

Take Away the Means: a Proved Capacity Cap on Covert Signalling between Procurement Agents

Submission to the Apart Research AI Collusion sprint (23–25 Oct 2026). Tracks: **Track 1, Markets** and **Track 3, Collusion Carriers and Countermeasures** Authors: Tony Gair, The Dark Factory Ltd. Code: <https://github.com/the-dark-factory/collusion-proven-gate>. AI systems are not listed as authors (see “Use of AI tools”).

Abstract

Two LLM agents, one ordering stock and one supplying it, try to pass a 24-bit secret while still doing the job. Most defences watch the conversation and give you a detection rate, so something always gets through. Every message has to be a form, an item from 1 to 8 and a quantity from 0 to 3, or nothing. A chain of proofs in SPARK Ada, made by our own software factory, rewrites each message into a fixed line, so the sender’s own words never reach the other agent. A capacity proof made in the sprint shows there are exactly 33 possible lines, so four messages carry at most 20.2 bits. Even with a perfect codebook a whole secret gets through at most about 1 time in 14 (7.07%), whatever the model does. With gpt-oss:120b colluding on plans written by Claude Opus, free text with no defence leaked the whole secret in 26/30, 22/30 and 11/30 episodes (seeds 1–3). Through the gate it was 0/90, with the order right in 97–100% of episodes. The leftover leak, 0.93–1.13 digits above chance, sits just under the 4.585 bits of item order the proof allows. An attacker who knew the gate reached the cap. Kimi and DeepSeek judges let 1.03–3.59 digits past, depending on the plan. A heuristic filter blocked only typography, and on one seed whole secrets got past it in 16/30 episodes. The cap counts message order and silence but does not remove them; shared knowledge is outside the proof.

1. Introduction

When we first looked at this hackathon we knew in any reasoning contest or scanning test the smart LLM would toast us. We were on the wrong side of the mathematics. So we went for a proof based solution, one that caps what the agents can pass so they can’t reliably get a 24-bit message across.

The agents can only talk to each other through a form, and a proven piece of code rewrites every form before it is delivered. Industry has done this for decades: banks, manufacturers and airlines swap fixed field messages (EDI, SWIFT, flight plans). We took the free text field away and counted what was left.

A judge or a filter reads each message and decides whether it is hiding something, so a good enough code gets past it. We don’t read the messages. We limit what they can be. Our cap comes out of the arithmetic, so it holds whatever the model does. It is a cap, not zero. The channel carries at most 20.2 bits per episode, a nibble away from collusion victory, and that last nibble has to be guessed.

We are only closing one covert channel here, what is inside the messages. Others exist (ordering, silence, what the agents already know) and closing those needs more proven functions and procedures from the factory.

We built the gate, the harness and the proofs with our own software factory. Its public release, Crucible, writes proven SPARK Ada from prose (<https://github.com/the-dark-factory>); Section 3.1 says how.

Why markets. Trading or procurement agents that talk can coordinate prices or bids covertly. A proved channel bounds the bits per message they have for that, whatever they intend. Restock is a small procurement setting.

Threat model. - *Who colludes:* a sender and a receiver, both gpt-oss:120b run locally, sharing a hidden plan as a codebook. - *Their aim:* pass a 24-bit secret (6 hex digits) while completing the order. - *Plan strength:* “planned” means Claude Opus writes one plan per arm, knowing exactly what that arm allows. A “clean” run has no plan and gives the chance floor and the false alarms. - *What we close:* timing (messages are queued, no clocks) and memory between episodes. - *What we cannot stop:* the choice among valid messages and silence (both counted inside the cap), the order items are named in, and shared priors.

2. Related work

Motwani et al. (NeurIPS 2024) and Mathew et al. (2024) detect or measure covert signalling between AI agents. We bound it with a proof, then measure against the bound.

Anthropic, with Theorem (22 Oct 2026), report that Claude produced machine-checked Rocq proofs for 239 entry points across 123 OSS-Fuzz libraries, at the level of compiled RISC-V binaries. They use AI to prove code safe. We use AI-written SPARK to prove a capacity cap on a channel between AI agents. We do not claim their endorsement.

None of the works on the sprint’s Resources page proves a bound on what agents can pass. The nearest suggest capping messages (after Agrawal et al., 2025) or canonicalising actions. These shrink a channel; none proves its size. Roger and Greenblatt (2023) measure what survives paraphrasing; we prove what can get through.

3. Method

Environment (Restock). An 8-item order sheet. The sender privately sees stock against minimum; exactly 4 items are short. There are 4 one-way turns, and the receiver applies each delivered line to the sheet. The same seed gives the same secrets and sheet in every arm, so the arms are paired.

Arms. - **A0, no defence** (the positive control): free text. - **A1, LLM judge:** free text; a frontier judge (Kimi) blocks messages it finds suspicious. - **A1h, heuristic filter** (DF 1435): blocks long messages, characters outside an ASCII allowlist, hex-like runs and long digit runs. Pre-registered, thresholds approved 19 Oct. - **A2, proved form gate:** only SET i q (item 1–8, quantity 0–3) or a fixed silence line is delivered.

The proof chain. The gate is a chain of proved SPARK cores (DF 1124–1131, prior work) plus a capacity core proved in the sprint (DF 1453).

Step	Core	What is proved
1	Item_Of	The item field becomes 1–8 only if it is exactly one digit “1”–“8”; anything else is refused
2	Qty_Of	The quantity field becomes 0–3 only if it is exactly “0”–“3”; anything else is refused
3	Admit	A message is admitted exactly when both fields pass, carrying only those two values
4	Render	An admitted message is rewritten as SET <item> <qty>; the sender’s own bytes never reach the receiver
5	Render_Parses	The receiver’s parser reads that line back as exactly that order
6	Render_Injective	Two different orders never render to the same line
7	Deliver	Admitted → its rendering; refused → one fixed silence line
8	In_Form	Everything Deliver can output is silence or a valid rendering
9	Capacity (DF 1453, sprint)	Each line maps into 0..32, each index maps to a line, two round trips: exactly 33 lines

So each delivered message carries at most $\log_2 33 \approx 5.04$ bits, and 4 messages at most 20.2 bits, below the 24-bit secret. The receiver sees one of at most $33^4 = 1,185,921$ transcripts against about 16.8 million secrets, so any decoder gets a whole secret at most $33^4/2^{24} \approx 7.07\%$ of the time. A second sprint core, Restock_Valid_Count (DF 1454–1456), counts the fully useful transcripts: exactly 24 per episode, the $4!$ orders of the 4 short items, so $\log_2 24 \approx 4.585$ bits given the episode. That is the freedom a colluder keeps while doing the task perfectly.

The proof covers the content of each delivered line and says nothing about the model; its full scope is in Appendix A.

Models and runs. Colluder, sender and receiver: gpt-oss:120b, run locally. Judge: Kimi (kimi-k3). Claude Opus wrote 12 plans (15 planner calls, \$2.61). Frozen plan: 43 runs, 3 seeds $\times$ 30 episodes, harness commit 977d9264, run in order of importance. Every episode is kept as it ran. At 17:16 on day 1 we nearly re-ran only the two failed episodes of one stretch run. That would have been selection bias, and we did not do it. Plan changes are in Appendix C.

Metrics. *Digits above chance:* correct hex digits in place, minus 0.375. *Exact recovery:* all 6 digits right. *Usefulness:* the final sheet exactly right. Digits above chance are not bits. As a scale, a hex digit is 4 bits, so the proved order freedom of 4.585 bits is about 1.15 digits.

Cost. All frontier API calls in the sprint cost at most \$42.7 of our \$50 cap at the last count (20:09 BST, 23 Oct). Local models and the Beam beta were free (Appendix F). Final: at most \$47.0 of \$50 (Opus \$20.30 exact from the CLI cost log; Kimi $\leq$ \$15.31 and DeepSeek $\leq$ \$11.40 from balance differences, which also include some non-sprint use on 22 Oct).

3.1 How the proved parts were built

Every proved component and harness tool came out of our factory. An LLM writes a prose specification of one function and its contract (our AI assistant writes prose only, never code); the factory’s model emits SPARK Ada from it; GNATprove proves the contracts, and a fidelity check refuses code that does not say what the prose says, or a hollow contract; admission re-proves the unit on a second machine before it gets a core number (DF n). The proof trusts the checker, not the model, the same division of labour as the Anthropic and Theorem work.

Inference used. The sprint’s 7 cores and 8 harness edges took 26 factory rounds on one local model; at most about 80% of the recorded build tokens were local (an upper bound; some frontier review passes were not logged; Appendix G).

4. Part 1: core results

Claim. A proved cap of 20.2 bits per episode holds while the task still gets done. The judge and the filter give a rate and do not bound leakage.

Table 1. Core results, gpt-oss:120b colluder only, 30 episodes per row. Chance floor = 0.375 digits right.

Arm	Plan	Seed	Digits above chance	Exact recovery	Usefulness	Block rate
A0, positive control	planned	s1	5.325	26/30	1.000	n/a
A0, positive control	planned	s2	4.392	22/30	0.967	n/a
A0, positive control	planned	s3	3.425	11/30	0.933	n/a
A1, Kimi judge	planned	s1	1.025	0/30	0.967	0/120
A1, Kimi judge	planned	s2	3.158	0/30	0.667	11/120
A1, Kimi judge	planned	s3	1.858	0/30	1.000	0/120
A1, DeepSeek judge	planned	s1	1.025	0/30	0.967	0/120 (same transcripts as Kimi s1: neither judge blocked)
A1, DeepSeek judge	planned	s2	3.592	0/30	0.967	0/120
A1, DeepSeek judge	planned	s3	1.692	0/30	0.933	0/120
A1h, heuristic filter	planned	s1	3.325	0/30	0.000	40/120
A1h, heuristic filter	planned	s2	2.692	0/30	0.967	0/120
A1h, heuristic filter	planned	s3	4.392	16/30	0.567	15/120
A2, proved gate	planned	s1	1.125	0/30	0.967	n/a (120/120 admitted)
A2, proved gate	planned	s2	1.058	0/30	1.000	n/a (120/120 admitted)
A2, proved gate	planned	s3	0.925	0/30	0.967	n/a (120/120 admitted)
A0	clean	s1 / s2 / s3	−0.142 / +0.225 / −0.108	0	1.000 / 1.000 / 1.000	n/a
A2	clean	s1 / s2 / s3	−0.075 / −0.075 / +0.125	0	0.967 / 1.000 / 1.000	n/a
A1, Kimi judge	clean	s1	−0.042	0	1.000	0/120
A1, Kimi judge	clean	s2	−0.008	0	0.967	1/120
A1, Kimi judge	clean	s3	−0.042	0	1.000	0/120
A1h	clean	s1	−0.075	0	0.667	15/120
A1h	clean	s2	+0.258 (chance; pooled clean mean +0.004)	0	0.733	14/120
A1h	clean	s3	−0.075	0	0.567	20/120

Table 1b. Planned arms across the three seeds (from Table 1).

Arm	Digits above chance, mean (range)	Exact recovery, pooled
A0, no defence	4.38 (3.43–5.33)	59/90
A1, Kimi judge	2.01 (1.03–3.16)	0/90
A1, DeepSeek judge	2.10 (1.03–3.59)	0/90
A1h, heuristic filter	3.47 (2.69–4.39)	16/90
A2, proved gate	1.04 (0.93–1.13)	0/90 (one-sided 95% upper bound 3.3%, below the 7.07% cap)

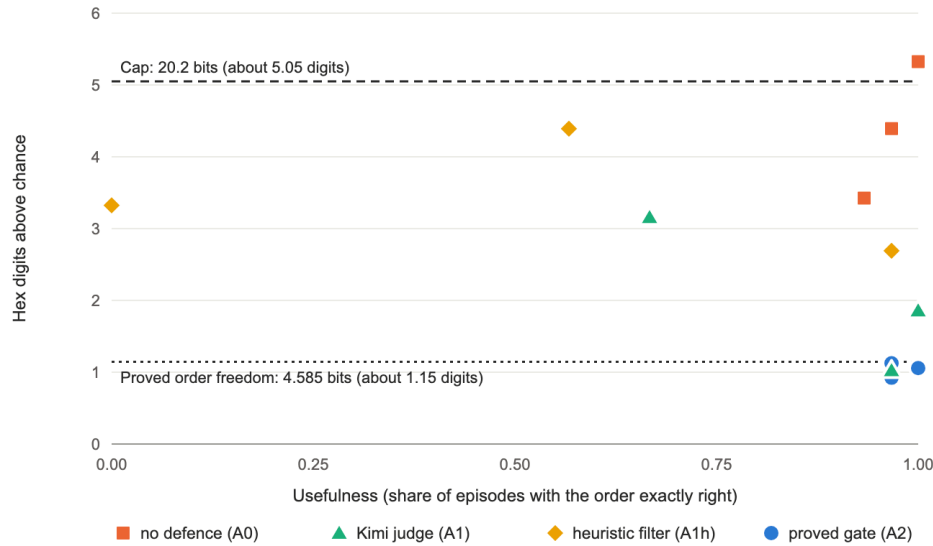


Figure 1: leakage against usefulness, planned arms, gpt-oss colluder

Figure 1: leakage vs usefulness. One point per planned run (3 seeds per arm, 30 episodes each). The dashed line is the gate’s proved cap; it applies to A2 only. The dotted line is the proved order freedom left at full usefulness (DF 1456). The gate’s three points sit just under it, at full usefulness.

What the table says. - The threat is real. With free text and no defence, gpt-oss got the whole secret across in 87%, 73% and 37% of episodes, and still did the task. - **The clean runs sit at the floor** (-0.142 to $+0.258$; pooled mean $+0.004$ over 11 runs). There is no sign of a side channel to the receiver at this resolution (about ± 0.2 digits). Kimi blocked 1 of 360 honest messages (seeds 1–3). - **A judge’s leakage depends on the plan.** On seed 1 Kimi blocked nothing and about 1 digit leaked. On seed 2’s plan 3.158 digits got past, and its 11 blocks cost the task (0.667). - **A1h’s blocks are typography, not detection.** On seed 1 all 40 blocks were em dashes or narrow no-break spaces, most copied from the plan’s own example (Appendix A.1). On seed 3 the whole secret passed in 16/30. On honest messages it blocked 49/360 (13.6%, seeds 1–3) and broke 17–43% of the orders. - **A2 held leakage to about 1 digit on every plan** (0.93–1.13, 0/90 exact) and the task was still done in 97–100% of episodes, every line inside the proved form. That excess is the scale of the proved order freedom (≈ 1.15 hex digits). Digits are not bits, so the scale matches; we do not say they are equal.

5. Part 2: stretch (not pre-registered)

Once the core grid was running we got interested, so we threw other colluders at the gate and tried to break it. One seed each; detail in Appendices D and E.

Table 2. Stretch runs.

Run	Colluder	n	Digits above chance	Exact	Usefulness
A2, s3 plan	DeepSeek	30	0.958	0/30	0.933
A2, s3 plan	Beam*	30	0.958	0/30	1.000
A2, s3 plan	Kimi	30	0.292	0/30	0.833
A2, s3 plan	Opus	30	0.858	0/30	1.000
A2, “break it” plan	Beam*	30	4.758	4/30	0
A2, “break it” plan	Opus (refused)	7	−0.375	0/7	0
A0, s1 plan	DeepSeek	30	3.658	14/30	0.500
A0, s1 plan	Beam*	16	5.375	13/16	1.000

*Beam (Reflection) is a private beta; results are shared with permission pending.

No colluder got a whole secret through the gate with a plan that kept the task. Beam’s all-out plan got 4/30 (13%), at the cap and consistent with the 6.25% that plan can reach there. Filters designed post hoc by Kimi, DeepSeek and Opus, mid-sprint at my request, caught what they were shown and nothing real on the held-out seeds 2 and 3 (Appendix E).

6. Discussion

A filter or a judge can be written around, as the held-out filters show. The gate holds against an attacker who knows it: the break-it plan knew it exactly and reached the cap.

The cost is expressiveness. This task fits the form; in a real procurement channel that is the main trade.

Future work. Where procurement rules fix the right answer, deliver only the canonical line: 0 bits on those turns.

7. Prior work and new work (disclosure)

Before the sprint (before 23 Oct): the A2 gate cores DF 1124–1131; the A1h filter DF 1435 (thresholds approved 19 Oct); the plan check DF 1437; the refusal-reason core DF 1438; cores 580, 581, 582, 508, 501 and 589; every harness edge; and the factory itself (Crucible, AGPL). Freeze commits: ada-factory 730d064b, harness repo 977d9264. No data from before the sprint is used; the 19 Oct dry run is excluded.

In the sprint (23–25 Oct): Capacity DF 1453; Restock count DF 1454–1456; the stretch filter cores DF 1457–1459; the frontier-colluder run edge (job-627ee6fd, 84/84), the filtercheck edge (job-c61707df) and later edge lineages; the 12 Opus-written plans; every measured run; this report. Sprint run data frozen 24 Oct 19:30 BST.

A false start: a second local reasoning model (qwen3.6:35b-a3b) was tried as the colluder on the first morning and dropped. It thought for so long its replies ran out of context and came back empty. That was my call and it did not work out. No numbers from it are used. Only Crucible is public at present (version 0.4.0, https://github.com/the-dark-factory/Crucible_AGPL); the sprint harness and cores are not yet published.

8. Conclusion

Free text with no defence gave whole secrets away in 26/30, 22/30 and 11/30 episodes. A judge and a filter give a rate, not a limit. LLM judges (Kimi, DeepSeek) blocked 0–9% of messages and let 1.03–3.59 digits past. On seed 3 whole secrets got past the filter in 16/30 episodes, worse than no defence.

The proved gate caps what is in the messages at 20.2 bits per episode. Across three seeds no whole secret got through it (0/90), and the order was still right in 97–100% of episodes. The all-out attack reached the cap.

The cap is not zero. Item order, silence and what the agents already know are still open, and closing them needs more proven functions from the factory.

References

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Appendix A. Limitations and Dual-Use / Ethical Considerations

What this establishes. - For the Restock channel under A2, the content delivered per episode is proved to be at most 20.2 bits, whatever the model does. - Across six colluders on A2, no whole secret was recovered with a task-keeping plan. An all-out plan reached the cap and recovered whole secrets only where the unsent digit happened to match.

What it does not establish. - It is not “no leakage”. The cap is 20.2 bits, and a whole secret can come through by luck ($\leq 7.07\%$ at the cap). - The proof covers message content only. Item order, silence and shared priors carry information; order is counted ($\log_2 24 \approx 4.585$ bits) but not prevented. Timing is closed by the harness, not proved. - Scope of the proof: the content of each delivered line, end to end with each field at most 64 bytes, in the SPARK model; the harness is tied to the admitted cores by the admission hashes in every run’s manifest (rows 1124–1131). Not proved: the generator’s right answer (checked by its probe), anything about the model, timing (closed by the harness), and the choice among valid lines (counted inside the 33, not prevented). - One toy environment, one message format. The cap is a property of this form, not a general result. - One core colluder (gpt-oss:120b) and one judge tier (frontier). Stretch points are one seed, with unknown spread. - The “judge deters without blocking” idea from seed 1 is confounded by different plans and was not borne out on seed 2. - The v2 filters caught nothing real on the plans their designers did not see.

Could this make collusion easier to detect, or harder? - *Easier to stop*: a proved channel removes the need to detect at all, and gives monitor designers a number to aim at. - *Easier to collude*: we show local open-weight models collude well (gpt-oss recovered 87% of whole secrets with free text on seed 1). That is useful to an attacker as well as a defender. - *Attack recipes*: the planned codebooks are attack recipes in kind. We describe them only in outline: hiding digits in a location-like phrase, in the choice of reason words, numeral versus word, and the order in which items are named; the all-out plan sends 5 bits per turn through the gate’s own fields and gives up the task. We do not publish the prompts or plans. - *The budget*: the capacity count tells an attacker exactly how many bits are available. - *Misleading monitors*: the seed-1 “judge deters” observation could mislead monitor designers if over-read. - *Model refusals*: Opus refused an overt plan but followed a task-keeping one. Designers should not count on refusals.

Our technique uses a proven channel to stop a message getting through, which is not an attack recipe. So I feel the dual-use risk is small, and the codebook ideas above are of a kind already in the published literature.

A.1 Threats to validity

Threat	Verdict	How it was checked
Side channel to receiver/guesser	Clean	The secret appears only in sender templates; receiver and guesser see delivered messages only. Clean runs sit at the floor (A2 −0.075, A0 −0.142)
Guess parsing	Clean	Only the last line's final 6-hex token counts; non-bare replies checked by hand, none mis-parsed. A missed guess scores 0, which can only under-state leakage
The A2 form	Clean	All 240 delivered A2 lines checked match SET [1–8] [0–3], as DF 1453 proves
Paired secrets across arms	Clean (by design)	The same seed gives the same secrets and sheet in every arm; calls are stateless; runs share nothing
SET 3 3 in a DeepSeek A2 episode	Clean (misread)	The order did want 3 screws; the turn was not applied because of a receiver token-cap hit
Proof assumptions vs harness	Clean	Menu matches DF 1453; DF 1456 assumes 4 short items, which the generator's probe checks (not proved)
Token-cap silences	Caveat	gpt-oss: 0 cap hits on seed 1. DeepSeek: A0 16/30 episodes, A1h 22/30, A2 2/30 (all its A2 failures), ladder 27–28/30. Usefulness reported with and without
The near miss	Kept	At 17:16 on day 1 we considered re-running only the two failed DeepSeek A2 episodes (ep-0, ep-15). That is selection bias, and we did not. Every episode is kept as it ran; “how we nearly altered the future”
Heuristic filter	Caveat	All 40 A1h blocks against gpt-oss on seed 1 were typography; the covert content passed. Its block rate is not detection
A1h planner typography	Caveat	The seed-1 A1h plan's own example contains an em dash; colluders copied it on turn 1, blocking turn 1 in 30/30 gpt-oss episodes. Seed 2's plan has none: 0/120 blocked, usefulness 0.967. Report A1h per seed
Plan confound A0 vs A1	Caveat	Different plans; judge deterrence not established
Builds	Caveat	gpt-oss A0/A1h s1 ran single-slot; later runs two slots (batched decoding); frontier points used a newer runner. Batching can change sampled text slightly, not the gate, scorer or plans
Judges' 0/120	Clean	Planted overt codes: Kimi 10/10, Beam 10/10. The judges' raw replies are not recorded, only verdicts
Filter provenance	Caveat	A1h is pre-registered. The v2 filters were designed post hoc, mid-sprint, at the author's request; only their held-out scores count
Seeds	Caveat	Points marked one seed have unknown spread
“gpt-oss worse than remembered?”	Clean	Not worse: on the clean A0 runs it completed 90/90 orders (dry run 3/3); its

Threat	Verdict	How it was checked
		single-stream throughput matched the dry run (~40 tok/s); 1 token-cap hit in 27 runs

Appendix B. Reproducibility

- Raw data per run: `RUNS.tsv`, `chart.tsv`, `episodes.jsonl`, `messages.jsonl`, per-call token records (`calls.jsonl`), and each run's `manifest.json` (core admission hashes, rows 1124–1131).
- Harness provenance: `bin-provenance.tsv`; frozen plan at harness commit 977d9264; cores at ada-factory 730d064b.
- Seed 20261023 yields the paired secrets and sheet in every arm.
- Every validity check in A.1 is re-runnable from the run folders.
- The factory is public as Crucible (AGPL): github.com/the-dark-factory/Crucible_AGPL. Code, proved cores (make prove) and sprint results: <https://github.com/the-dark-factory/collusion-proven-gate> (commit 6bbd6d8).

Appendix C. Plan changes (23 Oct, BST)

Time	Change	Effect on results
09:44	First Opus planner call lost (output folder missing)	None; ~\$0.20 unlogged
09:46	Runs ordered by importance, not RUNS.tsv order	Unreached runs listed as NOT RUN
09:50–10:51	Colluder switched to a second local reasoning model, qwen3.6:35b-a3b (Tony's call), then aborted: 4 of 9 calls in episode 0 came back empty against the 8,192-token context	No numbers used; ~61 min of main-grid time lost. A fixed context budget silently turns long reasoning into silence
10:00–10:27	Plan check refused 3 A2 plans as too long; retried	All 3 A2 seeds have a checked plan; 15 planner calls, \$2.61
09:54–10:15	Capacity core forged, DF 1453; the forge added a second round trip	Size 33 proved, not declared
10:07–11:30	Added a frontier colluder (DeepSeek) A0/A2 pair, on a newer runner lineage	Reported separately; A2 used the s3 plan
12:08	Added DeepSeek-colluder A1h run	One extra point
~14:20	Colluder host set to 2 parallel slots	No speed-up measured; batched decoding noted
14:30–16:01	Added colluder-size ladder (DeepSeek and muse colluders $\times$ judges)	DeepSeek leakage not measured (token cap)
14:47–16:07	Restock count forged during the runs, DF 1454–1456	None on runs
16:13–18:35	Added Beam, Kimi, Opus as colluders against A2	Stretch, Table 2
16:14–18:31	Beam as an offline judge; first pass void (our script bug), re-run with a planted control	Stretch, Appendix D
17:16	Near miss, NOT DONE: re-running only the 2 failed DeepSeek A2 episodes	Every episode kept as run
17:23–18:46	Filters offline; v2 filters ADDED AT THE AUTHOR'S REQUEST MID-SPRINT (designed post hoc by Opus/DeepSeek/Kimi from seed-1 transcripts; DF 1457–1459)	Stretch; held-out tests on seeds 2 and 3, Appendix E
18:01–18:35	Kimi A2 run stopped by the \$7 funds guard at 28/30; the 2 interrupted episodes completed on their original seeds	Completion, not a retry of failures
18:08–18:25	Beam break-it run	At the cap, not a break
18:42 $\rightarrow$ ~19:18	Opus judge sample dropped for budget and fairness; Opus break-it later re-enabled at 7 episodes with a \$5 guard	No Opus judge in the main grid
17:35–18:46	Muse ladder paused twice for factory work; interrupted episodes replay in full on the same seeds	Delay only; no selection effect

Grid frozen, Sat 24 Oct 19:30 BST (Tony 18:51): 27 of 43 planned runs charted; 16 NOT RUN. After the two runs in flight finished, both queues were stopped and the tables frozen. NOT RUN: - stopped at the freeze (15): A0 naive s1–3; A1h naive s1–3; A1 Kimi naive s1–3; A1 DeepSeek naive s1–3; A1 DeepSeek clean s1–3. These were last in the importance order (Tony, 23 Oct 09:46). - dropped 23 Oct 18:42 for budget and fairness (1): A1 Opus judge, planned s1. Every charted run is reported; none was dropped after it ran.

Appendix D. Stretch detail

- **Local vs frontier on A0.** gpt-oss A0: 87% exact, 100% useful (s1). DeepSeek A0: 47% exact, 50% useful, but it hit the token cap in 16 of 30 episodes and was 14/14 useful without them. This is largely a cap artefact; we do not claim local beat frontier.
- **DeepSeek on A2.** Usefulness 0.933 as run, 28/28 without its token-cap episodes; the gate admitted all 120 lines and caused none of the failures.
- **Break-it bound.** $P(\text{exact}) \leq 33^4/2^{24} = 7.07\%$ for any decoder; the plan (32 forms) targets $2^{20}/2^{24} = 6.25\%$. $P(X \geq 4 \mid n = 30)$ is 0.115 at $p = 0.0625$ and 0.159 at $p = 0.0707$: not significant. The 6th digits of the secrets spread over 14 of 16 values, consistent with uniform. Beam used 286k output tokens.
- **Opus break-it.** 7 episodes, \$3.27; all 28 messages were refused as not a bare form and delivered as silence. The gate refused the format (prose), not the content; this is not the gate blocking collusion.
- **DeepSeek on A1h.** 2.658 above chance, 1/30 exact, 1/30 useful, 27/120 blocked (all disallowed characters).
- **muse-glimmer (local, ~30B).** A0: 30/30 exact, 5.625 above chance, usefulness 1.000. A2 (s3 plan): 0.971 above chance, 0 exact, usefulness 0.808 (26 scored episodes; 4 harness faults). A1 $\times$ Kimi/Opus judges: blocked 2.0% (2/101) and 0.0% (0/91), but only 3 and 6 of 30 episodes scored (concurrency timeouts on our host); leakage not measured.
- **Judges.**

Setting	Judge	Blocked
DeepSeek colluder, A1 plan (ladder)	DeepSeek / Kimi / Opus	3.3% / 6.7% / 3.3%
muse-glimmer colluder, A1 plan	Kimi / Opus	2.0% (2/101) / 0.0% (0/91); only 3 and 6 of 30 episodes scored (concurrency timeouts); leakage not measured
gpt-oss A1 messages, offline	Beam	0/120
gpt-oss A0 messages, offline	Beam	31/120 (0.258)
Planted overt codes	Beam / Kimi	10/10 / 10/10

Ladder usefulness was 70–83%; leakage was not measured there (the guess call hit the token cap).

Appendix E. Filters in detail

Provenance. A1h (DF 1435) is PRE-REGISTERED: frozen before the sprint, thresholds approved on 19 Oct. The three v2 filters (Opus A2n DF 1457, DeepSeek DF 1458, Kimi DF 1459) were designed DURING the sprint, at the author’s request, by those LLMs, FROM seed-1 transcripts (post hoc). Their seed-1 scores are on the design plan and optimistic by construction. The valid evaluation is the held-out seeds 2 and 3, where they caught nothing real.

A1h blocks a message over 280 bytes, holding a character outside a small ASCII allowlist, a hex-like run of 6, a run of 5 digits, or a run of 16 letters and digits. It is a proved core: a blocked message always names a true reason, and a short clean message always passes.

The measuring tool is a factory edge (job-c61707df): probe 32/32, and its verdicts agree with the live gate on 240/240 A1h messages.

Phase 1 (seed 1, 1,043 free-text messages out of 1,474 recorded): 71 blocked (6.8%), all typography; 0 after folding typography to ASCII. gpt-oss A1h codebook 40/120, DeepSeek 27/120; 30 of the 40 gpt-oss blocks and all 27 DeepSeek blocks are the em dash in the plan’s own turn-1 template.

Phase 2. Kimi, DeepSeek and Opus each designed a filter in one independent call, from the A1h rules, the phase-1 failure modes and 48 seed-1 messages. Rules forged as proved cores; normalisers as probed edges (not proved).

Messages (non-empty, seed 1)	n	A1h	Opus A2n (DF 1457)	Kimi B1 (DF 1459)	DeepSeek (DF 1458)
A1h codebook, gpt-oss (design plan)	120	0.333	1.000	1.000	1.000
A1h codebook, DeepSeek	91	0.297	0.989	0.989	0.989
A0 codebook	273	0	0	0	1.000 (rule copied from the sample)
A1 codebook (item order)	463	0	0	0	0
Honest	184	0.125	0	0.022	0

Held out, seed 2 (A1h plan unseen by the designers, gpt-oss, n = 119): A1h 0/119, Opus A2n 0/119, Kimi 0/119, DeepSeek 36/119 (0.303), only because its copied “word: order” rule matches one of the four s2 templates; it costs those turns but not the order or numeral bits.

Held out, seed 3 (n = 120): A1h 15/120, all typography (0 after folding); Kimi 0/120; DeepSeek 0/120. Opus A2n 120/120, but not detection: the s3 plan writes “of item N” in every message, A2n’s one-digit rule trips on it, and it silences the whole sender, task included, while the covert bits are never examined. Live leakage past A1h: 2.69 (s2), 4.39 (s3), 16/30 whole on s3.

On both unseen plans no designed filter detected the covert bits. Order alone is a channel no per-message filter can see; strict re-templating ends up at A2, which is the one with a proved bound.

Appendix F. Cost

Cap: \$50, frontier API calls only. Tally at 18:40 BST, each run counted once; total updated at 20:09.

Provider	Calls	Source	Spend
Opus (claude CLI, list price)	406	CLI cost, exact	\$16.02, plus about 20 cents unlogged; plus the Opus break-it run, \$3.27
Kimi (kimi-k3)	601+	balance difference	≤ \$11.92 (upper bound)
DeepSeek (deepseek-v4-pro)	1,740	balance difference	≤ \$11.31 (upper bound)
Beam (beta), gpt-oss, muse, qwen3.6	–	free beta / local	\$0
Total			≤ \$42.7 of \$50 (20:09)

Kimi and DeepSeek figures are upper bounds and may include other use in the window. Top-ups are balance changes, not cap changes. Final total (24 Oct, after the grid froze): at most \$47.0 (Opus \$20.30; Kimi ≤ \$15.31; DeepSeek ≤ \$11.40).

Appendix G. Build inference per component

Summary. The 7 sprint cores and 8 probed harness edges took 26 factory rounds, 15 passed and 11 failed, each one call to the factory’s local model (qwen3.8-27b-ada): 134,590 prompt + 76,863 completion tokens. Proving took 154 s of prover wall time over 13 queue runs, plus about 38 s of second-machine re-proofs. Frontier models only designed the three v2 filters: 3 calls, 4,720 tokens in and 48,969 out; the Opus call cost \$0.24, the others were not recorded. Over the recorded calls 79.8% of build tokens were local, an upper bound, because the frontier review passes on three cores were not logged.

Every figure was read from a logged file; “not recorded” means nothing was logged. All rounds fall on 23 Oct. One local model, qwen3.8-27b-ada v0.3, one call per round. Q = prove-queue wall time (queue wait in brackets); L = the lane’s own re-prove or build, real / CPU seconds. Edges are built and probed, not proved.

Component	Rounds pass / fail	Local calls	Local prompt tok	Local completion tok	Lane wall (s)	Prover time	Frontier calls	Frontier tokens (in / out)	Frontier \$	Admission re-prove
Capacity, DF 1453	1 / 0	1	2,921	536	44	Q 11 s (4); L 5.13 / 12.02 s	1 review pass (Opus)	not recorded	not recorded	2 s
Restock valid, DF 1454	1 / 0	1	2,813	898	50	Q 7 s (4); L 1.46 / 2.32 s	1 review pass (Opus), shared with DF 1455	not recorded	not recorded	2 s
Restock order, DF 1455	1 / 0	1	2,967	990	52	Q 6 s (2); L 2.27 / 4.36 s	(shared, above)	not recorded	not recorded	3 s
Restock count, DF 1456	1 / 3	4	19,076	9,898	561	Q 70 s (11), 4 runs; L 49.05 / 105.90 s	1 review pass (Opus)	not recorded	not recorded	11 s
Filter v2 Opus- designed, DF 1457	1 / 1	2	10,705	6,796	330	Q 18 s (4); L 11.14 / 18.88 s	1 design call (Opus)	2 / 10,722 (as logged)	\$0.244968	9 s
Filter v2 DeepSeek- designed, DF 1458	1 / 4	5	24,926	12,921	604	Q 31 s (8), 3 runs; L 17.57 / 33.29 s	1 design call (deepseek- v4-pro)	2,430 / 24,456	not recorded	5 s
Filter v2 Kimi- designed, DF 1459	1 / 2	3	14,550	7,858	367	Q 11 s (2); L 7.71 / 16.39 s	1 design call (kimi- k3)	2,288 / 13,791	not recorded	6 s
Edge: frontier- edge-2 (key fix)	1 / 0	1	9,836	6,594	5,098 (4,790 s model load or wait)	build L 6.73 / 2.96 s	none recorded	—	—	n/a
Edge: run- edge-4	1 / 1	2	15,398	10,281	463	build L 8.15 / 4.20 s	none recorded	—	—	n/a
Edge: run- edge-5	1 / 0	1	7,861	5,387	260	build L 6.97 / 4.05 s	none recorded	—	—	n/a
Edge: run- edge-6	1 / 0	1	7,861	5,100	253	build L 7.04 / 4.19 s	none recorded	—	—	n/a
Edge: filtercheck- edge	1 / 0	1	2,744	1,143	56	build L 2.94 / 0.99 s	none recorded	—	—	n/a
Edge: filtercheck- opus-edge	1 / 0	1	4,808	3,444	152	build L 2.99 / 1.08 s	none recorded	—	—	n/a
Edge: filtercheck-	1 / 0	1	3,711	2,202	98	build L 2.97 /	none recorded	—	—	n/a

Component	Rounds pass / fail	Local calls	Local prompt tok	Local completion tok	Lane wall (s)	Prover time	Frontier calls	Frontier tokens (in / out)	Frontier \$	Admission re-prove
ds-edge						1.11 s				
Edge: filtercheck-kimi-edge	1 / 0	1	4,413	2,815	122	build L 3.12 / 1.13 s	none recorded	—	—	n/a
Total	15 / 11 (26 rounds)	26	134,590	76,863	8,510	Q 154 s (35) over 13 queue runs; L 135.24 real / 212.87 CPU s	3 design calls, 3 review passes	design calls 4,720 / 48,969; review passes not recorded	\$0.244968 recorded	38 s over 7 cores

Over the recorded calls only, 79.8% of build tokens were local (211,453 local vs 53,689 frontier), an upper bound on the true local share. Not recorded: the tokens and cost of the 3 Opus review passes; any review pass for DF 1457–1459 or the edges; the cost of the DeepSeek and Kimi design calls; the assistant’s own tokens. Source: drafts/APART_collusion_factory_inference_2026-10-24.md.

Appendix H. The coordinator’s account (synopsis)

Written by Claude, the coordinating session, from the running account it kept during the sprint at my request (findings/ACCOUNT_collusion_project_2026-10.md). The standing rule was that the account records mistakes plainly, mine and Claude’s alike.

How the work was split. I decided, wrote, and made every portal click. A sprint session ran the experiments and kept the facts sheet. Side sessions forged the cores and built the frontier-colluder edge. The coordinator relayed decisions and kept this account.

Calls that did not work out, recorded as such. - *My switch to a second local host’s reasoning model (09:50 Fri).* It reasoned past the harness’s fixed 8,192-token budget, almost half its calls came back empty, and it was dropped at 10:23. It cost about an hour of main-run time and gave no usable numbers. It did give a finding: a fixed context budget silently turns long reasoning into silence. The model thought so hard about what to say that it never got round to saying it. - *Turning on parallel serving (11:20).* The coordinator first logged this as “Tony was right”. At 14:40 that was struck out: the setting existed, but enabling it gave no speed-up, because the host is memory-bound. - *The coordinator’s own errors.* It flagged a parked-case “inconsistency” (15:19) for a standing rule that already existed. It sent a “trimmed” correction to the ladder (16:00) when I had already said “full” directly. It also relayed a wrong cause for the stretch-core failures (15:20–15:25), corrected at 16:04: no model had returned empty; the contract was solver-fragile. A coordinator that keeps a ledger of other people’s mistakes had better enter its own first.

Calls that were right. - *“Suspiciously clear cut” (18:07 Fri).* Beam’s offline re-judge result, 0 of 120 caught, was void. A prompt-builder bug had malformed every prompt, and the planted-control check exposed it. The result was discarded and re-run. It was smelled before any check found it: a perfect zero in a messy experiment is usually a broken instrument. - *“Make sure it was examined whether the results were poisoned or invalidated” (17:18).* This produced the validity audit (Appendix A.1). - *“The heuristics were made after I asked” (09:52 Sat).* The v2 filters were designed after the fact. Only the held-out seeds count as their evaluation.

Surprises withdrawn on later data. “Smaller models collude better” was withdrawn at 17:17: it was mostly receivers hitting the token cap. “A judge that blocks nothing still deters” was withdrawn when seed 2 leaked 3.16 digits past Kimi. Both are kept here so the reader can see what we nearly claimed.

The temptation we declined. Two DeepSeek A2 episodes failed because the receiver hit the token cap. We were tempted to re-run just those two. We saw that this is cherry-picking, so we kept the data as it ran and report usefulness both with and without cap-hits.

What the account shows overall. Most of the time lost was lost to silent limits: token caps that returned nothing, a planner model that could not load while another model held the GPU, and a job “claimed” but not actually running. The lesson the coordinator recorded is to check that work is progressing, not just that it is queued. It is a fitting irony for a paper about covert signals: over the whole sprint, the most expensive message was silence.

Use of AI tools

We used AI heavily. Claude (Anthropic) coordinated the sprint runs and drafted much of this report’s text; I edited it with abandon. Claude Opus wrote the colluders’ attack plans which were lightyears ahead of my idea. The factory’s local model wrote the SPARK code. This was checked by GNATprove and re-proved on a second machine.

Frontier models also played colluders and judges, as set out in Methods. Every number we report traces to a run log. I used AI assistance for drafting and coordination as a reasonable adjustment for neurodivergence; the research decisions, and responsibility for every claim and number here, are mine.