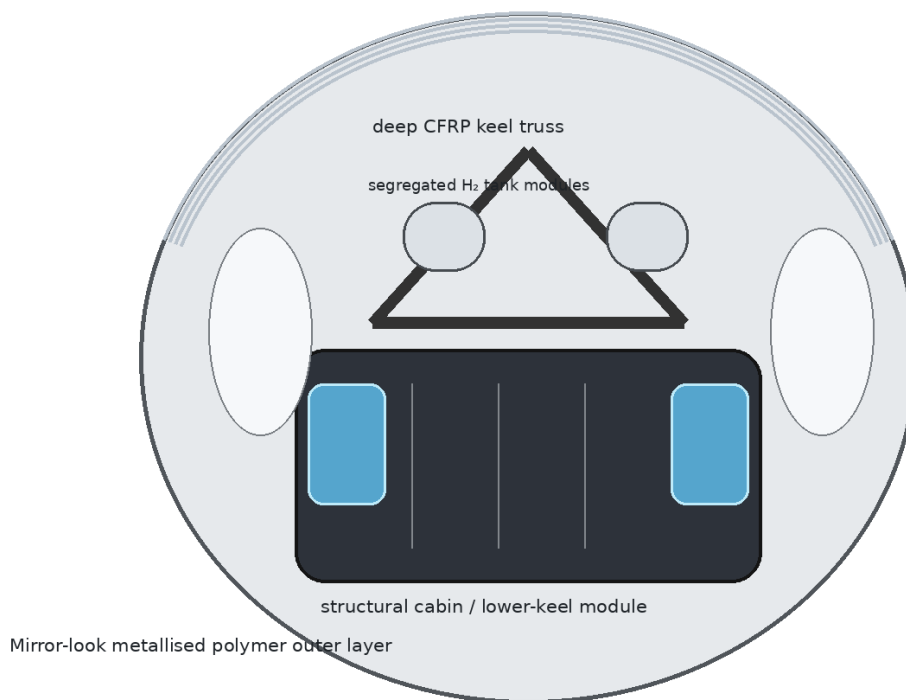
What this document does

It runs the H120-He60 sequentially through 32 technical, operational, customer, finance, certification and lifecycle perspectives, then repeats the same sequence through optimisation and design-freeze passes. It also gives each discipline its working document set and acceptance criteria. “Perfect” is treated as engineering convergence: remaining unknowns are converted into explicit tests or certification actions rather than hidden by false precision.

Parameter	v0.3 baseline
Product	H120-He60 regional / panorama airship bus
Configuration	Semi-rigid helium airship; passenger transport category concept
Length / max diameter	120 m / 25 m
External envelope volume	~36,100 m ³ preliminary shape model
Nominal usable helium	~31,700 m ³ (~88% of envelope volume)
Ballonet / gas-management volume	~4,400 m ³ total, split fore/aft and zoned
Passenger seats	60, single deck, 2+2 seating
Crew design basis	2 pilots + 2 cabin crew for CAT concept
Supported operating mass target	27.8 t, excluding lifting gas; PDR hard target
Preliminary hot-day useful static lift	~30.3 t at 50°C retained from prior model; re-validate
Propulsion	4 × 180 kW peak electric vectored propulsors + ~60 kW docking/thruster function
Primary energy	3 × 200 kW PEM fuel-cell modules; 600 kW nominal
Buffer battery	2 × 100 kWh LFP packs; dual HV buses
Hydrogen	~120 kg usable gaseous H ₂ , preliminary 350-bar architecture, segregated tanks
Cruise / max	85–95 km/h target cruise; 125–130 km/h preliminary max target
Range	350 km dispatch-planning target; 400–450 km technical objective only after test

Parameter	v0.3 baseline
Cabin	Unpressurised, ~23.5 m long, ~4.3 m wide, panoramic modular windows
Exterior concept	Mirror-look metallised polymer laminate; transparent aerospace window modules
Certification planning basis	EASA SC GAS Issue 01 + project-specific MoC; CS-30T/TAR legacy material as agreed MoC candidates
Program maturity	Integrated concept v0.3 / Pre-PDR candidate; no certification claim

Envelope / cabin cross-section concept



Not to scale. Final laminate, tank position and section geometry require structural, fire/H₂, RF/lightning and evacuation substantiation.

Figure 1 — Conceptual cross-section: semi-rigid keel, segregated H₂ modules, structural cabin and mirror-look envelope.

1.1 Mass budget: hard 27.8 t supported-mass target

Mass item	Allocation	Design note
Semi-rigid keel, local frames, hardpoints	4.20 t	CFRP-dominant; includes joint nodes
Envelope, fins, seams, gas-management hardware	3.10 t	Mirror finish included as lightweight film/coating concept
Cabin primary shell / floor / doors /	3.20 t	Cabin contributes to lower-keel stiffness

Mass item	Allocation	Design note
glazing		
Landing gear, mooring and towing hardware	1.10 t	Three-point gear + nose capture interface
Main propulsion, propellers, vectoring	1.10 t	Four distributed electric units
H ₂ tanks, PEMFC modules and balance-of-plant	3.80 t	Retained prior full-system target
Battery packs	1.30 t	2 × 100 kWh LFP preliminary
Electrical, avionics and flight-control hardware	1.00 t	Excludes propulsion motors
Cooling / ventilation / ECS	0.80 t	Two liquid loops + cabin ventilation
Seats, lavatory, galley, trim, passenger systems	1.40 t	Design-to-weight interior
Passengers, crew and baggage design payload	6.20 t	Prior program payload basis retained
Operational fluids / retained trim water / misc.	0.60 t	Limited water retention; otherwise drain/vent
TOTAL	27.80 t	Must remain ≤27.8 t at this baseline

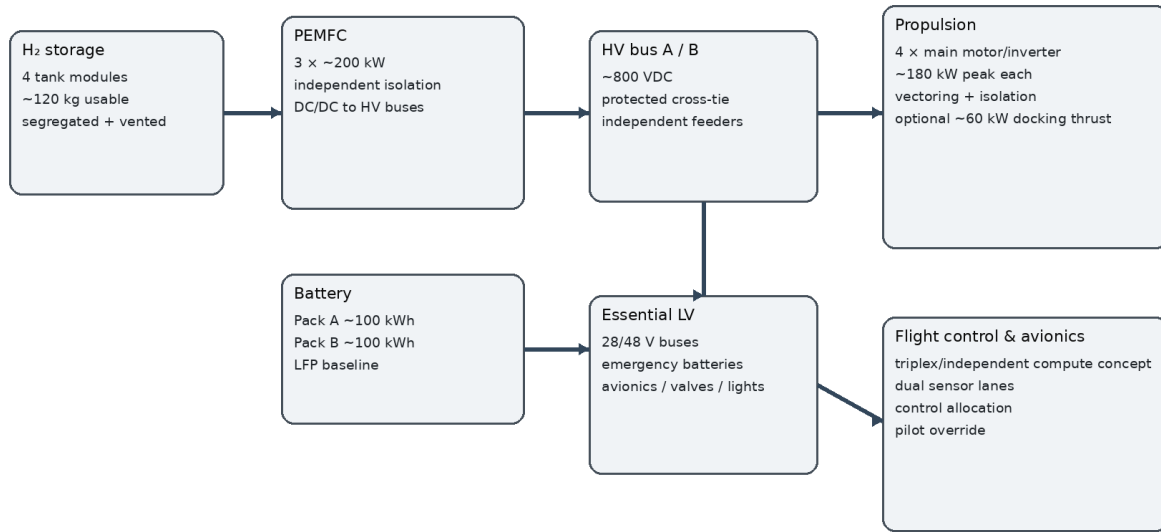
Mass discipline

The 27.8 t target is deliberately treated as a supported operating mass excluding the lifting helium itself. It must be reconciled against the final buoyancy model and atmospheric envelope. Any later increase creates a cascade into helium volume, drag, propulsion, H₂, structure and ground handling.

1.2 Energy and mission closure

- ~120 kg H₂ contains about 4.0 MWh LHV chemical energy. At a preliminary 50–55% net electrical conversion range, roughly 2.0–2.2 MWh may be available before auxiliaries and degradation; this is a planning calculation, not a certified endurance value.
- The 90 km/h / 350 km reference mission is about 3.9 h airborne before routing and reserve allowances. The aerodynamic programme therefore targets cruise electrical demand at or below ~380 kW so that mission energy, thermal rejection and reserve logic can close without increasing H₂ mass.
- PEMFC product water is roughly 9 kg per kg of H₂ consumed. A full 120 kg H₂ mission can therefore create on the order of 1,080 kg water if fully retained. The aircraft must not simply keep all of it: limited fore/aft water storage is used as a controllable trim tool, with approved discharge/vent strategy for excess.

H120-He60 energy / control architecture (concept)



Safety intent: no single fuel-cell module, battery pack, HV bus, main propulsor or flight-control lane is allowed to remove safe continued flight/landing capability.

Figure 2 — Modular energy and control architecture used after the second design iteration.

1.3 Certification reality

- EASA’s current SC GAS Issue 01 is listed as not superseded and exists because EASA has not published one conventional certification specification for large gas airships. EASA also states that project-specific means of compliance are expected for differing airship concepts.
- The H120-He60 should therefore enter early technical familiarisation with EASA rather than “design to a guessed CS” for years and discover late that novel features need different evidence.
- The legacy CS-30T/TAR, FAA airship criteria and applicable CS-25/CS-23 industry practices can be used as candidate means of compliance only where the authority agrees. Hydrogen-electric propulsion also requires explicit treatment of SC E-19 / EHPS and H₂-specific certification issues.
- Software, complex electronics and equipment qualification are planned around current recognised processes such as DO-178C/ED-12C, DO-254/ED-80, DO-160G, ARP4754B and ARP4761A where applicable and agreed.

2. Why the mirror exterior is kept — but not as literal mirrors

- The visual idea is retained: from a passenger or terminal viewpoint the H120 should read as a continuous silver mirror object with a dark panoramic window ribbon and large integrated company name.
- Rigid glass mirrors or metal mirror panels are rejected because they add mass, create thousands of fasteners/attachments, are poor on a flexing envelope and make repair/impact behaviour worse.
- The engineering implementation is a multilayer envelope whose outer weather film receives a very thin metallised or reflective coating. The outer system must be qualified for flexing, UV, rain, temperature, cleaning, adhesion, glare and lightning/EMI behaviour.
- Cabin “glass” becomes an aerospace transparency assembly: a replaceable scratch-resistant outer face can be thin chemically strengthened glass, while structural/fail-safe plies can use acrylic/polycarbonate as appropriate. This preserves the glass look while avoiding an unnecessarily heavy all-glass wall.
- The mirror layer is intentionally interrupted at RF antenna windows and may be micro-textured or lower-gloss near the cockpit, propulsors and ground-facing lower band to control glare. The company name is made through masked coating/printing, not raised metal letters.

3. Sequential multidisciplinary design cycle

Iteration rule

Every role is processed before the next iteration begins. Iteration 1 asks “can this architecture work safely?”. Iteration 2 asks “can it be made lighter, cheaper and easier to certify/operate?”. Iteration 3 asks “what can be frozen now, and what must remain an explicit verification item?”.

3.1 Iteration 1 — Feasibility / conflict discovery

1.1 01 Chief Engineer / Systems Engineering

Role objective: Own the aircraft-level requirements, architecture, interfaces, mass/power budgets and configuration control. Prevent local optimisations from breaking the aircraft as a whole.

Freeze the mission around 60 passengers, 350 km dispatch range and a semi-rigid 120 m × 25 m helium vehicle. Establish 27.8 t as a hard supported-mass target rather than a soft aspiration. Allocate mass, electrical power, thermal rejection, CG and safety objectives to every subsystem.

1.2 02 Certification / Airworthiness

Role objective: Create a certification path that EASA can actually review, including project-specific means of compliance for an unusual gas airship and hydrogen-electric propulsion.

Use EASA SC GAS Issue 01 as the anchor because EASA states that large gas airships do not have a single published CS and that project-specific MoC are expected. Treat CS-30T/TAR, FAA airship design criteria and applicable large-aircraft practices only as candidate means of compliance, subject to authority agreement.

1.3 03 Aerodynamics / Flight Physics

Role objective: Own outer mold line, drag, stability derivatives, control authority, gust response and performance across the mission envelope.

Retain a conventional streamlined hull, 120 m long and 25 m diameter, with max thickness ahead of mid-length and a tapered tail. Reject protruding architectural features that create unnecessary drag. Keep the passenger module mostly within the lower hull contour.

1.4 04 Loads / Statics

Role objective: Define all limit and ultimate load cases and turn them into traceable sizing loads for keel, cabin, envelope, fins, engine mounts, landing gear and mooring.

Create the load tree: envelope pressure, buoyancy distribution, cabin/payload, thrust/vectoring, gust, manoeuvre, landing, taxi, mooring, towing, crosswind, asymmetric propulsion, emergency descent, ditching and local service loads. Treat the airship as a flexible coupled membrane-beam system, not a simple beam.

1.5 05 Structures / Materials / Damage Tolerance

Role objective: Turn the load model into the lightest certifiable structure with inspectable fail-safe load paths and realistic manufacturing methods.

Use a semi-rigid deep CFRP keel rather than a scaled H350 rigid skeleton. Local circumferential distribution frames carry propulsors, gear, cabin and tail loads; the envelope carries membrane pressure and distributed aerodynamic loads.

1.6 06 Lightweight / Design-to-Cost / Value Engineering

Role objective: Challenge every kilogram, part count and supplier-specific feature while preserving safety, reliability and certification evidence.

Reject literal mirror panels, structural glass walls, decorative metal and redundant secondary structure. Set subsystem mass allocations and “mass-to-buy” rules: every new kilogram needs a signed trade study or compensating deletion.

1.7 07 Envelope / Helium / Thermal

Role objective: Provide shape retention, helium containment, pressure control, UV/weather protection, thermal stability and repairability at minimum areal mass.

Use a multi-layer airship laminate architecture rather than sheet metal: structural fabric, gas barrier, adhesive/sealing layer and weathering outer film. Divide the helium space into multiple controlled zones and use fore/aft ballonets for pressure and trim management.

1.8 08 Industrial / Exterior Designer

Role objective: Create an iconic object without forcing engineering to carry decorative mass or non-certifiable geometry.

Preserve the user’s mirror-airship idea: the hull reads as a single reflective silver body with a large, clean company wordmark. Windows are visually treated as a continuous dark ribbon even though structurally they remain modular.

1.9 09 Propulsion / Propeller Engineer

Role objective: Deliver efficient cruise thrust, low-speed control and failure tolerance with low noise and maintainable hardware.

Use four identical electrically driven main propulsors, distributed symmetrically and mounted to dedicated keel frames. Each unit targets ~180 kW peak and can vector for low-speed manoeuvring. Avoid unique left/right hardware where possible.

1.10 10 Hydrogen / PEM Fuel Cell / Thermal Engineer

Role objective: Store and convert hydrogen safely, provide continuous electrical power, reject heat and prevent any leak from becoming a cabin or envelope hazard.

Keep ~120 kg usable gaseous H₂ as the mission fuel. Use three ~200 kW fuel-cell modules instead of one monolith. Place tanks in segregated, directly vented technical volumes outside the passenger pressure/occupancy boundary and keep H₂ lines out of the cabin.

1.11 11 Electrical Power / EWIS Engineer

Role objective: Provide fault-contained HV/LV distribution, bonding, lightning protection and maintainable wiring without carrying unnecessary copper mass.

Use two physically separated ~800 VDC propulsion buses, each fed from fuel-cell DC/DC converters and one 100 kWh battery pack. Cross-tie only through protected contactors. Maintain separate 28/48 V essential and utility buses.

1.12 12 Avionics / Software / Cybersecurity

Role objective: Provide navigation, communication, surveillance, displays, computing and segregated software networks with certifiable development assurance.

Use dual flight/navigation sensor lanes, independent attitude/air-data sources, dual VHF and GNSS/INS. Passenger connectivity is physically/logically segregated from aircraft-control networks.

1.13 13 Flight Controls / Guidance Engineer

Role objective: Blend aerodynamic surfaces, vectored thrust and buoyancy/trim effects into predictable pilot handling and stable autopilot behaviour.

Use three tail surfaces with independent electromechanical actuation and four vectorable propulsors for low-speed control. Provide conventional pilot axes while control laws handle allocation across ruddervators and thrust vectoring.

1.14 14 Pilot / Flight Operations

Role objective: Ensure the aircraft can be flown, monitored, landed and handled safely by a human crew in real weather and abnormal situations.

Use two pilots side-by-side with a broad forward windshield, downward camera coverage and uncluttered primary displays. Put propulsion, electrical and H₂ status into system synoptics rather than dozens of discrete gauges.

1.15 15 Cabin Crew / Service Operations

Role objective: Make 60-passenger operations serviceable and evacuable with realistic crew stations, sightlines and procedures.

Plan two cabin-crew stations because 60 seats exceed the 50-seat-per-crew planning threshold used in current EASA CAT rules. Locate one forward and one aft, each adjacent to a primary exit and with direct view of their cabin zones.

1.16 16 Cabin / Interior / Product Engineer

Role objective: Deliver the “panoramic airship bus” experience with low mass, fast boarding, robust materials and realistic maintenance.

Use 15 rows of 2+2 seats for 60 passengers with ~34 in class seat pitch target, a generous central aisle and low window sill. Avoid heavy overhead bins; use underfloor/fore-aft baggage modules and small personal-item shelves.

1.17 17 Human Factors / Accessibility

Role objective: Eliminate foreseeable human error and make the aircraft usable by passengers and staff with a broad range of capabilities.

Design one level boarding path wherever terminal infrastructure allows. Provide at least one wheelchair-capable position without forcing a passenger transfer to a standard seat, and keep critical signage high-contrast despite the dark-window/mirror aesthetic.

1.18 18 Safety / Reliability / RAMS

Role objective: Identify failure conditions early and force the architecture to tolerate them before detailed design makes changes expensive.

Build aircraft-level FHA covering loss of thrust, asymmetric thrust, loss of flight controls, uncontrolled buoyancy/pressure, H₂ fire/explosion, battery thermal event, cabin fire, structural failure, electrical common cause, loss of navigation, uncontrolled mooring release and water ditching.

1.19 19 Fire / Emergency / Evacuation / Rescue

Role objective: Contain fire, isolate energy, keep exits usable and support land/water rescue on the actual North/Baltic Sea route set.

Separate H₂, HV batteries, fuel cells, cabin and baggage with dedicated detection and containment/vent paths. Place emergency exits so at least one pair remains usable after a local fire or ground obstacle.

1.20 20 Ground Handling / Mooring

Role objective: Make the 120 m vehicle commercially operable without an army of handlers and prevent unintended free flight.

Use steerable wheeled landing gear, vectored propulsion and a strong nose capture/mooring fitting tied into the keel. Avoid classic “many people on ropes” as the normal operating concept.

1.21 21 Maintenance / ICA / MRO

Role objective: Design access, inspections and replacement tasks before the surface is closed and expensive disassembly becomes inevitable.

Make fuel-cell modules, inverters, pumps, blowers, avionics LRUs and battery packs line-replaceable through dedicated lower technical doors. Keep H₂ tanks inspectable without opening the passenger cabin or envelope primary seams.

1.22 22 Manufacturing / Industrialisation

Role objective: Turn the design into repeatable hardware with realistic tooling, assembly sequence, takt and facility needs.

Split production into envelope panels, CFRP keel/frame modules, cabin module, propulsion pods and systems harnesses. Use repeatable left/right modules and supplier-preassembled LRUs.

1.23 23 Quality / Conformity

Role objective: Ensure design data, materials, supplier parts and certification test articles are traceable and conforming.

Create drawing/specification release, serialisation and material lot traceability from the first prototype. Treat envelope fabric lots, adhesives, CFRP cure/bond records, H₂ tanks and flight-critical electronics as controlled characteristics.

1.24 24 Supply Chain / Procurement

Role objective: Prevent a technically elegant design from depending on single-source, unfinanceable or decade-long lead-time components.

Classify critical long-lead items: envelope laminate, aerospace H₂ tanks, PEMFC modules, high-power motors/inverters, propellers, window transparencies and certifiable avionics. Establish make/buy decisions early.

1.25 25 Airport / Terminal / H₂ Infrastructure

Role objective: Make the vehicle fit real terminals, hydrogen logistics, rescue services and local operating restrictions.

Plan dedicated stands because a 120 m vehicle cannot be treated as a conventional gate aircraft. The terminal concept uses nose docking/capture, controlled passenger bridge/stair interface and a large clear manoeuvring area.

1.26 26 Airline / Operator / Dispatch

Role objective: Turn the aircraft into a repeatable transport product with predictable turnaround, weather reliability and dispatch rules.

Design around point-to-point 100–350 km routes with Hamburg–Sylt as premium reference and Helsinki–Tallinn as short-range high-frequency reference. Keep turnarounds simple: passengers, limited baggage, H₂ refuel, walk-around, health checks.

1.27 27 Passenger / Customer

Role objective: Protect the reason to buy the product: view, calm ride, accessibility, novelty and simple transport rather than technical spectacle alone.

Customers get large panoramic sightlines, quiet electric propulsion, 2+2 seating, generous pitch, Wi-Fi/USB-C power, one accessible lavatory and visible exterior branding that makes the vehicle an attraction itself.

1.28 28 Investor / Finance / Bankability

Role objective: Turn technical maturity into investable gates, protect capital from uncontrolled certification and supplier risk, and prove unit economics with conservative assumptions.

Use the existing ~€320M P50 programme baseline as a planning envelope, not a guarantee. Break financing into evidence-linked gates: architecture/material tests, subscale/iron-bird, first full-scale article, certification flight test and industrialisation.

1.29 29 Insurance / Product Liability / Legal

Role objective: Identify design and operational features that drive insurability, liability exposure and contractual risk before fleet entry.

Treat H₂, large flexible envelope, ground wind, passenger evacuation and novel flight controls as explicit risk classes. Record design mitigations and test evidence in an insurer-facing risk dossier.

1.30 30 Environment / Noise / Lifecycle

Role objective: Minimise lifecycle impacts beyond zero tailpipe carbon claims: helium, hydrogen source, materials, noise, maintenance and end-of-life.

Use helium recovery during maintenance rather than routine venting. Specify low-noise propellers/motors and use the reflective skin to reduce solar heat load rather than as decoration only.

1.31 31 Security / Operational Resilience

Role objective: Protect aircraft, ground links, H₂ interfaces and passenger operations from foreseeable malicious or accidental interference.

Physically segregate passenger Wi-Fi and maintenance networks from flight-control networks. Protect external service ports, refuelling commands and docking interfaces against unauthorised activation.

1.32 32 Verification / Ground Test / Flight Test

Role objective: Convert every important design assertion into a staged piece of physical or analytical evidence and stop unsafe jumps to full-scale flight.

Create the verification pyramid: materials/coupons, component rigs, envelope panels, H₂/FC iron-bird, electrical power rig, flight-control HIL, cabin mock-up, structural article, tethered/low-speed tests, then progressive flight envelope expansion.

3.2 Iteration 2 — Lightweight, cost and certification optimisation

2.1 01 Chief Engineer / Systems Engineering

Role objective: Own the aircraft-level requirements, architecture, interfaces, mass/power budgets and configuration control. Prevent local optimisations from breaking the aircraft as a whole.

Replace point solutions with modular architecture: 3×200 kW PEMFC, 2×100 kWh batteries, four main propulsors, dual HV buses and a cabin/keel module that carries structure, systems and passengers. Add strict interface control so propulsion, H₂, windows and envelope are not designed independently.

2.2 02 Certification / Airworthiness

Role objective: Create a certification path that EASA can actually review, including project-specific means of compliance for an unusual gas airship and hydrogen-electric propulsion.

Add SC E-19 / electric-hybrid propulsion considerations, DO-160 environmental qualification, software/electronic-hardware assurance and ARP4754B/ARP4761A lifecycle planning. Create explicit CRI candidates for H₂ storage, mirrored conductive skin, semi-rigid load path, automated docking and novel water-ballast control.

2.3 03 Aerodynamics / Flight Physics

Role objective: Own outer mold line, drag, stability derivatives, control authority, gust response and performance across the mission envelope.

Adopt a three-fin Y-tail as the starting configuration and distribute propulsion near the CG so vectoring can support pitch/yaw at low speed. Define a low-drag mirror surface with flush seams and modular but near-flush windows. Add a design objective of ≤ 380 kW shaft/electrical propulsion demand at 90 km/h before reserves.

2.4 04 Loads / Statics

Role objective: Define all limit and ultimate load cases and turn them into traceable sizing loads for keel, cabin, envelope, fins, engine mounts, landing gear and mooring.

Move major equipment close to the buoyancy/CG station to cut bending moment. Make the cabin floor/side frames a closed torsion box tied into the semi-rigid keel. Put propulsion and landing-gear reactions into dedicated hardpoint frames instead of diffusing them through envelope fabric.

2.5 05 Structures / Materials / Damage Tolerance

Role objective: Turn the load model into the lightest certifiable structure with inspectable fail-safe load paths and realistic manufacturing methods.

Use pultruded/braided CFRP tubes or profiles where load direction is stable; use bonded-bolted hybrid joints at detachable high-load interfaces. Isolate carbon from aluminium to prevent galvanic corrosion; reserve titanium for heavily loaded compact nodes where it actually saves system mass.

2.6 06 Lightweight / Design-to-Cost / Value Engineering

Role objective: Challenge every kilogram, part count and supplier-specific feature while preserving safety, reliability and certification evidence.

Make the cabin shell structural, move inverters near motors, use four main propulsors rather than six, modularise identical left/right parts, standardise fastener families and turn the mirror aesthetic into a micrometre-scale metallised film/coating rather than separate panels.

2.7 07 Envelope / Helium / Thermal

Role objective: Provide shape retention, helium containment, pressure control, UV/weather protection, thermal stability and repairability at minimum areal mass.

Adopt a mirror-look outer layer using metallisation or a reflective coating on the outer polymer film. Keep RF-transparent antenna windows and deliberately segmented conductive zones so the finish does not become an

uncontrolled lightning/EMI structure. Use anti-glare treatment around cockpit, propulsor sightlines and lower airport-facing surfaces.

2.8 08 Industrial / Exterior Designer

Role objective: Create an iconic object without forcing engineering to carry decorative mass or non-certifiable geometry.

Reduce visual clutter: no exposed pipes, radiators or random access panels on prime surfaces. Integrate propulsion pylons into four repeated sculpted pods. Put service doors and emergency markings into a restrained lower technical band.

2.9 09 Propulsion / Propeller Engineer

Role objective: Deliver efficient cruise thrust, low-speed control and failure tolerance with low noise and maintainable hardware.

Optimise large, low-tip-speed variable-pitch propellers for efficiency and cabin noise. A separate ~60 kW lateral/docking thrust function is retained only if crosswind and mast-capture simulations prove value greater than mass/cost.

2.10 10 Hydrogen / PEM Fuel Cell / Thermal Engineer

Role objective: Store and convert hydrogen safely, provide continuous electrical power, reject heat and prevent any leak from becoming a cabin or envelope hazard.

Adopt preliminary 350-bar storage because the airship has abundant volume and can trade volume for tank-system simplicity; retain 700 bar only as a later mass/volume trade. Put fuel cells and cooling close to the CG. Split H₂ isolation into tank, manifold and module-level shutoff zones.

2.11 11 Electrical Power / EWIS Engineer

Role objective: Provide fault-contained HV/LV distribution, bonding, lightning protection and maintainable wiring without carrying unnecessary copper mass.

Locate motor inverters close to motors to shorten high-current AC runs; route the two HV channels on opposite sides of the keel where practicable. Add independent low-voltage emergency batteries for avionics, flight-control computers, critical valves and lighting.

2.12 12 Avionics / Software / Cybersecurity

Role objective: Provide navigation, communication, surveillance, displays, computing and segregated software networks with certifiable development assurance.

Apply DO-178C/ED-12C planning for airborne software, DO-254/ED-80 for complex airborne electronic hardware where applicable, DO-160 environmental qualification and ARP4754B/ARP4761A system/safety development. Use DO-326A/ED-202A style security process for connected functions.

2.13 13 Flight Controls / Guidance Engineer

Role objective: Blend aerodynamic surfaces, vectored thrust and buoyancy/trim effects into predictable pilot handling and stable autopilot behaviour.

Add modes for cruise, approach, hover/low-speed, mast capture and engine-out. Keep automated docking as an augmentation; pilot retains immediate override. Product-water/ballonet trim commands are slow supervisory functions, never fast flight-control actuators.

2.14 14 Pilot / Flight Operations

Role objective: Ensure the aircraft can be flown, monitored, landed and handled safely by a human crew in real weather and abnormal situations.

Design for IFR-capable avionics but initially prohibit known icing and severe convective weather until dedicated protection and validation exist. Make low-speed vectoring intuitive with a single thrust/velocity command concept; avoid requiring pilots to manage four motors manually.

2.15 15 Cabin Crew / Service Operations

Role objective: Make 60-passenger operations serviceable and evacuable with realistic crew stations, sightlines and procedures.

Keep service simple: one compact galley/service module, one accessible lavatory, water sized for the route rather than airline long-haul norms. Boarding, door arming and safety demonstration must be achievable without specialist ground staff.

2.16 16 Cabin / Interior / Product Engineer

Role objective: Deliver the “panoramic airship bus” experience with low mass, fast boarding, robust materials and realistic maintenance.

Use 15 modular panoramic window bays per side as the visual rhythm rather than one huge continuous glass wall. Each bay can combine a thin abrasion-resistant glass face with structural acrylic/polycarbonate plies and a fail-safe inner pane. The exterior reads as a dark continuous ribbon against the mirror skin.

2.17 17 Human Factors / Accessibility

Role objective: Eliminate foreseeable human error and make the aircraft usable by passengers and staff with a broad range of capabilities.

Run task analyses for pilot mode awareness, H₂ refuelling, maintenance isolation, emergency door operation and passenger evacuation. Apply anthropometric reach/visibility studies before cockpit and service-panel freeze.

2.18 18 Safety / Reliability / RAMS

Role objective: Identify failure conditions early and force the architecture to tolerate them before detailed design makes changes expensive.

Use PSSA to allocate independence: 3 fuel-cell modules, 2 batteries, 2 HV buses, separated wiring, four propulsion units, multiple helium zones, redundant blowers/pressure sensing, multiple exits and physically separated avionics power.

2.19 19 Fire / Emergency / Evacuation / Rescue

Role objective: Contain fire, isolate energy, keep exits usable and support land/water rescue on the actual North/Baltic Sea route set.

For water routes, treat the gas envelope as buoyancy but do not rely on it as the sole life-saving means. Provide life vests and raft capacity sized for all occupants; keep principal exits above the predicted static waterline in ditching attitudes where practicable.

2.20 20 Ground Handling / Mooring

Role objective: Make the 120 m vehicle commercially operable without an army of handlers and prevent unintended free flight.

Develop powered capture line/winch and terminal mast interface. Use automated or semi-automated docking aids (GNSS/vision/LiDAR) but keep mechanical fail-safe restraint. Set an operational target of a five-person ground team, with three-person automated handling as an aspirational test objective rather than a promise.

2.21 21 Maintenance / ICA / MRO

Role objective: Design access, inspections and replacement tasks before the surface is closed and expensive disassembly becomes inevitable.

Add built-in leak/pressure trending for helium and H₂, motor/inverter health monitoring, battery cell monitoring and structural inspection points. Use modular window cartridges so scratched panes do not require major cabin disassembly.

2.22 22 Manufacturing / Industrialisation

Role objective: Turn the design into repeatable hardware with realistic tooling, assembly sequence, takt and facility needs.

Adopt roll-to-roll outer-film metallisation/printing so the mirror surface and branding are created during envelope manufacture. Use jigs that establish keel straightness and hardpoint station coordinates before envelope integration.

2.23 23 Quality / Conformity

Role objective: Ensure design data, materials, supplier parts and certification test articles are traceable and conforming.

Build conformity inspection into certification test planning so test evidence is not invalidated by undocumented article configuration. Require supplier first-article inspection and non-conformance disposition rules.

2.24 24 Supply Chain / Procurement

Role objective: Prevent a technically elegant design from depending on single-source, unfinanceable or decade-long lead-time components.

Standardise four identical propulsor modules, three identical fuel-cell modules and two identical battery packs. Prefer supplier risk-sharing on NRE while protecting second-source rights after agreed volumes/periods.

2.25 25 Airport / Terminal / H₂ Infrastructure

Role objective: Make the vehicle fit real terminals, hydrogen logistics, rescue services and local operating restrictions.

Separate H₂ refuelling from passenger boarding unless hazard analysis and local rules explicitly support simultaneous operations. Provide bonding/earthing, gas detection, emergency shutoff and exclusion zones at the refuelling interface.

2.26 26 Airline / Operator / Dispatch

Role objective: Turn the aircraft into a repeatable transport product with predictable turnaround, weather reliability and dispatch rules.

Create MEL/MMEL candidates for one fuel-cell module unavailable, selected avionics redundancy, non-essential cabin systems and one degraded ground-handling sensor — only where safety analysis supports dispatch. Do not trade away propulsion/control redundancy for schedule pressure.

2.27 27 Passenger / Customer

Role objective: Protect the reason to buy the product: view, calm ride, accessibility, novelty and simple transport rather than technical spectacle alone.

The mirror hull remains a signature feature but cabin comfort wins every trade against decorative weight. Window mullions, propulsion pods and emergency markings are visually minimised from seated eye level.

2.28 28 Investor / Finance / Bankability

Role objective: Turn technical maturity into investable gates, protect capital from uncontrolled certification and supplier risk, and prove unit economics with conservative assumptions.

Tie supplier risk-sharing to defined work packages and future workshare without granting unlimited exclusivity. Track recurring factory-cost target $\leq$ €25M against the earlier ~€23.61M parametric estimate and ~€50M mature selling-price concept.

2.29 29 Insurance / Product Liability / Legal

Role objective: Identify design and operational features that drive insurability, liability exposure and contractual risk before fleet entry.

Avoid opaque responsibility splits with ground-equipment suppliers, terminal operators and H₂ providers. Define interface responsibilities, maintenance ownership and occurrence-data sharing contractually.

2.30 30 Environment / Noise / Lifecycle

Role objective: Minimise lifecycle impacts beyond zero tailpipe carbon claims: helium, hydrogen source, materials, noise, maintenance and end-of-life.

Measure hydrogen origin and electricity mix in route LCA; do not call operations “zero emission” without boundary definition. Design replaceable batteries/fuel-cell modules and recyclable material streams where feasible.

2.31 31 Security / Operational Resilience

Role objective: Protect aircraft, ground links, H₂ interfaces and passenger operations from foreseeable malicious or accidental interference.

Use signed software loads, controlled maintenance credentials, tamper-evident access to H₂/HV service panels and logging of critical ground commands. The airship must remain safe if all external data links are lost.

2.32 32 Verification / Ground Test / Flight Test

Role objective: Convert every important design assertion into a staged piece of physical or analytical evidence and stop unsafe jumps to full-scale flight.

Use one full-scale ground/static article where economical and at least one flight-test article instrumented for loads, strain, pressure, thermal, power, vibration and control-law validation. Reuse rigs for certification regression tests after changes.

3.3 Iteration 3 — Integrated Pre-PDR freeze pass

3.1 01 Chief Engineer / Systems Engineering

Role objective: Own the aircraft-level requirements, architecture, interfaces, mass/power budgets and configuration control. Prevent local optimisations from breaking the aircraft as a whole.

Accept v0.3 only as a Pre-PDR candidate. Freeze geometry, mission, mass allocation and system boundaries; leave aerodynamic coefficients, structural allowables, detailed H₂ tank qualification, envelope laminate properties and exact control-law gains as verification items rather than invented final numbers.

Acceptance condition: Every top-level requirement has an owner, verification method and trace to a subsystem. Mass and power sums close with margin; no interface remains ownerless.

Working documents: H120-SYS-001 Aircraft-Level Requirements Specification; H120-SYS-002 Concept of Operations; H120-SYS-003 Aircraft Architecture Description; H120-SYS-004 Interface Control Document; H120-SYS-005 Mass/CG/Power/Thermal Budget; H120-CM-001 Configuration Management Plan

3.2 02 Certification / Airworthiness

Role objective: Create a certification path that EASA can actually review, including project-specific means of compliance for an unusual gas airship and hydrogen-electric propulsion.

Freeze a certification programme with compliance items grouped by flight, structure, design/construction, propulsion, equipment, operating limitations and ground-mooring interface. No design item may be called “compliant” until evidence exists; conceptual compliance remains “planned”.

Acceptance condition: Authority-facing claims are evidence-based, every novel feature has an agreed path to MoC, and design data are configuration-controlled.

Working documents: H120-CERT-001 Certification Programme; H120-CERT-002 Certification Basis & CRI Log; H120-CERT-003 Compliance Checklist; H120-CERT-004 Means-of-Compliance Matrix; H120-CERT-005 Authority Issue Paper Register; H120-CERT-006 Conformity & Certification Test Plan

3.3 03 Aerodynamics / Flight Physics

Role objective: Own outer mold line, drag, stability derivatives, control authority, gust response and performance across the mission envelope.

Do not freeze fin area, propeller diameter or high-speed limit from hand estimates. Freeze only the topology and the CFD/wind-tunnel campaign: hull pressure distribution, fin interactions, propulsor inflow, crosswind docking, one-engine-inoperative, gust and envelope distortion cases.

Acceptance condition: Predicted drag, stability and control authority are backed by correlated CFD/wind-tunnel data and close the power/range budgets with margin.

Working documents: H120-AERO-001 Outer Mold Line Definition; H120-AERO-002 Aerodynamic Methods & CFD Plan; H120-AERO-003 Stability & Control Analysis; H120-AERO-004 Performance Model; H120-AERO-005 Wind/Gust/Crosswind Envelope; H120-AERO-006 Propulsor-Airframe Interaction Report

3.4 04 Loads / Statics

Role objective: Define all limit and ultimate load cases and turn them into traceable sizing loads for keel, cabin, envelope, fins, engine mounts, landing gear and mooring.

Freeze station coordinates and load-introduction philosophy, not member sizes. Require global nonlinear FE, local joint FE and test-correlation before releasing laminate ply books or tube wall thicknesses.

Acceptance condition: Every primary structural part has governing limit/ultimate cases with traceable load factors; no “estimated” load is used for release drawings.

Working documents: H120-LOAD-001 Loads & Design Criteria; H120-LOAD-002 Load Case Catalogue; H120-LOAD-003 Mass Distribution & Inertia Model; H120-LOAD-004 Global FEM Load Extraction; H120-LOAD-005 Ground/Mooring Loads Report; H120-LOAD-006 Ditching/Emergency Landing Loads

3.5 05 Structures / Materials / Damage Tolerance

Role objective: Turn the load model into the lightest certifiable structure with inspectable fail-safe load paths and realistic manufacturing methods.

Require coupon → element → subcomponent → full-scale static test progression. No “minimum-gauge” CFRP part is accepted without impact/damage tolerance, moisture/temperature and manufacturing-variability knockdowns.

Acceptance condition: Positive margin of safety exists for all certified cases using approved allowables; critical joints are test-correlated and inspectable.

Working documents: H120-STR-001 Structural Design Principles; H120-STR-002 Material & Allowables Plan; H120-STR-003 Global/Local Sizing Report; H120-STR-004 Joint & Fastener Design Manual; H120-STR-005 Damage Tolerance / Inspection Plan; H120-STR-006 Static Test Article Plan

3.6 06 Lightweight / Design-to-Cost / Value Engineering

Role objective: Challenge every kilogram, part count and supplier-specific feature while preserving safety, reliability and certification evidence.

Set recurring factory-cost target $\leq \text{€}25\text{M}$ at maturity, consistent with the earlier $\sim \text{€}23.61\text{M}$ parametric factory-cost estimate and $\sim \text{€}50\text{M}$ sales-price concept. Require should-cost, mass and assembly-time review at every design release.

Acceptance condition: Any added feature proves passenger value, safety necessity or lifecycle savings. Mass and recurring cost stay inside allocations with explicit reserves.

Working documents: H120-DTC-001 Mass Reduction Register; H120-DTC-002 Design-to-Cost Target Book; H120-DTC-003 Part Count / Commonality Plan; H120-DTC-004 Make-Buy Trade Studies; H120-DTC-005 Value Engineering Decision Log

3.7 07 Envelope / Helium / Thermal

Role objective: Provide shape retention, helium containment, pressure control, UV/weather protection, thermal stability and repairability at minimum areal mass.

Freeze appearance and functional layer requirements, not a supplier chemistry. Qualification must prove biaxial strength, tear propagation, seam strength, helium permeability, UV/weathering, rain/hail erosion, flame behaviour, repairability and mirror-layer adhesion after cycling.

Acceptance condition: Envelope meets structural, leak, thermal and repair requirements after environmental ageing; mirror finish does not create unacceptable glare, EMI or RF loss.

Working documents: H120-ENV-001 Envelope Functional Specification; H120-ENV-002 Gas Cell/Ballonet Architecture; H120-ENV-003 Laminate Qualification Plan; H120-ENV-004 Seam & Repair Standard; H120-ENV-005 Helium Leak/Recovery Plan; H120-ENV-006 Solar/Thermal Model

3.8 08 Industrial / Exterior Designer

Role objective: Create an iconic object without forcing engineering to carry decorative mass or non-certifiable geometry.

Freeze an exterior style guide with “mirror zones”, low-glare operational zones, RF windows, rescue markings and maintenance-access seams. The company name is produced by masked coating/printing rather than heavy raised lettering.

Acceptance condition: The aircraft is recognisable at distance, all safety markings remain legible, and styling adds negligible structural mass and no hidden maintenance penalty.

Working documents: H120-ID-001 Exterior Design Language; H120-ID-002 Surface/Colour/Finish Specification; H120-ID-003 Window & Branding Layout; H120-ID-004 Operational Markings Plan; H120-ID-005 Access Panel Visual Integration Guide

3.9 09 Propulsion / Propeller Engineer

Role objective: Deliver efficient cruise thrust, low-speed control and failure tolerance with low noise and maintainable hardware.

Freeze modular interfaces, isolation, braking/feathering and single-failure behaviour. Propeller diameter, blade count and vector limits remain test/CFD outputs, not aesthetic choices.

Acceptance condition: Cruise efficiency closes range; loss/jam of any single unit remains controllable; propeller fragments and burst loads are contained/segregated by design.

Working documents: H120-PROP-001 Propulsion System Specification; H120-PROP-002 Propeller Sizing & Acoustic Report; H120-PROP-003 Vectoring Mechanism Design; H120-PROP-004 One-Propulsor-Inoperative Analysis; H120-PROP-005 Motor/Inverter Qualification Plan

3.10 10 Hydrogen / PEM Fuel Cell / Thermal Engineer

Role objective: Store and convert hydrogen safely, provide continuous electrical power, reject heat and prevent any leak from becoming a cabin or envelope hazard.

Use redundant leak detection, forced ventilation where needed, upward overboard vent paths, ignition-source control and independent emergency isolation. Product water is allowed into fore/aft trim tanks only under controlled mass/CG logic; excess water is discharged under approved procedures.

Acceptance condition: No single leak or valve failure can produce an unmonitored hazardous concentration in an occupied or ignition-prone space; thermal performance is demonstrated at hot/high and degraded modes.

Working documents: H120-H2-001 Hydrogen Storage & Distribution Specification; H120-H2-002 PEMFC Architecture & Performance Map; H120-H2-003 H₂ Hazard Analysis; H120-H2-004 Ventilation/Leak Detection Report; H120-H2-005 Thermal Management Design; H120-H2-006 Refuelling & Ground Safety Concept

3.11 11 Electrical Power / EWIS Engineer

Role objective: Provide fault-contained HV/LV distribution, bonding, lightning protection and maintainable wiring without carrying unnecessary copper mass.

Treat the metallised exterior as part of lightning/EMI design, not decoration. Define bonding jumpers, static discharge, antenna ground planes, shielding and RF-transparent breaks. Freeze EWIS separation rules before 3D routing starts.

Acceptance condition: No single electrical fault removes all propulsion control, flight controls or essential avionics; routing and protection are demonstrated by analysis/test.

Working documents: H120-ELEC-001 Electrical Load Analysis; H120-ELEC-002 HV/LV Single-Line Diagram; H120-ELEC-003 EWIS Zonal Design Rules; H120-ELEC-004 Bonding/Lightning/HIRF Plan; H120-ELEC-005 Battery Safety & Containment Design; H120-ELEC-006 Electrical Failure Modes Report

3.12 12 Avionics / Software / Cybersecurity

Role objective: Provide navigation, communication, surveillance, displays, computing and segregated software networks with certifiable development assurance.

Freeze functions and DAL/assurance allocation only after FHA/PSSA. No “AI autopilot” or cloud dependence in safety-critical control. Ground analytics may support maintenance but loss of connectivity cannot affect safe flight.

Acceptance condition: Safety-critical functions have deterministic, independently powered paths; non-safety networks cannot command or corrupt flight-critical systems.

Working documents: H120-AV-001 Avionics Architecture; H120-AV-002 Data Bus / Network ICD; H120-AV-003 Software Development Plan; H120-AV-004 Hardware Development Plan; H120-AV-005 Cybersecurity Plan; H120-AV-006 Environmental Qualification Matrix

3.13 13 Flight Controls / Guidance Engineer

Role objective: Blend aerodynamic surfaces, vectored thrust and buoyancy/trim effects into predictable pilot handling and stable autopilot behaviour.

Require piloted simulation, hardware-in-the-loop and progressive envelope expansion. Control-law gains, mode transitions and actuator rates remain verification outputs until validated against the flexible-airship model.

Acceptance condition: Single sensor, actuator or computer failures remain recoverable; mode logic is unambiguous to pilots and no hidden automation can command unrecoverable states.

Working documents: H120-FCS-001 Flight-Control Functional Specification; H120-FCS-002 Control-Law Architecture; H120-FCS-003 Actuator Sizing & Jam Analysis; H120-FCS-004 Handling-Qualities Plan; H120-FCS-005 HIL / Iron-Bird Test Plan

3.14 14 Pilot / Flight Operations

Role objective: Ensure the aircraft can be flown, monitored, landed and handled safely by a human crew in real weather and abnormal situations.

Freeze normal/abnormal/emergency procedures for fuel-cell module loss, HV-bus isolation, one/two propulsor loss, ballonet/blower faults, helium leak, H₂ detection, loss of docking automation and ditching. Human-in-the-loop simulator acceptance becomes a PDR/CDR gate.

Acceptance condition: Two qualified pilots can manage every credited failure without ambiguous mode awareness or excessive workload; direct visual/camera coverage supports ground operations.

Working documents: H120-OPS-001 Flight Deck Philosophy; H120-OPS-002 Crew Workload & Task Analysis; H120-OPS-003 Normal Procedures; H120-OPS-004 Abnormal/Emergency Procedures; H120-OPS-005 Operating Limitations Draft; H120-OPS-006 Training & Type-Rating Concept

3.15 15 Cabin Crew / Service Operations

Role objective: Make 60-passenger operations serviceable and evacuable with realistic crew stations, sightlines and procedures.

Freeze crew stowage, interphone, emergency equipment, medical kit, fire extinguishers and life-saving equipment locations. Cabin-crew procedures must be validated in full-scale mock-up drills.

Acceptance condition: Each crew member can see/control assigned zones, reach exits and emergency equipment, and perform normal turnaround tasks without unsafe workarounds.

Working documents: H120-CC-001 Cabin Crew Station Layout; H120-CC-002 Cabin Service Concept; H120-CC-003 Door/Exit Operating Procedures; H120-CC-004 Emergency Equipment Layout; H120-CC-005 Cabin Crew Training Syllabus

3.16 16 Cabin / Interior / Product Engineer

Role objective: Deliver the “panoramic airship bus” experience with low mass, fast boarding, robust materials and realistic maintenance.

Freeze four principal egress positions, modular seat tracks, one wheelchair restraint position, an accessible lavatory target, soft-surface flammability requirements, integrated dimmable lighting and acoustic treatment concentrated near propulsor transmission paths.

Acceptance condition: 60 occupants board, sit, view outside and evacuate without structural or service compromises; interior mass remains inside allocation and high-wear parts are replaceable.

Working documents: H120-CAB-001 Cabin Layout & LOPA; H120-CAB-002 Interior Materials Specification; H120-CAB-003 Window System Specification; H120-CAB-004 Baggage/Stowage Plan; H120-CAB-005 Passenger Systems & Lighting Plan; H120-CAB-006 Cabin Maintainability Plan

3.17 17 Human Factors / Accessibility

Role objective: Eliminate foreseeable human error and make the aircraft usable by passengers and staff with a broad range of capabilities.

Validate cockpit, cabin, maintenance and ground-handling tasks with physical mock-ups and representative users. Accessibility becomes a product requirement, not a late interior option.

Acceptance condition: Critical tasks are demonstrably understandable and reachable for intended users; no safety function depends on exceptional strength, memory or hidden knowledge.

Working documents: H120-HF-001 Human Factors Integration Plan; H120-HF-002 Cockpit Task Analysis; H120-HF-003 Cabin Accessibility Assessment; H120-HF-004 Maintainability Human Factors Study; H120-HF-005 Evacuation Human Factors Plan

3.18 18 Safety / Reliability / RAMS

Role objective: Identify failure conditions early and force the architecture to tolerate them before detailed design makes changes expensive.

Add common-mode, zonal and particular-risk analyses for lightning, HIRF, fire, water ingress, propeller debris, H₂ leak, bird/hail strike and maintenance error. Safety objectives drive DAL/IDAL and test evidence.

Acceptance condition: No catastrophic failure condition has a single point of failure or unmitigated common cause; credited mitigations have verification evidence.

Working documents: H120-SAF-001 Aircraft FHA; H120-SAF-002 System FHA Set; H120-SAF-003 PSSA; H120-SAF-004 FMEA/FMES Set; H120-SAF-005 Common Mode/Zonal/PRA; H120-SAF-006 SSA/ASA Plan; H120-RAM-001 Reliability & Dispatch Model

3.19 19 Fire / Emergency / Evacuation / Rescue

Role objective: Contain fire, isolate energy, keep exits usable and support land/water rescue on the actual North/Baltic Sea route set.

Set a 90-second evacuation design objective for mock-up demonstration even if the final certification basis differs. Add rescue cut zones, external shut-off points, emergency beacons and first-responder H₂/HV markings.

Acceptance condition: A credible fire or ditching scenario does not trap occupants behind one failed zone; rescuers can identify and isolate H₂/HV hazards.

Working documents: H120-FIRE-001 Fire Protection Assessment; H120-EVAC-001 Evacuation Analysis & Demonstration Plan; H120-DITCH-001 Ditching/Flotation Concept; H120-RES-001 Emergency Response Guide; H120-RES-002 Rescue/Isolation Marking Plan

3.20 20 Ground Handling / Mooring

Role objective: Make the 120 m vehicle commercially operable without an army of handlers and prevent unintended free flight.

Create defined wind envelopes for parked, docked, taxiing and boarding states; these must be demonstrated in simulation/full-scale trials. Ground equipment outside the aircraft type design is controlled by an interface specification and operator approval path.

Acceptance condition: Unintended free flight is prevented by independent restraints; handling remains safe in defined winds and does not depend on excessive manpower.

Working documents: H120-GH-001 Ground Handling Concept; H120-GH-002 Mooring Interface Specification; H120-GH-003 Ground Wind Envelope; H120-GH-004 Capture/Release Hazard Analysis; H120-GH-005 Towing/Taxi Procedures; H120-GH-006 Terminal Stand Geometry

3.21 21 Maintenance / ICA / MRO

Role objective: Design access, inspections and replacement tasks before the surface is closed and expensive disassembly becomes inevitable.

Define ICA task candidates, access envelopes, lifting points, safe HV/H₂ isolation and envelope patch procedures. Final intervals come from test/service evidence, not arbitrary calendar numbers.

Acceptance condition: Routine line maintenance can be completed without deflating the envelope; critical inspections have direct access and clear acceptance limits.

Working documents: H120-MNT-001 Maintenance Concept; H120-MNT-002 Instructions for Continued Airworthiness Outline; H120-MNT-003 Scheduled Maintenance Development Plan; H120-MNT-004 Zonal Inspection Programme; H120-MNT-005 LRU Removal/Installation Matrix; H120-MNT-006 Ground Safety / Isolation Manual

3.22 22 Manufacturing / Industrialisation

Role objective: Turn the design into repeatable hardware with realistic tooling, assembly sequence, takt and facility needs.

Plan final assembly/inflation in a purpose-sized hangar; define transportable module limits, manufacturing key characteristics, cure/bonding controls and end-of-line leak/electrical functional tests.

Acceptance condition: Every part has a feasible process, inspection route and supplier/factory owner; assembly sequence never requires impossible access after closure.

Working documents: H120-MFG-001 Manufacturing Plan; H120-MFG-002 Assembly Sequence & Station Plan; H120-MFG-003 Tooling/Jig Concept; H120-MFG-004 Special Process Specification Set; H120-MFG-005 End-of-Line Test Specification; H120-MFG-006 Industrial Capacity Model

3.23 23 Quality / Conformity

Role objective: Ensure design data, materials, supplier parts and certification test articles are traceable and conforming.

Freeze configuration baselines at each gate and use an as-built/as-tested record for every structural, system and flight test. No informal prototype modification may enter flight without engineering disposition.

Acceptance condition: Certification evidence is linked to a known conforming configuration and every critical material/process is traceable.

Working documents: H120-QUAL-001 Quality Plan; H120-QUAL-002 Conformity Inspection Plan; H120-QUAL-003 Supplier Quality Requirements; H120-QUAL-004 Non-Conformance / MRB Procedure; H120-QUAL-005 As-Built/As-Tested Configuration Procedure

3.24 24 Supply Chain / Procurement

Role objective: Prevent a technically elegant design from depending on single-source, unfinanceable or decade-long lead-time components.

Create obsolescence and export-control plans for electronics; require substitute-material qualification pathways for fabrics/resins. Never allow the mirror finish chemistry to be sole-sourced if it locks the entire envelope.

Acceptance condition: No single commercial supplier failure can indefinitely stop the programme without an identified alternate path or owned design data.

Working documents: H120-SCM-001 Supply Chain Strategy; H120-SCM-002 Critical Supplier Register; H120-SCM-003 Long-Lead Procurement Plan; H120-SCM-004 Dual-Source / Obsolescence Plan; H120-SCM-005 Supplier Risk-Sharing Framework

3.25 25 Airport / Terminal / H₂ Infrastructure

Role objective: Make the vehicle fit real terminals, hydrogen logistics, rescue services and local operating restrictions.

Define infrastructure data sheets for Hamburg/Sylt, Helsinki/Tallinn and later island routes: wind climate, stand geometry, rescue access, H₂ supply, noise and local permitting. Vehicle design must not assume infrastructure that does not exist.

Acceptance condition: A candidate route has a physically and regulatorily feasible stand, safe H₂ logistics and emergency access before it enters the commercial schedule.

Working documents: H120-INF-001 Terminal Interface Specification; H120-INF-002 H₂ Ground Interface Specification; H120-INF-003 Stand/Mast Layout Standard; H120-INF-004 Rescue/Fire Service Interface; H120-INF-005 Route Infrastructure Survey Template

3.26 26 Airline / Operator / Dispatch

Role objective: Turn the aircraft into a repeatable transport product with predictable turnaround, weather reliability and dispatch rules.

Define dispatch limits for wind, icing, thunderstorms, visibility, H₂ quantity, helium pressure and degraded systems. Use route weather statistics in the business case because wind cancellations can dominate economics even when energy costs are low.

Acceptance condition: Schedule assumptions use demonstrated operational limits and realistic turnaround/maintenance times, not brochure performance.

Working documents: H120-OPR-001 Airline Operating Concept; H120-OPR-002 Dispatch/MEL Philosophy; H120-OPR-003 Turnaround Process; H120-OPR-004 Route Weather Reliability Model; H120-OPR-005 Crew/Roster Concept; H120-OPR-006 Operations Manual Outline

3.27 27 Passenger / Customer

Role objective: Protect the reason to buy the product: view, calm ride, accessibility, novelty and simple transport rather than technical spectacle alone.

Validate through full-size cabin mock-up, boarding trials and motion/noise studies. Publish realistic journey time including boarding and weather buffers rather than comparing cruise speed only.

Acceptance condition: Representative users can board, stow items, see outside, understand safety information and remain comfortable for ~2–4 h mission durations.

Working documents: H120-CUST-001 Passenger Experience Requirements; H120-CUST-002 Cabin Mock-Up Evaluation Plan; H120-CUST-003 Accessibility/User Research Report; H120-CUST-004 Noise/Vibration Comfort Targets; H120-CUST-005 Brand/Wayfinding Guide

3.28 28 Investor / Finance / Bankability

Role objective: Turn technical maturity into investable gates, protect capital from uncontrolled certification and supplier risk, and prove unit economics with conservative assumptions.

Create downside cases for development overrun, certification delay, low dispatch reliability, H₂ price/infrastructure, lower utilisation and residual-value uncertainty. Investor reporting uses technical gate evidence, not percent-complete storytelling.

Acceptance condition: Capital is released against objective technical maturity; economics survive conservative utilisation/price cases without hiding certification or infrastructure costs.

Working documents: H120-FIN-001 Integrated Business Case; H120-FIN-002 Programme Funding Gate Plan; H120-FIN-003 Unit Economics / Sensitivity Model; H120-FIN-004 Supplier Risk-Sharing Term Framework; H120-FIN-005 Technical Due-Diligence Data Room Index

3.29 29 Insurance / Product Liability / Legal

Role objective: Identify design and operational features that drive insurability, liability exposure and contractual risk before fleet entry.

Create product-liability traceability from hazard → requirement → verification evidence, plus fleet safety monitoring and service-bulletin processes. Marketing claims must match certified limitations and demonstrated reliability.

Acceptance condition: Material operational risks have documented design/operational controls and contract ownership; no commercial promise exceeds certified capability.

Working documents: H120-RISK-001 Insurability Risk Dossier; H120-RISK-002 Product Liability Trace Matrix; H120-RISK-003 Ground/Infrastructure Responsibility Matrix; H120-RISK-004 In-Service Safety Monitoring Plan

3.30 30 Environment / Noise / Lifecycle

Role objective: Minimise lifecycle impacts beyond zero tailpipe carbon claims: helium, hydrogen source, materials, noise, maintenance and end-of-life.

Create environmental/noise certification and community test programme. Include reflective-glare assessment for terminals and nearby transport infrastructure.

Acceptance condition: Environmental claims have defined lifecycle boundaries and measured data; noise/glare do not prevent terminal permits or community acceptance.

Working documents: H120-ENVIR-001 Lifecycle Assessment Plan; H120-ENVIR-002 Noise Measurement & Community Plan; H120-ENVIR-003 Helium Management / Recovery Plan; H120-ENVIR-004 End-of-Life / Circularity Plan; H120-ENVIR-005 Glare Impact Assessment

3.31 31 Security / Operational Resilience

Role objective: Protect aircraft, ground links, H₂ interfaces and passenger operations from foreseeable malicious or accidental interference.

Run security threat assessment together with safety common-cause analysis so security mitigations do not introduce new unsafe failure modes. Define incident recovery and secure configuration baselines.

Acceptance condition: No unauthorised external interface can directly command flight-critical functions; loss/compromise of connectivity degrades service, not safety.

Working documents: H120-SEC-001 Aircraft Security Plan; H120-SEC-002 Threat Assessment; H120-SEC-003 Secure Maintenance Interface Specification; H120-SEC-004 Software/Configuration Integrity Procedure; H120-SEC-005 Security Incident Response Plan

3.32 32 Verification / Ground Test / Flight Test

Role objective: Convert every important design assertion into a staged piece of physical or analytical evidence and stop unsafe jumps to full-scale flight.

Freeze entry/exit criteria for each test gate. No flight test is used to discover basic H₂ containment, structural strength or software integration failures that should have been found on ground rigs.

Acceptance condition: Every aircraft-level requirement has a planned verification method and conforming evidence path; flight test progresses only after objective ground-test gates pass.

Working documents: H120-VV-001 Verification & Validation Master Plan; H120-TEST-001 Ground Test Master Plan; H120-TEST-002 Structural Test Plan; H120-TEST-003 Systems Iron-Bird Plan; H120-FT-001 Flight Test Master Plan; H120-FT-002 Envelope Expansion Cards/Process; H120-TEST-004 Test Evidence Configuration Index

4. Frozen v0.3 physical architecture

4.1 Outer mold line and envelope

- Overall length 120 m; maximum diameter 25 m; fineness ratio ~4.8. Preliminary prolate-reference surface area is ~7,540 m²; actual OML includes flattening, fins, window/cabin integration and requires CAD surface integration.
- Preliminary external volume is ~36,100 m³; nominal helium target ~31,700 m³. Remaining volume is used for ballonets, thermal/pressure management and geometric provisions. These figures are retained for design closure but require a single validated geometry model before PDR.
- Envelope functional stack: outer weather / reflective film; structural woven layer; helium barrier; bonding/heat-seal layer; local reinforcement/rip-stop architecture. Exact polymers/fibres remain supplier/test decisions.
- Helium space is divided into multiple monitored zones/compartments to limit loss and permit maintenance. Fore and aft ballonets provide pressure and slow trim authority. Pressure sensing is redundant by zone; blowers/valves have failure isolation.
- External mirror aesthetic: ≥70% of visually dominant hull area targets mirror-like reflectance; operational low-glare/RF/markings zones are exceptions. The coating system must be lightweight enough to be treated as a finish, not a secondary shell.

4.2 Semi-rigid keel and structural station concept

- Primary deep keel spans approximately x=18–108 m. It is a CFRP-dominant truss/box carrying cabin, propulsion, H₂, battery, gear, nose-mooring and tail-control reactions.
- Load-introduction stations are provisionally located around x=18, 32, 42, 55, 68, 82, 96 and 108 m. These are not heavy full rings; they are local frames/distribution structures that spread concentrated loads into keel and envelope.
- Passenger cabin between roughly x=38–72 m forms a closed lower torsion box and is structurally tied into the keel. This avoids a “structure inside another structure” mass penalty.
- Primary removable joints use bonded-bolted hybrid concepts with mechanical fail-safe retention. Titanium/approved aerospace bolts are reserved for compact high-load joints; secondary non-critical interiors use standardised smaller fastener families.
- CFRP/metal interfaces receive glass-fibre isolation, sealant and controlled drainage to prevent galvanic corrosion. All primary cavities get inspection access or NDI method definition.

4.3 Cabin and windows

- 15 rows × 4 seats = 60 passenger seats. Target seat pitch ~34 in (0.86 m) with a central aisle sized for normal boarding and emergency flow; final dimensions are verified by mock-up.
- Cabin length target ~23.5 m and width ~4.3 m, unpressurised. The interior has one compact forward service zone, one accessible-lavatory target and two cabin-crew stations near separated exit zones.
- 15 modular panoramic transparency bays per side create the visual effect of a continuous ribbon while preserving replaceability, local load paths and damage containment.
- Window cassette concept: thin hard/scratch-resistant outer face, one or more structural transparency plies, a fail-safe secondary pane, edge seal, flexible mount and replaceable interior reveal. Exact material stack is tested for impact, UV, abrasion and retention.
- Four principal egress positions are distributed fore/aft and left/right. Doors use light powered/manual assistance with mechanical emergency release. Water-route equipment includes life vests and raft capacity sized to all occupants.

4.4 Energy, propulsion and cooling

- Fuel-cell system: three identical ~200 kW modules; each has independent H₂ isolation, air supply, cooling interface, DC/DC and health monitoring. Loss of one module leaves ~400 kW plus battery support.
- H₂ storage: preliminary four modular tanks, total ~120 kg usable H₂, 350-bar baseline for the first detailed trade because volume is abundant. Tanks sit in segregated technical shoulder/keel volumes with direct upward vent paths and no passenger-cabin routing.
- Battery: two ~100 kWh LFP packs on separate HV buses, close to CG and physically separated. Battery provides transient peak power, fuel-cell smoothing, emergency manoeuvring and degraded-mode reserve; it is not sized as the sole full-route energy source.
- Main propulsion: four identical electric motor/inverter/propeller modules, approximately 180 kW peak each. Inverters are kept near motors to reduce heavy AC cable length. Propulsors vector for low-speed pitch/yaw/vertical-force assistance.
- Thermal: two liquid cooling circuits with cross-support philosophy; radiator placement is integrated into lower/side service zones with controllable airflow. Thermal design must reject several hundred kW of fuel-cell and electrical waste heat at hot-day power.

4.5 Electrical / avionics / flight control

- Two separated ~800 VDC buses feed propulsion and major conversion loads. Protected cross-tie supports reconfiguration without creating a common-cause short-circuit path.
- Independent 28/48 V essential buses supply flight controls, avionics, H₂ valves, blowers, detection, lights and communications. Dedicated emergency batteries preserve essential functions after total HV shutdown.
- Flight-control architecture uses multiple independent compute/sensor lanes. Control allocation blends Y-tail surfaces and thrust vectoring. Slow trim functions — ballonet and product-water management — are supervised separately from fast attitude control.
- Cockpit: two pilots, simplified primary flight/energy displays, large forward transparency, side view and downward camera coverage. Low-speed/docking mode shows vector commands, wind, ground track and mast relative position without requiring manual control of individual motors.
- Passenger Wi-Fi/IFE and maintenance/cloud services are segregated from safety-critical networks. Loss of external connectivity cannot affect safe continued flight.

4.6 Ground operations / terminals

- Three-point wheeled landing gear is integrated into the cabin/keel module. Main gear is placed around the CG; forward steerable gear supports taxi/docking. Final geometry comes from landing/load and ground-clearance studies.
- Nose mooring/capture fitting is a primary structural hardpoint. Powered capture rope/winch and mast interface are the normal commercial concept; manual lines remain emergency/backup tools, not the operating model.
- Boarding terminal target is step-free bridge access where infrastructure permits. Refuelling and passenger boarding are separated by default until a hazard analysis and local approval support any overlap.
- Ground wind limits are not guessed into the brochure. Separate limits will be tested for parking, moored, taxi, boarding and active docking states and then fed back into route dispatch economics.

5. Discipline document package

What the “right documents” means

Each discipline gets documents that let it perform and sign off its work. The register below is the minimum controlled package. The accompanying ZIP contains discipline briefs with the current design decisions, iteration history, required inputs/outputs and acceptance condition for every role.

Document ID	Title	Owner	Status	Gate
H120-SYS-001	Aircraft-Level Requirements Specification	Systems	DRAFT v0.3	Pre-PDR/PDR
H120-SYS-002	Concept of Operations	Systems	DRAFT v0.3	Pre-PDR/PDR
H120-SYS-003	Aircraft Architecture Description	Systems	DRAFT v0.3	Pre-PDR/PDR
H120-SYS-004	Interface Control Document	Systems	DRAFT v0.3	Pre-PDR/PDR
H120-SYS-005	Mass/CG/Power/Thermal Budget	Systems	DRAFT v0.3	Pre-PDR/PDR
H120-CM-001	Configuration Management Plan	Systems	DRAFT v0.3	Pre-PDR/PDR
H120-CERT-001	Certification Programme	Certification	DRAFT v0.3	Pre-PDR/PDR
H120-CERT-002	Certification Basis & CRI Log	Certification	DRAFT v0.3	Pre-PDR/PDR
H120-CERT-003	Compliance Checklist	Certification	DRAFT v0.3	Pre-PDR/PDR
H120-CERT-004	Means-of-Compliance Matrix	Certification	DRAFT v0.3	Pre-PDR/PDR
H120-CERT-005	Authority Issue Paper Register	Certification	DRAFT v0.3	Pre-PDR/PDR
H120-CERT-006	Conformity & Certification Test Plan	Certification	DRAFT v0.3	Pre-PDR/PDR
H120-AERO-001	Outer Mold Line Definition	Aerodynamics	DRAFT v0.3	Pre-PDR/PDR
H120-AERO-002	Aerodynamic Methods & CFD Plan	Aerodynamics	DRAFT v0.3	Pre-PDR/PDR
H120-AERO-003	Stability & Control Analysis	Aerodynamics	DRAFT v0.3	Pre-PDR/PDR
H120-AERO-004	Performance Model	Aerodynamics	DRAFT v0.3	Pre-PDR/PDR
H120-AERO-005	Wind/Gust/Crosswind	Aerodynamics	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
	Envelope			
H120-AERO-006	Propulsor-Airframe Interaction Report	Aerodynamics	DRAFT v0.3	Pre-PDR/PDR
H120-LOAD-001	Loads & Design Criteria	Statics	DRAFT v0.3	Pre-PDR/PDR
H120-LOAD-002	Load Case Catalogue	Statics	DRAFT v0.3	Pre-PDR/PDR
H120-LOAD-003	Mass Distribution & Inertia Model	Statics	DRAFT v0.3	Pre-PDR/PDR
H120-LOAD-004	Global FEM Load Extraction	Statics	DRAFT v0.3	Pre-PDR/PDR
H120-LOAD-005	Ground/Mooring Loads Report	Statics	DRAFT v0.3	Pre-PDR/PDR
H120-LOAD-006	Ditching/Emergency Landing Loads	Statics	DRAFT v0.3	Pre-PDR/PDR
H120-STR-001	Structural Design Principles	Structures	DRAFT v0.3	Pre-PDR/PDR
H120-STR-002	Material & Allowables Plan	Structures	DRAFT v0.3	Pre-PDR/PDR
H120-STR-003	Global/Local Sizing Report	Structures	DRAFT v0.3	Pre-PDR/PDR
H120-STR-004	Joint & Fastener Design Manual	Structures	DRAFT v0.3	Pre-PDR/PDR
H120-STR-005	Damage Tolerance / Inspection Plan	Structures	DRAFT v0.3	Pre-PDR/PDR
H120-STR-006	Static Test Article Plan	Structures	DRAFT v0.3	Pre-PDR/PDR
H120-DTC-001	Mass Reduction Register	Lightweight/DTC	DRAFT v0.3	Pre-PDR/PDR
H120-DTC-002	Design-to-Cost Target Book	Lightweight/DTC	DRAFT v0.3	Pre-PDR/PDR
H120-DTC-003	Part Count / Commonality Plan	Lightweight/DTC	DRAFT v0.3	Pre-PDR/PDR
H120-DTC-004	Make-Buy Trade Studies	Lightweight/DTC	DRAFT v0.3	Pre-PDR/PDR
H120-DTC-005	Value Engineering Decision Log	Lightweight/DTC	DRAFT v0.3	Pre-PDR/PDR
H120-ENV-001	Envelope Functional Specification	Envelope/Gas	DRAFT v0.3	Pre-PDR/PDR
H120-ENV-002	Gas Cell/Ballonet Architecture	Envelope/Gas	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
H120-ENV-003	Laminate Qualification Plan	Envelope/Gas	DRAFT v0.3	Pre-PDR/PDR
H120-ENV-004	Seam & Repair Standard	Envelope/Gas	DRAFT v0.3	Pre-PDR/PDR
H120-ENV-005	Helium Leak/Recovery Plan	Envelope/Gas	DRAFT v0.3	Pre-PDR/PDR
H120-ENV-006	Solar/Thermal Model	Envelope/Gas	DRAFT v0.3	Pre-PDR/PDR
H120-ID-001	Exterior Design Language	Exterior Design	DRAFT v0.3	Pre-PDR/PDR
H120-ID-002	Surface/Colour/Finish Specification	Exterior Design	DRAFT v0.3	Pre-PDR/PDR
H120-ID-003	Window & Branding Layout	Exterior Design	DRAFT v0.3	Pre-PDR/PDR
H120-ID-004	Operational Markings Plan	Exterior Design	DRAFT v0.3	Pre-PDR/PDR
H120-ID-005	Access Panel Visual Integration Guide	Exterior Design	DRAFT v0.3	Pre-PDR/PDR
H120-PROP-001	Propulsion System Specification	Propulsion	DRAFT v0.3	Pre-PDR/PDR
H120-PROP-002	Propeller Sizing & Acoustic Report	Propulsion	DRAFT v0.3	Pre-PDR/PDR
H120-PROP-003	Vectoring Mechanism Design	Propulsion	DRAFT v0.3	Pre-PDR/PDR
H120-PROP-004	One-Propulsor-Inoperative Analysis	Propulsion	DRAFT v0.3	Pre-PDR/PDR
H120-PROP-005	Motor/Inverter Qualification Plan	Propulsion	DRAFT v0.3	Pre-PDR/PDR
H120-H2-001	Hydrogen Storage & Distribution Specification	H2/PEMFC	DRAFT v0.3	Pre-PDR/PDR
H120-H2-002	PEMFC Architecture & Performance Map	H2/PEMFC	DRAFT v0.3	Pre-PDR/PDR
H120-H2-003	H ₂ Hazard Analysis	H2/PEMFC	DRAFT v0.3	Pre-PDR/PDR
H120-H2-004	Ventilation/Leak Detection Report	H2/PEMFC	DRAFT v0.3	Pre-PDR/PDR
H120-H2-005	Thermal Management Design	H2/PEMFC	DRAFT v0.3	Pre-PDR/PDR
H120-H2-006	Refuelling & Ground Safety	H2/PEMFC	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
	Concept			
H120-ELEC-001	Electrical Load Analysis	Electrical	DRAFT v0.3	Pre-PDR/PDR
H120-ELEC-002	HV/LV Single-Line Diagram	Electrical	DRAFT v0.3	Pre-PDR/PDR
H120-ELEC-003	EWIS Zonal Design Rules	Electrical	DRAFT v0.3	Pre-PDR/PDR
H120-ELEC-004	Bonding/Lightning/HIRF Plan	Electrical	DRAFT v0.3	Pre-PDR/PDR
H120-ELEC-005	Battery Safety & Containment Design	Electrical	DRAFT v0.3	Pre-PDR/PDR
H120-ELEC-006	Electrical Failure Modes Report	Electrical	DRAFT v0.3	Pre-PDR/PDR
H120-AV-001	Avionics Architecture	Avionics	DRAFT v0.3	Pre-PDR/PDR
H120-AV-002	Data Bus / Network ICD	Avionics	DRAFT v0.3	Pre-PDR/PDR
H120-AV-003	Software Development Plan	Avionics	DRAFT v0.3	Pre-PDR/PDR
H120-AV-004	Hardware Development Plan	Avionics	DRAFT v0.3	Pre-PDR/PDR
H120-AV-005	Cybersecurity Plan	Avionics	DRAFT v0.3	Pre-PDR/PDR
H120-AV-006	Environmental Qualification Matrix	Avionics	DRAFT v0.3	Pre-PDR/PDR
H120-FCS-001	Flight-Control Functional Specification	Flight Controls	DRAFT v0.3	Pre-PDR/PDR
H120-FCS-002	Control-Law Architecture	Flight Controls	DRAFT v0.3	Pre-PDR/PDR
H120-FCS-003	Actuator Sizing & Jam Analysis	Flight Controls	DRAFT v0.3	Pre-PDR/PDR
H120-FCS-004	Handling-Qualities Plan	Flight Controls	DRAFT v0.3	Pre-PDR/PDR
H120-FCS-005	HIL / Iron-Bird Test Plan	Flight Controls	DRAFT v0.3	Pre-PDR/PDR
H120-OPS-001	Flight Deck Philosophy	Pilot	DRAFT v0.3	Pre-PDR/PDR
H120-OPS-002	Crew Workload & Task Analysis	Pilot	DRAFT v0.3	Pre-PDR/PDR
H120-OPS-003	Normal Procedures	Pilot	DRAFT v0.3	Pre-PDR/PDR
H120-OPS-004	Abnormal/Emergency	Pilot	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
	Procedures			
H120-OPS-005	Operating Limitations Draft	Pilot	DRAFT v0.3	Pre-PDR/PDR
H120-OPS-006	Training & Type-Rating Concept	Pilot	DRAFT v0.3	Pre-PDR/PDR
H120-CC-001	Cabin Crew Station Layout	Cabin Crew	DRAFT v0.3	Pre-PDR/PDR
H120-CC-002	Cabin Service Concept	Cabin Crew	DRAFT v0.3	Pre-PDR/PDR
H120-CC-003	Door/Exit Operating Procedures	Cabin Crew	DRAFT v0.3	Pre-PDR/PDR
H120-CC-004	Emergency Equipment Layout	Cabin Crew	DRAFT v0.3	Pre-PDR/PDR
H120-CC-005	Cabin Crew Training Syllabus	Cabin Crew	DRAFT v0.3	Pre-PDR/PDR
H120-CAB-001	Cabin Layout & LOPA	Cabin	DRAFT v0.3	Pre-PDR/PDR
H120-CAB-002	Interior Materials Specification	Cabin	DRAFT v0.3	Pre-PDR/PDR
H120-CAB-003	Window System Specification	Cabin	DRAFT v0.3	Pre-PDR/PDR
H120-CAB-004	Baggage/Stowage Plan	Cabin	DRAFT v0.3	Pre-PDR/PDR
H120-CAB-005	Passenger Systems & Lighting Plan	Cabin	DRAFT v0.3	Pre-PDR/PDR
H120-CAB-006	Cabin Maintainability Plan	Cabin	DRAFT v0.3	Pre-PDR/PDR
H120-HF-001	Human Factors Integration Plan	Human Factors	DRAFT v0.3	Pre-PDR/PDR
H120-HF-002	Cockpit Task Analysis	Human Factors	DRAFT v0.3	Pre-PDR/PDR
H120-HF-003	Cabin Accessibility Assessment	Human Factors	DRAFT v0.3	Pre-PDR/PDR
H120-HF-004	Maintainability Human Factors Study	Human Factors	DRAFT v0.3	Pre-PDR/PDR
H120-HF-005	Evacuation Human Factors Plan	Human Factors	DRAFT v0.3	Pre-PDR/PDR
H120-SAF-001	Aircraft FHA	Safety/RAMS	DRAFT v0.3	Pre-PDR/PDR
H120-SAF-002	System FHA Set	Safety/RAMS	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
H120-SAF-003	PSSA	Safety/RAMS	DRAFT v0.3	Pre-PDR/PDR
H120-SAF-004	FMEA/FMES Set	Safety/RAMS	DRAFT v0.3	Pre-PDR/PDR
H120-SAF-005	Common Mode/Zonal/PRA	Safety/RAMS	DRAFT v0.3	Pre-PDR/PDR
H120-SAF-006	SSA/ASA Plan	Safety/RAMS	DRAFT v0.3	Pre-PDR/PDR
H120-RAM-001	Reliability & Dispatch Model	Safety/RAMS	DRAFT v0.3	Pre-PDR/PDR
H120-FIRE-001	Fire Protection Assessment	Emergency	DRAFT v0.3	Pre-PDR/PDR
H120-EVAC-001	Evacuation Analysis & Demonstration Plan	Emergency	DRAFT v0.3	Pre-PDR/PDR
H120-DITCH-001	Ditching/Flotation Concept	Emergency	DRAFT v0.3	Pre-PDR/PDR
H120-RES-001	Emergency Response Guide	Emergency	DRAFT v0.3	Pre-PDR/PDR
H120-RES-002	Rescue/Isolation Marking Plan	Emergency	DRAFT v0.3	Pre-PDR/PDR
H120-GH-001	Ground Handling Concept	Ground Handling	DRAFT v0.3	Pre-PDR/PDR
H120-GH-002	Mooring Interface Specification	Ground Handling	DRAFT v0.3	Pre-PDR/PDR
H120-GH-003	Ground Wind Envelope	Ground Handling	DRAFT v0.3	Pre-PDR/PDR
H120-GH-004	Capture/Release Hazard Analysis	Ground Handling	DRAFT v0.3	Pre-PDR/PDR
H120-GH-005	Towing/Taxi Procedures	Ground Handling	DRAFT v0.3	Pre-PDR/PDR
H120-GH-006	Terminal Stand Geometry	Ground Handling	DRAFT v0.3	Pre-PDR/PDR
H120-MNT-001	Maintenance Concept	Maintenance	DRAFT v0.3	Pre-PDR/PDR
H120-MNT-002	Instructions for Continued Airworthiness Outline	Maintenance	DRAFT v0.3	Pre-PDR/PDR
H120-MNT-003	Scheduled Maintenance Development Plan	Maintenance	DRAFT v0.3	Pre-PDR/PDR
H120-MNT-004	Zonal Inspection Programme	Maintenance	DRAFT v0.3	Pre-PDR/PDR
H120-MNT-005	LRU Removal/Installation Matrix	Maintenance	DRAFT v0.3	Pre-PDR/PDR
H120-MNT-006	Ground Safety / Isolation	Maintenance	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
	Manual			
H120-MFG-001	Manufacturing Plan	Manufacturing	DRAFT v0.3	Pre-PDR/PDR
H120-MFG-002	Assembly Sequence & Station Plan	Manufacturing	DRAFT v0.3	Pre-PDR/PDR
H120-MFG-003	Tooling/Jig Concept	Manufacturing	DRAFT v0.3	Pre-PDR/PDR
H120-MFG-004	Special Process Specification Set	Manufacturing	DRAFT v0.3	Pre-PDR/PDR
H120-MFG-005	End-of-Line Test Specification	Manufacturing	DRAFT v0.3	Pre-PDR/PDR
H120-MFG-006	Industrial Capacity Model	Manufacturing	DRAFT v0.3	Pre-PDR/PDR
H120-QUAL-001	Quality Plan	Quality	DRAFT v0.3	Pre-PDR/PDR
H120-QUAL-002	Conformity Inspection Plan	Quality	DRAFT v0.3	Pre-PDR/PDR
H120-QUAL-003	Supplier Quality Requirements	Quality	DRAFT v0.3	Pre-PDR/PDR
H120-QUAL-004	Non-Conformance / MRB Procedure	Quality	DRAFT v0.3	Pre-PDR/PDR
H120-QUAL-005	As-Built/As-Tested Configuration Procedure	Quality	DRAFT v0.3	Pre-PDR/PDR
H120-SCM-001	Supply Chain Strategy	Supply Chain	DRAFT v0.3	Pre-PDR/PDR
H120-SCM-002	Critical Supplier Register	Supply Chain	DRAFT v0.3	Pre-PDR/PDR
H120-SCM-003	Long-Lead Procurement Plan	Supply Chain	DRAFT v0.3	Pre-PDR/PDR
H120-SCM-004	Dual-Source / Obsolescence Plan	Supply Chain	DRAFT v0.3	Pre-PDR/PDR
H120-SCM-005	Supplier Risk-Sharing Framework	Supply Chain	DRAFT v0.3	Pre-PDR/PDR
H120-INF-001	Terminal Interface Specification	Infrastructure	DRAFT v0.3	Pre-PDR/PDR
H120-INF-002	H ₂ Ground Interface Specification	Infrastructure	DRAFT v0.3	Pre-PDR/PDR
H120-INF-003	Stand/Mast Layout Standard	Infrastructure	DRAFT v0.3	Pre-PDR/PDR
H120-INF-004	Rescue/Fire Service	Infrastructure	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
	Interface			
H120-INF-005	Route Infrastructure Survey Template	Infrastructure	DRAFT v0.3	Pre-PDR/PDR
H120-OPR-001	Airline Operating Concept	Operator	DRAFT v0.3	Pre-PDR/PDR
H120-OPR-002	Dispatch/MEL Philosophy	Operator	DRAFT v0.3	Pre-PDR/PDR
H120-OPR-003	Turnaround Process	Operator	DRAFT v0.3	Pre-PDR/PDR
H120-OPR-004	Route Weather Reliability Model	Operator	DRAFT v0.3	Pre-PDR/PDR
H120-OPR-005	Crew/Roster Concept	Operator	DRAFT v0.3	Pre-PDR/PDR
H120-OPR-006	Operations Manual Outline	Operator	DRAFT v0.3	Pre-PDR/PDR
H120-CUST-001	Passenger Experience Requirements	Customer	DRAFT v0.3	Pre-PDR/PDR
H120-CUST-002	Cabin Mock-Up Evaluation Plan	Customer	DRAFT v0.3	Pre-PDR/PDR
H120-CUST-003	Accessibility/User Research Report	Customer	DRAFT v0.3	Pre-PDR/PDR
H120-CUST-004	Noise/Vibration Comfort Targets	Customer	DRAFT v0.3	Pre-PDR/PDR
H120-CUST-005	Brand/Wayfinding Guide	Customer	DRAFT v0.3	Pre-PDR/PDR
H120-FIN-001	Integrated Business Case	Investor	DRAFT v0.3	Pre-PDR/PDR
H120-FIN-002	Programme Funding Gate Plan	Investor	DRAFT v0.3	Pre-PDR/PDR
H120-FIN-003	Unit Economics / Sensitivity Model	Investor	DRAFT v0.3	Pre-PDR/PDR
H120-FIN-004	Supplier Risk-Sharing Term Framework	Investor	DRAFT v0.3	Pre-PDR/PDR
H120-FIN-005	Technical Due-Diligence Data Room Index	Investor	DRAFT v0.3	Pre-PDR/PDR
H120-RISK-001	Insurability Risk Dossier	Insurance/Legal	DRAFT v0.3	Pre-PDR/PDR
H120-RISK-002	Product Liability Trace Matrix	Insurance/Legal	DRAFT v0.3	Pre-PDR/PDR
H120-RISK-003	Ground/Infrastructure	Insurance/Legal	DRAFT v0.3	Pre-PDR/PDR

Document ID	Title	Owner	Status	Gate
	Responsibility Matrix			
H120-RISK-004	In-Service Safety Monitoring Plan	Insurance/Legal	DRAFT v0.3	Pre-PDR/PDR
H120-ENVIR-001	Lifecycle Assessment Plan	Environment	DRAFT v0.3	Pre-PDR/PDR
H120-ENVIR-002	Noise Measurement & Community Plan	Environment	DRAFT v0.3	Pre-PDR/PDR
H120-ENVIR-003	Helium Management / Recovery Plan	Environment	DRAFT v0.3	Pre-PDR/PDR
H120-ENVIR-004	End-of-Life / Circularity Plan	Environment	DRAFT v0.3	Pre-PDR/PDR
H120-ENVIR-005	Glare Impact Assessment	Environment	DRAFT v0.3	Pre-PDR/PDR
H120-SEC-001	Aircraft Security Plan	Security	DRAFT v0.3	Pre-PDR/PDR
H120-SEC-002	Threat Assessment	Security	DRAFT v0.3	Pre-PDR/PDR
H120-SEC-003	Secure Maintenance Interface Specification	Security	DRAFT v0.3	Pre-PDR/PDR
H120-SEC-004	Software/Configuration Integrity Procedure	Security	DRAFT v0.3	Pre-PDR/PDR
H120-SEC-005	Security Incident Response Plan	Security	DRAFT v0.3	Pre-PDR/PDR
H120-VV-001	Verification & Validation Master Plan	Test	DRAFT v0.3	Pre-PDR/PDR
H120-TEST-001	Ground Test Master Plan	Test	DRAFT v0.3	Pre-PDR/PDR
H120-TEST-002	Structural Test Plan	Test	DRAFT v0.3	Pre-PDR/PDR
H120-TEST-003	Systems Iron-Bird Plan	Test	DRAFT v0.3	Pre-PDR/PDR
H120-FT-001	Flight Test Master Plan	Test	DRAFT v0.3	Pre-PDR/PDR
H120-FT-002	Envelope Expansion Cards/Process	Test	DRAFT v0.3	Pre-PDR/PDR
H120-TEST-004	Test Evidence Configuration Index	Test	DRAFT v0.3	Pre-PDR/PDR

6. Aircraft-level requirements baseline

ID	Category	Requirement	Verification	Status
H120-REQ-001	Mission	The aircraft shall be designed for 60 passenger seats on one passenger deck.	Inspection/analysis	PROPOSED
H120-REQ-002	Mission	The baseline commercial mission shall support 350 km planned route distance with approved reserves.	Performance test/analysis	PROPOSED
H120-REQ-003	Mission	Target cruise speed shall be 85–95 km/h in still air at nominal cruise condition.	Flight test	PROPOSED
H120-REQ-004	Mission	The aircraft shall be capable of commercial passenger operations under an agreed EASA certification basis.	Certification evidence	PROPOSED
H120-REQ-005	Geometry	Baseline overall length shall be 120 m class and maximum diameter 25 m class unless an approved trade changes the outer mold line.	Inspection	PROPOSED
H120-REQ-006	Architecture	The H120-He60 shall use a semi-rigid structural concept rather than a scaled H350 rigid skeleton.	Design review	PROPOSED
H120-REQ-007	Lift	Helium shall be the lifting gas. Hydrogen used for energy shall not be mixed with or used as lifting gas.	Inspection/analysis	PROPOSED
H120-REQ-008	Lift	Nominal usable helium volume shall target approximately 88% of the outer envelope volume, with pressure/thermal accommodation.	Analysis/test	PROPOSED
H120-REQ-009	Mass	Supported operating mass target shall not exceed 27.8 t at the Pre-PDR baseline without Chief Engineer approval.	Mass statement	PROPOSED
H120-REQ-010	Mass	Each subsystem shall maintain an allocated mass budget and growth allowance.	Mass audit	PROPOSED
H120-REQ-011	Energy	Usable mission hydrogen target shall be approximately 120 kg pending final performance closure.	Inspection	PROPOSED
H120-REQ-012	Energy	The fuel-cell system shall be modular such that loss of one	Safety analysis/test	PROPOSED

ID	Category	Requirement	Verification	Status
		module does not eliminate safe continued flight/landing capability.		
H120-REQ-013	Energy	Nominal fuel-cell installed electrical power shall be approximately 600 kW using at least three independent modules.	Inspection/test	PROPOSED
H120-REQ-014	Energy	The aircraft shall incorporate a split high-power buffer battery of approximately 200 kWh nominal total.	Inspection/test	PROPOSED
H120-REQ-015	Electrical	Propulsion power distribution shall use at least two fault-contained HV buses with protected cross-tie capability.	Analysis/test	PROPOSED
H120-REQ-016	Electrical	Loss of one HV bus shall not cause total loss of controllability.	Safety analysis/test	PROPOSED
H120-REQ-017	Propulsion	The baseline shall use four distributed main electric propulsors with independent isolation.	Inspection	PROPOSED
H120-REQ-018	Propulsion	Single main propulsor loss or shutdown shall remain controllable throughout the approved envelope.	Simulation/flight test	PROPOSED
H120-REQ-019	Propulsion	Low-speed control shall use vectored thrust and aerodynamic control surfaces with automatic control allocation.	HIL/flight test	PROPOSED
H120-REQ-020	Thermal	Thermal management shall support hot-day continuous power without exceeding qualified component limits.	Thermal rig/flight test	PROPOSED
H120-REQ-021	H2	Hydrogen storage and distribution shall be physically segregated from occupied cabin volume.	Inspection	PROPOSED
H120-REQ-022	H2	Hydrogen leak detection and overboard ventilation shall prevent undetected hazardous accumulation in enclosed spaces.	Hazard analysis/test	PROPOSED
H120-REQ-023	H2	Hydrogen lines shall not be routed through occupied cabin volume unless specifically justified and	Inspection	PROPOSED

ID	Category	Requirement	Verification	Status
		protected.		
H120-REQ-024	H2	Emergency isolation shall be available at tank/manifold and conversion-system boundaries.	Functional test	PROPOSED
H120-REQ-025	Cabin	The cabin shall provide 60 passenger seats in a 2+2 arrangement in the baseline LOPA.	Inspection	PROPOSED
H120-REQ-026	Cabin	The cabin shall provide panoramic external view using modular certified transparency assemblies.	Inspection/test	PROPOSED
H120-REQ-027	Cabin	The design shall provide at least four principal egress locations distributed along the cabin.	Inspection/evacuation demo	PROPOSED
H120-REQ-028	Cabin	At least one passenger position shall accommodate a wheelchair without mandatory transfer to a conventional seat.	Mock-up test	PROPOSED
H120-REQ-029	Cabin	The baseline shall include an accessible-lavatory target compatible with cabin geometry and mass constraints.	Design review/mock-up	PROPOSED
H120-REQ-030	Crew	The baseline crew concept shall provide two pilot stations and two cabin-crew stations for 60-seat CAT planning.	Inspection	PROPOSED
H120-REQ-031	Cockpit	The flight deck shall provide direct forward visibility plus augmented downward/ground visibility for low-speed operations.	Mock-up/flight test	PROPOSED
H120-REQ-032	Flight controls	No single flight-control computer, actuator or sensor failure shall cause uncontrollable flight.	Safety analysis/HIL	PROPOSED
H120-REQ-033	Flight controls	Automated docking/hover assistance shall be immediately overridable by the pilots.	HIL/flight test	PROPOSED
H120-REQ-034	Envelope	The envelope shall provide qualified strength, tear resistance, helium retention, environmental durability and repairability.	Material/element test	PROPOSED

ID	Category	Requirement	Verification	Status
H120-REQ-035	Envelope	The exterior shall achieve a mirror-like appearance without rigid mirror panels over the primary envelope.	Inspection/material test	PROPOSED
H120-REQ-036	Envelope	Exterior reflective treatment shall include glare-control zones around cockpit, propulsor sightlines and ground-facing areas as required by assessment.	Glare test/analysis	PROPOSED
H120-REQ-037	Envelope	RF antenna windows and lightning/EMI bonding paths shall be integrated into the metallised-skin design.	EMI/lightning test	PROPOSED
H120-REQ-038	Structure	Primary structure shall use inspectable fail-safe or damage-tolerant load paths appropriate to the certification basis.	Analysis/test	PROPOSED
H120-REQ-039	Structure	Cabin and keel structure shall be structurally integrated to minimise duplicated floor/keel mass.	Design review/test	PROPOSED
H120-REQ-040	Structure	CFRP-to-metal interfaces shall include galvanic isolation and approved joining processes.	Inspection/material test	PROPOSED
H120-REQ-041	Ground	The aircraft shall include a primary nose capture/mooring interface tied into primary structure.	Static test	PROPOSED
H120-REQ-042	Ground	Normal ground handling shall not rely on large manual rope teams.	Operational demo	PROPOSED
H120-REQ-043	Ground	Independent restraints shall prevent unintended free flight during boarding/refuelling conditions.	Hazard analysis/test	PROPOSED
H120-REQ-044	Ground	Ground wind limits shall be established separately for parking, mooring, taxi and boarding states.	Test/analysis	PROPOSED
H120-REQ-045	Water ops	For overwater routes, life-saving equipment shall be sized for all occupants and the ditching configuration shall maintain survivable egress.	Analysis/demo	PROPOSED
H120-REQ-046	Fire	Battery, H ₂ , fuel-cell, baggage and cabin fire risks shall be	Fire test/safety analysis	PROPOSED

ID	Category	Requirement	Verification	Status
		detected, isolated and mitigated with dedicated provisions.		
H120-REQ-047	Evacuation	The programme shall use a 90-second evacuation design objective for mock-up development unless superseded by the agreed certification basis.	Evacuation demonstration	PROPOSED
H120-REQ-048	Maintenance	Routine LRU replacement shall not require deflation of the main envelope.	Maintenance demo	PROPOSED
H120-REQ-049	Maintenance	Hydrogen/HV isolation points shall be accessible and positively identifiable to maintenance and rescue personnel.	Inspection/demo	PROPOSED
H120-REQ-050	Manufacturing	Envelope mirror finish and branding shall be integrated into the film/coating manufacturing process rather than heavy applied panels.	Process qualification	PROPOSED
H120-REQ-051	Manufacturing	Critical structural and envelope manufacturing processes shall be traceable by lot/batch and controlled parameters.	Quality audit	PROPOSED
H120-REQ-052	Quality	Certification test articles shall have controlled as-built/as-tested configuration records.	Conformity inspection	PROPOSED
H120-REQ-053	Software	Safety-related airborne software shall follow an agreed development-assurance process consistent with DO-178C/ED-12C where applicable.	Process audit	PROPOSED
H120-REQ-054	Hardware	Complex airborne electronic hardware shall follow an agreed process consistent with DO-254/ED-80 where applicable.	Process audit	PROPOSED
H120-REQ-055	Environment	Airborne equipment shall have environmental qualification appropriate to installation zones, with DO-160G used where applicable/agreed.	Qualification test	PROPOSED
H120-REQ-056	Security	Passenger and public networks shall be segregated from safety-critical aircraft-	Security test/inspection	PROPOSED

ID	Category	Requirement	Verification	Status
		control networks.		
H120-REQ-057	Security	Loss or compromise of external connectivity shall not prevent safe flight and landing.	Security/safety test	PROPOSED
H120-REQ-058	Operations	Initial operational approval shall exclude known icing unless dedicated protection and compliance evidence are available.	Limitations/flight test	PROPOSED
H120-REQ-059	Operations	Dispatch criteria shall include wind, visibility, convective weather, icing, H ₂ quantity, helium pressure and degraded-system status.	Operations approval	PROPOSED
H120-REQ-060	Noise	Propulsion shall be designed for low tip speed and low community/cabin noise consistent with performance needs.	Acoustic test	PROPOSED
H120-REQ-061	Environment	Helium recovery shall be used during planned maintenance where technically practicable.	Procedure/audit	PROPOSED
H120-REQ-062	Environment	Lifecycle environmental claims shall define electricity/hydrogen source and system boundaries.	LCA audit	PROPOSED
H120-REQ-063	Cost	Mature recurring factory cost target shall not exceed €25M without approved business-case revision.	Cost audit	PROPOSED
H120-REQ-064	Cost	Design changes that add recurring part count or mass shall include cost/mass trade justification.	Design review	PROPOSED
H120-REQ-065	Commercial	The baseline mature sales-price concept remains approximately €50M per aircraft for bankability analysis, not as a contractual price.	Business-case review	PROPOSED
H120-REQ-066	Reliability	No catastrophic failure condition shall depend on a single unmitigated point failure.	Safety assessment	PROPOSED
H120-REQ-067	Reliability	Common-cause, zonal and particular-risk assessments shall cover H ₂ , fire, lightning/HIRF, water ingress, propeller debris and	Safety assessment	PROPOSED

ID	Category	Requirement	Verification	Status
		maintenance error.		
H120-REQ-068	Test	Flight-test envelope expansion shall be preceded by ground evidence for basic structural integrity, H ₂ containment, HV protection and flight-control integration.	Gate review	PROPOSED
H120-REQ-069	Test	All certification evidence shall be linked to a conforming configuration.	Conformity review	PROPOSED
H120-REQ-070	Configuration	No safety-critical design change may enter flight without configuration-controlled engineering approval.	CM audit	PROPOSED
H120-REQ-071	Brand	Company branding shall remain legible without obscuring required operational or rescue markings.	Inspection	PROPOSED
H120-REQ-072	Glazing	Cabin transparency modules shall provide fail-safe retention after failure of one structural pane or attachment path, as justified by the agreed basis.	Analysis/test	PROPOSED
H120-REQ-073	Ditching	Hydrogen and HV systems shall have automatic/manual isolation logic for ditching/emergency landing.	Functional test	PROPOSED
H120-REQ-074	Water management	PEMFC product water may be retained for trim only within defined mass/CG limits; uncontrolled accumulation is prohibited.	Software/functional test	PROPOSED
H120-REQ-075	CG	Normal fuel consumption and water-management strategy shall keep CG within the approved range without passenger relocation.	Mass/CG analysis/flight test	PROPOSED
H120-REQ-076	Thermal	Reflective exterior treatment shall be evaluated for both solar absorptance and infrared emissivity; appearance alone shall not define coating selection.	Thermal/material test	PROPOSED
H120-REQ-077	RF	Metallised surface design shall preserve required antenna performance.	Antenna pattern/EMI test	PROPOSED
H120-REQ-078	Mooring	Ground equipment and	Document review/demo	PROPOSED

ID	Category	Requirement	Verification	Status
		aircraft interface responsibilities shall be explicitly defined in the interface specification and operating procedures.		
H120-REQ-079	Accessibility	Boarding interface shall support step-free passenger access where terminal infrastructure permits.	Terminal/mock-up demo	PROPOSED
H120-REQ-080	Data	Aircraft health-monitoring data shall support maintenance trending while remaining non-essential to immediate safe flight.	System test	PROPOSED

7. Loads and design-condition catalogue

Case	Condition	Purpose / governing area	Status
LC-001	Static buoyancy - nominal ISA	Baseline distributed buoyancy vs mass	OPEN
LC-002	Hot-day static buoyancy	50°C retained preliminary case	OPEN
LC-003	Cold-day / high-lift condition	Maximum static lightness and ballonet authority	OPEN
LC-004	Maximum ballonet inflation	Envelope/pressure and mass distribution	OPEN
LC-005	Maximum differential pressure	Envelope/seam sizing	OPEN
LC-006	Rapid pressure-control transient	Blower/valve failure transient	OPEN
LC-007	Cruise symmetric thrust	Nominal cruise bending/torsion	OPEN
LC-008	Maximum forward thrust	Peak propulsor hardpoint loads	OPEN
LC-009	Maximum reverse/vector thrust	Low-speed/docking load	OPEN
LC-010	One propulsor inoperative	Asymmetric yaw/roll	OPEN
LC-011	Two same-side propulsors degraded	Continued-control case	OPEN
LC-012	Vector actuator jam	Off-axis thrust load	OPEN
LC-013	Tail control maximum deflection	Fin/actuator/hull reaction	OPEN

Case	Condition	Purpose / governing area	Status
LC-014	Discrete vertical gust	Flexible hull + cabin response	OPEN
LC-015	Discrete lateral gust	Fin/hull/keel response	OPEN
LC-016	Continuous turbulence spectrum	Fatigue/handling	OPEN
LC-017	Crosswind approach	Side force + vectoring	OPEN
LC-018	Crosswind mooring	Nose fitting + gear + hull side load	OPEN
LC-019	Mast capture transient	Peak nose capture load	OPEN
LC-020	Mooring line snatch	Dynamic restraint load	OPEN
LC-021	Ground taxi braking	Gear/cabin floor load	OPEN
LC-022	Steering limit load	Nose gear / keel	OPEN
LC-023	Normal landing	Vertical/longitudinal gear reactions	OPEN
LC-024	Hard landing / emergency landing	Ultimate gear/cabin reactions	OPEN
LC-025	Uneven landing / one main gear	Torsion case	OPEN
LC-026	Tail contact / bumper	Tail local structure	OPEN
LC-027	Passenger cabin 60 occupants	Floor/seat track load	OPEN
LC-028	Passenger emergency load	Forward/lateral seat and restraint loads	OPEN
LC-029	Baggage maximum compartment load	Floor/local attachment	OPEN
LC-030	Door open ground wind	Door hinge/frame	OPEN
LC-031	Window pressure/impact load	Transparency frame	OPEN
LC-032	Bird/hail cockpit impact	Windshield/local nose	OPEN
LC-033	Propeller imbalance	Pylon fatigue/dynamic	OPEN
LC-034	Propeller blade-out / debris	Particular risk/local containment zoning	OPEN
LC-035	Battery crash/containment load	Battery attachment	OPEN

Case	Condition	Purpose / governing area	Status
LC-036	H ₂ tank inertial/crash load	Tank cradle/keel	OPEN
LC-037	Fuel-cell module inertial load	Module rack	OPEN
LC-038	Ditching symmetric	Cabin/gear/hull water entry	OPEN
LC-039	Ditching yawed	Asymmetric water load	OPEN
LC-040	Ground handling tow load	Tow points/gear	OPEN
LC-041	Maintenance lifting/jacking	Dedicated lift points	OPEN
LC-042	Envelope local maintenance load	Walk/handling protection zones	OPEN
LC-043	Ice/snow ground accumulation	Parking limitation / structural check	OPEN
LC-044	Thermal gradient skin/keel	Hot solar/cold shaded side	OPEN
LC-045	Emergency descent / maximum dynamic pressure	High-speed control/surface load	OPEN
LC-046	Maximum speed V-like design point	Ultimate aero load definition	OPEN

8. Preliminary aircraft hazard register

ID	Hazard	Initial class	Architecture / mitigation	Status
HZ-001	Total loss of propulsion	Catastrophic/Hazardous candidate	Redundant energy + four motors; aerodynamic controllability; emergency landing	OPEN / classify with authority
HZ-002	Loss of one main propulsor	Major candidate	Remaining 3 motors + control allocation	OPEN / classify with authority
HZ-003	Uncommanded asymmetric thrust	Hazardous candidate	Independent shutdown, vector limits, FCS detection	OPEN / classify with authority
HZ-004	Loss of one HV bus	Major candidate	Dual bus, cross-tie, essential LV	OPEN / classify with authority
HZ-005	Battery thermal runaway	Hazardous candidate	Separated packs, containment/vent, detection/isolation	OPEN / classify with authority
HZ-006	H ₂ leak in technical bay	Hazardous/Catastrophic candidate	Detection, ventilation, isolation, ignition-source	OPEN / classify with authority

ID	Hazard	Initial class	Architecture / mitigation	Status
			control	
HZ-007	H ₂ tank rupture	Catastrophic candidate	Tank qualification, location, blast/vent path, structural protection	OPEN / classify with authority
HZ-008	Fuel-cell module fire/overheat	Major/Hazardous candidate	Module isolation, thermal monitoring, fire protection	OPEN / classify with authority
HZ-009	Uncontrolled helium leak	Major/Hazardous candidate	Compartmentation, pressure monitoring, landing strategy	OPEN / classify with authority
HZ-010	Ballonet blower stuck off/on	Major candidate	Redundant blowers/valves, manual mode	OPEN / classify with authority
HZ-011	Envelope tear propagation	Hazardous candidate	Tear-resistant laminate, rip stops/zoning, inspection	OPEN / classify with authority
HZ-012	Loss/jam of tail surface	Major/Hazardous candidate	Three surfaces + thrust vectoring, jam analysis	OPEN / classify with authority
HZ-013	Flight-control computer common mode	Catastrophic candidate	Independent lanes, dissimilarity where justified, assurance process	OPEN / classify with authority
HZ-014	Erroneous docking automation	Major candidate	Pilot override, bounded authority	OPEN / classify with authority
HZ-015	Mooring restraint failure	Hazardous ground event	Independent restraint paths, monitoring, wind limits	OPEN / classify with authority
HZ-016	Unintended free flight during boarding	Catastrophic ground event	Independent restraints, interlocks, procedures	OPEN / classify with authority
HZ-017	Cabin fire	Hazardous candidate	Materials, detection, extinguishers, evacuation	OPEN / classify with authority
HZ-018	Baggage fire	Hazardous candidate	Detection/containment/access	OPEN / classify with authority
HZ-019	Loss of all displays	Major/Hazardous candidate	Independent standby instruments/displays	OPEN / classify with authority
HZ-020	Loss of external communications	Major candidate	Navigation/autonomy independent of data link	OPEN / classify with authority
HZ-021	Lightning strike	Hazardous/Catastrophic candidate	Bonding, strike paths, equipment qualification	OPEN / classify with authority
HZ-022	HIRF/EMI common cause	Hazardous candidate	Shielding, segregation, qualification	OPEN / classify with authority
HZ-023	Mirror-skin glare to pilot/ground traffic	Major operational candidate	Low-glare zones, assessment, surface treatment	OPEN / classify with authority
HZ-024	Antenna blockage by metallised skin	Major candidate	RF windows, antenna pattern tests	OPEN / classify with authority

ID	Hazard	Initial class	Architecture / mitigation	Status
HZ-025	Windshield/window failure	Major candidate	Fail-safe panes/retention, bird/hail testing	OPEN / classify with authority
HZ-026	Emergency exit blocked	Major/Hazardous candidate	Four distributed exits, crew stations, alternate routes	OPEN / classify with authority
HZ-027	Ditching water ingress	Hazardous candidate	Flotation analysis, exit location, rafts/life vests	OPEN / classify with authority
HZ-028	Hydrogen emergency during refuelling	Hazardous ground event	Ground detection, bond/earth, E-stop, exclusion zone	OPEN / classify with authority
HZ-029	Maintenance HV exposure	Hazardous ground event	LOTO/isolation, keyed connectors, training	OPEN / classify with authority
HZ-030	Incorrect software load/configuration	Hazardous candidate	Signed loads, CM, independent verification	OPEN / classify with authority
HZ-031	Incorrect mass/CG loading	Hazardous candidate	Automated W&B, baggage limits, checks	OPEN / classify with authority
HZ-032	Product-water over-retention	Major candidate	Level sensing, CG logic, controlled drain	OPEN / classify with authority
HZ-033	Cooling-system loss	Major/Hazardous candidate	Redundant loops/pumps, power derate	OPEN / classify with authority
HZ-034	Propeller blade failure	Hazardous candidate	Blade qualification, zoning, fragment trajectories	OPEN / classify with authority
HZ-035	Ground collision with propulsor	Major candidate	Placement, guards/zones, interlocks	OPEN / classify with authority
HZ-036	Icing encounter	Hazardous candidate	Initial operational prohibition/avoidance, sensors, later protection	OPEN / classify with authority
HZ-037	Thunderstorm/severe turbulence penetration	Hazardous candidate	Weather radar/operating limitations	OPEN / classify with authority
HZ-038	Pilot mode confusion	Major/Hazardous candidate	Simple modes, annunciation, simulator validation	OPEN / classify with authority
HZ-039	Cabin smoke with power loss	Hazardous candidate	Emergency lighting, independent detection/interphone	OPEN / classify with authority
HZ-040	Helium handling / oxygen-deficient maintenance space	Hazardous ground event	Ventilation, O ₂ monitoring, confined-space procedures	OPEN / classify with authority

9. Verification pyramid and physical evidence

- Level 0 — calculations and digital models: geometry, buoyancy, mass/CG, thermal, aerodynamic, structural, electrical load and safety models under configuration control.
- Level 1 — materials/coupons: envelope biaxial/tear/leak/weathering, CFRP coupons, bonded joints, window material, mirror finish, sealants and fire/flammability specimens.
- Level 2 — components: H₂ tank and valves, fuel-cell module, inverter/motor/propeller, battery enclosure, blowers/valves, windows/doors, landing-gear and mooring fittings.
- Level 3 — subsystem rigs: full H₂/PEMFC/HV iron-bird, flight-control HIL, thermal rig, envelope pressure section, cabin/door mock-up and capture/mooring rig.
- Level 4 — structural/static article: full or representative keel/cabin/hardpoint structure, plus envelope/attachment proof as agreed with authority.
- Level 5 — flight-test article: tethered/ground runs, low-speed handling, progressive speed/altitude/gust/crosswind envelope, degraded modes, performance, noise and route demonstrations.
- Level 6 — certification/production conformity: approved test plans, conforming articles, witnessed tests, final compliance reports and production-quality evidence.

10. Open actions before a credible PDR

Action	Discipline	Required work	Gate
OA-001	Aero	Generate high-fidelity CFD for outer mold line and propulsor interaction	Pre-PDR→PDR
OA-002	Aero	Wind-tunnel test 1:25 or similar model including crosswind/docking	PDR
OA-003	Loads	Create coupled flexible-body aeroelastic/load model	PDR
OA-004	Structures	Select candidate CFRP material system and build allowables plan	Pre-PDR
OA-005	Structures	Size keel/frame members from global FEM	PDR
OA-006	Envelope	Down-select 2–3 laminate constructions and test biaxial/tear/leak/UV	Pre-PDR
OA-007	Envelope	Demonstrate metallised mirror finish after flex/UV/rain cycles	PDR
OA-008	Envelope	Perform glare, IR emissivity and solar absorptance tests	PDR
OA-009	H ₂	Trade 350 bar vs 700 bar tank architecture with certified supplier data	Pre-PDR

Action	Discipline	Required work	Gate
OA-010	H2	H ₂ release/vent CFD and ignition hazard test plan	PDR
OA-011	Thermal	Full mission PEMFC + cooling heat balance	Pre-PDR
OA-012	Electrical	Cable/bus sizing and protection coordination study	PDR
OA-013	Electrical	Lightning/HIRF zoning and mirror-film bonding concept test	PDR
OA-014	Propulsion	Propeller sizing/noise optimisation and pylon aero trade	PDR
OA-015	Controls	6-DOF + flexible-body simulation with control allocation	PDR
OA-016	Controls	Pilot-in-loop simulator for low-speed and failure cases	PDR
OA-017	Cabin	Build 1:1 cabin/door/window mock-up	PDR
OA-018	Evacuation	Run representative passenger evacuation trials	CDR
OA-019	Ditching	Hydrostatic/hydrodynamic ditching and waterline analysis	PDR
OA-020	Ground	Full ground-handling wind and capture simulation	PDR
OA-021	Ground	Prototype capture/mooring rig	CDR
OA-022	Certification	Hold technical familiarisation meeting with EASA and agree certification basis	Pre-PDR
OA-023	Certification	Agree project-specific MoC for H ₂ , EHPS, automation and semi-rigid structure	PDR
OA-024	Safety	Complete AFHA/SFHA and initial PASA/PSSA	Pre-PDR
OA-025	Safety	Complete zonal/common-mode/particular-risk analyses	CDR
OA-026	Manufacturing	Industrialise envelope welding/seam/metallisation	PDR

Action	Discipline	Required work	Gate
		sample process	
OA-027	Manufacturing	Facility/hangar and module logistics study	PDR
OA-028	Supply chain	Obtain supplier ROM mass/power/cost data for critical LRUs	Pre-PDR
OA-029	Finance	Rebaseline €320M development model from supplier quotations	PDR
OA-030	Operations	Model route cancellation risk using real wind/icing/weather datasets	PDR
OA-031	Maintenance	Conduct maintainability mock-up and LRU removal trials	CDR
OA-032	Test	Build integrated H ₂ /FC/HV iron-bird before first flight article	CDR

11. Design convergence — what is frozen and what is not

Area	Frozen at v0.3	Not yet frozen / evidence needed
Mission	60 seats; 350 km planning; 85–95 km/h cruise target	Final reserves, route-specific dispatch and weather reliability
Geometry	120 m class, 25 m max dia, semi-rigid	Exact OML, fin geometry, pylon shapes
Mass	27.8 t supported-mass hard target and allocations	Detailed weight from released parts
Lift	Helium; ~88% nominal gas fraction	Final buoyancy across full atmospheric/thermal envelope
Energy	~120 kg H ₂ ; 3×200 kW PEMFC; 2×100 kWh battery	Tank pressure down-select, final net efficiency and reserve policy
Propulsion	Four distributed electric units + vectored thrust topology	Prop diameter/blades/RPM/vector limits and docking-thruster necessity
Structure	Semi-rigid CFRP keel + structural cabin module	Member dimensions, laminate ply books, joint allowables
Envelope	Flexible laminate + mirror-look metallised outer system	Exact fibre/barrier/coating supplier chemistry and seam process

Area	Frozen at v0.3	Not yet frozen / evidence needed
Cabin	15×2+2 seating; four exit zones; modular panorama windows	Final seat/door/window dimensions and evacuation substantiation
Cockpit/FCS	Two-pilot, multi-lane FBW, thrust/surface allocation	DAL assignment, control laws/gains, handling-quality data
Certification	SC GAS anchored, project-specific MoC approach	Authority agreement on full basis and novel-feature issue papers
Commercial	~€320M P50 programme plan; ≤€25M factory-cost target; ~€50M mature selling-price concept	Supplier quotes, certified dispatch reliability, infrastructure costs

Engineering stop condition

This iteration is intentionally stopped at a point where remaining uncertainty is mostly evidence-generation rather than unresolved architecture. It is not “perfect” or certified; the next honest improvement must come from CFD, FEM, materials tests, supplier data, H₂/fire rigs, human mock-ups and authority engagement rather than adding more unsupported numerical detail.

12. Sources and current standards references

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S2. EASA, SC GAS explanatory material: large airships use dedicated special-condition basis; project-specific MoC; legacy TAR/CS-30T etc. may be considered.

<https://www.easa.europa.eu/en/downloads/134946/en>

S3. EASA, draft CS-30T / Transport Airship Requirements.

<https://www.easa.europa.eu/en/downloads/139573/en>

S4. EASA, Aircraft certification process overview.

<https://www.easa.europa.eu/en/domains/aircraft-products/aircraft-certification>

S5. EASA, Special Condition SC E-19 - Electric / Hybrid Propulsion System.

<https://www.easa.europa.eu/en/special-condition-sc-e-19-electric-hybrid-propulsion-system>

S6. EASA, 2024 International Workshop on certifying hydrogen-powered aircraft.

<https://www.easa.europa.eu/en/newsroom-and-events/press-releases/easa-holds-first-international-workshop-certifying-hydrogen>

S7. EASA AMC 20-115D / ED-12C / DO-178C software development assurance.

<https://www.easa.europa.eu/en/document-library/easy-access-rules/online-publications/easy-access-rules-acceptable-means-0?page=22>

S8. EASA AMC 20-152A, development assurance for airborne electronic hardware.

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S9. RTCA, DO-160G Environmental Conditions and Test Procedures for Airborne Equipment.

<https://www.rtca.org/do-160/>

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<https://saemobilus.sae.org/standards/arp4754b-guidelines-development-civil-aircraft-systems>

S11. SAE ARP4761A, Guidelines for Conducting the Safety Assessment Process on Civil Aircraft, Systems, and Equipment, current revision 2023.

<https://saemobilus.sae.org/topics/tests-and-testing/certification/aircraft-certification>

S12. EASA Air Operations, ORO.CC.100 Number and composition of cabin crew (Revision 24, March 2026).

<https://www.easa.europa.eu/en/document-library/easy-access-rules/online-publications/easy-access-rules-air-operations?erules-id=ERULES-1963177438-18415>

S13. Deutsche Zeppelin-Reederei FAQ: Zeppelin NT envelope uses a three-layer Tedlar/polyester/polyurethane laminate; ballonets are used for pressure equalisation.

<https://zeppelinflug.de/en/faqs>

S14. Kang et al., Mechanical property characterization of film-fabric laminate for stratospheric airship envelope, Composite Structures 75 (2006).

<https://www.sciencedirect.com/science/article/pii/S0263822306001292>

S15. EASA CS-25 window/windshield guidance page describing common aircraft transparency materials including acrylic and polycarbonate.

<https://www.easa.europa.eu/en/document-library/easy-access-rules/online-publications/easy-access-rules-large-aeroplanes-cs-25?page=26>