RAVEN VALLEY / OPUS II

THE RAVEN VALLEY PLAY SYSTEM

A Parametric, Material, Mechanical, Narrative, Manufacturing, Collectible, and AI-Governed Framework for Figure Series and Play Objects

White Paper - Corpus Synthesis, Manufacturing Primer, Training Specification, and Governed Production Framework, Version 1.0

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NARRATIVE / FORM / MOTION / MATERIAL / MEMORY

A standalone field manual for translating story into buildable, testable, cataloged, repairable, and responsibly governed play objects.

PUBLICATION AND METHOD NOTE

Evidence, rhetoric, scope, safety, and the limits of a play-system framework

THE HONEST MEASURE

> *Name the resin before praising the shine.*
> *Name the unknown before releasing the joint.*
> *A rule becomes trustworthy when it reveals its source,*
> *its boundary, its test, and the hand authorized to change it.*

This paper consolidates the user-supplied outline with accessible Raven Valley and Opus II project documents, then expands the resulting propositions through peer-reviewed literature, official standards, institutional guidance, and established technical references. Internal project documents are treated as project precedent, not independent empirical proof. The paper preserves their terms - material truth, part as code, joint as agreement, functional filigree, heliometric attention, Cinch-and-Weave, provenance, and no-drift governance - while classifying each use as evidence, supported inference, project hypothesis, or speculation.

The prose uses repetition, parallel phrasing, contrast, progressive disclosure, mnemonic structure, embodied metaphor, and carefully paced instruction to support comprehension and recall. These are ordinary rhetorical and learning-design methods. No claim is strengthened merely because it is memorable or persuasive. Neurolinguistic programming is not used as a scientific authority; any relevant language or rapport claim is grounded separately in established cognitive, linguistic, instructional, or behavioral research.

No separately titled ARCH-3 or Dimensional Aesthetics source file was available in the supplied corpus. The nested-envelope, vertex, strut, offset, recurrence, and 3D-tool translations attributed to that lineage are therefore reconstructed from the user-provided outline and adjacent project precedent and are marked P-class. They are not represented as quotations or recovered requirements from an unavailable source.

Product-safety and compliance content is jurisdiction- and use-dependent. In the United States, ASTM F963-23 is the CPSC-accepted mandatory toy standard for applicable children's toys manufactured after 20 April 2024. The European Union's Regulation (EU) 2025/2509 generally applies from 1 August 2030, with transitional provisions. ISO 8124-1:2022 addresses mechanical and physical toy-safety aspects internationally. These references are not a universal certification packet; current editions, market rules, age grading, foreseeable use, materials, electronics, magnets, batteries, projectiles, and product-specific hazards must be reviewed by qualified personnel before release.

> **Publication status.** Research, training, and development framework. Not a product certification, legal opinion, chemical safety approval, tooling release, or substitute for licensed standards, laboratory methods, supplier data, factory manuals, qualified engineering, or market-specific compliance review.

ABSTRACT

From miniature sculpture to governed play system

THE WORLD IN THE HAND

> *A figure stands where story accepts gravity.*
> *A hinge gives the imagined body one honest freedom.*
> *Matter, color, package, record, and memory gather there;*
> *the small world becomes complete only when each can name the other.*

The Raven Valley Play System defines figures, toys, miniatures, creatures, vehicles, playsets, packaging, records, and collectible lineages as one governed product field. A figure is not merely a miniature sculpture. It is a narrative character, a geometric and mechanical system, a collection of material interfaces, a manufactured assembly, a controlled visual composition, a physical play interface, a packaged commercial object, a member of a series, a cataloged record, and an artifact whose meaning changes through handling, memory, repair, and provenance. The framework translates narrative intention into measurable constraints; form into geometry and motion; geometry into materials, parts, joints, molds, paint, and assembly; digital representations into prototypes; prototypes into verified production; and released products into traceable collectible lineages. Its governing methods are adapted from the Raven Valley Veil, Opus Core Framework, Cinch-and-Weave, Visual Equations, Physishop/Crypt inventory doctrine, and project studies of play and collecting. It integrates industrial design, mechanical reasoning, polymer and coating compatibility, additive and conventional manufacture, technical drawing, quality control, packaging, cataloging, market planning, lifecycle stewardship, and bounded AI assistance. The result is both a primer and an operating architecture: one capable of teaching a novice why a joint matters while giving an expert the interfaces, evidence classes, templates, gates, and records needed to challenge, verify, manufacture, and revise it.

Keywords: action figures; play systems; toy design; industrial design; articulation; degrees of freedom; joints; polymer compatibility; coatings; additive manufacturing; injection molding; packaging; collectibility; provenance; product lifecycle; technical drawing; AI governance; design education.

EXECUTIVE SUMMARY

The complete doctrine in compact form

TEN PROMISES OF THE OBJECT

Story enters form; form accepts the load.
Motion keeps its boundary; matter keeps its name.
The record follows every change through time,
and play remains free because production learned restraint.

Doctrine	Operational meaning
Narrative becomes constraints	Every story claim resolves into silhouette, scale, mass, surface, movement, material, accessory, package, cost, and evidence.
Part as code	Every part has stable identity, version, geometry, material, interfaces, tolerances, process, status, and verification.
Joint as agreement	The two parts, material pair, geometry, finish, assembly, load, motion, wear, and repair are designed as one interface.
Material truth	Specific grades, additives, lots, process histories, contacts, coatings, and tested properties replace generic names.
Motion before ornament	DOF, range, collision, balance, leverage, torque, retention, and wear begin before sculpt lock.
Functional filigree	Visible form may also stiffen, grip, align, mask, protect, connect, identify, ventilate, or permit service.
Canonical record	Diagrams, renders, BOMs, packages, listings, passports, and AI prompts are controlled views of one product truth.
Prototype before claim	Rendered feasibility is not mechanical, material, safety, or production feasibility.
Collector stewardship	Meaning, craft, lineage, honest variation, repair, and provenance replace manipulative scarcity.
No-drift governance	Every production decision and change leaves a recoverable, reviewable trail.

Text Diagram. Play-system summary equation

```
PLAY SYSTEM = NARRATIVE x FORM x MOTION x MATERIAL x MANUFACTURE x MEMORY

Subject to:
SAFETY ∩ INTENDED USE ∩ EVIDENCE ∩ MANUFACTURABILITY ∩ REPAIRABILITY ∩ PROVENANCE
```

Audio description: The project-defined equation multiplies six mutually dependent domains and constrains them by safety, use, evidence, manufacture, repair, and provenance. It is a design heuristic, not a scientific law.

EVIDENCE AND READER MAP

Four marks in the margin and six paths through the workshop

THE FOUR MARKS

One mark says the ground has carried weight.
One says the bridge is reasoned but local.
One says the Valley asks us to test.
One says imagine carefully beyond this line.

Class	Meaning	Use
E	Established evidence, formal standard, or current official requirement.	May define tests, constraints, or recurring principles within scope.
S	Supported design or engineering inference.	May guide a prototype but requires application-specific validation.
P	Raven Valley project hypothesis.	Requires comparison, measurement, or study before release as a default.
X	Speculative extension.	Research direction only; never represented as settled science or certified practice.

Suggested reader paths. Novices may begin with Chapters 1, 3, 6, 11, 16, 17, 22, 28, 35, 41, 45, 48, 51, and 58. Artists should add Chapters 7-10, 12, 27, 29-32, and 49. Mechanical and manufacturing practitioners should add Chapters 13-26 and 33-44. Catalog, commerce, and collector teams should add Chapters 50-57 and Appendices S-T and W. AI developers and trainers should read Chapters 2, 5, 15, 28-34, 42, 54-63, and Appendices K-L, T-V, and X. Release authorities should use the complete framework and source register.

SCOPE AND EXCLUSIONS

What the system includes, what it refuses, and what requires separate authority

NO PAINT OVER THE GAP

A beautiful render cannot certify the toy.
A collector label cannot erase foreseeable use.
Where the framework lacks evidence, it must stop,
and leave a clear gate for the qualified hand.

- Included: figures, dolls, miniatures, statues, designer toys, game pieces, creatures, vehicles, playsets, dioramas, construction interfaces, role-play objects, packaging, digital twins, catalogs, editions, provenance, repair, and AI-assisted development.
- Excluded as automatic conclusions: age grading, compliance certification, chemical approval, structural sign-off, medical or therapeutic claims, legal classification, market demand, authenticity, production quantity, and cultural authority.
- Weapons and hazardous mechanisms are treated as symbolic fantasy accessories only within this framework; real weapon design, harmful projectiles, and unsafe imitation are outside scope.
- Every deployed product requires a market-, material-, process-, user-, and hazard-specific review.

TERMINOLOGY AND CONTROLLED VOCABULARY

Canonical words before detailed work

THE FIRST FIXTURE IS LANGUAGE

Before the caliper, agree what is measured.
Before the mold, agree what counts as a part.
Words hold the first alignment of the team;
a drifting term becomes a drifting product.

Term	Working definition
Play system	Governed relation among narrative, form, motion, material, manufacture, user action, package, market, record, and memory.
Figure	Representational object whose identity includes a character body and designed display or play affordances.
Part	Smallest released physical component independently identified, materialized, interfaced, inspected, or replaced.
Joint	Designed interface permitting or constraining relative motion or detachable connection.
Edition	Governed release state distinguished by an explicit delta from a baseline.
Provenance	Evidence-backed history of design, manufacture, unit, ownership, repair, and representation.
Functional filigree	Visible form carrying aesthetic meaning and a testable practical function.
No-drift governance	Change control preventing silent alteration of released meaning, geometry, material, process, or record.

PROJECT-DOCUMENT LINEAGE

The internal precedents and their translated responsibilities

THE RIVER KEEPS ITS TRIBUTARIES

No framework arrives without older water.
The Veil brings material; Opus brings the record.
Play brings curiosity; Physishop brings the object home.
Name each source so synthesis does not become erasure.

Project source	Play-system contribution
Raven Valley Veil	Material truth, measured field, pattern/part as code, seam/joint as agreement, sample hierarchy, repair, provenance, and bounded AI.
Opus Core Framework	Typed modules, stable IDs, trace-back, trace-forward, verification intent, baselines, and change control.
Weaving Understanding	Cinch-and-Weave, uncertainty disclosure, analogy testing, and return to stable anchors.
Visual Equations / Unified Web Design Codex	Attention hierarchy, bounded variation, recurrence, Bauhaus/minimal function, cognitive load, and controlled views.
Fun for Everyone / Cards	Play, pattern, surprise, symbolic systems, physical handling, database/deck analogies, and cultural variation.
Physishop / Records and Streams / Payment Systems	Canonical inventory records, editions, condition, commerce states, portable projections, and provenance.
Wholesale as System	Supplier qualification, landed cost, receiving, source risk, inspection, and auditable procurement.
Book of Conduct / Development Codex	Stewardship, repair, training progression, feedback, and failure as information.

MASTER LIFECYCLE DIAGRAM

From observed need to archived lineage

THE LONG ROUTE

> *The object begins before the first sketch*
> *and continues after the package is opened.*
> *Design the return paths beside the forward road;*
> *the lifecycle is the truest silhouette of the product.*

Text Diagram. Master play-system lifecycle

```
OBSERVE / RESEARCH / SOURCE
          |
NARRATIVE + SERIES REQUIREMENTS
          |
CONCEPT -> TURNAROUND -> TECHNICAL DEFINITION
          |
3D APPEARANCE -> PART / JOINT / MATERIAL ENGINEERING
          |
PROTOTYPE -> TEST -> REVISE -> DFM
          |
TOOLING -> TOOL SAMPLES -> PREPRODUCTION -> PILOT
          |
MASS PRODUCTION -> QC -> PACKAGE -> CATALOG / PASSPORT
          |
DISTRIBUTION -> PLAY / DISPLAY / TRADE -> REPAIR / REISSUE / ARCHIVE
          ^
          +---------------- FEEDBACK / CHANGE CONTROL ----------------+
```

Audio description: Narrative and series requirements pass through controlled visual, mechanical, material, prototype, tooling, production, package, catalog, and lifecycle stages; feedback returns through change control.

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PART 1

THE GOVERNING SYNTHESIS

From toy as isolated commodity to play system as governed material narrative.

THE FIRST HAND

Before the figure, a gesture; before the gesture, a need.
The smallest world begins where a hand grants motion.
Name every hinge, every promise, every hidden cost,
and play becomes a craft that can remember its maker.

01

Genealogy and Scope

From miniature object to governed play, production, and memory system

THE FIRST FIGURE

> *A toy enters history twice: once through the factory gate,*
> *and once when a hand gives it a name.*
> *Between those entrances lie chemistry, story, labor, and law;*
> *the small body carries a world larger than itself.*

The Raven Valley Play System begins by enlarging the category of the figure. A figure is not only a sculpted likeness, nor only a mechanism, nor only an item sold on a card. It is a narrative character, geometric system, material assembly, physical interface, packaged offer, catalog record, and collectible artifact whose meaning may increase through play, display, repair, exchange, and inherited memory.

The governing precedent is the Raven Valley Veil, which treats apparel as a dynamic interface and manufacturing record rather than a decorative surface. In this paper, body field becomes object field; pattern becomes part, mesh, mold, and assembly code; seam becomes joint and joining agreement; dynamic fit becomes pose envelope and accessory interaction; and collector stewardship becomes documented authenticity, variation, repair, and ownership history (Conrad and OpenAI, *Raven Valley Veil* 3-8). The translation is not metaphor alone. It creates artifacts a manufacturer, cataloger, AI agent, or quality team can inspect.

The Opus Core Framework contributes a second lineage: one authoritative system of typed, uniquely identified modules capable of generating role-specific views without losing provenance. A character description, engineering mesh, paint master, package file, marketplace listing, and provenance passport are not separate truths. They are controlled projections of one product identity, linked by trace-back, trace-forward, verification intent, and baseline change rules (Conrad and OpenAI, *Opus Core Framework* 1-4).

Play scholarship supplies an essential caution. Play is heterogeneous: object play, constructive play, fantasy, games with rules, social play, collecting, and display do not produce identical experiences or developmental effects. Reviews support the importance of play broadly while cautioning against claiming that one play form uniquely causes every desirable outcome (Lillard et al. 1-34; Yogman et al.). The framework therefore designs affordances and studies outcomes rather than declaring a universal formula for fun.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Toy	An object or system intended or reasonably foreseeable for play, subject to age, marketing, jurisdiction, and hazard analysis.
Action figure	A character-centered articulated or rigid figure whose identity is communicated through form, costume, accessories, package, and series relationships.
Model / miniature	A scaled representation whose primary use may be construction, study, display, gaming, or simulation rather than open-ended character play.
Doll	A human or human-like figure whose play may emphasize caregiving, social role, dress, identity, or narrative; the term carries cultural rather than purely mechanical boundaries.
Statue / designer toy	A primarily display-centered object that may retain play, edition, authorship, and collectible functions even when articulation is absent.
Game piece / card / token	A physical carrier of rules, state, identity, or randomization; it can simultaneously function as image, data record, symbolic unit, and collectible (Conrad and OpenAI, Cards 1-2).

Variable / concern	Operational requirement
Vehicle / creature / playset	A larger interface that extends figure scale into seating, riding, environment, transformation, storage, and world-building.
Digital twin	A controlled digital representation linked to the physical product, its configuration, tests, lifecycle, and current state; a marketing render alone is not a digital twin.
Collectible artifact	An object whose value may arise from condition, authenticity, context, set relationships, scarcity, memory, repair history, and community knowledge.

Text Diagram. Six simultaneous identities of a play object

```
[ NARRATIVE CHARACTER ]
                                  |
[ CATALOG RECORD ] -- [ PHYSICAL PLAY OBJECT ] -- [ USER / HAND / DISPLAY ]
        |                         |                          |
[ PROVENANCE ]          [ MECHANISM + MATERIAL ]      [ MEMORY / MEANING ]
                                  |
                         [ PACKAGE + MARKET SYSTEM ]
```

Audio description: The physical play object sits at the center of narrative, user interaction, mechanism and material, package and market, catalog record, provenance, and memory.

PRODUCTION APPLICATION

- Assign a canonical product ID before final concept approval.
- Declare the intended age and use routes, including whether a concept is a child-directed toy, hobby model, adult collectible, or multi-route product.
- Create a terminology map so design, factory, legal, catalog, and marketing teams do not use the same word for different objects.
- Link every visual concept to a measurable product requirement or mark it illustrative only.

AI-AGENT INTERPRETATION

An AI agent may classify requested outputs, map relationships among character, part, package, and catalog entities, and identify missing records. It must not infer regulatory category, target age, authenticity, safety, or production status from visual style alone. When an ARCH-3 or other named project source is unavailable, the agent must preserve the user-supplied term, label the interpretation P-class, and request or identify the missing canonical source.

FAILURE CASES AND CORRECTIVE ACTION

- A team treats the sculpt as the whole product and discovers articulation, paint, packaging, or safety conflicts after tooling.
- Marketing names a product an adult collectible while imagery, play features, placement, or advertising indicate child-directed use.
- Multiple files share a character name but have no stable product, part, or version identifiers.
- A collector variation is discussed informally but never cataloged, allowing later confusion or counterfeit claims.

RELEASE GATE: No concept enters engineering until object category, intended users, canonical identity, interfaces, evidence class, and required downstream artifacts are declared.

Evidence classification and research anchors. E: toy safety definitions and standards; peer-reviewed play and consumer research; systems-engineering traceability. S: the six-identity object model. P: Raven Valley terminology and the translation of Veil principles into play-object governance.

Training exercise. Choose one familiar figure and describe it six times: as character, mechanism, material assembly, play interface, package, and catalog record. Mark what each description reveals and what it hides.

02

Ethics, Safety, Evidence, and Responsibility

A boundary against preventable harm, false certification, manipulative scarcity, and invented certainty

THE SMALL PART AND THE LARGE DUTY

> *A piece may fit the hand and still endanger the mouth.*
> *A bright promise may pass the shelf and fail the home.*
> *Let delight enter only through a door strong enough for truth;*
> *care is the first mechanism every toy must carry.*

Safety is not a late laboratory obstacle placed in front of an otherwise finished design. It is a primary design input that determines age grading, part size, geometry, material, paint, battery access, warnings, packaging, test plans, documentation, and whether the product should exist in its proposed form.

In the United States, ASTM F963-23 is the mandatory toy standard for applicable children's toys manufactured or imported on or after 20 April 2024, and the CPSC emphasizes that firms must identify which sections apply to the particular product. Small-parts restrictions and choking-hazard labeling exist in addition to broader mechanical, physical, flammability, and toxicological requirements (U.S. Consumer Product Safety Commission, "Toy Safety"; "Small Parts"). ISO 8124-1:2022 provides international requirements and test methods for toys intended for children from birth to fourteen, with requirements varying by age group. These references are starting points, not substitutes for jurisdiction-specific compliance review.

The European Union adopted Regulation (EU) 2025/2509 in late 2025. It entered into force in 2026 and generally applies from 1 August 2030, creating a transition period in which teams must manage both current and forthcoming obligations, including stronger chemical controls and digital product information. Connected toys may also invoke cybersecurity, privacy, radio, battery, and electronic-equipment regimes. The correct response is a live standards register with owners and update triggers, not a static compliance paragraph copied between products.

Ethical responsibility extends beyond physical injury. The framework prohibits false edition counts, artificial stock alarms, hidden restocks represented as final scarcity, counterfeit provenance, body or cultural stereotypes presented as universal truth, and AI-generated claims of test completion. Collector motivation and set completion can be commercially powerful, but the same mechanisms can be exploited. The project therefore separates invitation from coercion: a series may reward discovery without designing confusion or financial pressure as its primary play mechanic (Carey 336-47; Belk 139-68).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Intended age and user	Record the age-grading rationale, foreseeable misuse, dexterity, strength, cognition, and supervision assumptions; a printed age label cannot cure contradictory design or marketing.
Small parts	Evaluate detachable and released components before and after use-and-abuse testing; accessory count, replaceable hands, magnets, and fasteners can change the hazard profile.
Sharp points and edges	Control as-molded geometry, trimmed gates, metal parts, breakage surfaces, wear, and assembly damage.
Pinch, entrapment, and projectiles	Study moving clearances, stored energy, springs, elastic elements, launch velocity, access openings, and failure after impact.
Chemicals and coatings	Use supplier declarations, restricted-substance review, migration testing where applicable, and actual coating/substrate compatibility; color approval is not chemical approval.
Magnets and batteries	Use secured compartments, retention features, abuse testing, polarity and ingestion analysis, electrical safeguards, and current button-cell or battery rules where applicable.

Variable / concern	Operational requirement
Accessibility	Consider grip, force, visual contrast, tactile distinction, one-handed use, hearing, reach, and cognitive load without claiming universal access.
Culture and representation	Use research, consultation, provenance, and correction paths; avoid treating aesthetic reference as permission to collapse distinct cultures.
Privacy and connected play	Minimize data, separate child and collector accounts, define retention, secure update and pairing paths, and never hide recording or telemetry.
Honest scarcity	Record edition authority, count basis, production changes, reissues, destroyed units, samples, and uncertainty.

Text Diagram. Safety and ethics release gate

```
[ CONCEPT / INTENDED USE ]
            |
            v
[ AGE + JURISDICTION + FORESEEABLE USE ]
            |
            v
[ HAZARD ANALYSIS ] --> [ MATERIAL / MECHANISM / PACKAGE CONTROLS ]
            |                                |
            v                                v
[ APPLICABLE TEST PLAN ] ---------> [ ACCREDITED / COMPETENT REVIEW ]
            |                                |
            +------------ fail ------------+
            |
            v
[ CERTIFICATION / RECORD / MARKET RELEASE ]
```

Audio description: A concept is classified by intended use, age, jurisdiction, and foreseeable use; hazards shape design controls and tests; failed evidence loops back before certification and release.

PRODUCTION APPLICATION

- Create a product-specific hazard analysis before part-break freeze.
- Maintain a standards and regulation register with edition, jurisdiction, applicability, owner, and next-review date.
- Separate child-directed and adult-collector configurations when accessory size, magnets, sharp details, or packaging create different risk routes.
- Require chemical and coating documentation at material qualification, not after decorated samples arrive.
- Preserve test reports, certificates, batch links, corrective actions, and product-change assessments.

AI-AGENT INTERPRETATION

AI may retrieve current official requirements, compare declared product features to a controlled applicability checklist, draft hazard questions, and flag missing evidence. It may not certify compliance, select an age grade to avoid testing, invent laboratory results, treat warnings as substitutes for design, or recommend a restricted chemical without current jurisdictional review.

FAILURE CASES AND CORRECTIVE ACTION

- A designer labels a product "14+" solely to avoid child-product requirements while preserving child-directed play and marketing cues.
- A prototype passes appearance review but releases a small magnet, sharp shard, or painted fragment after impact or cycling.
- A factory substitutes a pigment, plasticizer, adhesive, or battery component without renewed compatibility and compliance review.
- An edition counter or rarity claim is generated by software without a verified production record.

RELEASE GATE: No product advances to tooling or market release while intended use, age route, applicable standards, hazard controls, test evidence, chemical declarations, or responsible approvals remain unknown.

Evidence classification and research anchors. E: CPSC guidance; ASTM F963-23; ISO 8124 series; Regulation (EU) 2025/2509; applicable battery, chemical, privacy, and connected-product rules. S: accessibility and ethical-scarcity translations. P: Raven Valley ethical release logic.

Training exercise. Take the Obsidian Veil figure and create separate hazard registers for a 4+ toy route and a 14+ collector route. Identify which design changes, accessories, warnings, tests, and marketing choices differ.

03

The Play Object as Interface

Body, hand, story, rule, environment, and memory meeting in one physical system

THE HAND COMPLETES THE CIRCUIT

> *The figure waits without stillness.*
> *Its hinge contains a sentence the hand has not spoken.*
> *When grip meets balance and story meets resistance,*
> *matter becomes an invitation rather than a command.*

A play object mediates. It translates narrative into affordances, force into movement, scale into grip, material into sensation, and collection into memory. Good interface design makes legitimate actions discoverable while leaving room for interpretation; it does not require the user to reverse-engineer hidden fragility or a marketing script.

The interface perspective joins industrial design with play theory. A handle, swivel, removable hood, vehicle seat, card-back grid, or storage bay communicates possible action. Affordance is not merely what a designer intends; it is what the user can perceive and successfully perform given body, knowledge, context, and product state. The same accessory may be a tool in narrative play, a balancing mass in display, a small-parts hazard in a younger user route, and a provenance marker for a collector.

Play may alternate between paidia - improvisational play - and ludus - rule-bound play. A figure line should support both without confusing them. Peg standards and docking systems create dependable rules; costume, character relationships, and environmental ambiguity create open interpretation. The design objective is bounded agency: enough constraint to make actions legible and repeatable, enough openness to permit ownership and surprise (Caillois; Huizinga).

The interface extends through time. Opening a blister, sorting accessories, finding a foot peg, repairing a joint, scanning a passport, and reselling a complete set are all interactions. Packaging, catalog, and aftercare are therefore not external services. They are later states of the same play system.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Holding	Locate stable and comfortable grip zones; protect paint, soft goods, joints, and fragile protrusions from normal handling.
Posing	Make axes, stops, clearances, and balance readable; avoid joints whose apparent freedom exceeds their safe range.
Dressing and equipping	Control order of operations, stretch, opening size, hand geometry, retention, and paint rub.
Combining and transforming	Define connector standards, state transitions, hard stops, lock confirmation, and reversal path.
Transporting and storage	Provide durable accessory retention, package or playset storage, and clear inventory of included pieces.
Cataloging and trading	Expose product, edition, accessory, condition, and provenance identifiers without requiring destructive inspection.
Photographing and display	Design silhouette, stance, finish, and support interfaces for common viewing distances and lighting.
Story construction	Use character, tool, environment, and series relationships to invite narrative without prescribing one canonical use.

Variable / concern	Operational requirement
Collection completion	Make set logic visible while avoiding deceptive scarcity or mandatory purchases that undermine standalone value.

Text Diagram. The play interface field

```
[ NARRATIVE ]
                        |
[ RULES ] ---- [ CHARACTER / OBJECT ] ---- [ USER BODY ]
    |                   |                       |
[ SERIES ] ---- [ MOTION + MATERIAL ] ---- [ HAND / SENSES ]
    |                   |                       |
[ CATALOG ] ---- [ PACKAGE / STORAGE ] ---- [ MEMORY ]
```

Audio description: Narrative, rules, series, catalog, motion, material, packaging, user body, senses, and memory converge on the character object.

PRODUCTION APPLICATION

- Write an affordance inventory for every moving, removable, wearable, connectable, storable, and scannable feature.
- Observe naive users before explaining the product; record where perceived action differs from intended action.
- Create a state map for transforms, removable parts, packaging, and repair.
- Validate standalone value for each figure even when it belongs to a larger set.

AI-AGENT INTERPRETATION

AI may translate a concept into an affordance inventory, generate state diagrams, compare interface consistency across a line, and flag actions that lack feedback or reversal. It must not treat user behavior as fully predictable, infer safety from apparent simplicity, or optimize only for engagement while ignoring autonomy, fatigue, cost, and repair.

FAILURE CASES AND CORRECTIVE ACTION

- A decorative strap looks usable but tears when the user reasonably treats it as a handle.
- A joint appears to be a ball joint but is only a swivel, inviting damaging force.
- Accessories have no storage or catalog map and are routinely lost or mismatched.
- A figure is intentionally incomplete unless the user buys an unrelated product.

RELEASE GATE: Every intended action must have a perceptible invitation, safe path, feedback state, failure limit, and recovery or repair rule.

Evidence classification and research anchors. E: established affordance, human-factors, play, and product-development literature. S: the time-extended interface model. P: Raven Valley bounded-agency and memory-interface terminology.

Training exercise. Without instructions, hand a prototype or proxy object to three people. Record the first five actions each attempts, the features they avoid, and the false affordances they perceive.

04

The Object Field

A measured, motion-aware representation of character, user, manufacture, package, and series context

THE FIELD AROUND THE SMALL BODY

> *No figure stands alone upon its foot.*
> *The shelf, the blister, the creature, and the hand lean inward.*
> *Measure the empty space as carefully as the solid part;*
> *what surrounds the object often decides whether it survives.*

The object field adapts the Veil's body-field method to play products. Instead of forcing every character into one inherited proportion or treating clearance as a single value, it records landmarks, envelopes, tolerances, interaction zones, production constraints, and contextual intentions around the actual object.

A figure exists inside several overlapping envelopes: character anatomy, sculpted costume, articulation sweep, accessory reach, user grip, packaging cavity, mold opening direction, paint-gun access, assembly tooling, display silhouette, and vehicle or playset fit. A change to one envelope can invalidate several others. A shoulder pad may preserve narrative authority while blocking arm rotation, increasing blister depth, hiding a paint mask, and requiring a new side action for the mold.

The object field therefore uses local offsets rather than one global "ease" or clearance. The conceptual expression $O(u,v) = C(u,v) + e(u,v)N(u,v)$ describes an object surface O offset from a character or engineering reference C by a local field e along the normal N. It is not a complete simulation. Its purpose is to require local intent: armor is close here, open there, reinforced at a boss, relieved through a motion zone, and expanded around a battery or fastener.

Field records also preserve uncertainty. When a rider, creature, package, or user-hand dimension is unknown, the interface is marked provisional rather than silently frozen. Cinch-and-Weave provides the governance pattern: hold stable anchors such as scale, safety, joint centers, and package limits; weave variable surface, pose, styling, and accessory options around them; test; then version (Conrad and OpenAI, *Weaving Understanding* 1-4).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Character anatomy field	Landmarks, proportion, species, costume thickness, stylization, asymmetry, and narrative deformation.
Pose envelope	Joint axes, sweep volumes, collision surfaces, soft-goods motion, and balance states.
Grip field	Likely pinch points, whole-hand and finger grips, applied force, paint contact, and one-handed operation.
Ground-contact field	Foot sole geometry, stance, center of mass, base pegs, surface friction, and display tolerance.
Accessory field	Hand openings, peg and port locations, reach, storage, removal force, and cross-product compatibility.
Manufacturing field	Draft, parting, gate, runner, ejector, wall thickness, undercuts, tool action, trim, paint, and assembly access.
Package field	Blister or tray cavity, restraint, abrasion, accessory presentation, package depth, and transport loads.
Repair field	Disassembly path, replaceable modules, fastener access, adhesive limits, touch-up, and provenance update.
Display and shelf field	Viewing distance, silhouette, glare, support, footprint, adjacency, and series rhythm.

Text Diagram. Nested object envelopes

```
[ SERIES / SHELF / MARKET ENVELOPE ]
  [ PACKAGE / TRANSPORT ENVELOPE ]
    [ USER GRIP / PLAY ENVELOPE ]
      [ ACCESSORY / POSE ENVELOPE ]
        [ SCULPT / MATERIAL ENVELOPE ]
          [ JOINT / STRUCTURAL CORE ]
```

Audio description: Six nested envelopes surround the structural core: sculpt and material, accessory and pose, user play, packaging and transport, and series and market.

PRODUCTION APPLICATION

- Create front, side, top, and section field overlays before final sculpt detail.
- Use swept-volume checks for joints, accessories, vehicle seating, and package restraint.
- Record local clearances and unknowns by zone instead of applying one generic tolerance.
- Re-run field checks after any armor, soft-goods, tool, material, or package change.

AI-AGENT INTERPRETATION

AI may compare envelopes, generate collision questions, propose parametric offsets, and detect mismatched assumptions among figure, accessory, vehicle, and package files. It must not infer hidden dimensions from beauty renders, assume cloth or polymer behavior from appearance, or convert an illustrative overlay into a released tolerance.

FAILURE CASES AND CORRECTIVE ACTION

- A figure meets nominal height but cannot sit in the stated vehicle because hip, coat, and cockpit fields were never combined.
- An accessory fits the hand in CAD but paint thickness and production variation eliminate usable clearance.
- A blister restrains the figure by pressing on decorated or flexible zones, causing rub or deformation.
- A repair fastener is visible in the render but inaccessible to an actual tool.

RELEASE GATE: The object field must demonstrate compatibility across character, motion, grip, accessory, manufacture, package, repair, and series envelopes before engineering freeze.

Evidence classification and research anchors. E: dimensional and tolerancing practice, kinematics, human factors, packaging engineering. S: local-offset field translation. P: Raven Valley object-field notation and envelope governance.

Training exercise. Draw concentric envelopes around a 3.75-inch figure: sculpt, motion, hand, package, and shelf. Identify three places where an outer envelope changes the inner design.

05

The Play-System Ontology

Canonical entities, relationships, states, identities, and events

THE NAME THAT SURVIVES THE BOX

> *A factory calls it part seven; a child calls it the lost hand.*
> *A collector calls it first issue; a database asks for the key.*
> *Give every name a place and every place a relation,*
> *so meaning may travel without changing its face.*

Ontology is the controlled answer to the question "what kind of thing is this, and how is it related to everything else?" Without it, a sculpt name becomes a product name, a paint change becomes an edition, a package revision becomes a new figure, and ownership history becomes a note no system can reliably interpret.

The ontology separates identity from state. A character can appear in many products. A figure product can have several tool, paint, and package versions. A manufactured unit belongs to a batch and may later accumulate ownership, condition, and repair events. An accessory can be included in one package, reused across a series, or replaced without changing the identity of the character. These distinctions allow accurate catalogs, recall scope, cost rollups, variant analysis, and provenance.

Cards provide a useful precedent because a card can be image, rule unit, physical object, ordered member, database record, randomizer, and collectible at once. The correct system does not force one identity to erase the others; it records typed relationships among them (Conrad and OpenAI, *Cards* 1-2). The same applies to figures: "Obsidian Veil Operative" may be a character, a 3.75-inch product, a sculpt revision, a package name, and a collector shorthand, but the system must know which meaning is active.

Events are append-only where history matters. Production release, batch creation, inspection, sale, transfer, repair, return, retirement, and destruction should not be overwritten by the current status. The canonical state is derived from the event record, preserving a truthful route back through time.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Character	Narrative identity independent of any one scale, costume, pose, or product.
Product / figure	Commercial and engineering configuration offered as a defined unit.
Part	Independently identified component with geometry, material, process, interfaces, and version.
Joint / interface	Typed relationship that permits or prevents motion, attachment, load transfer, signal, or service.
Accessory	Separate functional or narrative object with compatibility and inclusion relationships.
Vehicle / creature / environment	Higher-order object that supports seating, riding, docking, scale, and world interaction.
Series / wave / assortment	Planning structures that organize release, narrative, case pack, price, and collector relationships.
Edition / variant / revision	Distinct controlled concepts: edition is authorized identity; variant is a known difference; revision is a change to a controlled artifact.
Prototype / master / tool / mold	Development and production objects with different authority, material, and evidentiary status.
Unit / batch / production run	Physical instances and grouped manufacture linked to facility, date, materials, process, inspection, and release.

Variable / concern	Operational requirement
Catalog / ownership / repair record	Information objects that describe identity, state, evidence, custody, and intervention.

Text Diagram. Canonical identity graph

```
[ CHARACTER-ID ]
       |
       +--> [ PRODUCT-ID ] --> [ EDITION-ID ] --> [ UNIT-SERIAL ]
                    |                 |                  |
                    +--> [ PART-IDs ] +--> [ PACKAGE ]   +--> [ OWNERSHIP EVENTS ]
                    |                 |                   +--> [ REPAIR EVENTS ]
                    +--> [ TOOL-IDs ] +--> [ PAINT VER ]  +--> [ CONDITION STATE ]
                    +--> [ TESTS ]    +--> [ CATALOG VIEW ]
```

Audio description: A character links to products; products link to parts, tools, tests, and editions; editions link to package and paint versions; individual units accumulate ownership, repair, and condition events.

PRODUCTION APPLICATION

- Create stable, non-semantic IDs for characters, products, parts, tools, editions, packages, batches, and units.
- Define controlled relationship types and state transitions before database or packaging implementation.
- Separate aliases and display names from canonical identity.
- Use append-only events for changes whose history must remain auditable.

AI-AGENT INTERPRETATION

AI may map natural-language descriptions to ontology candidates, detect duplicate identities, generate derived views, and flag impossible relationships. It must not merge records solely because names are similar, create provenance events without evidence, or promote an informal nickname into canonical identity without approval.

FAILURE CASES AND CORRECTIVE ACTION

- A package color revision is cataloged as a new sculpt, or a new sculpt is hidden under the old product ID.
- A returned unit loses its ownership and repair history when status changes back to available.
- An accessory is described only in marketing copy and has no part, material, or compatibility identity.
- The factory and catalog use different identifiers with no controlled crosswalk.

RELEASE GATE: No production package is released until all required entities, relationships, states, and identifiers can be resolved from one canonical record.

Evidence classification and research anchors. E: systems architecture, configuration management, database identity, lifecycle records. S: append-only provenance and multi-identity play object. P: Raven Valley play ontology and identifier grammar.

Training exercise. Model one figure, two paint variants, one running package change, one repaired unit, and one reissue. Identify which entities remain the same and which require new IDs.

PART 2

FROM NARRATIVE TO PRODUCT FORM

Translating story, character, culture, and intention into measurable design constraints.

THE STORY TAKES WEIGHT

A name enters the workshop without a shadow.
Line gives it posture; mass gives it consequence.
When story accepts the discipline of measure,
imagination learns how to stand upon the table.

06

Narrative Decomposition

Converting prose, culture, character, and story arc into controlled product variables

THE SENTENCE ENTERS THE SHOP

> *"Ancient sentinel" is smoke until the line chooses a spine.*
> *"Kind" is air until the hand opens instead of closes.*
> *The story does not lose wonder when it accepts dimension;*
> *it gains a road by which wonder may arrive intact.*

Narrative decomposition converts expressive language into a traceable design brief without pretending that story can be reduced to geometry. The goal is not to drain ambiguity from the character. It is to identify which meanings must survive scale, articulation, material, paint, package, cost, and manufacturing limits.

A narrative statement contains several layers: role, world, temperament, history, technology, movement, relationships, vulnerabilities, tools, rituals, and change over time. Each layer can produce formal candidates. "Ancient technological sentinel" may imply vertical stability, repeated service lines, repaired surfaces, a protected face, deliberate movement, and an accessory that reads as both instrument and relic. These are hypotheses, not automatic truths; they remain linked to the source statement and tested against audience interpretation.

Structure-mapping research supports using analogy through relational correspondences rather than superficial resemblance. A designer can map the relational logic of a cathedral - hierarchy, threshold, buttress, nave, light - onto a figure without copying literal windows onto armor. The Weaving Understanding framework adds a falsification step: state what the analogy predicts, what would break it, and what minimal test can reveal whether it helps (Conrad and OpenAI, *Weaving Understanding* 2-4).

The resulting brief should contain both positive requirements and exclusions. A character may need to feel "ceremonial but field-ready," which can require high focal order, durable joint protection, and limited bright accents while excluding fragile ornament, random noise, and surfaces that cannot survive handling. Exclusions are not creative punishment. They define the design space in which coherent invention becomes possible.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Role	What the character does, for whom, under what authority, and with what recurring tasks.
Setting	Historical, speculative, ecological, architectural, and technological context; distinguish documented reference from fictional synthesis.
Temperament	Translate into posture, openness, symmetry, rhythm, facial treatment, and accessory behavior without claiming personality can be read universally from form.
Culture	Record source, meaning, permission, variation, and consultation; avoid generic fusion that erases distinct histories.
Movement style	Cadence, reach, stability, speed, restraint, transformation, and characteristic poses.
Vulnerability	Narrative weakness, exposed mechanism, repair, protective feature, or limitation that creates readable stakes.
Tools and rituals	Objects and repeated actions that reveal role and provide play affordances.
Story arc	Identify which states deserve separate products, removable parts, transformations, damage, or package narratives.
Silhouette output	Dominant mass, centerline, proportion, negative space, and recognition distance.

Variable / concern	Operational requirement
Series position	Hero, guide, worker, antagonist, creature, vehicle, environment, or connective role in the assortment.

Text Diagram. Narrative-to-product translation

```
[ SOURCE NARRATIVE ]
        |
        v
[ ROLE / WORLD / TEMPERAMENT / ACTION / MEMORY ]
        |
        v
[ RELATIONAL ANALOGIES + CONSTRAINTS ]
        |
        v
[ SILHOUETTE / SCALE / MOTION / MATERIAL / ACCESSORY / PAINT ]
        |
        v
[ PROTOTYPE INTERPRETATION TEST ] -- mismatch --> [ REVISE MAPPING ]
```

Audio description: Narrative is decomposed into role, world, temperament, action, and memory, then mapped through analogies and constraints into product variables and tested through prototypes.

PRODUCTION APPLICATION

- Preserve the exact source phrase beside each derived design requirement.
- Label direct requirement, supported inference, project hypothesis, and decorative option separately.
- Create at least three materially different silhouette responses before choosing one.
- Write exclusions and failure signs as clearly as desired features.
- Test whether the product communicates the intended role without package copy.

AI-AGENT INTERPRETATION

AI may extract narrative entities, propose several relational mappings, generate controlled design packets, and show which phrases support each output. It must not treat cultural motifs as a free asset library, collapse temperament into physiognomic stereotypes, or claim one visual interpretation is psychologically universal.

FAILURE CASES AND CORRECTIVE ACTION

- The design copies nouns from the brief but loses relationships, making the object literal and incoherent.
- An analogy imports hidden assumptions that conflict with safety, culture, or character role.
- Package copy carries all narrative identity because silhouette, tool, and motion communicate nothing.
- AI generates many details that have no trace to source, function, or series grammar.

RELEASE GATE: A narrative-derived requirement must show its source, interpretation, evidence class, product consequence, exclusion, and verification method before it becomes authoritative.

Evidence classification and research anchors. E: analogy and metaphor research; narrative and design precedents. S: translation into controlled design constraints. P: Raven Valley narrative packet and falsification gate.

Training exercise. Decompose "ancient technological sentinel" into ten narrative relations, three shape grammars, two motion styles, two material hierarchies, and one falsifiable prototype test.

07

Bauhaus Translation: Form, Function, and Constraint

Using geometric discipline and workshop integration without reducing character to generic minimalism

THE WORKSHOP AND THE MASK

> *The square is not honest merely because it is plain.*
> *The circle is not humane merely because it is whole.*
> *Form follows function only after function has been named;*
> *discipline becomes beauty when labor and purpose meet.*

Bauhaus precedent is useful not as a command to make every figure geometric and sparse, but as a model for integrating art, craft, industry, material, typography, and repeatable production. The translation must preserve narrative difference while making the formal system teachable and manufacturable.

The Bauhaus sought a new relationship among workshop practice, modern industry, visual order, and everyday life. Its legacy includes geometric reduction, modular composition, material experimentation, typographic hierarchy, and the effort to join art with production. A Raven Valley figure may use these principles to clarify mass, joint, interface, and package rather than to imitate a historical style superficially (Museum of Modern Art; Metropolitan Museum of Art).

A formal translation begins with relational properties. Stability can become a broad support polygon, vertical alignment, low visual noise, and protected joints. Speed can become directional taper, forward mass, and repeated diagonals. Authority can become a strong centerline, controlled symmetry, and concentrated contrast. Mystery can become recess, occlusion, and limited visual access. These are design hypotheses to test, not natural laws of meaning.

Constraint is productive when it is explicit. A line may be restricted to one dominant shape family, one secondary counter-shape, three surface rhythms, and a limited color hierarchy. Variation then occurs through proportion, interruption, material, and local filigree. The Unified Web Design Codex offers a parallel project precedent: limited palettes, grids, hierarchy, cognitive-load reduction, and purposeful degrees of freedom make systems easier to understand and maintain (Conrad and OpenAI, *Unified Web Design Codex* 1-3).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Stability	Broad base, aligned load path, reduced top-heaviness, repeated horizontal or vertical anchors.
Speed	Forward lean, taper, directional diagonals, exposed trajectory, and reduced rearward visual drag.
Authority	Central axis, high-contrast focal mass, controlled symmetry, and deliberate spacing.
Mystery	Occlusion, recess, negative space, partial reveal, and limited high-value detail.
Fragility	Thin transitions, suspended mass, exposed dependency, or transparent layers - used only when safe and structurally truthful.
Adaptability	Modular interfaces, repeatable connector grammar, reversible parts, and visible service logic.
Antiquity	Layering, wear, repair, accumulated geometry, patina logic, and evidence of prior use.
Technology	Repetition, grids, interface lines, service panels, controlled radii, and system feedback.
Bauhaus restraint	Remove ornament that lacks narrative, structural, perceptual, or manufacturing function; preserve expressive irregularity when it carries meaning.

Text Diagram. Constraint-led form translation

```
NARRATIVE PROPERTY
       |
       v
RELATIONAL MEANING
       |
       v
SHAPE + MASS + RHYTHM + MATERIAL + COLOR
       |
       v
MANUFACTURING / MOTION / PLAY CHECK
       |
       +-- conflict --> REVISE FORM, NOT THE EVIDENCE
```

Audio description: Narrative property becomes relational meaning, then formal variables, then passes manufacturing, motion, and play checks; conflicts require revision.

PRODUCTION APPLICATION

- Build a shape grammar sheet before sculpting secondary detail.
- Limit the first pass to silhouette, dominant planes, joint centers, and material zones.
- Test the design in black silhouette, flat value, and untextured clay render.
- Use grids and modular dimensions for packaging and playset systems while allowing character-specific departures.

AI-AGENT INTERPRETATION

AI may generate alternative formal translations from the same narrative property, compare constraint compliance, and produce shape-grammar tables. It must not equate Bauhaus with a generic "minimalist" look, erase craft and material history, or claim that geometric meanings are universal across cultures.

FAILURE CASES AND CORRECTIVE ACTION

- Geometric reduction removes narrative evidence and produces interchangeable characters.
- Ornament is removed from renders but structural clutter and manufacturing inefficiency remain.
- A shape is chosen for symbolic meaning but creates poor balance, unsafe points, or impossible tooling.
- Packaging imitates vintage modernism while information hierarchy and accessibility fail.

RELEASE GATE: Formal restraint is approved only when each retained feature supports narrative, perception, manufacture, motion, play, or service - and each removed feature is not carrying an unrecognized function.

Evidence classification and research anchors. E: Bauhaus historical scholarship and established visual-design principles. S: narrative-to-form translation table. P: Raven Valley constraint grammar.

Training exercise. Translate the same character through stability, speed, and mystery. Produce three silhouette briefs that use the same accessory and scale but different mass, line, and negative-space systems.

08

Shape Grammar and Series Language

Building recognizable families without making every product a repetition

THE FAMILY OF FORMS

> *One arch can shelter a city or become a cage.*
> *One triangle can warn, ascend, or wound.*
> *Repeat the relation, not the costume;*
> *a true family resembles itself without becoming a copy.*

A shape grammar is a controlled vocabulary of forms and transformations that allows a series to remain coherent across characters, creatures, vehicles, packages, and playsets. The grammar should create family resemblance while preserving role, scale, silhouette, and individual narrative.

The grammar identifies primitives - circle, triangle, square, arch, spine, rib, shell, plate, filament, void - and rules for combining them. A faction may use nested arches for protection, split triangles for mobility, and copper lines for service paths. A rival faction may use radial shells, exposed voids, and high-chroma interruption. The rule is not "put this emblem everywhere." It is "preserve these relationships across scale and function."

Visual Equations provides a project precedent for distributed coherence: local regions should retain ratios, directions, rhythms, or semantic cues that point back to the whole. This is a design-programming analogy rather than literal holography. The practical consequence is that a boot tread, chest panel, package border, and playset doorway can echo the same grammar without duplicating the same picture (Conrad and OpenAI, *Visual Equations* 1-3).

Series language also includes negative rules. Connector diameters may be standardized while hand sculpts vary. Paint accent positions may share hierarchy while hues differ. Hero figures may break one faction rule deliberately, creating salience that is legible because the baseline is stable. A grammar without permitted exception becomes monotony; exception without baseline becomes noise.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Primitive shapes	Define the basic forms and the physical or narrative relations they usually carry within the project.
Transformation rules	Scale, rotate, mirror, split, nest, repeat, taper, interrupt, and bridge shapes under controlled constraints.
Dominant / subordinate hierarchy	Assign one primary form, one counter-form, and limited tertiary detail families.
Faction grammar	Record shared silhouettes, materials, line directions, interfaces, and symbols across related products.
Role differentiation	Use proportion, density, openness, posture, and accessory logic to distinguish hero, worker, civilian, antagonist, creature, and vehicle.
Cross-scale recurrence	Echo structural relationships from figure microdetail to package and playset architecture.
Connector standards	Standardize only where interoperability, safety, tooling reuse, or play benefits justify it.
Controlled exception	Name which rule a special character breaks, why, and how the rest of the grammar maintains recognition.

Text Diagram. Series grammar with controlled exception

```
[ PRIMITIVES ] -> [ COMBINATION RULES ] -> [ FACTION BASELINE ]
                                                  |
                        +-------------------------+------------------+
                        |                         |                  |
                  [ HERO ]                   [ WORKER ]         [ VEHICLE ]
            breaks one rule               preserves rules      scales rules
            keeps all anchors              shifts proportion    changes structure
```

Audio description: Primitives and combination rules form a faction baseline that branches into hero, worker, and vehicle expressions with controlled differences.

PRODUCTION APPLICATION

- Create a series grammar sheet with allowed primitives, transformations, materials, accents, and exclusions.
- Audit every new character against family anchors and role differentiation.
- Record cross-line connector and accessory standards separately from aesthetic grammar.
- Test recognition using silhouette and grayscale before logos or package names are shown.

AI-AGENT INTERPRETATION

AI may classify form, compare a proposal to a grammar, generate bounded variants, and explain which rules are preserved or broken. It must not generate infinite superficial variations, treat stylistic similarity as proof of shared identity, or introduce a connector standard without mechanical and safety review.

FAILURE CASES AND CORRECTIVE ACTION

- Every character shares the same torso and differs only by color, weakening role and narrative.
- Rules are so vague that any design can be declared compliant after the fact.
- Cross-scale motifs are pasted as decoration rather than translated to structural function.
- An intentional exception is not documented and later becomes uncontrolled drift.

RELEASE GATE: A series design must demonstrate family recognition, role differentiation, cross-scale coherence, and a documented reason for every rule exception.

Evidence classification and research anchors. E: shape grammar, Gestalt, series and product-family design precedents. S: distributed coherence translation. P: Raven Valley faction grammar and exception protocol.

Training exercise. Define a five-rule shape grammar for the Obsidian Veil line, then design a hero, field worker, creature harness, and package border using the same relations at different scales.

09

Heliometric Composition and Focal Hierarchy

One primary sun, several moons, and a controlled path of attention

THE LIGHT CHOOSES A CENTER

> *Every figure gathers the eye around something.*
> *Choose badly and detail becomes weather without direction.*
> *Choose well and every lesser mark keeps its orbit,*
> *guiding the hand toward the story it can enter.*

Heliometry is used here as a project term for governing attention, not as a canonical law of physics. A product or presentation should identify one primary focal center - the sun - while secondary features remain moons that support, delay, frame, or redirect attention without becoming equal competing centers.

The sun may be a face, helmet aperture, chest emblem, creature head, signature tool, transforming mechanism, or package title. Its identity depends on task. In a narrative render the face may lead; in a technical view the joint section or exploded interface becomes the sun; in a shelf package the brand and silhouette must cooperate. Heliometric governance is therefore viewpoint-specific and should never hide safety or manufacturing information for visual drama.

Attention research indicates that gaze is influenced by salience, meaning, task, expectation, and scene structure. The Visual Equations paper translates this into bounded circulation: guide scanpaths through repeated angle, contrast, rhythm, and semantic anchors; prevent visual weight from accumulating in dead zones; and ensure local detail still points back to global composition (Conrad and OpenAI, *Visual Equations* 1-4).

For a small figure, focal hierarchy is constrained by scale. Paint operations and microtexture can disappear at shelf distance, while a silhouette break or metallic accent remains legible. The design should be tested at intended viewing distances, in the package, in neutral light, and in the hand. A high-resolution render is not the authoritative perception test.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Primary sun	The feature that should receive first attention for the current view and task.
Secondary moons	Supporting features that preserve relevance but remain subordinate in contrast, scale, density, or placement.
Scanpath	The intended sequence of attention across figure, accessory, package, and information.
Salience channels	Value, hue, gloss, edge, scale, isolation, movement, symmetry break, and semantic meaning.
Viewing distance	Macro silhouette, mid-range material and color blocks, near-range sculpt and microdetail.
Task change	Narrative, technical, safety, retail, catalog, and training views may require different suns.
Circulation	Repeated directional cues should move attention through the product rather than trap it in visual clutter.
Attention ethics	Do not use hierarchy to conceal warnings, edition uncertainty, required accessories, or degraded function.

Text Diagram. One sun, several product moons

```
( material accent )
                      ( accessory ) ---- [ PRIMARY SUN ] ---- ( silhouette break )
                      /
             ( joint rhythm )

MOONS REMAIN LEGIBLE, BUT DO NOT BECOME EQUAL CENTERS
```

Audio description: A primary feature is surrounded by material, accessory, silhouette, and joint-rhythm moons that remain subordinate.

PRODUCTION APPLICATION

- Declare the focal sun for each render, package face, card back, technical sheet, and catalog image.
- Test hierarchy at thumbnail, shelf, arm-length, and close-view scales.
- Use paint and finish operations where they improve recognition, not merely because detail is available.
- Confirm that warnings and critical technical information remain legible even when not visually dominant.

AI-AGENT INTERPRETATION

AI may score or compare contrast, density, edge, and semantic emphasis; produce alternative focal hierarchies; and flag competing suns. It must not represent a salience score as a universal measure of beauty or attraction, and it must preserve task-critical information even when optimizing visual clarity.

FAILURE CASES AND CORRECTIVE ACTION

- Every surface is highly detailed and metallic, eliminating hierarchy.
- Package art, figure silhouette, title, and accessory callouts compete equally at shelf distance.
- A technical render uses cinematic darkness that hides the exact interface under review.
- AI concentrates attention by exaggerating culturally sensitive or anatomically intimate features without instruction.

RELEASE GATE: The intended focal order must remain legible at actual scale, actual package, actual light, and actual task without concealing safety, identity, or evidence.

Evidence classification and research anchors. E: attention, salience, task, and perception research. S: focal hierarchy and viewing-distance tests. P: Raven Valley heliometric vocabulary.

Training exercise. Create four focal maps for one figure: narrative portrait, engineering review, retail card, and catalog record. Explain why the sun changes and which moons must remain visible.

10

Functional Filigree for Play Objects

Elegance that carries structural, mechanical, informational, or service value

THE LINE THAT EARNS ITS PLACE

> *Let the spiral guide the thumb to release.*
> *Let the rib strengthen what the eye admires.*
> *Beauty is not excused from labor;*
> *the finest ornament remembers how to help.*

Functional filigree is ornament whose visible form also performs structural, tactile, optical, thermal, electrical, informational, fastening, manufacturing, protective, or service work. The term does not declare every decorative line functional. The function must be named, tested, and preserved through change.

In a figure, filigree can stiffen a thin panel, shield a joint gap, provide grip, divide paint masks, conceal a gate or ejector witness, register assembly, route light, protect a printed symbol, mark an access panel, or identify an edition. In a package, it can guide the eye, reinforce a hanger region, separate legal information, or create a tamper-evident pattern. A single geometry may carry several roles, but each role introduces constraints and possible failure.

The Raven Valley Veil defines functional filigree as ornament that can carry load, signal, heat, light, air, fastening, protection, or repair access; the Book of Conduct extends the principle by requiring elegance to improve orientation rather than burden the user (Conrad and OpenAI, *Raven Valley Veil* 3-4; *Book of Conduct* 49-50). Play objects add molding, paint, assembly, grip, and catalog functions to that list.

Filigree must survive translation across scale and process. A line wide enough in concept art may vanish in injection molding, trap paint, create a sharp ridge, or increase tool complexity. A deep recess that looks ancient may become an air trap or contamination pocket. Functional claims therefore belong in the engineering record, not only the artist statement.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Grip filigree	Texture and contour that improve handling without creating sharpness, soil traps, paint wear, or difficult cleaning.
Structural filigree	Ribs, beads, corrugation, gussets, and shells that increase stiffness or distribute load while respecting molding rules.
Joint shielding	Surface overlap that hides gaps and protects pins without blocking range or increasing friction.
Paint boundary	Raised or recessed geometry that supports masks, pad printing, or color separation and reduces overspray risk.
Tooling witness management	Place gates, ejectors, parting lines, and fasteners where form can absorb or honestly display them.
Registration	Keys, asymmetry, stops, and tactile marks that prevent incorrect assembly.
Optical / electrical route	Light pipes, windows, traces, channels, speakers, sensors, and battery access integrated with visible pattern.
Provenance mark	Molded, printed, or digital identifiers positioned for durability and inspection without counterfeiting theater.
Service access	Panels, seams, screws, and release points made legible through the visual language.

Text Diagram. Functional filigree audit

```
VISIBLE FEATURE
      |
      +--> NARRATIVE / SYMBOLIC VALUE
      +--> STRUCTURAL / MECHANICAL VALUE
      +--> MANUFACTURING / ASSEMBLY VALUE
      +--> PLAY / ACCESS / SERVICE VALUE
      |
      v
TEST EACH CLAIM -> PRESERVE IN CHANGE CONTROL -> REMOVE FALSE CLAIMS
```

Audio description: A visible feature may carry narrative, structural, manufacturing, play, access, or service value; each claimed function is tested and governed.

PRODUCTION APPLICATION

- Annotate every filigree feature with claimed functions, process consequences, and verification method.
- Prototype tactile and joint-shielding features at actual scale.
- Include paint, cleaning, tool action, and wear in the review.
- Do not hide safety-critical defects or unauthorized changes beneath decorative geometry.

AI-AGENT INTERPRETATION

AI may propose multi-function geometry, compare filigree density to series grammar, and produce a function-to-feature matrix. It must not call a feature functional without an explicit mechanism and test, nor hide a gate, fastener, or seam in a way that prevents inspection or repair.

FAILURE CASES AND CORRECTIVE ACTION

- Ribs are added as visual texture but cause sink, knit lines, or stress concentration.
- A joint cover improves silhouette but grinds paint and reduces range.
- An edition mark is easy to remove, reproduce, or separate from the actual product record.
- A service panel is visually integrated so completely that users pry the wrong seam.

RELEASE GATE: Every functional-filigree claim must identify the load, signal, action, process, or service it supports and pass an actual-scale verification.

Evidence classification and research anchors. E: structural design, molding, ergonomics, visual communication, and serviceability. S: integration of aesthetic and practical functions. P: Raven Valley functional-filigree doctrine.

Training exercise. Choose five decorative features on the Obsidian Veil figure. Give each a measurable secondary function or remove it. Then identify one new failure created by each function.

PART 3

SCALE, GEOMETRY, STRUCTURE, AND TECHNICAL DEFINITION

The controlled language through which form becomes buildable and inspectable.

THE SMALL ARCHITECTURE

A fraction is not a lesser world.
It is a world whose errors have nowhere to hide.
The small wall still carries load; the small hand still asks clearance.
Precision is mercy practiced before assembly.

11

Scale Systems

Nominal height, relational scale, interface scale, and the compromises hidden inside a number

THE FRACTION AND THE WORLD

> *Three and three-quarter inches can hold a kingdom,*
> *but only if the door, the hand, and the horse agree.*
> *Scale is not the number printed beneath the name;*
> *it is the covenant by which separate things can meet.*

Scale is a network of relationships, not a single height. A nominal 3.75-inch figure may be called 1:18, yet character height, stylization, footwear, helmet, species, packaging, vehicle seating, hand openings, and accessory diameter can make the practical system diverge from literal mathematical scale.

A production record should distinguish stated scale, nominal product height, character-relative height, eye height, hip height, shoulder width, foot length, stance footprint, hand opening, joint-center locations, and standard interface dimensions. These values answer different questions. Eye height helps vehicle and environment alignment; hip height governs seating; hand opening governs accessory interchange; footprint governs balance and package cavity.

Scale compression is sometimes legitimate. Hands and feet may be enlarged for readability and strength; weapons and tools may be thickened for mold filling and safety; vehicle interiors may be expanded for articulation and soft goods; architecture may use forced perspective to preserve shelf size. Every compression should be recorded because it affects cross-line compatibility and interpretation. A stated ratio is honest only when the deviations are known.

The scale system must also preserve human use. Extremely small accessories increase loss and choking risks. Very narrow grips require excessive force. Larger figures increase mass, fall energy, package volume, tooling cost, and shelf footprint. The correct scale is therefore an intersection of narrative, play, safety, manufacturing, transport, and market constraints.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Stated scale	The ratio or category communicated to users; record whether it is literal, approximate, or a product-family convention.
Nominal height	The released dimension from defined datum to defined top point, excluding or including removable headgear as stated.
Character-relative height	The intended height relationship among characters independent of product category.
Landmark heights	Eye, shoulder, elbow, hand, hip, knee, and seat references for cross-object interaction.
Interface scale	Hand openings, ports, pegs, seat width, foot pegs, docking bays, doors, ladders, and environmental clearances.
Stylization allowance	Document purposeful enlargement, shortening, thickening, or compression.
Package scale	Cavity, card, tray, carton, case, and shelf-module constraints.
Perceptual scale	The size at which silhouette, face, emblem, material break, and paint remain readable.

Text Diagram. Scale relationship stack

```
[ NARRATIVE CHARACTER HEIGHT ]
              |
[ PRODUCT NOMINAL HEIGHT ]
              |
[ LANDMARK + JOINT CENTER SCALE ]
              |
[ HAND / ACCESSORY / VEHICLE INTERFACE SCALE ]
              |
[ PACKAGE / CASE / SHELF SCALE ]
```

Audio description: Narrative height is translated into product height, landmark and joint scale, interface scale, and finally packaging and shelf scale.

PRODUCTION APPLICATION

- Publish one scale datum and measurement method for every product family.
- Maintain a cross-character landmark chart and an interface gauge library.
- Test figures with vehicles, creatures, playsets, stands, and packages using production-intent proxies.
- Declare all scale compression and whether compatibility is full, partial, or visual only.

AI-AGENT INTERPRETATION

AI may calculate proportional conversions, compare landmark tables, identify incompatible interfaces, and generate scale diagrams. It must not infer actual human height from a stylized figure, assume a nominal category equals an exact ratio, or resize one asset without propagating interface, wall, joint, and package consequences.

FAILURE CASES AND CORRECTIVE ACTION

- A 1:18 figure cannot use another 1:18 line because hand, seat, and foot interfaces were never standardized.
- Helmet height is included in one product and excluded in another, corrupting line planning.
- Accessories are visually scaled but too thin to mold or too small for the intended age route.
- Packaging dictates a crouched or deformed pose that permanently changes soft material.

RELEASE GATE: Scale release requires defined datums, landmark dimensions, interface gauges, compression notes, and verified compatibility with the objects the product claims to use.

Evidence classification and research anchors. E: dimensional practice, anthropometry, human factors, packaging and toy-safety constraints. S: multi-layer scale model. P: Raven Valley scale passport.

Training exercise. Build a scale card for a 95.25 mm figure with eye, shoulder, hip, seat, hand, and foot references. Test one accessory, one doorway, and one vehicle seat against it.

12

Character Anthropometry and Stylization

Transforming anatomy into readable, manufacturable, and respectful small-scale form

THE BODY WITHOUT A THRONE

> *A ratio may guide the line but cannot crown the body.*
> *The face may be enlarged so memory can find it.*
> *Let stylization declare its purpose and its cost;*
> *no measurement is permitted to become a verdict.*

Character anthropometry names the measurable relationships of a designed body. Stylization changes those relationships to support recognition, narrative, movement, strength, or manufacture. The framework rejects the use of one ideal human canon as a universal law and rejects body shape as a basis for moral, personality, fertility, or health inference.

At small scale, literal reduction can fail. A correctly scaled hand may be unable to hold an accessory; a thin ankle may fracture; realistic eyelids may disappear under paint; costume layers may widen a joint beyond the body reference. The designer therefore distinguishes character anatomy from product anatomy. The difference is documented, intentional, and tested rather than hidden under the phrase "stylized."

Head-count proportion, shoulder-to-hip relation, limb length, hand and foot size, joint bulges, armor offsets, and garment thickness should be mapped to character role and motion. Childlike proportions demand special care because large head, short limb, and facial cues can alter perceived age and marketing. Creature and robotic anatomy require equivalent discipline: define functional joints and load paths rather than borrowing human axes where the narrative body does not support them.

Representation is contextual. Cultural dress, disability, age, body diversity, and gender expression should be sourced and reviewed without turning population averages into destiny. The Veil precedent is useful: historical proportion systems can inform relationships but should not erase actual bodies or chosen intention (Conrad and OpenAI, *Raven Valley Veil* 3-10).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Reference body	The narrative and anatomical basis before costume, armor, stylization, and articulation accommodation.
Product body	The engineered body after strength, grip, paint, wall, joint, and mold requirements are applied.
Head-count proportion	A descriptive ratio for design comparison, not a value ranking.
Hands and feet	Often enlarged for recognition, balance, grip, wall thickness, and durability; record interface effects.
Joint accommodation	Local volume added or relieved around swivels, hinges, sockets, and captive features.
Costume and armor offsets	Layer thickness, air gaps, overlap, undercuts, and motion clearances.
Age and species cues	Use responsibly; do not allow ambiguous age coding to conflict with marketing, sexualization, or safety.
Asymmetry	Distinguish intentional anatomy, injury, equipment, pose, and manufacturing error.
Soft goods	Account for seam, hem, closure, bulk, fray control, and scale stiffness.

Text Diagram. Reference body to product body

```
[ REFERENCE ANATOMY ]
        + [ NARRATIVE STYLIZATION ]
        + [ COSTUME / ARMOR OFFSET ]
        + [ JOINT / WALL / TOOL NEED ]
        + [ GRIP / BALANCE / PAINT NEED ]
        = [ PRODUCT BODY ]

PRODUCT BODY MUST STILL TRACE BACK TO CHARACTER INTENT
```

Audio description: Reference anatomy is modified by stylization, costume, joints, wall, tooling, grip, balance, and paint to create the product body.

PRODUCTION APPLICATION

- Overlay reference anatomy, product anatomy, costume, joint centers, and wall sections in separate controlled layers.
- Create a stylization delta table rather than relying on visual memory.
- Test recognition and respectful interpretation with representative reviewers.
- Validate balance, strength, grip, and vehicle fit after every major proportion change.

AI-AGENT INTERPRETATION

AI may compare proportions, generate stylization deltas, propose joint accommodation, and flag inconsistent age or species cues. It must not infer protected or sensitive personal attributes from body shape, rank bodies, or claim attraction or personality outcomes from proportions.

FAILURE CASES AND CORRECTIVE ACTION

- Literal anatomy creates fragile ankles, invisible facial detail, or unusable hands.
- Stylization is used to excuse inconsistent scale and untracked interface changes.
- Armor offsets are modeled as surface detail and collide with joints or vehicle seats.
- A body type is presented as inherently heroic, villainous, intelligent, or comic.

RELEASE GATE: Product anatomy is released only when every major stylization delta has narrative, perceptual, mechanical, or manufacturing rationale and no prohibited inference.

Evidence classification and research anchors. E: anthropometry, biomechanics, perception, product safety, representation ethics. S: reference-body/product-body separation. P: Raven Valley stylization delta register.

Training exercise. Create a two-column anatomy sheet showing reference and product dimensions for head, hand, ankle, shoulder, hip, and costume thickness. Explain each deviation.

13

Parametric Geometry and ARCH-3 Translation

Outer shell, inner core, corresponding vertices, nested frames, and controlled recurrence

THE FRAME WITHIN THE FRAME

An outer wall can sing while an inner rib carries the night.
Corresponding points remember where force must cross.
Offset the skin, preserve the relation, name the change;
architecture becomes portable when its rules can travel.

ARCH-3 is treated in this paper as a P-class project language because no canonical ARCH-3 source file was accessible. The user-supplied concepts - outer and inner envelopes, corresponding vertices, connecting struts, nested frames, controlled offsets, rotations, repeated modules, and preserved structural relationships - are translated into explicit parametric product logic and grounded through established CAD, structural, and tolerancing practices.

The fundamental move is to separate visible shell from structural core while preserving controlled correspondence. A shoulder armor plate may be an outer shell; a torso rib, joint carrier, or fastener boss forms the inner core; webs and struts transfer load between them. The design is not complete when surfaces look related. The model must state which vertices, axes, datums, and offsets govern the relation and which may vary.

Parametric geometry enables a family of controlled solutions: overall scale, shell thickness, core thickness, joint-center location, connector diameter, clearance, offset, rotation, deformation allowance, accessory port, and center-of-mass target. Parameters require units, bounds, dependencies, default status, and verification. A number hidden in a modifier stack is not a governed parameter.

The model should preserve semantic layers across tools. Sculpt packages may use subdivision surfaces; CAD packages use solids, features, constraints, and datums; rendering tools use meshes and materials. Translation is valid only when the structural relationships survive. ASME Y14.5-2018 provides a recognized language for communicating dimensional and geometric requirements in drawings and digital models, while model-based workflows require verification that exported geometry preserves intended product manufacturing information (ASME; Lubell, Hartman, and Cheney).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Outer envelope	Visible shell, armor, skin, facade, or package surface that carries silhouette and environmental interaction.
Inner envelope	Structural core, cavity, support frame, electronics volume, joint carrier, or assembly space.
Corresponding vertices / landmarks	Paired control points, axes, or datums that preserve relation through scale and deformation.
Connecting struts	Ribs, webs, bosses, pins, hinges, seams, or supports transferring load or maintaining spacing.
Nested frames	Figure, accessory, vehicle, package, and playset modules sharing a hierarchy of reference systems.
Controlled offset	Local distance between reference and shell, including wall, clearance, gap, or protective volume.
Rotation and recurrence	Repeated modules preserve axis and interface rules while allowing role-specific variation.
Parameter governance	Name, symbol, unit, nominal, range, source, dependency, owner, version, and test.

Variable / concern	Operational requirement
Tool translation	Document what is authoritative in sculpt, CAD, mesh, render, slice, and manufacturing files.

Text Diagram. ARCH-3 play-object translation

```
OUTER SHELL / VISIBLE ENVELOPE
          |
   RIBS / WEBS / STRUTS
          |
INNER CORE / CAVITY / JOINT CARRIERS
          |
JOINT + FASTENER + ACCESSORY NETWORK
          |
DATUMS + PARAMETERS + VERSIONED RELATIONSHIPS
```

Audio description: The visible shell connects through ribs and webs to an inner core, then to joint and fastener networks governed by datums and parameters.

PRODUCTION APPLICATION

- Create a parameter register before generating variants or size changes.
- Define a common origin, axis system, primary datums, and nested local frames.
- Run section checks at all joint carriers, bosses, thin shells, and accessory ports.
- Round-trip test CAD and mesh exports and compare units, orientation, topology, and critical dimensions.
- Label ARCH-3-derived rules P-class until a canonical source is attached and reconciled.

AI-AGENT INTERPRETATION

AI may generate parameter tables, compare outer and inner envelopes, locate unsupported shells, and propose recurrence across a family. It must not claim access to absent ARCH-3 documents, invent authoritative values, or treat visually similar meshes as geometrically equivalent.

FAILURE CASES AND CORRECTIVE ACTION

- Outer form changes while joint centers and package cavity remain frozen.
- Parametric modifiers create self-intersection, zero-thickness regions, or inaccessible fasteners.
- Export preserves appearance but changes scale, origin, normals, or critical curves.
- A recurring motif is copied without preserving load or interface relationships.

RELEASE GATE: No parametric family is baselined until parameters, datums, dependencies, limits, tool authority, and verification outputs are explicit and repeatable.

Evidence classification and research anchors. E: CAD constraint systems, ASME Y14.5, model-based definition, structural design. S: shell/core and nested-frame translation. P: ARCH-3 terminology and project recurrence rules.

Training exercise. Model a torso as outer shell, inner core, two shoulder carriers, and three connecting ribs. Change overall scale by ten percent and list which parameters should and should not scale linearly.

14

Load Paths and Structural Zones

Where force enters, travels, concentrates, and leaves the object

THE QUIET ROAD OF FORCE

> *Impact speaks at the surface but travels through the unseen.*
> *A thin corner may inherit the burden of an entire arm.*
> *Draw the road before the fall arrives;*
> *strength begins where consequence is allowed to be visible.*

A load path is the route by which force travels through a part and assembly. Small figures can conceal severe leverage: a long accessory turns a wrist peg into a lever; a rigid coat transfers a fall into an ankle; a tight snap fit stores stress beside a knit line. Structural zones make those relationships inspectable.

Each part should be classified by structural role. Cosmetic shells carry appearance and limited environmental contact. Primary structures carry dominant load. Secondary reinforcements stabilize. Joint carriers receive repeated torque. Wear surfaces accept friction. Impact surfaces receive drops. Fastener bosses localize assembly forces. Flexible membranes bend intentionally. Decorative inserts should not accidentally become structural without being designed and tested as such.

The basic load modes are tension, compression, bending, shear, torsion, impact, and sustained load leading to creep. Real failures combine them. Stress concentration occurs at abrupt thickness change, notch, sharp internal corner, weld line, gate, void, screw boss, or material interface. The response is not simply to add material; added mass can increase sink, cooling variation, stiffness mismatch, and impact energy.

Structural analysis for toys and figures ranges from hand calculation and physical testing to finite-element simulation. Simulation is a hypothesis conditioned on geometry, mesh, boundary conditions, material model, and load case. It cannot replace abuse testing, material conditioning, or observation of production defects. The most useful early tool is often a clear load-path sketch followed by instrumented prototypes.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Cosmetic shell	Controls appearance and surface contact; do not assume it can carry joint or fall loads.
Primary structure	The core route carrying the dominant mechanical load.
Secondary reinforcement	Ribs, gussets, bridges, and shells that stabilize or distribute load.
Joint carrier	Local structure surrounding a pin, socket, hinge, axle, or fastener.
Flexible membrane	TPE, textile, living hinge, or thin section designed to bend within a defined strain range.
Impact surface	Region likely to strike during drops, collisions, packaging, or play.
Wear surface	Contact region designed for friction and repeated movement; material pairing and finish matter.
Boss / insert zone	Concentrated assembly feature requiring wall, radius, draft, torque, and weld-line review.
Stress concentration	Geometry or process condition that raises local stress and can initiate crack or whitening.
Creep and fatigue	Time-dependent deformation and progressive damage under sustained or repeated load.

Text Diagram. Simplified figure load path

```
ACCESSORY FORCE
      |
[ HAND / PEG ] -- torsion --> [ ARM ] -- bending --> [ SHOULDER CARRIER ]
                                                              |
DROP IMPACT --> [ TORSO CORE ] --> [ HIP CARRIERS ] --> [ LEGS / FEET ]
                                                              |
                                                  [ GROUND CONTACT ]
```

Audio description: Accessory force travels from hand through arm and shoulder, while drop impact travels through torso, hips, legs, and feet to the ground.

PRODUCTION APPLICATION

- Annotate expected load entry, transfer, concentration, and exit for every joint and major accessory.
- Use section views to review wall transitions, radii, bosses, ribs, and knit-line risk.
- Condition and cycle prototypes before drop and impact tests.
- Compare predicted and observed failure locations and update the model rather than merely thickening the broken zone.

AI-AGENT INTERPRETATION

AI may generate load-case checklists, identify obvious thin transitions and long lever arms, compare stress maps, and summarize failure records. It must not create material allowables, boundary conditions, or safety factors without validated inputs and engineering authority.

FAILURE CASES AND CORRECTIVE ACTION

- A long rifle or wing multiplies torque on a small wrist or shoulder peg.
- A rigid decorative skirt transfers impact into the hip socket and splits the torso.
- A thicker boss produces sink and a weak knit line rather than increased reliability.
- Finite-element color maps are approved without validating material, contact, or load assumptions.

RELEASE GATE: Every load-bearing or repeatedly moved interface requires a declared load path, failure mode, test condition, and acceptable result linked to production material and process.

Evidence classification and research anchors. E: mechanics of materials, polymer design, fatigue, creep, impact, and product testing. S: structural-zone taxonomy for figures. P: Raven Valley load-path record.

Training exercise. Draw the load path for a figure falling from table height while holding a long accessory. Mark three stress concentrations and propose three different mitigations.

15

Technical Drawings and Dimension Systems

Communicating form, fit, function, and inspection without relying on attractive ambiguity

THE DRAWING SPEAKS TO DISTANT HANDS

> *A render may charm the eye and leave the caliper blind.*
> *A dimension may be exact and still measure the wrong thing.*
> *Name the datum, the tolerance, the status, the view;*
> *clarity is the bridge by which strangers build one object.*

A technical drawing or model-based definition communicates design intent to people who were not present when the object was conceived. It must distinguish reference information from controlled requirements and identify what is critical to function, safety, assembly, paint, packaging, and interchangeability.

The minimum figure package typically includes orthographic front, rear, left, right, top, and bottom views; exploded assembly; joint close-ups; sections through carriers and walls; accessory interaction; package orientation; paint masks; and mold-parting studies. Not every view belongs on one crowded sheet. Each view should have purpose, scale, units, revision, product and part IDs, status, and approval.

Dimensions require datums and tolerance logic. Overall height may be a reference while shoulder-axis position is critical to fit. A hand-opening diameter may be a limit dimension; a cosmetic fold may be profile-controlled; a foot sole may require flatness and relationship to peg holes. ASME Y14.5-2018 provides a recognized GD&T language, but the team must apply it competently rather than decorate drawings with symbols (ASME).

Visual and manufacturing authority must be separated. A beauty render illustrates appearance. A controlled drawing or model defines released geometry. A paint master controls color placement. A golden sample controls aspects difficult to express numerically. Conflicts require a documented precedence rule and change request; operators should never be forced to choose among contradictory files at the line.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Reference dimension	Informative value derived from controlled geometry; not independently inspected as a requirement.
Controlled dimension	Released requirement with tolerance, datum context, and verification method.
Critical-to-function	Dimension or characteristic whose variation affects motion, assembly, safety, compatibility, or required appearance.
Datum	Stable reference feature or system used to orient and locate requirements.
Tolerance	Permitted variation based on function and process capability, not arbitrary decimal precision.
Draft and radii	Tool-release and stress-control geometry identified by zone and material/process.
Wall thickness	Section requirement tied to flow, cooling, stiffness, sink, impact, and material.
Surface / finish / color	Separate texture, gloss, color, coating, and cosmetic acceptance criteria.
Revision and status	Draft, review, approved, superseded, archived, or reference-only; never infer authority from newest timestamp alone.

Text Diagram. Drawing authority stack

```
[ PRODUCT REQUIREMENTS ]
          |
[ CONTROLLED CAD / MBD ]
          |
[ DRAWINGS + CTQ TABLES ]
          |
[ PAINT / MATERIAL MASTERS ]
          |
[ PHYSICAL GOLDEN SAMPLE ]
          |
[ INSPECTION RESULTS ]

CONFLICT -> CHANGE REQUEST -> DECISION -> VERIFIED RELEASE
```

Audio description: Requirements flow into controlled CAD, drawings, masters, samples, and inspection; conflicts return through change control.

PRODUCTION APPLICATION

- Create a drawing index that states purpose, authority, format, owner, and release status.
- Identify critical-to-quality characteristics and inspection method.
- Use section and detail views at every joint, snap, boss, thin wall, and paint boundary.
- Define precedence among CAD, drawing, paint sheet, material passport, and physical sample.
- Issue redlines only through controlled revision.

AI-AGENT INTERPRETATION

AI may check missing units, duplicated dimensions, inconsistent part IDs, view coverage, and unverified references. It may draft drawings from controlled geometry but must not invent tolerances, datum schemes, process capability, or approval status.

FAILURE CASES AND CORRECTIVE ACTION

- An overall dimension is tightly toleranced while the actual interface is uncontrolled.
- Technical sheets use perspective views that hide thickness and alignment.
- A physical sample differs from CAD, but no authority or change record explains which is correct.
- Manufacturing receives beauty renders without sections, part IDs, or inspection criteria.

RELEASE GATE: No tool or production operation begins from a file set that lacks units, datums, tolerance intent, status, authority, critical characteristics, and conflict precedence.

Evidence classification and research anchors. E: ASME Y14.5, model-based definition, configuration management, inspection practice. S: drawing authority stack. P: Raven Valley technical package order.

Training exercise. Create a drawing index for a five-point figure. Mark which view controls overall height, shoulder axis, hip axis, hand opening, foot flatness, and paint mask.

PART 4

MOTION, DEGREES OF FREEDOM, AND JOINT SYSTEMS

Designing movement as bounded agency rather than adding it after sculpt approval.

THE HINGE REMEMBERS

Freedom begins at the shape of its boundary.
The hinge speaks by stopping as clearly as by moving.
A joint survives when both sides keep the agreement,
and motion returns without spending the body away.

16

Degrees of Freedom

Defining what a mechanism may do by naming what it cannot do

THE BOUNDARY MAKES MOTION LEGIBLE

> *Freedom without axis is only force searching for damage.*
> *A stop without reason is only a hidden wall.*
> *Name the path, the range, the return, the wear;*
> *a useful motion is liberty that remembers consequence.*

A degree of freedom is an independent mode of motion. In figure design, a joint may rotate about one axis, rotate about several axes, translate, flex, or combine movements. The count is not a quality score. More articulation can increase pose, cost, gaps, wear, assembly, and failure; fewer joints can improve silhouette, durability, and vintage clarity.

Every joint record should identify axis or axes, coordinate frame, nominal range, hard stop, soft stop, clearance, intended torque or retention behavior, expected cycles, load case, collision surfaces, failure mode, and repairability. The same external appearance can conceal different mechanisms. A round neck may be swivel, ball, mushroom peg, or captive barbell; the user should not be invited to apply motion the mechanism cannot tolerate.

Kinematic description separates mechanism from pose. A three-axis ball joint may still have a limited reachable orientation because the sculpt collides. A hinge may have one theoretical rotational degree of freedom but a ratchet creates discrete states. A living hinge deforms rather than rotating about a perfect line. Modern Robotics and related kinematic texts provide formal languages for frames, joints, configuration, and motion; the toy application uses simplified but explicit models (Lynch and Park).

Degrees of freedom should be allocated by play scenario and silhouette. Head swivel supports orientation; shoulder swivel supports tool direction; hip swivel supports sitting or walking stance. Additional elbows, knees, wrists, or torso joints are justified only when their actions survive scale, material, paint, package, and cost constraints.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Zero DOF	Rigid connection; movement is not intended and force should transfer through controlled structure.
One-axis swivel	Rotation about a single axis, commonly head, shoulder, wrist, waist, or hip.
One-axis hinge	Rotation through an arc with visible axis and stops.
Two-axis universal-type motion	Two rotational axes combined through linked elements or geometry.
Three-axis ball motion	Orientation around a center with range limited by socket, stem, sculpt, and material.
Sliding joint	Translation along a path; control retention, dirt, pinch, and end stops.
Compound joint	Multiple joints whose order and interaction create the usable pose envelope.
Flexible joint	Motion through material deformation; strain, aging, tear, and environment govern life.
Rotational plus translational	Telescoping, cam, track, or transform mechanisms requiring state and lock control.

Text Diagram. Joint definition record

```
JOINT-ID
  |-- FRAME / AXIS OR AXES
  |-- NOMINAL RANGE
  |-- HARD STOP / SOFT STOP
  |-- CLEARANCE / COLLISION
  |-- TORQUE / RETENTION TARGET
  |-- LOAD / EXPECTED CYCLES
  |-- FAILURE MODE
  |-- ASSEMBLY / REPAIR METHOD
```

Audio description: The joint record branches into frames, range, stops, clearance, torque, load, failure, assembly, and repair.

PRODUCTION APPLICATION

- Create a joint center and axis map before final costume and armor surfaces.
- Use swept-volume and physical collision checks, not range numbers alone.
- Define the user-visible motion promise through silhouette and seam language.
- Cycle joints with production-intent material, paint, lubrication, and assembly conditions.

AI-AGENT INTERPRETATION

AI may derive a kinematic chain from declared joints, visualize pose envelopes, compare range to collision, and flag inconsistent axis definitions. It must not assume a joint type from appearance, invent torque targets, or treat simulation as cycle-life evidence.

FAILURE CASES AND CORRECTIVE ACTION

- A ball-joint appearance encourages multi-axis force on a single-axis peg.
- Nominal range ignores costume collision and is printed as a marketing claim.
- Additional articulation breaks silhouette and increases loose-joint complaints without meaningful play benefit.
- A living hinge is tested once but not aged, cycled, or conditioned.

RELEASE GATE: Every moving feature must have a complete joint record and physical verification of range, stops, retention, wear, collision, and foreseeable user force.

Evidence classification and research anchors. E: kinematics, mechanism design, polymer fatigue, human factors. S: play-driven DOF allocation. P: Raven Valley bounded-agency joint doctrine.

Training exercise. For one shoulder joint, define local frame, axis, range, hard stop, clearance, torque target class, expected cycles, load, failure, assembly, and repair.

17

The Five-Point Articulation Baseline

Vintage clarity, contemporary detail, and deliberate mechanical restraint

FIVE GATES OF MOTION

> *The head turns to meet the world.*
> *Two arms carry tools; two legs carry the story forward.*
> *Five gates are not poverty when each one speaks clearly;*
> *restraint becomes richness when form survives the hand.*

The five-point baseline uses one head swivel, two shoulder swivels, and two hip swivels. It is historically associated with classic 3.75-inch figures and remains useful when the design objective prioritizes silhouette, robust handling, simple assembly, paint continuity, compact packaging, and an eighties-style interaction grammar.

Limited articulation should not be confused with lack of engineering. The five joints still require axis placement, stem and socket geometry, material pairing, assembly sequence, retention, torque, cycling, and collision control. A figure with only five joints can fail through loose hips, split torso, paint lock, peg whitening, or off-axis assembly. Simplicity reduces part count but increases the importance of each interface.

The baseline creates a particular mode of play. It encourages iconic stance, tool carrying, head orientation, vehicle seating where hip geometry permits, and imaginative completion by the user. It does not offer kneeling, expressive elbows, or natural wrists. The design should embrace that grammar rather than sculpting false elbow or knee seams that imply unavailable motion.

Contemporary detail can coexist with vintage mechanical simplicity if detail hierarchy is controlled. Deep coat layers, hood, boots, and copper filigree must preserve hand clearance, hip swing, torso split, mold draw, paint masks, and package restraint. The anchor Obsidian Veil figure uses this chapter as its introductory mechanical standard; all numeric targets in Appendix Z are development hypotheses pending material and factory tests.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Head swivel	Orientation around a defined neck axis; protect hood, collar, chin, paint, and retention.
Shoulder swivels	Tool direction and arm silhouette; manage arm-to-torso gaps, shoulder armor, coat, and peg loads.
Hip swivels	Standing, stride suggestion, and vehicle seating; manage skirt, coat tails, pelvis, foot orientation, and balance.
Vintage silhouette	Keep joint breaks subordinate and avoid unnecessary visible mechanism.
Contemporary sculpt	Use controlled planes and local detail that survive mold, paint, and actual scale.
Assembly simplicity	Minimize parts and operations without making repair, inspection, or material pairing impossible.
Accessory strategy	Hands and tools carry much of the pose variety; grip and retention become critical.
Nostalgic interaction	Use carded presentation and clear mechanical language without falsely claiming historical authenticity.

Text Diagram. Five-point articulation map

```
[ 1 HEAD SWIVEL ]
                  |
[ 2 LEFT SHOULDER ] -- [ TORSO ] -- [ 3 RIGHT SHOULDER ]
                  |
        [ PELVIS / HIP CARRIER ]
             /             [ 4 LEFT HIP ]             [ 5 RIGHT HIP ]
```

Audio description: A head swivel connects above the torso, shoulder swivels attach left and right, and two hip swivels attach beneath the pelvis.

PRODUCTION APPLICATION

- Freeze the five joint centers before high-detail coat and armor sculpting.
- Build separate appearance and engineering prototypes to compare silhouette with retention and range.
- Limit paint near moving interfaces or qualify flexible and wear-resistant systems.
- Test standing, accessory use, basic stride, package fit, and intended vehicle seating.
- Use a 1980s visual presentation without reproducing protected trade dress or implying licensed lineage.

AI-AGENT INTERPRETATION

AI may generate five-point part-break options, compare silhouette and gap placement, and produce pose and accessory studies. It must not add unrequested hidden joints, claim vintage authenticity, or use copyrighted franchise-specific design elements as if they were generic standards.

FAILURE CASES AND CORRECTIVE ACTION

- Coat tails and hip shapes eliminate meaningful leg rotation.
- Shoulder pins are short or brittle and loosen after cycling.
- Fine sculpt creates paint pooling and unreadable texture at 3.75 inches.
- Marketing depicts poses impossible for the five-point figure.

RELEASE GATE: The five-point figure is approved only when mechanical restraint is intentional, all five joints are robust and legible, accessory play is credible, and imagery represents actual capability.

Evidence classification and research anchors. E: mechanism, materials, manufacturing, truthful advertising, and historical product precedent. S: limited-articulation design trade-offs. P: Obsidian Veil five-point baseline.

Training exercise. Compare a five-point and fourteen-point version of the same character across silhouette, parts, paint operations, package volume, assembly, cost, play, and failure risk.

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Joint Atlas

A controlled library of motion interfaces, material pairings, assembly routes, and failure signatures

THE MANY DIALECTS OF MOTION

> *A pin speaks differently from a ball.*
> *A ratchet remembers stations; a hinge remembers an arc.*
> *Choose the joint whose language the object can sustain,*
> *and do not ask one mechanism to impersonate another.*

A joint atlas is a governed reference library, not a menu of fashionable articulation. Each entry defines geometry, motion, material pairing, tool direction, assembly, tolerances, surface requirements, expected wear, visual consequences, common failures, test method, and repair potential.

Joint choice begins with the required action and load, then considers scale, wall, silhouette, material, assembly, paint, safety, and cost. A ball-and-socket offers multi-axis orientation but requires socket strain, stem strength, and opening geometry. A straight swivel is compact and clear but limited. A ratchet can retain heavy poses but adds noise, discrete movement, tooth wear, and assembly complexity.

Material pairing matters as much as geometry. Similar hard plastics can seize or squeak; a soft socket can relax; paint can raise friction and weld surfaces; metal pins can concentrate stress or corrode at incompatible interfaces. The atlas should therefore reference qualified compound pairs and surface states rather than generic labels such as "PVC joint."

The atlas improves reuse without erasing context. A proven shoulder peg may be reused only when loads, wall, range, material, process, and assembly remain within its validated envelope. Reuse outside that envelope is a new design that requires a new verification record.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Straight pin swivel	Compact one-axis rotation; control pin bending, interference, retention, and torso split.
Mushroom peg	Undercut head captured by flexible opening; control insertion strain and long-term relaxation.
Barbell peg	Two captured ends supporting rotation and limited orientation; inspect stem and head transitions.
Ball-and-socket	Multi-axis movement; control socket opening, cup depth, ball finish, stem strength, and pop-off.
Hinge / disc hinge	Defined arc and visible axis; control pin capture, side load, gaps, and paint.
Double hinge	Greater folded range with more parts, gaps, assembly, and tolerance stack.
Universal joint	Two linked axes; compactness, sequencing, and cross-pin strength govern use.
Ratchet / detent	Discrete pose retention; tooth geometry, noise, wear, and overload release must be designed.
Sliding / telescoping	Translation with guides and end stops; contamination, binding, and pinch require review.
Living / textile hinge	Material deformation or fabric connection; fatigue, fray, aging, and replacement govern life.
Magnetic interface	Fast attachment and alignment; ingestion, polarity, pull force, shielding, and retention require strict review.

Text Diagram. Joint selection sequence

```
REQUIRED ACTION + LOAD
          |
      SCALE / SPACE
          |
MATERIAL PAIR + PROCESS
          |
ASSEMBLY + PAINT + SERVICE
          |
HAZARD + FAILURE + TEST
          |
      SELECT / PROTOTYPE
          |
  QUALIFY VALIDATED ENVELOPE
```

Audio description: Joint selection moves from action and load through scale, material, assembly, safety, prototype, and validated reuse envelope.

PRODUCTION APPLICATION

- Assign each joint family a controlled atlas ID and validated-use envelope.
- Keep physical reference coupons and cycled samples beside digital geometry.
- Record insertion force, retention behavior, range, wear, conditioning, and observed failure.
- Require requalification when material, scale, wall, paint, tool, or load changes outside the envelope.

AI-AGENT INTERPRETATION

AI may retrieve compatible atlas candidates, compare trade-offs, and detect use outside validated ranges. It must not select a joint solely by requested pose count, invent material pair performance, or copy a joint from an unrelated product without dependency and test review.

FAILURE CASES AND CORRECTIVE ACTION

- A known joint is scaled down uniformly until stems and socket walls become unmanufacturable.
- Paint is added after qualification and the joint becomes locked or abrasive.
- A magnet is treated as a convenient connector without ingestion and retention analysis.
- Atlas entries lack failed samples and therefore hide the boundaries of use.

RELEASE GATE: A joint may be reused only when geometry, material, process, surface, load, assembly, environment, and test conditions remain inside its documented validated envelope.

Evidence classification and research anchors. E: mechanism design, snap-fit and polymer design guides, fatigue and wear testing. S: controlled joint atlas. P: Raven Valley validated-envelope reuse rule.

Training exercise. Create one atlas entry for a mushroom peg and one for a straight swivel. Include section sketch, materials, assembly, expected wear, failure, and test plan.

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Joining Methods

Permanent, reversible, and serviceable agreements among parts and materials

WHAT HOLDS AND WHAT MAY RETURN

> *A weld remembers heat; a screw remembers the tool.*
> *Adhesive remembers every surface it was asked to trust.*
> *Choose whether the bond must endure, release, or confess failure;*
> *a joining method is a promise about the future.*

Joining converts parts into assemblies. The method - snap, press, pin, rivet, screw, stake, weld, adhesive, sew, lace, crimp, insert, overmold, magnet, or threaded insert - must be selected with part geometry, material, tolerance, surface, load, assembly equipment, inspection, service, and lifecycle.

The governing translation from the Veil is direct: joint, part geometry, material, tolerance, assembly method, surface finish, and expected load form one system. A snap fit cannot be specified without strain and insertion path; a screw cannot be specified without boss design and torque; an adhesive cannot be specified without substrate preparation, cure, bondline, environment, and disassembly policy.

Permanent joining may reduce fasteners and tampering but can obstruct repair and root-cause analysis. Ultrasonic welding can be fast and clean but requires compatible polymers, energy directors, horn access, fixture, and controlled process. Heat staking captures dissimilar parts but introduces thermal deformation. Solvent welding depends on chemistry and can create stress cracking or residues. Reversible screws and pins may improve service but add parts, access, and visible witnesses.

Design for assembly favors orientation, error prevention, minimal handling, stable fixturing, and confirmation. Design for lifecycle adds another question: what should happen when the product fails? Some toy routes require inaccessible fasteners or secured battery doors; some collector products benefit from replaceable modules. The decision should be explicit rather than inherited from habit.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Snap fit	Integral elastic connection; design strain, lead-in, catch, stop, insertion direction, and release or no-release intent.
Press fit	Interference connection dependent on material, surface, tolerance, temperature, and insertion support.
Pin / axle / rivet	Mechanical capture for rotation or retention; control heading, bending, wear, corrosion, and removal.
Screw / threaded insert	Serviceable or secured joint; control boss, pilot, torque, strip, access, and thread-forming behavior.
Heat staking	Thermally formed retention; control heat, time, pressure, deformation, and nearby finish.
Ultrasonic welding	High-frequency energy joining; control resin compatibility, joint design, energy director, horn, fixture, and cosmetic witness.
Solvent / adhesive bonding	Chemistry-dependent joining; require surface preparation, cure, bondline, environment, and stress-cracking review.
Sewing / lacing / textile joining	Needle, thread, seam, allowance, fray, scale bulk, and replacement path.

Variable / concern	Operational requirement
Insert / overmolding	Encapsulate dissimilar components; control adhesion, mechanical key, temperature, contamination, and tool sequence.
Magnet	Reversible attraction requiring secured containment, polarity control, corrosion protection, and hazard analysis.

Text Diagram. Joining method decision

```
MUST THE CONNECTION MOVE? -- yes --> JOINT ATLAS
             |
             no
             v
MUST IT BE SERVICED? -- yes --> SCREW / PIN / RELEASED SNAP / TEXTILE
             |
             no
             v
MATERIAL + LOAD + ACCESS + SAFETY
             |
   WELD / STAKE / ADHESIVE / CAPTIVE SNAP
             |
        PROCESS VALIDATION
```

Audio description: The decision separates moving joints, serviceable connections, and permanent connections, then validates process against material, load, access, and safety.

PRODUCTION APPLICATION

- Create joining coupons using actual materials, surfaces, and process equipment.
- Define assembly fixture, force or energy, confirmation signal, defect criteria, and rework rule.
- Keep join method separate from cosmetic closure in the BOM and drawing.
- Require substitution review for adhesive, fastener, welding parameter, thread, or textile change.

AI-AGENT INTERPRETATION

AI may compare joining methods, retrieve design checks, draft operation and inspection plans, and flag incompatible service goals. It must not specify machine energy, cure, torque, or solvent compatibility without manufacturer data and qualified trials.

FAILURE CASES AND CORRECTIVE ACTION

- An adhesive bonds prototype resin but attacks production ABS or paint.
- A snap fits during assembly but remains highly stressed and creeps open in storage.
- Ultrasonic weld geometry is added after sculpt freeze and leaves visible sink or flash.
- A repairable feature becomes permanently sealed without provenance or service update.

RELEASE GATE: Every connection requires declared permanence, motion, service, material, process window, inspection, rework, failure mode, and approved substitution path.

Evidence classification and research anchors. E: DFMA, snap-fit, adhesive, welding, fastener, and textile engineering. S: lifecycle joining decision. P: Raven Valley joining agreement record.

Training exercise. Select three joining methods for a torso shell, removable pack, and cloth hood. Compare assembly, hazard, appearance, repair, and evidence requirements.

20

Kinematics, Collision, and Pose Envelope

The real motion remaining after sculpt, cloth, gravity, and accessories impose their limits

THE ARC MEETS THE WALL

A joint dreams in degrees; the sculpt answers in contact.
Gravity edits every heroic pose without apology.
Map the arc, the cloth, the tool, the ground;
motion is true only where the whole object can follow.

Kinematics describes possible motion from joint geometry; the pose envelope describes achievable, stable, non-damaging configurations after collision, material deformation, gravity, accessory mass, user grip, and ground contact are included. Marketing should represent the pose envelope, not the theoretical joint range.

Collision analysis includes hard sculpt, soft goods, armor overlap, joint covers, hair, capes, accessories, vehicle interiors, creature saddles, and package restraints. A shoulder may rotate ninety degrees in isolation but only forty when the coat and backpack are present. A hip may sit in a vehicle only if thigh, pelvis, skirt, seat, and steering interfaces are modeled together.

Balance requires center of mass projected into a support polygon defined by the feet or display base. Joint torque and foot friction affect whether a pose persists. An accessory can shift mass beyond the polygon; a soft cape can act as a support or destabilizing spring; a narrow boot can make a mechanically sound pose unusable. Pose retention is therefore an assembly-level property.

Digital collision and rigid-body simulations are useful for screening, but material softness, tolerances, paint, friction, and user behavior demand physical prototypes. A pose library should include intended hero stance, neutral stance, accessory use, seated posture, riding posture, package posture, and recovery after storage.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Arc clearance	Swept volume of each moving part through intended range with production tolerances.
Sculpt collision	Contact among rigid surfaces, including hidden internal stops and external armor.
Cloth / flexible collision	Drape, fold, compression, memory, fray, and spring response around movement.
Joint exposure	Visible gap and mechanism at extreme pose; balance aesthetics, range, contamination, and safety.
Center of mass	Assembly mass distribution in each pose and accessory state.
Support polygon	Area bounded by ground contacts or base; projected center of mass must remain suitably supported.
Joint torque	Resistance and retention behavior across range, temperature, wear, and load.
Accessory interaction	Grip, reach, mass, collision, storage, and hand-to-object orientation.
Vehicle / creature fit	Seat, saddle, foot, hand, restraint, headroom, and egress relationships.
Pose truth	Published imagery and claims reflect verified physical capability.

Text Diagram. Pose-envelope derivation

```
THEORETICAL JOINT RANGE
          - SCULPT COLLISION
          - SOFT-GOODS INTERFERENCE
          - ACCESSORY / VEHICLE CONTACT
          - BALANCE / TORQUE LIMIT
          - PAINT / WEAR LIMIT
          = VERIFIED POSE ENVELOPE
```

Audio description: The verified pose envelope is theoretical range reduced by collision, soft goods, accessories, balance, torque, paint, and wear limits.

PRODUCTION APPLICATION

- Generate swept-volume overlays at nominal and tolerance limits.
- Build a physical pose matrix with required states and accessory combinations.
- Measure or classify retention after cycling and environmental conditioning.
- Photograph verified poses for marketing and instructions.
- Check package posture for permanent deformation or joint preload.

AI-AGENT INTERPRETATION

AI may generate kinematic chains, collision matrices, balance estimates, and pose coverage reports. It must not fabricate friction, torque, soft-goods behavior, or stable poses from an unvalidated render.

FAILURE CASES AND CORRECTIVE ACTION

- Advertised poses require stands or digital deformation not included with the product.
- A figure can sit only by overstressing the coat or hip pegs.
- Paint is abraded at the first full-range motion.
- Package restraint preloads joints and changes torque before opening.

RELEASE GATE: All claimed poses, vehicle interactions, and package states require physical verification with production-intent materials, accessories, paint, and tolerances.

Evidence classification and research anchors. E: kinematics, statics, friction, human factors, packaging and wear testing. S: verified pose-envelope subtraction model. P: Raven Valley pose truth rule.

Training exercise. Create a pose matrix for neutral, hero, tool-use, seated, riding, packaged, and dropped states. Mark collision, balance, and wear risks for each.

21

Motion Failure and Wear

How joints loosen, seize, whiten, split, abrade, deform, and transfer damage

THE COST OF EVERY RETURN

> *Each motion spends a little surface.*
> *Each stop remembers the force that arrived too quickly.*
> *Design not for the first perfect turn but for the thousandth honest one;*
> *wear is time writing its review into matter.*

Motion systems fail through material, geometry, process, environment, surface, assembly, and user-force interactions. A failure atlas should describe signatures and causes rather than treating every loose joint as the same defect or every crack as insufficient thickness.

Loose hips may result from insufficient interference, socket relaxation, plasticizer migration, polished wear, out-of-round molding, assembly damage, temperature, or incompatible lubricant. Seized joints may result from excess interference, paint bridging, flash, chemical attack, poor alignment, surface roughness, or cold-temperature brittleness. Corrective action depends on identifying the mechanism.

Stress whitening is evidence of local plastic deformation, not merely a cosmetic issue. Bent pins reveal load or assembly misalignment. Split sockets may begin at notch, knit line, sharp radius, or excessive insertion strain. Ratchet wear can round teeth or crack the carrier. Soft parts can tear at thin transitions or hard inserts. Metal interfaces can corrode or concentrate stress; incompatible metals may create galvanic concerns in wet or ionic environments.

Wear testing should include repeated motion, accessory load, conditioning, storage preload, temperature and humidity where relevant, contamination, and inspection intervals. The test report records torque or qualitative retention over time, noise, debris, paint transfer, visible change, functional change, and final failure. Negative results are design information, not material to hide.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Loose joint	Loss of retention or torque from tolerance, relaxation, wear, heat, chemistry, or assembly variation.
Seized joint	Motion blocked by interference, paint, flash, contamination, deformation, corrosion, or cold behavior.
Paint lock / rub	Coating bridges moving parts or abrades under contact; redesign clearance, mask, material, or coating.
Split socket	Crack from insertion strain, notch, weld line, wall, embrittlement, or impact.
Bent or broken pin	Overload, long lever, misalignment, inadequate section, poor material, or assembly damage.
Stress whitening	Visible plastic deformation signaling high local strain.
Creep	Time-dependent dimensional change under sustained stress or storage preload.
Fatigue	Progressive damage under repeated cyclic load.
Surface abrasion	Loss of finish, texture, or material at repeated contact.
Chemical / galvanic interaction	Degradation at material, lubricant, cleaner, paint, adhesive, or metal interfaces.

Text Diagram. Failure investigation loop

```
OBSERVED FAILURE
      |
[ GEOMETRY ] [ MATERIAL ] [ PROCESS ] [ SURFACE ] [ ASSEMBLY ] [ USE ]
      \          |           |           |            |          /
       +---------- ROOT-CAUSE HYPOTHESES ------------------------+
                             |
                        MINIMAL TESTS
                             |
                    CORRECT / RE-TEST
                             |
                   UPDATE ATLAS + LIMITS
```

Audio description: Observed failure is analyzed across geometry, material, process, surface, assembly, and use, then tested, corrected, and added to the atlas.

PRODUCTION APPLICATION

- Photograph and retain failed parts with batch and test state.
- Separate symptom, proximate cause, and root cause.
- Track retention or torque at intervals rather than only pass/fail at the end.
- Update joint atlas limits and downstream designs after confirmed failure.
- Do not repair a test sample and continue as though the interruption did not occur.

AI-AGENT INTERPRETATION

AI may cluster failure descriptions, compare geometry and process history, propose testable root-cause hypotheses, and search prior corrective actions. It must not select a single cause from a photograph, erase uncertainty, or recommend field repair that changes safety or provenance without review.

FAILURE CASES AND CORRECTIVE ACTION

- The team thickens a cracked socket without examining insertion strain or knit line.
- Loose joints are concealed by changing photography or adding stands.
- Only one room-temperature sample is cycled, ignoring storage and environment.
- Failed parts are discarded and the same problem returns in a later product.

RELEASE GATE: A motion failure is closed only when evidence supports root cause, correction is verified under relevant conditions, affected configurations are traced, and atlas limits are updated.

Evidence classification and research anchors. E: polymer fatigue, creep, wear, stress cracking, coating and corrosion science. S: multi-domain failure loop. P: Raven Valley negative-result archive.

Training exercise. Write three competing root-cause hypotheses for a loose hip after six months. Define the smallest test that would distinguish them.

PART 5

MATERIALS, CHEMISTRY, PAINT, AND SURFACE SYSTEMS

Material truth from polymer grade and migration to coating cure and visible history.

THE MATTER BENEATH COLOR

Black paint cannot make an unknown resin honest.
Copper light cannot strengthen a brittle promise.
Name the substance, the solvent, the heat, the years:
surface becomes trustworthy when depth is recorded.

22

Material Families

Polymers, elastomers, resins, metals, textiles, paperboard, magnets, adhesives, and coatings as engineered choices

THE MATERIAL HAS A HISTORY BEFORE COLOR

PVC bends because a chemistry permits it.
ABS keeps an edge because structure survives the heat.
No material enters the object as a generic name;
its grade, process, and future arrive with it.

Material selection begins with function and process, not with a short label such as plastic, rubber, metal, or cloth. The record must identify grade or qualified compound, supplier, color and additive package, mechanical and thermal behavior, shrinkage, hardness, finish, chemical restrictions, processing window, aging concerns, and evidence status.

Rigid figure bodies commonly use styrenic or engineering thermoplastics such as ABS or HIPS because they can hold detail and structure; flexible heads, capes, hands, or overlays may use plasticized PVC or thermoplastic elastomers; living hinges often use polypropylene or related materials; low-friction parts may use acetal or nylon; clear parts require optical and stress-cracking review. These are broad tendencies, not automatic selections. Product grade, wall, tool, color, process, and compliance determine performance.

Prototype materials are not production equivalents. SLA and DLP photopolymers can capture detail but may remain brittle, anisotropic, light-sensitive, or dependent on wash and post-cure. FDM materials show layer-direction effects and process-dependent properties. Cast polyurethane may reproduce a sculpt but differ sharply from injection-molded thermoplastics. A prototype demonstrates selected questions only.

Metals introduce mass, conductivity, corrosion, sharpness, and interface concerns. Textiles introduce weave, fray, seam bulk, dye, scale stiffness, and care. Paperboard and clear packaging polymers are structural and chemical systems, not disposable background. Magnets and adhesives carry both performance and hazard implications. The material passport keeps these identities visible across design, factory, catalog, repair, and archival care.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
PVC and flexible vinyl compounds	Useful for flexible detail and captured joints; qualify plasticizer, migration, hardness, paint, odor, restricted substances, and aging.
ABS / HIPS	Rigid, detailed shells and bodies; review impact, stress cracking, weld lines, sink, paint, and process.
PP / PE	Tough, chemically resistant, lower-surface-energy polymers; adhesion and print often require treatment or process-specific design.
Nylon / acetal and engineering polymers	Useful for strength, fatigue, wear, or low friction; moisture, shrinkage, surface, and cost require control.
TPE / silicone / elastomers	Soft grips, skins, seals, and flexible parts; hardness, tear, set, tack, contamination, and overmold adhesion govern use.
Polyurethane / epoxy / polyester casting resins	Development and low-volume casting; mix, cure, exotherm, inhibition, shrink, brittleness, and worker safety matter.
Photopolymer resins	High-detail additive prototypes; wash, post-cure, residual chemistry, light aging, orientation, and end-use limits must be declared.

Variable / concern	Operational requirement
FDM filaments	PLA, PETG, ABS, ASA, nylon, and composites differ in heat, moisture, warpage, layer adhesion, and emissions.
Metals and magnets	Steel, aluminum, zinc alloys, copper, and magnetic materials add mass, fasteners, conductivity, corrosion, and hazard.
Textile / leather / paperboard	Fiber, construction, finish, thickness, dye, stiffness, seam, print, humidity, abrasion, and archival behavior.
Adhesives and coatings	Chemistry is specific to substrate, surface preparation, cure, environment, and service.

Text Diagram. Material selection hierarchy

```
FUNCTION + HAZARD + LIFETIME
          |
PART GEOMETRY + PROCESS + SCALE
          |
QUALIFIED MATERIAL FAMILY
          |
GRADE / COMPOUND / COLOR / ADDITIVES
          |
COATING / ADHESIVE / CONTACT PAIRS
          |
TESTED MATERIAL PASSPORT + LOT CONTROL
```

Audio description: Function and hazard lead to process and geometry, then material family, grade, contact system, and a tested lot-controlled passport.

PRODUCTION APPLICATION

- Issue a material passport for every production material and critical prototype material.
- Keep supplier technical and safety data with current revision and lot linkage.
- Test actual color and additive packages, not only natural resin.
- Review all long-term material contacts and package restraints.
- Declare prototype-to-production differences explicitly.

AI-AGENT INTERPRETATION

AI may compare known material properties, generate qualification questions, and detect vague or conflicting material names. It must not select a resin grade, declare chemical compliance, or substitute a prototype material for production evidence without current supplier and laboratory data.

FAILURE CASES AND CORRECTIVE ACTION

- A BOM says "PVC" without hardness, plasticizer, color, supplier, or paint compatibility.
- A rigid 3D-print resin prototype is used to approve an impact or living-joint claim.
- A metal insert creates hidden stress and corrosion at a wet interface.
- Packaging plastic transfers or abrades coating during storage.

RELEASE GATE: No material is production-approved by family name alone; grade, lot, additives, process, contacts, restrictions, tests, and lifecycle risks must be recorded.

Evidence classification and research anchors. E: polymer, metal, textile, coating, packaging, and toxicology literature; supplier and regulatory data. S: play-object material passport. P: Raven Valley material-truth extension.

Training exercise. Create a material passport comparison for torso, flexible head, joint peg, cloth hood, metallic paint, blister, and card stock.

23

Material Chemistry and Compatibility

Migration, solvent attack, stress cracking, cure inhibition, oxidation, hydrolysis, moisture, and long-term contact

THE QUIET REACTION

> *Two materials may rest together and still be changing.*
> *A solvent may leave while its damage remains.*
> *The slow failure is no less mechanical for arriving through chemistry;*
> *compatibility is a promise measured across time.*

Material compatibility is the behavior of materials, additives, coatings, adhesives, cleaners, lubricants, metals, packages, and environments when they contact or influence one another. Short assembly success does not establish long-term compatibility.

Plasticizers in flexible PVC are not covalently bound and can migrate; migration depends on composition, concentration, molecular characteristics, contact, temperature, and time. Studies of children's products demonstrate why generic assumptions about soft vinyl are insufficient and why restricted-substance compliance is only one part of material aging (Babich et al.). Migration can change hardness, tack, paint, adjacent materials, package contact, and conservation behavior.

Environmental stress cracking occurs when stress and chemical exposure combine to cause premature brittle failure. The chemical may be cleaner, lubricant, adhesive carrier, paint solvent, fragrance, packaging additive, skin oil, or another polymer. Hansen and later reviews show that molecular compatibility and applied stress both matter; a material can appear unaffected without load yet crack around a press fit or boss in service (Hansen; Robeson).

Cure inhibition and incomplete cure can leave tack, weak bonds, residual chemistry, or print sensitivity. Oxidation, ultraviolet exposure, hydrolysis, and moisture absorption change color and mechanical behavior. Differential thermal expansion can preload joints and coatings. Galvanic couples can corrode metals when moisture and electrolyte are present. Compatibility testing should therefore use the actual stack: substrate, pigment, coating, adhesive, lubricant, metal, textile, blister, and environmental cycle.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Plasticizer migration	Movement of additives from flexible polymer into surface, air, coating, package, or adjacent part.
Solvent attack	Swelling, crazing, dissolution, softening, or residual stress caused by paint, cleaner, adhesive, or process chemical.
Environmental stress cracking	Brittle failure from combined stress and chemical contact.
Cure inhibition / incomplete cure	Interference with adhesive, silicone, resin, or coating polymerization.
Surface energy	Influences wetting and adhesion; low-energy substrates may require treatment or specialized chemistry.
Oxidation / UV	Chain change, embrittlement, chalking, yellowing, and color loss under oxygen and light.
Hydrolysis / moisture absorption	Water-driven degradation or dimensional and mechanical change.
Thermal expansion and shrinkage	Differential dimensional change across materials, coatings, and inserts.
Paint transfer and blocking	Coating moves, sticks, prints, or bonds under pressure, heat, or package contact.
Corrosion / galvanic interaction	Metal degradation governed by material pairing, environment, finish, and electrical contact.

Variable / concern	Operational requirement
Off-gassing / odor	Volatile release affecting users, package, adjacent surfaces, and perceived quality.

Text Diagram. Compatibility matrix logic

```
FOR EACH MATERIAL A:
  contact with B / C / COATING / ADHESIVE / LUBRICANT / PACKAGE
              |
      TEMPERATURE + HUMIDITY + LIGHT + LOAD + TIME
              |
      OBSERVE MASS / COLOR / TACK / CRACK / BOND / TORQUE
              |
      ACCEPT / LIMIT / BARRIER / SUBSTITUTE / REJECT
```

Audio description: Every material contact is tested under environment, load, and time for physical, visual, adhesive, and motion changes.

PRODUCTION APPLICATION

- Create a pairwise and stack-level compatibility matrix.
- Test stressed specimens, not only flat unstressed plaques.
- Include package contact, storage pressure, skin oils, likely cleaners, and lubricants.
- Record barriers, primers, surface treatments, and permitted service chemicals.
- Retest after supplier, color, plasticizer, coating, or cure changes.

AI-AGENT INTERPRETATION

AI may build compatibility matrices, retrieve known failure mechanisms, and flag untested contact pairs. It must not infer chemical compatibility from shared brand name, generic polymer family, or short prototype success.

FAILURE CASES AND CORRECTIVE ACTION

- A paint solvent crazes ABS around a press-fit shoulder after assembly.
- A flexible cape becomes tacky and transfers pigment to the blister.
- A silicone mold or cast is inhibited by uncured contamination.
- A cleaner approved for one plastic attacks the coating or adjacent material.

RELEASE GATE: Every long-term contact and every chemical process must have documented compatibility evidence under relevant stress, environment, and time.

Evidence classification and research anchors. E: polymer migration, stress-cracking, adhesion, corrosion, aging, and toxicology research. S: stack-level compatibility matrix. P: Raven Valley contact passport.

Training exercise. Build a compatibility test matrix for ABS torso, flexible vinyl head, acrylic paint, adhesive emblem, metal pin, textile hood, and PET blister.

24

Material Selection by Function

Choosing the stack from loads, touch, motion, optics, safety, process, and afterlife

THE TASK CHOOSES THE SUBSTANCE

> *Do not ask the clear part to bear a hidden hinge without reason.*
> *Do not ask the soft hand to keep a sharp memory forever.*
> *Let function invite the family and testing choose the grade;*
> *material wisdom begins by refusing the convenient guess.*

Material selection by function reverses the common habit of assigning familiar plastics to familiar parts. The team first defines loads, deformation, touch, optics, heat, chemistry, safety, manufacturing process, decoration, cost, repair, and lifetime, then qualifies a material stack.

A rigid structural torso requires detail, weldability or fastening, impact, boss strength, paint, and dimensional stability. A gripping hand requires controlled flexibility, tear resistance, accessory retention, paint or molded color, and safe release. A transparent visor requires optical quality, scratch and chemical resistance, low stress, and controlled assembly. A vehicle chassis requires stiffness, impact, fastener, axle, and package load performance. These functions can point toward different materials even when parts appear similar.

Multi-material design creates useful gradients but increases interfaces. Overmolded hands, soft armor, metal pins, cloth garments, and light pipes can improve play and appearance while increasing tooling, contamination, adhesion, tolerance, and recycling complexity. The system should justify each additional material by measurable value.

Lifecycle function includes repair and archival behavior. A replaceable module may favor a durable mechanical connection; a collectible surface may require stable pigments and non-blocking coatings; a recycled-content package may need structural and print qualification. Selection is complete only when the material can be procured, processed, tested, documented, and responsibly changed.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Rigid structural part	Stiffness, impact, boss, weld or fastener, dimensional stability, paint, and detail.
Flexible garment or overlay	Flex, tear, set, thickness, drape, paint, migration, and cold behavior.
Transparent element	Transmission, haze, color, scratch, solvent, stress, and assembly.
Joint carrier	Creep, fatigue, notch, strain, wear, friction, and dimensional repeatability.
Gripping hand	Elastic opening, tear, retention, release, accessory paint, and user force.
Impact-resistant accessory	Bending, points, projectile potential, stress whitening, and safe break behavior.
Fine-detail head	Surface reproduction, paint, flexibility or rigidity, assembly, and face-scale readability.
Soft creature skin	Tear, thickness, tactile response, insert support, seam, and long-term set.
Vehicle chassis	Stiffness, axle, fastener, crash, mass, large-tool flow, and package transport.
Packaging tray / blister	Clarity, stiffness, seal, scuff, restraint, recyclability, and coating contact.
Decorative metal	Mass, edge, corrosion, plating, conductivity, and attachment.
Replaceable component	Durability, interface life, availability, identification, and repair documentation.

Text Diagram. Function-first material selection

```
FUNCTION / LOAD / TOUCH / OPTICS / SAFETY
                  |
      PROCESS + GEOMETRY + VOLUME
                  |
       MATERIAL CANDIDATE SET
                  |
      COMPATIBILITY + DECORATION
                  |
      PROTOTYPE + TEST + COST
                  |
       QUALIFIED GRADE / STACK
```

Audio description: Functional requirements narrow materials through process, compatibility, prototype, test, and cost to a qualified stack.

PRODUCTION APPLICATION

- Write functional requirements before naming the material family.
- Compare at least two candidates for critical parts and record trade-offs.
- Qualify complete stacks, not isolated resin data sheets.
- Include procurement continuity and substitution control in selection.
- Use recycled or bio-based claims only with documented composition and performance.

AI-AGENT INTERPRETATION

AI may structure functional requirements, compare candidate data, and expose trade-offs. It must not optimize a single property, confuse prototype and production data, or declare sustainability from marketing labels without verified boundary and composition.

FAILURE CASES AND CORRECTIVE ACTION

- A transparent part is selected for clarity but cracks around a press fit.
- A soft hand retains an accessory initially but relaxes in packaged storage.
- An extra material adds cost and recycling complexity without measurable function.
- A supplier substitute matches color but changes hardness and joint behavior.

RELEASE GATE: The selected grade and stack must satisfy prioritized function, hazard, process, compatibility, cost, supply, decoration, test, and lifecycle requirements.

Evidence classification and research anchors. E: materials selection and manufacturing engineering. S: function-first stack method. P: Raven Valley material decision packet.

Training exercise. Select candidate materials for torso, head, hand, joint pin, visor, cape, and blister. Rank criteria and document why one candidate loses despite a strong single property.

25

Paint and Decoration Systems

Coatings, inks, masks, prints, transfers, metal effects, texture, and controlled visual assembly

COLOR MUST ALSO ADHERE

> *Paint gives the surface a memory the resin did not carry.*
> *Yet beauty laid upon an unready ground becomes dust.*
> *Prepare, apply, cure, test, and only then name the color;*
> *a finish is a material system wearing light.*

Paint and decoration are engineered layers. Waterborne and solventborne acrylics, enamels, lacquers, urethanes, inks, primers, adhesion promoters, clears, metallics, pearlescents, fluorescents, transparents, decals, transfers, flocking, and metallization each interact with substrate, process, mask, cure, handling, joint motion, packaging, and safety.

Method choice follows geometry and production volume. Hand brushing and airbrushing support prototypes and low volume but vary by operator. Spray masks create large color zones but add fixtures and edge-control demands. Pad printing transfers fine repeated graphics onto curved surfaces. Screen and digital printing suit defined substrates and shapes. Decals offer detail but require surface, carrier, edge, clear, and aging control. Vacuum metallization and hot stamping create strong effects with special adhesion and wear concerns.

Surface preparation can include cleaning, abrasion, flame, plasma, corona, primer, or adhesion promoter depending on substrate and chemistry. Low-surface-energy polymers often resist ordinary coating. Excess solvent can attack stressed plastic. Thick film can fill texture and lock joints. Insufficient cure can block against blisters or transfer during assembly. Universal settings are therefore rejected; supplier data and qualified process trials govern.

Decoration should be designed into the sculpt. Raised boundaries can support masks; recessed eyes can improve pad registration; protected emblems reduce rub; molded color can eliminate operations. The target is not maximum operation count. A vintage-style figure may gain authenticity from bold molded color and a few precise applications rather than photorealistic gradients that cannot survive cost or handling.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Waterborne acrylic	Lower solvent burden in some systems; cure, coalescence, substrate wetting, humidity, and block resistance still require qualification.
Solventborne acrylic / lacquer / enamel	Potentially strong flow and adhesion with solvent, worker, plastic attack, cure, and emissions concerns.
Urethane / durable clear	Potential wear and chemical resistance; mixing, pot life, cure, safety, yellowing, and flexibility require control.
Primer / adhesion promoter	Interface layer chosen for specific substrate and topcoat; not a universal repair for poor preparation.
Spray mask / airbrush	Large zones and gradients; fixture, overspray, edge, film, and operator control.
Pad printing	Fine repeatable graphics on complex surfaces; cliché, pad, ink, solvent, registration, and deformation matter.
Screen / digital print	Efficient planar or controlled-surface graphics; adhesion, resolution, cure, and substrate geometry govern use.
Decal / transfer	High detail with carrier, edge, conformability, clear, abrasion, and aging concerns.

Variable / concern	Operational requirement
Dry brush / wash / weathering	Narrative finish with variability; define master, amount, sequence, and acceptance range.
Metallization / hot stamp / foil	Reflective effects requiring base, vacuum or transfer process, protection, and wear review.
Flocking	Fiber texture requiring adhesive, coverage, shedding, cleaning, and package-contact control.

Text Diagram. Decoration process chain

```
SUBSTRATE + MOLD SURFACE
          |
CLEAN / TREAT / PRIME
          |
MOLDED COLOR / BASE COAT
          |
MASK / PAD / PRINT / DECAL / EFFECT
          |
FLASH / CURE / CLEAR
          |
ASSEMBLY + JOINT CHECK
          |
ADHESION / RUB / COLOR / PACKAGE TEST
```

Audio description: The substrate is prepared, colored, decorated, cured, assembled, and tested for adhesion, rub, color, and package contact.

PRODUCTION APPLICATION

- Design a decoration operation map before tooling freeze.
- Use actual molded color and surface texture in coating trials.
- Keep moving interfaces, snaps, and weld zones protected from uncontrolled film.
- Create approved masters under controlled illumination.
- Record rework limits and when a cosmetically repaired unit becomes a different condition class.

AI-AGENT INTERPRETATION

AI may generate operation sequences, mask maps, color hierarchy, and defect checklists. It must not specify thinning, cure, spray pressure, or film without paint-system and equipment data, nor approve color from uncalibrated images alone.

FAILURE CASES AND CORRECTIVE ACTION

- Paint adheres to a flat plaque but fails on textured, flexed, or stressed production geometry.
- Joint motion abrades metallic finish into visible debris.
- Weathering varies so widely that products appear damaged or counterfeit.
- Blister pressure blocks insufficiently cured paint.

RELEASE GATE: Decoration release requires qualified substrate preparation, system-specific process, cure, master, adhesion, rub, joint, package-contact, and chemical evidence.

Evidence classification and research anchors. E: coatings science, ASTM D3359-23, ISO 2409:2020, color and abrasion standards, supplier process data. S: design-integrated decoration. P: Raven Valley surface narrative hierarchy.

Training exercise. Reduce a twelve-operation paint concept to seven operations while preserving face, silhouette, faction, material hierarchy, and one functional filigree cue.

26

Paint Specification and Color Governance

From named color to reproducible system, master, tolerance, process, and change record

THE COLOR HAS A PROVENANCE

> *"Black" is a word until light, gloss, and substrate answer.*
> *Copper may be pigment, foil, plate, or memory.*
> *Name the standard, the master, the cure, the allowed difference;*
> *color becomes trustworthy when it can be made again.*

A paint specification records the complete color and coating system: manufacturer, product code, substrate, molded base, primer, mix or ready-use state, viscosity method, application, film target, flash, cure, mask sequence, gloss, color standard, approved master, test, storage, and revision.

Color numbers are not sufficient. The same nominal color changes with resin, texture, film thickness, opacity, metallic orientation, gloss, illuminant, surrounding color, and aging. Governance therefore combines instrumented values where appropriate with controlled visual standards and master samples. ASTM D2244 provides methods for calculating color differences from instrumental measurements, while visual acceptance still requires agreed lighting and observer conditions.

Coating adhesion methods must be represented honestly. ASTM D3359-23 and ISO 2409:2020 classify tape or cross-cut behavior within defined limits; they do not establish every form of adhesion or predict all service. Rub and abrasion tests address different mechanisms. A paint system can pass one test and fail at a joint, flex zone, or package contact. The specification should use a test suite tied to actual failure modes.

Change control is strict because apparently minor substitutions can alter hue, gloss, cure, flexibility, migration, and chemical compliance. New pigment, reducer, clear, supplier, booth, line, substrate, or texture may require renewed approval. Masters should be dated, protected, and superseded rather than overwritten.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Color identity	Project name plus standard or measured target, master reference, and intended appearance under defined light.
Substrate and base	Material grade, molded color, texture, preparation, and primer.
Coating system	Manufacturer, code, batch, components, mix, pot life, and compatible clear.
Application	Hand, air, automated spray, pad, screen, digital, transfer, or other controlled method.
Process window	Viscosity method, equipment, pass count, flash, cure, environment, and handling state.
Film and edge	Coverage, opacity, texture retention, mask edge, and joint exclusion.
Appearance	Hue, value, chroma, gloss, metallic orientation, transparency, and texture.
Verification	Color difference, adhesion, abrasion, flex, chemical, joint, package, and aging tests as applicable.
Master hierarchy	Digital target, drawdown, plaque, decorated part, golden sample, and retained production sample.
Change record	Who changed what, why, impact, tests, approval, compatibility, and effective lot.

Text Diagram. Color governance hierarchy

```
DESIGN INTENT
     |
DIGITAL / STANDARD TARGET
     |
MATERIAL + TEXTURE PLAQUE
     |
DECORATED PART MASTER
     |
GOLDEN ASSEMBLY
     |
RETAINED PRODUCTION LOT SAMPLE

CHANGE AT ANY LEVEL -> REVIEW DOWNSTREAM LEVELS
```

Audio description: Color intent moves through digital target, material plaque, decorated part, golden assembly, and retained production sample, with change review at every level.

PRODUCTION APPLICATION

- Use controlled lighting and labeled master conditions for visual approval.
- Link instrumented tolerance to material, finish, and perceptual relevance.
- Specify test method edition and acceptance class or limit.
- Protect and inventory physical masters; define replacement and expiration.
- Review every process or supplier change for color and chemistry impact.

AI-AGENT INTERPRETATION

AI may organize color records, calculate differences from supplied measurements, compare operation maps, and flag master or revision mismatch. It must not color-match from uncontrolled photographs or claim a coating passes a standard without test data.

FAILURE CASES AND CORRECTIVE ACTION

- A Pantone-like reference is treated as proof of appearance on metallic textured plastic.
- Digital render color becomes factory authority despite unknown monitor and lighting.
- Tape test results are described as universal durability.
- A new clear coat shifts metallic hue and joint friction without renewed approval.

RELEASE GATE: No color or paint revision is released without a complete system specification, approved master hierarchy, applicable test evidence, and lot-effective change record.

Evidence classification and research anchors. E: colorimetry and coating standards, ASTM D2244, D3359, D4060, ISO 2409, supplier data. S: master hierarchy. P: Raven Valley color provenance rule.

Training exercise. Write a full paint record for Obsidian Black, including substrate, finish, master, process variables, joint exclusions, tests, and change triggers.

27

Surface Narrative

Using material, wear, cleanliness, repair, and finish to communicate history without manufacturing false evidence

THE SURFACE REMEMBERS WHAT DID NOT HAPPEN

> *A scratch can tell a story or merely imitate one.*
> *Patina can honor time or counterfeit its authority.*
> *Let every mark know whether it is function, fiction, or actual repair;*
> *honest surfaces distinguish memory from costume.*

Surface narrative is the controlled use of color, gloss, texture, wear, dirt, repair, material break, and finish to communicate age, faction, environment, wealth, ritual, technology, danger, cleanliness, ownership, and history. It must distinguish fictional weathering from real product condition and repair.

Narrative wear should follow use. Edges, grips, feet, knees, tool contacts, exposed fasteners, airflow, water paths, and maintenance zones age differently. Random silver dry brushing may create visual activity but not credible history. A service-oriented character may show carefully renewed surfaces and visible repairs rather than generalized decay.

Finish hierarchy communicates material. Matte cloth, satin leather, dark metal, copper trace, glassy visor, and dusty stone should differ through controlled reflectance and texture, not color alone. At 3.75-inch scale, exaggerated but bounded differences may be necessary for readability. The same finish must still meet paint, wear, package, and safety requirements.

Collector truth requires labels. Factory-applied weathering is part of the edition. Actual wear is condition. Authorized repair is a provenance event. Restoration is not original. Reissue weathering must not be used to simulate a vintage unit. The catalog and package should prevent narrative finish from becoming authentication confusion.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Age	Controlled fading, abrasion, oxidation, residue, or repair language linked to narrative time.
Use	Wear concentrated at contact, movement, load, and maintenance zones.
Faction	Shared finish hierarchy, maintenance culture, color, and material practice.
Environment	Dust, salt, moisture, heat, cold, biological growth, or industrial residue represented safely and coherently.
Wealth and ritual	Material refinement, polish, inlay, ceremonial contrast, or deliberate restraint.
Technology	Service panels, heat zones, traces, seals, vents, optical surfaces, and controlled wear.
Cleanliness	Clean is a narrative condition with material and role meaning, not absence of design.
Danger	High-value warning, damage, contamination, or energy cue without obscuring actual safety information.
Repair history	Factory narrative repair versus actual intervention, each separately recorded.
Rarity and edition	Finish variation must be authorized and documented rather than inferred from inconsistency.

Text Diagram. Surface truth layers

```
[ MATERIAL-INHERENT COLOR / TEXTURE ]
                  +
[ FACTORY COATING / PRINT / WEATHERING ]
                  +
[ PRODUCTION VARIATION ]
                  +
[ OWNERSHIP WEAR / DAMAGE ]
                  +
[ REPAIR / RESTORATION ]
                  =
[ CURRENT CONDITION WITH PROVENANCE ]
```

Audio description: Current surface condition is the sum of material, factory finish, production variation, ownership wear, and repair history.

PRODUCTION APPLICATION

- Create wear logic maps based on movement, contact, environment, and maintenance.
- Use gloss and texture standards alongside color.
- Photograph factory weathering masters and acceptable variation.
- Keep repair and restoration records separate from edition identity.
- Label sample, test-shot, damaged, restored, and production finishes accurately.

AI-AGENT INTERPRETATION

AI may generate wear hypotheses from declared use, compare finish hierarchy, and draft condition descriptions. It must not authenticate a unit from surface appearance alone or erase the distinction among factory weathering, actual wear, and repair.

FAILURE CASES AND CORRECTIVE ACTION

- Weathering is random and obscures sculpt, paint boundaries, or safety marks.
- Factory variation is marketed after the fact as a rare edition.
- Restored paint is represented as untouched original condition.
- AI invents a battle or ownership story from scratches in a photograph.

RELEASE GATE: Surface narrative is approved only when fictional finish, production variation, actual condition, and repair can be distinguished in both product record and collector description.

Evidence classification and research anchors. E: coatings, wear, conservation, material culture, authenticity research. S: use-based wear mapping. P: Raven Valley surface-truth layers.

Training exercise. Map expected wear on boots, cuffs, hood, pack, weapon grip, and copper filigree. Separate factory narrative marks from future condition marks.

PART 6

DIGITAL DESIGN, RENDERING, AND FILE GOVERNANCE

One canonical object expressed through controlled digital views, meshes, models, and records.

THE SECOND BODY

The mesh is not the mold, though both may share a face.
The render is not the test, though light may hide the seam.
Give every file a lineage and every export a witness,
so the second body does not betray the first.

28

Concept Art and Technical Image Development

A controlled progression from narrative image to manufacturable communication

THE IMAGE LEARNS TO ANSWER QUESTIONS

> *The first drawing may lie beautifully and still be useful.*
> *The next must confess the back, the bottom, and the hidden hinge.*
> *Each view removes one refuge of ambiguity;*
> *by the final sheet, imagination has become accountable.*

Concept art explores possibility; technical images reduce ambiguity. The workflow should preserve creative breadth early and progressively introduce scale, orthography, part breaks, articulation, materials, paint, sections, and manufacturing status. A later technical sheet must not inherit impossible perspective or hidden geometry from an attractive early image.

The required progression is narrative brief, shape studies, silhouette set, character turnaround, articulation overlay, part-break study, material and paint study, and technical schematic. Additional views may include expression, accessory interaction, vehicle seating, exploded assembly, mold direction, and package presentation. Each image declares whether it is exploratory, illustrative, review, or manufacturing-authoritative.

Turnarounds should use consistent projection and landmarks. Perspective may support presentation but should not define dimension. Articulation overlays identify axes and swept volumes before costume detail is final. Part-break studies test where seams, split lines, pins, snaps, tools, and paint can exist. Technical images should reference the canonical geometry and not become a separate hand-corrected truth.

AI-generated imagery can expand ideation but increases provenance and consistency risks. Prompt, model, version, references, edits, selection rationale, and authoritative status should be recorded. Generated images may contain impossible backs, inconsistent accessories, fused materials, and false text; they are hypotheses to interpret, not geometry to trace blindly.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Narrative brief	Source role, world, constraints, exclusions, evidence class, and intended outputs.
Shape studies	Rapid mass, proportion, and negative-space exploration without premature detail.
Silhouette set	Recognition, role, family grammar, and scale test.
Turnaround	Controlled front, side, rear, and three-quarter views with common landmarks.
Articulation overlay	Joint centers, axes, range, collision, and visible seam strategy.
Part-break study	Manufacturing splits, material zones, assembly, service, and paint access.
Material and paint study	Molded color, coating operations, gloss, texture, metallic, transparency, and wear.
Technical schematic	Dimensions, IDs, status, callouts, sections, and explicit authority.
Image provenance	Creator or model, date, prompt, references, edits, license, approval, and supersession.

Text Diagram. Image-development ladder

```
NARRATIVE BRIEF
      |
SHAPE + SILHOUETTE STUDIES
      |
TURNAROUND + SCALE LANDMARKS
      |
ARTICULATION + PART BREAK
      |
MATERIAL + PAINT + ACCESSORY
      |
TECHNICAL SCHEMATIC + STATUS
      |
CONTROLLED GEOMETRY / PROTOTYPE
```

Audio description: Image development climbs from narrative and silhouettes to turnarounds, articulation, part breaks, materials, technical schematic, and controlled prototype.

PRODUCTION APPLICATION

- Apply visible status labels to every image.
- Use consistent camera and landmarks across turnaround views.
- Resolve contradictions among generated or hand-drawn views before 3D modeling.
- Link technical images to product and geometry versions.
- Archive rejected studies with rationale when they affect later lineage.

AI-AGENT INTERPRETATION

AI may produce exploratory images, extract shape language, generate view checklists, and compare consistency. It must not claim a generated rear view is authoritative when no source supports it, fabricate readable labels, or obscure model and reference provenance.

FAILURE CASES AND CORRECTIVE ACTION

- A side view is inferred from a front image and changes costume, anatomy, or accessory attachment.
- Perspective art is traced directly into orthographic dimensions.
- Generated detail increases every revision because no shape grammar or status exists.
- Factory treats a mood image as a part or paint specification.

RELEASE GATE: No image advances into manufacturing authority until projection, version, product identity, geometry source, status, and unresolved contradictions are explicit.

Evidence classification and research anchors. E: industrial design drawing, model-based workflow, visualization and AI governance. S: progressive image ladder. P: Raven Valley image provenance packet.

Training exercise. Take one cinematic character image and list the additional views, dimensions, unknowns, contradictions, and status labels required before modeling.

29

3D Modeling Environments

Sculpt, polygon, CAD, cloth, procedural, texture, and simulation tools with explicit authority

THE TOOL SEES ONE FACE OF THE OBJECT

> *The sculpting brush knows the skin but not the tolerance.*
> *The CAD constraint knows the center but not the story.*
> *No tool is the whole workshop;*
> *wisdom lies in naming what each file is allowed to decide.*

Different modeling environments represent different truths. Polygonal modeling controls topology and shape; digital sculpting develops organic detail; parametric CAD governs dimensions and features; cloth simulation explores flexible behavior; procedural tools generate recurrence; UV and texture tools govern image mapping; rendering tools communicate appearance; mechanical simulation explores motion and load.

The workflow should be software-independent at the governance level while allowing software-specific implementation. Blender, Maya, ZBrush, Fusion, and related tools can all contribute, but the product record must state the authoritative source for silhouette, controlled dimensions, part interfaces, textures, materials, and manufacturing geometry. An .obj exported from a sculpt is not automatically a CAD master; a CAD solid may not preserve production-ready organic surface quality.

Tool transitions create loss: units, axes, hierarchy, names, normals, smoothing, UVs, vertex color, material assignments, instances, curves, tolerances, and metadata may change. The model should use controlled interchange packages and round-trip tests. NIST work on product-model testing and additive-manufacturing data emphasizes common dictionaries, data models, exchange formats, and provenance as foundations of interoperability (Li et al.).

A practical pipeline may begin with low-resolution blockout, move to sculpt, retopology, engineering reconstruction, part split, tolerance and draft, prototype mesh, print supports, texture and render, then tooling geometry. The order can vary, but no step should silently overwrite the source of authority.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Polygonal modeling	Controlled topology, silhouette, hard-surface and organic forms, animation or pose meshes.
Digital sculpting	High-resolution form and detail; requires scale, topology, thickness, part, and manufacturing translation.
Parametric CAD	Dimensions, constraints, datums, solids, assemblies, drawings, and controlled variants.
Subdivision workflow	Smooth surfaces derived from cages; export and manufacturing resolution require control.
Hard-surface modeling	Panels, shells, interfaces, and mechanical form; verify thickness, radii, draft, and solids.
Cloth simulation	Exploratory drape and collision; scale stiffness, seam, fiber, and manufacturing must be validated physically.
Procedural geometry	Repeatable rules and variants; parameters, seeds, dependencies, and bake status must be recorded.
Retopology / UV / texture	Render and visualization representations distinct from engineering surface authority.
Mechanical simulation	Kinematics, contact, and load hypotheses dependent on validated inputs.
Rendering	Communication view with camera, light, materials, geometry, and status recorded.

Text Diagram. Multi-tool authority map

```
SCULPT TOOL ---- appearance detail ----+
POLYGON TOOL --- topology / render -----+--> CONTROLLED PRODUCT RECORD
CAD TOOL ------- dimensions / parts ----+
CLOTH TOOL ----- flexible hypothesis ---+
SIM TOOL ------- motion / load hypothesis+
TEXTURE TOOL --- color / surface map ----+

EACH OUTPUT HAS STATUS, VERSION, AND ALLOWED AUTHORITY
```

Audio description: Sculpt, polygon, CAD, cloth, simulation, and texture tools contribute different controlled views to one product record.

PRODUCTION APPLICATION

- Create a tool-authority matrix and file manifest.
- Use locked units, axes, naming, origin, and product IDs across applications.
- Run import-export-import round trips on representative parts.
- Compare critical dimensions and topology after every interchange.
- Archive native and neutral formats with dependencies and checksums.

AI-AGENT INTERPRETATION

AI may assist with retopology, naming, conversion checks, procedural generation, and file-manifest audits. It must not merge conflicting sources without precedence, claim cloth or stress accuracy from default simulation, or discard native provenance after export.

FAILURE CASES AND CORRECTIVE ACTION

- A sculpt is scaled independently in several tools and no file matches nominal height.
- CAD part splits are rebuilt manually in the render mesh and drift.
- Procedural seeds change, altering detail after approval.
- Textures use missing external paths and render differently at the manufacturer.

RELEASE GATE: Every modeling environment must have declared inputs, outputs, authority, units, version, dependencies, interchange test, and archival path.

Evidence classification and research anchors. E: CAD, digital content creation, AM data interoperability, and configuration management. S: multi-tool authority map. P: Raven Valley second-body governance.

Training exercise. Build a tool matrix for Blender, ZBrush, Fusion, Substance, and a slicer. State what each tool may control and what it may not.

30

Sculpting Versus Engineering Geometry

Separating appearance, motion, print, mold, collision, packaging, and archival models

THE BEAUTIFUL MESH AND THE BUILDABLE PART

> *A cheek may be perfect while the neck has no wall.*
> *A coat may flow while the mold has no path to open.*
> *Honor both bodies: the one the eye believes,*
> *and the one matter can repeat without betrayal.*

A beautiful sculpt is not a tooling file. Product development requires several representations with controlled relationships: appearance mesh, pose or animation mesh, engineering CAD, mold-ready geometry, print-ready geometry, collision proxy, package proxy, render mesh, and archival master.

Appearance geometry prioritizes silhouette, anatomy, surface, folds, and narrative detail. Engineering geometry prioritizes wall, draft, radii, split, joint, tolerance, boss, gate, ejection, assembly, and inspection. They should remain visually and dimensionally related, but one cannot automatically substitute for the other. The engineering team may need to rebuild or surface the sculpt while preserving controlled landmarks and deviation limits.

Print-ready geometry introduces orientation, supports, drain holes, hollowing, minimum feature, compensation, and post-process access. Mold-ready geometry introduces parting, draft, shutoffs, actions, polish, texture, gate, vent, cooling, and ejectors. Collision proxies simplify shape for kinematics and packaging. Render meshes may use displacement and shaders that do not exist physically. Each representation requires a clear disclaimer and version link.

Deviation management preserves design intent. Compare silhouette sections, landmark coordinates, surface distance, volume, and focal features between sculpt and engineering model. Not every microdetail should survive; detail below process and paint capability may be removed or exaggerated. Decisions are recorded rather than left as undocumented "cleanup."

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Appearance mesh	Primary visual and narrative surface; not manufacturing authority unless specifically engineered.
Pose / animation mesh	Rigged or deformable representation for articulation and presentation.
Engineering CAD	Controlled parts, datums, interfaces, dimensions, tolerances, and assembly.
Mold-ready geometry	Draft, splits, shutoffs, tool actions, gates, vents, ejectors, radii, and process compensation.
Print-ready geometry	Watertight output with orientation, support, hollowing, drain, compensation, and post-process plan.
Collision proxy	Simplified volumes for motion, contact, package, and seating analysis.
Packaging proxy	Controlled envelope, restraint, center, accessory layout, and carton fit.
Render proxy	Optimized mesh and materials for communication, clearly labeled illustrative.
Archival master	Native and neutral sources, dependencies, checksums, units, and manifest.

Text Diagram. Representation lineage

```
[ APPEARANCE MASTER ]
       | landmarks / approved deviation
       v
[ ENGINEERING MASTER ] ---> [ MOLD / TOOL GEOMETRY ]
       |       |                    |
       |       +--> [ COLLISION ]   +--> [ INSPECTION ]
       +--> [ PRINT MODEL ]
       +--> [ RENDER MODEL ]
       +--> [ PACKAGE PROXY ]

NO DERIVED MODEL SILENTLY BECOMES THE MASTER
```

Audio description: The appearance master maps into engineering, which generates mold, inspection, print, render, collision, and package derivatives without reversing authority silently.

PRODUCTION APPLICATION

- Create deviation reports between appearance and engineering geometry.
- Define which microdetails are molded, painted, printed, or omitted.
- Use separate file IDs and statuses for every representation.
- Review tool and print geometry against the approved silhouette and focal features.
- Prevent derived render or slicer files from replacing archival masters.

AI-AGENT INTERPRETATION

AI may compare surfaces, detect non-manifold or thin geometry, classify representations, and draft deviation reports. It must not convert a sculpt into production geometry without engineering review or represent displacement and shader effects as physical features.

FAILURE CASES AND CORRECTIVE ACTION

- High-resolution sculpt detail becomes fragile tool steel or paint noise.
- Engineering rebuild changes face, posture, or silhouette without approval.
- A hollow print model with drain holes is sent as mold geometry.
- A decimated render mesh becomes the only surviving archive.

RELEASE GATE: Manufacturing release requires an approved engineering master, documented deviation from appearance intent, and controlled derived models for tool, print, collision, package, and render.

Evidence classification and research anchors. E: CAD, DFM, AM, model-based definition, and digital preservation. S: representation lineage. P: Raven Valley dual-body review.

Training exercise. List the differences required among a sculpt mesh, engineering torso, SLA prototype, injection-mold tool model, render mesh, and blister proxy.

31

Topology, Surface Resolution, and Scale Readability

Managing meshes, thin features, undercuts, detail loss, and the physical limits of small objects

THE DETAIL THAT SURVIVES

> *A million polygons cannot force a shallow line to mold.*
> *A pore enlarged too far becomes a crater.*
> *Let resolution answer process, paint, and distance;*
> *detail is true when the finished hand can still find it.*

Topology and resolution are not abstract digital quality metrics. They influence sculpt continuity, deformation, export, watertightness, tooling, printing, texture, render performance, and the survival of detail at actual scale. The correct density is the density required by the representation and process.

Polygon distribution should follow curvature, deformation, part boundaries, and intended edits. Subdivision surfaces require clean cages and controlled creases. Engineering solids require valid topology and manufacturable features. Non-manifold edges, self-intersections, inverted normals, duplicate shells, open boundaries, and zero-thickness regions can render convincingly while failing downstream processes.

Detail has a process chain: modeled depth, tool reproduction, molded material, surface texture, paint film, wear, lighting, and viewing distance. At 3.75-inch scale, realistic pores, cloth weave, and engraving may disappear or become noise. Exaggeration can improve readability but should preserve hierarchy and avoid sharpness, contamination traps, sink, or fragile steel. Detail coupons and painted prototype parts provide better evidence than zoomed renders.

Undercuts and thin surfaces must be classified. Some undercuts require tool action; some can flex; some should be split into parts; some are only render displacement and should be removed. Shelling and hollowing require drainage and support in additive prototypes and wall/cooling control in molding. Decimation is a derivative operation and must not alter critical contours or interfaces.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Polygon distribution	Allocate geometry to curvature, silhouette, deformation, seam, and edit need rather than uniform density.
Subdivision	Control cage, creases, poles, pinching, and export level.
Watertightness	Closed, orientable volume required by many print and manufacturing operations.
Non-manifold geometry	Edges, faces, or volumes that do not define a valid solid or predictable surface.
Thin feature	Wall, blade, cloth edge, rib, engraving, or protrusion below process, strength, paint, or safety capability.
Undercut	Geometry that prevents straight tool release or requires flex, split, action, or alternate process.
Normals / smoothing	Surface orientation and shading data that affect render and exchange but do not repair invalid geometry.
Decimation	Controlled reduction for derivative use; protect silhouette, landmarks, joint, and detail hierarchy.
Microdetail	Feature evaluated by actual scale, process, paint, light, and viewing distance.
Resolution coupon	Test artifact reproducing representative lines, textures, radii, gaps, text, and paint.

Text Diagram. Detail survival chain

```
DIGITAL FEATURE
      |
TOOL / PRINT CAPABILITY
      |
MATERIAL REPRODUCTION
      |
SURFACE + PAINT FILM
      |
HANDLING + WEAR
      |
ACTUAL LIGHT + VIEWING DISTANCE
      |
PERCEIVED FINISHED DETAIL
```

Audio description: Digital detail passes through process, material, coating, handling, light, and viewing distance before becoming perceived product detail.

PRODUCTION APPLICATION

- Run mesh and solid validation before every major handoff.
- Use scale-specific detail and texture coupons in production materials.
- Inspect painted parts at actual size and intended distance.
- Identify undercuts and thin features before tool quote.
- Protect critical contours during decimation and format conversion.

AI-AGENT INTERPRETATION

AI may detect mesh defects, estimate feature scale, compare model and process resolution, and flag undercuts. It must not decide that a feature is manufacturable without process, material, tool, and supplier data.

FAILURE CASES AND CORRECTIVE ACTION

- A high-resolution sculpt hides self-intersection and zero-thickness cloth.
- Engraved text is legible only in render and fills with paint.
- Decimation changes eyelids, hand openings, or peg geometry.
- Fine texture causes tool polish difficulty and inconsistent paint.

RELEASE GATE: Geometry advances only after validity, feature-size, undercut, wall, detail-coupon, paint, and actual-scale readability checks.

Evidence classification and research anchors. E: computer graphics, CAD topology, additive and molding process capability. S: detail survival chain. P: Raven Valley actual-scale readability gate.

Training exercise. Select ten details from a high-resolution sculpt and classify each as molded, painted, printed, implied by texture, exaggerated, or removed.

32

Rendering Standards

Narrative, engineering, material, package, catalog, and AI-training views with declared truth status

THE LIGHT MUST STATE ITS PURPOSE

> *One light flatters; another reveals the seam.*
> *One camera tells the legend; another measures the stance.*
> *Neither is dishonest when its purpose is named;*
> *a render fails when beauty pretends to be evidence.*

Rendering is a communication process. Different tasks require different cameras, lights, materials, backgrounds, scales, overlays, and disclaimers. A render standard prevents cinematic imagery, engineering review, catalog record, and manufacturing instruction from being confused.

Narrative presentation may use atmosphere and directional light to communicate character. Design review uses neutral or controlled lighting and consistent lenses. Material review requires color-managed environments and separated surface channels. Articulation demonstration uses verified joint states and clear backgrounds. Exploded assembly uses orthographic or low-distortion views with IDs and sequence. Packaging renders include actual cavity, card, warnings, and scale. Catalog images preserve identity and condition rather than dramatic ambiguity.

Every render should carry product ID, geometry version, material and paint status, camera, lighting environment, scale reference, render date, author or model, approval status, and statement of authority. If soft goods are simulated, the material and seam assumptions are listed. If a pose is digitally supported or deformed, it is marked illustrative. The rendering file is linked to the controlled geometry manifest.

AI training adds provenance and negative examples. Training sets should distinguish approved physical capability from concept fantasy, and superseded safety-critical instructions from current ones. Generated outputs should preserve source IDs and evidence class where possible. A visually convincing hallucination is a high-risk failure in manufacturing communication.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Narrative render	Atmospheric communication of role and world; illustrative unless linked to verified product state.
Design review render	Consistent camera, neutral materials or controlled appearance, and comparison-friendly views.
Material review	Color, gloss, roughness, transmission, metallic, and texture under defined environment.
Articulation render	Joint axes, range, collision, and verified poses; no impossible deformation.
Exploded assembly	Part IDs, order, orientation, joining method, and hidden interfaces.
Packaging render	Product and accessory restraint, card, blister, legal and information zones, and case context.
Sales render	Truthful product capability, included contents, scale, and edition.
Catalog archive	Standard views, neutral background, ID, dimensions, accessories, and version.
AI-training render	Labeled authority, provenance, known errors, supersession, and intended task.

Text Diagram. Render status labels

```
CONCEPT / MOOD
      |
DESIGN REVIEW
      |
ENGINEERING / VERIFIED GEOMETRY
      |
MATERIAL / PAINT MASTER
      |
MARKETING / SALES
      |
CATALOG / ARCHIVE

EACH LEVEL DECLARES WHAT IT CAN AND CANNOT PROVE
```

Audio description: Render status moves from concept through design, engineering, material, marketing, and archive, with explicit authority at each level.

PRODUCTION APPLICATION

- Use a render cover slate with IDs, versions, camera, light, status, and limitations.
- Create standard camera sets for line comparison.
- Include neutral clay, silhouette, section, and actual-scale reference views.
- Compare packaging renders to physical prototypes and printer dielines.
- Archive scene files, assets, color transforms, and output checksums.

AI-AGENT INTERPRETATION

AI may generate render briefs, enforce metadata, compare view consistency, and produce controlled draft images. It must not present generated detail, labels, poses, or materials as manufactured fact without verified source geometry and status.

FAILURE CASES AND CORRECTIVE ACTION

- Cinematic shadow hides joint gaps or package contents.
- Different lenses distort character proportions across the line.
- AI adds accessories not included in the BOM.
- Marketing render shows metallic or transparent effects not achievable by the approved process.

RELEASE GATE: No render is used for manufacturing, sales, catalog, or training until its purpose, source geometry, material state, camera, lighting, version, and limitations are declared.

Evidence classification and research anchors. E: visualization, color management, model-based communication, AI provenance. S: role-specific render standard. P: Raven Valley truth-status slate.

Training exercise. Render the same figure as mood, design review, engineering, material, package, and catalog image. Write the authority and limitation of each.

33

File Handling and Interchange

Units, axes, naming, formats, dependencies, checksums, export validation, and round-trip truth

THE FILE CROSSES A BORDER

> *A millimeter may become a meter without changing its digits.*
> *An upright figure may arrive sleeping on another axis.*
> *Give every crossing a manifest and every return a comparison;*
> *interchange is safe only when difference is made visible.*

File interchange is a controlled translation. Units, coordinate systems, origin, orientation, hierarchy, names, materials, textures, curves, metadata, tolerances, instancing, and geometry can change across software and formats. A successful open command is not proof of faithful transfer.

The file standard should define units, up axis, forward axis, handedness, origin, world and local frames, naming grammar, collection hierarchy, pivot placement, transform policy, modifier state, texture paths, color space, and version. The manifest lists native source, neutral exchange, derivative files, software and version, plugins, external assets, checksum, and owner.

Formats have different purposes. STEP supports product-model and CAD exchange; STL is a triangle surface with limited semantic information; OBJ supports mesh and basic material linkage; 3MF carries richer additive-manufacturing packages and is standardized as ISO/IEC 25422:2025; glTF is optimized for efficient 3D transmission and rendering; OpenUSD supports composed scenes and complex pipelines. None is universally best. The package must state what information is expected to survive.

Round-trip testing imports the exported file into an independent or receiving system, then compares scale, orientation, part count, bounding box, critical dimensions, topology, normals, materials, hierarchy, and metadata. NIST product-model testing work demonstrates the importance of testing translators and product manufacturing information rather than trusting file extensions (Lubell, Hartman, and Cheney).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Units	Authoritative unit and conversion policy; never infer from nominal height alone.
Axes and handedness	Up, forward, coordinate handedness, world frame, local frames, and joint axes.
Origin and pivots	Product origin, datum relationship, part pivot, assembly location, and export transform.
Naming	Stable IDs plus readable labels; avoid names that change with hierarchy or artist preference.
Hierarchy and instances	Assemblies, collections, layers, references, and repeated parts.
Textures and color	Embedded or linked files, relative paths, UDIMs, color spaces, channels, and transforms.
Formats	Native source and task-specific neutral derivatives with declared information limits.
Compression and archives	Package dependencies without corrupting paths or losing checksums and permissions.
Checksums	Detect file identity and accidental change; checksum does not prove correctness.
Round-trip validation	Export, import, compare, document differences, and approve translator path.

Text Diagram. Controlled file handoff

```
NATIVE SOURCE + DEPENDENCIES
          |
     EXPORT PROFILE
          |
 NEUTRAL / TASK FORMAT + MANIFEST
          |
     RECEIVING IMPORT
          |
 SCALE / AXIS / PART / DIMENSION / TOPOLOGY / MATERIAL CHECK
          |
     APPROVED TRANSLATION PATH
```

Audio description: A native source is exported with a profile and manifest, imported by the receiver, and compared before the translation path is approved.

PRODUCTION APPLICATION

- Use a release package with readme, manifest, checksums, preview, and validation report.
- Keep native masters and neutral derivatives separate.
- Test representative complex parts before bulk conversion.
- Lock units and axes in templates and export presets.
- Archive software and plugin versions required for reconstruction.

AI-AGENT INTERPRETATION

AI may validate naming, manifests, units, bounding boxes, part counts, and checksums; generate conversion reports; and identify format limitations. It must not assume semantic equivalence because two files render similarly.

FAILURE CASES AND CORRECTIVE ACTION

- An STL arrives at the wrong scale and is manually resized without updating the product record.
- Joint pivots are lost in mesh export and rebuilt inconsistently.
- Texture files are absolute paths to an artist workstation.
- A compressed archive contains multiple "final" files with no manifest.

RELEASE GATE: A handoff is complete only when the receiver can reconstruct the intended view, verify critical data, and trace every file to source, version, format purpose, and checksum.

Evidence classification and research anchors. E: ISO STEP, ISO/IEC 25422:2025, ISO/ASTM 52950 and 52951, glTF, OpenUSD, NIST translator testing. S: controlled interchange packet. P: Raven Valley file passport.

Training exercise. Export one assembly to STEP, STL, OBJ, 3MF, and glTF. Record what each format preserves, loses, or approximates.

34

Versioning and No-Drift Digital Production

Keeping character, design, engineering, tool, paint, package, and catalog views connected to one identity

THE VERSION THAT REMEMBERS WHY

A newer file is not always the truer one.
A silent correction may become an untraceable defect.
Let each change name its cause, its reach, and its witness;
continuity is preserved by visible difference.

No-drift production prevents separate teams and files from becoming incompatible while retaining similar names. Character, design model, engineering model, tool geometry, paint master, packaging model, and catalog projection remain controlled views over one canonical product identity.

The Opus Core Framework defines modules as the smallest units that can be independently versioned, traced, tested, and deprecated. It requires trace-back to source, trace-forward to verification and downstream use, no orphan requirements, baseline control, and documented duplication resolution (Conrad and OpenAI, *Opus Core Framework* 2-4). The Play System applies those rules to product artifacts.

A change request states problem, affected IDs, source, rationale, proposed change, alternatives, risk, cost, schedule, compatibility, tests, approvals, and effective configuration. A revised hood may alter silhouette, head range, material, paint, package depth, instruction, catalog images, and edition interpretation. Impact analysis finds those links before release.

Baselines are named configurations, not folders called FINAL. Drafts may move quickly; released artifacts require controlled status. Superseded files remain archived for lineage and service. A catalog view can be regenerated from the current baseline while preserving historical views for earlier units.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Canonical product identity	Stable object around which all views and events are organized.
Configuration item	Independently controlled part, file, material, process, test, package, or record.
Baseline	Approved set of compatible configuration items at a named release point.
Revision	Controlled change to an artifact; distinguish major compatibility change from minor correction.
Change request	Problem, rationale, impact, proposed action, tests, authority, and closure.
Trace-back	Connection from requirement or artifact to source and decision.
Trace-forward	Connection to dependent parts, files, tests, packages, catalogs, and users.
Supersession	New authoritative artifact replaces an older one without deleting history.
Compatibility	Full, conditional, partial, none, or unknown across versions and accessories.
Release manifest	Exact configuration, checksums, approvals, and effective batch or date.

Text Diagram. Canonical product views

```
[ CHARACTER ]
     |
[ CANONICAL PRODUCT ]
  |-- DESIGN MODEL
  |-- ENGINEERING MODEL
  |-- TOOLING MODEL
  |-- PAINT MASTER
  |-- PACKAGE MODEL
  |-- TEST RECORDS
  |-- CATALOG / PROVENANCE VIEW

CHANGE -> IMPACT MAP -> TEST -> APPROVE -> NEW BASELINE
```

Audio description: One canonical product branches into design, engineering, tooling, paint, package, test, and catalog views; changes pass impact, test, approval, and baseline.

PRODUCTION APPLICATION

- Use stable IDs and explicit statuses instead of filename adjectives.
- Generate release manifests automatically where possible.
- Require impact analysis across geometry, material, process, paint, package, safety, catalog, and service.
- Archive superseded baselines with read-only protection and lineage.
- Reject silent supplier and factory changes.

AI-AGENT INTERPRETATION

AI may trace dependencies, compare baselines, generate impact lists, detect orphan requirements, and prepare release manifests. It must not approve changes, rewrite provenance, or treat an unreviewed newer file as authoritative.

FAILURE CASES AND CORRECTIVE ACTION

- Paint sheet and package render use different sculpt revisions.
- A factory fixes a tool locally and sends only a new sample, not revised geometry or change record.
- Catalog images are updated but earlier units become indistinguishable.
- A shared accessory changes diameter and breaks several released hands.

RELEASE GATE: No baseline changes without logged request, impact analysis, verification, approval, release manifest, and supersession record.

Evidence classification and research anchors. E: configuration management, ISO architecture and lifecycle information, NASA systems engineering. S: multi-view product core. P: Raven Valley no-drift production doctrine.

Training exercise. Simulate a hood change that adds 1.5 mm rear depth. Build the trace-forward impact list and define the tests required before release.

PART 7

PROTOTYPING, TOOLING, AND MANUFACTURING

Converting geometry into repeatable matter through samples, process controls, and verification.

THE TOOL OPENS

A prototype is a question given weight.
A mold is an answer multiplied under pressure.
Record the shrink, the scar, the hand that corrected it,
or repetition will only manufacture the error.

35

Prototype Strategy and Sample Hierarchy

Each sample as a question, instrument, and controlled step toward production evidence

THE QUESTION GIVEN WEIGHT

> *A prototype is not a smaller factory promise.*
> *It is a question made solid enough to fail honestly.*
> *Ask one thing clearly, record what answered,*
> *and the next sample will know why it exists.*

Prototype strategy defines what each sample is intended to learn. A beautiful appearance sample cannot approve joint life; an articulation proof cannot approve paint; a first tool sample cannot approve final package. The hierarchy preserves purpose and prevents premature release claims.

The proposed sequence is narrative and silhouette study, scale maquette, appearance prototype, articulation proof, engineering prototype, material prototype, paint and decoration master, packaging prototype, tooling master, first tool sample, revised tool sample, preproduction sample, pilot-run sample, golden production sample, and retention sample. Projects may combine stages when risk is low, but the omitted question must still be answered.

A sample record includes product and part IDs, purpose, process, material, scale, deviations, preparation, date, maker, condition, tests, findings, decisions, and next action. It states what the sample cannot prove. A resin print may confirm silhouette and part split while explicitly excluding impact, long-term joint, coating, chemical, and production shrink conclusions.

Samples are preserved selectively. Masters, failures that changed design, tool samples, preproduction approvals, golden samples, and lot retention samples support provenance and future diagnosis. Storage must prevent deformation, UV, chemical contact, and confusion. Destructive tests are documented with before/after evidence and sample disposition.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Narrative / silhouette study	Question: does the product communicate role and family at intended scale?
Scale maquette	Question: do mass, proportion, footprint, and interactions work physically?
Appearance prototype	Question: does the designed surface and detail hierarchy survive actual size?
Articulation proof	Question: do joint centers, range, collision, and assembly work?
Engineering prototype	Question: do parts, tolerances, joining, load paths, and service work?
Material prototype	Question: do candidate materials and contact stacks behave as required?
Paint master	Question: can the appearance be produced, cured, and repeated?
Packaging prototype	Question: does package protect, present, inform, seal, ship, and open as intended?
Tool samples	Question: what does the production process actually create and what must be corrected?
Preproduction / pilot	Question: can the complete line, people, fixtures, materials, and records repeat the approved object?
Golden / retention	Question: what physical reference governs release and later comparison?

Text Diagram. Sample hierarchy as evidence ladder

```
IDEA / SILHOUETTE
      |
APPEARANCE / SCALE
      |
MOTION / ENGINEERING
      |
MATERIAL / PAINT / PACKAGE
      |
TOOL SAMPLE / REVISION
      |
PREPRODUCTION / PILOT
      |
GOLDEN PRODUCTION / RETENTION

EACH RUNG ANSWERS NAMED QUESTIONS ONLY
```

Audio description: Samples progress from concept through appearance, motion, materials, tooling, preproduction, and retained production reference.

PRODUCTION APPLICATION

- Write the sample question and exclusions before fabrication.
- Assign sample ID, process, material, version, and disposition.
- Photograph, measure, test, and annotate findings.
- Preserve failures that changed a requirement or validated limit.
- Do not authorize bulk production from appearance-only evidence.

AI-AGENT INTERPRETATION

AI may generate sample plans, map requirements to sample stages, and flag claims unsupported by the sample type. It must not infer production performance from render or prototype appearance.

FAILURE CASES AND CORRECTIVE ACTION

- A resin prototype is called production sample and used to approve impact.
- Each sample changes several variables, preventing causal learning.
- Failures are discarded and only successful samples are archived.
- Golden sample has no exact file, material, process, or approval link.

RELEASE GATE: A sample can approve only the questions, materials, processes, conditions, and acceptance criteria declared in its record.

Evidence classification and research anchors. E: product development, design of experiments, manufacturing validation, configuration management. S: sample hierarchy. P: Raven Valley sample-as-instrument doctrine.

Training exercise. Create a fifteen-stage sample plan for the Obsidian Veil figure and identify the minimum evidence each stage must return.

36

Additive Manufacturing

FDM, vat photopolymerization, powder-bed, jetting, and metal processes as controlled prototype tools

THE OBJECT BUILT IN LAYERS

> *Layer upon layer, the machine remembers direction.*
> *The surface may look whole while strength still knows the seam.*
> *Orient the question before orienting the part;*
> *printing is a process history made visible in matter.*

Additive manufacturing creates parts by successive material addition, but each process produces distinct geometry, surface, anisotropy, support, post-process, safety, and data requirements. ISO/ASTM 52900:2021 establishes common AM terminology; qualification and data standards should guide serious industrial use.

Material extrusion processes such as FDM are accessible and useful for scale, fit, fixtures, package proxies, and some functional parts, but layer orientation, bead bonding, temperature, moisture, raster, wall, infill, support, and warpage influence performance. Reviews document strong orientation-dependent behavior in additively manufactured polymers, so a printed peg or hinge cannot be treated as isotropic production plastic (Zohdi and Yang).

Vat photopolymerization - SLA, DLP, and LCD - offers fine detail and smooth surfaces. Exposure, resin state, orientation, support, wash, drain, post-cure, temperature, and aging affect dimensions and properties. Post-cure can change strength, hardness, color, and residual chemistry; manufacturer guidance must be validated for the actual resin and part rather than applied generically.

Powder-bed processes such as SLS or MJF can create complex nylon parts without conventional supports, but surface, porosity, powder refresh, dimensional behavior, and material qualification remain. Metal AM and binder processes have specialized safety and qualification needs and are rarely justified for ordinary figure parts, though they may support tooling, inserts, or premium components. NIST emphasizes common data dictionaries, models, exchange formats, and provenance for scalable AM data (Li et al.).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
FDM / material extrusion	Layer height, nozzle, temperature, chamber, raster, wall, infill, support, moisture, shrink, and orientation.
SLA / DLP / LCD	Resin, exposure, orientation, support, hollowing, drain, wash, post-cure, light aging, and handling safety.
SLS / MJF	Powder material, packing, refresh, orientation, surface, porosity, cooling, and dimensional compensation.
Binder / metal processes	Feedstock, debind, sinter, shrink, density, safety, and specialized qualification.
Orientation	Controls support, surface, anisotropy, drainage, warpage, and critical feature quality.
Support strategy	Attachment, scarring, removal access, deformation, and protected surfaces.
Compensation	Process- and geometry-specific scale, hole, wall, and fit adjustment validated with coupons.
Post-processing	Wash, cure, depowder, heat, machine, sand, seal, prime, and inspect.
Safety	Resin contact, solvent, emissions, powder, dust, UV, heat, ventilation, and waste.

Variable / concern	Operational requirement
Data package	Machine, material, batch, build file, orientation, settings, post-process, operator, results, and deviations.

Text Diagram. AM prototype record

```
GEOMETRY VERSION
      |
PROCESS / MACHINE / MATERIAL LOT
      |
ORIENTATION / SUPPORT / SETTINGS
      |
BUILD + POST-PROCESS
      |
DIMENSION / SURFACE / MECHANICAL FINDINGS
      |
SAMPLE LIMITATIONS + NEXT ACTION
```

Audio description: A geometry version is linked to process, machine, material, orientation, build, post-process, findings, limitations, and next action.

PRODUCTION APPLICATION

- Print calibration and interface coupons with each critical build family.
- Orient around the question being tested, not merely shortest build time.
- Record settings and post-process as configuration items.
- Condition printed parts before fit or load comparison.
- Use ISO/ASTM terminology and qualification concepts consistently.

AI-AGENT INTERPRETATION

AI may generate orientation comparisons, support-risk maps, build manifests, and process-specific checklists. It must not invent exposure or temperature values, infer production-equivalent strength, or recommend unsafe resin and solvent handling.

FAILURE CASES AND CORRECTIVE ACTION

- A printed joint works in one orientation and is assumed valid in another.
- Post-cure changes fit after the measurement record is taken.
- Drain holes are omitted from a hollow resin part.
- An AM prototype is used to approve regulatory material or mass-production performance.

RELEASE GATE: Every printed sample requires traceable geometry, process, machine, material lot, orientation, settings, post-process, safety handling, measured results, and declared limitations.

Evidence classification and research anchors. E: ISO/ASTM 52900, 52920, 52950, 52951; NIST AM data; peer-reviewed anisotropy and post-cure research. S: AM sample record. P: Raven Valley question-first orientation rule.

Training exercise. Print one shoulder joint in three orientations and compare dimensions, surface, insertion, retention, and failure. Do not change geometry between builds.

37

Subtractive and Hand-Built Prototyping

CNC, machining, laser, vacuum forming, sheet, armature, clay, wax, foam, styrene, and mixed media

THE HAND REMOVES WHAT THE MACHINE CANNOT IMAGINE

> *Some forms arrive by addition; others by disciplined absence.*
> *A knife, mill, wire, and thumb each ask different truths.*
> *Choose the method that makes the question easiest to hear;*
> *craft is not primitive when it reveals the hidden error first.*

Subtractive and hand-built methods remain essential because they expose scale, ergonomics, assembly, material, and process questions that digital models can conceal. CNC, machining, laser cutting, vacuum forming, sheet fabrication, armatures, clay, wax, putty, foam, model board, styrene, textile mockups, and mixed media each create different evidence.

CNC and machining produce precise hard parts, fixtures, inserts, molds, and gauges. Tool access, cutter radius, workholding, stock, deflection, and finishing shape the result. Laser cutting and sheet fabrication quickly test packaging, panels, frames, soft architecture, and playset modules but introduce kerf, heat, bend radius, grain, and edge concerns. Vacuum forming is useful for blister and shell prototypes when draft and webbing are understood.

Hand-built maquettes allow immediate proportion and grip correction. Wire armatures reveal balance and pose. Clay and wax support sculpt decisions. Epoxy putty and styrene support part-break, seam, and surface studies. Foam and model board establish playset mass and vehicle scale. Textile mockups reveal scale stiffness and seam bulk. These models are valuable precisely because they are not production-perfect.

The record should state which dimensions and functions are trustworthy. A foam playset can answer volume and reach but not load. A machined acetal joint can answer geometry and friction but not injection-mold shrink or weld lines. Mixed-media prototypes often have hidden adhesives, screws, and internal supports; documentation prevents them from becoming misleading masters.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
CNC / machining	Tool path, stock, cutter, fixture, tolerance, surface, burr, and material.
Laser cutting	Kerf, heat-affected zone, edge, focus, material emissions, and flat-pattern translation.
Vacuum forming	Sheet, heat, draw ratio, draft, webbing, trim, and restraint geometry.
Sheet fabrication	Bend, score, fasten, weld, laminate, and edge treatment.
Wire armature	Pose, balance, centerline, and gross proportion.
Clay / wax / putty	Direct sculpt, revision, casting master, and surface study with shrink and durability limits.
Foam / model board	Rapid volume, environment, package, and ergonomic mockup.
Styrene / kit-bash	Part-break and hard-surface exploration; source and ownership must be clear.
Textile mockup	Drape, bulk, opening, closure, seam, and interaction at scale.
Mixed-media master	Multiple materials and hidden supports documented before reproduction.

Text Diagram. Prototype method by question

```
QUESTION: SILHOUETTE / GRIP -> FOAM / CLAY / ARMATURE
QUESTION: FIT / JOINT -> MACHINED / PRINTED / STYRENE
QUESTION: PACKAGE -> BOARD / LASER / VACUUM FORM
QUESTION: SOFT GOODS -> TEXTILE MOCKUP
QUESTION: TOOL / INSERT -> CNC / MACHINING

METHOD IS SELECTED BY EVIDENCE NEEDED
```

Audio description: Prototype methods are selected by whether the question concerns silhouette, joint, package, soft goods, or tooling.

PRODUCTION APPLICATION

- Select method from the question and declare limitations.
- Measure hand-built revisions and update controlled geometry rather than leaving them only in the physical sample.
- Document hidden supports, adhesives, and nonproduction materials.
- Use gauges and fixtures produced by subtractive methods to improve repeatability.
- Review shop safety, dust, fumes, heat, blades, and machine guarding.

AI-AGENT INTERPRETATION

AI may compare prototype methods, generate cut lists and process plans, and translate measurements back into CAD. It must not assume a handmade correction is captured digitally or recommend shop processes beyond available safety controls and competence.

FAILURE CASES AND CORRECTIVE ACTION

- A hand-corrected master becomes the only source and cannot be reproduced.
- Kit-bashed protected components are treated as original production design.
- A machined prototype hides molding constraints.
- Laser-cut material emits hazardous fumes because compatibility was not checked.

RELEASE GATE: A physical prototype may govern only the questions and dimensions recorded, and all approved hand changes must be transferred to the canonical model or drawing.

Evidence classification and research anchors. E: modelmaking, machining, fabrication, occupational safety, prototyping. S: question-to-method matrix. P: Raven Valley physical-to-digital correction rule.

Training exercise. Choose the cheapest reliable prototype method for silhouette, shoulder joint, cloth hood, blister, and playset wall. State what each cannot prove.

38

Mold-Making and Casting

Silicone, rigid support, gates, vents, keys, pressure, vacuum, cure, shrink, and demolding

THE NEGATIVE HOLDS THE MEMORY

> *The mold learns every edge by becoming its absence.*
> *Air remembers the places resin cannot reach.*
> *Cut the path for entry, escape, and return;*
> *repetition begins in the shape of the void.*

Prototype mold-making and casting translate a master into repeatable low-volume parts. One-part, two-part, multi-part, cut, glove, and rigid-mother-mold systems differ in undercut handling, seam, support, labor, material, and mold life. Gate, vent, key, release, cure, and demold are designed, not improvised after the mold is closed.

Silicone selection considers hardness, tear, elongation, viscosity, shrink, catalyst, inhibition, release, and compatibility with master and casting material. A soft mold may release undercuts but distort; a hard mold may preserve dimension but tear or trap the part. Glove molds require mother molds. Cut molds trade planned parting geometry for skilled incision and registration.

Vacuum degassing removes entrained air from mixed mold or casting material; pressure casting compresses bubbles during cure. Neither fixes poor venting, fast gel, moisture, or inaccessible geometry. Slush casting creates hollow shells by coating the mold interior; rotational casting distributes material through controlled motion. Process selection follows wall, detail, volume, equipment, safety, and required repeatability.

Mold life is finite and changes over cycles. Tear, swelling, release buildup, distortion, and surface loss affect parts. The record links each cast to mold ID and cycle. Shrink compensation should be measured across master, mold, cast, post-cure, and aging rather than borrowed as a generic percentage.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
One-part mold	Simple open-face geometry with limited undercut and one exposed side.
Two-part mold	Controlled parting, keys, gate, and vents for enclosed geometry.
Multi-part mold	Complex undercuts and removable blocks with higher labor and seam risk.
Cut mold	Flexible block cut around the master; seam skill and registration govern result.
Glove / mother mold	Thin flexible skin supported by rigid shell; alignment and support are critical.
Vacuum degassing	Removes mixed air before pour; material pot life and equipment matter.
Pressure casting	Compresses bubbles during cure; vessel rating and safe operation are mandatory.
Slush / rotational casting	Creates hollow shells through repeated coating or rotation; wall uniformity and cure matter.
Keys / gates / vents	Registration, material entry, air exit, trim, and cosmetic placement.
Release and inhibition	Surface chemistry can prevent cure or damage master and mold.
Mold life	Track cycles, inspection, maintenance, distortion, and retirement.

Text Diagram. Casting system

```
MASTER
  |
MOLD DESIGN: PARTING + KEYS + GATE + VENTS
  |
MOLD MATERIAL + SUPPORT + CURE
  |
CAST MATERIAL + MIX + VACUUM / PRESSURE
  |
DEMOLD + TRIM + POST-CURE
  |
DIMENSION / SURFACE / DEFECT / MOLD-CYCLE RECORD
```

Audio description: The master drives mold design, material and cure, casting, demold, post-cure, and a recorded inspection linked to mold cycle.

PRODUCTION APPLICATION

- Create a mold drawing before pouring material.
- Test cure compatibility on representative master and release surfaces.
- Label mold ID, material, date, cavity, cycle, and condition.
- Record mix, temperature, pressure or vacuum, cure, demold, and post-cure.
- Retire molds by measured defect and distortion, not intuition alone.

AI-AGENT INTERPRETATION

AI may draft mold plans, identify likely undercuts and air traps, and generate cycle records. It must not specify pressure-vessel use, chemistry, mix, or cure without qualified equipment, safety, and manufacturer data.

FAILURE CASES AND CORRECTIVE ACTION

- A mold cures incompletely against a contaminated or incompatible master.
- Air traps recur because no vent path was designed.
- A flexible mold distorts and cast dimensions are accepted without support review.
- Mold wear creates an unrecorded running variant.

RELEASE GATE: No mold or cast is approved without master version, mold design, chemistry compatibility, process record, cycle trace, dimension, surface, defect, and safe equipment review.

Evidence classification and research anchors. E: moldmaking and casting practice, material data, shop safety. S: mold-cycle provenance. P: Raven Valley negative-as-memory doctrine.

Training exercise. Design a two-part silicone mold for a hooded head. Mark parting line, keys, gate, vents, support, demold direction, and likely seam cleanup.

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Production Molding Processes

Injection, overmold, insert, blow, rotational, compression, thermoform, resin, die-cast, and elastomer production

THE CAVITY UNDER PRESSURE

Molten matter enters with heat, speed, and memory.
The tool answers through steel, cooling, and escape.
Every sink and knit line is a sentence about the path;
production becomes repeatable when flow is allowed to speak.

Production molding transforms qualified material through a controlled process and tool. Each process has characteristic part types, material options, tooling, wall logic, draft, undercuts, gates, runners, vents, ejectors, shrink, cycle, defects, and economics. Process selection begins before detailed sculpt freeze.

Injection molding is central to mass-produced figures and accessories. Resin is plasticized, injected, packed, cooled, and ejected. Part geometry influences flow, pressure, weld lines, air traps, sink, warp, and cycle. Consistent wall and radiused transitions are useful principles, but tool design, resin, gate, cooling, and cosmetic intent determine specific solutions. Manufacturer and resin-supplier design guides should inform the part from the beginning (Malloy; Osswald, Turng, and Gramann).

Overmolding and insert molding create multi-material or encapsulated parts but require sequence, adhesion or mechanical key, insert location, thermal compatibility, and flash control. Blow molding and rotational molding support hollow forms and larger volumes. Compression molding suits selected thermosets or elastomers. Thermoforming supports trays, blisters, and shells. Die casting adds metal mass and detail with tool, draft, porosity, sharpness, and finishing concerns.

The tool is a configuration-managed product. Cavity, core, actions, slides, lifters, shutoffs, gate, runner, vent, cooling, ejector, texture, polish, steel-safe areas, and repair history require IDs and revisions. Tool changes can create collectible micro-variants, but they are first manufacturing changes and must be recorded before market mythology develops.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Injection molding	High-volume thermoplastic parts; flow, pack, cooling, ejection, shrink, and tool action govern result.
Overmolding	Second material around substrate; adhesion, key, contamination, heat, and dimensional sequence.
Insert molding	Metal, magnet, textile, or rigid insert captured in mold; fixture and displacement control are critical.
Blow molding	Hollow parts formed by inflation; wall distribution, pinch-off, opening, and trim.
Rotational molding	Hollow larger forms through rotating heated mold; wall and cycle differ from injection.
Compression molding	Material compressed in heated cavity; charge, flow, cure, flash, and demold.
Thermoforming	Heated sheet drawn over or into tool; draft, webbing, trim, clarity, and thickness distribution.
Resin casting	Low-volume liquid casting; chemistry, mold life, bubbles, cure, and labor.
Die casting	Metal forced into die; mass, draft, porosity, gate, trim, finish, and corrosion.
Elastomer molding	Rubber or silicone process with cure, vent, flash, tear, and post-cure concerns.

Variable / concern	Operational requirement
Common defects	Short shot, flash, sink, knit line, warp, burn, splay, bubble, void, ejector mark, contamination, and color drift.

Text Diagram. Molding process control

```
PART REQUIREMENT
      |
PROCESS + MATERIAL + TOOL CONCEPT
      |
DFM: WALL / DRAFT / GATE / VENT / EJECT / COOL
      |
TOOL BUILD + FIRST SAMPLE
      |
MEASURE DEFECT + CAPABILITY + APPEARANCE
      |
CORRECT / VALIDATE / PREPRODUCTION / CONTROL
```

Audio description: Part requirements lead to process, material, tool DFM, first samples, measurement, correction, and controlled production.

PRODUCTION APPLICATION

- Complete process-specific DFM before tool authorization.
- Approve gate, parting, ejector, and cosmetic witness locations.
- Create defect standards and measurement plans at first tool sample.
- Record tool corrections, cavity differences, and effective batch.
- Validate process window and line conditions before bulk release.

AI-AGENT INTERPRETATION

AI may compare process suitability, generate DFM questions, and classify defects from documented examples. It must not set molding conditions, tool steel, shrink, or acceptance without material, supplier, tool, and process data.

FAILURE CASES AND CORRECTIVE ACTION

- Sculpt detail creates trapped steel, impossible shutoffs, or unplanned actions.
- Gate and ejector marks appear on focal surfaces.
- Tool correction changes silhouette but only the sample, not CAD and catalog records.
- Process settings are adjusted to hide a geometry defect, narrowing robustness.

RELEASE GATE: Tool release requires process-specific DFM; production release requires validated material, tool, process window, defect standard, capability, and change control.

Evidence classification and research anchors. E: injection and plastics engineering, manufacturer guides, toolmaking and quality control. S: process-control chain. P: Raven Valley tool provenance rule.

Training exercise. Choose molding processes for torso, flexible hood, hollow creature body, clear blister, metal medallion, and soft grip. Explain why each alternative was rejected.

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Design for Manufacture and Assembly

Reducing avoidable complexity while preserving function, repair, narrative, and inspection

THE PART COUNT AND THE PROMISE

> *One less part may save a motion or erase a repair.*
> *One shared pin may unify a line or spread one defect everywhere.*
> *Simplify only after the function has been counted;*
> *efficiency is wisdom when it does not hide the cost.*

Design for manufacture and assembly, or DFMA, asks whether the product can be made, handled, oriented, joined, decorated, inspected, repaired, and scaled with unnecessary complexity removed. The objective is not minimum part count at any cost; it is the simplest robust system that preserves requirements.

DFMA principles include reducing unnecessary parts and fasteners, using repeated interfaces where justified, designing obvious orientation, preventing incorrect assembly, minimizing regrip and fixture changes, providing tool access, controlling snap order, separating cosmetic and load-bearing roles, and placing unavoidable gates, ejectors, seams, and fasteners deliberately. Boothroyd, Dewhurst, and Knight provide established methods for analyzing manufacture and assembly efficiency.

Part consolidation can improve cost and reliability but may create complex tools, thick walls, poor paint access, mixed functions, or impossible repair. Shared parts can reduce tooling and improve interoperability but may flatten character differentiation or spread one weak interface across the line. The decision should compare total lifecycle cost and risk, not unit part count alone.

Error-proofing is especially valuable. Asymmetric keys, clear orientation, controlled color or tactile cues, fixtures, sensors, go/no-go gauges, and assembly confirmation reduce mistakes. Rework routes must be defined because forcing a misassembled snap apart can create hidden damage. The operation bulletin should reflect actual line sequence and worker reach.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Part count	Count only after functions, materials, process, repair, and tool complexity are considered.
Fastener standardization	Reduce types and tools where torque, scale, hazard, and service permit.
Orientation	Make correct assembly self-evident through geometry, keying, and fixtures.
Error prevention	Prevent wrong part, reversed part, missed insert, incorrect polarity, and paint contamination.
Tool access	Provide space, line of sight, support, and fixture for assembly and service tools.
Snap order	Define sequence so earlier connections do not block later ones or preload parts.
Paint access	Avoid trapped surfaces, contact damage, and assembly through uncured or delicate coatings.
Witness marks	Define acceptable gate, ejector, seam, fastener, trim, and weld appearance.
Repairability	Preserve replaceable modules where value exceeds added complexity and safety remains.
Cosmetic versus load-bearing	Do not force decorative inserts to carry unverified structural loads.
Assembly ergonomics	Reach, force, repetition, posture, fixture, and worker safety.

Text Diagram. DFMA decision balance

```
REQUIREMENTS
   |
PART / MATERIAL / PROCESS OPTIONS
   |
MANUFACTURE + ASSEMBLY + PAINT + INSPECTION
   |
SAFETY + REPAIR + VARIETY + COST
   |
SIMPLIFY WHERE TOTAL SYSTEM IMPROVES
   |
PROTOTYPE LINE / VERIFY / RELEASE
```

Audio description: Requirements are balanced through manufacture, assembly, safety, repair, variety, and cost before simplification and line verification.

PRODUCTION APPLICATION

- Run part and operation reviews with design, engineering, tooling, paint, assembly, quality, and repair roles present.
- Use time and motion observations on pilot assembly.
- Design go/no-go gauges and fixture confirmation for critical operations.
- Quantify trade-offs before consolidating or standardizing parts.
- Update work instructions after actual line learning.

AI-AGENT INTERPRETATION

AI may identify repeated parts and operations, draft assembly precedence, compare part-consolidation scenarios, and flag tool-access conflicts. It must not optimize labor count without worker safety, quality, repair, and cultural context.

FAILURE CASES AND CORRECTIVE ACTION

- Part consolidation creates a complex side-action tool and worse cost.
- A shared joint simplifies inventory but fails across the entire wave.
- Assembly order requires flexing decorated parts past their safe range.
- Rework is common but not documented, creating hidden damage and variation.

RELEASE GATE: DFMA approval requires complete operation sequence, error-proofing, worker access, inspection, rework, repair, cost, and risk comparison - not a part-count target alone.

Evidence classification and research anchors. E: DFMA literature, human factors, quality and manufacturing engineering. S: lifecycle DFMA balance. P: Raven Valley simplification-with-memory rule.

Training exercise. Review a twelve-part figure and propose two consolidations, two standardizations, and one retained separate module. Explain total-system effects.

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Assembly, Paint, and Finishing Route

The controlled operation sequence from received part to packed product

THE LINE OF MANY HANDS

Each station inherits what the last one allowed.
A hidden burr becomes a paint scar three rooms later.
Let the route make cause and consequence visible;
quality is carried forward one confirmed act at a time.

The manufacturing route is the ordered sequence by which molded, cast, printed, cut, sewn, coated, assembled, inspected, and packed components become a released unit. It names inputs, equipment, fixtures, process controls, acceptance, rework, records, and handoff at every operation.

A typical route receives and conditions parts; inspects material, color, and critical geometry; trims and deflashes; cleans or treats surfaces; primes or base-coats; performs masks, pad print, decals, and details; cures; assembles joints and soft goods; checks torque and motion; touches up within limits; performs final inspection; inventories accessories; and packages. The actual sequence may differ because welding should occur before some paints, soft goods may require late installation, and package restraint can influence joint state.

Operations should be designed around contamination and damage control. Mold release, skin oil, dust, uncured coating, metal debris, adhesive squeeze-out, and trim fragments can migrate downstream. Finished surfaces require defined trays, gloves, racks, cure time, and contact points. A line that repeatedly repairs preventable damage is not controlled merely because final inspection catches some of it.

The operation bulletin should include part IDs, station, method, equipment, setting reference, fixture, standard time where appropriate, in-process check, defect and rework codes, safety, and record. Machine settings remain linked to material and equipment specifications rather than universalized in the white paper.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Receiving and conditioning	Verify part ID, lot, material, color, quantity, moisture or temperature condition, and visible defects.
Trim and deflash	Remove gates, flash, supports, sprues, or threads without changing controlled geometry or creating sharpness.
Surface preparation	Clean, treat, abrade, prime, mask, and protect based on qualified coating system.
Decoration sequence	Base, mask, print, decal, weather, clear, flash, and cure in controlled order.
Joining sequence	Press, snap, pin, weld, stake, screw, bond, sew, or lace with fixture and confirmation.
Joint test	Range, retention, noise, damage, and paint contact checked at appropriate stage.
Touch-up	Limited and documented correction with criteria for rejection or downgrade.
Accessory kitting	Count, identify, orient, restrain, and verify small components.
Final inspection	Identity, completeness, cosmetics, motion, warnings, package, and traceability.
Packaging	Restraint, card, blister or tray, seal, code, carton, and release sample.

Text Diagram. End-to-end operation route

```
RECEIVE -> INSPECT -> CONDITION -> TRIM / CLEAN
   -> PRIME / BASE -> MASK / PRINT / DETAIL -> CURE
   -> JOIN / ASSEMBLE -> JOINT TEST -> TOUCH-UP LIMIT
   -> FINAL QC -> ACCESSORY KIT -> PACKAGE / SEAL
   -> CASE / TRACE / RELEASE
```

Audio description: Parts move through receiving, preparation, decoration, cure, assembly, testing, final quality, kitting, packaging, and release.

PRODUCTION APPLICATION

- Create an operation bulletin and visual standard for every station.
- Identify contamination barriers and protected contact zones.
- Build in-process checks before defects become hidden or expensive.
- Define rework limit, downgrade, scrap, and provenance consequences.
- Run the full route during preproduction and pilot, not only individual operations.

AI-AGENT INTERPRETATION

AI may generate route drafts, dependency checks, station work packets, and traceability fields. It must not set process parameters or standard times without factory, material, equipment, labor, and safety evidence.

FAILURE CASES AND CORRECTIVE ACTION

- Weld or press operations damage finished paint because sequence was not integrated.
- Touch-up hides recurring process failure and creates untracked finish variation.
- Accessories are kitted by visual similarity and mismatched across editions.
- Final QC discovers defects that should have been prevented at an earlier station.

RELEASE GATE: The complete line route must be demonstrated with production-intent parts, people, equipment, fixtures, records, and defect/rework controls before preproduction approval.

Evidence classification and research anchors. E: manufacturing planning, coatings, assembly, quality, ergonomics. S: integrated line route. P: Raven Valley handoff-as-memory rule.

Training exercise. Write a fourteen-operation route for the Obsidian Veil figure, identifying input, fixture, check, defect, and record at each station.

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Quality Control and Verification

Inspection, test, sampling, traceability, and the difference between conformance and confidence

THE MEASURE AFTER THE PROMISE

> *A sample may pass while the process still wanders.*
> *A dimension may conform while the joint already tires.*
> *Inspect the object, study the process, preserve the lot;*
> *quality is not a gate alone but a memory of variation.*

Quality control verifies that parts and products conform to released requirements and that the process remains capable and traceable. It includes incoming inspection, in-process checks, final inspection, functional and abuse tests, package and transport tests, sampling plans, corrective action, and retained evidence.

Verification method should match the requirement: inspection for visible or dimensional characteristics; demonstration for operation; test for performance; analysis for justified predictions. Critical-to-safety and critical-to-function characteristics may require different sampling or full inspection than ordinary cosmetics. ISO 2859-1:2026 provides acceptance-sampling procedures indexed by acceptance quality limit, but sampling does not transform unknown hazards into acceptable ones and must be selected by qualified quality authority.

Typical figure tests include dimensions, color and gloss, coating adhesion, rub, joint retention or torque, articulation cycling, accessory retention, drop and impact, small parts, sharp edges and points, package seal, transport simulation, heat and humidity, UV or aging where relevant, chemical compatibility, and batch traceability. Each test records method edition, equipment, calibration, sample conditioning, configuration, result, deviation, and disposition.

Quality data should feed design and supplier governance. Defect Pareto, cavity patterns, station patterns, lot correlations, trend, and corrective action reveal systemic issues. A pass/fail spreadsheet without product and process identity is not an evidence system. The golden sample supports appearance but does not replace numerical or functional requirements.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Incoming inspection	Material, component, declaration, lot, dimensions, color, and supplier evidence before use.
In-process inspection	Checks placed before defects become hidden, combined, or expensive.
Final inspection	Complete product identity, function, cosmetic, accessories, warnings, package, and trace.
Critical characteristics	Safety, motion, compatibility, assembly, or focal appearance features requiring special control.
Sampling plan	Lot, inspection level, AQL or alternate logic, sample size, acceptance, rejection, and escalation.
Functional test	Joint, retention, transform, electronics, light, sound, vehicle, or package operation.
Environmental test	Heat, cold, humidity, light, chemical, storage, and transport conditioning.
Package test	Seal, scuff, abrasion, restraint, compression, vibration, drop, and distribution simulation.
Traceability	Product, batch, cavity, material lot, line, date, inspection, test, and disposition.
Corrective action	Contain, identify root cause, correct, verify, prevent recurrence, and update records.

Text Diagram. Verification loop

```
REQUIREMENT -> VERIFICATION METHOD -> SAMPLE / CONDITION
      -> MEASURE / OBSERVE -> RESULT / UNCERTAINTY
      -> ACCEPT / REJECT / CONTAIN
      -> ROOT CAUSE / CORRECTIVE ACTION
      -> RE-VERIFY -> UPDATE PROCESS + RECORD
```

Audio description: Requirements map to methods, conditioned samples, results, decisions, corrective action, re-verification, and process update.

PRODUCTION APPLICATION

- Create a requirement-to-verification matrix.
- Use calibrated equipment and controlled test samples.
- Link results to exact configuration, cavity, lot, line, and date.
- Preserve rejected and corrected evidence where it informs risk.
- Use transport standards such as ASTM D4169 or ISTA procedures only with product-appropriate distribution assumptions.

AI-AGENT INTERPRETATION

AI may generate inspection plans, trend data, cluster defects, and flag missing trace links. It must not choose acceptance levels, certify compliance, or reinterpret a failed result as acceptable without authorized disposition.

FAILURE CASES AND CORRECTIVE ACTION

- A golden sample is used as the only definition of joint performance.
- Sampling plans are copied from another product without risk review.
- Test results cannot identify material lot or product revision.
- Corrective action closes after containment but before verified prevention.

RELEASE GATE: Release requires complete traceable evidence that applicable safety, critical function, appearance, package, and process requirements are verified by authorized methods and dispositions.

Evidence classification and research anchors. E: ISO 2859-1:2026, ISO 9001:2015, toy standards, coating and packaging methods. S: integrated verification matrix. P: Raven Valley evidence-return loop.

Training exercise. Build a verification matrix for overall height, shoulder range, hip retention, paint adhesion, small parts, accessory count, blister seal, and batch ID.

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Manufacturing Pitfalls

A field atlas of defects, hidden causes, unauthorized fixes, and recurring drift

THE DEFECT HAS AN ANCESTOR

> *Flash is born before the knife meets it.*
> *Color drift begins before the eye rejects the part.*
> *Find the ancestor rather than polishing the descendant;*
> *pitfalls repeat when the system records only the scar.*

A failure atlas trains teams to recognize common manufacturing defects while resisting superficial correction. Warpage, sink, short shot, flash, knit line, bubble, void, brittle joint, shrink error, loose or seized motion, paint rub, poor adhesion, color drift, overspray, mask creep, decal silvering, tooling mismatch, trapped air, misassembly, package scuff, accessory loss, and supplier drift each require process-specific investigation.

Molding defects often reveal the interaction of geometry, tool, material, and process. Sink may reflect thick sections or inadequate packing and cooling. Short shot may reflect flow resistance, venting, gate, or process. Flash may reflect parting, clamp, pressure, wear, or contamination. Knit lines can be cosmetic or structural depending on location and conditions. Warpage can arise from orientation, cooling, wall, fiber, residual stress, or assembly preload.

Decoration defects have equivalent depth. Poor adhesion can begin with substrate, release, cleaning, treatment, cure, compatibility, or film. Color drift can arise from pigment, molded base, thickness, gloss, lighting, batch, or instrument. Mask creep and overspray can reflect fixture wear, angle, viscosity, pressure, or handling. Decal silvering reflects trapped air or poor surface contact, not merely an operator mistake.

Administrative pitfalls may be more dangerous than visible defects: undocumented tool polishing, supplier compound substitution, local rework, mixed cavities, overwritten files, missing labels, and inspection records detached from batches. These changes can produce apparently good products whose future compatibility and recall scope are unknowable.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Warpage	Dimensional distortion from material, cooling, residual stress, geometry, storage, or assembly.
Sink / void	Surface depression or internal absence related to section, pack, cooling, gas, or cure.
Short shot	Incomplete fill caused by flow, vent, gate, temperature, pressure, material, or tool.
Flash	Excess material at parting, shutoff, ejector, or insert interface.
Knit / weld line	Flow fronts rejoin; location, temperature, pressure, contamination, and load determine consequence.
Brittle joint	Material, stress, notch, weld line, aging, cold, chemistry, or process issue.
Loose / seized joint	Tolerance, surface, paint, wear, creep, assembly, or contamination.
Paint rub / adhesion	Coating system, contact, cure, clearance, flex, or package issue.
Color drift	Material, pigment, film, gloss, lighting, measurement, or master control.
Misassembly	Wrong part, orientation, sequence, polarity, accessory, or configuration.
Package damage	Scuff, deformation, seal, restraint, vibration, drop, or humidity.

Variable / concern	Operational requirement
Supplier drift	Unapproved material, process, facility, tool, or documentation change.

Text Diagram. Pitfall containment and learning

```
DETECT -> STOP / CONTAIN -> IDENTIFY AFFECTED CONFIGURATION
  -> PRESERVE SAMPLES / DATA -> ROOT CAUSE
  -> CORRECT DESIGN / TOOL / PROCESS / RECORD
  -> VERIFY -> RELEASE / RECALL / DOWNGRADE
  -> UPDATE FAILURE ATLAS + TRAINING
```

Audio description: Defects are detected, contained, traced, investigated, corrected, verified, dispositioned, and added to training.

PRODUCTION APPLICATION

- Publish defect photos and tactile references by material and process.
- Define contain, rework, downgrade, scrap, and escalation criteria.
- Link corrective action to drawing, tool, process, supplier, and training changes.
- Preserve cavity and station identifiers where feasible.
- Investigate administrative drift with the same rigor as physical defects.

AI-AGENT INTERPRETATION

AI may classify documented defects, compare conditions, and retrieve prior causes and controls. It must not diagnose from one image, conceal uncertainty, or recommend parameter changes without responsible process authority.

FAILURE CASES AND CORRECTIVE ACTION

- Operators trim recurring flash indefinitely while tool wear worsens.
- Paint rub is accepted as vintage character without edition or quality decision.
- Mixed cavities produce visible differences that later become counterfeit confusion.
- Supplier drift is discovered only after collector complaints.

RELEASE GATE: A recurring defect cannot be normalized by rework; root cause, affected scope, verified correction, and controlled record change are required.

Evidence classification and research anchors. E: plastics, coatings, assembly, packaging, quality, and corrective-action practice. S: combined physical and administrative failure atlas. P: Raven Valley defect ancestry doctrine.

Training exercise. Choose three defects that look similar but have different causes. Build a decision tree using evidence rather than appearance alone.

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The Complete Production Lifecycle

Observe, define, design, prototype, qualify, tool, produce, catalog, distribute, learn, and preserve

THE OBJECT RETURNS AS MEMORY

> *The first sketch already casts a shadow toward the landfill.*
> *The final unit still points backward to the first decision.*
> *Build the road in both directions;*
> *a product is complete only when its making and afterlife remain legible.*

The complete lifecycle connects observation and narrative to requirements, concept, geometry, prototyping, material and paint qualification, DFM, tooling, samples, preproduction, pilot, production, quality, packaging, catalog, provenance, distribution, feedback, repair, reissue, and archive. Each stage has entry evidence, outputs, authority, and return paths.

Stage-gate structure makes increasing commitment visible. Early stages are reversible and exploratory. Later stages add tool cost, material orders, compliance, production capacity, marketing, and public expectation. A gate does not guarantee success; it confirms that named questions have sufficient evidence for the next level of exposure.

Feedback is not reserved for the end. Prototype failure returns to geometry; tool samples return to DFM; pilot defects return to process; market complaints return to hazard and use analysis; collector discoveries return to catalog and provenance; repair returns to design for service. The lifecycle becomes a loop rather than a one-way launch pipeline.

The system of record captures decisions and physical evidence so future teams can distinguish intentional design, running change, defect, repair, reissue, and counterfeit. Lifecycle stewardship also includes retirement: separate electronics and hardware where possible, preserve records, disclose restoration, and learn which choices created unnecessary waste.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Observe	User, play, culture, collection, environment, technology, and problem evidence.
Define	Narrative, product, age, market, requirements, exclusions, risk, and identity.
Design	Shape, scale, articulation, parts, materials, paint, package, catalog, and service.
Prototype	Question-driven samples, measurements, failures, and revisions.
Qualify	Materials, contact stacks, processes, coatings, joints, package, tests, and suppliers.
Tool	DFM, tool design, build, first samples, correction, and controlled geometry.
Validate	Preproduction, pilot, line, fixtures, people, quality, and release evidence.
Produce	Controlled lots, inspection, deviations, containment, and retained samples.
Catalog and distribute	Identity, offer, package, transport, sale, ownership, and support.
Learn and preserve	Feedback, complaint, repair, reissue, recall, archive, and research update.

Text Diagram. Complete Raven Valley lifecycle

```
OBSERVE -> NARRATIVE / REQUIREMENTS -> CONCEPT -> TECHNICAL TURNAROUND
  -> 3D APPEARANCE -> ARTICULATION / PART BREAK -> ENGINEERING
  -> PROTOTYPES -> MATERIAL / PAINT / PACKAGE QUALIFICATION
  -> DFM -> TOOLING -> TOOL SAMPLES -> PREPRODUCTION -> PILOT
  -> PRODUCTION -> QC -> PACKAGE -> CATALOG / PROVENANCE
  -> DISTRIBUTION -> FEEDBACK / REPAIR / REISSUE / ARCHIVE
                          ^                              |
                          +------------ LEARNING ------------+
```

Audio description: The product moves from observation through design, tooling, production, catalog, distribution, and lifecycle learning that returns to earlier stages.

PRODUCTION APPLICATION

- Define entry and exit criteria for every stage.
- Link each gate to artifacts, evidence, owner, and approval.
- Permit backward loops without hiding schedule or cost impact.
- Create a release packet and post-release review.
- Preserve product and information configuration together.

AI-AGENT INTERPRETATION

AI may organize the lifecycle, detect missing gates, generate artifact checklists, trace feedback to affected stages, and compare planned versus actual outcomes. It must not advance a gate, hide failed evidence, or replace accountable human release authority.

FAILURE CASES AND CORRECTIVE ACTION

- Tooling begins before safety, scale, and joint requirements stabilize.
- Launch date prevents a failed pilot from returning to process correction.
- Catalog and support are created from marketing rather than product truth.
- Post-release complaints are treated as isolated customer behavior rather than design evidence.

RELEASE GATE: A stage closes only when required artifacts, verification, unresolved risk, authority, and trace links are complete and visible to the next responsible role.

Evidence classification and research anchors. E: product development, systems engineering, lifecycle and configuration management. S: closed-loop production lifecycle. P: Raven Valley memory-return model.

Training exercise. Map the Obsidian Veil figure through all lifecycle stages and identify five legitimate return loops after failure.

PART 8

ACCESSORIES, PLAYSETS, PACKAGING, AND SERIES DESIGN

Extending the figure into worlds, interfaces, stories, assortments, and protective presentation.

THE WORLD AROUND THE FIGURE

The hand asks for a tool; the tool asks for a place.
The rider asks the creature where balance lives.
A package is a threshold, not a coffin:
it must protect the world without silencing the invitation.

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Accessories as Functional Narrative

Tools, artifacts, storage, grip, safety, compatibility, and story in small independent objects

THE OBJECT HELD BY THE OBJECT

> *A tool reveals the hand that was designed to carry it.*
> *A key implies a door; a pack implies a road.*
> *Let every accessory change the story or the action;*
> *otherwise it is only a small piece waiting to be lost.*

Accessories extend character role and play, but each accessory is also a separate product component with scale, material, part, paint, hazard, grip, retention, storage, package, catalog, and compatibility requirements. Part count alone does not equal value.

A useful accessory answers at least one question: what does the character do, how does it interact, what new pose or story becomes possible, where is the object stored, and how is it distinguished from similar pieces? A data slate may support role and catalog identity; a modular pack may store tools and alter silhouette; a staff may provide support or interface with a playset. The design should resist generic weapon accumulation that adds risk and cost without narrative function.

Grip compatibility includes opening, shape, insertion force, retention, release, paint, deformation, hand material, and repeated use. Storage may be on figure, in pack, in vehicle, in playset, or in package. Cross-line reuse can increase play and reduce tooling, but must be declared and verified. Small parts and sharp features require age-specific analysis.

Accessory completeness is a major collector signal. Catalog records should include part ID, name, material, color, markings, dimensions, inclusion, variant, compatibility, and images. Replacement policy and provenance should distinguish original, authorized replacement, reproduction, and custom accessory.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Character relevance	Role, culture, task, ritual, vulnerability, or story transition.
Play value	New action, choice, connection, storage, transformation, or world interaction.
Grip compatibility	Hand opening, force, retention, release, paint, wear, and deformation.
Storage	On-body, pack, vehicle, playset, package, or archival location.
Material and paint	Strength, flexibility, point, surface, visibility, and chemical compatibility.
Safety	Small part, sharpness, projectile, magnet, cord, battery, and foreseeable misuse.
Loss risk	Size, color, shape, count, storage, inventory, and replacement.
Packaging volume	Presentation, restraint, scuff, visibility, and seal.
Reuse and compatibility	Shared standards, visual fit, functional fit, and version.
Collector identity	Part markings, catalog, edition, replacement, and counterfeit distinction.

Text Diagram. Accessory value test

```
ACCESSORY
  |-- CHANGES CHARACTER UNDERSTANDING?
  |-- CREATES A PLAY ACTION?
  |-- FITS / STORES / SURVIVES?
  |-- PASSES AGE + HAZARD REVIEW?
  |-- CAN BE CATALOGED AND REPLACED?
  |-- JUSTIFIES COST / PACKAGE VOLUME?

NO MEASURABLE VALUE -> REMOVE OR REDESIGN
```

Audio description: An accessory must support character, play, fit, storage, safety, catalog, replacement, cost, and package value.

PRODUCTION APPLICATION

- Assign each accessory a part ID and compatibility matrix.
- Test grip and storage after paint and cycling.
- Create accessory inventory images and package maps.
- Design replacement and missing-part response.
- Limit included count to meaningful, distinguishable objects.

AI-AGENT INTERPRETATION

AI may generate accessory-role matrices, detect redundant objects, compare grip dimensions, and draft catalog entries. It must not add undeclared weapons or parts to imagery, infer original completeness from one photo, or classify reproductions as authentic.

FAILURE CASES AND CORRECTIVE ACTION

- Accessory paint transfers into the hand or blister.
- Extra hands are included but too small for intended toy route.
- A pack cannot store the tools shown in art.
- Reused accessories lack faction or scale fit and appear arbitrary.

RELEASE GATE: An accessory is included only when narrative, play, mechanical, safety, storage, package, catalog, and lifecycle value are defined and verified.

Evidence classification and research anchors. E: human factors, toy safety, product and collector research. S: functional narrative accessory test. P: Raven Valley accessory value gate.

Training exercise. Audit six proposed accessories and remove two. Justify retained items by action, narrative, storage, safety, and catalog value.

46

Creatures, Vehicles, and Riding Systems

Rider geometry, saddles, cockpits, restraints, center of mass, chassis, wheels, and docking

THE RIDER AND THE LIVING MACHINE

> *The rider does not sit upon an image but within a geometry.*
> *The creature feels the burden through points of contact.*
> *Balance the hand, the foot, the seat, the turning world;*
> *a journey begins where separate bodies agree to move.*

Riding and vehicle systems combine figure, creature or chassis, seat, saddle, hands, feet, restraint, controls, accessory storage, center of mass, articulation, scale compression, and egress. The system must work as an assembly, not as separate attractive objects.

Rider-to-saddle geometry includes pelvis width, hip angle, coat and skirt clearance, thigh sweep, foot support, hand reach, rein or control position, headroom, and center of mass. A five-point figure has limited sitting adaptation, so saddle and cockpit may need to accept straight hip axes and stylized posture. Soft goods can compress, but should not be used as an unmeasured tolerance sink.

Creature design includes anatomy, articulation, foot and leg load, rider mass, saddle attachment, skin or armor, tail and horn hazards, balance, and package. Vehicle design includes chassis, shell, axle, wheel, steering or transform, seating, accessory storage, impact, fasteners, and playset docking. Scale compression should be declared and tested for visual and functional coherence.

The Obsidian Veil rider and triceratops serves as an advanced case: the animal must support rider and pack, preserve recognizable mass, avoid unsafe horn geometry for the intended route, provide stable feet and center of mass, and use saddle or harness filigree that carries actual attachment and orientation functions.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Rider pelvis and hip	Seat width, hip axis, coat clearance, insertion, and retention.
Hand-to-control	Reach, grip, orientation, rein, handle, steering, or tool interaction.
Foot support	Stirrup, peg, floor, platform, or passive clearance.
Center of mass	Combined figure, accessory, creature or vehicle mass across poses and motion.
Creature articulation	Head, jaw, limbs, tail, saddle, and load-bearing interfaces.
Vehicle seating	Cockpit, headroom, controls, restraints, egress, and package state.
Chassis	Primary structural path for wheels, axles, seats, shell, transforms, and impact.
Storage	On-board accessory, figure, pack, and package retention.
Scale compression	Declared deviations for creature, wheel, cockpit, door, or architecture.
Docking	Shared connector, alignment, load, release, and version with playsets.

Text Diagram. Rider-system contact map

```
[ HAND / CONTROL ]
                  |
[ FOOT SUPPORT ]--[ RIDER ]--[ SEAT / SADDLE / RESTRAINT ]
                  |
           [ CREATURE / CHASSIS CORE ]
              /          |                    [ GROUND ]  [ STORAGE ]  [ DOCKING ]
```

Audio description: The rider connects through hands, feet, seat, and restraint to a creature or chassis that meets ground, storage, and docking systems.

PRODUCTION APPLICATION

- Use combined digital and physical rider-system prototypes.
- Test insertion, egress, balance, controls, and accessory storage.
- Load-test saddle, seat, axle, and docking interfaces.
- Check horn, edge, pinch, entrapment, and projectile hazards by age route.
- Publish compatibility and required figure configurations.

AI-AGENT INTERPRETATION

AI may calculate reach and collision from supplied geometry, generate contact maps, and compare center-of-mass estimates. It must not infer animal biomechanics, safe load, or stability from a posed image alone.

FAILURE CASES AND CORRECTIVE ACTION

- Rider fits only after flexing or damaging coat and hips.
- Creature is stable alone but tips with rider and accessory.
- Controls cannot be reached by the actual hand articulation.
- Docking connector supports alignment but not the load or repeated release.

RELEASE GATE: Riding or vehicle claims require verified combined fit, contact, stability, load, egress, hazard, storage, and docking with production-intent figures and accessories.

Evidence classification and research anchors. E: kinematics, statics, ergonomics, vehicle and mechanism design, toy safety. S: rider-system contact map. P: Obsidian Veil triceratops case.

Training exercise. Define all rider contact points and swept volumes for a five-point figure on a triceratops saddle. Identify three design changes forced by limited articulation.

47

Playsets and Environmental Systems

Floors, walls, thresholds, platforms, modularity, transformations, storage, lighting, sound, and safe collapse

THE ROOM THAT AGREES TO PLAY

> *A wall becomes a world when the figure can reach its door.*
> *A bridge becomes a rule when the peg knows where to stop.*
> *Build the environment as both architecture and invitation;*
> *every threshold should explain how the story may cross.*

A playset is an environment and mechanical system scaled to figures and users. It combines structure, modular interfaces, circulation, reach, storage, transformation, hazards, package, sound or light, and narrative. ARCH-3 principles are applied provisionally through nested frames, modular bays, corresponding connectors, and controlled structural recurrence.

Environmental components include floors, walls, platforms, doors, ladders, bridges, tiles, facades, furniture, traps, supports, elevators, docks, storage, lighting, and sound. Each must be tested with actual figure landmarks and articulation. A ladder rung may look correct in scale but fail hand opening; a doorway may fit the body but not the hood or carried weapon; a platform may support static display but fail a user leaning on it.

Structural design distinguishes visible shell from load-bearing frame. Modular tiles and bays use defined datums and connectors. Transformations require state, lock, release, pinch, stored energy, and reset logic. Controlled collapse can create play but must fail without sharp fragments, trapping, or unexpected force. Electronics add battery, wire, heat, sound pressure, firmware, privacy, and service requirements.

Playset modularity should reduce repetition and increase world-building rather than force endless purchase. A base unit must have standalone play value. Expansion rules, compatibility, and edition should be explicit. Storage can be integrated as functional filigree: walls hold accessories, floors contain figures, and package elements become scenery when safety and durability permit.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Floor / platform	Load, flatness, peg pattern, texture, figure balance, and user lean.
Wall / facade	Shell, frame, connector, opening, decoration, and package volume.
Door / threshold	Figure, hood, accessory, hand reach, hinge, stop, pinch, and passage.
Ladder / bridge	Grip, foot, load, deflection, fall, edge, and attachment.
Modular tile / bay	Datum, connector, orientation, repeat, tolerance, and compatibility.
Furniture / prop	Scale, stability, storage, interaction, and small-part risk.
Trap / transform	Trigger, stored energy, path, lock, pinch, reset, and truthful instruction.
Lighting / sound	Power, battery, heat, brightness, sound, access, failure, privacy, and repair.
Safe collapse	Controlled separation and energy without sharpness, entrapment, or hidden damage.
Storage	Figures, accessories, panels, instructions, and provenance integrated into environment.

Text Diagram. Nested playset architecture

```
[ USER ROOM / FLOOR ]
   [ PLAYSET SHELL / FACADE ]
      [ STRUCTURAL FRAME / BAYS ]
         [ MODULAR CONNECTORS ]
            [ FIGURE / ACCESSORY INTERFACES ]
               [ STORAGE / SERVICE / POWER ]
```

Audio description: The playset nests user space, shell, structural frame, modular connectors, figure interfaces, and service systems.

PRODUCTION APPLICATION

- Prototype environment at actual figure and hand scale.
- Load-test platforms, bridges, hinges, and connectors.
- Create state diagrams for every transform or trap.
- Test module assembly across tolerance and repeated cycles.
- Provide storage, service, and compatibility records.

AI-AGENT INTERPRETATION

AI may generate modular layouts, connector maps, reach and passage checks, and transform state diagrams. It must not claim structural safety, sound level, battery compliance, or privacy without engineering and test evidence.

FAILURE CASES AND CORRECTIVE ACTION

- A beautiful doorway cannot pass the figure with accessories.
- Modular walls drift out of square across multiple bays.
- A transform has an ambiguous locked state and pinches fingers.
- Integrated electronics become inaccessible after assembly.

RELEASE GATE: A playset is released only after figure compatibility, load, reach, transform, connector, hazard, storage, electronics, package, and service verification.

Evidence classification and research anchors. E: structural, architectural, human-factors, mechanism, electronics, and toy-safety practice. S: nested playset architecture. P: ARCH-3 translation and Raven Valley environment grammar.

Training exercise. Design one 12-inch modular wall bay with doorway, platform, storage, and docking port. Define frame, shell, loads, connectors, and figure interactions.

48

Packaging Architecture

Protection, information, shelf interface, evidence, collector artifact, and archival threshold

THE THRESHOLD AROUND THE OBJECT

> *The package must hold without bruising, reveal without misleading.*
> *It speaks before the joint can move or the hand can decide.*
> *Let protection, information, and invitation share one wall;*
> *a threshold earns trust by showing what it guards.*

Packaging is a structural, informational, regulatory, retail, environmental, and collectible system. It protects and restrains the product, communicates identity and age, organizes accessories, carries warnings and legal data, survives distribution, supports shelf presentation, and may become part of the collection.

The package architecture includes primary product contact, blister or tray, card or carton, insert, accessory wells, ties or restraints, seal, tamper evidence, hanger, print, code, instructions, case pack, and shipping container. Restraint should protect without preloading joints, abrading paint, deforming soft goods, or creating difficult and hazardous opening.

Information hierarchy should place series identity, product name, age or audience, included contents, primary warnings, and essential use information where they can be found. Legal information must not be reduced below usability. Collector storytelling, card-back grids, lore, and provenance entry can enrich the package while remaining subordinate to truthful contents and safety.

Packaging is also part of authenticity. Dieline, print version, blister shape, seal method, code, factory, date, and running changes become collector micro-signals. These signals should be cataloged without encouraging destructive comparison or pretending every process variation is an edition.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Protection	Impact, vibration, compression, scuff, dust, moisture, light, deformation, and loss.
Restraint	Control movement without paint contact, joint preload, puncture, or soft-goods set.
Information	Identity, age, contents, warnings, instructions, manufacturer, codes, and service.
Shelf interface	Hanger, footprint, facing, readability, adjacency, and tamper visibility.
Accessory organization	Visible, counted, retained, and removable with minimal damage.
Tamper evidence	Makes opening or access legible without false security claims.
Legal carrier	Jurisdictional markings, warnings, traceability, language, and responsible party.
Collector artifact	Art, lore, grid, edition, codes, print, seal, and condition.
Archival record	Package version and retained sample linked to product configuration.
Environmental design	Material reduction, separation, recycled content, recyclability, and verified claims.

Text Diagram. Packaging layers

```
[ SHIPPING / CASE ENVIRONMENT ]
   [ CARD / CARTON INFORMATION ]
      [ BLISTER / TRAY RESTRAINT ]
         [ FIGURE + ACCESSORIES ]
      [ SEAL / TAMPER / OPENING ]
   [ CATALOG / TRACE / COLLECTOR SIGNAL ]
```

Audio description: Shipping surrounds information and restraint layers, which hold figure and accessories while preserving seal, opening, catalog, and collector signals.

PRODUCTION APPLICATION

- Create packaging requirements before final product envelope freeze.
- Prototype restraint with decorated production-intent parts.
- Test opening, accessory removal, and damage risk.
- Validate print hierarchy and warnings at actual size.
- Link dieline, print, blister, seal, code, and case configuration by version.

AI-AGENT INTERPRETATION

AI may generate information hierarchy, check declared contents, compare package and product versions, and flag missing trace fields. It must not generate regulatory text without current review or represent package security and sustainability beyond evidence.

FAILURE CASES AND CORRECTIVE ACTION

- Blister presses on metallic paint and coat tails during storage.
- Accessories are hidden or appear included when they are only illustrated.
- Warnings are technically present but unreadable.
- A package revision is mixed across a lot without catalog or trace update.

RELEASE GATE: Packaging release requires verified protection, restraint, opening, information, warnings, print, seal, distribution, traceability, and compatibility with the exact product configuration.

Evidence classification and research anchors. E: packaging engineering, ASTM D4169, ISTA, labeling and toy-safety requirements. S: packaging-as-interface model. P: Raven Valley package provenance layer.

Training exercise. Create a package architecture for a 3.75-inch figure with six accessories. Identify every contact point and information priority.

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Preserving an Eighties Presentation

Vintage clarity with contemporary manufacturing, safety, information, and provenance

THE OLD CARD AND THE NEW DUTY

> *Keep the bold name, the clear blister, the painted horizon.*
> *Keep the row of figures promising a larger world.*
> *But do not preserve the silence around chemistry and trace;*
> *honor the era by carrying its invitation more responsibly.*

An eighties-style presentation is a visual and interaction grammar, not a license to reproduce a protected brand identity or outdated safety and production practice. The goal is strong hero imagery, clear blister silhouette, large series name, simple character plate, compact lore, high contrast, limited type hierarchy, card-back assortment grid, and restrained callouts.

Vintage clarity often came from limits: fewer colors, simple photography or illustration, large titles, visible product, and a direct relationship between character and package. Contemporary production can preserve those strengths with better print, structural design, coatings, testing, traceability, accessibility, and honest materials. Artificial yellowing, simulated damage, or illegible pseudo-retro typography should not replace authentic formal discipline.

The figure itself can preserve mechanical simplicity and iconic silhouette while using contemporary sculpt and controlled detail. Paint operations remain bold and economical. Accessories are arranged as readable shapes. The package back shows the series as a map, but should distinguish released, forthcoming, and concept items. Lore is concise and supports rather than obscures product facts.

Intellectual-property review is essential. General era qualities, geometric framing, halftone, limited palette, and carded format are broad design territory; specific logos, trade dress, character likenesses, names, layouts, and distinctive franchise cues may be protected. Original Raven Valley identity must be clear.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Hero field	One strong illustration or photograph with clear figure relationship.
Series identity	Large original wordmark and recognizable framing.
Character nameplate	Simple, high-contrast, and consistent across the wave.
Blister silhouette	Visible figure and accessories arranged with strong negative space.
Type hierarchy	Few sizes and roles; readable at shelf and close range.
Card-back grid	Series map with accurate release and inclusion status.
Compact lore	Short character and world text that supports play without overwhelming facts.
Color and print	Limited high-contrast palette, controlled halftone or texture, contemporary print quality.
Feature callouts	Only features that exist and matter.
Modern substrate	Current safety, chemical, traceability, recycling, and information requirements beneath vintage language.

Text Diagram. Eighties presentation hierarchy

```
TOP: ORIGINAL SERIES MARK
     |
HERO IMAGE / WORLD ATMOSPHERE
     |
CLEAR BLISTER: FIGURE + ACCESSORIES
     |
CHARACTER NAMEPLATE
     |
BACK: GRID + LORE + FACTS + WARNINGS + TRACE
```

Audio description: The package moves from series mark to hero image, clear product, character plate, and a back containing grid, lore, facts, warnings, and trace.

PRODUCTION APPLICATION

- Create era-reference boards that separate general principles from protected identifiers.
- Test package hierarchy at actual retail distance.
- Use physical print proofs for black, metallic, halftone, and small type.
- Ensure product photography shows actual included configuration.
- Add modern trace and safety information without burying it.

AI-AGENT INTERPRETATION

AI may analyze era-level composition, propose original variants, and check hierarchy and content truth. It must not imitate a living artist, protected franchise, logo, or trade dress so closely that origin becomes confusing.

FAILURE CASES AND CORRECTIVE ACTION

- Retro design relies on fake wear and poor legibility.
- Card-back grid depicts unreleased products as available.
- Package resembles a specific franchise more than Raven Valley.
- Contemporary warnings and trace data are hidden for aesthetic purity.

RELEASE GATE: Vintage presentation is approved only when original identity, product truth, current safety, readable information, IP review, and collector provenance remain intact.

Evidence classification and research anchors. E: design history, packaging, trademark and trade-dress principles, safety labeling. S: vintage-clarity translation. P: Raven Valley eighties presentation grammar.

Training exercise. Redesign one modern crowded package using no more than five type roles, four colors, one hero field, one blister, one nameplate, and one card-back grid.

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Packaging Materials and Production

Paperboard, corrugated, clear polymers, inks, coatings, adhesives, forming, die cutting, sealing, and archival behavior

THE CARD, THE WINDOW, THE SEAL

> *Paper carries image; clear film carries the gaze.*
> *Adhesive carries the promise that both will remain together.*
> *Choose every layer for print, pressure, time, and release;*
> *even the package has a material passport.*

Packaging materials and processes are specified with the same material truth as the figure. Paperboard grade, caliper, fiber direction, coating, print, ink, adhesive, clear polymer, forming, seal, score, die, window, carton, and storage environment determine protection, appearance, opening, recyclability, and collector condition.

Solid bleached sulfate and related paperboards offer smooth print and stiffness; corrugated materials support cases and transport; recycled content can alter color, stiffness, dust, and surface. Clear blisters and trays may use PET, recycled-content PET, or other approved polymers, with clarity, stress, forming, seal, scratch, and recycling considerations. Material claims require supplier and testing evidence.

Printing may use offset, flexographic, digital, screen, foil, emboss, deboss, spot varnish, and specialty coatings. Each adds registration, rub, cracking, cure, and recyclability consequences. Die cutting and scoring must account for fiber direction, rule, nick, crease, fold, and hanger load. Heat sealing or adhesive bonding must be compatible with card coating and clear polymer while meeting opening and tamper requirements.

Archival behavior matters for collector products. Light, humidity, acid, plasticizer, adhesive yellowing, metal corrosion, and package contact can change the object. The framework does not promise museum permanence, but it requires known materials, storage guidance, and honest limitations. Package conservation should not require destroying product identity or obscuring repair.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Paperboard	Fiber, grade, caliper, stiffness, coating, print, score, fold, humidity, and recycled content.
Corrugated	Flute, liner, compression, stacking, moisture, print, and case pack.
Clear polymer	Resin, thickness, clarity, forming, stress, scratch, seal, scuff, contact, and recycling.
Tray / clamshell / window	Restraint, access, edge, hinge, seal, nesting, and material volume.
Ink and coating	Color, adhesion, rub, cure, migration, gloss, crack, and recyclability.
Foil / emboss / varnish	Special effect with registration, pressure, tooling, cracking, and cost.
Die cut and score	Geometry, rule, nick, crease, grain, fold, hanger, and waste.
Adhesive / heat seal	Substrate, coat, activation, bond, aging, opening, and contamination.
Carton tolerance	Product, insert, case, pallet, compression, and distribution fit.
Archival concern	Light, humidity, acidity, migration, yellowing, deformation, and storage.

Text Diagram. Packaging material stack

```
PRINT / COATING / FOIL
          |
PAPERBOARD / CARTON STRUCTURE
          |
ADHESIVE OR HEAT-SEAL INTERFACE
          |
CLEAR BLISTER / TRAY
          |
PRODUCT CONTACT / RESTRAINT
          |
CASE / CORRUGATED / DISTRIBUTION
```

Audio description: Print and board connect through seal to clear restraint, product contact, and distribution case.

PRODUCTION APPLICATION

- Create material passports and approved samples for card, blister, ink, coating, adhesive, and case.
- Test forming, seal, opening, print rub, hanger, and distribution.
- Check long-term contact with decorated product.
- Use physical dieline and production proof approval.
- Record packaging substitutions and effective lots.

AI-AGENT INTERPRETATION

AI may compare packaging specifications, calculate layouts from supplied constraints, and flag missing material or seal data. It must not declare recyclability, food-contact safety, archival permanence, or seal performance without evidence.

FAILURE CASES AND CORRECTIVE ACTION

- Clear blister scuffs metallic paint or develops stress whitening.
- Board grain and score cause cracking at the fold.
- Adhesive yellows or releases under humidity.
- Spot varnish or foil obscures barcode, warnings, or small type.

RELEASE GATE: Packaging materials are released only after print, forming, seal, opening, product contact, transport, trace, and environmental claims are verified on the complete stack.

Evidence classification and research anchors. E: paper, polymer, printing, adhesive, package and distribution engineering. S: package material passport. P: Raven Valley collector-archive limitations.

Training exercise. Specify a carded blister package stack and list one process test, one distribution test, one product-contact test, and one archival concern for each layer.

PART 9

COLLECTOR MENTALITY, PHYSISHOP, CATALOGING, AND MARKET SYSTEMS

Treating collection as memory, classification, stewardship, and honest exchange.

THE SHELF AS CONSTELLATION

One object is a possession; the second begins a relation.
A missing piece can bend the orbit of desire.
Let provenance outlast urgency and rarity answer truth,
so the shelf becomes a history rather than a trap.

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The Collector Interface

Object, person, memory, sequence, knowledge, community, condition, and imagined completion

THE SHELF LOOKS BACK

> *A collection is not merely many objects near one another.*
> *It is a map of choices, absences, knowledge, and return.*
> *Let the catalog illuminate without commanding desire;*
> *stewardship begins where possession learns to remember.*

Collecting is a relationship among object, person, memory, identity, category, knowledge, community, history, condition, uncertainty, and imagined completion. The product system should support cataloging, interpretation, verification, care, trade, and narrative without turning incompleteness into a mechanism of coercion.

Belk's extended-self framework describes how possessions can become integrated into identity, while collecting research shows that set completion can change perceived value and motivate acquisition (Belk 139-68; Carey 336-47). These findings explain both the cultural power and ethical risk of figure lines. A series grid can help users understand a world; it can also create pressure when scarcity is artificial, status is hidden, or essential parts are distributed manipulatively.

The Raven Valley Veil identifies collector archetypes such as completionist, connoisseur, hunter, archivist, custodian, identity builder, technologist, and narrative collector. These are not diagnoses. They are design viewpoints that reveal different needs: sequence, craft detail, discovery, data, conservation, self-expression, interaction, and story. One interface may support several without reducing collectors to a single motive.

The collector interface should function as catalog, map, memory aid, verification tool, narrative guide, research assistant, marketplace record, collection planner, provenance archive, and relationship graph. It should expose uncertainty: unknown accessory, disputed variant, estimated date, restored paint, or incomplete provenance should remain visible rather than forced into false certainty.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Object	The physical unit with material, condition, markings, accessories, package, and configuration.
Person	Owner, user, maker, seller, researcher, custodian, or inheritor with distinct permissions and goals.
Memory	Personal event, cultural association, play history, purchase, repair, and inherited narrative.
Category and sequence	Series, wave, faction, scale, edition, set, checklist, and missing relationship.
Knowledge	Identification, comparison, context, condition, manufacture, variation, and uncertainty.
Community	Shared standards, trade, display, research, correction, and social meaning.
Condition	Material and package state separated from rarity, authenticity, and personal value.
Completion	Visible set logic without engineered frustration or deceptive scarcity.
Interface roles	Catalog, map, memory, verification, narrative, marketplace, plan, archive, and graph.

Text Diagram. Collector relationship field

```
[ OBJECT ] ---- [ MEMORY ] ---- [ PERSON ]
    |               |               |
[ SERIES ] ---- [ KNOWLEDGE ] ---- [ COMMUNITY ]
    |               |               |
[ CONDITION ] -- [ PROVENANCE ] -- [ EXCHANGE ]
                    |
               [ UNCERTAINTY ]
```

Audio description: Object, memory, person, series, knowledge, community, condition, provenance, exchange, and uncertainty form the collector field.

PRODUCTION APPLICATION

- Create catalog views for completion, craft, provenance, condition, and story.
- Design series products to retain standalone narrative and play value.
- Expose released, announced, concept, canceled, and unknown statuses distinctly.
- Allow user notes and ownership history without overwriting canonical product data.
- Provide correction and evidence submission workflows.

AI-AGENT INTERPRETATION

AI may organize records, compare known variants, explain uncertainty, and surface relationships. It must not exploit user vulnerability, rank personal worth by completion, fabricate market scarcity, or authenticate from incomplete imagery.

FAILURE CASES AND CORRECTIVE ACTION

- A checklist implies every concept image is a required released item.
- Completion rewards depend on purchasing unrelated duplicates.
- Condition and authenticity are collapsed into one opaque score.
- Personal ownership notes overwrite shared product facts.

RELEASE GATE: Collector features must improve knowledge, stewardship, agency, and truthful exchange without relying on hidden status, false scarcity, or invented certainty.

Evidence classification and research anchors. E: consumer collecting, extended self, set completion, authenticity, and information-system research. S: multi-role collector interface. P: Raven Valley collector archetype map.

Training exercise. Design three views of the same figure record for a completionist, archivist, and custodian. Keep the canonical facts identical while changing emphasis.

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Collector Micro-Signals

Mold, paint, package, stamp, code, factory, revision, and repair details that distinguish lineage

THE SMALL MARK THAT OPENS HISTORY

> *A date stamp can outlive the advertisement.*
> *A changed buckle may name a tool correction no one recorded.*
> *Attend to the small mark without worshiping accident;*
> *micro-signals are evidence only when relation gives them meaning.*

Collector micro-signals are small physical or informational differences that help identify product lineage: sculpt detail, copyright stamp, country mark, factory code, date code, cavity number, paint placement, accessory geometry, header or card variation, packaging revision, production change, event release, repair, and prototype history.

A micro-signal is not automatically a variant. It may be normal process variation, cavity difference, tool wear, supplier change, repair, counterfeit error, or undocumented running change. Reliable interpretation combines multiple signals with provenance, package, material, date, and known production history. Grayson and Martinec distinguish forms of authenticity judgment that depend on resemblance and factual connection; figure authentication similarly requires more than visual likeness (296-312).

The product should intentionally include durable identification without turning every mark into public-facing clutter. Product and edition IDs can appear on package and passport; molded marks can identify copyright, country, tool, cavity, or part; hidden service codes can support batch trace. Security features should be evaluated against counterfeit risk, privacy, cost, accessibility, and the chance that they will be separated from the object.

Micro-signal catalogs should show location, type, known range, source, confidence, and alternative explanation. Images must use controlled scale and light. User-submitted observations remain provisional until verified. Disputed features should not be suppressed; uncertainty is part of the record.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Sculpt lineage	Controlled geometry changes, facial or costume features, and source master.
Copyright / country / factory mark	Legal or production information with location, font, method, and date range.
Date / batch / cavity code	Trace link to production event, tool cavity, or line.
Paint variation	Authorized master, normal tolerance, defect, rework, or running change.
Accessory variation	Geometry, material, color, marking, inclusion, and compatibility.
Header / card / blister variation	Print, dieline, language, code, seal, material, or restraint change.
Event / retailer release	Authorized distribution relation supported by records.
Production change	Tool, material, process, facility, or assembly revision.
Documented error	Known defect or misprint; do not manufacture error to simulate discovery without disclosure.
Repair / prototype provenance	Intervention, sample status, maker, source, and chain of custody.

Text Diagram. Micro-signal evaluation

```
OBSERVED DETAIL
      |
LOCATION + MEASUREMENT + IMAGE
      |
COMPARE: MASTER / CAVITY / LOT / PACKAGE / ACCESSORY / PROVENANCE
      |
AUTHORIZED VARIANT? NORMAL VARIATION? DEFECT? REPAIR? UNKNOWN?
      |
CONFIDENCE + ALTERNATIVE EXPLANATIONS + SOURCE RECORD
```

Audio description: An observed detail is measured and compared across master, lot, package, accessories, and provenance before classification with confidence.

PRODUCTION APPLICATION

- Design trace marks and their reading method before tooling.
- Photograph production-intent marks at actual scale.
- Maintain a controlled micro-signal catalog by version and lot.
- Separate observed difference from authorized variant status.
- Preserve alternative explanations and confidence.

AI-AGENT INTERPRETATION

AI may compare signal locations and images, retrieve known records, and calculate similarity. It must not authenticate, assign rarity, or declare a variant from one visual cue without provenance and configuration evidence.

FAILURE CASES AND CORRECTIVE ACTION

- Tool wear is marketed as a scarce sculpt variant.
- A counterfeit reproduces visible packaging while internal part and material signals are ignored.
- Repair paint is mistaken for factory application.
- User-submitted variation becomes canonical without source review.

RELEASE GATE: A micro-signal affects identity, variant, or authenticity only when its relation to controlled production or provenance evidence is established and uncertainty is stated.

Evidence classification and research anchors. E: authenticity, connoisseurship, manufacturing traceability, forensic comparison. S: multi-signal evaluation. P: Raven Valley micro-signal catalog.

Training exercise. Choose five possible differences between two figures and write at least three competing explanations for each before calling either a variant.

53

Variants, Editions, and Honest Scarcity

Colorway, running change, sample, reissue, reproduction, and counterfeit as distinct controlled categories

THE NUMBER MUST ANSWER TO THE OBJECT

Rarity without record is rumor wearing a seal.
A reissue is not a betrayal when lineage remains visible.
Count what was made, distinguish what was changed,
and let desire meet truth before it meets urgency.

A variant is a known difference; an edition is an authorized product identity or release; a revision is a controlled change; scarcity is a factual condition or bounded estimate. Honest collectibility requires these categories to remain distinct and documented.

Colorway, paint revision, running change, material change, accessory change, package change, regional release, retailer release, event edition, test shot, sample, artist proof, reissue, remaster, reproduction, custom, restoration, and counterfeit have different relationships to authority and manufacture. A test shot is not a retail edition; a factory error is not automatically a chase; a reissue may share character and sculpt while requiring a new product or edition identity.

No edition claim should exist without authority, difference definition, identification method, count basis, manufacturing record, and reissue policy. Counts may be confirmed, maximum, estimated, or unknown. Destroyed rejects, samples, replacements, overrun, and retained units affect interpretation. "Limited" without a limit or basis is an incomplete claim.

Honest scarcity avoids artificial stock alarms, hidden restocks, destructive practices, and repair obstruction. A line can create discovery through transparent event distribution, documented colorways, or earned narrative differences. Completion pressure should not override standalone value or informed choice.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Colorway	Authorized molded and coated color configuration with distinct ID or edition relation.
Paint revision	Change to color, placement, method, or master; may or may not create a new edition.
Running change	Production modification effective from a batch or range, documented for compatibility and catalog.
Material / accessory / package variant	Known change with cause, identification, and effect.
Regional / retailer / event edition	Authorized distribution-specific release supported by contract and record.
Test shot / sample / artist proof	Nonstandard development or approval object with clear status and chain.
Reissue / remaster	New manufacture related to prior product; disclose shared and changed elements.
Reproduction	Object intended to recreate another; must be clearly distinguishable and authorized.
Counterfeit	Unauthorized object represented as authentic.
Count status	Confirmed, maximum, estimate, announced, unknown, or disputed.

Text Diagram. Edition authorization record

```
EDITION AUTHORITY
      |
DEFINED DIFFERENCE + PRODUCT RELATION
      |
IDENTIFICATION METHOD
      |
COUNT BASIS + PRODUCTION RANGE
      |
PACKAGE / CATALOG / PROVENANCE
      |
REISSUE / REPLACEMENT / REPAIR POLICY
```

Audio description: Edition authority flows through difference, identification, count, production, catalog, and lifecycle policy.

PRODUCTION APPLICATION

- Create an edition record before public announcement.
- Assign count status and evidence rather than using one undifferentiated number.
- Link running changes to effective batches and compatibility.
- Distinguish replacement and repair parts from original included parts.
- Disclose reissues and remasters with visual and record-level identifiers.

AI-AGENT INTERPRETATION

AI may compare edition records, identify conflicting claims, and calculate counts from verified production events. It must not manufacture scarcity language, predict market value as fact, or classify an object as counterfeit without evidence and review.

FAILURE CASES AND CORRECTIVE ACTION

- A normal paint tolerance is sold as a rare chase after discovery.
- A hidden second run contradicts a final-edition claim.
- A reissue shares all marks with the original and creates avoidable authentication confusion.
- Edition count includes only shipped units while samples and replacements remain undisclosed.

RELEASE GATE: Scarcity and edition claims require documented authority, difference, identification, count basis, production scope, lifecycle policy, and truthful public language.

Evidence classification and research anchors. E: consumer protection, collecting, authenticity, production and inventory records. S: count-status taxonomy. P: Raven Valley honest-scarcity doctrine.

Training exercise. Write records for one colorway, one running paint change, one event edition, one test shot, and one reissue. Make their identity differences explicit.

54

Provenance and the Figure Passport

Identity, configuration, manufacture, ownership, condition, repair, and source confidence

THE RECORD TRAVELS BESIDE THE OBJECT

> *The object can outlive the box and forget the name of its maker.*
> *The ledger can outlive the object and forget the warmth of the hand.*
> *Bind them without confusing one for the other;*
> *provenance is the bridge that lets memory cross loss.*

The figure passport is a portable, versioned record that links product identity to configuration, manufacture, edition, accessories, known variations, ownership events, repairs, authentication evidence, and source confidence. It supports stewardship but does not replace physical examination or legal title.

The minimum record includes product ID, character ID, series and wave, edition, sculpt version, tool version, paint version, package version, facility or factory, batch, date range, materials, accessories, known variations, ownership events, repairs, authentication evidence, source citations, confidence, and privacy status. Individual serials may be public, private, or pseudonymous depending on design and consent.

Provenance claims are evidence-weighted. Manufacturer record, retained sample, original invoice, photograph, credible chain of custody, expert comparison, and owner statement have different strengths. The passport should store source type and uncertainty rather than produce one unexplained authenticity score. Repair records state who changed what, why, with which material, and whether function, appearance, or care changed.

Digital signatures, QR or NFC links, and portable payloads can improve access but introduce dependency, security, cloning, link rot, privacy, and platform risk. The physical object should retain durable human-readable identity where feasible, and data should be exportable. A token or scan is not proof of the object unless the connection is maintained and inspectable.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Product and character identity	Stable IDs and names with aliases and relationships.
Configuration	Sculpt, tool, paint, material, package, accessory, and firmware versions.
Manufacture	Facility, line, batch, date, cavity, material lots, and release evidence.
Edition	Authorized difference, count status, identification, and reissue relation.
Ownership event	Transfer date, source, optional price, custody, and privacy.
Condition	Observed material and package state at a date with method and images.
Repair / restoration	Intervention, parts, materials, authority, effect, and disclosure.
Authentication evidence	Source documents, marks, comparison, chain, and confidence.
Portable link	Human-readable code, QR, NFC, signed file, export, and fallback.
Privacy	Owner controls, data minimization, retention, sharing, and deletion where lawful.

Text Diagram. Figure passport layers

```
IDENTITY
  + CONFIGURATION
  + MANUFACTURE / BATCH
  + EDITION / VARIATION
  + OWNERSHIP EVENTS
  + CONDITION / REPAIR
  + EVIDENCE / CONFIDENCE
  + PRIVACY / ACCESS
  = PORTABLE PROVENANCE PASSPORT
```

Audio description: The passport combines identity, configuration, manufacture, edition, ownership, condition, evidence, and privacy.

PRODUCTION APPLICATION

- Create the seed passport at production release.
- Use append-only events for manufacture, transfer, repair, and retirement.
- Provide human-readable and machine-readable export.
- Separate object evidence from account identity and payment data.
- Design for platform migration and offline verification.

AI-AGENT INTERPRETATION

AI may organize evidence, flag contradictions, summarize provenance, and generate confidence explanations. It must not invent ownership events, legal title, authenticity, signatures, or factory records.

FAILURE CASES AND CORRECTIVE ACTION

- QR link fails and no durable object identity remains.
- Repair overwrites original configuration instead of adding an event.
- Owner identity is exposed by default.
- A signed digital record is treated as proof of the physical object despite broken linkage.

RELEASE GATE: A passport claim is published only with source, confidence, object linkage, privacy authority, and immutable event history sufficient for its stated meaning.

Evidence classification and research anchors. E: provenance, authenticity, digital signatures, privacy and lifecycle records. S: portable passport. P: Raven Valley figure passport schema.

Training exercise. Create a passport for a unit that changed owners twice, lost an accessory, received a replacement hand, and had package restoration.

55

Physishop and Crypt Integration

Canonical product identity, portable records, marketplace views, GI payloads, and append-only events

THE OBJECT ENTERS THE SYSTEM WITHOUT LOSING ITS BODY

> *A marketplace sees price; a gallery sees image.*
> *A collector sees lineage; a warehouse sees location.*
> *Let every surface read from one durable truth,*
> *so the object does not become four contradictions when it crosses a screen.*

Physishop and Crypt integration treats the product record as the system of record and marketplace, gallery, viewer, inventory, provenance, and AI surfaces as projections. Canonical identity precedes discovery and transaction. The same unique object should not acquire incompatible truths because it appears in several channels.

Records and Streams offers an adjacent inventory precedent: structured fields for item identity, edition, format, condition, quantity, price, location, comments, source, and status support search and channel operations (Conrad and OpenAI, *Records and Streams* 1-2). Play products extend the schema with character, figure, part, joint, accessories, tool, paint, package, batch, provenance, and repair.

Mutable relationships and immutable events should be separated. Current price, location, listing status, and collection membership may change. Manufacture, sale, transfer, repair, test, and recall events remain. Deterministic projections generate listing, gallery card, package data, GI payload, and AI packet from the canonical record, preserving identifiers and source confidence.

Transaction integration must preserve one-off inventory truth. Authorization is not settlement, and a browser success page is not authoritative fulfillment evidence. The payment-system precedent therefore reserves, sells, returns, and transfers the exact unit through verified server events while updating provenance separately from payment credentials (Conrad and OpenAI, *Payment Systems* 1-3).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Canonical identity	Product, edition, and unit IDs remain stable across channels.
Portable record	Schema-governed export with version, provenance, and validation.
Rich metadata	Character, series, scale, parts, materials, paint, package, condition, and history.
Source provenance	Field-level source, confidence, date, and reviewer.
Aliases	Search names separated from canonical identity.
Mutable relationship	Price, status, location, collection, listing, and current owner permission.
Immutable event	Manufacture, test, release, sale, transfer, repair, recall, and retirement.
Deterministic projection	Marketplace, catalog, viewer, package, and AI views generated from controlled truth.
Crypt / GI payload	Portable visual-information object linked to schema and source record.
Channel adapter	Maps canonical data to external requirements without surrendering identity.

Text Diagram. Physishop canonical flow

```
CANONICAL PRODUCT / UNIT RECORD
      |
      +--> INVENTORY / LOCATION
      +--> CRYPT / GI VIEWER
      +--> MARKETPLACE LISTING
      +--> GALLERY / CATALOG
      +--> PACKAGE / PASSPORT
      +--> AI TRAINING / AGENT PACKET
      |
EVENTS RETURN -> SALE / TRANSFER / REPAIR / FEEDBACK
```

Audio description: One canonical record feeds inventory, viewer, marketplace, catalog, package, and AI, while events return to the record.

PRODUCTION APPLICATION

- Define schema and validation before channel templates.
- Use stable IDs in images, files, orders, listings, and provenance.
- Keep field-level source and confidence.
- Reconcile external channel events into canonical states.
- Version adapters and payloads separately from core identity.

AI-AGENT INTERPRETATION

AI may generate validated projections, normalize aliases, enrich with sourced data, and detect channel divergence. It must not overwrite canonical fields from unsourced listing text or create sale, ownership, or authenticity events without verified system evidence.

FAILURE CASES AND CORRECTIVE ACTION

- Marketplace title becomes the canonical product name.
- Sold status updates one channel but not the unique inventory record.
- Generated GI image contains metadata that conflicts with the product schema.
- External platform deletes a listing and the only provenance record disappears.

RELEASE GATE: A channel may publish or transact only through a validated adapter that preserves canonical IDs, required fields, state transitions, provenance, and reconciliation.

Evidence classification and research anchors. E: schema, inventory, payment event, configuration and provenance systems. S: deterministic multi-channel projection. P: Physishop/Crypt figure integration.

Training exercise. Map one figure unit from canonical record to e-commerce listing, gallery view, GI payload, package passport, sale event, and ownership transfer.

56

Line Planning and Assortment Design

Hero, secondary, army builder, creature, vehicle, environment, wave, tooling reuse, and collector pressure

THE WAVE AND THE SHORE

> *A hero alone cannot make a world.*
> *A hundred soldiers cannot replace one meaningful difference.*
> *Plan the wave as rhythm, tool, price, and story;*
> *let abundance widen play rather than narrow choice.*

Line planning coordinates narrative, product roles, tooling, materials, price points, case assortments, retail space, production capacity, collector completion, and release timing. A wave is both a story structure and a supply decision.

Hero characters attract attention; secondary characters deepen relationships; army builders support multiplicity; creatures and vehicles expand scale; environments create context. Each role should have standalone value and a reason to occupy tooling, package, case, and customer budget. A weak assortment can contain excellent individual figures yet fail through repetition, missing scale support, or price imbalance.

Tooling reuse is valuable when it preserves product quality and character distinction. Shared bodies, joints, weapons, and package structures reduce cost and improve interoperability, but overuse creates sameness and can spread defects. Reuse should be visible in cost and configuration records and evaluated against narrative and collector response.

Collector completion pressure must be governed. Case-pack scarcity, retailer exclusives, chase variants, staggered releases, and blind distribution can create excitement or frustration. The framework favors transparent availability, reasonable standalone completeness, documented edition differences, and recovery paths for missed items where commercially feasible.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Hero character	Primary focal product supporting series identity and marketing.
Secondary character	Relationship, faction, role, or story depth.
Army builder	Intentional multiplicity with accessible distribution and variation logic.
Creature / vehicle	Scale expansion, riding, transformation, storage, and higher price tier.
Environment / playset	World, display, storage, modularity, and figure interaction.
Wave balance	Role, silhouette, color, scale, price, tooling, age, and narrative variety.
Case assortment	Units per case, demand assumptions, retailer needs, replenishment, and imbalance risk.
Tooling reuse	Shared parts and interfaces with cost, risk, visual, and compatibility record.
Variant allocation	Transparent edition, quantity, channel, and recovery policy.
Narrative progression	Release sequence supports story without making core understanding dependent on every purchase.

Text Diagram. Assortment balance

```
STORY ROLES + PRODUCT TYPES + PRICE TIERS
              |
TOOLING / MATERIAL / CAPACITY / PACKAGE
              |
CASE MIX / CHANNEL / TIMING / DEMAND
              |
COLLECTOR ACCESS + STANDALONE VALUE
              |
PILOT / SELL-THROUGH / FEEDBACK / NEXT WAVE
```

Audio description: Assortment combines story, product, price, tooling, capacity, case, channel, access, and feedback.

PRODUCTION APPLICATION

- Create a wave matrix covering role, silhouette, scale, price, tool reuse, accessories, and channel.
- Stress-test case-pack demand assumptions.
- Document shared tooling and affected risk.
- Provide clear exclusive and variant policies.
- Use post-release data without letting short-term scarcity define all future design.

AI-AGENT INTERPRETATION

AI may compare assortment diversity, simulate case mixes, identify tooling reuse, and flag access pressure. It must not predict demand as certainty, optimize artificial scarcity, or reduce cultural and narrative roles to sales stereotypes.

FAILURE CASES AND CORRECTIVE ACTION

- A desirable secondary character is deliberately short-packed without evidence or recovery.
- One body reuse makes all characters interchangeable.
- Price tiers omit an accessible entry product.
- AI forecast drives overproduction without uncertainty and scenario ranges.

RELEASE GATE: A line plan requires documented narrative, tooling, cost, capacity, case, channel, access, and uncertainty analysis with standalone value for each product.

Evidence classification and research anchors. E: assortment, inventory, demand, product-family and consumer research. S: ethical wave planning. P: Raven Valley collector-pressure gate.

Training exercise. Plan an eight-item wave containing hero, guide, two workers, antagonist, army builder, creature, and environment. Balance tooling and price without short-packing the most desired role.

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Costing, Pricing, and Market Position

From design and tooling through landed cost, channel margin, retail, returns, and secondary value

THE PRICE HAS MANY ANCESTORS

> *The number on the shelf contains steel, freight, labor, and risk.*
> *The number in the auction contains memory, absence, and desire.*
> *Do not confuse the two rivers because they meet at value;*
> *price is clearest when every cost and uncertainty keeps its name.*

Costing distinguishes design cost, sculpt, engineering, prototypes, tooling, materials, molding, paint, assembly, packaging, testing, freight, duty, storage, distribution, returns, royalties, support, and overhead. Pricing distinguishes unit manufacturing cost, amortized tooling, landed cost, wholesale, suggested retail, direct retail, marketplace price, and secondary-market value.

The cost model should preserve fixed and variable components. Tooling and development can be amortized over forecast units, but low volume increases per-unit burden and demand uncertainty. Paint operations and assembly labor often grow faster than part volume suggests. Packaging, testing, freight, and returns can erase apparent savings achieved by a fragile or oversized design.

Wholesale and channel structures change economics. A direct channel may retain more gross margin while assuming fulfillment, customer service, fraud, and returns. Distributor and retailer channels trade margin for reach and operations. Marketplace fees and promotions affect realized price. The Wholesale as System document contributes a useful doctrine: define landed cost and risk before buying or committing, preserve source and remedy evidence, and treat documentation as part of the merchandise (Conrad and OpenAI, *Wholesale as System* 1-4).

Secondary-market value is not manufacturer revenue and should not be represented as guaranteed investment. It reflects condition, scarcity, demand, authenticity, narrative, and market context. The line may study resale as feedback but should not manipulate supply solely to manufacture speculation.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Development cost	Research, concept, sculpt, CAD, engineering, prototypes, test, package, and project management.
Tooling cost	Molds, fixtures, gauges, print plates, dies, and corrections.
Unit manufacture	Material, molding, paint, assembly, accessories, scrap, inspection, and package.
Landed cost	Unit manufacture plus freight, duty, insurance, handling, and destination costs.
Channel cost	Distributor, retailer, marketplace, payment, fulfillment, promotion, and return costs.
Wholesale price	Price to channel partner with required margin and terms.
Suggested / direct retail	Market position, channel conflict, margin, tax, and consumer value.
Returns reserve	Expected defect, damage, preference, fraud, and support exposure.
Tool amortization	Forecast units, scenario range, and remaining unamortized exposure.
Secondary value	External market outcome, not guaranteed product performance or issuer return.

Text Diagram. Landed product cost

```
DESIGN + SCULPT + ENGINEERING + PROTOTYPES + TOOLING AMORTIZATION
+ MATERIALS + MOLDING + PAINT + ASSEMBLY + PACKAGING + TESTING
+ FREIGHT + DUTY + STORAGE + DISTRIBUTION + RETURNS + ROYALTIES
= LANDED / FULL COST BASIS

COST BASIS + CHANNEL + POSITION + RISK -> PRICE SCENARIOS
```

Audio description: All development, production, logistics, channel, and risk costs form the cost basis used for price scenarios.

PRODUCTION APPLICATION

- Build low, base, and high volume and defect scenarios.
- Cost each part, operation, package, test, and channel explicitly.
- Link design changes to cost and schedule deltas.
- Separate gross margin, contribution, cash timing, and accounting profit.
- Do not advertise secondary appreciation or scarcity as assured value.

AI-AGENT INTERPRETATION

AI may calculate cost scenarios from supplied data, compare BOM revisions, and identify high-value or high-risk nodes. It must not invent supplier quotes, demand, margins, exchange rates, freight, or future resale value.

FAILURE CASES AND CORRECTIVE ACTION

- Tooling is excluded from price because it is treated as sunk before units sell.
- Paint and assembly operations are counted by color rather than actual passes and fixtures.
- Direct retail price ignores returns, fulfillment, and support.
- Secondary-market speculation becomes the primary customer value claim.

RELEASE GATE: Pricing decisions require traceable cost, volume, yield, return, channel, cash, and uncertainty scenarios approved by responsible business and production roles.

Evidence classification and research anchors. E: managerial accounting, pricing, wholesale, inventory and market research. S: lifecycle cost model. P: Raven Valley value-without-exploitation doctrine.

Training exercise. Build a landed-cost model for a 10,000-unit figure and compare the effect of one extra paint operation, one new tool, a deeper blister, and a higher return rate.

PART 10

TRAINING, AI GOVERNANCE, AND LIFECYCLE STEWARDSHIP

Building human and artificial competence without permitting invented certainty or silent drift.

THE STEWARD OF MANY HANDS

A system is not wise because it speaks without pause.
It is wise when it marks the edge of what it knows.
Teach the hand, train the model, preserve the correction:
the Valley survives by remembering how it learned.

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Human Training Ladder

From play-system citizen to model apprentice, operator, technician, architect, and steward

THE WORKSHOP TEACHES IN LAYERS

> *First learn the name of the tool and the danger near its edge.*
> *Then learn the motion, the reason, the exception, the repair.*
> *Mastery is not speed alone but the ability to teach the boundary;*
> *a steward leaves the next hand more capable than the last.*

The training ladder teaches plain-language concept, workshop action, engineering reason, evidence class, failure recognition, and governance in parallel. Advancement is based on demonstrated competence and safe judgment, not time served or rhetorical confidence.

Stage 0, Play-System Citizen, understands terminology, age and safety boundaries, product identity, scale, parts, materials, and documentation. Stage 1, Model and Diagram Apprentice, creates controlled sketches, views, dimensions, and simple models. Stage 2, Figure Development Operator, builds part breaks, basic joints, prototypes, paint sheets, and packaging layouts under review. Stage 3, Mechanical and Manufacturing Technician, manages tolerance, materials, molds, assembly, tests, and supplier communication.

Stage 4, Series Architect, coordinates product families, tooling reuse, visual grammar, packaging, catalog, cost, and release waves. Stage 5, Raven Valley System Steward, governs evidence, baseline, change, training, AI agents, provenance, lifecycle, and research. The ladder supports specialization; a paint technician need not become a sculptor to achieve advanced authority in coating systems.

Cognitive apprenticeship provides a useful teaching structure: model the task, coach performance, scaffold complexity, articulate reasoning, reflect on outcomes, and gradually fade support. Practice uses real artifacts and failure samples. The Raven Valley Development Codex similarly emphasizes clear goals, feedback, challenge matched to skill, and iterative projects (Conrad and OpenAI, *Development Codex* 1-2).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Stage 0 - Citizen	Terminology, safety, identity, evidence, and basic lifecycle literacy.
Stage 1 - Apprentice	Views, scale, diagrams, file discipline, and supervised prototype work.
Stage 2 - Operator	Part, joint, material, paint, package, and sample packets under review.
Stage 3 - Technician	Process, tolerance, tooling, test, quality, supplier, and corrective action.
Stage 4 - Series Architect	Cross-product grammar, assortment, tooling reuse, cost, catalog, and release.
Stage 5 - System Steward	Governance, evidence, change, research, training, AI, provenance, and lifecycle.
Competence evidence	Observed work, teach-back, tests, failure analysis, and approved artifacts.
Specialist path	Deep domain authority without forced generalist promotion.
Model-Coach-Fade	Demonstrate, support, challenge, verify, and withdraw assistance progressively.

Text Diagram. Training progression

```
CITIZEN -> APPRENTICE -> OPERATOR -> TECHNICIAN -> ARCHITECT -> STEWARD
   |           |           |            |            |           |
TERMS       VIEWS       PRODUCT      PROCESS      SERIES     GOVERNANCE
SAFETY      MODELS      PACKETS      TESTS        LINES      EVIDENCE
EVIDENCE    FILES       SAMPLES      SUPPLIERS    COST       TRAINING
```

Audio description: The ladder advances from terminology and safety through modeling, product packets, process, series architecture, and governance.

PRODUCTION APPLICATION

- Define role competencies and prohibited unsupervised tasks.
- Use controlled sample libraries including failures.
- Require teach-back and artifact review before advancement.
- Keep training linked to current baselines and archived versions.
- Provide specialist and cross-disciplinary pathways.

AI-AGENT INTERPRETATION

AI may tutor, simulate review, generate exercises, compare work to checklists, and personalize practice. It must not certify competence, override safety supervision, or conceal that guidance is based on incomplete or superseded material.

FAILURE CASES AND CORRECTIVE ACTION

- Trainees memorize terms without producing or inspecting artifacts.
- Experts are assumed competent outside their domain.
- Training uses perfect samples and hides real failures.
- AI gives immediate answers that prevent learners from practicing diagnosis.

RELEASE GATE: A person receives authority only after demonstrating the required task, explanation, boundary recognition, error response, documentation, and escalation behavior.

Evidence classification and research anchors. E: cognitive apprenticeship, deliberate practice, feedback and training research. S: staged manufacturing curriculum. P: Raven Valley stewardship ladder.

Training exercise. Create one practical assessment for each stage using the same Obsidian Veil figure and progressively increasing responsibility.

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AI-Agent Roles

Bounded agents for narrative, form, scale, joints, materials, CAD, manufacturing, quality, catalog, and change

THE MANY VOICES AROUND ONE TRUTH

> *One agent sees the story; another sees the tolerance.*
> *One compares colors; another listens for missing evidence.*
> *Let them share a record but not imitate authority;*
> *intelligence becomes useful when its role has edges.*

AI agents should be defined by task, inputs, outputs, authority, evidence, dependencies, abstention conditions, and human review. A general model may support many roles, but the system should not blur them into one unaccountable voice.

Potential roles include narrative decomposition, silhouette and shape grammar, scale and measurement, articulation planning, joint selection, material compatibility, paint planning, CAD audit, render specification, prototype planning, manufacturing-package generation, quality checklist, packaging layout, cataloging, provenance comparison, market scenario, and change-control audit. Each role reads a bounded packet and returns a typed artifact.

The OCF module pattern is appropriate: stable ID, type, primitive mapping, statement set, parameters, dependencies, provenance, trace-forward, verification intent, status, and change log. Agent outputs should identify source, evidence class, assumptions, unknowns, and required verification. No agent output silently becomes a baseline requirement.

Multi-agent workflows need conflict rules. A material agent may reject a paint plan; a packaging agent may expose a safety conflict; a catalog agent may find an edition mismatch. The orchestrator should surface contradictions and route them to accountable humans rather than averaging them into a plausible answer.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Narrative agent	Maps source story to traceable design constraints and alternatives.
Shape / silhouette agent	Generates bounded formal variants within series grammar.
Scale agent	Calculates supplied ratios, landmarks, and compatibility; does not invent measurements.
Articulation / joint agent	Uses declared loads and atlas entries to propose candidates and tests.
Material / paint agent	Builds qualification and compatibility questions from supplied data.
CAD / render audit agent	Checks files, metadata, geometry status, and view consistency.
Prototype / manufacturing agent	Maps requirements to samples, operations, and release packets.
Quality agent	Maps requirements to inspection and test, then checks trace completeness.
Packaging / catalog agent	Generates controlled projections and identifies mismatches.
Provenance / market agent	Organizes evidence and scenarios without inventing authenticity or demand.
Change-control agent	Builds impact maps, compares baselines, and flags orphan changes.

Text Diagram. Bounded AI production system

```
CANONICAL RECORD
   |-- NARRATIVE / FORM AGENTS
   |-- SCALE / JOINT / MATERIAL AGENTS
   |-- CAD / RENDER / PROTOTYPE AGENTS
   |-- MANUFACTURING / QUALITY AGENTS
   |-- PACKAGE / CATALOG / PROVENANCE AGENTS
   |
CONFLICT + UNCERTAINTY REGISTER
   |
HUMAN REVIEW / TEST / APPROVAL
   |
BASELINED ARTIFACT
```

Audio description: Specialized agents read one record, return conflicts and uncertainty, and remain subordinate to human review and test before baseline.

PRODUCTION APPLICATION

- Define an agent card with role, schema, sources, limits, and escalation.
- Use structured inputs and outputs for safety-critical workflows.
- Log prompts, model, tools, references, outputs, edits, and approval.
- Test agents on known failures and adversarial omissions.
- Keep agent permissions least-privileged.

AI-AGENT INTERPRETATION

This chapter defines the AI role directly: propose, compare, calculate from supplied data, document, trace, and flag. It does not grant authority to certify, invent, or release.

FAILURE CASES AND CORRECTIVE ACTION

- One assistant produces story, engineering, compliance, and market claims without role boundaries.
- Agent conflict is hidden to make the final answer appear coherent.
- Prompts and source versions are not retained.
- Generated output enters CAD or catalog without human and test gate.

RELEASE GATE: An AI agent may operate only with defined role, schema, source scope, evidence labels, abstention, logging, permissions, evaluation, and accountable human review.

Evidence classification and research anchors. E: NIST AI RMF, systems architecture, human factors, configuration management. S: bounded role system. P: Raven Valley AI agent cards.

Training exercise. Write agent cards for a joint-selection agent and a provenance agent, emphasizing why their authority and abstention differ.

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AI Boundaries and Safe Abstention

What agents may organize and propose, and what they must never invent

THE EDGE OF THE MODEL

> *Wisdom is not the absence of an answer.*
> *It is the courage to mark where evidence ends.*
> *Name the missing measure, preserve the immediate safety,*
> *and make uncertainty a door toward verification.*

Safe abstention is an operational requirement. AI may propose, compare, classify, calculate from supplied inputs, format, document, trace, flag conflicts, generate controlled drafts, and create training exercises. It may not invent measurements, test results, legal compliance, toxicity approval, joint life, production counts, factory provenance, supplier capability, tooling approval, authenticity, ownership, demand, or engineering sign-off.

The uncertainty protocol follows Cinch-and-Weave: preserve immediate safety and identity anchors; state the unknown; identify the smallest missing input; prefer reversible action; provide evidence basis; define a verification path; and record the result without universalizing it (Conrad and OpenAI, *Weaving Understanding* 1-4). Fluency is not evidence. A confident tolerance or material claim is more dangerous than an explicit gap.

Abstention should be specific. "I cannot answer" is less useful than "The shoulder interference cannot be calculated because production compound, molded dimensions, surface finish, and target retention are not supplied; use the joint coupon and cycle protocol before release." The agent can still organize known data and create the next-step packet.

Boundaries include privacy and influence. Agents should not infer sensitive personal attributes from collector behavior, body imagery, or purchases; use psychological language to pressure acquisition; or generate deceptive scarcity. Human review is required for culture, representation, safety, legal, manufacturing, authenticity, and consequential commercial decisions.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
May propose	Alternatives with assumptions, trade-offs, sources, and verification.
May compare	Declared values, records, files, images, and evidence within stated limits.
May calculate	Only from supplied or sourced values with units and method.
May document	Structured packets, trace maps, logs, checklists, and summaries.
Must not invent measurements	Unknown geometry remains unknown.
Must not invent test or compliance	No simulated result becomes certification.
Must not invent provenance	Ownership, factory, edition, and authenticity require evidence.
Must not invent market demand	Forecasts are scenarios with uncertainty.
Must not sign off	Release authority remains with competent accountable roles.
Must abstain safely	State gap, consequence, reversible action, and verification path.

Text Diagram. Safe abstention protocol

```
REQUEST
  |
KNOWN? SOURCE? CURRENT? WITHIN ROLE?
  | yes                          | no
  v                              v
BOUNDED OUTPUT            STATE UNKNOWN
+ EVIDENCE                IDENTIFY MISSING INPUT
+ ASSUMPTIONS             PROTECT SAFETY / IDENTITY
+ VERIFICATION            PROPOSE REVERSIBLE NEXT STEP
  |                              |
  +---------- LOG / HUMAN REVIEW +
```

Audio description: The agent answers only when sourced and within role; otherwise it states the gap, protects safety, and proposes verification.

PRODUCTION APPLICATION

- Create prohibited-claim and mandatory-abstention tests for each agent.
- Require units, source, date, and evidence class in technical outputs.
- Log unknowns and whether they were later resolved.
- Route safety and release decisions to named humans.
- Use negative examples where plausible but false answers are rejected.

AI-AGENT INTERPRETATION

The governing statement is itself the AI interpretation: uncertainty must remain visible and actionable. An agent is rewarded for calibrated abstention, not for completing every field.

FAILURE CASES AND CORRECTIVE ACTION

- AI fills an empty material grade with a likely commercial resin.
- A generated standard citation is obsolete or nonexistent.
- Agent infers edition rarity from marketplace listings.
- Human reviewers accept output because formatting resembles an approved technical pack.

RELEASE GATE: Any safety, compliance, material, performance, provenance, market, or release claim without traceable evidence and competent authority is blocked or explicitly provisional.

Evidence classification and research anchors. E: NIST AI RMF, uncertainty and metacognition research, systems safety. S: specific abstention packet. P: Raven Valley ignorance contract.

Training exercise. Give an AI agent an incomplete joint request and score whether it identifies missing material, dimensions, load, cycles, paint, process, and test rather than inventing them.

61

Production Package and Release Control

The complete controlled artifact set required to make, inspect, package, catalog, and support a product

THE PACKET THAT PRECEDES THE FACTORY

> *A factory cannot manufacture the intention you forgot to write.*
> *A signature cannot repair the drawing it never examined.*
> *Gather every part, test, master, exception, and name;*
> *release is the moment responsibility becomes shared.*

The production package is the controlled set of product brief, narrative brief, approved turnarounds, scale sheet, points of measure, part list, articulation map, joint specifications, material passports, BOM, CAD and mesh manifest, paint sheets, assembly sequence, tooling notes, sample history, test reports, packaging files, catalog record, provenance seed, approvals, and change log.

Completeness is role-specific. Design needs silhouette and material intent; pattern or CAD needs dimensions and interfaces; factory needs material, process, tool, operations, acceptance, and substitutions; quality needs critical characteristics and tests; packaging needs exact product and accessory configuration; catalog needs canonical identity and version; service needs disassembly, replacement, and repair information. One large PDF can summarize, but authoritative source files and manifests remain linked.

Release control defines gates: design intent, product field and fit, material passports and BOM, geometry and tools, seam or joint library, paint and decoration, package, preproduction sample, top of production, sealed reference, and catalog/provenance. Any conditional approval must state condition, owner, due date, affected configuration, and whether production is permitted.

No silent substitutions apply to material, grade, color, coating, adhesive, fastener, joint, tolerance, tool, process, facility, country, package, or source. A substitution request records original, proposal, reason, cost and schedule, appearance, fit, strength, care, safety, collector and provenance effect, compatibility, sample, tests, authority, and status. The Obsidian Veil manufacturer pack establishes this precedent for apparel and is translated here into play products.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Product / narrative brief	Purpose, audience, story, requirements, exclusions, and evidence.
Turnarounds / scale / POM	Controlled views, datums, dimensions, landmarks, and interfaces.
Part / joint / BOM	Identity, quantity, material, process, joining, motion, and cost.
Digital manifest	Native, neutral, derivative files, versions, checksums, and authority.
Material / paint passport	Grade, lot, contacts, process, master, tests, and restrictions.
Tooling / operations	Tool IDs, cavity, gates, fixtures, assembly, paint, and inspection.
Sample / test history	Questions, configurations, results, failures, decisions, and retained evidence.
Packaging	Dieline, material, print, blister, seal, warnings, case, and tests.
Catalog / provenance seed	Canonical identity, edition, manufacture, accessories, and initial events.
Approvals / change	Authority, condition, date, release, supersession, and substitutions.

Text Diagram. Release packet gate

```
REQUIREMENTS + IDENTITY
   + GEOMETRY + PARTS + JOINTS
   + MATERIALS + PAINT + BOM
   + TOOLS + OPERATIONS + QC
   + PACKAGE + CATALOG + PROVENANCE
   + SAMPLES + TESTS + APPROVALS
   = CONTROLLED RELEASE PACKAGE

ANY CRITICAL BLANK / CONDITIONAL UNKNOWN -> HOLD
```

Audio description: All design, engineering, manufacturing, package, catalog, evidence, and approval artifacts combine into a release packet; critical gaps hold release.

PRODUCTION APPLICATION

- Use a package checklist generated from product type and jurisdiction.
- Assign an owner and authoritative file for each artifact.
- Run cross-file consistency and trace audits.
- Issue one signed release manifest to factory and internal teams.
- Archive returned redlines, substitutions, samples, and final as-built records.

AI-AGENT INTERPRETATION

AI may assemble, validate, compare, and trace package contents; detect missing or conflicting fields; and produce role-specific views. It must not approve the packet or create evidence to fill missing gates.

FAILURE CASES AND CORRECTIVE ACTION

- Factory receives a tech pack but not the actual controlled CAD and paint masters.
- Conditional approval has no expiration or closure evidence.
- Package art shows an accessory removed from the BOM.
- As-built tool and process changes never return to the release archive.

RELEASE GATE: Bulk production is prohibited while any critical artifact, authority, test, condition, substitution, or as-built trace remains blank or supported only by illustrative imagery.

Evidence classification and research anchors. E: lifecycle information, configuration management, production packages, quality systems. S: integrated release packet. P: Raven Valley no-silent-substitution rule.

Training exercise. Audit a mock figure package and identify ten missing artifacts that would prevent responsible bulk release.

62

Repair, Circularity, and Afterlife

Replacement, disclosure, parts harvesting, conservation, separation, reissue, and digital preservation

THE OBJECT AFTER THE FIRST LIFE

> *A broken hand is not the end of the character.*
> *A repaired hinge is not untouched, yet it may be more faithfully kept.*
> *Let the intervention enter the lineage instead of hiding beneath paint;*
> *afterlife begins when care becomes part of design.*

Repair and circularity treat the figure as an object with service, conservation, reuse, material, and record afterlives. Replaceable accessories, joints, textile parts, and modules can extend use when safety, compatibility, identification, and disclosure are preserved.

Repair-safe design provides access, replacement interfaces, compatible materials, instructions, and limits. Some child-directed products cannot expose service fasteners or magnets; some welded shells should be replaced rather than opened; some collector items benefit from screws, removable textiles, or modular hands. The decision balances hazard, cost, appearance, authenticity, and lifecycle.

A repair record distinguishes original, authorized replacement, third-party replacement, custom, restoration, and modification. A repaired product must not be represented as untouched. Touch-up paint, replaced joint, resealed blister, reproduced card, or substituted accessory can preserve use or display while changing condition and authenticity. The provenance passport carries the intervention.

Circularity includes material reduction, durable use, repair, part reuse, modular upgrade, package separation, responsible electronics and battery removal, recycling where feasible, and digital preservation of files and records. Recycling claims should not erase mixed-material reality. Parts harvesting requires trace so repaired units do not become counterfeit composites.

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Replaceable accessory	Available, identified, compatible, safe, and recorded.
Replacement joint	Material, geometry, load, assembly, color, and disclosure.
Repair-safe assembly	Access and method that avoid hidden damage and preserve safety.
Paint touch-up	Compatible coating, visible disclosure, scope, and condition effect.
Textile replacement	Pattern, material, stitch, scale, color, and provenance.
Package conservation	Cleaning, flattening, backing, reseal, reproduction, and disclosure.
Parts harvesting	Donor identity, compatibility, intervention, and resulting composite status.
Material separation	Electronics, batteries, metals, textiles, paper, and polymers where practical.
Reissue ethics	Preserve identifiers and original/reissue distinction while supporting access.
Digital preservation	Native files, neutral formats, manifests, checksums, documentation, and migration.

Text Diagram. Lifecycle after release

```
USE / DISPLAY / STORAGE
      |
WEAR / DAMAGE / LOSS / OBSOLESCENCE
      |
REPAIR / REPLACE / RESTORE / HARVEST / RETIRE
      |
SAFETY + COMPATIBILITY + DISCLOSURE
      |
PROVENANCE UPDATE + CONDITION UPDATE
      |
REUSE / ARCHIVE / MATERIAL SEPARATION
```

Audio description: After wear or loss, the object enters repair, replacement, restoration, harvesting, or retirement with safety, disclosure, and provenance updates.

PRODUCTION APPLICATION

- Define serviceable and non-serviceable modules during design.
- Provide part IDs, approved replacement criteria, and repair limits.
- Update passports after intervention.
- Preserve original removed parts when practical and requested.
- Archive files and instructions in open or documented formats.

AI-AGENT INTERPRETATION

AI may identify repair options from controlled records, generate disassembly guidance for qualified roles, and update provenance drafts. It must not recommend unsafe opening, conceal restoration, or certify a repaired unit without inspection.

FAILURE CASES AND CORRECTIVE ACTION

- Repair instructions expose a magnet or battery hazard.
- Replacement part fits visually but changes load or chemical compatibility.
- Resealed package is sold as factory sealed.
- Digital masters are lost when proprietary software or storage expires.

RELEASE GATE: Repair or afterlife action is approved only when safety, compatibility, method, condition effect, provenance, and representation are explicit.

Evidence classification and research anchors. E: repairability, conservation, circular design, product safety, digital preservation. S: repair-event model. P: Raven Valley afterlife stewardship.

Training exercise. Develop repair paths for a loose hip, lost data slate, torn hood, scratched copper paint, and crushed blister. Classify what can be restored and what must remain disclosed.

63

Validation and Research Agenda

Testing where the framework helps, where it fails, and what evidence requires it to become

THE FRAMEWORK ENTERS THE LAB

> *Do not build the test to prove the Valley right.*
> *Build it to discover where the map ends too early.*
> *Publish the failure, narrow the claim, revise the rule;*
> *a living system grows by allowing evidence to change it.*

Validation does not prove Raven Valley correct as a total doctrine. It tests whether specific methods improve design clarity, manufacturability, safety, play, catalog quality, repair, and AI reliability; where they add burden; and where evidence requires narrower or different rules.

The proposed research program compares articulation levels, joint systems, paint and wear, material contact stacks, scale readability, vintage package response, accessory play value, AI manufacturability auditing, functional filigree, provenance features, repairability, and no-drift governance. Each study defines claim class, hypothesis, method, sample, measurement, uncertainty, ethics, and decision threshold.

Pilot products should include a simple unpowered figure, a modular articulated figure, a creature or vehicle, a playset module, and a collector package. The Obsidian Veil 3.75-inch figure serves as the first controlled case. Human and AI teams should generate outputs from both unstructured prompts and structured packets; errors, drift, omissions, and correction effort can be compared.

Negative results are published internally and, where appropriate, externally. Defaults remain provisional until replicated in relevant materials, scales, processes, users, and environments. Version 1.1 should identify which values survived, which narrowed, which were removed, and which new unknowns appeared. The Veil validation principle remains governing: the purpose is to discover usefulness and limits, not to protect the framework from correction (Conrad and OpenAI, *Raven Valley Veil* 51-52).

OPERATIONAL VARIABLE REGISTER

Variable / concern	Operational requirement
Articulation value	How much motion improves play or display before silhouette, durability, cost, or cognitive load worsens.
Joint retention	Which geometries and material pairs retain usable motion across cycles, environment, and storage.
Paint and motion	How film, clearance, cure, and surface influence wear and torque.
Material compatibility	Which contact stacks create migration, tack, cracking, discoloration, or corrosion.
Scale readability	Which details, colors, and shapes survive process and viewing distance.
Vintage presentation	How clear eighties-style hierarchy affects recognition, trust, and collector response.
Accessory play value	Which accessories increase action and narrative rather than only part count.
AI auditability	Whether structured packets reduce hallucination, drift, and untraceable output.
Functional filigree	Whether multi-function surface features improve strength, grip, paint, assembly, or service.
Provenance and stewardship	Which records improve authentication, repair disclosure, and long-term care.

Text Diagram. Validation cycle

```
CLAIM + EVIDENCE CLASS
      |
HYPOTHESIS + METHOD + SAMPLE + METRIC
      |
PROTOTYPE / TEST / USER STUDY / AUDIT
      |
RESULT + UNCERTAINTY + NEGATIVE FINDINGS
      |
RETAIN / NARROW / REVISE / REJECT
      |
NEW BASELINE + RESEARCH REGISTER
```

Audio description: Claims are tested through explicit methods, results and uncertainty, then retained, narrowed, revised, or rejected into a new baseline.

PRODUCTION APPLICATION

- Create a research register with owner, method, data, status, and update trigger.
- Predefine acceptance and failure criteria where feasible.
- Use representative materials, processes, users, and contexts.
- Compare structured and unstructured AI workflows.
- Release revised defaults only through change control.

AI-AGENT INTERPRETATION

AI may assist literature review, protocol drafting, data checking, and hypothesis generation. It must not fabricate data, p-hack analyses, erase negative results, or generalize beyond the tested sample and conditions.

FAILURE CASES AND CORRECTIVE ACTION

- Tests are chosen only after favorable observations.
- One material and one sample are generalized across all figures.
- Collector survey measures purchase intent but is described as play value.
- AI evaluation rewards fluent completion instead of calibrated accuracy and abstention.

RELEASE GATE: A Raven Valley rule becomes a released default only after its evidence class, test scope, uncertainty, negative results, applicability, and update trigger are visible.

Evidence classification and research anchors. E: experimental design, product testing, AI evaluation, human factors. S: framework validation program. P: Play System research agenda and summary equation.

Training exercise. Choose one P-class rule from the paper and write a study capable of rejecting it, including sample, method, metric, and decision threshold.

APPENDIX A

Narrative-to-Product Brief

THE NAME ENTERS THE SHOP

A character arrives as weather, rumor, posture, and wound.
The brief gives each shadow a measurable edge.
What cannot yet be built is not discarded;
it is named as unknown and carried toward the test.

This brief converts narrative language into an auditable product hypothesis. It is completed before detailed sculpting and remains linked to every later design, engineering, packaging, and catalog decision.

Field / control	Required record or instruction
Narrative invariant	What must remain true across sculpt, colorway, scale, and package.
Design freedoms	What may change without changing character identity.
Prohibited shortcuts	Narrative cues that may not be simulated through unsafe, culturally reductive, or misleading design.
Verification hook	Observable test that confirms the product still expresses the intended role.

CONTROLLED TEMPLATE

```
BRIEF ID:
CHARACTER / OBJECT ID:
SERIES / WAVE:
INTENDED USER AND AGE ROUTE:
NARRATIVE ROLE:
SETTING / CULTURE / TECHNOLOGY:
TEMPERAMENT / MOVEMENT STYLE:
PRIMARY SILHOUETTE:
DOMINANT / SECONDARY SHAPE FAMILIES:
MATERIAL HIERARCHY:
ARTICULATION PRIORITIES:
ACCESSORY ACTIONS:
PAINT HIERARCHY:
PACKAGE ATMOSPHERE:
TARGET SCALE / PRICE / COST:
SAFETY-CRITICAL UNKNOWNS:
EVIDENCE CLASS BY CLAIM:
APPROVAL / DATE / VERSION:
```

USE NOTES

- Do not treat generated concept prose as dimensional authority.
- Separate source-derived lore from newly invented design interpretation.
- Record unresolved cultural, historical, or safety questions before the first approval gate.

APPENDIX B

Character and Series Ontology

THE WORLD IS NAMED IN PARTS

A world becomes governable when its names stop drifting.
Character is not figure; wave is not edition.
Each relation receives a stable address,
and the archive can follow the story without guessing.

The ontology defines canonical entities and relations so that art, CAD, manufacturing, packaging, commerce, and AI agents refer to the same product truth.

Field / control	Required record or instruction
Stable identifier	Non-semantic immutable ID; names and marketing labels may change.
Entity type	Controlled vocabulary term defining responsibilities and permissible relations.
Status	Draft, reviewed, baselined, released, superseded, retired, archived.
Provenance	Source, author, date, version, and transformation history.
Trace-forward	Files, tests, package records, listings, units, and events dependent on the entity.

CONTROLLED TEMPLATE

```
ENTITY TYPES:
Character | Figure | Body | Part | Joint | Costume | Armor | Accessory
Vehicle | Creature | Environment | Playset | Display Base | Packaging
Series | Wave | Assortment | Edition | Variant | Prototype | Master
Tool | Mold | Production Run | Catalog Record | Ownership Event | Repair Event

REQUIRED RELATIONS:
CHARACTER represented_by FIGURE
FIGURE composed_of PART
PART connected_by JOINT
FIGURE member_of SERIES
FIGURE released_in WAVE
EDITION differs_from BASELINE by DELTA
UNIT produced_in PRODUCTION_RUN
UNIT documented_by PASSPORT
UNIT changed_by REPAIR_EVENT
```

APPENDIX C

Scale and Points-of-Measure Templates

THE FRACTION KEEPS ITS BODY

The measure descends, but function does not shrink away.
A hand still closes; a foot still seeks the floor.
Scale is honest when every interface remembers
which dimensions are visual, mechanical, and shared.

This template distinguishes nominal size, represented scale, character-relative proportion, and critical interface dimensions. Values are not inferred from marketing height alone.

Field / control	Required record or instruction
Nominal height	Marketing convention, clearly separated from actual measured product height.
Represented scale	Ratio only when based on a declared fictional or real character dimension.
Critical-to-function	Joint centers, grip interfaces, ground contact, vehicle seating, and package fit.
Reference-only	Dimensions useful for communication but not acceptance.
Scale family rule	Shared ports, grips, seats, and environmental clearances within a product ecosystem.

CONTROLLED TEMPLATE

```
PRODUCT ID / SCALE BASIS:
NOMINAL OVERALL HEIGHT:
REPRESENTED CHARACTER HEIGHT:
HEAD TOP / EYE / SHOULDER / HIP / KNEE / GROUND Z:
SHOULDER WIDTH / HIP WIDTH / CHEST DEPTH:
HAND GRIP DIAMETER RANGE:
FOOTPRINT LENGTH / WIDTH:
PEG / PORT / SADDLE / SEAT INTERFACES:
PACKAGE ORIENTATION ENVELOPE:
MEASUREMENT DATUMS:
TOLERANCE CLASS:
INSPECTION METHOD:
REVISION:
```

APPENDIX D

Degrees-of-Freedom Worksheet

THE BOUNDARY MAKES MOTION LEGIBLE

Freedom without an axis is only a promise in fog.
The stop, the clearance, the load, and the wear
draw the true map of movement;
every pose is permission bounded by matter.

Complete one record for every joint or flexible connection. Nominal range is a design claim until verified on the actual material and production process.

Field / control	Required record or instruction
Axis definition	Use a declared coordinate system and joint-center datum.
Pose envelope	Record reachable poses, not only isolated angular maxima.
Torque	Specify method, conditioning state, temperature, and cycle count.
Failure	Separate cosmetic rub, loss of pose, fracture, pop-off, and unsafe detachment.

CONTROLLED TEMPLATE

```
JOINT ID / PART IDS:
JOINT FAMILY:
AXIS / AXES:
DOF COUNT:
NOMINAL RANGE:
HARD STOP / SOFT STOP:
CLEARANCE MAP:
TARGET TORQUE / RETENTION CLASS:
EXPECTED CYCLES:
LOAD CASES:
COLLISION PARTS:
PAINT / COATING EXCLUSION:
ASSEMBLY METHOD:
FAILURE MODES:
REPAIR ROUTE:
TEST METHOD / SAMPLE SIZE:
RESULT / VERSION:
```

APPENDIX E

Joint Atlas

THE SMALL COVENANT

Two parts meet where certainty is thinnest.
There the designer must speak in radius and strain.
A good joint does not boast of freedom;
it returns, again and again, without betrayal.

The atlas is a selection guide, not a universal dimension table. Every joint is resolved through geometry, material pair, process capability, loads, appearance, assembly, and test.

Field / control	Required record or instruction
Straight swivel	One rotational axis; simple silhouette; watch peg shear, paint lock, and axial pull-off.
Mushroom peg	Compliant insertion with retained head; tune neck and undercut to actual resin.
Ball-and-socket	Three-axis orientation with coupled limits; inspect socket split, creep, and pop-off.
Hinge / disc hinge	One axis with visible or concealed knuckle; control pin, barrel, stop, and side play.
Universal joint	Two intersecting axes; compact but part- and tolerance-intensive.
Ratchet / detent	Discrete retention; acoustically and tactilely expressive but vulnerable to tooth wear.
Sliding / telescoping	Translation; protect rails from flash, paint, debris, and overextension.
Living hinge	Flexure in one material; validate strain, radius, orientation, and environmental life.
Textile / elastic	Distributed flexible connection; inspect fray, creep, attachment, and cleanability.
Magnetic interface	Detachable attraction; evaluate ingestion hazard, polarity, retention, corrosion, and electronics interaction.

USE NOTES

- Create a separate controlled detail drawing and worksheet for each released joint.
- Do not copy peg diameters or interference values across dissimilar resins or factories without validation.
- Collector repairability and child-safety requirements may require different architectures.

APPENDIX F

Joining and Fastener Matrix

THE PLACE WHERE PARTS AGREE

No fastener works alone.
The boss, the resin, the tool, and the hand share the load.
Join what must remain; release what must be served;
and record the cost of making either choice permanent.

The matrix supports joining-method selection. A released joint statement includes adjoining materials, geometry, tolerance, finish, process, loads, service intent, and inspection.

Field / control	Required record or instruction
Snap fit	Fast assembly; sensitive to resin modulus, undercut, draft, creep, and repeated service.
Press fit	Simple and compact; requires stable dimensions and controlled insertion force.
Pin / axle	Supports rotation or alignment; control material, end retention, burrs, and corrosion.
Rivet / heat stake	Permanent or semi-permanent capture; verify head formation and surrounding stress.
Screw / threaded insert	Serviceable; control boss design, torque, strip resistance, and access.
Ultrasonic weld	Rapid permanent polymer join; requires energy-director and process-window development.
Solvent / adhesive bond	Can preserve surface continuity; requires chemical compatibility, cure, ventilation, and aging validation.
Sewing / lacing	Soft-goods connection; control seam, thread, allowance, tension, abrasion, and repair.
Insert / overmolding	Integrates unlike functions; validate adhesion or mechanical lock, thermal history, and tool sequence.
Magnet / removable tab	Modular and intuitive; requires safety, polarity, retention, and provenance control.

APPENDIX G

Material Passport

MATTER GIVES ITS TRUE NAME

Do not write plastic where a grade must stand.
Do not write metal where a finish hides a risk.
Every substance enters with a history and limit;
every substitution changes the future of the object.

The material passport is the minimum identity record for every polymer, metal, textile, paperboard, coating, adhesive, magnet, and electronic component.

Field / control	Required record or instruction
Identity	Specific grade and supplier, not only material family.
Process truth	Conditioning, drying, cure, shrinkage, and relevant process window.
Interface truth	All paints, plasticizers, adhesives, metals, textiles, and packaging touching the material.
Evidence	Supplier data, certificates, internal tests, external tests, and unresolved limitations.

CONTROLLED TEMPLATE

```
MATERIAL ID / COMMERCIAL NAME / SUPPLIER:
POLYMER OR ALLOY FAMILY / GRADE:
COLOR / MASTERBATCH / ADDITIVE PACKAGE:
HARDNESS / DENSITY / RHEOLOGY OR RELEVANT PROPERTIES:
PROCESS / DRYING / MOLD OR CURE WINDOW:
SHRINKAGE DATA AND SOURCE:
COATING / ADHESIVE COMPATIBILITY:
CONTACT MATERIALS:
RESTRICTED-SUBSTANCE / SAFETY RECORDS:
UV / HEAT / HUMIDITY / HYDROLYSIS CONCERNS:
RECYCLED CONTENT / END-OF-LIFE NOTES:
LOT / CERTIFICATE / TEST REFERENCES:
APPROVED SAMPLE / VERSION / SUBSTITUTION STATUS:
```

APPENDIX H

Material Compatibility Matrix

THE CONTACT OUTLIVES THE ASSEMBLY

Two stable things may become unstable together.
Time is the third material inside every contact.
Test the touch, the heat, the darkness, and the years;
compatibility is an observed relation, not a family name.

The matrix begins as a risk register and becomes evidence only after representative contact-stack testing. It should identify chemical, thermal, mechanical, optical, and aging interactions.

Field / control	Required record or instruction
Flexible PVC - rigid styrenic	Check plasticizer migration, tack, discoloration, stress cracking, and paint transfer.
ABS - solvent coating	Check crazing, softening, adhesion, and residual-solvent stress.
Acetal - paint / adhesive	Low surface energy commonly complicates coating and bonding; prefer mechanical function or qualified treatment.
Nylon - dimensional interface	Moisture uptake can alter dimensions and stiffness; condition before measurement.
Photopolymer resin - skin / production	Prototype chemistry and brittleness are not presumed suitable for released toys.
Steel pin - humid polymer cavity	Check corrosion, staining, lubricant, and galvanic conditions around other metals.
Magnet - coating / adhesive	Verify plating integrity, corrosion resistance, retention, and hazard containment.
Textile - flexible polymer	Check dye transfer, plasticizer interaction, abrasion, fray, and cleaning.
PET blister - printed card / figure	Check scuffing, coating transfer, sealing heat, humidity curl, and long-term contact.
Adhesive - any substrate	Confirm surface preparation, bond-line design, cure inhibition, VOC control, and aging.

USE NOTES

- Record contact area, pressure, temperature, humidity, light exposure, duration, and conditioning.
- A passing short test does not establish archival compatibility.
- Substitution of colorant, plasticizer, primer, or adhesive can invalidate prior compatibility.

APPENDIX I

Paint and Decoration Specification

COLOR MUST KEEP ITS PROMISE

The eye meets color before the hand finds the seam.
Yet beauty that powders, blocks a joint, or migrates is debt.
Let every layer confess its substrate and cure,
so the surface may age without rewriting the object.

The paint sheet governs each decoration operation from substrate preparation through approved appearance and performance.

Field / control	Required record or instruction
Color authority	Physical master plus instrument record where appropriate; screen appearance alone is insufficient.
Process authority	Actual supplier instructions and validated production window.
Motion protection	No uncontrolled film buildup on friction, interference, snap, or weld surfaces.
Variation	Define acceptable visual range, not only a single ideal image.

CONTROLLED TEMPLATE

```
OPERATION ID / PART ID / ZONE:
SUBSTRATE MATERIAL AND CONDITION:
PAINT / INK / PRIMER / CLEAR SYSTEM:
SUPPLIER / PRODUCT / BATCH:
COLOR STANDARD / MASTER SAMPLE:
PRETREATMENT / CLEANING / ADHESION PROMOTER:
APPLICATION: spray | pad | screen | brush | decal | transfer | other
MIX / THIN / VISCOSITY / POT LIFE:
MASK / FIXTURE / REGISTRATION DATUM:
FILM TARGET / FLASH / CURE:
GLOSS / TEXTURE / METALLIC OR EFFECT ORIENTATION:
JOINT EXCLUSION AND CLEARANCE:
ADHESION / RUB / COLOR / AGING TEST:
APPROVED LIMIT SAMPLE / VERSION:
```

APPENDIX J

Technical Drawing Templates

THE LINE BECOMES INSTRUCTION

A drawing is a promise made visible before matter arrives.
One line may be shape; another may decide acceptance.
Name the datum, the tolerance, the view, the revision;
precision begins by telling the reader which marks can govern.

Technical drawings use a declared standard and separate design illustration from manufacturing authority.

Field / control	Required record or instruction
Reference dimension	Communicative only; clearly marked and not used as acceptance without explicit instruction.
Controlled dimension	Part of the released definition and measured by stated method.
Critical-to-function	Dimension or characteristic whose failure compromises motion, assembly, safety, fit, or package.
Illustrative render	Never allowed to override a baselined drawing or model.

CONTROLLED TEMPLATE

```
DRAWING NUMBER / TITLE / PRODUCT / PART:
REVISION / STATUS / SCALE / UNITS:
PROJECTION / DATUM SYSTEM:
MATERIAL / FINISH / COLOR:
GENERAL TOLERANCE:
CTF DIMENSIONS AND CHARACTERISTICS:
FRONT / REAR / LEFT / RIGHT / TOP / BOTTOM:
SECTIONS / DETAILS / EXPLODED VIEW:
PARTING / GATE / EJECTOR / DRAFT NOTES:
JOINT AND ASSEMBLY INTERFACES:
PAINT MASK / PRINT REGISTRATION:
INSPECTION METHOD:
SOURCE MODEL / CHECKSUM:
APPROVALS:
```

APPENDIX K

CAD, Mesh, Texture, and Render File Standard

THE FILE LEAVES A TRAIL

A copied name is not a lineage.
An export without units is a door without a floor.
Let every coordinate, texture, and revision return home,
and the digital body may survive the tools that made it.

This standard defines portable, inspectable handoff while preserving native source files and one canonical released identity.

Field / control	Required record or instruction
Native master	Preserve authoring structure, modifiers/history, units, dependencies, and tool version.
Neutral interchange	Export with documented tessellation or precision and verify reimport.
Render package	Camera, lens, lighting, color management, geometry version, and material status.
Release manifest	Hashes, file roles, approvals, superseded artifacts, and compatibility notes.

CONTROLLED TEMPLATE

```
PROJECT ROOT:
/00_ADMIN
/01_BRIEF_REFERENCE
/02_CONCEPT
/03_SCULPT
/04_ENGINEERING_CAD
/05_TOOLING
/06_TEXTURE_PAINT
/07_RENDER
/08_PROTOTYPE
/09_PACKAGE
/10_TEST_QC
/11_CATALOG_PROVENANCE
/12_RELEASE
/99_ARCHIVE

FILE: [PROJECT]_[OBJECT]_[ARTIFACT]_[STATE]_[REV].[EXT]
UNITS / AXES / ORIGIN / DATUM:
COLOR SPACE / TEXTURE RESOLUTION / UDIM OR UV RULE:
MESH STATUS: concept | appearance | print | engineering proxy | archive
CHECKSUM / DEPENDENCIES / LICENSE / SOURCE:
EXPORT VALIDATION / ROUND-TRIP RESULT:
```

APPENDIX L

Naming, Versioning, and Folder Structure

THE NAME MUST SURVIVE CHANGE

> *The object changes coats, factories, colors, and years.*
> *Its name must not become the disguise of another thing.*
> *Keep identity stable and revision explicit;*
> *memory fails where filenames pretend continuity.*

The naming system separates identity from mutable description. Semantic labels help humans; immutable IDs and controlled revisions preserve machine traceability.

CONTROLLED TEMPLATE

```
PROJECT ID: RVPS-[####]
CHARACTER ID: CHAR-[####]
PRODUCT ID: PROD-[####]
PART ID: PART-[####]
JOINT ID: JNT-[####]
MATERIAL ID: MAT-[####]
PACKAGE ID: PKG-[####]
RUN ID: RUN-[YYYY]-[####]
UNIT SERIAL: [PRODUCT]-[RUN]-[SERIAL]
CHANGE REQUEST: CR-[YYYY]-[####]

REVISION RULE:
DRAFT d0.x -> REVIEW r0.x -> BASELINE v1.0 -> COMPATIBLE v1.x -> BREAKING v2.0
NO OVERWRITE OF RELEASED ARTIFACTS.
```

USE NOTES

- A marketing rename does not mint a new product identity unless product definition changes.
- A colorway is an edition or variant with an explicit delta record.
- Every released file references the same Product ID and applicable part/material/package versions.

APPENDIX M

3D-Printing Development Log

THE LAYER REMEMBERS GRAVITY

> *Every layer carries the angle of its making.*
> *Support leaves a scar; cure leaves a future tension.*
> *Print not only the object, but the conditions around it,*
> *so failure may be repeated, understood, and corrected.*

The log records additive process conditions sufficient to compare prototypes and avoid treating a successful print as an undocumented miracle.

CONTROLLED TEMPLATE

```
PRINT ID / DATE / OPERATOR:
SOURCE FILE / HASH / SCALE / ORIENTATION:
PROCESS: material extrusion | vat photopolymerization | PBF | other
MACHINE / FIRMWARE / SLICER:
MATERIAL / LOT / CONDITIONING:
LAYER / NOZZLE OR EXPOSURE / TEMPERATURES:
SUPPORT STRATEGY / INFILL / SHELL / HOLLOWING / DRAINS:
COMPENSATION / ANTIALIASING / SHRINK ASSUMPTION:
POST-PROCESS / WASH / CURE / ANNEAL:
MEASURED DIMENSIONS / DISTORTION:
SURFACE / FIT / JOINT / FAILURE OBSERVATIONS:
SAFETY AND WASTE RECORD:
DISPOSITION / NEXT TEST:
```

USE NOTES

- Prototype photopolymers are not presumed production-safe or mechanically representative.
- Measure after the declared conditioning and post-cure state.
- Keep orientation and support artifacts visible in the development record.

APPENDIX N

Mold and Tooling Request Package

THE CAVITY ASKS FOR FORESIGHT

> *The tool receives every silence in the model.*
> *Undercut, trapped air, thin wall, and hidden witness return as cost.*
> *Before steel remembers the error,*
> *let the request name each risk and each permitted mark.*

The tooling request is issued only after design, materials, part breakdown, and critical interfaces are sufficiently controlled for a DFM exchange.

CONTROLLED TEMPLATE

```
TOOL REQUEST ID / PRODUCT / PARTS:
TARGET PROCESS / MATERIAL / ANNUAL AND LIFETIME VOLUME:
CAVITY PLAN / FAMILY TOOL RATIONALE:
PARTING / ACTIONS / INSERTS / SHUT-OFFS:
DRAFT / WALL / RIB / BOSS / UNDERCUT REVIEW:
GATE / RUNNER / VENT / EJECTOR PROPOSAL:
COSMETIC SURFACES / PERMITTED WITNESS MARKS:
CRITICAL DIMENSIONS / SHRINK BASIS:
TEXTURE / POLISH / ENGRAVING / DATE CODE:
COOLING / CYCLE / AUTOMATION ASSUMPTIONS:
SPARES / MAINTENANCE / TOOL OWNERSHIP:
TRIAL PLAN: T0 | T1 | PP | TOP
DELIVERABLES / SCHEDULE / APPROVALS:
```

USE NOTES

- Toolmaker returns annotated DFM rather than silently altering geometry.
- Every shrink or steel-safe assumption is material- and process-specific.
- Tool modifications create versioned records linked to affected parts and samples.

APPENDIX O

Bill of Materials and Assembly Route

THE OBJECT IS A SEQUENCE

> *A figure is not its parts alone.*
> *It is the order in which heat, paint, force, and inspection meet them.*
> *Write the route beside the bill,*
> *for sequence is a material hidden inside assembly.*

The BOM identifies what exists; the route identifies how it becomes a released unit. Both are baselined and costed together.

CONTROLLED TEMPLATE

```
BOM FIELDS:
LINE | PART ID | DESCRIPTION | QTY | MATERIAL ID | COLOR | TOOL/CAVITY
SUPPLIER | MAKE/BUY | SCRAP | UNIT COST | REV | SUBSTITUTE STATUS

ROUTE FIELDS:
OP ID | PREDECESSOR | WORKCENTER | FIXTURE/TOOL | METHOD
PROCESS WINDOW | INSPECTION | ACCEPTANCE | REWORK | TIME | OWNER

LOT LINKAGE:
RUN ID | MATERIAL LOTS | PAINT BATCHES | OPERATORS/LINES | DATE/TIME
TOP SAMPLE | DEVIATIONS | RELEASE STATUS
```

USE NOTES

- Snapshots preserve the actual BOM and route used for each production run.
- Rework is a controlled route, not an invisible return to the line.
- Costing includes scrap, inspection, fixtures, packaging, freight, and returns reserve.

APPENDIX P

Prototype and Sample Approval Forms

THE SAMPLE IS A WITNESS

A sample does not flatter the drawing.
It returns the truth of material and process.
Seal what passed, mark what failed, preserve the condition;
approval without a witness is only remembered enthusiasm.

This form establishes the purpose, authority, condition, and disposition of each concept, appearance, engineering, tooling, paint, package, preproduction, pilot, golden, and retention sample.

CONTROLLED TEMPLATE

```
SAMPLE ID / TYPE / PRODUCT / VERSION:
DATE / FACILITY / MATERIAL LOT / PROCESS:
PURPOSE AND QUESTIONS:
REFERENCE FILES / DRAWINGS / PREVIOUS SAMPLE:
MEASUREMENTS / FUNCTION / APPEARANCE / SAFETY RESULTS:
DEVIATIONS / PHOTOS / DESTRUCTIVE TEST STATUS:
DECISION: APPROVE | CONDITIONAL | REVISE | REJECT | ARCHIVE
CONDITIONS / EXPIRATION / REQUIRED ACTIONS:
SEALED REFERENCE LOCATION:
APPROVAL ROLES / DATES:
SUPERSESSION / RETENTION SCHEDULE:
```

USE NOTES

- Conditional approval must have an explicit condition and expiration.
- A render cannot serve as a physical golden sample.
- Destructive and non-destructive sample states are clearly distinguished.

APPENDIX Q

Quality-Control and Test Records

THE MEASURE RETURNS FROM THE LINE

> *Inspection is not suspicion of the worker.*
> *It is the system listening to what production became.*
> *Count the defect, preserve the lot, correct the cause;*
> *quality is memory applied before repetition.*

The QC record links design requirements, sampling plans, test methods, actual lots, instruments, results, deviations, and release decisions.

CONTROLLED TEMPLATE

```
CONTROL PLAN LINE:
CHARACTERISTIC / CTF CLASS / SPEC LIMIT / METHOD / GAUGE
FREQUENCY / SAMPLE PLAN / OWNER / REACTION PLAN / RECORD

TEST RECORD:
TEST ID / STANDARD OR INTERNAL METHOD / EDITION
SAMPLES / CONDITIONING / EQUIPMENT / CALIBRATION
RESULTS / UNCERTAINTY / FAILURES / PHOTOS / RAW DATA
DISPOSITION / CAPA / RETEST / RELEASE AUTHORITY

LOT RELEASE:
RUN / DATE / QUANTITY / AQL PLAN IF APPLICABLE
CRITICAL / MAJOR / MINOR DEFECT RESULTS
DEVIATIONS / HOLD / RELEASE / REWORK / SCRAP
```

USE NOTES

- Acceptance sampling does not replace process control or safety-critical testing.
- Use the current applicable standard and record edition and deviations.
- Preserve failed samples and negative data when useful for root-cause analysis.

APPENDIX R

Packaging Dieline and Information Hierarchy

THE WINDOW AND THE WALL

> *The package guards the object and teaches the first story.*
> *It must not make safety small or scarcity loud.*
> *Let title, figure, accessory, warning, and record find their order;*
> *a clear window is also a clear promise.*

The package packet coordinates structural protection, visual hierarchy, legal information, accessory retention, production, transport, retail, opening, and collector storage.

CONTROLLED TEMPLATE

```
PACKAGE ID / PRODUCT / MARKET / AGE ROUTE:
DIELINE VERSION / BOARD / BLISTER OR TRAY MATERIAL:
FINISHED SIZE / HANG / CASE PACK / CARTON:
BLEED / SAFE / SCORE / CUT / SEAL / ADHESIVE ZONES:
FIGURE AND ACCESSORY ORIENTATION:
FRONT HIERARCHY: BRAND > SERIES > CHARACTER > HERO FIELD > ACCESSORIES
BACK HIERARCHY: LORE > SERIES GRID > FEATURES > PASSPORT > LEGAL
WARNINGS / TRACEABILITY / COUNTRY / DATE CODE / BARCODE:
PRINT / COLOR / COATING / FOIL / EMBOSS:
TRANSPORT / SCUFF / SEAL / AGING TESTS:
APPROVALS / GOLDEN PACKAGE / VERSION:
```

USE NOTES

- Vintage presentation does not excuse illegible warnings or deceptive scarcity.
- Blister and card interactions are tested for sealing, curl, scuff, and long-term contact.
- Package revision is part of the unit provenance.

APPENDIX S

Collector Provenance Passport

THE OBJECT CONTINUES AFTER SALE

> *The maker releases matter, not memory.*
> *The owner adds handling, repair, place, and time.*
> *Let history remain append-only and honest,*
> *so age becomes evidence rather than disguise.*

The passport begins at production and may continue through ownership, exhibition, repair, authentication, transfer, and retirement. It does not guarantee authenticity by itself; it preserves evidence and confidence.

CONTROLLED TEMPLATE

```
UNIT / PRODUCT / CHARACTER / SERIES / WAVE / EDITION:
SCULPT / TOOL / MATERIAL / PAINT / PACKAGE VERSIONS:
RUN / FACTORY / DATE / SERIAL / COUNTRY:
ACCESSORY COMPLEMENT:
KNOWN VARIATIONS / IDENTIFYING MARKS:
SOURCE DOCUMENTS / AUTHENTICATION EVIDENCE:
OWNERSHIP EVENTS [DATE | PARTY/PRIVACY | BASIS]:
REPAIR EVENTS [WHAT | WHY | WHO | MATERIAL | EFFECT]:
EXHIBITION / PUBLICATION / MEDIA EVENTS:
CONDITION OBSERVATIONS:
CONFIDENCE BY FIELD:
DIGITAL SIGNATURE / HASH / EXPORT HISTORY:
```

USE NOTES

- Do not erase repairs, replaced parts, or package changes.
- Privacy fields remain separable from public provenance.
- A lost passport may be reconstructed only with explicit uncertainty and evidence sources.

APPENDIX T

Physishop Product and Edition Schema

THE RECORD BECOMES A PORTABLE BODY

> *Inventory is not a shelf count alone.*
> *It is identity crossing image, offer, payment, shipment, and memory.*
> *Keep one truth beneath every projection,*
> *and the object may travel without becoming many strangers.*

This schema adapts the Physishop/Crypt canonical-record doctrine to figures and play objects. JSON below is illustrative and must be validated against the deployed schema.

Field / control	Required record or instruction
Canonical core	Identity, edition, part, material, articulation, package, provenance, and lifecycle state.
Projection	Marketplace listing, gallery view, package copy, technical sheet, or AI prompt generated from the core.
Mutable state	Inventory, offer, ownership, condition, repair, and commerce events.
Immutable event	Released definitions, production events, ownership transfers, and repair history preserved append-only.

CONTROLLED TEMPLATE

```
{
  "schema": "GI_PLAY_OBJECT_v1",
  "product_id": "PROD-0001",
  "character_id": "CHAR-0001",
  "title": "Obsidian Veil Operative",
  "category": "3.75-inch action figure",
  "series": {"id":"SER-0001","wave":"W01"},
  "edition": {"id":"ED-BASE","delta":[]},
  "articulation": {"points":5,"joints":["JNT-..."]},
  "materials": ["MAT-..."],
  "parts": ["PART-..."],
  "accessories": ["ACC-..."],
  "package_id": "PKG-0001",
  "provenance": {"run_id":"RUN-2027-0001","confidence":"verified"},
  "commerce": {"status":"prototype","condition":null,"price":null},
  "sources": [{"id":"SRC-...","location":"..."}],
  "version": "1.0"
}
```

APPENDIX U

AI Input, Output, and Abstention Schemas

THE AGENT MUST SHOW ITS BOUNDARY

A fluent answer can still be an untested part.
Confidence is not a certificate and likeness is not fit.
Let the agent name its source, unknown, and handoff,
and intelligence becomes useful without pretending authority.

These schemas bind AI assistance to explicit inputs, source classes, output status, uncertainty, validation, and human release authority.

Field / control	Required record or instruction
May do	Propose, compare, classify, calculate from supplied values, format, trace, flag, and generate controlled drafts.
May not invent	Dimensions, test results, compliance, material identity, production count, provenance, demand, approval, or authenticity.
Release authority	Human roles approve safety, engineering, material, cultural, manufacturing, legal, and commercial claims.
Audit	Every AI output retains model/tool context, sources, prompt packet, status, and downstream use.

CONTROLLED TEMPLATE

```
INPUT PACKET:
request_id | task_type | product_id | source_ids | source_priority
constraints | known_values | unknown_values | prohibited_inference
jurisdiction | intended_use | evidence_policy | output_schema

OUTPUT PACKET:
status: proposal | comparison | audit | abstention
assumptions | source_trace | claim_classes | generated_artifacts
unknowns | conflicts | safety_flags | verification_plan
human_roles_required | compatibility | version

ABSTENTION:
reason_code | missing_critical_fields | risk_if_guessed
smallest_useful_question | reversible_interim_action | escalation
```

APPENDIX V

Supplier Change and Substitution Request

NO SILENT SUBSTITUTE

A substitute may look the same beneath showroom light.
Time, heat, joint wear, and paint may reveal another object.
Name the change before the line absorbs it,
and let compatibility be decided rather than assumed.

No material, colorant, coating, fastener, tool, process, facility, country, package stock, or test method changes silently after baseline.

CONTROLLED TEMPLATE

```
CHANGE REQUEST / SUPPLIER / DATE:
ORIGINAL ITEM / OPERATION / VERSION:
PROPOSED SUBSTITUTE / SOURCE / LOT:
REASON / AVAILABILITY / LEAD TIME:
COST / SCHEDULE / MOQ EFFECT:
DIMENSION / FIT / MOTION / ASSEMBLY EFFECT:
MATERIAL / CHEMISTRY / PAINT / AGING EFFECT:
SAFETY / REGULATORY / TEST EFFECT:
APPEARANCE / PACKAGE / COLLECTOR EFFECT:
COMPATIBILITY WITH RELEASED UNITS:
REQUIRED SAMPLES / TESTS / DOCUMENTS:
DISPOSITION: APPROVE | CONDITIONAL | REJECT | HOLD
APPROVAL ROLES / DATE / IMPLEMENTATION RUN:
```

USE NOTES

- Approval is tied to specific evidence and implementation run.
- A change that breaks interchangeability or appearance may require a new edition or major version.
- Cost savings do not override safety, provenance, or released function.

APPENDIX W

Costing and Assortment Worksheets

THE PRICE CARRIES THE WHOLE ROUTE

> *Cost begins before resin enters the gate.*
> *It follows revision, inspection, freight, return, and shelf.*
> *Price the object that will actually exist,*
> *not the optimistic shadow drawn before failure.*

The worksheet separates non-recurring development and tooling from recurring unit cost, landed cost, channel economics, and assortment risk.

CONTROLLED TEMPLATE

```
NON-RECURRING:
design + sculpt + engineering + prototypes + tests + tooling + fixtures + package development

UNIT COST:
materials + molding/casting/printing + paint + assembly + QC + package + scrap/rework

LANDED COST:
unit cost + freight + duty/tax + brokerage + warehousing + handling + finance + returns reserve

CHANNEL:
landed cost | wholesale price | distributor margin | retailer margin | DTC cost | royalty | promotion

ASSORTMENT:
SKU | case qty | demand scenario | tooling reuse | visual role | narrative role | margin | risk

SENSITIVITY:
volume | scrap | cycle | paint ops | freight | exchange | return rate | sell-through
```

USE NOTES

- Do not treat tooling amortization as absent merely because it is prepaid.
- Run low/base/high scenarios and identify value nodes and bottlenecks.
- Avoid using chase scarcity to conceal weak assortment economics.

APPENDIX X

Standards and Source-Update Register

THE RULE HAS A DATE

A standard is not eternal because it carries a number.
Editions move; jurisdictions divide; products change their use.
Write the source, the date, the trigger, and the owner,
so yesterday does not masquerade as present authority.

The register prevents standards and regulations from becoming static folklore. Every deployment identifies jurisdiction, product scope, current edition, access date, owner, and update trigger.

Field / control	Required record or instruction
Toy safety - United States	CPSC / 16 CFR part 1250 / ASTM F963-23; verify product scope, manufacture date, testing and certification duties.
Toy safety - international	ISO 8124 series; verify current part, edition, market adoption, and national deviations.
Toy safety - European Union	Regulation (EU) 2025/2509 applies generally from 1 Aug. 2030; transitional and implementing provisions require current review.
Technical definition	ASME Y14.5-2018 (R2024) or contractually selected GPS/GD&T system; do not mix conventions silently.
Quality sampling	ISO 2859-1:2026 when applicable; sampling does not replace full safety or process controls.
Additive manufacturing	ISO/ASTM 52900:2021 terminology and 52920:2023 production-site qualification principles; process-specific standards as relevant.
Paint / coating tests	ASTM D3359, ISO 2409, ASTM D2244, ASTM D4060 or validated product-specific methods as applicable.
Distribution	ASTM D4169 / applicable ISTA procedure selected for actual distribution system.
AI governance	NIST AI RMF 1.0 and current profiles/playbooks; note that AI RMF 1.0 is under revision as of this publication.

USE NOTES

- Recheck before each market release and whenever intended use, age grading, materials, electronics, projectiles, magnets, or jurisdiction changes.
- Record licensed standard access and do not reproduce protected full text.
- Where standards conflict, obtain qualified legal, safety, and engineering interpretation.

APPENDIX Y

Controlled Vocabulary and Glossary

THE WORD HOLDS THE INTERFACE

A shared word is a tool passed hand to hand.
If its edge changes silently, every later measure drifts.
Define the term, preserve its scope, name its evidence;
language becomes part of the fixture that keeps work aligned.

The glossary is a governed interface. Local or supplier terms may be recorded as aliases but do not silently replace canonical meanings.

Field / control	Required record or instruction
Action figure	A representational play or display object whose identity includes a character body and one or more designed movement or interaction affordances.
Articulation	Designed relative motion between parts, including joint type, degrees of freedom, range, retention, clearance, and wear.
Body field / object field	Project model of measured geometry, motion, interfaces, context, manufacture, handling, package, and time.
Critical-to-function	Characteristic whose failure compromises intended motion, assembly, safety, compatibility, fit, or required presentation.
Edition	A governed release state distinguished by explicit, documented delta from a baseline.
Functional filigree	Visible geometry carrying aesthetic meaning and a testable structural, gripping, assembly, paint, protective, informational, or service function.
Golden sample	Approved physical production reference sealed and controlled for a defined purpose and period.
Heliometric composition	Raven Valley project term for organizing one primary attention center with subordinate features in coherent orbit; not a recognized physical law.
Material passport	Versioned identity, property, process, compatibility, evidence, lot, and lifecycle record for a material or component.
No-drift governance	Change control preventing silent alteration of baselined meaning, geometry, material, process, package, or record.
Part as code	Doctrine that each part is a versioned manufacturing instruction with identity, geometry, material, interfaces, tolerances, process, and verification.
Play system	Governed relation among narrative, form, motion, material, manufacture, user action, package, market, record, and memory.
Provenance	Evidence-backed history of design, manufacture, edition, unit, ownership, repair, and representation.
Sample hierarchy	Ordered physical evidence from concept through retained production reference, each with a defined question and authority.
Variant	A documented difference within a product lineage; its relation to edition, running change, or error must be explicit.

APPENDIX Z

Complete Obsidian Veil 3.75-Inch Figure Case Study

THE SMALL STEWARD

The garment becomes armor, the memory becomes a mark.
Five hinges carry a world larger than the figure.
Keep the silhouette clear and the lineage deeper;
the simplest artifact may hold the most disciplined system.

This case study translates the Obsidian Veil visual system and the preceding framework into one controlled product-development path.

Z.1 Controlled case-study status

The Obsidian Veil Operative is the first end-to-end application of the framework. It translates the Raven Valley Veil garment system into a compact figure while preserving the vintage five-point articulation grammar. All dimensions, material grades, torque bands, process windows, age grading, and regulatory conclusions below are **development proposals** until supplier review, engineering calculation, representative samples, laboratory testing, and jurisdictional release establish them. The case study is not authorization for bulk production.

CASE-STUDY RELEASE STATUS: DEVELOPMENT REFERENCE - NOT SAFETY CERTIFIED - NOT TOOLING RELEASED - NOT BULK AUTHORIZED.

Z.2 Canonical product record

Field	Development record
Product ID	RVV-OV-AF-001
Character ID	RVV-OV-CHAR-001
Name	Raven Valley Obsidian Veil Operative
Format	3.75-inch / 95.25 mm nominal action figure
Articulation	5 points: head swivel, left/right shoulder swivels, left/right hip swivels
Design intent	Vintage 1980s silhouette clarity with contemporary controlled surface detail
Visual hierarchy	Obsidian black primary; graphite structure; dark leather brown; restrained copper and silver accents
Narrative role	Field-ready steward and systems operative equipped for repair, reconnaissance, and environmental passage
Package route	Vintage-inspired carded blister with modern safety, traceability, and provenance fields
Status	P-class development case study; no production or safety claims

Z.3 Narrative-to-form translation

Narrative property	Formal and manufacturing consequence
Stewardship	Repair satchel, data slate, visible service seams, replaceable accessory logic.

Narrative property	Formal and manufacturing consequence
Readiness	Upright stance, accessible hands, stable feet, high-contrast face/hood focal center.
Mystery	Recessed face plane, hood shadow, restrained negative space rather than unsafe sharpness.
Ancient technology	Layered plates, repeated copper pathways, engraved interface marks, controlled wear.
Mobility	Coat tails separated around hip arcs; shoulder silhouettes clear of arm rotation.
Material truth	Molded, painted, textile, and metallic-looking features clearly distinguished in the BOM.
Functional filigree	Ribs stiffen thin tails, copper paths divide paint masks, pack geometry conceals attachment.

Z.4 Text-only turnaround and articulation map

Text Diagram. Obsidian Veil figure system

```
FRONT                        SIDE                          REAR
       [H01 HOODED HEAD]             [H01]                      [H01]
           (J01)                     (J01)                      (J01)
    [A-L]--[T01 TORSO]--[A-R]       [T01]                [PACK PORT / P01]
      J02       |       J03       J02/J03                      |
                |                 shoulder arc           [T02 BACK SHELL]
          [HIP BAR / T03]               |                      |
           J04       J05              [LEG]                J04       J05
         [L-L]       [L-R]                                    [L-L] [L-R]
            \         /                                        \   /
          [GROUND CONTACT]                                   [GROUND CONTACT]

DOF: J01 yaw; J02/J03 shoulder rotation; J04/J05 hip rotation.
NO elbow, wrist, waist, knee, ankle, or ball-joint claim in baseline.
```

Audio description: Front, side, and rear definitions identify five swivel joints and the main part groups; all other body regions are rigid in the baseline.

Z.5 Proposed part architecture

Part ID	Part / role	Proposed process and interface
H01	Hooded head core	Fine-detail molded part; J01 swivel socket or neck peg; face paint protected from insertion fixture.
T01/T02	Torso front and back	Rigid shell halves; capture shoulder and hip interfaces; permanent join selected after DFM.
A01/A02	Left and right arms	Single-piece arms with shoulder peg; hands integral for vintage simplicity.
L01/L02	Left and right legs	Single-piece legs with hip pegs; enlarged feet for stable display.
C01	Coat-tail shell or soft overlay	Split rear/front tails clear hip arcs; molded flexible or controlled textile route.
P01	Modular field pack	Removable or captured depending age route; keyed attachment; accessory storage study.
AC01	Field instrument	Blunt fantasy reconnaissance tool; hand-grip and package-retention interface.
AC02	Data slate	Flat symbolic information object; optional passport token; small-parts review.
AC03	Repair satchel / tool roll	Narrative utility accessory; flexible or rigid route after hazard and deformation review.
PK01	Card and blister system	Printed SBS card plus PET/rPET blister or qualified alternative.

Z.6 Development dimensions and joint targets

The following values are starting hypotheses for comparative prototypes, not production requirements. They intentionally use ranges because polymer grade, colorant, moisture, temperature, tool finish, gate location, part geometry, and assembly history materially change fit and torque.

Characteristic	P-class starting target	Verification
Overall height	95.25 mm nominal; exact height controlled after sculpt and package review.	CMM or calibrated height gauge after conditioning.
Head yaw	At least approximately 60 degrees each side unless hood collision intentionally narrows it.	Cycle and collision map.
Shoulder rotation	Nominal continuous swivel with sculpt-defined hard stops.	Angle, torque, paint-rub, and pull-off tests.
Hip rotation	Nominal standing-to-seated arc sufficient for selected vehicle/creature interface.	Pose envelope and seating buck.
Diametral / interface clearance	Initial CAD study 0.15-0.30 mm where a running clearance is intended; not universal.	Tool-sample dimensional and functional study.
Joint torque class	Head/shoulders approximately 0.015-0.035 N m; hips approximately 0.020-0.050 N m as comparative targets only.	Defined torque fixture, temperature, conditioning, cycle count.
Development cycling	Minimum 500 controlled cycles for early comparison; final protocol based on risk and intended use.	Pre/post torque, fracture, whitening, rub, pop-off.
Ground stability	Unaided standing on declared reference plane in approved neutral pose.	Tip and center-of-mass study with accessories.

Z.7 Proposed material stack

Zone	Candidate material strategy	Primary risks and gates
Torso	ABS or qualified HIPS/rigid polymer selected for dimensional stability, weld/join process, paint, and impact.	Stress cracking, sink, weld strength, paint adhesion, restricted substances.
Head / arms / legs	Qualified flexible PVC or alternative TPE/TPU route for insertion and tactile resilience; exact grade required.	Plasticizer migration, creep, paint transfer, torque drift, odor, chemical compliance.
Joint carrier / pin	Integral compatible peg or qualified acetal/engineering-resin insert where function justifies complexity.	Low surface energy, interference stability, moisture, wear debris.
Coat tails / hood overlay	Thin flexible molded part or textile soft good; choose one controlled baseline.	Hip collision, tearing, fray, dye transfer, small-parts detachment.
Accessories	ABS, PP, TPE, textile, or metal-like polymer selected by stiffness, deformation, safety, and paint needs.	Sharpness, loss, grip stress, chemical contact, magnet prohibition unless fully assessed.
Package	SBS card with PET/rPET blister or qualified recyclable structure.	Seal, curl, scuff, plastic contact, archival aging, opening experience.

Z.8 Paint and decoration plan

The baseline should preserve an eighties-style economy of operations. Detail is produced through sculpted form, molded color, selective metallic accents, and one precise identity operation rather than dense all-over weathering.

Operation	Proposed treatment	Control
Molded base	Obsidian black torso and major body parts.	Color master and lot record.
Graphite break	Selective armor / cloth differentiation in dark gray.	Mask or controlled pad/spray operation.
Leather brown	Straps, pack, belt, boot or glove zones.	Registration and rub risk.
Copper accent	Filigree paths and hardware; metallic appearance restrained.	Orientation, film, mask, adhesion.
Silver accent	Service marks, buckles, small focal details.	Avoid excessive competition with face.

Operation	Proposed treatment	Control
Face / visor	Minimal eyes, visor, or shadow plane according to approved identity.	Pad-print datum and approved master.
Clear / finish	Only where required for rub or gloss control.	No joint lock or unintended sheen.

Z.9 Accessory and intended-use routes

Two routes are evaluated early rather than relabeling the same design late. A children's toy route requires age grading, hazard analysis, testing, certification, durable accessory retention, and marketing consistent with actual play. A collector route does not create a loophole: foreseeable use, presentation, design, and jurisdiction still govern. Accessories are simplified, blunt, and narratively functional.

Route	Accessory policy	Package / record consequence
Route A - children's toy	Remove or enlarge detachable small parts where needed; no accessible magnets; blunt tools; robust retention and abuse testing.	Age grading and warnings based on evidence; applicable toy testing and certification.
Route B - 14+ collector product	May retain finer removable accessories where legally and ethically appropriate; still evaluate foreseeable handling and breakage.	Clear collector positioning without false safety implication; provenance and edition detail expanded.
Shared baseline	Field instrument, data slate, repair satchel/pack, removable hood only when retention and hazard review permit.	Every included item receives part ID, material, package location, inspection, and replacement policy.

Z.10 Packaging concept

Text Diagram. Vintage card hierarchy

```
+-------------------------------------------------+
| RAVEN VALLEY VEIL                               |
|                 OBSIDIAN VEIL OPERATIVE         |
|  [HERO ART / CATHEDRAL FIELD]  [CLEAR BLISTER]  |
|                              [FIGURE][TOOLS]     |
|  simple nameplate / series mark / age route     |
+-------------------------------------------------+
| BACK: compact lore -> series grid -> functions  |
|       passport / product ID -> warnings/legal   |
|       material + repair + provenance statement  |
+-------------------------------------------------+
```

Audio description: The front emphasizes series, character, hero art, figure, and accessories; the back orders lore, series relationships, passport, safety, and traceability.

- Provisional card size: 6 by 9 inches for layout study; final size follows blister, retail, transport, and print review.
- Use a bold black field, restrained copper/silver accents, strong nameplate, and limited type hierarchy.
- Series grid identifies real planned or released products; silhouettes or future concepts are labeled as such.
- QR or NFC may link to the passport but does not replace on-package legal and traceability information.
- No false production count, artificial stock alarm, concealed reissue, or unmarked package revision.

Z.11 Prototype, tooling, and production route

Text Diagram. Obsidian Veil development route

```
BRIEF -> SILHOUETTES -> TURNAROUND -> 3D APPEARANCE SCULPT
  -> FIVE-JOINT / PART-BREAK MODEL -> PRINTED APPEARANCE SAMPLE
  -> JOINT COUPONS + ENGINEERING PROTOTYPE -> MATERIAL / PAINT TESTS
  -> PACKAGE BUCK -> DFM -> TOOLING QUOTE -> T0 / T1 SAMPLES
  -> PREPRODUCTION SAMPLE -> PILOT LOT -> TOP RELEASE
  -> CATALOG / PASSPORT / DISTRIBUTION -> FEEDBACK / REPAIR / REISSUE
```

Audio description: The case moves through controlled art, engineering, prototype, material, package, tooling, sample, production, and lifecycle gates.

Z.12 Quality and release plan

Control area	Development checks	Release evidence
Identity / appearance	Silhouette, focal hierarchy, paint registration, surface and package comparison.	Approved appearance and paint masters.
Dimensions / assembly	CTF dimensions, part orientation, join integrity, gate/ejector witness acceptance.	Drawings, measurement record, sealed sample.
Motion	Range, torque, cycling, rub, stress whitening, pull-off/pop-off, pose retention.	Joint test report by material lot and sample stage.
Material / chemistry	Supplier identity, contact matrix, paint/adhesive, restricted substances, aging plan.	Material passports and applicable laboratory reports.
Safety / intended use	Small parts, sharp edges/points, pinch/entrapment, abuse, labeling, market scope.	Qualified compliance review and market-specific test/certification file.
Package	Seal, retention, scuff, curl, transport, barcode and traceability, opening.	Golden package and distribution test record.
Provenance	Versions, run, factory, paint, package, accessories, deviations.	Seed passport and catalog release.

Z.13 Variant, reissue, and repair policy

- **Colorway:** records changed molded colors and paint operations; package and passport identify it.
- **Running change:** allowed only through change control; collector-relevant differences are published.
- **Tool repair or resculpt:** creates a tool/sculpt version and compatibility note.
- **Reissue:** is labeled as a reissue even when packaging evokes the original release.
- **Repair:** replacement hood, pack, accessory, or joint service is recorded; restored units are not represented as untouched.
- **Counterfeit resistance:** relies on layered evidence - mold marks, package details, run records, and provenance - not a single hidden gimmick.

Z.14 Seed passport

```
UNIT SERIAL: [assigned at run]
PRODUCT: RVV-OV-AF-001
EDITION: ED-BASE-01
SCULPT: SCULPT-v1.x
TOOL: TOOL-[pending]
MATERIAL STACK: [approved passport IDs]
PAINT: PAINT-v1.x
PACKAGE: PKG-v1.x
RUN / FACTORY / DATE: [pending]
ACCESSORIES: AC01 / AC02 / AC03 / P01 / optional C01
DEVIATIONS: [none or linked CR]
OWNERSHIP / REPAIR EVENTS: append-only
```

```
AUTHENTICATION CONFIDENCE: field-specific
STATUS: prototype | pilot | released | repaired | retired
```

Z.15 Case-study conclusion

The Obsidian Veil figure succeeds only when the vintage visual grammar, modern detail, five-point movement, material stack, accessory logic, packaging, testing, catalog record, and future repair all describe the same object. Its apparent simplicity is not the absence of engineering. It is the visible result of disciplined reduction.

Case-study evidence class. E for cited safety, material, drawing, additive, quality, and systems-engineering precedents; S for translating the Raven Valley Veil and Opus governance into figure development; P for the specific dimensions, joint targets, material candidates, styling rules, and Obsidian Veil product architecture. Every P-class value requires prototype and production validation.

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A claim without a source may still be true,
but it cannot yet govern another hand.
Let every bridge show where its stone was quarried,
and every future builder know which ground to test again.

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Canonical Release Record

THE BOOK ENTERS MEMORY

A version is a door closed carefully, not a tomb.
Record what entered, what remained unknown, and who may reopen it.
The future may revise the rule without denying the past;
lineage is how correction keeps its honor.

Field	Record
Title	THE RAVEN VALLEY PLAY SYSTEM
Subtitle	A Parametric, Material, Mechanical, Narrative, Manufacturing, Collectible, and AI-Governed Framework for Figure Series and Play Objects
Authors	Noel Michael Conrad and OpenAI
Version	White Paper - Corpus Synthesis, Manufacturing Primer, Training Specification, and Governed Production Framework, Version 1.0
Date	2 Aug. 2026
Primary project sources	Raven Valley Veil; Opus Core Framework; Weaving Understanding; Visual Equations; Unified Web Design Codex; Fun for Everyone; Cards; Physishop-adjacent inventory, commerce, and wholesale papers; user-supplied outline.
Evidence policy	MLA-style citations; primary and official sources preferred; E/S/P/X claim classes; current-edition recheck required before deployment.
Diagram policy	Text-only diagrams and equations for audiobook and screen-reader translation.
Canonical status	Version 1.0. Future revisions preserve lineage, compatibility, supersession, and negative findings.
Release limitation	Human review remains required for safety, material, engineering, cultural, legal, manufacturing, market, and regulatory claims.

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