ProDyn.ai

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Motion design guide · DSM 2.2

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ProDyn motion guide

Motion makes a state change legible. It does not stand in for one.

This chapter connects ProDyn's visual language to authored interaction: a signal is acquired, an item retains its identity through a layout change, a headline resolves, an aperture follows a deliberate input. The aim is memorable, precise work that remains useful when still—not a page full of demonstrations.

Visual guide · Patterns · Engines · Authoring · Verification · Brief · Handoff

Authority and scope

Read the agent manual, canonical tokens, motion registry and font license gate alongside this guide. The manual owns policy; `tokens.css` owns numeric design values; `tokens.json` mirrors them; visible specimens define construction. Implementation notes cannot overrule those sources.

Canonical scope. DSM v2.2 adds M15–M18 through the machine-readable registry, matching manual, token policy and visible specimens. Adopt that integrated revision as a unit, not an isolated draft or laboratory experiment. A library installation or capability-catalog entry is not primitive approval. Do not infer authorization for neighboring effects from these names.

- Preserve M1–M14, including their exact implementations and limits. This add-on does not retune them.
- **M8 remains the default whole-page atmosphere; M1 remains the default polished footer where appropriate.** Use the shared sources, not a shader or library imitation. Quiet reading/task surfaces may justify omitting atmosphere; omission is not permission to replace it with a novel effect.
- M10 remains explicitly technical/diagnostic, not a decorative page grid. M11/M12 require their operational context; never fabricate a live feed to justify them.
- **M13 requires explicit per-page approval**, lazy loading, containment and its static fallback. Another renderer does not provide a loophole around that gate.

- A library is an implementation mechanism, not a new brand primitive. New silhouettes, springs, shaders, scroll spectacles, audiovisual motifs or material behaviors need separate DSM review if the registry does not describe them.

Start with the task and the still

Choose one primary surface before choosing an engine:

Surface	Reader's task	Motion's job	Static baseline
Explore	Understand a relationship	Reveal one cause and consequence	Annotated diagram with ordinary controls
Inspect	Follow a selected object	Conserve identity and location	Selected item and readable detail
Operate	Make a deliberate change	Acknowledge input without delaying it	Immediate state, visible result/error
Monitor	Detect a real change	Localize meaningful new information	Timestamped state and trend; real data only
Learn	Read an argument	Pace an optional illustration	Complete linear text and figures

Write a one-sentence motion brief: **"When [cause], [state changes]; [visual consequence] preserves [what the user must understand]."** If the consequence has no useful referent, remove it or make the artistic purpose explicit and request review.

Design entry, settled, error and reduced/static compositions first. Essential headings, copy, controls and destinations must exist outside canvases, export players and animation callbacks. Do not begin with invisible content that only becomes readable after a successful animation.

Art direction: one foreground event

ProDyn's field is near-black, with ivory type mass, sparse cyan signal and quiet negative space. Use square geometry, hairline separators and deliberate left/asymmetric alignment. Copper and state colors mark exceptions within the manual's restraint limit; do not turn an escalation color into a decorative transition wash.

Build three layers:

1. **Reading layer:** stable type, logical order, controls and focus. Nothing atmospheric crosses or obscures this layer.
2. **Causal layer:** one selected route, conserved item, headline treatment or bounded aperture. Its scale and contrast communicate priority.
3. **Atmospheric layer:** the exact eligible registry implementation, subordinate to the other two. Do not combine unrelated loops merely because they fit behind the text.

Choreograph attention, not just properties. Establish a still; acknowledge input; show the relationship changing; stop in a meaningful pose. Use negative space as the stage rather than adding chrome around every moving object. Repetition should establish a grammar, not identical fade-ups on every section. A strong chapter cut can be immediate.

Typography: Oxanium for display; Departure Mono for short HUD/status roles. Use the canonical body fallback while PP Neue Machina remains license-gated; no PPNM font serving, embedding or outline conversion as a rights workaround. Preserve real text. Weight treatment should strengthen hierarchy, not make a paragraph breathe indefinitely.

Timing and choreography

Read durations and easing from canonical tokens at runtime when JavaScript needs them. Preserve units: CSS durations may be seconds; WAAPI consumes milliseconds; an authored frame count needs the actual project frame rate and a recorded rounding policy. Do not scatter replacement literals throughout an engine adapter.

Role	Existing token starting point	Direction
Acknowledge a local action	`--t-fast`, `--ease-hover`	Immediate semantic response; short visual confirmation
Resolve a bounded change	`--t-med`, `--ease-enter`	Converge on a stable state; no mandatory wait
Deliberate entrance	`--t-slow`, `--ease-enter`	Reserve for hierarchy, not every block
Existing atmosphere	Its exact registry source	Preserve the primitive's timing and composed freeze

These are roles, not authorization to apply every token to every primitive. The registry assigns **M15** `--t-slow` **with** `--ease-enter`**; M16** `--t-med` **with** `--ease-enter`**; M17** `--t-slow` **with** `--ease-enter`**; M18 direct input mapping with no autonomous loop**. M18's native range is 0–1, mapped to normalized geometry; explicit Replay may run one finite transit using `--t-slow` and `--ease-enter`, canceled by new input. M1/M8 and other exact-source effects retain their specific timing. Numeric tokens are unchanged by this add-on; proposing a new amplitude, phase or easing is a design change, not an engine optimization.

Sequence by dependency. Commit selection first; animate its consequence second; reveal optional supporting detail only when useful. Labels describe actual state, not timeline progress. Network work completes when the operation completes—not when a flourish reaches its endpoint. A progress illustration must identify synthetic/demo progress and must never claim a real operation succeeded merely because its animation finished.

Interruption is part of the design. A new selection replaces old intent rather than queuing a ceremonial replay. Reset restores a defined state; cancel does not equal success. For direct manipulation, update the bounded scalar immediately; for a finite transition, settle or retarget from the current visible state. Document which behavior applies. Preserve explicit Pause across visibility and history changes.

The four additions

Primitive	Canonical semantic purpose	Bounded construction	Not included
M15 · Signal acquisition	Explain acquisition/progress for one signal	SVG progress with a finite WAAPI presentation; semantic status independent of the clock	Fake telemetry, indefinite loading theater, arbitrary tracing effects
M16 · Spatial continuity	Preserve item identity during semantic reordering	Persistent DOM items, actual order change, FLIP presentation	CSS-only visual reorder, route-transition system, arbitrary zoom/pin choreography
M17 · Kinetic typography	Resolve or emphasize a short meaningful text unit	Original semantic text plus transient visual glyph/weight handling	Endless scramble, animated body prose, invented font axes, interactive descendants split apart
M18 · Aperture transit	Expose a controlled relation between opening and position	One bounded scalar controls SVG aperture/path presentation and a DOM value	Full-page wipes, unrelated morphs, organic shader fields, hidden navigation

Each primitive must identify its purpose, input range, owner, clock, settled pose, error behavior, interruption, reduced/static behavior and release method. The pattern chapter describes composition; the specimen remains the source for exact geometry and implementation.

Ownership is a design constraint

Assign **one owner per animated property, one clock per continuous system, one semantic source of truth**. Keep layout, effect and content wrappers distinct when they need separate property ownership. Do not ask CSS, WAAPI, GSAP and Motion to drive `transform` on the same node. Avoid a second state machine hidden inside an asset that disagrees with the host.

A minimal controller has these responsibilities:

Operation	Required meaning
`set(input)`	Validate finite/ranged data; commit host state; present it
`pause()`	Stop owned progression without discarding selection or focus
`resume()`	Resume only when policy, visibility and user intent permit
`reset()`	Invalidate pending completions and restore the documented baseline
`destroy()`	Idempotently release owned work; never destroy shared services

These are interface roles, not required method names. Guard asynchronous work with an abort signal or generation identity. A late asset load must dispose its own resources rather than take control from the new selection. Semantic updates must remain possible after visual teardown.

Reduced motion is a live policy, not a startup-only checkbox. Use a composed final/current meaningful state; stop decorative interpolation explicitly. Near-zero CSS durations alone do not cancel WAAPI, a library ticker, a worker or audio. Provide a user pause/stop/hide mechanism for automatically moving content where the WCAG criterion applies; reduced-motion support is not a substitute for that control.[5] [6]

Delivery and adoption

Use native HTML/CSS/minimal JavaScript unless the existing application or authored requirement justifies more. Choose a library by the smallest necessary capability, its ownership/lifecycle fit, rights and measured cost—not by a showcase ranking. The engine recipes cover alternatives without importing those runtimes into the DSM kit.

Use the authoring contract for editable assets, and the verification gates for release evidence. A polished experience needs human composition and usability review as well as behavioral tests. A still proves composition at one moment; a test proves a specific behavior; neither alone proves audience understanding.

The capability catalog preserves the original research IDs and independently labels lab exercise, documentary authoring, device gates and this repository's specimen relationship. The source ledger contains selected atomic claims, quotations, dates and source conflicts. It does not ship vendor pages or establish all-library mastery. Treat its version records as a dated research snapshot, not “latest” recommendations.

Sources

[5] https://www.w3.org/WAI/WCAG22/Understanding/pause-stop-hide.html

[6] https://developer.mozilla.org/en-US/docs/Web/CSS/@media/prefers-reduced-motion

Motion patterns

Guide · Visual specimens · Engines · Verification

Patterns compose approved primitives; they are not additional registry entries. Follow the authority boundary: adopt M15–M18 from the integrated DSM v2.2 manual, registry, tokens and specimens. Existing M1–M14 definitions and M13's per-page gate remain unchanged.

M15 · Signal acquisition

Use when: one user-triggered acquisition or bounded progress relationship needs explanation. A demonstration is labeled illustrative; a real operation owns its own status.

Compose: keep the title, source label and result visible. Place a single SVG progress element beside its DOM value, not behind the whole page. Emphasize one cyan route against quiet linework. The status must be understandable without reading a moving path.

Implement: validate the progress range; commit the semantic value; cancel the previous visual job; animate only the owned presentation. A normalized SVG `pathLength` can align dash progress with the shared value. On reset, invalidate completion callbacks before returning to the initial pose. On failure, show the actual error and last valid state. Do not interpret animation completion as server confirmation.

Reduced/static: show the correct current or settled value immediately with a complete path/pose. No-JS retains the explanation and a labeled static figure. A genuinely JS-only demo control starts disabled and is enabled only after successful initialization.

Proof: observe an intermediate dash/value and the final state; reset midflight; activate twice; deny WAAPI; toggle reduced motion while running. Old completion must not overwrite the new state. The absence of animation does not mean the operation failed.

M16 · Spatial continuity

Use when: persistent items change their actual semantic order and the reader would otherwise lose identity.

Compose: conserve the item's label and visual identity. Keep movement within the inventory/list surface. Avoid enlarging everything, adding depth rotation or making the selected object fly across unrelated sections.

Implement: measure First; change the actual DOM order; measure Last; Invert the geometric delta on an effect wrapper; Play back to the resting layout. Batch reads and writes. Reuse the same elements or stable framework keys; do not replace the list with regenerated HTML. Cancel or settle an existing transition before taking a new measurement. The new semantic order exists immediately, not only after completion.

Focus: retain the active item/control node. If an item is removed as a separate application behavior, select a deliberate fallback destination before removal. Do not use CSS `order` as a substitute for document order. A View Transition or framework projection may be an alternative implementation only after it proves the same semantics and scoped visual result; a full router transition is not granted here.

Reduced/static: reorder immediately and remove temporary transforms. Resizing, changed labels and failed layout measurement leave a normal list, not absolutely positioned remnants.

Proof: verify element identity, DOM order, intermediate displacement, settled rectangles, rapid reverse reorder and focus continuity. Repeat with a changed item count, long labels and a breakpoint crossing.

M17 · Kinetic typography

Use when: a short heading or selected label earns a finite typographic resolution. Never animate a reading passage, legal notice, essential instruction or live status character by character.

Compose: let type mass carry the hierarchy. Use the exact display family and real supported axis; control the region so wrapping remains deliberate. A weight or glyph treatment should settle into the final text, not become its own looping ornament.

Implement: preserve the original semantic text and accessible name. If visual glyphs are needed, create a temporary `aria-hidden` presentation layer, segment by grapheme, and keep it out of pointer/focus interaction. Measure after font readiness; remeasure or abandon the effect after a resize/content/language change. Restore ordinary selectable text and remove wrappers on finish, cancel, reset and teardown. Do not clone an interactive heading subtree and hide its semantics.

Weight: inspect the supplied font before using an axis. The studied Oxanium file has `wght` only; a variable-font guide is not evidence that this asset supports width or optical-size animation. Keep the canonical family/weight bounds and never serve license-gated PPNM. Reserve stable layout or choose immediate weight change if interpolation causes disruptive reflow.

Reduced/static: render the original text at its correct final weight. If segmentation, font loading or measurement fails, leave the same ordinary heading—not an empty visual layer.

Proof: inspect the accessible name and actual rendered glyph family; test combining marks, emoji clusters, longer localized copy, blocked fonts and a content update during animation. Confirm no stale wrappers or duplicate announcements survive.

M18 · Aperture transit

Use when: one control must make the relation between an aperture and a path position visible.

Compose: contain the illustration in one figure. Keep the control and numeric/text result outside its SVG clipping boundary. Opening size and marker transit share a cause; they are not separately timed decorations.

Implement: validate and clamp one scalar, then derive both aperture geometry and position from it. Record units and endpoints. Keep the path/mask geometry from the specimen; replacing it with an arbitrary morph is a new design. Ensure mask IDs are unique per instance and the viewBox/sizing contract survives relocation. Invalid input preserves the last valid figure.

Reduced/static: direct input updates the meaningful still without inertial trailing. Unsupported mask/path presentation falls back to the same value and an annotated static figure. No visual mask may clip essential text or focus outlines.

Proof: sample both endpoints and an interior value; assert aperture and position agree with the same input. Test pointer and keyboard range changes, invalid/out-of-range values, resize and reduced-motion changes. Test actual pixels, not only a changed `d` attribute.

Compositions that remain within the grammar

Pattern	Primitive mapping	Choreography	Guardrail
Explorable service path	M15; static SVG labels	Select a route → progress illustrates acquisition → settled explanation	Public approved topology; no invented health state
Reordered evidence inventory	M16	Actual list reorder → continuity movement → stop	Reading order and focus are authoritative
Editorial chapter emphasis	M17, optionally M18 in a separate figure	Resolve one heading; later let the reader manipulate one aperture	No forced pacing, scroll trapping or body-text animation
Acquisition beside an inventory	M15 + M16	Acquire a result, then reorder only if the application's state calls for it	Separate owners; no concurrent unrelated foreground events
Quiet operational page	Exact M8; eligible M15–M18 locally; exact M1 footer	Atmosphere stays subordinate to each local event	Do not increase defaults' density or retune timing
Real telemetry inspection	Existing M2/M5/M11 as permitted by the manual	Localize a real update inside the surface	A synthetic design demo does not authorize a production live-data claim
Meaningful cutout asset	Exact M14	Preserve the canonical contained drift	Not a spring, card swarm or new holographic material

Escalate rather than relabel

A scrolling camera journey, liquid transition, magnetic cursor, elastic drag toy, audio-reactive field, shader material, arbitrary SVG morph or rigid-body scene is **not** M15–M18 merely because it uses progress, layout, type or a scalar. Write the purpose, proposed new behavior, static counterpart, rights and performance budget; request a registry review. Until approved, ship the existing primitive or static alternative. Three-dimensional memory-manifold work also retains M13's explicit page approval.

Engine selection and portable recipes

Choose a mechanism after choosing the primitive. The recipes below are implementation guidance, not new approved effects or a promise that every feature of each library has been mastered. No vendor runtime is bundled by this chapter. Pin dependencies in the adopting project; record the source, version, license, assets and runtime evidence there.

Decision ladder

Need	Start with	Escalate when
Local state/hover/finite progress	CSS, SVG, WAAPI	A mutable sequence needs coordinated labels and cancellation
Persistent semantic reorder	Native FLIP	Nested layout complexity justifies GSAP Flip or an existing framework owner
React presence/state	Existing React state; Motion if needed	Exit retention/layout projection is genuinely required
Interrupted target following	A bounded scalar; React Spring in an existing React surface	The approved behavior actually needs a spring, not fixed duration
Document progress	Native scrolling and CSS timeline enhancement	Authored geometry needs ScrollTrigger measurement
Stateful vector asset	SVG/DOM state	Editable vector state machine repays Rive authoring/runtime cost
Fixed vector sequence	SVG/WAAPI	An approved export needs a Lottie/dotLottie player
Authored numeric tracks	A small controller	Theatre serialized state materially improves authoring
Dense 2D display list	Canvas	Measured draw cost justifies Pixi or a specialized GPU path
Original material/compute	Static illustration first	Approved design and actual device measurements justify WebGL/WebGPU
Collisions/constraints	No physics for a simple transition	The task is genuinely a simulation, with separately reviewed behavior
Sound/haptics	Silent, visual/DOM feedback	Explicit opt-in and actual output-device review justify augmentation

“Escalate” does not waive registry or M13 approval. M15–M18 themselves can remain native. Existing exact-source M1/M8 implementations are not candidates for casual engine ports.

Native browser toolkit

CSS and WAAPI: finite presentation owned by one controller

Use CSS for state-derived styling and WAAPI for a cancellable finite job. `Element.animate()` returns an Animation object; keep it rather than losing the handle.[1] For M15:

1. Start with a readable result/status and a valid SVG pose.
2. Validate input; increment a generation counter; cancel the old owned animation.
3. Commit the host's semantic state independently. Start the presentation only if the API and live motion policy permit it.
4. Observe the owned `finished` promise. Treat cancellation as cancellation; report unexpected failures. Ignore stale generations.
5. Write the final style/attribute explicitly, then release the transient animation. On reset/destroy, invalidate the generation before cancellation.

Do not put business success in `onfinish`. Do not apply the controller to all animations on the page; it owns only its targets. Test a real intermediate value, reset midflight and blocked API, not merely a final value assigned by application code.

Typed properties, SVG and scroll/view timelines

`@property` registers a typed custom property in CSS.[2] For a shared scalar, use an explicit syntax, inheritance policy and initial value; derive geometry from one owner. Registration enables interpolation, not a guarantee of GPU compositing. For M18, prefer direct input-to-state updates; a CSS property is not required if JavaScript owns the same bounded SVG value cleanly.

Use normalized SVG dash geometry for M15; path/mask geometry for M18. Define the viewBox, mask coordinate system and unique IDs; clamp values before rendering. Restrict filter regions. Keep text/control semantics outside masks and renderer surfaces. Inspect actual repaint cost for filters, masks and font changes.

For document progress, declare the visible static state first. Add scroll/view timeline behavior only inside exact support and no-reduced-motion conditions. Put `animation-timeline` **after** the `animation` shorthand, which otherwise resets it.[3] Test two actual scroll positions and reverse movement. Do not turn every entering section into an invisible reveal waiting for intersection.

View Transitions: presentation around a semantic update

The update callback follows the old-page snapshot.[4] Keep a single state-update function that also runs directly when the API is unavailable or motion is reduced. Assign unique transition names; skip an older transition before a replacement. Handle rejected readiness without losing the state change. Restore/retain focus according to the application task, not the snapshot.

A same-document shared-element experiment is not proof of cross-document routing, history or framework integration. M16 authorizes bounded continuity around actual item order—not a default page-transition spectacle. Match the canonical specimen before selecting this alternative.

GSAP: mutable authored sequences and plugins

Use a scoped context and owned timeline. Build from a stable semantic DOM; assign timeline labels to meaningful phases; read the applicable token values instead of substituting library-default easing. Kill/revert the owned work on release and restore the intended final state. No global selector/ticker cleanup in a shared application.

The captured standard license permits no-charge commercial use, including formerly members-only plugins, but it is a custom license, not MIT.[7] Its ordinary website/app/interface permission includes companies competing with Webflow in other business areas; the prohibited-use definition concerns competing no-code visual-animation builders.[7][22] Review the complete applicable terms before distributing a builder or repackaging the product. Downloadability is not unrestricted licensing.

Mechanism	Portable implementation recipe	Ownership/failure trap and required proof
GSAP core	Bind one timeline to one region; choose explicit initial/settled values, labels and token-derived durations; replace the timeline on changed intent	Cancel during a phase and verify no stale callback commits state; do not mutate framework-owned properties from an unrelated timeline
Flip	Capture `Flip.getState(items)`; reorder persistent DOM items; animate with `Flip.from(state, options)`; clear temporary layout styles at settlement	Keep stable keys/identity, batch layout work, test changed count and resize. Nested absolute reparenting needs separate evidence. Flip is documented for changed DOM states.[8]
ScrollTrigger	Measure a stable trigger and animate its child; link progress to actual scroll; refresh after fonts/data/layout changes	Avoid animating measurement geometry. Kill owned triggers on teardown. Native progress is not proof of pin/snap, horizontal stories or proxy integration. `refresh()` recalculates geometry.[9]
ScrollTo	Choose a real destination; cancel the previous scroll; use an explicit nested/document target and user-interruption policy; manage hash/focus as separate semantics	Do not combine with CSS smooth scrolling on that target.[18] Test backward target, interruption, anchors, focus and native scrolling after release
ScrollSmoother	Use one deliberately chosen wrapper/content pair; wait for startup and fonts; keep fixed UI outside transformed content; provide a native-scroll mode	It transforms content to catch up with native scroll measured through ScrollTrigger.[19] Test sticky/fixed descendants and focus; the lab's frame-contained trial is not outer-document/touch proof
Observer	Listen in one region; normalize intent into a bounded host action; retain equivalent buttons/keys and an escape path	Observer supplies input deltas, not authoritative document position.[14] Do not infer physical touch coverage from a wheel test or prevent all page scrolling

Mechanism	Portable implementation recipe	Ownership/failure trap and required proof
Draggable	Give a dedicated handle bounded coordinates; map them to host state; provide equivalent native keyboard controls; refresh bounds on resize	Own the same position only once. Test actual pointer drag, keyboard range and cleanup; inertia coupling is a separate integration, not proved by independent tests
Inertia	Declare velocity units, resistance and endpoint bounds; feed a measured/explicit velocity into an owned tween; interrupt on new input	The plugin honors starting velocity and optional end restrictions.[15] Numeric-velocity fixtures do not prove pointer tracking. Elastic/inertial brand behavior still needs registry approval
SplitText	Apply only to suitable plain text or an isolated visual copy; preserve original semantics; measure after fonts; revert on end/cancel/content change	Its default approach does not preserve nested interactive semantics.[16] Test graphemes, wraps, re-splitting and screen-reader behavior; M17 is not permission to split a linked paragraph
MorphSVG	Use approved source/target geometry, fixed viewBox and explicit mapping; compare start/interior/end `d` and pixels; cancel/revert cleanly	It animates SVG path data.[17] Arbitrary path morphing is not M18: that primitive requires the specified shared-scalar aperture/path relation

Only the named bounded mechanisms are covered here. DrawSVG, MotionPath, ScrambleText or other plugins appearing in vendor navigation are not thereby practiced or added to the original catalog. Choose the native primitive or perform a separate versioned lookup, review and test before using an additional plugin.

Motion, Anime.js, React Spring and AutoAnimate

Motion: React state and presence

Keep keys stable and property ownership inside the React subtree. `AnimatePresence` retains exiting motion descendants until their exit animations complete.[10] Use that retention only when the approved interaction needs it. Move focus before removing focused content; retain the same inspector node when policy changes. Test the exit interval, actual visual change and eventual removal, not just “closed” state.

Version-specific caution: the captured reduced-motion documentation says the hook responds live, while the inspected `framer-motion` 13.2.0 hook stores the preference with `useState`.[11][12] The historical lab records the corresponding failed live-update test and uses a native `matchMedia` change subscription via `useSyncExternalStore`. Recheck after upgrading; this is not a timeless claim about Motion. Subscribe even retained exit children to the current policy. Test SSR/hydration and StrictMode separately when the adopting app uses them.

For M16 alternatives, prove DOM order and stable identity as well as layout projection. A passing presence example is not evidence for shared-layout, gesture or router mastery.

Anime.js: a bounded tween or local sequence

Create one explicit animation of an owned scalar/property. On changed intent, stop/revert or retarget according to the specified interruption contract; update semantic state independently. Map durations/units from the pinned API and tokens. Use `revert()` when the desired cleanup is full stop/destruction, as the documentation specifies.[23] Verify that inline state and callbacks are gone; then render the correct settled state.

The lab exercised an interrupted transform tween in 4.5.0, not every timeline, Scope or WAAPI-backend feature. Do not mix v3 examples with v4 imports/options. A timeline sequence needs its own phase/interruption tests.

React Spring: interrupted target following

Use one hook/controller per owned subtree and bind its output to an `animated` element. Separate the target from its presentation; on a new target retain the current trajectory only when that is the approved behavior. Stop the controller on unmount and render a static target for reduced motion. Springs do not have a predetermined curve or duration by default.[20] Therefore a spring is not automatically equivalent to a canonical fixed-duration transition.

Specify mass, tension/damping, overshoot limits and a settling criterion in the project brief. Prove a changed target while moving, stop/unmount, numerical bounds and settled result. List/transition hooks and StrictMode require separate tests; the historical scalar exercise does not establish them.

AutoAnimate: immediate-child layout changes

Attach one owner to a container; let the application add/move/remove persistent immediate children. AutoAnimate observes those immediate-child changes.[21] Set explicit timing/policy and disable it when motion is reduced. Before container removal, disable the controller and cancel any owned retained animations. Verify no detached work continues; disabling is not automatically proof of complete resource disposal.

Test the actual interior and later phases of add/move/remove, not just an early zero-opacity frame. Flex growth, virtualization and nested observers can change geometry and need explicit transfer tests. Do not use AutoAnimate alongside Flip/Motion layout ownership on the same children. Its implicit effects must match M16 rather than silently adding a new entry/exit vocabulary.

Lenis and shared clocks

Native scroll remains the baseline. Use Lenis only when designed momentum materially benefits an approved experience. Start with an opt-in bounded reader; preserve wheel/touch, keyboard, anchors, selection and focused-element visibility before and after setup/failure/teardown.

Manual Lenis `raf` takes milliseconds; its documented destroy method removes instance events, not the application's independent clock.[13] If integrating with GSAP, use one owner callback that converts ticker seconds to milliseconds, pass `autoRaf: false`, remove that exact callback at release, then destroy the instance. Never run automatic RAF plus an external driver, or Lenis plus ScrollSmoother on the same target. Verify the time conversion by measured progress, not by apparent smoothness.

Pause owned work offscreen/hidden without overriding explicit Pause. Test a real cached Back navigation and restoration of manual scroll position. The historical lab used nested Lenis; pagewide smoothing, Safari, physical touch and shared-clock ScrollTrigger integration remain separate proof gates.

Vector runtimes and authored tracks

Rive

Load the asset and matching local WASM/renderer under a generation guard. Resolve exact artboard, state-machine and binding names/types after load; clamp values; let HTML own state and essential labels. In the captured canvas 2.42.0 types, singular `stateMachine` supersedes the deprecated plural option.[42] Dispose late loads and owned runtime/listeners.

Configure both primary and fallback WASM paths: the captured loader types document a CDN fallback.[43] For a local-only contract, explicitly disable that fallback with the pinned supported API and test missing WASM under external-request denial. A successful primary load does not exercise this failure path. A repository test fixture is not original ProDyn artwork or Rive Editor practice.

Lottie and dotLottie

Choose the exact player and renderer before asset approval. Load one contained illustration with autoplay/loop explicitly off unless the brief says otherwise; seek named frames; compare decoded pixels; destroy on release. Preserve editable source and referenced images separately. A code-authored JSON fixture is not an AE export.

The dotLottie 2.0 format supports optional packaged state machines.[44] Define animation/state IDs, event and numeric guards, legal transitions, reset and paused rendering. Test reported state **and** visible output. The historical 0.80.0 trial needed an explicit refresh on a paused-state change; isolate and retest such workarounds instead of making them universal policy. Conversion/package success does not prove equivalent frames or event behavior.

Theatre core and Studio

Export authored project state, load it through `getProject(name, { state })`, await readiness, bind the exact sheet/object names, and subscribe only owned presentation values. Seek reference times before playing. Pause/unsubscribe/detach owned objects at teardown; avoid reusing a process-cached project identity when comparing independent fixtures. Studio exposes state serialization, but localStorage alone is not a handoff.[47]

Exclude Studio imports from production, not merely its initialize call. The captured 0.7.2 core license is Apache-2.0; Studio's is AGPL, with the exact package recorded as AGPL-3.0-only.[45][46] Review the applicable distribution obligations. The historical Studio exercise edited a code-seeded midpoint and exported it; it did not author a complete visual timeline from scratch.

Graphics: prove pixels, then justify cost

Canvas supplies a bitmap, not the document's semantic structure.[24] Keep headings, controls and outcomes in HTML. Use one bounded renderer; validate dimensions, seed, finite inputs and sample counts before replacing a good frame. Switch renderers serially with generation guards. Record the actual selected backend.

Mechanism	Portable recipe	Negative test / release
Canvas 2D	Size CSS and drawing buffer deliberately; cap pixel area/DPR per brief; draw a deterministic frame from a bounded input	Invalid input preserves the last valid frame; a one-shot figure has no persistent RAF
OffscreenCanvas	Transfer before obtaining a main-thread context; send typed bounded messages; ignore stale generations	OffscreenCanvas is transferable.[24] On transfer/worker failure create a new main-thread canvas; terminate the worker on release
PixiJS	Construct then await `app.init`; use an owned stopped ticker for one-shot work; record actual renderer and texture ownership	Async initialization is required by v8 guidance.[25] Destroy owned resources after pending-init races; do not claim WebGL/Canvas feature parity
Raw WebGL / GLSL	Compile/link with diagnostics; define uniforms, precision, viewport, blending and framebuffer ownership; draw known input	Read actual pixels; induce context loss; show a static fallback; delete owned programs/buffers/textures and restore with a fresh context
OGL	Use its renderer/program/geometry abstractions around original shader code; set the same coordinate/input contract as the baseline	Track who owns the context and resources; shader portability is not a performance result. Registry metadata declares Unlicense but the audited package lacked a root notice: review before redistribution.[31]
regl	Define a draw command with explicit uniforms/resources; invoke on state changes rather than starting an unnecessary frame loop	Cancel owned frame handles; `regl.destroy()` releases context-associated resources.[28] Do not destroy a shared context
p5.js	Use instance mode and a dedicated container; `noLoop()` for one-shot work; redraw after valid input	`remove()` stops the sketch loop and removes sketch-created elements.[30] The researched 2.3.2 package declares LGPL-2.1, not MIT.[32]
WebGPU compute	Request a real adapter/device; bound storage inputs; guard workgroup tails; dispatch; copy to MAP_READ; compare all output with a CPU oracle	API presence alone is not usable hardware.[29] Label missing adapter/device as fallback; unmap/destroy resources; test device loss and denied capability

Resolve evidence conflicts narrowly. The Pixi 8.16 announcement describes an experimental Canvas renderer, while the captured general renderer guide still said “Coming-soon.”[26][27] The lab's 8.20.1 Canvas pixels support existence in that setup, not full parity or universal support. Do not mirror the stale guide or extrapolate from one contour rendering to heavy continuous throughput.

A shader/material or compute study does not grant a new ProDyn effect. Keep exact M8/M1 sources unchanged; M13 approval still applies to its 3D use. Benchmark the actual composition rather than selecting an engine from an invented universal particle-count threshold.

Physics, audio and haptics

For simple input acknowledgment, use the canonical finite transition; do not introduce a solver. If a separately approved task truly requires force or collision:

- **Custom springs/forces:** specify units, mass, restoring force, damping and integration method. Use fixed steps, clamp elapsed accumulation and cap catch-up. Record discarded wall time, settling tolerance and overshoot. Test retarget/reset, not only a pretty bounce.
- **Matter.js:** update with milliseconds and explicit fixed steps; clear owned Composite contents as well as engine caches.[33][34] Keep the render clock separate from the solver.
- **Planck.js:** use a fixed world step; avoid mutating/destroying bodies inside a locked step.[35] Define world-to-screen scale and test contact against a known fixture.
- **Rapier:** await WASM initialization; create an owned world with explicit timestep; dispose stale initialization; call `world.free()` once and never read freed handles.[36] Test failed initialization and rapid backend switching.
- **cannon-es:** step with the specified fixed interval; remove owned bodies on release and cancel the external loop independently.[37] Do not claim cross-solver numerical equivalence or cross-machine determinism from similar final poses.

Sound starts silent. A user gesture opts into audio; consent is distinct from autoplay technically succeeding. Keep a visual/text alternative, explicit mute/stop and a context owner. Never restart sound on history restoration.

- **Web Audio:** create/resume an owned context after activation; connect a bounded envelope and stop/disconnect owned nodes. Use OfflineAudioContext for sample analysis, not proof of audible output—it does not render to device hardware.[38]
- **Tone.js:** select a pinned integration that does not create live global audio before opt-in; assign the owned context before starting/constructing instruments. The inspected `start()` resumes the global context, so ownership matters.[39] Avoid copying update-sensitive private deep imports without tests. Dispose transport events, instruments and only an exclusively owned context.
- **Howler.js:** set explicit autoplay, loop, gain, rate and activation policy. Unload the owned Howl on release; the documented method stops its sounds and removes it from cache.[40] Do not close a context shared with the rest of the application.
- **Haptics:** request only a bounded opt-in event; cancel outstanding patterns on stop/hide. API presence or a successful return is not actuator proof; unsupported devices can do nothing.[41] Require actual hardware review, or report unavailable without blocking the task.

Listening quality, touch latency, vibration and mobile energy use require human/physical-device evidence. The catalog preserves these gates rather than converting sample analysis or emulated input into certification.

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Authoring and asset handoff

Guide · Engine recipes · Verification · Handoff template

Preserve the editable source and prove the delivered result separately. A runtime asset is not a complete authoring project. An export dialog reporting success is not evidence of visual fidelity, rights clearance or a reproducible build.

The seven families below are documentary workflows. The historical motion lab did not operate these original authoring/export pipelines. Its Rive runtime fixture and separate bounded Theatre Studio export exercise do not change that status. Use the recipes with an authorized editor/operator, then attach actual source-reopen and runtime evidence to the adopting project.

The source/runtime contract

Choose the source format and intended runtime before detailed animation work. Keep a small chain: one source, one deliberate export, one runtime. Additional conversion stages need their own loss/fidelity checks.

Contract	Record before handoff
Identity	Asset ID, owner, source revision, exact editor/exporter/runtime versions; who may approve changes
Rights	Provenance and permission for artwork, fonts, footage, music, templates, plugins and data; required notices; distribution scope
Geometry/time	Dimensions, pixel aspect, units, orientation, frame rate, time origin, range, markers, seed and fixture
Behavior	Exact artboard/object/state/input/event names; types/ranges/defaults; reset, invalid input and interruption
Export	Settings, intentional simplification/baking, unsupported features, asset references and diagnostics
Accessibility	Semantic HTML equivalent, reduced/static pose, keyboard actions, focus and optional-media controls
Reproduction	Relocated native-source reopen; clean export; exact-runtime decode/reload; start/interior/end and meaningful-state comparisons
Operations	Allowed network destinations, loading/cancellation, cache restoration, cleanup, bytes and measured performance conditions

An asset cannot approve a new brand behavior. Match M15–M18 or another registered primitive; submit any new effect for review. M13 retains per-page approval. Keep essential copy and controls in HTML even when a source editor can embed text or interaction.

Rights are layered

Separate **editor access**, **export entitlement**, **runtime software license**, **asset rights** and **deployment scope**. Clearing one does not clear the others. Publicly viewable/forkable artwork is not automatically commercially reusable. A font embedded in a vector asset or converted to outlines still needs appropriate rights.

Use the repository's font license record. Self-host only approved WOFF2 files and preserve notices. PP Neue Machina remains excluded from public serving/redistribution until rights are confirmed; the public body fallback is Oxanium. Do not include editor caches, source maps, private paths or dependency trees in a public delivery.

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1. Figma and Variables

Choose for: layout, token mapping, prototype states and visual review—not production animation execution.

1. Receive an editable file/revision and permitted local backup. Preserve review decisions and linked-library dependencies separately: a local copy omits comments/history and becomes a new disconnected file when reimported.[50]
2. Derive a disposable token adapter from `tokens.css`; never make a prototype collection the new source of truth. Separate brand primitives from transient state such as selected step or playback.
3. Use the documented native DTCG JSON import route when appropriate. Import duration values in seconds and font-family as one string; maintain a companion mapping for CSS fallback stacks, clamp expressions, easing and other unsupported composites.[48]
4. Dry-run normalized names and compare resolved values after import. Slash-normalized duplicate names may be ignored; do not judge success from a dialog alone.[48]
5. Author ordinary, changed-content, loading, error, reduced/static and narrow/wide-phone frames. Use explicit prototype actions and conditions. A clickthrough does not prove semantic HTML or keyboard behavior.
6. Export the selected mode data and a fresh source copy; reopen in a disposable context and compare names, types, aliases, dependencies and text wrapping against the input mapping. Record losses instead of silently flattening them.

Access gate: the captured Variables REST page is Enterprise-gated but conflicts internally on exact seat requirements (prose says Full seat; GET table says any organization member).[49] Check the current account's actual permission before automation. A documentation read does not establish access.

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2. Rive Editor

Choose for: an original stateful vector illustration whose editable transition graph materially helps maintain the approved behavior.

1. Obtain native editable source and a `.rev` backup. Do not accept a playing `.riv` as a complete source handoff: backup retains information stripped from runtime export.[52]

2. Define exact artboard/state-machine/binding names and typed inputs. The host owns semantic selection, labels and user policy; the asset owns only illustration. Record reset, unknown events and interrupted transitions.
3. Build a minimal graph using only required features before polishing. Keep essential text in HTML; audit any embedded fonts/images separately.
4. Export runtime `.riv` and backup `.rev` from the same revision. Record the actual export options and current entitlement. Both export routes were documented as paid-plan features in the captured source.[51][52]
5. Reopen the backup independently; load runtime output with matching renderer/WASM; compare every meaningful state and invalid transition. A newer file may load in an older runtime while newer features are skipped.[51]
6. Test pending-load cancellation, missing local WASM, denied outside requests, reset and destroy with the runtime recipe.

Official runtime MIT licensing is distinct from the editor/export gate and asset rights.[53] Do not manufacture a `.riv` and describe it as an editor export. Original authoring remains unexercised until those actual steps have evidence.

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3. After Effects + Bodymovin / Lottie

Choose for: a finite vector sequence with a deliberately supported export subset, not a hidden application state machine.

1. Receive `.aep`, footage, fonts/rights, effects/plugins, exact versions, composition dimensions, pixel aspect, frame rate, frame bounds, markers and color settings. Preserve an editable-text source before any export preparation.
2. Freeze the revision and use Collect Files for the chosen dependencies. The resulting package includes a new project, footage/proxies and a report naming required files, effects and fonts; later edits to the original do not automatically update that collected copy.[56]
3. Enumerate masks/mattes, expressions, 3D, text, blend modes and images. Run a minimal export before final design. Bodymovin's documented workflow selects a composition and destination, then Render; images may accompany the JSON.[54]
4. Inspect diagnostics and decide per feature: preserve, simplify, bake intentionally or use video/still. The historical wiki documents an unsupported-feature report but was visibly last edited in 2020; it is a diagnostic lead, not a current exhaustive matrix.[55]
5. Select the exact web player/renderer and explicit autoplay/loop/segment behavior. Record frame-boundary conversion; do not mix editor-inclusive and runtime-exclusive ranges without a test.
6. Export to a clean output directory. Check relative asset paths, fonts/images, dimensions and frame range; compare editor references against decoded runtime start/interior/end, segment transitions and reduced stills.
7. Reopen the collected source with original paths unavailable. A runtime playback check and a source editability check are separate results.

Adobe access, exporter compatibility, third-party templates, stock, music and font rights must be cleared independently. A code-authored Lottie JSON is not proof that After Effects or Bodymovin was exercised. If packaging as dotLottie, retain the original export and compare both renders after conversion.

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4. Cavalry

Choose for: procedural 2D relationships and legitimate variants that repay a native procedural source.

1. Record the actual edition/build and account entitlement before opening or converting source. The captured current site advertises free individual access; legacy Starter/Professional documentation describes restricted save/render behavior for Pro-feature files.[57][58] Do not merge those contexts into a single entitlement claim.
2. Preserve editable scene/project, referenced scenes, assets, script versions, data fixture and seed. Name useful parameters and define units/time origin; avoid a graph whose only reproducible input is the designer's machine state.
3. Test a small representative composition using native Lottie export via File or Render Manager.[59] Record what stays procedural, what is baked and which target features fail.
4. Budget for baking: the export documentation describes shape baking, unsupported filters/shaders and text exported as shapes rather than editable text.[59] If material fidelity needs blur/noise, choose a raster/video output deliberately rather than promise parity.
5. Export a clean artifact, reopen source in the matching edition, rerender the same fixture, and compare topology, masks, timing, text and size. Record export settings and any unsupported-feature losses.

Free software access is not a license to redistribute every imported asset. Current/legacy contract applicability and actual account access require verification before release; this guide does not perform account migration or editor setup.

5. Blender

Choose for: reusable geometry/material/animation assets when spatial inspection is justified and approved—not as a mandatory route to a motion figure.

1. Preserve `.blend`, editable modifiers/rigs, linked libraries, textures, caches, plugin versions and asset rights. Set named objects, origin, world scale, axes, intended camera and export collection in a working copy.
2. Pack eligible resources and save; packing takes effect on save, and some external resources such as videos/movie clips cannot be packed.[61] Inventory the rest and reopen from a relocated copy.
3. Prepare supported mesh/material/animation output. The pinned Blender 4.5 glTF reference describes supported forms and triangulation/vertex expansion at some boundaries; it is not evidence for every feature in a later installed editor.[60]
4. Bake unsupported procedural materials deliberately; record extensions and target support, clip names/ranges, root motion, color space and texture settings. Preserve a pre-bake source.
5. Export GLB or glTF plus all buffers/textures. Reimport to a fresh editor file and independently decode in the actual target runtime. Compare dimensions, scale/orientation, materials, transparency, clips and missing-extension behavior.
6. Measure delivered bytes, decoded texture/geometry cost and actual device frame cost; optimize the asset before adding rendering complexity. Ship a meaningful static poster/diagram.

Blender distinguishes its software license from creator-owned artwork/data; imported third-party content still needs its own permission.[62] A GLB is not a full editable Blender project. M13's page approval is not supplied by an asset export.

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6. Spline

Choose for: editor-authored spatial interaction only when preserving its semantics and delivery model is a justified requirement.

1. Obtain editable source and a `.spline` local backup, which the documentation identifies as a local scene format.[65] Do not substitute a runtime `.splinecode` URL for a demonstrated editable backup.
2. Inventory objects, states/events, variables, camera, materials, assets and responsive behavior. Decide whether native Spline interaction must survive.
3. If selecting GLB/glTF, explicitly accept the loss boundary: captured guidance supports baked position/rotation/scale tracks but excludes states, events, interactivity, components and variables.[63]
4. If selecting self-hosted runtime output, verify current entitlement first; the captured self-hosted export page specifies Enterprise access.[64] Do not treat ordinary embed/code export as proof of that entitlement.
5. Export source and runtime independently. Audit all network destinations, runtime/WASM/assets and build requirements; test with outside requests denied rather than trusting “offline” labeling.
6. Reopen source, compare its editable structure, then exercise runtime state/reset/resize, pending load, missing assets, hidden/cache restoration and teardown. Preserve a no-WebGL explanation and DOM controls.

A runtime-controlled scene is not automatically keyboard accessible. A plan, source file and product terms must be checked before making rights or self-hosting claims for a particular delivery.

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7. ShaderToy-format shader work

Choose for: original shader research and a host-input convention, not a commercial asset marketplace or complete production renderer.

1. Prefer original code. If adapting a shader, record the exact URL and revision, creator, explicit license, every pass and each texture/audio/cubemap dependency. The captured terms allow creator-selected licensing and display a noncommercial share-alike default, not blanket MIT permission.[66]
2. Preserve one source per pass plus the pass graph: inputs, target formats/sizes, feedback dependencies, clear/load policy, sampling and initialization. A screenshot or single fragment is not a complete feedback system.
3. Write an explicit host adapter. The documented image entry is `mainImage`; the host supplies inputs and handles pixel output. `fragCoord` uses pixel units and `iResolution` supplies surface resolution.[67] Verify other input names/types against the actual interface before implementation.
4. Declare target GLSL/WebGL version, precision, coordinate origin, CSS versus drawing-buffer size, time/delta/frame/reset, alpha/premultiplication and color space. Do not assume the source site's alpha semantics match a transparent web layer.

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5. Compile in the actual host and compare deterministic time/input stills. Reset feedback, reject invalid dimensions/NaNs, test missing textures/extensions, shader compilation failure and context loss. Bound render work and provide a static counterpart.
6. Pause offscreen/hidden and release owned programs, shaders, buffers, textures and framebuffers. Audio passes require separate opt-in and rights review.

The historical ShaderToy documentation recovery was partial; no editor, shader-specific license or original host port was exercised. Unknown rights block commercial reuse. A new shader material also requires DSM review; it is not an M18 variant by analogy.

Worked adaptation: instrument to editorial case study

This is an original **specification example**, not a claim of an exported asset, tested audience response or deployed customer result.

Technical version: “Continuity, made inspectable”

Task: explain why an event arriving and a useful handoff being retained are different. Use a clearly labeled illustrative model, never fabricated uptime, throughput or live health data.

Baseline: semantic HTML, three labeled stages—Capture, Retain, Resume—and a static SVG figure. Native controls select a stage and toggle whether context is retained. The host owns `stage`, `hasContext`, playback preference and all copy. Invalid input preserves the last valid state; asset failure leaves the same explanation.

Beat	Composition	Primitive and owner	Settled result
Entry	Asymmetric Oxanium title, short deck, ordinary controls	Static; no entrance gate	Whole model readable immediately
Capture	One route and its caption receive attention	M15; progress presentation only	Full route and a truthful illustrative status
Compare order	A separate “reorder stages for comparison” control changes a bounded inventory	M16; persistent DOM items	New semantic order; same focused node
Chapter emphasis	One short heading receives optional Replay	M17; transient visual treatment	Original selectable heading
Inspect relationship	A contained range control exposes an aperture/path relation	M18; direct scalar mapping	Numeric output and geometry agree

Do not force all four beats into a small page. Keep only those necessary to explain the argument. M8/M1 remain eligible exact atmosphere/footer defaults, but a comparison-focused instrument can omit them to protect attention. No M10 page grid or fake M11 telemetry; no M13 without page approval.

Editorial adaptation: “Designing a handoff that can be inspected”

The reader now needs a linear argument, not a persistent instrument. Change structure, not just styling:

- Replace stage selection with **Problem → Decision → Example → Limits** in document order.

- Replace the retention toggle with two static captioned figures: “With context” and “Without context.” Expose both consequences without interaction.
- Remove acquisition playback and reorder from the baseline. Keep the complete heading rather than a mandatory M17 replay. M18, if useful, becomes an optional figure after the static explanation.
- Use Oxanium body prose and relaxed reading rhythm; reserve Departure Mono for figure labels. Do not use license-gated PPNM for editorial impact.
- Use ordinary contents/anchor links and printable figures. At 700px and 390px, stack comparisons in reading order rather than shrinking the diagram or concealing prose.
- Put optional media behind a clearly labeled control, with poster, description and pause/stop; no automatic audio. Media failure must not affect the argument.

Source choice: Figma may supply layout/state review; Rive is conditional on original source/export access. AE/Cavalry may supply an optional fixed clip, not semantic state. Blender/Spline/ShaderToy are rejected for this brief unless a later requirement earns their complexity.

Acceptance: a reader can identify the distinction and both consequences with motion off, scripts blocked and in print. A reviewer checks orientation/readability and the actual target device; no conversion lift, award quality or user comprehension result is claimed until measured.

Bad brief to reject: “Use every engine, animate all text, start with a loader, add a GPU background and make it feel live.” Replace it with one task, one foreground cause/effect, a complete still, actual data provenance and an explicit verification budget.

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Verification and release gates

Prove the visible behavior, the stable fallback and the resource lifecycle separately. A successful import, API probe or animation callback is not evidence that the intended pixels appeared. A browser test is not human art direction, screen-reader certification or real-mobile validation.

This is a verification contract for adopting projects. The capability catalog records historical lab scope separately from repository specimens; it is not a report that every gate below passed in this checkout. Use actual repository test output for the integrated M15–M18 specimens. Preserve failures, skips and device blockers as distinct outcomes.

Declare the acceptance conditions before testing

For each primitive, name:

- semantic input, valid range, initial/current/settled/error state;
- property/resource owner and time units;
- expected intermediate output and how it is measured;
- reset/interruption behavior, live reduced-motion policy and no-JS result;
- keyboard/focus contract and target viewports/devices;
- loading/network/asset fallback and cleanup boundary;
- payload, frame-work and lifecycle budgets, with method and test conditions.

Run a deliberately failing behavioral slice before implementation when changing code. A meaningful negative control removes the behavior under test and causes the assertion to fail. Do not weaken the assertion after seeing results just to label the build green.

State and output matrix

Case	Required observation	Common false positive
Primary action	Correct host state, visible intermediate effect, correct settled result	Status text changed while the animation never rendered
Changed context	Long/localized copy, changed item count/input and resize remain valid	Replaying the same fixture called transfer testing
Interruption	New intent wins; reset cannot be undone by a stale callback	Only testing after animation has finished
Reduced at load	Complete static composition; no unnecessary work starts	CSS duration shortened while a JS loop continues
Reduced midflight	Immediate intentional settlement, preserved focus/current content	Replacing a focused subtree to make the screenshot static

Case	Required observation	Common false positive
Missing JS/API	Essential content and normal navigation remain; unavailable enhancements are honest	A headline is visible but the rest of the explanation is hidden
Missing asset/renderer	Current semantic state and meaningful fallback survive	Infinite loader, blank canvas or silent CDN fallback
Release/remount	No stale input, callbacks, tickers or owned resource activity	Detached DOM alone mistaken for zero-memory-leak proof

Primitive-specific assertions

- **M15:** observe an interior progress/dash value, completion and explicit reset; reset during acquisition, repeat activation, and deny WAAPI. Ensure no retained running animation and no animation-driven false claim of operational success.
- **M16:** retain the same DOM item identities, verify actual reading order, an interior FLIP displacement and settled rectangles; rapidly reverse, change item count/labels, and cross a breakpoint. Focus stays with the actual retained node.
- **M17:** verify the original semantic text/accessible name, actual glyph family and final weight; test grapheme clusters, wrapping, changed language/copy midflight and blocked fonts. No stale visual copy, interactive clone or repeated announcement survives.
- **M18:** sample the native range's endpoints and interior; verify both aperture and marker derive from the same normalized value. Invalid values cannot corrupt the last valid pose. Direct mapping has no autonomous loop; reduced mode still exposes the same relationship.

Use deterministic sampling where possible: set controlled animation time or wait for a measured interior condition rather than relying only on wall-clock sleeps. Pair DOM/geometry assertions with actual rendered inspection; pixel hashes alone need a stated tolerance and rasterizer context.

Lifecycle: pause is not destroy

Use an explicit lifecycle model such as `idle → running ↔ suspended → destroyed`. Track the reasons for suspension independently: user pause, reduced policy, offscreen, hidden and cached navigation. Removing one reason must not erase another. One-shot renderers should never create a perpetual loop in the first place.

Visibility: stop owned advancement when hidden/offscreen. On return, update from valid host state and reset stale wall-clock deltas; do not replay missed work or begin a long catch-up. Verify the actual hidden-tab path as well as viewport intersection. Synthetic events test handlers, not browser lifecycle behavior.

Back/forward cache: `pagehide` is compatible with bfcache.[68] On `pagehide.persisted`, suspend recoverable resources rather than terminally destroying the component. On persisted `pageshow`, restore the same selection, manual pose/scroll and focused node; respect explicit pause. Never automatically resume sound. A nonpersisted departure/unmount can use terminal teardown.

A cache test must navigate away and Back and record actual `pageshow.persisted` or equivalent browser evidence. Remove a harness's bfcache-disabling default when necessary. An ordinary reload, synthetic `PageTransitionEvent` or unproven Back is not a cache pass. If the browser declines cache eligibility, report the reason and mark the case skipped/blocked; separately test the noncached restoration path.

Async races: delay asset/WASM/worker initialization, switch twice, then release. A stale result must dispose itself, not seize the canvas or update new content. Use generation IDs or abort signals; include failures after cancellation rather than swallowing every rejection.

Teardown inventory: cancel owned WAAPI and frame/ticker handles; clear timers; unsubscribe media/visibility/input observers; remove transient text wrappers; terminate workers; destroy owned textures/buffers/contexts/worlds; unload audio resources. Closing an application-shared audio/GPU context is a bug, not thorough cleanup. Run repeated mount/action/destroy cycles and verify the count of live owned resources returns to baseline.

Content, focus, fonts and access

Test keyboard use end to end: Tab order, Enter/Space, range keys, dismissal/reset, anchors, scrollable regions and visible focus. Preserve the focused node across reduced-motion changes and semantic reorders. Before removing a focused panel or frame, move focus to its documented trigger or successor. Never use a screen snapshot as the focus source of truth.

Inspect the accessible tree and use a real screen-reader review for production-critical interactions. Decorative visual glyphs and duplicate SVG labels must not duplicate essential announcements. Do not announce every animation frame. Check actual hit targets and contrast; an automated accessibility scan does not cover all of them.

Fonts need two proofs: the face loaded, and the intended glyphs actually rendered. `document.fonts.ready` and `document.fonts.check()` are useful but insufficient when a downloaded optional font leaves fallback glyphs on screen. Inspect rendered fonts (for example, Chromium's platform-font query for the text node), cold load behavior and line wrapping. Verify the actual asset's axes instead of assuming a variable font supports all registered axis types.

Deny font requests in a test: the fallback must preserve readable layout and must not leave M17 waiting forever. Preload only the allowed above-fold fonts, using exact URLs and `crossorigin`; use the licensed self-hosted assets. Inspect requests for PPNM and font CDNs rather than trusting the stylesheet's intent.

Test 390px narrow-phone, **700px wide-phone**, and a desktop width, plus either side of layout changes at the canonical 640/768/1024/1200 breakpoints. Check zoom, long labels, orientation changes, print and horizontal overflow. Emulated width is a layout test, not evidence for touch latency, heat, memory pressure or mobile battery use.

Negative tests that can falsify the result

1. Block the actual JS bundle and reload. Do not merely set a developer “failed” flag.
2. Deny the relevant font, image, vector asset and WASM independently; deny outside requests to catch fallback CDNs.
3. Remove a typed-property registration in a test response when interpolation is claimed. Require the intermediate-value test to fail rather than accepting a final application assignment.
4. Disable or force rejection of the exact animation/renderer API. Label this **forced-unavailable**, distinct from a real unsupported device.
5. Inject nonfinite, out-of-range and malformed inputs without replacing the last good state.

6. Trigger actual WebGL context loss, failed GPU adapter/device acquisition or a delayed worker reply for the adopted graphics path.
7. Toggle motion preference while a panel is exiting or a font/asset is loading. Preserve current semantics and focus.
8. Release during pending work, then deliver old events. No old DOM/state/scroll may change.

Keep an allowlist of **expected injected failures**, separate from unexpected console/network errors. Happy-path acceptance requires no unexpected errors; negative tests require the specific fallback, not a blanket ignored error log.

Measured performance gates

Set project budgets **before** testing. The DSM does not claim a universal renderer/particle threshold or an already-passed mobile budget. A target without its units, conditions and measurement method is not a useful gate.

Metric	Method and record	Acceptance rule
Initial/optional bytes	Actual transfer and decoded asset inventory; cold/warm cache distinguished	Essential content has no optional renderer dependency; each declared payload cap passes
Startup	Navigation/marks around import, asset decode and first useful output	Compare against the predeclared cap on named device/browser; separate network from CPU
Interaction work	Trace input → host update → visual frame; report long tasks and frame-work distribution	State acknowledgment remains prompt; predeclared percentile/max work budget passes
Continuous rendering	Record viewport, DPR, backend, scene count and sample interval	Meet the declared sustained budget; stop or reduce nonessential work when the agreed fallback threshold is crossed
Simulation	Fixed-step count, catch-up cap and discarded elapsed time	No unbounded catch-up or nonfinite states; units and stable fixture checked
Lifecycle	Owned-resource census before/after cycles; CPU/work when static/hidden	No continuing owned work after release; no unexplained growth over the declared run
GPU	Actual adapter/backend, readback or timestamp method if supported	Valid output first; no “GPU speedup” claim without a comparable measured baseline

rAF intervals are not GPU timings. Fast one-shot contour output is not continuous heavy-scene throughput. API availability is not execution. For WebGPU compute, read back every expected output and compare with a CPU oracle; do not infer device identity from an unrelated WebGL string. For audio, sample analysis is not listening quality.

If a budget fails, reduce pixel area, passes, texture size, object count or optional motion; then rerun the same fixture and report the visual compromise. An adaptive-quality claim requires exercising the governor through pressure, downgrade and recovery—not just printing frame statistics. Missing physical-device access remains a release limitation, not a fabricated pass.

Portable delivery and acceptance packet

Test the assembled artifact at its actual mounted path, including a relocated/subpath delivery where supported. Inspect relative assets, anchor destinations, MIME types, license notices and blocked-network behavior. A development server at `/` alone is insufficient. Reproduce from clean source and lockfiles separately from a warm checkout rerun; record exactly which occurred.

Deliver:

- source/runtime revisions and rights inventory;
- brief plus primitive/property ownership map;
- behavioral/output/lifecycle results with expected faults separated;
- full/reduced/no-JS reference states and inspected viewport/font evidence;
- measured budgets with browser/version, device/OS, viewport/DPR, cache state, backend, fixture and method;
- human design/accessibility/device reviews, or clearly named outstanding gates;
- exact commands and relative evidence paths, refresh triggers and known limitations.

A release report states what changed, what the tools actually verified and what remains unverified. Do not promote documentary editor recipes, historical lab tests or another browser's output into current repository proof.

Sources

[68] https://developer.mozilla.org/en-US/docs/Web/API/Window/pagehide_event

Source record

The complete Markdown sources below are rendered in order. SHA-256 values identify the exact source snapshot; the revision identifies the base commit and may include working-tree changes. Print geometry is medium-adapted; canonical source rules remain binding.

```
dsm/motion/guide.md
4707c3b2cdfa32be7ec19df4aa281ed29a1f4f8cc3f6db7afd864509978ad53b

dsm/motion/patterns.md
a65a83e0a309250c6ee77cfefcaaaa67520cff18c4b0f999179ebe9de506da07

dsm/motion/engines.md
1de142be0b8d38172156d5967834ee2fdb13433fd4a471c95daaf5dc93683e19

dsm/motion/authoring.md
131521d3f55cdbf6d539120070404cb7b9abea1fd1307ff3a5b6a76b87fa7fe4

dsm/motion/verification.md
1dcff1c8b9f727f507147c226f457d0510b3d5d0e699964b6b79a4ea0e35f372
```