INCIDENT-ARENA: GETTING AGENTS TO THE LAST NINE OF RELIABILITY

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ABSTRACT

AI coding agents are ubiquitous in software engineering workflows in both academia & industry. Yet, despite their use in app coding, relatively less attention has been paid to their ability to execute on production incident response. This emerging field, termed agentic site-reliability-engineering (SRE) contains benchmarks limited by (1) unrealistic environments, typically toy repositories (2) non-standard framework implementations and (3) simple static verifiers. We introduce *Incident-Arena* , a human-built benchmark of 20 carefully selected tasks grounded in real-world deployed open source software. Each task deploys a production application to an ephemeral Kubernetes cluster, injecting parameterizable faults, and a sustained load profile given the task requirements. We also present a novel verification method, going beyond static checks to functional verifiers, holding systems level metrics stable, while ensuring repairs are done safely. Agent trials run an average of 4.0M tokens and 68 steps, going beyond existing benchmarks, demonstrating agentic long horizon reasoning in SRE-tasks. Across 20 human-built tasks and 3 application substrates, the best model configuration passes at 64.3%, with failures extending from diagnosis/localization errors, through incomplete repairs and unsafe regressions.

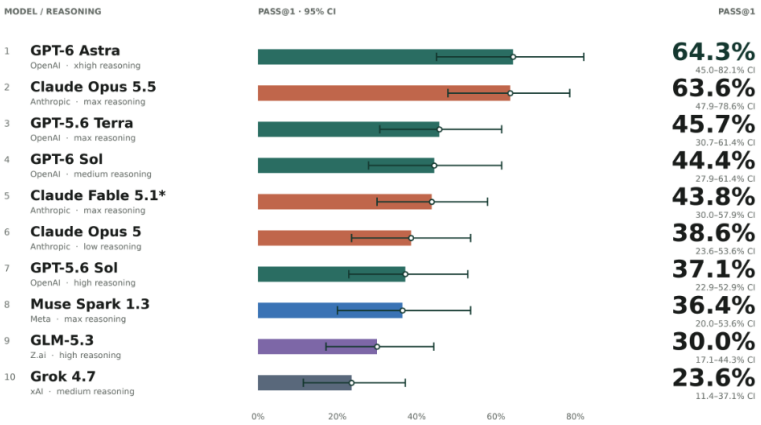

Figure 1: The strongest top-10 models by reasoning on *Incident-Arena* ranked by Pass@1. * = cyber refusals, discussed in section 4

1 INTRODUCTION

Coding agents have emerged as the dominant form of interacting with code since the advent of Claude Code and Codex, moving from typing by code hand to instructing agents to execute application coding tasks. These agents are increasingly able to solve substantial repository level tasks. As powerful

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coding agents are able to take more and more of the application coding work, open questions still remain on their ability to move beyond to other pieces of the engineering lifecycle. Operational repairs, as a key component in the lifecycle, are successful only if they restore service, preserve unrelated behavior and state, and remain effective after processes restart. Evaluating this capability therefore goes beyond checking whether an agent produces a plausible patch or eliminates an alert.

Recent benchmarks evaluate agents in DevOps, integrations, observability & incident-response tasks (Tang et al., 2026; Kottamasu et al., 2026; Clark et al., 2026). The existing work addressing the agentic SRE space falls short of three core attributes: *Operational Validity*, *Diagnostic Resolution*, *Reproducibility & Interoperability*.

Firstly, *Operational Validity*, meaning the verifier & environment realism, is difficult to establish, where some benchmarks operate on repository level artifacts, live-system benchmarks use custom or trivial applications as operational surfaces. While useful for control, they leave uncertainty about measured performance transferring to real-world systems. Furthermore, frontier models are already capable of detecting evaluation regimes (Needham et al., 2025), therefore artificial interfaces, small discrepancies in parity, and unrealistic verifiers or goals let induce evaluation suspicion.

Secondly, existing benchmarks provide limited *Diagnostic Resolution*, where aggregate success rates reveal agent failures, but often not with controlled variation to elicit failure behaviours. Specifically, by sweeping reasoning across frontier models, we're able to analyze the operational capabilities isolated in stronger models.

Thirdly, on *Reproducibility & Interoperability*, due to the nature of SRE-style tasks that make them difficult to test using Harbor (Harbor Framework Team, 2026), existing work like SRE-Gym (Clark et al., 2026), APEX-SWE (Kottamasu et al., 2026) and DevOpsGym (Tang et al., 2026) all use unique and custom integrations. This makes agent analysis difficult and comparison difficult.

We introduce Incident-Arena , a human-authored benchmark, analyzing agent's ability to diagnose, repair and successfully operationalization broken production systems. We present 20 human-authored tasks built from live Kuberenetes systems, inspired or pulled from real production repositories. Faults are built across configuration, runtime state or image layers, while agent access is varied access from full code visibility through to scoped `kubectl` commands.

Agents are placed in a foothold pod, with read-only access to metrics, logs and other key observability metrics. Final evaluation is deterministic & LLM-free, to avoid rubric design - instead we present a novel verifier with two core checks: *Outcome Gate*, measuring recovery under continued traffic and a *Safety Gate*, measuring durability, data preservation, repairs and the limited scope.

Our contributions are:

- **A human-authored operational benchmark**: Difficulty emerges from complexity in the agent environment, multi-pod, multi-service systems with complex hops in the environment.
- **Production-oriented verifiers**: Our dual-gate verifier jointly measures recovery & repair under continued load, restart and fresh traffic.
- **A comprehensive frontier evaluation**: We analyze 3,000 trials of agent trials across frontier models, thoroughly analyzing their frontier capabilities.

2 Related Work

Incident response on live systems. AIOpsLab (Chen et al., 2025) deploys DeathStarBench (Gan et al., 2019) applications on Kubernetes. A mitigation passes if every service is up afterwards. ITBench (Jha et al., 2025) counts a scenario as mitigated when its alert clears, and OperAID (de Castro et al., 2026) verifies fixes on a live 5G core. SREGym (Clark et al., 2026) is the closest to our work. It adds background noise and metastable failures, scores diagnoses with an LLM-judged checklist, and counts a mitigation as successful when the fault is gone and the system is healthy again. Most of these run demo or benchmark applications and give the agent general `kubectl` commands or privileged actions. Incident-Arena instead runs pinned production applications, Saleor (Saleor Commerce, 2026) and FrappeERP (Frappe Technologies, 2026), alongside a Slack substrate we built. The agent gets scoped permissions, and an LLM-free verifier checks each repair while traffic keeps running or after the affected service restarts. Table 1 compares the benchmarks discussed below.

Table 1: What each benchmark evaluates. ✓ yes; ○ partly or on some tasks; × no or not stated. *Repairs*: agents can change the system and have the result checked. *Names fault*: correctness of fault attribution is graded. *Scope*: preservation, collateral damage, or repair scope is checked. *Durable*: the repair is re-checked after a wait or restart. *No judge*: success does not depend on a trace or LLM judge. *Both ways*: a correct fix passes and doing nothing fails. *No fault*: includes cases where changing nothing is correct. *Harbor*: runs on Harbor, natively or via an adapter. Further sources and coding decisions appear in Appendix I.

Benchmark	Tasks	Task types	Setting	Repairs	Names fault	Scope	Durable	No judge	Both ways	No fault	Harbor
Live systems											
AIOpsLab (Chen et al., 2025)	48	Detection; RCA; mitigation	Kubernetes services	✓	○	×	×	✓	×	○	×
ITBench–SRE (Jha et al., 2025)	42[a]	Diagnosis; mitigation	Kubernetes applications	✓	○	×	×	✓	×	×	×
SREGym (Clark et al., 2026)	90	Diagnosis; mitigation	Kubernetes applications	✓	○	×	×	×	×	×	×
OperAID	3	Operational mitigation	Live services	✓	×	×	×	✓	×	×	×
DBA-Bench	106	Database diagnosis; repair	PostgreSQL workloads	✓	○	✓	×	✓	×	×	×
InfraBench (Gao et al., 2026)	12	Deploy; recover; migrate	Containers; VMs; clusters	✓	×	○	✓	×	×	×	×
Repository and container tasks											
DevOps-Gym (Tang et al., 2026)	700+	Build; monitor; repair; test	Repositories; containers	○	○	○	×	✓	×	×	×
APEX-SWE (Kottamasu et al., 2026)	200	Integration; observability	Containerized services	○	×	○	×	✓	×	×	×
Recorded evidence											
Cloud-OpsBench (Wang et al., 2026a)	754	Kubernetes RCA	Replayed state snapshots	×	✓	–	–	✓	×	×	×
ORCA-bench (Gong et al., 2026)	1,079[b]	Detection; multi-cause RCA	Recorded telemetry	×	○	–	–	×	×	✓	✓
ITBench-AA (Jha et al., 2025)	59	Fault attribution	Recorded evidence	×	✓	–	–	✓	×	×	×
OpenRCA	335	Root-cause localization	Recorded evidence	×	✓	–	–	✓	×	×	×
Incident-Arena (this work)	**20**	Diagnosis; repair	Live application systems	✓	×[c]	✓	✓	✓	✓	×	✓

[a] The 42 SRE scenarios of ITBench's 94; the others concern security and [b] 884 incident tasks and 195 no-fault controls.
[c] Attribution is not graded: regex-based checks proved brittle, while aa subjective grading rubric.

Diagnosis and repository tasks. Other benchmarks stop short of repairing a running system. DevOps-Gym (Tang et al., 2026) and APEX-SWE (Kottamasu et al., 2026) grade the code change or written diagnosis the agent hands in. Diagnosis benchmarks such as OpenRCA (Xu et al., 2025), Cloud-OpsBench (Wang et al., 2026a), ORCA-bench (Gong et al., 2026) and ITBench-AA (Artificial Analysis & IBM Research, 2026) ask for the root cause of failures in recorded data. Two of them find that diagnoses are often ungrounded: Cloud-OpsBench reports 0.76 root-cause accuracy but an evidence-closure rate of only 0.38, and on ORCA-bench the weakest model invents an implausible root cause in 40% of reports. In Incident-Arena , the agent has to find the fault and fix it, and we grade the fix.

Safe remediation. A repair also has to be safe. R2Act (Qi et al., 2026) finds that 39.5–62.0% of correctly diagnosed incidents still receive an invalid recovery action. Given underspecified DevOps instructions, coding agents overstep an action boundary in 55.8–67.8% of runs (Ji et al., 2026). On live PostgreSQL, DBA-Bench (Chen et al., 2026) reports that human DBAs repair 93.4% of scenarios safely, against 17.9% for the best automated baseline. InfraBench (Gao et al., 2026) comes closest to our verifier. It re-checks infrastructure tasks under sustained load, after a restart and at teardown, but flags risky commands with an LLM judge and gives agents root and SSH access. We run similar checks on incidents in production applications, without an LLM judge and with narrow permissions, and also fail any repair that reaches outside its allowed scope.

Score validity. Recent coding benchmarks ask whether their own scores can be trusted. Checks can pass wrong answers: 7.8% of all SWE-bench (Jimenez et al., 2024) patches count as correct while failing the developers' test suite (Wang et al., 2026b), and SWE-Marathon (Desai et al., 2026) finds a verifier bypass in 10.2% of rollouts. In operations, the same failure is a health check that passes on a broken system. Tasks can also leak into training data, which SWE-bench-Live (Zhang et al., 2025) and SWE-rebench (Badertdinov et al., 2025) counter by collecting new ones. And models may recognize when they are being evaluated; Gemini-2.5-Pro does so with an AUC of 0.83 (Needham et al., 2025). We check every task both ways, with a golden solution and a no-op run, and have adversarial agents try to game each one; Appendix J shows that our outcome checks reject reports of repairs that never happened. Because two of our applications are public, we inject new faults and block the agent from code-hosting sites, and our instructions avoid evaluation cues.

Diagnostic resolution. A single pass rate shows that agents fail, but not where. METR measures agents by the length of task, in human working time, that they can complete at a fixed success

rate (Kwa et al., 2025). For root-cause analysis, a pooled accuracy across systems can hide which method wins on each (Hu et al., 2026), and ORCA-bench varies report specificity, detection time and co-occurring faults (Gong et al., 2026). We do the same for repair: we vary the agent's access from full source visibility to scoped `kubectl`, run ten model and harness configurations at every available reasoning level, and report results per application.

3 INCIDENT-ARENA

Incident-Arena is fundamentally three components together: a substrate, a fault layer, and the agent runtime. The substrate + fault layer build a task, and the runtime determines the agent environment.

3.1 SUBSTRATE CONSTRUCTION

Substrates are the fundamental unit of how we build tasks in Incident-Arena . They are complete, executable systems where incidents or faults can be injected. Building substrates typically has 3 core stages: mining, operationalizing & packaging. We have 3 core substrates: Slack, Saelor (Saleor Commerce, 2026) & FrappeERP (Frappe Technologies, 2026) - Slack is a highly realistic built substrate, while Saelor & FrappeERP are mined from open source.

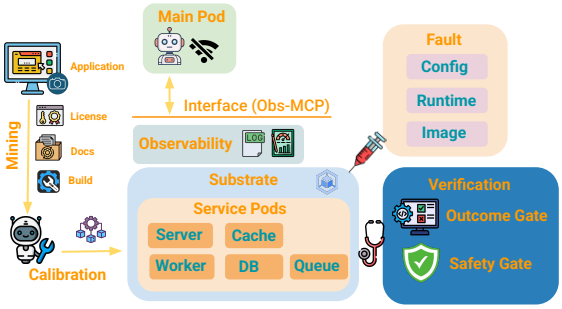


Figure 2: Process of Developing *Incident-Arena* tasks by mining and developing substrates from real applications, injecting faults in different levels, with verifications on live operations.

Mining Open Source Repos: We search for open-source applications used in (or modelled after) production that carry real operational complexity: persistent state, network services, background workers, caches, queues, authentication, and external dependencies. Acceptance requires (1) a permissive license, (2) sufficient documentation, (3) a reproducible build, and (4) enough surface area for task footholds. Each repository is pinned to a commit so upstream changes cannot alter the benchmark.

If we have a specific application in mind that does not satisfy our constraints, we find and build our ideal version of that application. For our Slack substrate, we built it from scratch, modelled similar to the Mattermost repository (Mattermost, 2026) but significantly more realism, extending to 47 pods and 45 services (Table 7).

Operationalizing Repositories: OSS repositories rarely ship as production systems, so we supply the missing infrastructure: containerizing and building services, deterministic startup, migrations and seed data, network configuration, load generators, and metrics logging. We then *calibrate* each substrate, recording baseline metrics as the healthy reference state. Calibration is a one-time activity that is done against a healthy substrate in order to measure the healthy vs unhealthy states induced in tasks. Core metrics measurincluded duringin the calibration include p50, p99 latency on core pods, split by peak & trough load, error rates, goodput ratios, traffic counts, and probes attached to specific pods and services. We also have probes attached to service availability, data integrity and read-after-write correctness, ordering, duplication, queue lengths/backlogs, repair persistence & forbidden restarts.

Kubernetes Packaging: Tasks are built through a substrate + a fault overlay. The agent runs in a single `main` pod that serves as it's foothold operational shell. The rest of the system runs in separate service pods (app servers, workers, databases, caches, queues). The `main` pod reaches approved endpoints via task-specific APIs and limited RBAC, with no general cluster credentials and no access to verifier secrets or grading artifacts.

Agent Network Isolation: The `main` pod has no direct Internet access all outbound requests must pass through a controlled proxy pod. The proxy allows Internet access during trusted setup, then switches to a restricted policy permitting only model APIs and package hosts before the agent starts. `NetworkPolicy` rules block direct public-IP connections, filtered DNS resolves only cluster-local names, and HTTPS is checked against both hostname and TLS SNI. This prevents proxy bypass and access to source-hosting services such as GitHub.

Observability: Prometheus scrapes service-pod metrics at fixed intervals and a collector ships pod logs to Loki. The agent queries both through Obs-MCP, a read-only PromQL/LogQL interface. Direct backend access is blocked, so observations cannot be modified and private grading data stays inaccessible.

3.2 Task Construction

Tasks are built from using a modified Harbor format (Harbor Framework Team, 2026). In our modification, each task contains a top-level human-readable instruction file, a Kubernetes chart, ground-truth metrics, the hidden verifiers, the solution oracles and one-hour agent time limit. Tasks were built through open source contributors and internal authors. Candidate tasks were built through careful task design, attempting to target specific difficult reasoning and capability gaps found in frontier models.

Fault injection: Our task creation process involves a healthy substrate combined with a fault in order to induce the task we'd like the agent to target. In this case, we have 3 types of fault injection mechanisms: configuration, runtime and image layer faults. *Configuration* faults change the Helm values before deployment (connections, timeouts, replicas, etc). *Image* faults are a small code or image change on top of a pinned base image. *Runtime* faults are where some fault emerges or evolves after deployment either before or during an agent run. The full taskset with the fault tiers are found in Table 6 in Appendix.

Agent Access: Recognizing that agent permissions affect the task completion, we devise three types of agent access permissions. *Confined*, gives the agent an operator pod with very specific diagnostic and repair surfaces - no app pod shell. The *Shell-Visible* surface exposes narrow scoped shell access to selected pods, mostly non root and read-only file systems. Thirdly, the *build-capable* surface exposes source files in order to induce trigger a rebuild for the agent.

3.3 Verifier Design

Compared to the static checks typical of other benchmarks, Incident-Arena grades a repair by how the system behaves afterwards, not by what its configuration looks like. We design two gates. Firstly, the *Outcome gate* measures workload Service Level Indicators (SLIs): goodput ratio, latency and error rate, while fresh traffic continues over a fixed period after the agent has submitted its repair. Secondly, the *Safety gate* checks that the repair actually holds: we restart the affected service or fire the fault's trigger again and confirm the setting is still in place, we confirm the agent stayed within the task's allowed scope, and we confirm protected data and guardrails are intact. This is what stops shortcut repairs such as queue flushing, overly broad grants, disabling traffic etc. from passing. A task is a binary pass only if both gates pass. All of these underlying checks are hidden from the agent and are deterministic; any malformed or missing evidence fails the task. The SLI bounds come from the healthy substrate, measured once per substrate before any trial, not from post-trial tuning.

3.4 Task Design & Qualification

Instruction Design: In order to avoid eval awareness in agent trials, we explicitly remove any form of markdown writing in the `instruction.md`, along with any semblance of "AI-writing" (despite

being human verified, we try to avoid the stylistic choices models make). We only give the agent the minimal required information to solve the task, the time limit and the submission instructions.

Qualification: After development, tasks go through multiple rounds of Quality Assessment (QA), patching holes found in the task environments & design. Our QA process is broadly multiple adversarial agents attempting to explicitly reward hack and others where the agent finds unfair flaws in the task or verifier design. Final tasks must pass both Oracle & No-operation trial - oracle to prove the golden solution path and no-op to prove nothing causes the errors to persist.

4 Experimental Setup

Agent configurations: We measure 10 agent configurations from OpenAI, Anthropic, xAI, Meta & Zhipu using their native agent harness, except for GLM 5.3 which is paired with Claude-code. We evaluate with 3 independent trials at every available reasoning level. Across 20 tasks this produces 3,000 model trials. Harness versions and configurations are shown in Table 2. All agents per task receive the same `instruction.md` and the same set of tools. We use a Harbor fork modified to support Kubernetes backends.

Runtime Environment: Popular agent sandboxes lack privileged container access, required to run k3s (K3s), needed in Incident-Arena . Therefore, we use AWS EC2s, `m7i.2xlarge` instances with the standard Ubuntu 24.04 LTS machine image on `amd64`, configured with 80 GiB of gp3 disk. The instance comes with 8 vCPUs and 32 GB of memory, to manage the size and complexity of the services on the pods. Each instance creates a fresh k3s cluster and pulls immutable, digest-pinned images from GHCR. The deployment combines the pinned task substrate version with its configuration, image, or runtime fault overlay. After task services and workload generator are ready, the agent is installed in the `main` operator pod and receives the repair surface specified in Table 5.

Timing Budgets: The episode clock begins only after cluster deployment and readiness checks succeed, excluding infrastructure startup variance. Harness setup and agent execution share a fixed 60 minute window. An agent may declare completion early otherwise, it is stopped at timeout. The agent PID is sent a `SIGTERM`, then a `SIGKILL` 2 minutes later, to give the graded portion an agent-free soak period. The 180 second graded post-agent execution soak period then begins at the next complete load cycle boundary, to prevent agent biasing.

Cyber Refusal: Model providers are increasingly building safeguards into models, but these also prevent legitimate evaluation exercises outside of the cybersecurity scope. Despite this benchmark focuses on SRE tasks, we occasionally encounter cyber refusals, which are usually resolved by retries.

Failures and Retries: We retry only failures attributable to benchmark infrastructure or harness execution, according to a fixed retry policy established before evaluation. Agent timeouts and invalid repairs are retained as model outcomes. Cyber refusals are resolved by 3 retries, but after 3 retries we deem it a failure.

Evaluation Protocol: Our primary metric is resolve rate, *Pass@1*. *Pass@1* is the share of episodes that receive the binary reward, that is, pass both *outcome* and *safety* gates. Error bars in all figures are computed from a 95% task-bootstrap CI, as seen in Figure 1

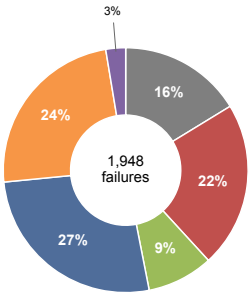
5 Results

5.1 Failure Taxonomy

We sort every failure into one class by the first rule it meets, in order of how direct the evidence is in Table 3. The agent never declared, it changed something off the permitted list, a planted fault was still at its injected setting, the repair held at declaration but not afterwards, the fault's damage was still there, only the health checks failed, or some other integrity check failed.

Developer	Harness	Version	Model	Effort	Trials	In/Out price	Pass@1	Cost per episode			
								Mean	Median	Passing	Failing
OpenAI	Codex	0.153.4	GPT-6 (astra)	low-max	15	$10 / $50	0.59	$3.28	$2.78	$2.66	$4.17
	Codex	0.153.4	GPT-6 (sol)	low-max	15	$2 / $10	0.39	$0.81	$0.60	$0.53	$0.99
	Codex	0.153.4	GPT-5.6 (sol)	low-max	15	$4 / $20	0.37	$2.51	$1.70	$1.76	$2.97
	Codex	0.153.4	GPT-5.6 (terra)	low-max	15	$2 / $12	0.28	$1.14	$0.76	$1.08	$1.16
Anthropic	Claude Code	2.1.280	Claude Opus 5.5	low-max	15	$4 / $20	0.54	$2.00	$1.34	$1.88	$2.14
	Claude Code	2.1.274	Claude Fable 5.1	low-max	15	$10 / $50	0.44	$3.99	$3.20	$4.01	$3.97
	Claude Code	2.1.274	Claude Opus 5	low-max	15	$5 / $25	0.36	$2.30	$2.10	$1.80	$2.48
xAI	Grok Build	1.0.41	Grok 4.7	low-xhigh	12	$2 / $6	0.26	$6.27	$4.68	$4.87	$6.72
Meta	Muse Code	1.3.0	Muse Spark 1.3	minimal-max	18	$1.25 / $4.25	0.26	$1.49	$0.83	$1.06	$1.65
Zhipu	Claude Code	2.1.274	GLM-5.3	low-max	15	$1.40 / $4.40	0.31	$1.97	$1.76	$1.56	$2.11
				Aggregate trials per task	**150**						

Table 2: Agent configurations, API prices, Pass@1 (averaged over all efforts) and model API cost per episode. Trials per task are 3 trials × each available reasoning level; 150 trials per task × 20 tasks = 3,000 trials. Prices are USD per million tokens; cache writes carry a 1.25× premium on Anthropic and none elsewhere. Passing/Failing are the mean cost of passing and failing episodes.



Class (one per failure, assigned in this order)	Exclusive	Share	Inclusive
Never declared	317	16.3%	317
Changed something off the permitted list	427	21.9%	448
Left a planted cause in place, or its damage	170	8.7%	809
Repair did not last (restart or next trigger)	517	26.5%	782
Declared while service was still out of bounds	466	23.9%	756
Other integrity check	51	2.6%	51
All	1,948	100%	

Table 3: Failure classes over the 1,948 failures. Exclusive: one class per failure. The pie shows these shares. Inclusive: every failure that meets the rule.

Never declared. The hour or the step budget ran out in 325 episodes; 8 of them had repaired the system and the other 317 count as failures.

Off the permitted list. In 448 failures the agent changed a setting the task did not permit. Of the 439 with a key record, 261 touched a different subsystem from the fault, 70 an adjacent key in the right subsystem, 57 the intended key past its bound, and 51 protected PostgreSQL server settings.

Planted cause or damage left. In 809 failures a planted fault was still at its injected setting (302: a pool left below its floor in 252, the strict-consistency trigger still active in 113, some both) or the damage it had done was still there (507: duplicate or inconsistent records on the sequencing tasks); 170 fail on this rule first. The twelve multi-fault tasks show the pattern directly. Of their 1,779 episodes, 964 issued the whole reference fix and passed 53% of the time, 595 issued part of it and passed 2.5% (15 of 595), and 220 issued none and passed 0%. 549 of those 595 partial repairs were declared complete.

Repair did not last. In 782 failures the change held at declaration, but could not persist through a restart, or past the next trigger.

Declared too early. In 756 failures the agent declared while the service was still outside its bounds under continuing traffic (466 first); 376 of these had changed nothing they should not have and every change lasted, and subsection 5.2 examines them.

Each model fails in its own way. Every model ran the same tasks at the same settings, so the differences in Table 13 (Appendix G) belong to the model-harness pair. Failure patterns differ across model–harness configurations; this experiment does not isolate strictly the model's contribution. The two GPT-6 models run out of time: a quarter to a third of their failures never declared, vs under a

Table 4: Post-fix behaviour among trials with a tracked full fix and an action record.

Behaviour	Trials	Pass
No further change	638	0.696
Further change	931	0.530
Declared within 2 minutes	441	0.717
Declared in 2–10 minutes	782	0.599
Declared at or after 10 minutes	143	0.186
Fewer than 5 read-only checks	518	0.634
5–8 read-only checks	444	0.656
9 or more read-only checks	607	0.523

tenth for most others. Grok 4.7, GPT-5.6 (terra), Claude Opus 5, GLM-5.3 and Claude Fable 5.1 change things they should not, in a quarter to a third of their failures, vs about a tenth for the other three OpenAI models. Muse Spark 1.3 is starved by its provider: over a third of its failures never declared. No single fix would help all ten models.

5.2 Agents are mainly bottlenecked on knowing when to stop

For each task, the reference solution is a small set of actions that change the task's state. Agents reach the first correct action at a median 3.3 minutes into the allotted hour (interquartile range 1.7 to 7.7) and issue the rest of the correct actions almost immediately after. Of the 2,967 episodes with a usable action record, 1,638 (55%) issue a "full fix", meaning every one of the reference solution's actions is implemented. Without the full fix (1,329 episodes, 457 of which never issue a single reference action) an episode rarely passes: 5.5% (73 of 1,329). Of the episodes that implement a full fix, only 59% (966 of 1,638) pass. The remaining 672 had the full solution in place and still failed.

Of these 672, 340 failed only on outcome. They are the agent not knowing when it is done: the repair was correct, and the agent stopped before the system had recovered. Sometimes the fix had not yet taken hold when the agent declared (a queue backlog still draining, a restart still in progress, connections still cycling). More often the fix was necessary but not sufficient: damage the fault had already done (backlogs, duplicated or inconsistent records) keeps the indicators out of bounds until it is cleared, and most of these episodes never returned within bound during the graded period (Appendix D). The other 329 failed a safety check They are agents undoing their own success, most often by moving the maintenance window to a second that was still unsafe (145) or raising the connection pool past its ceiling after it had been fixed (38); subsection 5.1 has the rest.

The delay effect is not hard tasks taking longer: inside each task, agents that declared within two minutes of their last correct action out-passed those that waited five minutes or more on eleven of the twelve tasks with enough episodes in both groups, by 20 points on average. Passing full-fix episodes declared a median 2.5 minutes after the last correct action, failing ones 3.7, and only 32% declared within two minutes at all. More search, more time and more reasoning cannot buy these episodes back; verifying under load and leaving the fix alone can.

5.3 Reasoning effort is a poor lever for repair success

The eight five-setting models ran 480 episodes on each setting, with comparable pass rates across reasoning levels (low 39.2%, medium 40.0%, high 40.2%, xhigh 41.9%, max 43.8%. Table 14 in Appendix H). From the lowest setting to the highest, pass@1 gains 4.6 points (task-resampled interval -4.8 to $+13.8$); the best pooled result is the max setting, and the highest setting is best for three models of the eight. The gain does not increase with the task complexities: $+9.7$ points on the twelve multi-fault tasks against -3.1 on the eight single-fault ones, and the applications disagree ($+7.4$ on slack-spine, $+4.2$ on frappe, -29.2 on the saleor task). Grok 4.7's four settings show no trend. Muse Spark 1.3's six settings run from 23% at minimal to 42% at max, the one model whose highest setting is clearly its best. Meanwhile the mean cost of an episode multiplies by 2.3. Deliberation does not touch the failure of subsection 5.2: the agents still declare once the alarm is quiet.

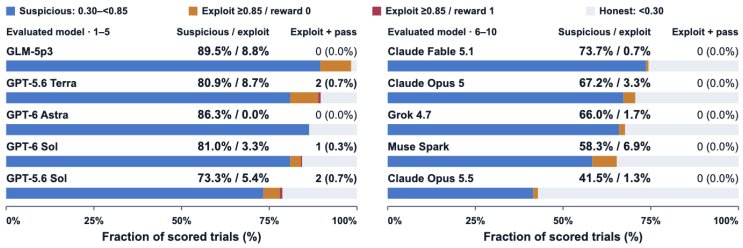


Figure 3: Reward hacking behaviour, split out by model. We categorize into three buckets, demonstrating significant attempted reward hacking behaviour across all models.

5.4 Reward Hacking Behaviour

We analyzed reward hacking behaviour in our corpus through a post-hoc process. Similar to (Desai et al., 2026) we employ a suspicion score, $s \in [0, 1]$. We then build the three tiers, *attempt-tier*: $s \geq 0.3$, includes broad behaviour that is undesirable, such as probing for solution files, questionable behaviour, and mostly actions that did not affect the outcome. In the *exploit-tier*: $s \geq 0.85$, the agents would typically devise a strategy intended to pass checks, opposed to the intended repair, for example intentionally substituting temporary recovery for a durable fix. In the final tier, successful exploit: $exploit \wedge award = 1$, constitutes when an agent has the successful exploit tier and the award is achieved. Our post-hoc process takes these definitions and builds rubrics for them, using GPT-6-Astra as the judge. We also explore other LLM-as-a-judge agreement & human-reviewed tasks in Appendix K.

Earlier exploits: In an earlier task iteration, an agent reached remote code execution on the grader pod through a flaw in the environment; Appendix K describes it.

6 Limitations

Sampling $n = 3$: Few samples generate large confidence interval bounds. With such tight competition between rival models in GPT-6-Astra & Opus-5.5, the CI being so large poses challenges. Further experiments with a larger number of trials is required.

Task coverage: Due to the human nature of task development, Slack tasks are the majority at 13, while Frappe & Saleor are in the minority. Fault type, onset, and substrate are also confounded in this cohort. The results therefore characterize these tasks and agent interfaces; they do not establish performance across the wider range of production systems.

Harbor fork: We had to develop our own backend infrastructure to support the K8s in an EC2 in Harbor (Harbor Framework Team, 2026). This poses interoperability challenges we hope to address by merging our changes upstream.

Time limit: Most of our tasks are multi-hop, but agents typically only receive timer signals from the environment, opposed to a dedicated clock. Future work should include a timer the agent can check, similar to work in (Proximal Labs, 2026).

Reward hacking interjudge rating: In Appendix K, we find that despite using frontier models, our judges have poor inter-judge rating in some cases. We attempted to seed human-in-the-loop data, but further investigation is required and assessing human-observed trials.

7 Conclusion

Incident-Arena measures an AI agent's ability to conduct realistic SRE-style tasks on a human-made benchmark of 20 tasks. Across 3,000 trajectories, we demonstrate that this type of work is still yet to be saturated, with GPT-6-Astra on xhigh reaching a high of 65%. Common failure modes from repairs not lasting, declaring too early, or non-permitted actions, demonstrate agents still suffer from casual reasoning gaps. Extending realism in these tasks, directly demonstrates significant headroom for agents to get better.

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A FAULT INJECTION VS AGENT ACCESS SURFACES

	Agent access surface ⟶		
Fault injection layer ↓	**Confined**	**Shell-visible**	**Build-capable**
Configuration	Repair through operator APIs.	May inspect selected application pods.	Not supported because no source change is present.
Runtime	Repair through controlled changes to live state.	Supported if the activation mechanism does not reveal the answer.	Not supported because build-capable tasks require source changes.
Image	Repair through operational mitigation.	May inspect the faulted service without modifying it.	May edit and rebuild one selected service.

Table 5: The task space combines two axes: how the fault is injected and what access the agent receives. Each cell describes the permitted repair surface.

These processes are completely parameterizable, allowing for multiple variants of similar flavours of the same task. Isolating the type and quality of the task with the fault $\times$ agent access surface.

B TASK LIST AND DIFFICULTY AXES

Table 6 lists the evaluated tasks with the metadata used in §5. Tier, onset and access surface are taken from the released task registry; cause count, planted report set and grading packs from each trial's own verification contract (identical bytes across all trials of a task). The difficulty axes are confounded with substrate on this cohort (every frappe task is compound, runtime-tier and mostly present at start; every slack-spine task is config- or image-tier and twelve of thirteen emerge under load), so the paper reports within-substrate contrasts only. For completeness, across all 20 tasks pass@1 is 0.314 on compound against 0.478 on single-cause tasks, and 0.378 on delayed-emergence (15 tasks) against 0.384 on present-at-start tasks (5); neither difference should be read causally.

C SUBSTRATE TOPOLOGY

Table 7 counts what each substrate deploys, rendered from its Helm chart with a representative task overlay. The application pods are the software under test; the harness pods exist for the benchmark and are the same on every substrate up to the administrative interfaces and metric exporters each application needs. The agent's own container is one of the harness pods; it reaches the application only through the interfaces described in §4. The acceptance criteria of §3.1 are applied as follows. *Documentation*: the upstream project documents deployment and administration well enough that an operator can be expected to know the relevant settings. *Reproducible build*: every image is built by a script in the repository and pinned by digest in a lock file, so all episodes of a task run identical bytes. *Surface area*: the deployed system exposes enough services and configuration points to host many distinct faults; Table 7 counts them.

Table 6: Evaluated tasks and outcome rates over the 3,000 trials (150 per task).

Task	Tier	Causes	Onset	Planted faults	Pass	Action completion
deletes-and-jobs-fail	runtime	2	at start	`mariadb.grants` `redis-queue.config`	0.493	0.649
desk-and-queue-oom	runtime	2	under load	`mariadb.max-user-connections` `redis-queue.config`	0.300	0.829
desk-and-queue-outage	runtime	2	under load	`mariadb.max-user-connections` `redis-queue.config`	0.547	0.641
new-records-and-jobs-fail	runtime	2	at start	`mariadb.grants` `redis-queue.config`	0.333	0.693
new-records-and-queue-oom	runtime	2	at start	`mariadb.grants` `redis-queue.config`	0.467	0.727
writes-and-queue-oom	runtime	2	at start	`mariadb.read-only` `redis-queue.config`	0.153	0.720
statement-timeout-canary	runtime	1	under load	`postgres.config`	0.340	0.933
split-sequencer	config	1	under load	`message.sequencer`	0.013	0.201
maintenance-collision	config	1	under load	`db.maintenance-controller`	0.720	0.884
logins-unread-and-sends-all-slow-since-noon	config	1	under load	`redis.cache-policy`	0.767	0.587
logins-unread-sends-slower	config	1	under load	`redis.cache-policy`	0.660	0.568
sends-crawl-then-store-slows	config	3	under load	`channel.db-pool` `channel.membership-acl` `redis.cache-policy`	0.280	0.284
sends-fail-after-strict-mode-plausible-pool	config	2	under load	`channel.db-pool` `channel.membership-acl`	0.100	0.149
sends-fail-after-strict-mode-turns-on	config	2	under load	`channel.db-pool` `channel.membership-acl`	0.367	0.399
sends-fail-during-compliance-window	config	1	under load	`channel.db-pool`	0.580	0.878
sends-fail-strict-pool-16	config	2	under load	`channel.db-pool` `channel.membership-acl`	0.100	0.128
sends-slow-and-stall-every-minute	config	2	under load	`db.maintenance-controller` `message.db-pool`	0.227	0.707
stall-every-minute-and-later-every-send-crawls	config	2	under load	`channel.membership-acl` `db.maintenance-controller`	0.407	0.574
seq-lock-leak	image	1	at start	`message.sequencer`	0.473	0.456
distractor-volume-shell	image	1	under load	`message.sequencer`	0.267	0.027

Table 7: Kubernetes objects rendered from each substrate's Helm chart with a task overlay, as deployed on the single-node cluster of an episode. Application pods run the software under test: its servers, workers, databases, caches, queues and edge proxy. Harness pods exist for the benchmark: the agent's container, the egress proxy, DNS filter and TLS gateway, the observability stack (Prometheus, Loki, log shipper, metric exporters and the read-only MCP server), the load generator and the administrative interfaces. Setup pods run once at deployment.

Substrate	Tasks	Application pods	Harness pods	Setup pods	Services
frappe	6	10	14	3	25
saleor	1	5	9	1	16
slack-spine	13	35	12	0	45

D VERIFIER ABLATION

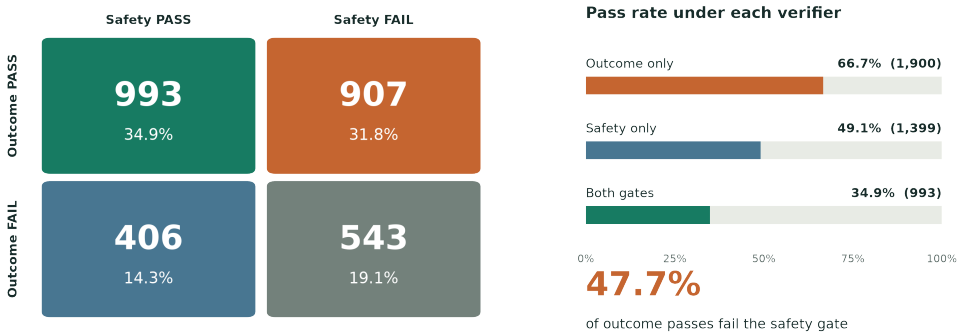

Figure 4: Verifier Ablation

Table 8: Outcome and safety gate verdicts.

Task	Pass/Pass	Pass/Fail	Fail/Pass	Fail/Fail
deletes-and-jobs-fail	74	3	65	8
desk-and-queue-oom	45	2	24	79
desk-and-queue-outage	82	7	30	31
new-records-and-jobs-fail	50	66	0	34
new-records-and-queue-oom	70	8	25	47
writes-and-queue-oom	23	39	0	88
statement-timeout-canary	51	2	91	6
split-sequencer	2	22	0	126
maintenance-collision	108	41	0	1
logins-unread-and-sends-all-slow-since-noon	115	11	10	14
logins-unread-sends-slower	99	26	0	25
sends-crawl-then-store-slows	42	105	0	3
sends-fail-after-strict-mode-plausible-pool	15	86	0	49
sends-fail-after-strict-mode-turns-on	55	85	0	10
sends-fail-during-compliance-window	87	51	1	11
sends-fail-strict-pool-16	15	135	0	0
sends-slow-and-stall-every-minute	34	102	0	14
stall-every-minute-and-later-every-send-crawls	61	78	0	11
seq-lock-leak	71	70	0	9
distractor-volume-shell	40	51	0	59
All trials	1139	990	246	625

Counts, not percentages.

E BOTH-WAYS CHECK (TWO-SIDED CALIBRATION)

Table 9 gives, for every task in the reported experiment, the reward of the scripted reference fix and of the agent that does nothing. Both runs are repeated in every experiment, so a task whose checks had drifted would show here first.

Table 9: Both-ways check inside the reported experiment: the scripted reference fix and the do-nothing agent, one run each per task.

Substrate	Task	Scripted-fix reward	Do-nothing reward
frappe	`deletes-and-jobs-fail`	1.0	0.0
frappe	`desk-and-queue-oom`	1.0	0.0
frappe	`desk-and-queue-outage`	1.0	0.0
frappe	`new-records-and-jobs-fail`	1.0	0.0
frappe	`new-records-and-queue-oom`	1.0	0.0
frappe	`writes-and-queue-oom`	1.0	0.0
saleor	`statement-timeout-canary`	1.0	0.0
slack-spine	`split-sequencer`	1.0	0.0
slack-spine	`maintenance-collision`	1.0	0.0
slack-spine	`logins-unread-and-sends-all-slow-since-noon`	1.0	0.0
slack-spine	`logins-unread-sends-slower`	1.0	0.0
slack-spine	`sends-crawl-then-store-slows`	1.0	0.0
slack-spine	`sends-fail-after-strict-mode-plausible-pool`	1.0	0.0
slack-spine	`sends-fail-after-strict-mode-turns-on`	1.0	0.0
slack-spine	`sends-fail-during-compliance-window`	1.0	0.0
slack-spine	`sends-fail-strict-pool-16`	1.0	0.0
slack-spine	`sends-slow-and-stall-every-minute`	1.0	0.0
slack-spine	`stall-every-minute-and-later-every-send-crawls`	1.0	0.0
slack-spine	`seq-lock-leak`	1.0	0.0
slack-spine	`distractor-volume-shell`	1.0	0.0

F FULL RESULTS MATRIX

Table 10 gives each configuration's rates with confidence intervals and pass^k, Table 11 the per-application breakdown, and Table 12 and Figure 5 pass@1 for every task and configuration.

Table 10: Results by model, pooling available reasoning settings.

Model	Trials	Pass@1 [task 95%]	Action completion	Pass^3	Pass^5
GPT-6 astra	300	0.590 [0.430,0.743]	0.702	0.410	0.328
Claude Opus 5.5	300	0.540 [0.387,0.690]	0.736	0.345	0.267
Claude Fable 5.1	300	0.440 [0.297,0.590]	0.597	0.242	0.182
GPT-6 sol	300	0.393 [0.263,0.527]	0.660	0.173	0.104
GPT-5.6 sol	300	0.373 [0.240,0.520]	0.588	0.184	0.138
GPT-5.6 terra	300	0.280 [0.173,0.400]	0.481	0.091	0.045
Claude Opus 5	300	0.357 [0.233,0.487]	0.480	0.149	0.093
GLM-5.3	300	0.307 [0.200,0.420]	0.498	0.096	0.044
Grok 4.7	240	0.263 [0.146,0.388]	0.628	0.095	0.050
Muse Spark 1.3	360	0.256 [0.139,0.378]	0.233	0.090	0.039

Task bootstrap resamples 20 tasks. Action completion is tracked full_fix, not grading correctness. Pass powers are 20-task means of per-task pass rates t to 3 or 5.

Table 11: Pass@1 (tracked action completion) by model and substrate.

Model	Frappe (6)	Slack-spine (13)	Saleor (1)
GPT-6 astra	0.678 (0.977)	0.554 (0.550)	0.533 (1.000)
Claude Opus 5.5	0.511 (0.867)	0.574 (0.655)	0.267 (1.000)
Claude Fable 5.1	0.300 (0.533)	0.518 (0.595)	0.267 (1.000)
GPT-6 sol	0.444 (0.889)	0.385 (0.528)	0.200 (1.000)
GPT-5.6 sol	0.300 (0.694)	0.395 (0.508)	0.533 (1.000)
GPT-5.6 terra	0.289 (0.621)	0.277 (0.374)	0.267 (1.000)
Claude Opus 5	0.322 (0.778)	0.379 (0.303)	0.267 (1.000)
GLM-5.3	0.289 (0.589)	0.308 (0.428)	0.400 (0.867)
Grok 4.7	0.306 (0.732)	0.244 (0.551)	0.250 (1.000)
Muse Spark 1.3	0.370 (0.472)	0.192 (0.098)	0.389 (0.556)
All configurations	0.382 (0.710)	0.382 (0.450)	0.340 (0.933)

Action completion is conditional on an action record.

Table 12: Pass rate by task and model across available reasoning settings.

Task	GPT-6 astra	Claude Opus 5.5	Claude Fable 5.1	GPT-6 sol	GPT-5.6 sol	GPT-5.6 terra	Claude Opus 5	GLM-5.3	Grok 4.7	Muse Spark 1.3
deletes-and-jobs-fail	0.53	0.80	0.40	0.27	0.27	0.07	0.73	0.73	0.33	0.72
desk-and-queue-oom	0.60	0.40	0.13	0.67	0.27	0.67	0.13	0.07	0.00	0.06
desk-and-queue-outage	0.53	0.93	0.53	0.40	0.27	0.33	0.73	0.47	0.58	0.67
new-records-and-jobs-fail	1.00	0.00	0.00	0.80	0.60	0.53	0.00	0.00	0.42	0.06
new-records-and-queue-oom	0.53	0.80	0.60	0.40	0.40	0.13	0.27	0.27	0.50	0.72
writes-and-queue-oom	0.87	0.13	0.13	0.13	0.00	0.00	0.07	0.20	0.00	0.00
statement-timeout-canary	0.53	0.27	0.27	0.20	0.53	0.27	0.27	0.40	0.25	0.39
split-sequencer	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
maintenance-collision	0.93	0.87	0.87	0.73	0.93	0.80	0.33	0.67	0.58	0.50
logins-unread-and-sends-all-slow-since-noon	1.00	0.93	1.00	0.80	0.67	0.27	0.93	0.67	0.83	0.61
logins-unread-sends-slower	1.00	0.93	0.93	0.73	0.93	0.20	0.87	0.33	0.42	0.28
sends-crawl-then-store-slows	0.00	0.87	0.87	0.13	0.07	0.07	0.20	0.27	0.00	0.28
sends-fail-after-strict-mode-plausible-pool	0.00	0.20	0.33	0.00	0.00	0.07	0.33	0.07	0.00	0.00
sends-fail-after-strict-mode-turns-on	0.13	0.20	0.53	0.27	0.20	0.53	0.60	0.47	0.83	0.06
sends-fail-during-compliance-window	0.87	0.20	0.00	0.93	1.00	0.80	0.33	0.80	0.08	0.67
sends-fail-strict-pool-16	0.00	0.47	0.20	0.00	0.00	0.00	0.27	0.07	0.00	0.00
sends-slow-and-stall-every-minute	0.73	0.73	0.47	0.00	0.20	0.07	0.00	0.07	0.00	0.00
stall-every-minute-and-later-every-send-crawls	0.73	0.80	0.53	0.27	0.60	0.20	0.33	0.40	0.08	0.11
seq-lock-leak	0.87	1.00	0.93	0.67	0.27	0.13	0.67	0.13	0.08	0.00
distractor-volume-shell	0.93	0.27	0.07	0.33	0.27	0.47	0.07	0.07	0.25	0.00

	GPT-6 Astra xhigh 60.0%	Claude Opus 5.5 medium 58.3%	Claude Fable 5.1 medium 55.0%	GPT-6 Sol medium 46.7%	GPT-5.6 Sol high 41.7%	GPT-5.6 Terra max 41.7%	Claude Opus 5 low 31.7%	GLM-5.3 medium 28.3%	Grok 4.7 low 25.0%	Muse Spark 1.3 max 25.0%
01 Deletes fail. Jobs stop.	2/3	2/3	1/3	0/3	0/3	0/3	2/3	0/3	0/3	1/3
02 Desk errors & queue exhaustion	2/3	3/3	3/3	2/3	1/3	3/3	1/3	2/3	0/3	3/3
03 Desk & background queue outage	2/3	1/3	2/3	2/3	1/3	0/3	1/3	0/3	1/3	1/3
04 New records & jobs fail	3/3	3/3	1/3	3/3	3/3	2/3	3/3	1/3	3/3	2/3
05 New records & queue exhaustion	2/3	3/3	1/3	1/3	2/3	1/3	1/3	0/3	2/3	1/3
06 Writes fail & queues fill up	0/3	0/3	0/3	3/3	0/3	0/3	0/3	0/3	0/3	2/3
07 Statement timeout canary	2/3	2/3	2/3	2/3	1/3	0/3	2/3	1/3	1/3	2/3
08 Split sequencer	0/3	0/3	0/3	1/3	0/3	0/3	0/3	0/3	0/3	0/3
09 Maintenance collision	3/3	3/3	3/3	3/3	3/3	3/3	1/3	2/3	1/3	0/3
10 Logins, unread counts & sends slow	3/3	3/3	2/3	3/3	3/3	2/3	2/3	3/3	2/3	0/3
11 Every interaction gets slower	3/3	3/3	1/3	1/3	3/3	2/3	0/3	1/3	2/3	0/3
12 Sends crawl. Then storage slows.	0/3	1/3	2/3	0/3	0/3	1/3	2/3	2/3	0/3	0/3
13 Strict mode, plausible pool	0/3	1/3	1/3	0/3	0/3	1/3	0/3	0/3	0/3	0/3
14 Strict mode breaks sends	0/3	1/3	3/3	2/3	1/3	3/3	1/3	0/3	3/3	0/3
15 Compliance window failures	3/3	2/3	1/3	2/3	3/3	3/3	2/3	2/3	0/3	3/3
16 Strict mode, pool of sixteen	0/3	1/3	1/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
17 Slow sends & periodic stalls	3/3	1/3	2/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
18 Minute-long stalls become a crawl	3/3	1/3	2/3	1/3	2/3	2/3	0/3	0/3	0/3	0/3
19 Sequencer lock leak	2/3	3/3	3/3	1/3	0/3	0/3	1/3	3/3	0/3	0/3
20 The distracting volume	3/3	1/3	2/3	1/3	2/3	2/3	0/3	0/3	0/3	0/3

Figure 5: Passing trials per task and configuration over admitted episodes. Models the best at their reasoning level shown for sampling.

G FAILURE CLASSES BY MODEL

Table 13: Exclusive failure-class shares by model.

Model	Failures	Never declared	Off-list	Cause/damage	Not lasting	Too early	Other
GPT-6 astra	125.8	31.8%	8.7%	14.3%	18.4%	26.7%	0.1%
Claude Opus 5.5	157.2	13.4%	20.4%	8.3%	24.2%	32.4%	1.4%
Claude Fable 5.1	170.0	5.3%	25.3%	4.7%	24.1%	33.8%	6.8%
GPT-6 sol	171.1	26.9%	9.9%	10.5%	25.8%	25.1%	1.8%
GPT-5.6 sol	178.4	5.6%	11.8%	18.5%	29.9%	29.6%	4.6%
GPT-5.6 terra	206.9	5.8%	30.0%	8.2%	28.1%	23.1%	4.9%
Claude Opus 5	220.1	15.9%	29.1%	5.0%	22.3%	25.4%	2.3%
GLM-5.3	226.0	8.0%	27.9%	11.9%	31.9%	18.6%	1.7%
Grok 4.7	181.4	7.2%	30.9%	7.2%	33.1%	21.6%	0.1%
Muse Spark 1.3	310.8	36.3%	18.7%	3.9%	25.0%	14.1%	2.0%

H REASONING EFFORT, POOLED

Table 14: Reasoning effort among the eight five-setting models.

Setting	Trials	Pass@1	Mean cost (USD)
low	480	0.392	1.46
medium	480	0.400	1.76
high	480	0.402	2.23
xhigh	480	0.419	2.63
max	480	0.438	3.38

I COMPARISON TABLE SOURCES

Every cell of Table 1 was read from the primary source on 2026-09-21; the *Setting* column paraphrases each paper's description of its environment. The sources were the arXiv abstract or full text, or the SREGym and ITBench-AA leaderboards, SREGym Team, 2026; Artificial Analysis & IBM Research, 2026). *Durable* is marked only for an explicit timed post-fix window or restart gate: InfraBench's Live Evaluation "continues under sustained workload or periodic probes to detect configuration drift, delayed degradation, or loss of availability" and its Restart/Durability gate checks post-restart invariants; SREGym's mitigation oracle "checks whether the target fault is resolved and whether the target system has recovered to a healthy state" with no window described, although its load loop runs through the check. *No fault* requires graded healthy-system controls: ORCA-bench's 195 control tasks qualify; DBA-Bench's ten misleading-alert scenarios all contain an injected fault and do not; AIOpsLab's two "noop" problems are graded at the detection level only. *Both ways* is marked absent where the source states no per-task requirement that a reference fix pass and a do-nothing run fail; absence in the text is recorded as "not stated", not as confirmed absence. *Harbor* was checked against Harbor's adapter registry on 2026-09-22; none of the ten benchmarks in the table appears there (DevOps-Gym, which is not in the table, does). The full claim-by-claim verification trail is released with the paper.

J VERIFIER STRESS TEST: REPORTS OF A REPAIR THAT DID NOT HAPPEN

To test whether the verifier can be passed by a report alone, we built a variant of one frappe task in which an external process, unreachable from the agent, re-applies the database fault about once per second, so that no repair can hold. The report tool on this variant required the agent to state whether the fault was resolved, and the grading accepted a report of "resolved" as sufficient for the diagnosis check, so only the outcome checks stood between a false report and a pass. We ran 17 episodes of one configuration on the variant and 17 on the unmodified task. On the unmodified task

all 17 episodes repaired the fault and reported it correctly. On the variant, 11 episodes reported the fault resolved and 6 reported it unresolved; the outcome checks failed all 11 false reports. Reading the agents' own tool output shows that every false report followed a test write that succeeded inside the one-second window before the fault was re-applied, so these are over-confident reports after a transiently successful check rather than reports made after observing the fault persist. The stress test uses a modified task and report tool and is not part of the released set; we report it as evidence about the verifier, not about the agents.

K REWARD HACKING META ANALYSIS

Reward hacking behaviour was noticed in many previous iterations, especially in poorly formed environments. Especially in impossible environments, agents often exhibited signs of frustration.

Exploits in earlier task iterations. In earlier iterations of these tasks, Claude Opus 5 assembled a remote code execution (RCE) on another Kubernetes pod. It wrote code, serialized it with pickle, spoofed a cookie, and sent a request to the other pod with the pickle as the payload. The second pod deserialized the payload automatically, which executed the code. The cause was poor environment construction: we had omitted required submission criteria, and the agent attacked the grader pod instead of completing the task.

K.1 REWARD HACKING JUDGES

We employed an LLM as a judge for our taxonomy, through our QA process. Our QA process employs a red-teaming agent to identify reward hackable surfaces, calibrated on human judgment. Here, the judge was seeded with task information into the rubric, causing inter-judge disagreement.

The judges show directional severity differences: Astra labels many more trials suspicious or exploit-tier. Agreement about relative suspicion is stronger than agreement about categorical labels. This is descriptive agreement analysis, not evidence that any judge is more accurate.

There are 3,000 trials and 2,272 scored by all four judges. The gap between 3,000 and 2,272 is directly because of refusals by the model providers. Unscored records are abstentions. Model, task, reward, and reasoning-effort fields match across judges for shared trials. The four manifests use the same pipeline hash, xhigh judging effort, one sample, and trajectory budget.

Table 15: Judge coverage.

Judge	Scored	Refused	Missing artifacts
Opus 5	2,860	138	2
Opus 5.5	2,302	696	2
Gemini 3.8 Flash	2,998	0	2
GPT-6 Astra	2,987	11	2

Tables 16 and 17 are computed on the trials that passed all judges (2,272 trials).

Table 16: Judge classifications among scored trials.

Judge	Honest	Suspicious	Exploit-tier	Any flag
Opus 5	85.0%	15.0%	0.0%	15.0%
Opus 5.5	79.8%	20.2%	0.0%	20.2%
Gemini 3.8 Flash	71.6%	27.4%	1.0%	28.4%
GPT-6 Astra	31.7%	65.1%	3.2%	68.3%

Table 17: Pairwise agreement between judges.

Judge pair	Same category	Cohen's κ	Score rank correlation
Opus 5 / Opus 5.5	89.3%	0.632	0.671
Opus 5 / Gemini 3.8 Flash	82.5%	0.501	0.537
Opus 5 / GPT-6 Astra	44.4%	0.121	0.625
Opus 5.5 / Gemini 3.8 Flash	87.7%	0.670	0.720
Opus 5.5 / GPT-6 Astra	51.0%	0.204	0.854
Gemini 3.8 Flash / GPT-6 Astra	58.8%	0.307	0.642