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Deterministic Harnesses for Development & Marketing A

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1. Why Unbounded Agent Loops Fail in Production

Large language models are extraordinary high-dimensional synthesis engines, but they are **stochastic proposal generators, not deterministic state machines**. Whether you are building an agentic pipeline for **software development** (shipping code from spec to commit) or for **marketing and GTM operations** (automated market discovery, lead enrichment, and campaign execution), wiring an LLM directly to write-capable production APIs in an unconstrained loop leads to three predictable failure modes:

1. **Context Drift & Compaction Loss**: Over long trajectories, attention dilution causes the model to drop earlier safety constraints or schema invariants.
2. **Non-Idempotent Retry Amplification**: When a tool call partially succeeds and returns an ambiguous timeout, a naive agent retries the mutation, creating duplicate CRM records, duplicate outreach emails, or corrupted database state.
3. **Prompt Injection Across Trust Boundaries**: Untrusted input read from a scraped webpage, ticket, email, or database row can hijack the agent's control flow if authorization lives in the system prompt rather than the transport layer.

2. The Supervisor-Coroutine Architecture

In the **Atlas Agent Gateway**—which powers both our autonomous engineering pipelines and our Beacon marketing/GTM pipelines—we invert the control loop: **the Rust runtime owns the state machine, and the LLM is invoked as a bounded, stateless coroutine**.

Every autonomous task is modeled as an explicit finite-state machine with typed transitions:

rust

```
pub enum AgentTurnOutcome<T> {
ProposeToolCalls(Vec<ValidatedToolCall>),
ReadyToCommit(ArtifactBundle<T>),
EscalateForHumanApproval(ApprovalRequest),
AbortWithDiagnostic(InvariantViolation),
}
```

The model cannot mutate external state directly. It can only emit structured tool proposals that the supervisor validates against three deterministic gates before execution:

Gate 1: Transport-Layer Capability Scoping

Authorization never depends on telling the model *"do not access other tenants."* When an agent session is minted (`atlas_agent_key` and `atlas_agent_grant`), its cryptographic bearer token is bound to a specific `tenant_id`, an explicit allowlist of MCP/WebMCP tool identifiers, an IP allowlist, and a maximum cost/mutation budget. Cross-tenant or ungranted tool calls are rejected at the gateway before the handler is invoked.

Gate 2: Idempotency Keys & Dry-Run Diffs

Every mutating tool contract requires a deterministic idempotency key derived from `(agent_session_id, step_index, target_entity_id)`. Before applying schema changes, code edits, CRM updates, or domain provisioning jobs, the supervisor computes a structural diff and