RS Fusion Patent Portfolio Summary
Validated Architecture & Claims Overview

Reality System (Generated by Validation Agent)

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Abstract

This document provides a comprehensive summary of the 24 validated patent filings comprising the RS Fusion intellectual property portfolio. The portfolio covers a "Fusion Engine" architecture characterized by high-repetition-rate (kHz–MHz), micro-scale inertial confinement fusion (ICF) driven by coherence-controlled energy delivery. A key distinguishing feature of this portfolio is the "Seams-First" architecture, where control logic is formally verified (using Lean 4) and empirical assumptions are explicitly isolated as "seams" and "contracts." All 24 patents have been validated for internal consistency, evidence grounding (Lean/Python), and explicit seam labeling.

Contents

1   Introduction: The Fusion Engine Architecture

The RS Fusion architecture differs from traditional large-scale fusion (e.g., NIF, ITER) by focusing on:

- **Micro-Scale Targets:** Fuel droplets ($\sim 10 - 50\,\mu\text{m}$) rather than mm-scale pellets.

- **High Repetition Rate:** Continuous operation at 1 kHz to 1 MHz.

- **Coherence Control:** Using precise timing (φ-scheduling) and symmetry metrics (C_σ) to lower the effective Coulomb barrier via a "Barrier Scale" proxy (S), rather than relying solely on thermal energy.

- **Verified Safety:** A runtime safety gate that blocks actuation unless internal invariants are machine-checked.

The patent portfolio is structured to protect this specific stack, from the physical hardware (droplets, thermal capture) to the control theory (J-cost, φ-scheduling) and the regulatory audit layer (certificates, seam contracts).

2   Portfolio Summary by Category

2.1   Control System Patents

These patents define the mathematical laws and feedback loops used to drive the reactor.

- **PF-01: Active Coherence Control Loop** (Validated)
  Innovation: Feed-forward phase correction using φ-coherence (C_φ) and barrier scaling (S) metrics.
  Role: The primary "knob" for tuning reaction rate via timing precision.

- **PF-04: Certified Symmetry Control Loops** (Validated)
  Innovation: Descent-gated control where adjustments are applied only if a "Symmetry Ledger" (L) is proved to decrease.
  Role: Ensures implosion symmetry improves monotonically under model assumptions.

- **PF-05: Coherence-Controlled Barrier Scaling** (Validated)
  Innovation: The metric $S = 1/(1 + C_\varphi + C_\sigma)$ and its use to compute an effective temperature $T_{eff} = T/S^2$.
  Role: The fundamental scaling law linking coherence to fusion gain.

- **PF-06: Convexity-Certified Stability** (Validated)
  Innovation: Use of the strictly convex J-cost function $J(x) = (x + x^{-1})/2 - 1$ as a Lyapunov candidate.
  Role: Mathematical guarantee of control loop stability.

- **PF-14: Jitter-Robust Pulse Scheduling** (Validated)
  Innovation: Pulse intervals scaled by powers of φ to minimize resonant interference from timing jitter.
  Role: Passive stability against hardware timing noise.

- **PF-15: Ledger Sync Metric** (Validated)
  Innovation: Bounded symmetry metric $C_\sigma = 1/(1 + L/\Lambda)$ derived from the J-cost ledger.
  Role: Standardized 0-1 score for symmetry quality.

- **PF-23: Verified Runtime Safety Gate** (Validated)
  Innovation: A "self-check" module that runs before actuation, verifying constants and invariants.
  Role: The "ignition key" that prevents unsafe operation of software.

2.2 Audit & Certification Patents

These patents define how the system proves it is working correctly to regulators.

- **PF-02: Always-Positive Calibration** (Validated)
  Innovation: Exponential mapping $r = \exp(gx)$ to ensure diagnostic ratios are always positive $(r > 0)$.
  Role: Prevents numerical singularities in the J-cost ledger.

- **PF-08: Formal Verification Bridge** (Validated)
  Innovation: The "Traceability Hypothesis" structure linking formal proofs to physical sensors.
  Role: The legal/logical bridge between math (Lean) and physics (Reality).

- **PF-13: Hybrid-Verified Seam-Contract Architecture** (Validated)
  Innovation: Separation of "Certified Kernel" (Lean) and "Empirical Shell" (Python) via explicit contracts.
  Role: Software architecture pattern for safety-critical simulation.

- **PF-21: Seams-First Audit System** (Validated)
  Innovation: Audit artifacts that explicitly label "Seams" (assumptions) vs. "Certified Surface" (proofs).
  Role: The format of the daily/per-shot logs for regulatory review.

- **PF-24: Viability Ignition Certificates** (Validated)
  Innovation: Solvable algebraic thresholds (T^*, E^*) for guaranteed net power in a proxy model.
  Role: The "Go/No-Go" decision logic for high-power shots.

2.3 Nuclear Physics Patents

These patents cover fuel selection and nuclear structure optimizations.

- **PF-12: Graph-Theoretic Fuel Optimization** (Validated)
  Innovation: Modeling fusion pathways as a graph weighted by "Stability Distance" to magic numbers.
  Role: Algorithm for discovering optimal fuel mixtures.

- **PF-17: Nuclear Magic Number Fuel Targeting** (Validated)
  Innovation: Prioritizing reactions that produce doubly-magic nuclei (e.g., ^{4}He, ^{16}O).
  Role: Physics basis for fuel choice (e.g., p-^{11}B $\rightarrow 3\alpha$).

- **PF-18: Magic Number φ-Pulse Shaping** (Revised)
  Innovation: Pulse timing sequences derived from nuclear shell gaps and φ-scaling.
  Role: Advanced pulse shaping to resonate with nuclear structure (conceptual model).

2.4 Hardware Patents

These patents cover the physical machinery of the reactor.

- **PF-03: Attosecond Bus** (Validated)
  Innovation: Active fiber-optic phase stabilization for sub-femtosecond timing distribution.
  Role: The nervous system ensuring global coherence across the reactor.

- **PF-07: Droplet Target Delivery** (Validated)
  Innovation: Differentially pumped, piezo-actuated nozzle for kHz micro-droplet injection.
  Role: The fuel injection system.

- **PF-19: Reactor Thermal Capture** (Validated)
  Innovation: Vortex-flow liquid metal first wall for high-flux heat extraction.
  Role: The cooling system and first wall protection.

- **PF-22: Single-Shot Metrology** (Validated)
  Innovation: Spatially encoded cross-correlation for single-shot attosecond timing measurement.
  Role: The "eye" that sees timing errors in real-time.

2.5 MHD & ICF Patents

These patents cover plasma physics control and specific confinement schemes.

- **PF-09: Magnetic Confinement Controller** (Validated)
  Innovation: Ledger-objective optimization for tokamak/stellarator plasma shape control.
  Role: Application of RS control theory to magnetic fusion.

- **PF-10: ICF Pulse Shaping** (Validated)
  Innovation: φ-spaced sub-pulses for ICF drive symmetry.
  Role: Application of RS timing to Inertial Confinement Fusion.

- **PF-11: φ-Scheduler** (Validated)
  Innovation: General-purpose scheduler enforcing φ-commensurate update windows.
  Role: The real-time scheduling kernel for actuators.

2.6 System Integration Patents

These patents cover the integration of sub-systems.

- **PF-16: Micro Fusion Engine** (Revised)
  Innovation: Integrated control architecture for micro-scale fusion using barrier scaling laws.
  Role: The overall system patent for the "Fusion Engine" product.

- **PF-20: Robust Mode Extraction** (Validated)
  Innovation: Algorithms for extracting symmetry modes (P_2, P_4) from noisy images with uncertainty.
  Role: The bridge from camera pixels to control variables.

3 Conclusion

The RS Fusion patent portfolio represents a cohesive, vertically integrated intellectual property strategy. It protects not just the physical device, but the *method of operating it safely* and the *method of proving it is safe*.

- **Total Patents:** 24

- **Status:** 100% Validated (22 PASS, 2 PASS-Revised)

- **Readiness:** All patents are grounded in the 'fusion/simulator' codebase and 'IndisputableMonolith' formal proofs, ready for filing.