

YS

Cumulative Engineering Changelog

Updated: 2026-08-10

Current release: v9.6.0 Revolution Beta - Unified Runtime / Core Stability Milestone

Release history, implemented systems, fixes, validation and honest validation boundaries from the earliest recoverable browser build through the current release.

Release discipline

Every new build updates this cumulative record and ships both Markdown and PDF copies. Historical gaps remain explicitly marked rather than reconstructed from guesswork.

v9.6.0 Revolution Beta - Unified Runtime / Core Stability Milestone

- Promoted the simulator out of the 9.5.6 RC chain into a dedicated v960 runtime generation. The launcher, server identity, simulator shell, application JavaScript, map engine, deployment map, service worker, diagnostics and Windows launch scripts now share one 9.6 build identity instead of inheriting RC-era filenames.
- Added an authoritative runtime supervisor for SETUP / ENTERING / AIR / ROAD / HANGAR / TRANSITION state and AIR vs ROAD domain ownership. Player physics now consults that authority rather than relying only on scattered presentation flags.
- Added a low-frequency runtime invariant supervisor. It detects and repairs presentation contradictions such as an AIR model visible during ROAD, a cockpit visible during ground operation, stale ground-mode presentation after an AIR transition, or exterior/cockpit visibility mismatches. Repairs and mismatches are black-box logged and exported.
- Added visible 9.6 Systems telemetry for CORE PHASE, DOMAIN and SELF-REPAIRS so runtime recovery is no longer hidden from the user.
- Added an independent essential HUD layer for speed, altitude, heading, VSI, G and AGL. It updates separately from secondary map/navigation presentation so an auxiliary HUD subsystem fault cannot remove all basic flight information.
- Hardened cockpit lifecycle across warm aircraft changes. Aircraft model, animation payload and cockpit model now load as one transaction; the old aircraft remains active until all required replacement assets settle, and the real cockpit model is retained rather than being discarded during a warm swap.
- Preserved F1 real-cockpit routing and RMB free-look while keeping exterior and cockpit visibility mutually exclusive under the runtime supervisor.
- Hardened ROAD ownership. ROAD transition blocks AIR physics until the vehicle is active, keeps AIR geometry suppressed while driving, maintains the selected vehicle plus visible fallback geometry, and lets road/terrain refinement continue after the vehicle becomes controllable.
- Reworked tactical-map presentation cadence to approximately 29 Hz scheduling when interaction demands it, increased the pan/rotation preload ring, retained decoded current tiles for 3.2 seconds, and waits for roughly 70% of a replacement map layer before retiring the prior decoded layer. This targets the green/blank flashes and sluggish pan/zoom reported on the target machine without changing the geographic ownership math.
- Deployment-map tiles now retain a short stale-image layer during pan/zoom rather than immediately blanking decoded tiles while replacements arrive. Existing immediate deployment-pin placement remains intact.
- Kept same-region RAM world reuse, bounded map/ROAD disk caches, cache repair, Safe Mode, diagnostic bundle generation, controller identity hardening, live weather, Living World load shedding, landing/damage systems, navigation, logbook/passport/achievements and the 9.5.6 feature foundation.
- Preserved fixed-step 120 Hz AIR player physics, corrected yaw conventions, YS mouse-stick, RC4+ rotorcraft systems and the six ROAD vehicle assets. The 88 aircraft GLBs and 88 aircraft animation payloads are byte-identical to RC11; all 87 installed cockpit GLBs and all six ROAD vehicle GLBs are also byte-identical.
- Added a dedicated 9.6 Revolution regression plus a 9.6 runtime validator. Accumulated Node suite: 53/53 PASS. Runtime validator: 495 unique UI IDs, 88 aircraft and the 9.6 supervisor/HUD/cockpit/ROAD/map invariants PASS.
- Added a real Chromium JavaScript-engine smoke test using local inline/mock dependency surfaces. It caught and corrected a wrong map-engine global name in the first 9.6 self-test implementation. After correction, the 9.6 runtime probe and self-test report OK with no page errors or console errors in that controlled browser-engine test. This is not claimed as a live Cesium/GPU rendering validation.
- Honest boundary: live Windows/Cesium GPU rendering, provider latency, target-machine controller feel, subjective helicopter handling and sustained photorealistic frame pacing still require the user's real-machine test. 9.6 materially strengthens state ownership and failure isolation but does not claim that external network/GPU conditions can never stutter.

v9.5.6 Beta RC11 - Runtime Scope / ROAD / Cockpit Recovery

- Fixed the root JavaScript scope defect behind the target-machine running `is not defined` and `cameraMode is not defined` failures. Newer recovery/feature helpers had been appended after the simulator IIFE closed and could not access core state.
- Restored one coherent simulator runtime scope and added a regression that fails if integrated systems ever move outside that scope again.
- Added a non-sensitive runtime probe covering core state visibility for diagnostics.
- F1 cockpit now enables the installed per-aircraft cockpit GLB when available and suppresses the rejected synthetic CSS cockpit/dashboard overlay in that case.
- ROAD launch now trusts the simulator's actual mode state rather than a potentially stale hidden form value.
- Added a low-profile visible ROAD underbody fallback beneath the selected real GLB so delayed/rejected model decoding cannot leave an empty aerial scene.
- Preserved 120 Hz fixed AIR physics, RC10 anti-lurch clamping, filtered structural-G damage input, map tile retention, deployment pin behavior, helicopter systems and warm-region caching.
- Full accumulated Node regression suite: 52/52 PASS. Runtime validator: 485 unique UI IDs, 88 aircraft, fixed 120 Hz AIR core, indexed ROAD lookup and immutable RC11 cache PASS.
- Honest boundary: the scope defect is deterministic and fixed in source. Actual Windows/Cesium cockpit/ROAD visuals, live provider behavior and subjective helicopter feel still require target-machine validation.

v9.5.6 Beta RC9 - Core Runtime Recovery

- Reworked ROAD entry so the selected ground vehicle becomes active immediately; AIR model rendering is blocked whenever ROAD is selected or active, while road and terrain data refine asynchronously.
- Replaced the converted cockpit-shell camera path with a true aircraft-eye cockpit path using each aircraft's YS cockpit position inside the actual airframe; the slab-prone converted cockpit shell is hidden.
- Hardened HUD execution so tactical-map/navigation auxiliary failures cannot abort the primary flight HUD update.
- Promoted `running` and `cameraMode` to true global runtime properties for compatibility with browser callbacks/dynamic handler scopes after real-machine `ReferenceError` reports.
- Rebalanced helicopter cyclic disc tilt and rate-command authority to avoid double-counted rotor/fuselage response; added low-speed hover translational damping under helicopter SAS.
- Added immutable RC9 runtime/cache identity and stale-build rejection.
- Full accumulated Node regression suite: 50/50 PASS after updating superseded implementation assertions to the replacement behavior.

v9.5.6 Beta RC8 - Runtime / Interaction / Helicopter Recovery

- Built RC8 from the exact RC7 branch after target-machine feedback exposed simultaneous ROAD, cockpit/HUD, tactical-map, waypoint, visual-quality and helicopter failures. This release is a recovery pass, not a feature expansion.
- Introduced an immutable RC8 runtime generation (`*-rc8` core assets plus `?b=956rc8`) and a new `ys-v956-rc8-core` service-worker namespace. Activation removes earlier YS/YS Live World core caches so RC5/RC6/RC7 JavaScript cannot silently mix with the RC8 shell.
- Retained compatibility aliases for legacy v9.5.6 filenames, but all RC8 launch HTML references only the immutable RC8 asset generation.
- Corrected a fundamental helicopter longitudinal-cyclic contradiction: positive/nose-up cyclic had been rotating the fuselage nose-up while tilting rotor thrust forward. Rotor-disc thrust-vector sign is now coherent with the preserved pitch-control convention; nose-up cyclic produces an aft thrust component and nose-down cyclic produces a forward component.

- Added an RC8 numerical regression that evaluates the cyclic vector itself instead of merely checking for the existence of helicopter code. All five installed rotorcraft continue to retain rotor-RPM/energy, ETL, ground effect, VRS, autorotation, retreating-blade-stall and anti-torque systems.
- Added a ROAD-domain physics guard. While ROAD entry is still resolving/creating the ground vehicle, the fixed-wing/helicopter player physics kernel does not run, preventing the selected AIR aircraft from falling into the terrain/exploding before Ground Mode becomes active. AIR and cockpit models are hidden immediately when ROAD entry begins.
- Disabled the legacy FLIGHT DECK status strip in the recovery build. F1 remains the cockpit camera and uses the installed per-aircraft cockpit GLB plus the cockpit MFD/navigation/system overlay; the rejected flight-deck strip is no longer presented as a substitute for cockpit view.
- Raised SAFE and BALANCED scene-resolution floors and restored a 60 Hz visual target for SAFE. Under pressure, RC8 sheds photogrammetry/terrain detail more aggressively before collapsing the entire rendered scene into a visibly low-resolution image.
- Increased tactical-map location/footer readability while retaining live reverse-geocoded location context, manual pan/zoom, waypoint projection and the dedicated on-screen waypoint cue.
- Added an RC8 runtime-recovery regression covering immutable asset/cache identity, ROAD pending-state isolation, helicopter cyclic vector direction, cockpit routing and graphics-resolution floors.
- Full accumulated Node regression suite: **49/49 PASS** after updating inherited harnesses to the deliberate RC8 asset/build generation. Runtime validator: **485 unique UI IDs, 88 aircraft, fixed 120 Hz AIR core, indexed ROAD lookup, immutable RC8 cache, ROAD guard and helicopter cyclic recovery PASS.**
- Honest boundary: the cache-generation and deterministic control-vector fixes are source/package validated. Subjective rotorcraft feel, live provider behavior, photorealistic visual quality and Windows/browser input behavior still require the target-machine run.

v9.5.6 Beta RC7 - Frame Pacing / Stability Hardening

- Performed a stability-only pass with no new gameplay systems and no changes to fixed-wing or helicopter aerodynamic equations. The fixed-step 120 Hz player integrator, RC4 helicopter dynamics, RC6 cockpit/free-look behavior, ROAD vehicle physics and tactical-map interaction remain intact.
- Removed AI traffic and Living World presentation updates from the deterministic 120 Hz player-physics wrapper. They now run on an independent auxiliary cadence so a traffic/facility update cannot land inside a player-physics catch-up step.
- Reordered the main frame path so fixed-step player integration and the Cesium aircraft/world render happen before nonessential presentation, diagnostics, weather polling and route prefetch work. This prioritizes control-to-photon consistency under transient main-thread load.
- Added a bounded per-frame headroom gate. Optional presentation/network work yields when the current frame has consumed its budget, when physics backlog is elevated, or when long-task pressure is high.
- Added pressure-aware auxiliary-world cadence: normal traffic/facility presentation can run at 20 Hz, but decorative world work falls to roughly 7 Hz or 3 Hz under sustained pressure instead of competing with AIR rendering.
- Removed deliberate active-flight render-rate reduction based on long-task pressure. The configured render cadence remains the target; Auto Graphics, dynamic resolution, world LOD and decorative load shedding absorb pressure first.
- Replaced per-physics-step render-pose object/array allocation with reusable double-buffered pose storage and a reusable interpolation scratch pose. This removes a continuous allocation source from the 120 Hz path without changing simulated position/orientation values.
- Deferred routine 10-second recovery-snapshot persistence to browser idle time. Forced lifecycle snapshots remain available for background/page-hide recovery, while ordinary local-storage serialization no longer intentionally lands on the hot render path.
- Throttled career/achievement evaluation out of the 20 Hz presentation loop to a 1 Hz cadence.
- Added frame-pacing diagnostics for optional-work deferrals, maximum observed callback work time, reusable-pose status and confirmation that auxiliary world updates are outside player physics.
- Bound the Windows launcher to an RC7 build identity in `/map-health`, preventing an already-running RC5/RC6 server with the same public 9.5.6 version from being silently reused.

- Added a dedicated RC7 frame-pacing regression. Full accumulated Node regression suite: **48/48 PASS**. Runtime validator remains **480 unique UI IDs, 88 aircraft, fixed 120 Hz AIR core, indexed ROAD lookup and cached drag-pan tactical map PASS**.
- Honest boundary: these changes remove deterministic sources of main-thread contention and allocation pressure, but absolute zero-stutter performance cannot be guaranteed without the target Windows GPU/browser/provider workload. RC7 exports the new frame-pacing counters so any remaining spike can be classified from the user's real session.

v9.5.6 Beta RC6 - Re-Entry / ROAD / Cockpit Hardening

- Corrected the warm-region cache anchor. The retained RAM world is now centered on the prepared deployment bubble rather than being recentered to the aircraft's last in-flight position when returning to the hangar. Flying away from DFW and then changing aircraft no longer invalidates the DFW warm cache merely because the sortie ended elsewhere.
- Warm-region reuse now stores the prepared radius and resolved ground height. Same-spawn swaps can reuse the known ground solution instead of forcing another terrain-height request.
- Removed redundant blocking work from warm aircraft swaps. The selected aircraft model/animation remains part of the readiness path, while map-bubble refresh and neighbor-aircraft warming are scheduled in the background after the new aircraft is ready.
- Added warm-swap timing telemetry to the launch status and renews the 45-minute RAM-cache lease on successful reuse.
- Hardened ROAD entry around slow external road data. If no local road segment is already available, ROAD waits only about 1.15 seconds before creating the selected vehicle on a clearly labeled fallback surface; the road request continues asynchronously.
- Added late ROAD-network handoff. When road data arrives after fallback entry, the active vehicle adopts nearby real-road guidance without requiring the user to leave and re-enter ROAD mode.
- Improved cockpit free-look presentation. The flight-deck framing now shifts/fades with cockpit yaw/pitch so the dashboard is not visually glued to the screen while looking down or sideways; aft look de-emphasizes forward panel framing.
- Added explicit tactical-map keyboard zoom with +, -, numpad + and numpad -; manual zoom continues to take ownership from Auto Zoom.
- Preserved RC4 helicopter dynamics, the fixed-step 120 Hz AIR integrator, corrected yaw conventions, YS mouse-stick, existing map drag/pan, ROAD tire/drivetrain physics, aircraft assets and world-streaming architecture.
- Added a dedicated RC6 re-entry/ROAD/cockpit/map regression. Full accumulated Node regression suite: **47/47 PASS**. Runtime validator: **480 unique UI IDs, 88 aircraft, fixed 120 Hz AIR core, indexed ROAD lookup and cached drag-pan tactical map PASS**.
- Honest boundary: browser/Cesium visual feel, live-provider response timing, Windows mouse behavior and actual warm-cache speed still require the user's target-machine run.

v9.5.6 Beta RC5 - ROAD Vehicle Fleet / Warm Region Re-Entry / Cockpit Recovery

- Added six self-contained drivable 3D ROAD vehicles: Apex Sedan, Vector Coupe, Atlas SUV, Frontier Pickup, Interceptor and Metro Utility Van. Each vehicle has its own mass, power, wheelbase, grip and top-speed envelope; ROAD no longer presents the player as only abstract boxes.
- Added a ROAD vehicle selector to launch configuration and a vehicle-backed Cesium model path with night head/tail marker lighting.
- Hardened ROAD entry so live/cached OSM road geometry is still preferred, but provider failure now enters a clearly labeled free-drive fallback surface instead of silently refusing to start.
- Added bounded same-region warm reuse. Returning to the hangar keeps the existing terrain/3D/road world alive in RAM for up to 45 minutes. Re-entering within the warm radius with the same world mode swaps aircraft and refreshes local map/aircraft assets without rebuilding the entire deployment bubble.
- The existing bounded disk map/ROAD caches remain in place; the new warm-region layer specifically preserves the expensive active Cesium world in memory and expires automatically.

- Added warm-cache status/readiness messaging so the user can see when a deployment is a full prepare versus an in-memory reuse hit.
- Reworked the cockpit presentation into an unmistakable F1 flight-deck view with deeper canopy/glare-shield treatment while retaining live MFD/navigation/system data.
- Expanded RMB free-look pitch travel to support looking substantially farther down into the cockpit and sideways while preserving YS mouse-stick isolation.
- Preserved the RC4 helicopter dynamics recovery and the fixed-step 120 Hz AIR integrator unchanged.
- Added a dedicated RC5 regression covering all six vehicle GLBs, ROAD fallback entry, warm-region TTL/reuse, hangar retention, cockpit routing and deep free-look.
- Full accumulated Node regression suite: **46/46 PASS**. Runtime validator: **480 unique UI IDs, 88 aircraft, fixed 120 Hz AIR core, indexed ROAD lookup and cached drag-pan tactical map PASS**.
- Honest boundary: the six vehicle assets, control/data paths and warm-region logic are source/package validated here; final vehicle visual orientation, photogrammetry placement, cockpit ergonomics and real provider behavior still require the user's Windows/Cesium run.

v9.5.6 Beta RC4 - Helicopter Dynamics Recovery / Rotorcraft Control-Law Polish

- Reworked the dedicated helicopter control law after real-machine feedback showed rotorcraft handling was still far from acceptable despite the prior sign fix.
- Removed fixed-wing SAS preprocessing from helicopter controls; rotorcraft now owns its own cyclic/pedal stabilization path.
- Recalibrated full cyclic/pedal rate authority from the previous few-degrees-per-second behavior to bounded rotorcraft response envelopes: approximately 30-36 deg/s pitch, 36-43 deg/s roll and 29-35 deg/s yaw for the installed helicopter set, depending on aircraft maneuver data.
- Added first-order rotor-disc cyclic/flapping lag so thrust-vector tilt responds promptly without snapping instantaneously.
- Added low-speed helicopter SAS attitude hold independent of AGL, with neutral-stick pitch/roll leveling and yaw anti-torque assistance; Full Manual keeps this aid disabled.
- Preserved and retuned rotor RPM governing, rotor-energy storage, ETL, ground effect, vortex-ring state, retreating-blade stall, tail-rotor authority/LTE and autorotation behavior.
- Added anisotropic helicopter fuselage drag so lateral/vertical translation damps more strongly than clean forward translation.
- Corrected helicopter airborne initialization to use an ETL-compensated collective setting rather than the fixed-wing 62% start value.
- Added a helicopter-specific autopilot law so altitude hold commands collective and heading/speed hold commands rotorcraft controls instead of treating collective as airplane throttle.
- Guided/Realistic rotorcraft presets now select helicopter SAS directly; the helicopter status surface explicitly reports rate-command plus hover-attitude-hold behavior.
- Added a dedicated numerical/source regression across all five installed helicopters, validating sea-level hover power margin, hover trim near 57% collective, climb/descent authority, control-rate envelopes, SAS separation, cyclic lag and rotorcraft edge-state hooks.
- Full accumulated Node regression suite: **45/45 PASS**. Runtime validator remains **478 unique UI IDs, 88 aircraft, fixed 120 Hz AIR core, indexed ROAD lookup and cached drag-pan tactical map PASS**.
- Honest boundary: the new rotorcraft equations are deterministic/source validated here, but final subjective control feel still requires the user's real Windows input hardware and frame timing.

v9.5.6 Beta RC3 - Interaction Recovery / Real-Machine Regression Fixes

- Fixed the tactical-map manual zoom regression: wheel and +/- zoom now disable speed-driven Auto Zoom before applying the requested level, so the user's zoom is no longer immediately overwritten on the next map paint.
- Fixed ROAD startup being silently blocked by its own performance gate. Explicit/forced ROAD entry now bypasses nearby-3D/FPS decorative fetch gating and actually requests road data before nearest-road deployment.
- Added bounded ROAD provider redundancy across multiple OpenStreetMap Overpass endpoints while retaining disk-cache/stale-cache recovery and response-size limits.
- Corrected helicopter pedal yaw sign to the same positive-YawLeft convention preserved by the fixed-wing YS control core.
- Normalized a fixed-wing FBW selection to helicopter SAS at helicopter launch instead of carrying the wrong assist category into rotorcraft operation. Raw/manual remains available when explicitly selected.
- Hardened RMB mouse free-look so right-button free-look is established before any YS mouse-stick pointer-capture request; left-click remains the only path that requests mouse-stick pointer capture.
- Added immediate cockpit camera presentation synchronization so F1/camera switching explicitly restores the cockpit overlay rather than waiting for a later HUD paint to reveal it.
- Added a dedicated user-reported interaction recovery regression covering cockpit presentation, RMB free-look ordering, manual map zoom ownership, forced ROAD fetch, helicopter yaw/assist convention, and ROAD provider redundancy.
- Full accumulated Node regression suite: **44/44 PASS**. Runtime validator remains **478 unique UI IDs, 88 aircraft, 120 Hz AIR core, indexed ROAD lookup and cached drag-pan tactical map PASS**.
- Real-machine boundary remains explicit: helicopter handling feel, Cesium/provider behavior, mouse hardware/browser interaction and map tile delivery must still be judged on the user's Windows machine.

v9.5.6 - Beta Candidate / Simulation Experience Expansion & Recovery Hardening

- Rebranded the current simulator-facing shell to **YS** while retaining historical YS Live World references in the cumulative engineering record.
- Preserved the proven fixed-step 120 Hz AIR player-physics loop, corrected YS yaw/control conventions, YS mouse-stick behavior, RMB free-look, fixed-wing/helicopter equations, ROAD tire/drivetrain model, map architecture, photorealistic near-field priority, damage/landing foundations, live weather plumbing and streaming governor.
- Expanded landing results into persistent career data. Existing touchdown scoring now feeds best-landing records and the career system rather than creating a second landing model.
- Added a crash/damage summary overlay with impact-state telemetry and direct access to the session debrief/restart flow.
- Added a navigation ribbon with destination bearing/distance presentation and a **NEAREST FIELD** diversion action that evaluates the active airport/runway database when available.
- Added bounded training emergency scenarios for engine power loss, flight-control damage, landing-gear failure, electrical/HUD degradation, engine fire and bird strike. Emergency effects reuse the existing component-damage system rather than changing the baseline flight equations.
- Added cockpit-camera inertial head movement as a presentation-only layer; it does not feed back into controls or player physics.
- Extended existing aerodynamic visuals with humidity/high-AOA wing condensation and a bounded screen-space exhaust heat-haze presentation. Existing altitude/Mach/afterburner contrail behavior remains in place.
- Preserved existing touchdown tire-smoke behavior and exposed it as part of the expanded landing presentation.
- Added storm/lightning presentation hooks and distance/performance-gated aircraft navigation/beacon lighting for night/storm operation.
- Preserved and surfaced local-time Living World density scaling so road/city activity changes across rush-hour, daytime, evening and late-night periods while continuing to yield to AIR physics and nearby 3D refinement.

- Added ROAD navigation over the already-loaded OSM road graph using a bounded A*-style search with one-way handling. If the destination is outside the loaded road graph, YS reports that limitation instead of drawing a fake route through buildings.
- Added Random Flight generation that chooses a fixed-wing departure/destination pair within a bounded practical range and configures the deployment/route state.
- Added persistent pilot career statistics: logged sessions, cumulative time, distance, airports, countries, best landing and achievement history. Existing World Hub logbook sessions now feed the career layer.
- Added a World Passport/achievement layer with milestones for first sortie, flight time, distance, airport/country exploration, high landing scores and supersonic flight.
- Added a session debrief showing duration, distance, max speed/altitude, G range, landing result, airframe state, weather and destination; debriefs can be saved into the existing local logbook.
- Added an 8-second performance auto-tuner that samples frame performance and selects a suitable existing graphics policy rather than modifying physics.
- Fixed pre-release integration issues found during regression: FIRST SORTIE no longer unlocks before a session exists, automatically logged hangar sessions now feed career totals, debrief save state resets between sorties, and new aircraft-light/ROAD-route primitives are explicitly cleaned up on hangar return.
- Added same-package **SAFE MODE**. It boots the recovery terrain world with SAFE rendering, disables optional AIR/Living World traffic, uses smart streaming and a small preload radius. Safe Mode is explicitly a recovery path, not a substitute for the normal photorealistic experience.
- Added **CREATE DIAGNOSTIC BUNDLE** for Windows. It packages launcher/server logs and machine/runtime information while deliberately excluding `config-v956.js`, provider credentials, cached imagery and browser-profile data.
- Added bounded startup cache repair: malformed map tiles are discarded and malformed ROAD JSON cache files are quarantined before they can poison a session.
- Windows launch remains self-bootstrapping: it prefers its private runtime, accepts a verified installed Python 3 fallback, and can download the official Python 3.12.10 embeddable runtime into the simulator folder when neither is present. This build does **not** claim an already-bundled Windows Python runtime because that binary could not be embedded from this build environment.
- Full accumulated Node regression suite: **43/43 PASS**. Runtime validator: **478 unique simulator UI IDs, 88 aircraft, 120 Hz AIR core, indexed ROAD lookup and cached drag-pan tactical map PASS**.
- All 88 principal aircraft GLBs and all 88 aircraft animation payloads remain byte-identical to v9.5.5B.
- Honest validation boundary: Windows WPF appearance, PowerShell bootstrap behavior, physical controls, live provider availability, Cesium/GPU frame pacing and the subjective feel/appearance of the new effects require the user's real Windows/GPU/network session.

v9.5.5B - Cinematic Startup / Loading Experience Polish

- Added an immediate native Windows startup panel so the simulator presents a branded boot sequence before the local web runtime is available.
- The native panel reports real startup phases including package preflight, runtime discovery/bootstrap, runtime verification, local-core startup, health verification and deployment handoff.
- First-launch private Python bootstrap now reports its progress through the branded loader instead of interrupting startup with a plain informational dialog.
- Rebuilt the browser-side deployment loader with a cinematic radar sweep, aircraft wireframe, staged system telemetry, animated progress, health state and clean handoff into the simulator.
- Corrected the loader aircraft-catalog cache-buster to the current v9.5.5 generation.
- No AIR/ROAD physics, aircraft assets, map logic, world streaming, audio, damage, controls or simulator equations were changed.
- Full accumulated regression suite remains 42 / 42 Node modules PASS; runtime validator remains PASS with 440 UI IDs and 88 aircraft.

- Honest boundary: the native WPF loader is source-validated here but final appearance/animation timing requires the real Windows desktop compositor.

v9.5.5A - Windows First-Launch Python Bootstrap Hotfix

- Fixed the Windows first-launch blocker on systems with no Python installation.
- If no usable Python 3 runtime exists, the launcher now automatically downloads the official Python 3.12.10 Windows x64 embeddable runtime from python.org over HTTPS.
- The private runtime is stored under `runtime\python312` inside the simulator folder and is reused on later launches. No system-wide Python installation, PATH modification, registry modification, or administrator access is required.
- Bootstrap uses bounded download validation, temporary extraction, Python 3 self-test, cleanup on failure and persistent launcher logging.
- The simulator runtime itself remains v9.5.5 and is byte-identical for the core JavaScript/HTML/server surfaces; all 88 aircraft GLBs and 88 animation payloads are unchanged.
- Full accumulated regression suite: 42 / 42 Node modules PASS. Runtime validator PASS.
- Honest boundary: the first-run download requires Windows network access to python.org; restrictive firewall/security policy can still block that external download and will be reported in the launcher log.

v9.5.5 - Stage Final Plus / Cache & Startup Resilience

- Preserved the v9.5.4 simulation branch and all proven AIR/ROAD physics behavior; no flight-equation changes in this pass.
- Hardened Windows startup by probing candidate interpreters and accepting only a working Python 3 runtime before starting the local server.
- Changed ROAD network disk-cache commits to atomic temporary-file replacement, preventing interrupted writes from leaving partially-written JSON as the primary cache entry.
- Bound tactical-map tile retry timers to their tile lifecycle and explicitly cancel stale retry callbacks when tiles are removed, replaced or destroyed during rapid pan/zoom activity.
- Retained v9.5.4 startup logging, bounded port search, map drag/pan, tile backoff, fixed 120 Hz AIR physics, YS controls, photorealistic priority and recovery diagnostics.

v9.5.4 - Stage Final / First-Run Reliability Seal

- Frozen the proven v9.5.3 simulation/world branch for this stage: no flight-equation, aircraft-model, animation, ROAD tire-model, map-renderer or photorealistic-world feature expansion was introduced.
- Hardened the Windows double-click launch chain with required-runtime-file preflight before attempting to start the local server.
- Added persistent launcher, server stdout and server stderr diagnostics under `.yslw-cache/logs` so hidden startup failures are no longer silent.
- Startup failures now show the exact launcher-log location in a Windows dialog.
- Preserved reuse of an already healthy matching local runtime and bounded port selection across 8108-8114.
- Increased bounded health polling for slower Windows startup while still terminating an unhealthy candidate instead of leaving orphan local-server processes.
- Preserved the fixed-step 120 Hz AIR core, corrected YS yaw/control conventions, YS mouse-stick, RMB free-look, fixed-wing/helicopter dynamics, ROAD physics, Shadow DOM tactical map/cache, photorealistic near-field priority, world streaming, live weather, damage/landing and recovery systems.

- Release validation includes the complete accumulated Node suite, JavaScript/Python syntax, aircraft/JSON/GLB integrity, launcher-chain checks, packaged HTTP smoke checks, final ZIP integrity and cumulative changelog render verification.
- Honest boundary: real Windows GPU/Cesium/provider behavior and physical controller feel remain target-machine checks; this release specifically improves the evidence available if first-run startup fails.

v9.5.3 - Frame Scheduling / ROAD Lookup / Tactical Map Hardening

- Removed avoidable decorative work from the 120 Hz player hot cadence: Living World airport/facility presentation now runs at a capped 20 Hz while fixed-step AIR physics remains unchanged and traffic retains its own bounded cadence.
- Restored a metric spatial index for the ROAD network. Nearest-road queries inspect nearby indexed cells, deduplicate segments and use a safe geometric early-exit once the current best segment is closer than any unsearched grid cell.
- Added ROAD lookup telemetry for index-cell count, candidate segments inspected and nearest-query count. A synthetic 3,600-segment regression resolves the same exact nearest segment as brute force while evaluating 30 candidates in the exercised case.
- Made ROAD rendered-scene height sampling adaptive to speed and runtime pressure. Photorealistic sampleHeight probes yield under low FPS/main-thread pressure or while nearby 3D is cold, falling back to the existing road/coarse height path instead of forcing synchronous scene sampling.
- Added ROAD surface-sample and skipped-sample counters to exported diagnostics.
- Added real pointer drag/pan to the Shadow DOM tactical map overlay, including heading-up coordinate transformation and bounded repaint cadence.
- Fixed double-click waypoint placement after search/focus/manual pan: screen coordinates are now projected from the current map center rather than always from aircraft position.
- Added two bounded tile retries with short backoff before a tactical-map tile becomes a final error; retry count is exposed in diagnostic export.
- Updated in-simulator map help/cursor behavior to expose drag-pan, wheel/+/- zoom, double-click waypoint and recenter behavior.
- Preserved fixed-step 120 Hz AIR physics, bounded hitch recovery, corrected YS yaw/control conventions, YS mouse-stick, RMB free-look, Fixed Wing/Helicopter dynamics, landing/damage systems, live weather, Auto Graphics, photorealistic near-field priority/collision, ROAD tire/drivetrain physics, controller identity hardening and recovery/profile systems.
- All 88 aircraft GLBs and all 88 animation payloads are byte-identical to v9.5.2.
- Full accumulated regression suite: 41 Node modules PASS. Runtime validator: 440 unique simulator UI IDs and 88 aircraft. All 93 JSON files parse; all 88 aircraft GLB headers validate as GLB 2.0.
- Packaged local HTTP smoke returned 200 for map health, system info, simulator shell, launcher, aircraft catalog and map-cache status.
- Honest boundary: live Windows/Cesium/GPU frame pacing, real provider availability, real-world tile retry recovery and photorealistic surface-sampling behavior remain target-machine validation items.

v9.5.2 - Burn-In Window Integrity / Recovery-Aware Diagnostics

- Fixed a long-session diagnostics latch where cumulative simulation-drop time was treated as a recent fault signal. Once lifetime SIM DROP exceeded roughly 80-120 ms, the bottleneck classifier and future burn-in windows could remain stuck in SIMULATION / degraded state even after the simulator had fully recovered.
- Added a bounded rolling simulation-drop event window. Physics still records lifetime SIM DROP totals, but bottleneck classification and burn-in health now use the most recent 5-second window.

- Routed fixed-step overflow events through the new rolling recorder while preserving the proven bounded 120 Hz hitch-recovery behavior.
- Burn-in health now measures active simulator time rather than wall-clock time spent sitting in the launcher. This prevents a long setup/preload period from making a brand-new sortie look like a mature burn-in session.
- Near-field cold-time in burn-in health now accumulates only while Photorealistic 3D mode is actually active; OSM/recovery-world refinement no longer pollutes photorealistic quality-debt health.
- Reworked burn-in grading around sustained evidence: degraded-window ratio, severe-window ratio, consecutive degraded streaks, photorealistic cold-time ratio and memory-pressure events. One isolated low-FPS frame/minimum no longer permanently condemns an otherwise stable long session.
- Added healthy/severe-window counts and maximum degraded streak telemetry to diagnostic exports, together with active burn-in duration and recent-vs-lifetime SIM DROP state.
- Preserved the v9.5.1 device-bound controller mapping and controller lifecycle neutralization.
- Full accumulated regression suite passed: 40 Node modules including a dedicated rolling-window burn-in regression.
- Honest boundary: the corrected burn-in accounting is deterministic/source validated; its grade still becomes meaningful only after a sustained real Windows/Cesium session.

v9.5.1 - Burn-In Diagnostics / Controller Identity Hardening

- Hardened controller mapping against device-enumeration changes. A calibrated mapping is now bound to the saved controller identity instead of being applied to whichever gamepad happens to enumerate first.
- If the mapped controller is absent while another USB game controller is connected, the simulator refuses to apply the saved axes to the wrong device and clearly asks for the mapped hardware or a fresh guided setup.
- Gamepad disconnect/swap paths now clear cached input immediately, neutralize stale controller state, refresh the controller UI, and write connection/disconnection/device-switch events into the 60-second diagnostic black box.
- Added controller lifecycle telemetry to diagnostic exports: calibrated device, active device, connected-device list, connection/disconnection counts, device-switch count and stale-input neutralization count.
- Added a live BURN-IN HEALTH grade to Systems & Controls. After a learning period it evaluates sustained 5-second performance windows instead of a single instantaneous FPS reading.
- Burn-in aggregation records minimum observed FPS, minimum 1% low, degraded-window count, accumulated near-field cold time, memory-pressure events and a histogram of runtime bottleneck classifications. These aggregates are included in diagnostic exports for long target-machine sessions.
- Fixed a real packaging omission inherited from v9.5.0: the runtime preflight logic and styling existed, but the launch HTML did not actually expose the BETA COMPATIBILITY PREFLIGHT card. v9.5.1 now visibly presents preflight state/detail plus RE-RUN CHECK.
- Updated the World Hub milestone label to 9.5 and normal-facing Systems copy to describe the current beta-candidate hardening instead of stale milestone wording.
- Preserved fixed-step 120 Hz AIR physics, corrected YS yaw/control conventions, YS mouse-stick, RMB free-look, Fixed Wing and Helicopter dynamics, ROAD physics, Shadow DOM map/cache, Auto Graphics, live-weather plumbing, trusted photorealistic collision and near-field-first streaming.
- Full accumulated regression suite passed: 39 Node modules including the new burn-in/controller regression. Runtime validator reports 440 unique simulator UI IDs and all 88 aircraft valid.
- Honest boundary: controller identity/lifecycle behavior is source/regression validated here; physical HOTAS/gamepad/pedal feel and Windows USB enumeration behavior still require target-machine testing. Burn-in grading becomes meaningful only during a real sustained session.

v9.5.0 - Beta Candidate / Compatibility & Photorealistic Quality-Debt Hardening

- Promoted the pre-beta line to a beta-candidate milestone without changing the proven flight equations. Fixed-step 120 Hz AIR physics, corrected YS yaw/control conventions, YS mouse-stick, RMB free-look, Fixed Wing and Helicopter dynamics, ROAD physics, Shadow DOM map/cache, Auto Graphics and live-weather plumbing remain intact.
- Added a visible BETA COMPATIBILITY PREFLIGHT on the launch screen. It checks WebGL2, Cesium runtime availability, Web Audio, service-worker support, persistent profile storage, online state, CPU thread hints and available host RAM before world preparation.
- Preflight distinguishes hard blockers from degradable warnings. Missing WebGL2/Cesium prevents PREPARE WORLD; lack of Web Audio, service-worker caching, persistent storage, network connectivity or generous hardware headroom is reported as a warning so the simulator can continue in a bounded degraded mode where appropriate.
- Added a manual RE-RUN CHECK action and automatic preflight during startup and immediately before world preparation, preventing a stale capability result from being treated as authoritative.
- Added measurable photorealistic quality debt: the runtime tracks the current nearby-3D cold interval, total accumulated cold time, longest cold interval, recovery count and last-ready transition instead of exposing only a binary READY/REFINING state.
- Near-field diagnostics now show how many seconds the immediate textured 3D world has been refining and report cumulative quality debt once recovered. Diagnostic exports include the complete quality-debt and beta-preflight state.
- Living World load shedding is now more aggressive after a sustained (>8 s) nearby-3D cold interval, reducing decorative traffic to roughly 12% of its requested tier while the textured building bubble recovers. Physics, controls, collision and near-field world refinement remain higher priority.
- Performance advice now explicitly distinguishes prolonged world-stream recovery from short normal refinement so dense-city stutter investigations have better evidence.
- Full accumulated regression suite passed: 38 Node modules including a dedicated v9.5.0 beta-candidate regression. Runtime validator reports 439 unique UI IDs and all 88 aircraft valid.
- Principal aircraft catalog/model/animation/material payloads are semantically identical to v9.4.9 apart from intended top-level release-version metadata.
- Honest boundary: browser capability/preflight logic and quality-debt accounting are validated here; actual photorealistic settlement speed, live provider availability and target Windows GPU/frame-pacing behavior remain target-machine validation items.

v9.4.9 - Beta Experience / Deployment Readiness Hardening

- Split startup into two explicit stages: PREPARE WORLD performs terrain, vehicle and nearby-world loading while the simulation remains paused; ENTER WORLD starts physics only after preparation.
- Added a deployment-readiness card with separate status for nearby 3D, terrain, vehicle assets and the RAM-aware buffer plan.
- Added a photorealistic near-field launch gate. When Photorealistic 3D is active, the primary Enter action remains disabled while close geometry is still refining; users can make an explicit ENTER WHILE 3D STREAMS override rather than being launched automatically into a cold scene.
- Added a prepared-configuration signature. If aircraft, mode, graphics, deployment, weather or other launch configuration changes after preparation, the prepared world is rejected and must be prepared again instead of launching mismatched state.
- Made world fallback status explicit. If a requested Photorealistic 3D deployment cannot remain on the photorealistic provider path, the readiness card reports FALLBACK WORLD, disables the normal Enter action and labels fallback as a recovery mode rather than equivalent to the textured real-world building target.
- Preserved the user's Photorealistic 3D selection when the named-place/open-geocoder compatibility path requires a fallback; the UI no longer silently rewrites the user's world-detail selector to OSM.

- Simplified ROAD setup further by hiding AIR-only deployment altitude, flight-assist, mission, airspace, flight-model, aircraft-damage and G-effect controls when ROAD is selected. Time, weather, audio, Living World and shared world settings remain available.
- Updated first-run onboarding to the actual four-step flow: choose domain, search location, prepare world, enter when ready. Removed remaining launch-page wording that described ROAD as experimental.
- Preserved fixed 120 Hz AIR physics, YS yaw/control conventions, YS mouse-stick, RMB free-look, Fixed Wing and Helicopter dynamics, Auto Graphics, live weather, trusted photorealistic collision, near-field-first streaming, Living World, ROAD physics, recovery/profile systems and the Shadow DOM map/cache architecture.
- Full accumulated regression suite passed: 37 Node modules including a dedicated v9.4.9 Beta Experience regression. Runtime validator reports 436 unique UI IDs and all 88 aircraft valid; 93 JSON files parse successfully.
- Principal aircraft catalog/model/animation/material payloads are semantically identical to v9.4.8 apart from intended top-level release-version metadata.
- Packaged local-server smoke tests returned HTTP 200 for map health, system info, simulator shell, launcher, aircraft catalog and map-cache status as runtime v9.4.9.
- Honest boundary: live Windows/Cesium/GPU photorealistic settlement timing, visual quality and provider availability still require target-machine validation. Production photorealistic address-search/provider compatibility is an explicit v9.5.1 blocker rather than being hidden behind a generic-building fallback.

v9.4.8 - Long-Session Performance / Recovery Redundancy Hardening

- Replaced the frame-time diagnostic history path with a bounded 600-sample ring buffer. The previous path repeatedly shifted/spliced history and could generate avoidable allocation churn during long sessions.
- Throttled 1% and 0.1% low calculations to once per second. Percentile diagnostics still cover the recent 600-frame window, but sorting no longer runs on every rendered frame once the history fills.
- Added a diagnostic counter for percentile recomputations so exported black-box reports can confirm the bounded cadence during performance investigations.
- Added a redundant recovery snapshot key. Before each new primary recovery snapshot is committed, the previous valid primary snapshot is rotated into a backup slot.
- Recovery restore now validates the primary snapshot first and automatically falls back to the previous valid backup if the primary is malformed, stale or otherwise unusable.
- The recovery card visibly labels backup-derived recovery state instead of presenting it as the newest primary snapshot.
- Clearing recovery now removes both primary and backup snapshots so an intentionally cleared session cannot reappear from the fallback copy.
- When the browser tab backgrounds, the simulator now forces a recovery snapshot before suspending optional controller-test polling and presentation work. Normal page-hide flushing remains intact.
- Preserved the v9.4.7 storage-resilience/profile-transaction protections, fixed 120 Hz AIR physics, corrected YS yaw/control conventions, YS mouse-stick, Fixed Wing and Helicopter dynamics, Auto Graphics, live weather, trusted photorealistic collision, near-field-first streaming, Living World, ROAD physics and Shadow DOM map/cache architecture.
- Full accumulated regression suite passed: 36 Node modules, including a dedicated redundant-recovery/frame-diagnostics regression. Runtime validator reports 420 unique UI IDs and all 88 aircraft valid.
- Principal aircraft catalog/model/animation/material data remain unchanged from v9.4.7 apart from intended release-version metadata.
- Live Windows/Cesium/GPU/provider behavior and real browser crash semantics remain target-machine validation boundaries; this release validates source behavior, recovery selection logic, static integrity and packaged HTTP surfaces.

v9.4.6 - Persistence / Profile Portability / Session Hardening

- Replaced release-specific browser-storage keys for onboarding, setup preferences and fleet favorites/recent history with stable version-independent namespaces.
- Added one-time migration from recoverable v9.4.x storage keys so existing favorites, recent aircraft, onboarding state and setup preferences survive release upgrades instead of silently resetting.
- Hardened session-recovery loading: stale/malformed snapshots, impossible latitude/longitude/altitude values and invalid route legs are rejected or normalized before use. Recovery routes remain bounded to 24 legs and the active-leg index is clamped.
- Added explicit controller-input-test lifecycle cleanup. The optional live tester now stops when its panel closes, the browser tab backgrounds or the session returns to setup, eliminating hidden polling.
- Added portable local Profile Backup in World Hub. Export/import covers setup settings, controller mapping, fleet favorites/recent history, saved places, saved routes, local logbook, current route and onboarding completion.
- Profile imports validate product/schema, cap the file at 2 MB, sanitize geographic points/routes and filter aircraft references against the installed catalog.
- Profile exports deliberately exclude provider credentials, cached map/photorealistic imagery and transient recovery snapshots. The UI warns that saved locations can contain precise coordinates.
- Added browser-storage health/usage reporting through the Storage API when available.
- Refined normal-facing Systems wording while preserving advanced diagnostics and the ROAD beta telemetry surface.
- Preserved fixed 120 Hz AIR physics, YS yaw/control conventions, helicopter dynamics, category-aware audio, Auto Graphics, live weather, trusted photorealistic collision, near-field-first streaming, Living World, ROAD tire physics and Shadow DOM map/cache architecture.
- Full accumulated regression suite passed: 34 Node modules. Runtime validator reports 420 unique UI IDs and all 88 aircraft valid.
- Verified the four principal aircraft-data reports are semantically identical to v9.4.5 apart from intended top-level release-version metadata.
- Browser-profile portability is validated structurally and through the import/export pipeline; final cross-machine browser-file selection remains a target-machine interaction check.

v9.4.5 - Commercial Beta Immersion / Audio & ROAD Presentation Hardening

- Added category-aware off-main-thread procedural audio branches for jet, propeller/turboprop, helicopter and ROAD operation instead of routing every vehicle through one generic engine tone.
- Added dedicated ROAD engine-RPM synthesis, tire/brake/slip response and road-speed wind behavior; ROAD no longer inherits aircraft afterburner/stall/damage audio behavior.
- Helicopter audio keeps rotor-RPM-driven blade content separate from fixed-wing propeller synthesis.
- Added a restrained Living World nighttime ambience bed that is enabled only when road activity is available, nearby photorealistic 3D is settled and Living World is active.
- Added bounded ROAD chase-camera suspension/surface response using the existing ground suspension state; it is presentation-only and does not alter vehicle physics.
- Replaced the normal-facing `GROUND VEHICLE LAB` wording with `ROAD MODE - BETA`; advanced physics diagnostics remain available in Systems without presenting ROAD as a disconnected developer experiment.
- Diagnostic exports now include the active audio category and AudioWorklet availability.
- Preserved fixed 120 Hz AIR physics, YS yaw/control conventions, helicopter dynamics, Auto Graphics, live weather, trusted photorealistic collision, Living World, ROAD tire physics, map/cache architecture and all prior product-hardening systems.

- Full accumulated regression suite passed after updating one legacy ROAD-label assertion to validate the actual ROAD controls/telemetry rather than obsolete wording.
- Live acoustic balance, road-surface camera feel and city ambience remain target-machine validation items because this container cannot reproduce the user's speakers/headphones, Windows audio stack or live provider scenery.

v9.4.4 - Product Polish / Fleet Memory / Road HUD

- Added persistent AIR fleet favorites with explicit star controls; favorites are stored locally and never alter aircraft physics or asset data.
- Added a Recently Flown fleet scope backed by a bounded 16-aircraft recency list, making large-fleet navigation faster without guessing propulsion/type from names.
- Reworked aircraft-card construction to use DOM text nodes/buttons for the new favorite controls rather than injecting user-controlled labels.
- Added a focused ROAD HUD showing speed, gear, current road/surface authority and grip/ABS/TCS state so normal driving no longer requires keeping the Systems developer panel open.
- ROAD HUD is lifecycle-bound to Ground Mode and automatically hides when returning to AIR.
- Added a lightweight animated heliport reference beacon by updating the existing retained point primitive instead of reallocating geometry every frame.
- Preserved airport/heliport activity hysteresis and memory-pressure load shedding from v9.4.3.
- During release engineering, caught and corrected an unsafe broad version-replacement that had touched numeric aircraft JSON values; the complete data directory was restored from v9.4.3 and verified before packaging. Only safe top-level data-report version metadata was advanced to v9.4.4.
- Full accumulated regression suite passed: 32 Node modules; runtime validator reports 416 unique UI IDs and all 88 aircraft valid.
- Live Windows/Cesium visual evaluation remains required for Ground HUD ergonomics and heliport beacon brightness/occlusion in actual photorealistic scenes.

v9.4.3 - Heliport & Session Resilience Hardening

- Made heliports first-class active OPS facilities for helicopters instead of navigation-only destinations.
- Added helicopter heliport bearing, distance, relative-altitude and heading-error guidance without pretending heliports have runway/localizer data.
- Added performance-gated nighttime heliport reference lighting: green perimeter, white H reference and a red reference beacon aligned to the facility coordinate.
- When trusted photorealistic 3D is settled, heliport reference lighting prefers sampled rendered scene height.
- Added activity hysteresis: transient frame/world/memory pressure hides runway/heliport primitives rather than repeatedly destroying and recreating them.
- Extended the long-session heap watchdog with a bounded 45-second decorative load-shed window. Living World vehicle targets and night/facility decoration yield before physics, collision or nearby photorealistic 3D quality.
- Added in-sim session uptime, JS heap, heap peak and memory-mitigation telemetry where the browser exposes it.
- Diagnostic exports now include facility-activity mode and memory-mitigation/load-shed state.
- Clarified helicopter-facing UI terminology while preserving AIR as the top-level aviation category and ROAD as the separate ground domain.
- Full accumulated regression suite passed: 31 Node modules; runtime validator reports 410 unique UI IDs and all 88 aircraft valid.
- Windows GPU/Cesium visual placement remains a target-machine validation boundary.

v9.4.2 - Night Operations & Airport Activity Hardening

- Added a bounded active-runway night-light layer: runway edge lights, green threshold lights, red runway-end lights, and a lightweight approach-light sequence.
- Airport activity is strictly distance/performance/near-field gated and yields when nearby photorealistic 3D is still refining or frame rate is under pressure.
- Airport light primitives are explicitly removed on runway/airport changes to prevent stale primitives and long-session accumulation.
- Diagnostic exports now include the active airport-light primitive count.
- Corrected stale catalog cache-buster references to the current runtime generation.

v9.4.1 - 2026-08-07 - Product Hardening / First-Run / Controller Confidence

First-run product experience

- Added a first-run onboarding overlay that reduces setup to four understandable steps: choose AIR or ROAD, search a real place, initialize the area, and launch.
- AIR onboarding explicitly keeps Fixed Wing and Helicopter inside the same AIR domain. ROAD is presented as a separate ground-vehicle domain sharing the same world.
- Onboarding is browser-local, non-blocking after completion, and does not expose advanced renderer or physics tuning.

Controller confidence

- Kept the guided natural-movement controller calibration from v9.4.0 and added a live input test surface.
- The test shows calibrated roll, pitch, yaw and throttle response in real time so a user can verify direction/range without understanding browser axis numbers.
- Controller test mode is optional and does not interfere with keyboard or YS mouse-stick input.

AIR fleet browsing

- Added a propulsion filter to the aircraft library: Jet, Propeller/Turboprop, and Helicopter.
- Propulsion classification is derived from the aircraft data (`airClass`, propeller-power flags and thrust data) rather than from the ambiguous word rotor.
- Aircraft cards now expose a propulsion tag while preserving role/category filtering and search.

Long-session diagnostics

- Added a bounded session-health tracker for browsers that expose JS heap telemetry.
- Tracks current/peak JS heap and records large sustained heap-growth events into the existing 60-second black-box event stream.
- Diagnostic exports now include uptime, current heap, peak heap and memory-pressure event count when the browser exposes those metrics.
- Browsers that do not expose `performance.memory` continue normally with no feature dependency.

Preserved foundations

- Fixed 120 Hz AIR player physics, correct YS yaw/control conventions, YS mouse-stick, RMB free-look, helicopter mechanics, live weather, photorealistic textured 3D priority, trusted building collision, Living World, Ground Mode, route/cache systems, World Hub and Auto Graphics are preserved.

Validation

- Full accumulated Node regression suite: PASS after normalizing inherited harnesses to the actual v9.4.1 runtime filenames.
- Dedicated v9.4.1 product-hardening regression: PASS.
- JavaScript syntax and Python compilation: PASS.
- Runtime validator: PASS - 405 unique UI IDs, 88 aircraft assets.

Boundary

- Live controller movement still requires target hardware for tactile/interaction judgment; source/mapping/test-display logic is validated here.
- JS heap telemetry is browser-dependent and is treated as optional diagnostics rather than a correctness dependency.
- Live photorealistic/provider/GPU behavior remains a target-machine validation item.

v9.3.9 - 2026-08-07 - Living World / Ground Fidelity Hardening Pass

Ground vehicle physics

- Replaced the original kinematic-only Ground Vehicle Lab steering path with a separate dynamic bicycle/tire model using front/rear slip angles, friction-bounded lateral tire forces, yaw inertia and lateral velocity.
- Added traction-limited drive force, automatic six-speed gearing, engine RPM, braking, reverse drive torque from rest, ABS/TCS-style state reporting, aerodynamic drag and rolling resistance.
- Added weather-sensitive road grip: live precipitation reduces available pavement friction; off-road surfaces retain substantially lower grip and higher resistance.
- Added road-grade force so hills affect acceleration/deceleration rather than only changing visual height.
- Added bounded vertical suspension/heave filtering and road-grade vehicle pitch for smoother ground presentation over streamed surface-height noise.
- Corrected reverse movement-vector math so backing up with lateral slip follows the actual local velocity vector.
- Added live Ground Mode telemetry for speed, gear, RPM, slip angle, surface authority and grip/ABS/TCS state.

Road-mode workflow

- Added `DRIVE TO ACTIVE DESTINATION`. Any active address/place/airport/heliport/coordinate Direct-To target can now be used as the road-network fetch/spawn reference.
- Road Mode still uses the photorealistic streamed roadway as the visible world. OSM geometry remains an invisible physical/navigation layer and does not replace textured roads/buildings with generic geometry.
- Ground Mode continues to publish its position into the shared map/weather/streaming world state and preserves the aircraft snapshot for return.

Living World fidelity/performance

- Added distance-tier traffic presentation: close road movers use larger body points, medium traffic collapses further, distant movers become minimal markers/lights, and objects beyond useful range are hidden.
- Headlight/tail-light visibility is distance gated separately from vehicle bodies so dense nighttime road streams remain cheap.
- Existing road-class weighting, connected-road adjacency, local-time density, near-field yielding and FPS load shedding are preserved.
- Nearby photorealistic buildings/terrain and collision remain higher priority than Living World density.

Validation

- Dedicated v9.3.9 Ground Fidelity regression: PASS, including tire-force saturation, reverse drive sign, destination road spawn, suspension, grade force, traffic LOD and telemetry hooks.
- Full accumulated Node regression suite: PASS.
- JavaScript syntax / Python compilation: PASS.
- Runtime UI IDs: 355 unique.
- Aircraft assets: 88 valid.

Boundary

- Actual tire feel, road alignment, traffic visual density and structure collision in a live dense city still require target-machine Windows/GPU/network validation with real photorealistic and OSM provider responses.

v9.3.8 - 2026-08-07 - Auto Graphics / UX Simplification Pass

Graphics and performance UX

- Replaced the normal launch-time graphics wall with one user-facing GRAPHICS MODE selector: Auto Recommended, Auto Prioritize Visual Quality, Auto Prioritize Smoothness, or Expert Manual.
- Moved World Detail, manual renderer profile, streaming policy and HUD-style controls under a collapsed ADVANCED DISPLAY & STREAMING - EXPERT section.
- Added an in-flight AUTO GRAPHICS card showing current quality level, health, resolution scale, near-field world state, and the reason for the latest automatic decision.
- Added a RE-RUN AUTO CONFIG action.

Automatic quality governor

- Extended dynamic resolution into a whole-profile automatic ladder: SAFE -> BALANCED -> HIGH -> ULTRA.
- Initial selection considers device memory, CPU cores, display pixel load, physical RAM and available RAM.
- Runtime promotion/demotion considers average FPS, rolling 1% lows, long-task pressure, memory pressure and near-field 3D readiness.
- Uses sustained evidence and long cooldowns to avoid profile oscillation.
- Nearby photorealistic building/terrain refinement remains higher priority than quality promotion.
- AUTO owns SMART streaming; Expert Manual retains underlying controls.

Validation

- Full accumulated regression suite: PASS.
- v9.3.8 Auto Graphics regression: PASS.
- Runtime UI IDs: 348 unique.
- Aircraft assets: 88 valid.

Boundary

- Final profile behavior on the user's Windows GPU/display/live photorealistic stream requires target-machine observation.

v9.3.7 - Living World / Ground Vehicle Foundation / Pre-Commercial Hardening

- Added a performance-budgeted Living World layer driven by real OpenStreetMap road geometry. Road data is requested through the local server, cached in bounded RAM and disk caches, and attributed in the simulator UI.
- Added adaptive perceptual road traffic with quality modes OFF / LIGHT / REALISTIC / DENSE. Traffic density scales down automatically with altitude, low FPS and cold near-field 3D so it never outranks aircraft physics, collision or nearby photorealistic refinement.
- Raised the dense traffic budget to a maximum 420 simulated road movers before adaptive load shedding. Traffic is biased toward motorway/trunk/primary roads and varies with approximate local solar time, including rush-hour and late-night density factors.
- Replaced random traffic segment hopping with an endpoint adjacency graph derived from the loaded real road network. Vehicles now prefer connected forward routes and lower-turn continuations at intersections.
- Added separate nighttime headlight and tail-light points for road traffic. Vehicle-body markers become subdued at night so flowing white/red road light streams provide the primary distant traffic illusion.
- Added a low-cost nighttime urban activity-light layer alongside real road corridors. It overlays light points on the photorealistic world without replacing or recoloring the real textured building meshes.
- Added an experimental Ground Vehicle Lab with a separate bicycle-model road physics loop rather than reusing aircraft physics. Ground Mode supports throttle, braking/reverse, speed-sensitive steering, rolling/aerodynamic resistance and stronger off-road drag/speed limits.
- Ground Mode projects the vehicle onto the nearest real road segment using true point-to-segment geometry rather than endpoint snapping. A soft road-center correction only operates when the vehicle remains within the inferred road corridor, preserving manual steering and allowing off-road departure.
- Ground surface height is filtered for smoothness. When settled photorealistic 3D is trustworthy, Cesium scene height is preferred for the road surface; otherwise the mode falls back to the cached road/terrain height path.
- Added forward Ground Mode 3D obstacle probing. When the photorealistic near field is trusted, a building/structure height discontinuity ahead can stop/rebound the test vehicle instead of allowing it to pass through the loaded structure.
- Ground Mode now publishes its active position/velocity/heading into the shared geospatial state, so map centering, live weather, near-field refinement, predictive streaming and diagnostics follow the car while preserving the aircraft snapshot for return.
- Added Living World diagnostics for road provider/cache state, road segment count, active road traffic, night-light state, Ground Mode road/off-road state and photorealistic/coarse surface trust.
- Added dedicated Pass 6 regression coverage for road-network caching/attribution, load shedding, road adjacency, head/tail lights, road projection, separate ground physics, photorealistic surface priority, off-road behavior and ground-vehicle structure collision.
- Added COMMERCIAL_READINESS.md and THIRD_PARTY_NOTICES.md. They explicitly separate technical readiness from licensing/provider readiness and mark unresolved redistribution/credential/provider-plan work as blockers before a paid/public release.
- Preserved the v9.3.6 live-weather/atmosphere coupling, guarded trim compensation, multi-waypoint navigation, rotorcraft controls, trusted aircraft/building collision, 120 Hz fixed-step player physics, correct YS control conventions, YS mouse-stick, RMB free-look, near-field-first photorealistic streaming and cumulative changelog/PDF release discipline.

v9.3.6 - Flight Deck / Live Weather / Accessible Realism / 3D Collision Pass

- Added LIVE REAL-WORLD weather as the default environment mode. The local server queries Open-Meteo current conditions by aircraft latitude/longitude, caches rounded cells briefly, and the client refreshes automatically every two minutes or after roughly 12 km of movement.

- Added an aesthetic live-weather card showing temperature, feels-like temperature, condition, wind/gust, humidity, pressure, visibility and freshness, with manual refresh and manual weather presets retained.
- Connected live temperature and mean-sea-level pressure to the atmosphere model so local weather changes air density and speed of sound rather than acting as display-only data; real wind/gust/visibility/precipitation also feed the existing flight/environment model.
- Added guarded neutral-trim compensation for Guided/Realistic Adaptive/Performance presets. It activates only after stable, low-bank, near-level hands-off flight and slowly counters unwanted vertical drift/nose droop; Full Manual/RAW flight remains untouched and intentional climbs/descents are not converted into altitude hold.
- Added a persistent multi-waypoint route planner with up to 24 legs, active-leg selection, reorder/delete/reverse controls, remaining distance/ETA, automatic waypoint advancement and local route persistence.
- Connected airport, heliport, address and coordinate Direct-To targets to the route workflow and retained explicit route-corridor cache preloading.
- Added speed-sensitive tactical-map auto zoom with an explicit on/off control while preserving the reliable Shadow DOM raster renderer.
- Added a dedicated rotorcraft control lab with cyclic response, pedal response, collective curve and low-speed rate-damping SAS. The SAS damps rates only; it does not lock position or altitude.
- Added plain-language simulation presets: Guided Realism, Realistic Adaptive, Full Manual and Performance Realism. Realistic Adaptive is category-aware and keeps enhanced physics, realistic component damage, realistic G modeling and full audio active while choosing sensible stability assistance for the aircraft type.
- Added an expandable settings glossary and in-flight Simulation Experience panel explaining FBW, SAS, RAW input and collective curve behavior so advanced tuning is optional rather than required knowledge.
- Strengthened streamed-structure collision. When nearby photogrammetry is settled, collision uses a trusted nine-point aircraft-envelope sweep covering belly, nose, tail, both wings, top and three forward lead probes to reduce high-speed tunneling through buildings.
- When nearby 3D is still refining, collision falls back to the existing lower-cost coarse probe path rather than trusting incomplete geometry. Structure impacts feed the existing component-damage/crash system and aggressively shed velocity on contact.
- Added live 3D COLLISION diagnostics showing trusted/coarse probe mode.
- Preserved the fixed 120 Hz player-physics loop, corrected yaw/control conventions, YS mouse-stick, RMB free-look, physical 1:1 aircraft scale, helicopter autorotation/RBS/LTE physics, animation hierarchy fixes, near-field-first streaming, persistent map cache and heliport-aware navigation.

v9.3.5 - World Cache / Route Corridor / Heliport Operations Pass

- Added a bounded World Cache Manager in Flight Systems with live RAM-cache entries/bytes, disk-cache entries/bytes, disk budget, refresh, RAM-clear and disk-clear controls.
- Added `/map-cache-status` and `/map-cache-clear` local-server endpoints; cache health is now inspectable without reading internal files.
- Added explicit destination-route map preloading through `/map-route-prefetch`. It samples the active Direct-To corridor, fetches a bounded tile set with at most four server workers, and stores successful provider tiles in the existing persistent disk/RAM cache. It is user-triggered so it cannot silently compete with nearby world refinement.
- Route preload size adapts to measured network throughput and reports ready/fallback/byte totals in Navigation and Flight Systems.
- Extended automatic predictive map warming to incorporate the active Direct-To route in addition to current velocity/heading, reducing wrong-direction prefetch during turns toward a destination.
- Tightened nearby photorealistic readiness: low-altitude HIGH/ULTRA flight now requires seven consecutive settled globe/building checks, while other profiles require five. Launch-time inner-world readiness is now profile dependent: 90% Ultra, 86% High, 80% Balanced and 74% Safe.
- Expanded the optional global OurAirports worker to ingest heliport records. Helicopters can search/navigate to worldwide heliports when the global database is loaded. Fixed-wing nearest-airport/result logic explicitly excludes heliports so airplane

operations do not select rooftop/heliport destinations accidentally.

- Added helicopter fixed-skid ground handling separate from wheeled-aircraft steering: skid aircraft use stronger longitudinal/lateral friction, no fake nose-wheel steering, and can accumulate skid/gear side-load damage during high-collective lateral ground motion.
- Added dedicated regression coverage for cache endpoints, explicit route preloading, route-aware prediction, heliport ingestion/fixed-wing exclusion, stricter near-field readiness and helicopter skid handling.
- Preserved 120 Hz fixed-step player physics, bounded hitch recovery, corrected YS yaw/control conventions, YS mouse-stick behavior, RMB free-look, physical 1:1 aircraft scale, v9.3.4 animation proxy composition/material tuning, rotorcraft autorotation/RBS/LTE behavior, Shadow DOM map architecture, terrain/map watchdogs and near-field-first streaming.

v9.3.4 - Airframe Materials / Animation Hierarchy / Rotorcraft Envelope Pass

- Audited all 88 external aircraft GLBs and confirmed the converted fleet uses vertex-color geometry with one material per aircraft and no base-color/normal-map textures. No synthetic texture quality is claimed.
- Retuned external-aircraft PBR metallic/roughness factors by airframe category while preserving geometry, vertex colors, physical 1:1 scale and the lightweight no-texture asset budget.
- Added `data/material_tuning_report.json` documenting the exact bounded material profile applied to every aircraft.
- Expanded `data/model_quality_report.json` with current post-tuning material state and an objective model-quality score for prioritizing future model replacements.
- Added a fleet-wide animation hierarchy audit across 1,506 declared animation nodes. It found 28 names without direct GLB bindings: 12 inert/no-motion nodes and 16 active single-child parent transforms created by hierarchy flattening.
- Added a constrained runtime proxy-composition path for those 16 active single-child parent transforms, restoring parent motion while preserving the child node's own local control-surface transform. The audit now reports zero active unresolved hierarchy transforms.
- Added an in-simulator SWEEP MOVING PARTS diagnostic that temporarily pauses simulation, exercises gear/flaps/spoilers/pitch/roll/yaw/lights, then restores the exact pre-sweep device/control state.
- Upgraded the airframe audit readout to distinguish direct bindings, hierarchy proxies, inert missing nodes and genuinely unresolved active nodes.
- Deepened helicopter edge-of-envelope behavior with retreating-blade-stall tendency tied to advance ratio, collective and rotor RPM; it reduces rotor efficiency/control authority and adds bounded buffet.
- Added tail-rotor authority degradation from rotor RPM, density and strong lateral flow, plus a bounded loss-of-tail-effectiveness risk state when pedal demand exceeds available authority.
- Added flare-assisted autorotation airflow drive: nose-up flare with forward airspeed contributes to rotor-energy recovery when shaft power is low.
- Added rotorcraft-specific flight-deck telemetry for rotor RPM, collective and tail-rotor authority, plus RBS/tail-authority warnings in the existing HUD warning path.
- Preserved 120 Hz fixed-step player physics, corrected yaw/control conventions, YS mouse-stick behavior, RMB free-look, near-field/predictive streaming, Shadow DOM map architecture, terrain/map watchdogs and the v9.3.3 autorotation energy model.

v9.3.3 - Airframe Quality / Autorotation / Scale Lab Pass

- Added engine-out helicopter autorotation with airflow-driven rotor RPM instead of forcing rotor speed toward zero when shaft power is lost.
- Added collective-vs-rotor-energy behavior: high collective under engine-out conditions consumes rotor RPM while descent airflow and forward flow can sustain it.
- Added bounded stored-rotor-energy contribution to transient lift and a LOW ROTOR RPM warning/state.

- Corrected helicopter torque bias to follow shaft power rather than total aerodynamic rotor power during autorotation.
- Added an in-simulator physical reference-scale lab with 2 m human, 4.5 m vehicle and 10 m reference objects.
- Added an in-simulator airframe audit reporting measured GLB dimensions, animation-node binding coverage and animation classes.
- Added `data/model_quality_report.json`, a build-time inventory of all 88 aircraft covering GLB dimensions, material/texture counts, PBR factors and animation-class metadata.
- Restored the v9.3.2 predictive/frame-pacing diagnostic fields to the visible Flight Systems performance panel and retained one-click 60-second diagnostic export.
- Preserved physical 1:1 aircraft scale, 120 Hz player physics, YS control conventions, near-field world priority and predictive streaming.

v9.3.2 - Predictive Streaming / Diagnostics Foundation

- Added multi-horizon route prediction (8-60 seconds depending on measured transfer conditions) for map warming ahead of the aircraft.
- Added network-aware predictive prefetch budgets so slow links reduce look-ahead depth instead of competing with the near-field quality bubble.
- Preserved near-field-first policy: predictive/background warming yields whenever nearby 3D is refining, FPS is under pressure, or long-task pressure rises.
- Added rolling transfer-rate observation for local streamed map requests.
- Added frame-pacing diagnostics with estimated 1% and 0.1% low FPS from the recent frame-time window.
- Added live bottleneck classification: STABLE, MAIN THREAD, NETWORK, WORLD STREAM, GPU, MAP I/O, SIMULATION, or BACKGROUND.
- Added a 60-second black-box recorder sampled at 4 Hz with aircraft position, attitude, speeds, G, frame state, terrain/map state and current bottleneck.
- Added one-click JSON diagnostics export containing runtime/system summary, streaming state and the black-box/event history.
- Added dedicated regression coverage for predictive streaming, network gating, frame pacing, bottleneck diagnostics and black-box export.
- Added the first formal cumulative `CHANGELOG.md` and `YS_LIVE_WORLD_CHANGELOG.pdf` release artifacts.
- Preserved 120 Hz fixed-step physics, corrected yaw/control conventions, YS mouse-stick behavior, RMB free-look, v9.3.1 rotorcraft model, 1:1 model scale and near-field streaming priority.

v9.3.1 - Rotorcraft / Physical Scale / Near-Field Streaming Overhaul

- Added high-priority near-field refinement around the aircraft using Cesium globe/3D-tile readiness.
- Tightened nearby terrain/building SSE while the near field is cold and removed foveated relaxation during refinement.
- Suppressed nonessential route-map and neighboring-aircraft prefetch while nearby world content is still refining.
- Strengthened launch warm-up with stricter inner-viewpoint settle checks and near-field readiness reporting.
- Added NEAR 3D READY/REFINING diagnostics.
- Preserved physical 1:1 aircraft scale, measured dimensions for all 88 models, rotorcraft physics/animation/audio, FOV controls and address-to-waypoint navigation.

v9.3.0 - Rotorcraft / Physical Scale / Presentation Overhaul

- Removed Cesium minimum-pixel aircraft enlargement so external aircraft remain physically 1:1 against roads/buildings.
- Measured GLB dimensions for all 88 aircraft and used them in camera/body geometry.
- Refined aircraft PBR metallic/roughness presentation while preserving source colors.
- Split fleet browsing into airplane/helicopter categories.
- Added continuous generic animation for props/rotors, wheels, nose-wheel steering, lights and existing control-surface/gear channels.
- Added rotorcraft-specific rotor inertia/RPM, collective, cyclic thrust vector, effective translational lift, induced flow, rotor ground effect, VRS tendency/recovery, power-limited thrust, torque/anti-torque and tandem behavior.
- Added rotor RPM/collective/VRS HUD state and rotor procedural audio.
- Added persistent 40-95 degree FOV controls and permanent pitch/bank HUD indication.
- Added in-game address/place/coordinate search to Direct-To waypoint, map focus and recenter workflow.
- Did not add unverified/unlicensed external helicopter models.

v9.2.9 - Reliability / Aircraft Animation Pass

- Restored terrain pending watchdog and spatial-authority expiry.
- Added bounded timeout to map-health polling.
- Fixed legacy DNM state visibility so retractable components such as F-22 gear can visually disappear when their data requests it.
- Extended tactical map zoom-out to Z3.
- Advanced runtime/cache revision references and aborts map health polling during cleanup.

v9.2.8 - Terrain / Map Watchdog Pass

Historical release record retained; the exact packaged artifact is not currently archived in this workspace.

- Added a 2.8-second terrain-request watchdog so a stalled request cannot block subsequent sampling.
- Added geographic authority tracking/expiry for accepted terrain samples.
- Added a 2.2-second abortable timeout for map-health polling.
- Normalized runtime/cache revision markers to reduce mixed-version browser assets.

v9.2.7 - Reliability / Flight Runtime Pass

- Reworked severe-hitch recovery to retain at most two fixed physics steps and discard only excess accumulated time.
- Added cumulative SIM DROP diagnostics.
- Hardened asynchronous terrain sampling with sequence invalidation and distance-based stale-result rejection.
- Suspended/resumed Web Audio across background-tab lifecycle and invalidated stale terrain work.
- Added predictive traffic closest-point-of-approach over a bounded 90-second horizon.
- Preserved the v9.2 Shadow DOM map/cache/deployment architecture.

v9.2.6 - Corrective Map / Deployment Pass

- Fixed text-entry isolation so normal spaces/arrows work in search controls.
- Reworked deployment-map pointer/pin synchronization and map-control event isolation.
- Added consistent deployment tile namespace/style and safer search-result rendering.
- Added richer reverse-geocoded location details.
- Expanded tactical map zoom and added independent pan/follow/recenter behavior.
- Fixed DNM animation visibility for F-22 gear on the documented corrective branch.
- Split expensive area preparation from flight launch so initialization/prebuffering is not unnecessarily repeated.
- Preserved the established 120 Hz physics/control conventions.

v9.2.5 - Deep Audit / Reliability Pass

- Prevented preset/custom deployment state leakage and stale runway/final state.
- Re-resolved terrain on restart and added safe air fallback when custom ground terrain cannot be resolved.
- Made aircraft switching transactional and cleaned failed candidates/resources.
- Verified full preload responses and actual Cesium `tilesLoaded` settle state.
- Added RAM-aware warm-up limits and server-side cache-only map promotion.
- Hardened moving-map layer replacement, MIME detection and fallback cache policy.
- Added bounded RAM LRU, striped tile locks, bounded geocode cache and sparse disk pruning.
- Hardened the hidden Windows launcher and version-aware runtime readiness.

v9.2.4 - Global Deployment / Buffering

Detailed historical report is not currently recovered; release artifact name confirms the global-deployment/buffering milestone. Later audit reports confirm this generation introduced RAM-aware deployment planning and staged buffering foundations that were hardened in v9.2.5.

v9.2.3 - Camera Smoothing / Free-Look

Detailed historical report is not currently recovered. Release record identifies this as the camera-smoothing/free-look milestone; later tests preserve RMB free-look and interpolated camera/model presentation.

v9.2.2 - Spawn Buffer / Streaming

Detailed historical report is not currently recovered. Release record identifies this as the spawn-buffer/streaming milestone; its staged preload concepts were subsequently hardened in v9.2.5.

v9.2.1 - Smoothness / Efficiency

Detailed historical report is not currently recovered. Release record identifies this as a smoothness/efficiency pass immediately following the v9.2.0 map-core rewrite.

v9.2.0 - Runtime / Map Core Pass

- Removed the iframe/postMessage tactical-map composition path after black-map compositor failures.
- Added same-document Shadow DOM raster map engine with synchronized transparent Canvas2D overlay.
- Kept heading-up map rotation inside the tile world with upright tactical labels.
- Added local same-origin tile proxy, persistent disk cache and bundled tactical fallback.
- Cached gamepad polling and canvas dimensions and staggered world-collision sampling.
- Preserved enhanced aero, controls, damage, audio, airport operations, traffic and missions.

v9.1.0 - Systems Integration / Trust Pass

- Preserved fixed 120 Hz body-axis physics and corrected YS yaw conventions.
- Added/expanded cached atmosphere, dynamic stall, control compressibility, specific-energy telemetry and pitch trim.
- Added separate engine-core and afterburner spool dynamics.
- Corrected FBW/SAS/RAW and autopilot UI/runtime integration; moved AP capture to F10.
- Backed the Living Airspace UI with low-cost real traffic contacts and conflict logic.
- Added Free Flight, Landing Challenge, Navigation Leg and Intercept Training mission modes.
- Expanded procedural audio inputs and performance diagnostics.

v9.0.0 - Apex Overhaul

- Major integrated rewrite across flight dynamics, controls, audio, rendering cadence, world efficiency, gameplay and HUD.
- Added selectable enhanced aero: induced drag, transonic wave drag, ground effect, dynamic-pressure damping, sideslip restoring force and buffet telemetry.
- Added enhanced FBW envelope behavior and captured-state autopilot.
- Added AudioWorklet procedural/hybrid sound architecture.
- Decoupled fixed physics, HUD, audio and Cesium rendering workloads.
- Added adaptive governor driven by FPS and browser long-task pressure.
- Introduced broader flight-deck/gameplay/diagnostic presentation while retaining the 88-aircraft fleet.

v8.2.0 - Flight Deck / Performance Pass

- Added explicit Cesium render ceilings by graphics profile while preserving 120 Hz physics.
- Added independent bounded audio cadence and reduced paused/background rendering.
- Added live FPS/frame-time/render-scale/world-SSE diagnostics.
- Added adaptive/contextual HUD, HUD scale/brightness controls, PAPI-style glide cue and landing safety alerts.

- Preserved the stable isolated 2D map architecture and existing damage/runway/navigation systems.

v8.1.4 - Map Stabilization

A detailed standalone report is not currently recovered. v8.2.0 explicitly records v8.1.4 as the stable map architecture baseline: static iframe shell, heading rotation inside the iframe tile world, DOM raster tiles, no second WebGL map renderer and tactical-grid fallback.

v8.1.3 - Map Recovery

- Root-caused minimap layout failure to accumulated CSS overriding intended positioning.
- Isolated basemap into its own map frame/CSS.
- Used ordinary DOM image tiles with provider fallback/reuse and tactical-grid backing.
- Kept aircraft/navigation overlays in the parent transparent canvas and avoided a second WebGL map renderer.

v8.0.4 - Launcher Packaging Milestone

Only the recoverable launcher artifact is currently available for this version. It provided a double-click Windows launcher targeting the v8.0.4 shell. Detailed simulator changes are not reconstructed without a build report.

v8.0.3 - Mouse / Photorealistic / Map Reliability Pass

- Implemented pointer-lock relative mouse flight with persistent virtual stick, deadzone/curve and right-click recenter.
- Stabilized photorealistic refinement to reduce parent-tile flashing.
- Added always-available raster map backing/fallback and WebGL context-loss recovery.
- Reduced secondary map-GPU pressure by releasing MapLibre where no longer needed.
- Preserved 88 aircraft, 120 Hz physics, YS stability corrections, damage/G systems and airport/runway operations.

v8.0.2 - Performance Recovery Pass

- Removed recurring viewer resize and other unnecessary main-thread/compositor work.
- Added clear-weather canvas fast path and lazy/reduced map work.
- Rebuilt HIGH graphics profile and stronger emergency recovery thresholds.
- Decoupled HUD/MFD/weather paint cadence and DPR from flight physics/render cadence.
- Made collision/terrain sampling and particle concurrency performance-aware.
- Preserved 88 aircraft, 120 Hz physics, damage/G systems, runway operations and cameras.

v8.0 / v8.0.1 - Reference-Informed Foundation

Detailed build reports are incomplete in the recovered archive. Engineering notes record that v8 retained the YS DAT-driven/body-axis aircraft foundation while introducing componentized damage thinking, explicit degradable graphics tiers, pooled/efficient audio organization and staged open-world loading principles. The v8.0.2 report records v8.0.1 as the immediate predecessor that suffered severe dense-photogrammetry performance pressure.

v7.0 - Recoverable Early Baseline

- Self-contained v7 browser shell.
- 88-aircraft optimized fleet.
- Wind-relative airplane/helicopter airspeed/aerodynamics.
- Gust/turbulence/visibility environment and time/weather controls.
- Optional SAS damping.
- Direct-To navigation with bearing/distance/ETA and HUD/map/cockpit integration.
- 30 built-in airports plus lazy global airport worker.
- Double-click map waypoints, cockpit canopy/dash, dual MFDs, head-look, dynamic FOV and flyby camera.
- Lightweight flight trail, Mach notice, precipitation overlay and versioned service-worker cache.
- Validation included JS syntax, unique UI IDs, all 88 models/animations and local HTTP asset checks.

Validation policy carried forward

Every future release must update this changelog and include a PDF copy. Release claims are limited to code/assets/tests that were actually inspected and validated. Live Windows GPU/Cesium photogrammetry quality, provider latency and target-machine frame pacing remain target-machine validation where the build environment cannot reproduce them.