Apollo 13, read as a topology

An OptaCat v0.9.1 analysis of the Mission Control voice loops, set beside the Apollo 13 Review Board

Corpus: 55:46:11–62:06:53 GET · 36 Scenes · 5,385 Lines · 733 events · 690 callbacks · 287 canonical entities

What happened

Apollo 13 launched on 11 April 1970 to land Jim Lovell and Fred Haise in the Fra Mauro highlands while Jack Swigert orbited in the command module. The spacecraft was two vehicles docked nose to nose: the Command/Service Module **Odyssey**, which carried the crew, the main engine, the fuel cells and their oxygen, and the Lunar Module **Aquarius**, built to land two men on the Moon for about two days.

At 55:52 Ground Elapsed Time (GET), almost 56 hours into the flight and about 200,000 miles from Earth, Mission Control asked the crew to stir the cryogenic oxygen tanks. A damaged heater wire inside oxygen tank 2 ignited the insulation, and at 55:54:53 the tank failed. The crew heard a bang and saw a master alarm; Swigert reported "Houston, we've had a problem." MAIN bus B lost voltage and two of the three fuel cells began to die.

For the first hour the White team under Gene Kranz treated the readings as a possible instrumentation fault and tried to restore power: reconnecting buses, shutting fuel cell reactant valves, switching heaters and fans. Lovell then saw gas venting from the service module, and tank 1 was clearly draining as well. With the command module's power and oxygen running out, the controllers turned the LM into a lifeboat. The Black team under Glynn Lunney took over at 57:07. The crew powered up Aquarius and transferred the guidance platform's alignment from Odyssey, and Odyssey was shut down at about 58:40 to save its batteries for re-entry.

The spacecraft was on a trajectory that would not return to Earth unaided. Rather than trust the service module engine next to the damaged bay, the team used the LM descent engine. At 61:29:43 a 38 fps burn (MCC-4) put Apollo 13 back on a free-return path around the Moon. This corpus ends at 62:06:53, as the ground settled how the LM would be configured overnight. A second burn after rounding the Moon, improvised CO_2 scrubbers and a cold, power-starved coast followed, and the crew splashed down safely on 17 April 1970.

The most interesting findings, in plain words

1. **The fix and the rescue were two different stories.** For the first hour the controllers worked on the electrical problem: is it the instruments, can we reconnect the buses, will closing the fuel cell valves stop the leak? None of that work leads, by any chain of dependencies, to the burn that brought the crew home. The rescue grew from a separate root: tank 1's falling pressure, read out every few minutes, and an early suggestion that "we'd better think about getting in the LM".
2. **The most important early act was a failed one.** Scene_09, the attempt to save oxygen tank 1, carries more of the story than any other Scene (274 later events depend on it). The attempt did not work, but the readings it produced (318, then 297 psi, then "100 psi in 1 h 54 min, that's the end") are what forced the LM decision.

3. **The rescue's backbone was the guidance platform, not the engine.** Almost half of the early events upstream of the burn concern one problem: carrying the CSM's alignment over to the LM before Odyssey died. That meant keeping the CSM gyros alive on a re-entry battery, the coarse align, and Stafford's warning that a star alignment through the LM telescope would be very hard. The burn was flown on that platform.
4. **A man in the middle, not at the top.** CAPCOM is both the most central and the biggest bridge in the network: almost every order passes through him. But his ASC is below 1: the voice that carries the most is not the one whose acts others build on. That role belongs to EECOM, the console whose proposals most often became decisions.
5. **Kranz's shift: low agency, high load.** Kranz has one of the lowest ASCs (0.79), yet the second-highest actor load (318). His acts were rarely taken further directly; his shift was the failed diagnosis. But they came early, and everything after was built on top of them, including the order to plan around the Moon on the LM.
6. **Seventeen minutes without control, and a wrong reassurance.** Between Odyssey's gyros going off (58:18) and "we've got attitude control now in the LM" (58:35), neither vehicle could hold attitude. CAPCOM told the crew the LM already had control; the real cause was an open breaker (ATCA) on panel 11.
7. **The plan that never happened.** The backup guidance system (AGS) is the strongest "hidden attractor": discussed again and again, never switched on. Water, the PTC rotation, BATTERY A and the dead tank 2 belong to the same group of things that hung over the room without being acted on in this window.
8. **The biggest break was the loss of tracking.** The sharpest change in the whole corpus comes right after Odyssey is shut down, when INCO finds the ground cannot track the LM because the spent S-IVB stage's radio is on the same frequency. The Board's findings do not mention this. OptaCat ranks it as the main turning point.
9. **The officer who found the way home is nearly invisible.** FDO, who proposed the 16 fps burn that became the decision, speaks so rarely that the visibility gate drops him from the "dark horse" ranking. Without the gate he would be first.

What was analysed

OptaCat is a topological cartography engine for corpus-based processes. It turns a text into three frozen layers: a corpus of Lines, a canonical identity hierarchy, and a graph of atomic directed events. Each event has one source, one target and one label, and is anchored to one Line. A later event records a **callback** to an earlier one only when removing the earlier event would cost the later one a specific part of its meaning. An event's **weight** is one plus its inbound callbacks. **Load**, the ninth reading, is the transitive closure of that graph: how many events in the whole corpus depend on a Scene or an Actor, directly or through a chain.

The corpus is contemporaneous, not curated. Unlike the SVB and ExComm analyses, nothing here was selected by an investigator. The Lines are the verbatim Flight Director loop and air-ground loop for the six hours and twenty minutes after the cryo stir, transcribed by the apollo13rt project (CC0) from the NASA recordings. The two loops are merged by timestamp. FLIGHT is split at the 57:06:51 handover into the White team (Gene Kranz) and the Black team (Glynn Lunney). Hardware that exists twice is split by vehicle, for example the CSM and LM IMUs and the two sets of thrusters.

Run. Policy `optacat_apollo13_v0_9_1` (SHA-256 `516942cf…`), ledger mode `source_weight_target_flat`. All four input files are byte-frozen and hash-bound. The only departure from the Appendix A.4 defaults is the declared outcome: the six events of scene_34, the MCC-4 DPS burn that restored the free-return trajectory. Structural QA is OK on every layer. Callback density is a reviewed WARNING (0.94 callbacks per event): it comes from Mission Control's relay structure (console → FLIGHT → CAPCOM → crew → switch), in which every link is a separate, counterfactually dependent act.

The official reference is the *Report of Apollo 13 Review Board* (Cortright, 15 June 1970), chiefly the findings and determinations of Chapter 5. Page numbers below refer to that report.

How to read the numbers

All of OptaCat's numbers come from one picture: a chain of **events** (who did what to whom or to what) linked by **callbacks** (a later act that would not make sense without an earlier one). Everything below is counted on that chain; nothing is a judgement of whether a decision was good.

- **Event.** One act on one Line of the transcript, such as "FLIGHT orders CAPCOM to turn BATTERY A on" or "CDR reports venting". It has a source, a target and a label (command, report, refusal and so on).
- **Callback.** A link from a later event back to an earlier one, kept only when removing the earlier event would leave the later one missing part of its meaning. "CAPCOM relays the order" calls back to "FLIGHT gives the order".
- **Weight.** One plus the number of later events that call back to this event. Weight 1 means nobody built on it; weight 9 means nine later acts directly needed it.
- **Load and tiers.** How many events in the whole corpus depend on a Scene or an Actor, directly or through any chain of callbacks: how much of the story would collapse if it were removed. Tiers group the loads: tier 1 is what the most rests on. **Stability** says how often the same items stay in tier 1 when callbacks are randomly removed (0.60 or more is solid).
- **ASC (Actor State Coefficient).** An actor's average score per appearance. Each time the actor *initiates* an event they score that event's weight; each time they are the *target* of someone else's act they lose 1. ASC is the total (the actor's **weight** in the agency table) divided by the number of appearances (**inc**). High ASC means the actor mostly started things that others built on (EECOM 1.66: proposals that became decisions). Around 1 means a mix of acting and being acted on (CAPCOM 0.95: relays orders, but also receives every order to relay). Below 0 means the actor was mostly on the receiving end (the call signs Aquarius and Odyssey, addressed but rarely acting). The numbers say how the actor sat in the chain, not how good they were.
- **Centre.** Who sits in the middle of the network of interactions, connected to most others most often.
- **Bridge.** Who connects parts of the network that would otherwise be apart; remove a bridge and the groups stop reaching each other.
- **Rupture.** How much the cast of actors and objects, and the relations between them, change from one Scene to the next (0 = same picture, 1 = entirely new picture). A high value marks a turning point.

- **Hidden attractor.** An object that keeps being talked about but rarely acted upon, something that hangs over the story without moving it.
- **Structural attractor.** An object that many events actually pass through and act on.
- **Recurrence.** How regularly an object or actor reappears across Scenes.
- **Invariant relation.** A pairing (A acts on B) that persists across the corpus while everything else changes.
- **Perturber.** An actor whose appearance tends to be followed by a change in the structure.
- **Dark horse.** An actor whose influence is larger than their visibility. The visibility gate drops actors seen too rarely to judge.
- **Outcome support.** The set of all events from which a chain of callbacks leads to the declared outcome (here, the MCC-4 burn). **Jaccard** stability of that set: 1.0 means the same events every time callbacks are randomly dropped, 0.21 means the set reshuffles a lot.
- **Callback density.** Callbacks per event. Above 0.50 the specification raises a warning, because dense graphs can inflate load.

Official findings beside the OptaCat readings

The Board's Chapter 5 states more than a dozen findings that fall inside this window. The table sets each against what the topology says.

Official finding (Review Board)	OptaCat reading	Verdict
Det. 1, 36d (pp. 5-6, 5-27). The tank failed by internal combustion. Neither the crew nor Mission Control was aware that tank 2 pressure had risen abnormally.	The stir that preceded the failure is in the corpus, and nothing depends on it: the stir request carries weight 1 and scene_01 carries load 0. The record before the bang is structurally silent.	Agrees
28a–b, Det. 2 (pp. 5-22–23). The O_2 master alarm was inhibited by a low-hydrogen warning already in effect, so a problem "can go unnoticed".	Not observable. The voice loops contain no Line about the masked alarm, so no event can carry it.	Silent
Det. 36 (p. 5-27). It was reasonable to suspect an instrumentation problem, given the earlier quantity-sensor failure.	The instrumentation frame is among the heaviest early events: EECOM's "we may have had an instrumentation problem" has weight 5, and scene_03 has load 94 (tier 2). EECOM's retraction, "not an instrumentation problem", has weight 1: nothing hangs on the correction. None of the events that diagnose the electrical problem reaches the burn's support set.	Agrees, and adds that the diagnosis branch is a dead end
Det. 37-1 (p. 5-28). It was logical to try to regain power to the busses.	Fuel-cell reconnect and open-circuit events in scenes 03–04 (reconnect failure weight 3; scene_04 load 15, tier 3). The attempt is present, but it carries little.	Agrees
38, Det. 38-1 (p. 5-28). The talkbacks show "closed" only when both valves are closed. The crew "could possibly have acted in time to delay the failure of fuel cells".	The reactant-valve episode is a structural dead end. Fuel cell 3 is closed, then "the pressure still appears to be going down" (weight 3). The barber-pole verification has weight 2. Scenes 12–13 carry load 14 and 2 (tiers 3–4).	Agrees: the closures changed nothing downstream
Det. 39-3 (p. 5-29). Mission Control correctly determined the RCS status and advised the crew.	GNC: quad C PROP ISOL valves closed by the shock and unpowered on MAIN B (weight 3), relayed as "disable AUTO RCS quad C".	Agrees
Det. 40-1, 40-2 (p. 5-30). Entry-battery use protected MAIN A, and emergency power-down lists sped load reduction.	The emergency power-down 1-5 proposal has weight 3 (scene_06 load 41). The cost of the entry battery is explicit: "what we take out of the battery we won't get back" sits in the burn's support set.	Agrees
Det. 41-1 (p. 5-31). Under normal conditions, heaters and fans might have raised oxygen pressure.	Scene_09, *Saving tank 1*, carries the **highest load of the corpus (274)**. The attempt failed, but tank 1's measured decline (318 → 297 → "100 psi in 1 h 54 min") is the chain from which the LM decision and, eventually, the burn descend.	Agrees, with more weight than the Board gives it
42a, 42c (p. 5-31). The LM was needed as a lifeboat and had to be activated as fast as possible.	The whole activation run, scenes 14–18, is tier 1. The LM is the dominant structural attractor (28) and the most recurrent object (0.39). Kranz's "plan assuming we go around the Moon and use the LM" (weight 4) is the root of the outcome chain.	Agrees, strongly
Det. 42-2 (p. 5-32). Mission Control made workable on-the-spot changes to the checklists.	Observed with a twist. The heaviest late event is Lunney's "stick with what we know works; by the book" (weight 6), which overrules the consoles' power-saving deviation. Deletions such as the PGNS self-test and the AGS activation are present as refusals.	Agrees; adds the counter-move

Official finding (Review Board)	OptaCat reading	Verdict
Det. 44 (p. 5-32). The LM controllers were not needed for an hour, but their early presence helped.	TELMU flagged the LM heater current at 56:06, and FLIGHT deferred it ("one problem at a time"). TELMU then carries actor load 214 (tier 2) from only 24 sourced events: few acts, each with many dependants.	Agrees
45a (p. 5-33). Mission Control made major revisions to water, oxygen and power use.	Water is a top-10 hidden attractor (17.3). "34 hours of descent water" has weight 4. The burn decision is explicitly a water trade: "3 pounds of water to keep [the PGNS] up for another hour... seems worth it".	Agrees
46a (p. 5-34). The LM LiOH would have saturated at about 100 h.	Barely present: FLIGHT's "LM LiOH is 48 man-hours, that doesn't sound right" has weight 1. The problem matured after this window.	Outside the window
p. 3-28. A 38-fps MCC-4 by the LM DPS placed the spacecraft on a free return.	The declared outcome. The PAD components (−21.3, +4.1, −31.2 fps) give a magnitude of 38 fps. FDO's first spoken estimate was "about 16". The post-burn data show a pericynthion of 136.75 nm, "doppler within 7 cycles".	Agrees
(No Board finding.) S-IVB/IU transponder interference with LM tracking.	**The strongest rupture of the corpus**, scene_22→23 (1.00), is the moment Odyssey goes dark and INCO reports no usable tracking (weight 5). The tracking test that cost half an hour of COMM (scene_27) is the third-highest rupture (0.95).	OptaCat only

What the topology says that the Board does not

The diagnosis and the rescue are two separate trees. The burn's support set covers 100 of 733 events, and it contains not a single event from scenes 01–04, 06–08 or 12–13. In other words, none of the electrical diagnosis is upstream of the burn: the instrumentation hypothesis, the bus reconnections, the reactant closures, the handover. The rescue descends from a different root: tank 1's pressure readings → EECOM's "we'd better think about getting in the LM" → Kranz's plan around the Moon on the LM → TELMU's lifeboat procedures → the alignment chain (Stafford's warning about the AOT, the coarse align, the CSM IMU held on BATTERY A) → the 16-fps free return. The Board describes the response as one continuous effort. The topology separates it into a diagnosis that failed and a parallel plan that inherited none of it.

The alignment, not the engine, is the backbone of the outcome. Of the early support events, nearly half belong to the alignment problem: P52, coarse align, the CSM IMU kept alive, and "do we really want to spend entry batteries to keep the platform on?". The platform carried the CSM's reference across to the LM, and the burn was flown on it.

Seventeen minutes without attitude control. Between the CSM IMU power-down (58:18) and "we've got attitude control now in the LM" (58:35), neither vehicle could hold attitude. CAPCOM told the crew the LM already had control (scene_21); the topology records this as a reveal contradicted two Lines earlier. Control came only after the ATCA (PGNS) breaker on panel 11 was closed (weight 3). The Board treats gimbal lock only in the context of LM jettison (Det. 52).

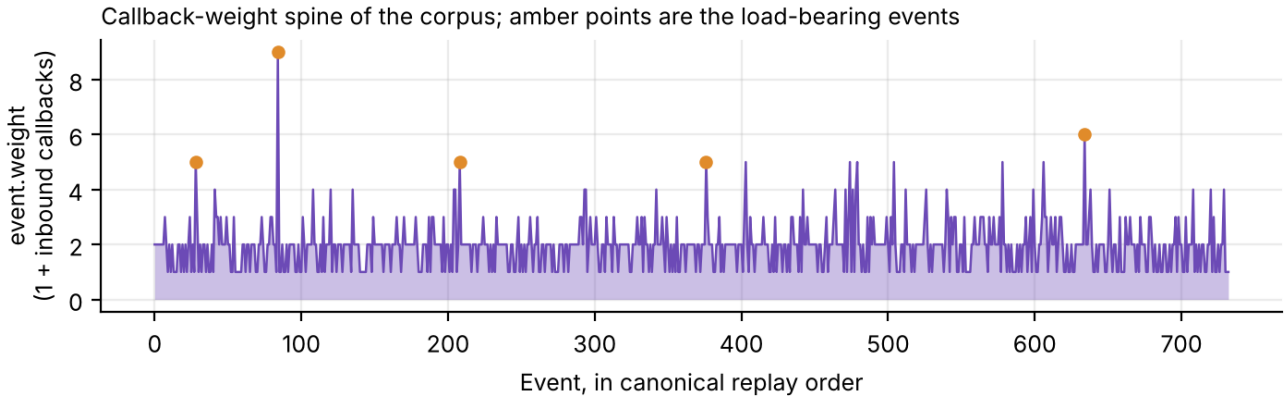
The AGS is the plan that never happened. It is the strongest hidden attractor (27.5): mentioned in seven Scenes and the subject of events in six, from 59:14 to the end of the window, and never powered. The burn was flown on the PGNS.

CAPCOM is the bottleneck. CAPCOM is both centre (0.99) and bridge (0.95), and the most invariant relation of the corpus is CAPCOM → crew (0.71). By ASC, though, CAPCOM ranks below EECOM, Lunney and Lovell: the most connected node is not the one whose acts the others built on.

The dark horse was gated out. The visibility gate excludes FDO, whose ungated score (0.20) is the highest of all. The 16-fps free return was FDO's proposal, and it became the decision.

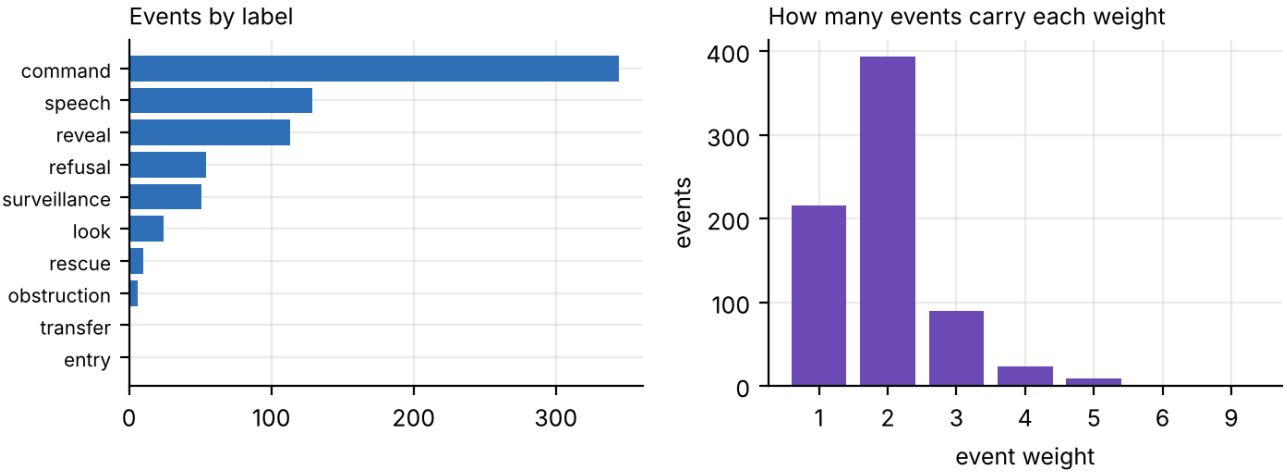
Figures, and how to read them

Every chart below is drawn from the same frozen run. Under each chart, *How to read* says what the axes and colours mean; *What it shows* says what we take from it.



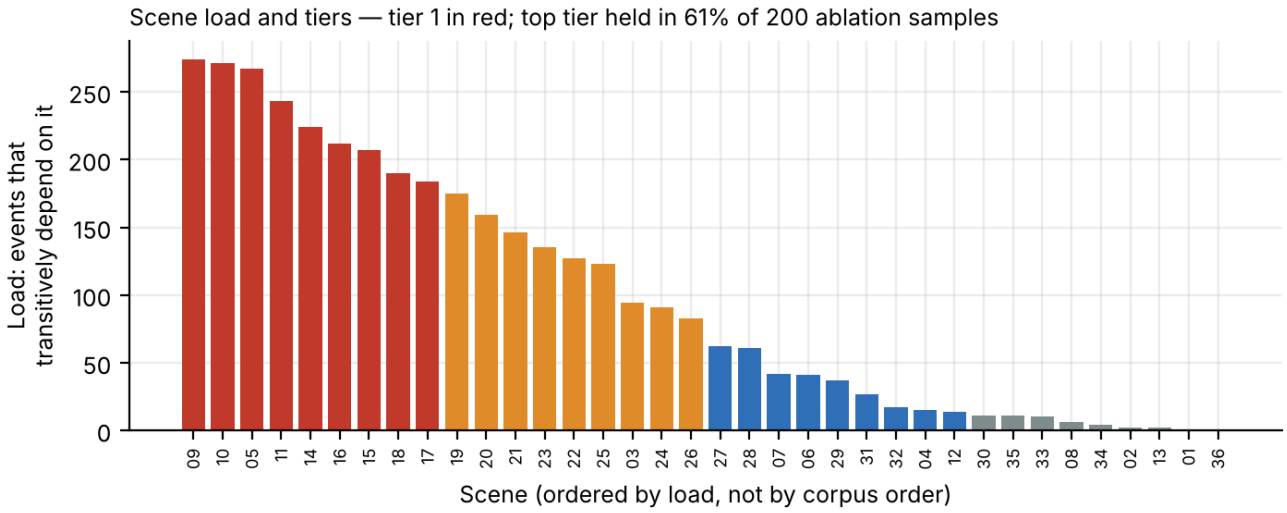
How to read. Every event of the corpus in time order, left to right. The height is the event's weight: 1 means no later act built on it, higher means more later acts needed it. The amber points are the five heaviest.

What it shows. Most acts carry weight 1 or 2: an order and its relay. The few peaks are the moments the room kept coming back to: Lovell's "we are venting something" (weight 9), EECOM's instrumentation hypothesis, Kranz's plan around the Moon on the LM, the entry-battery concern, and Lunney's "by the book" (weight 6).



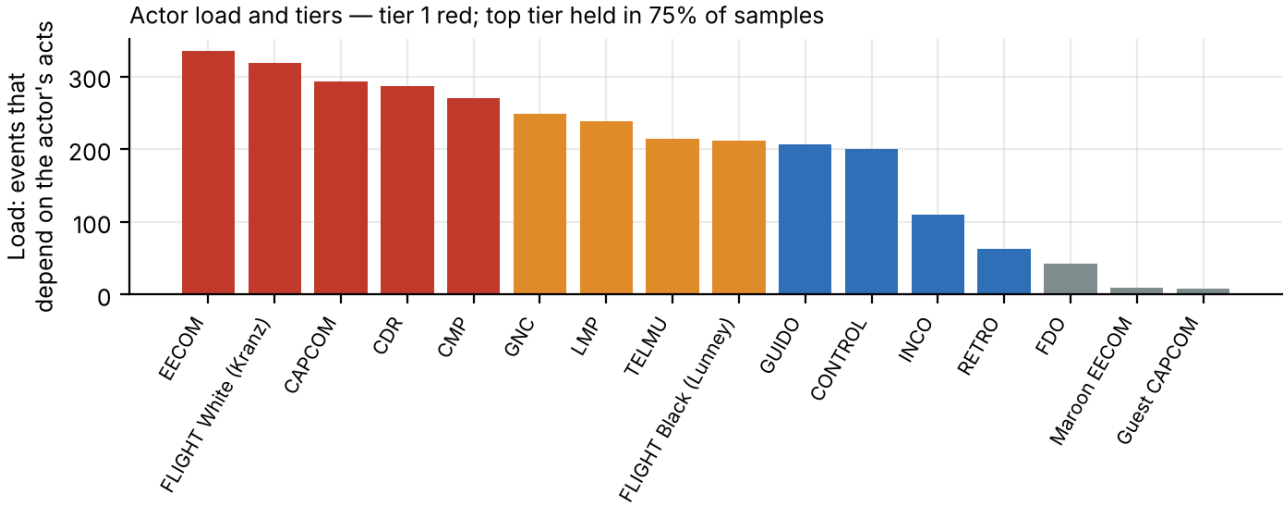
How to read. Left: how many events of each kind the corpus has. Right: how many events carry each weight.

What it shows. Mission Control talks in orders: commands (344) outnumber all other kinds together, followed by proposals to FLIGHT (speech, 129) and reports (reveal, 113). More than half of the events have weight 2 (394), the typical order-plus-relay pair; only 34 events reach weight 4 or more.



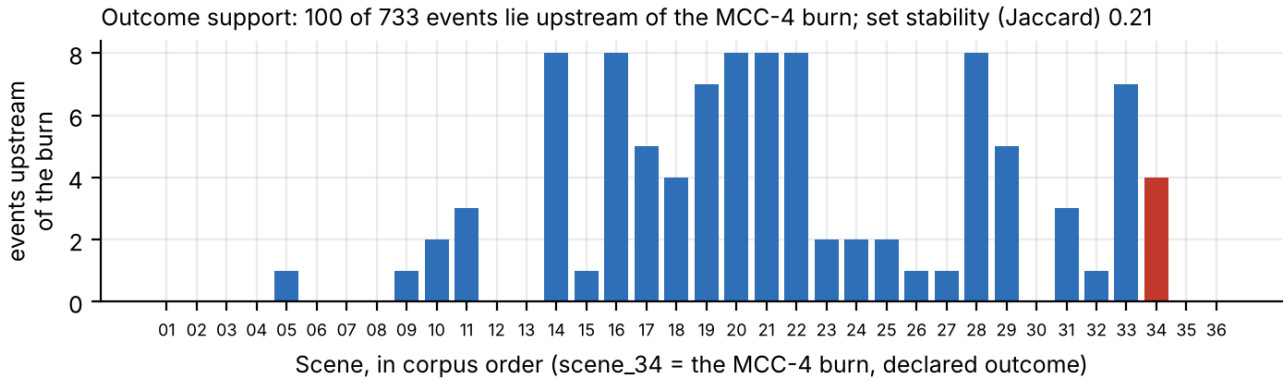
How to read. Each bar is a Scene, sorted from the most to the least load-bearing. Height is the number of later events that depend on the Scene through any chain. Colours are tiers: red = what the most rests on.

What it shows. The red tier is the first two hours of the crisis: the venting (05), the attempt to save tank 1 (09–11) and the LM lifeboat and transfer (14–18). The early diagnosis Scenes (01–04, 06–08) and the reactant valve episode (12–13) sit near the bottom: much talk, little built on it.



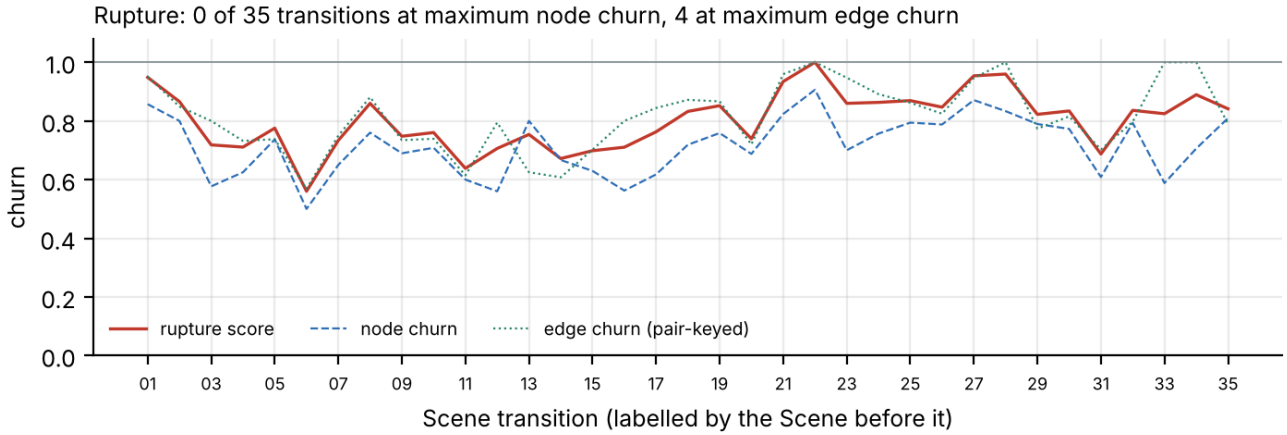
How to read. As above, but per actor: how many later events depend on what each actor initiated. Same tier colours.

What it shows. EECOM, Kranz, CAPCOM, Lovell and Swigert are tier 1 (stable in 75% of samples). Kranz has high load despite a low ASC: his acts were early, so a lot was built on top. FDO is near the bottom, though his proposal became the decision.



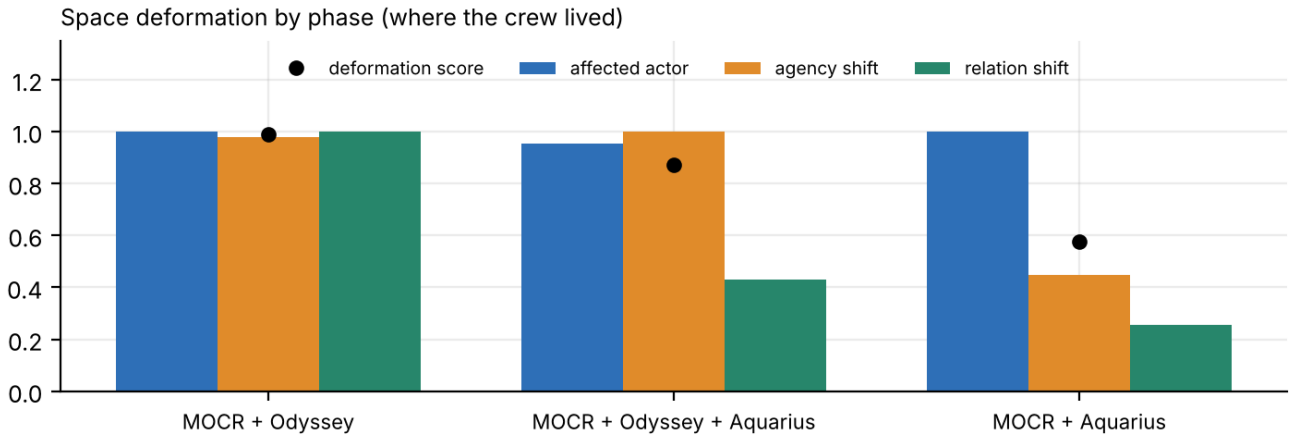
How to read. For each Scene, how many of its events lead, by a chain of callbacks, to the MCC-4 burn (red bar, scene_34).

What it shows. The burn's roots are in Scenes 05 and 09–11 (the LM idea and the tank 1 decline), and its trunk runs through the alignment and LM activation (14–22) and the free-return decision (28–29). Scenes 01–04, 06–08 and 12–13, the electrical diagnosis, contribute nothing.



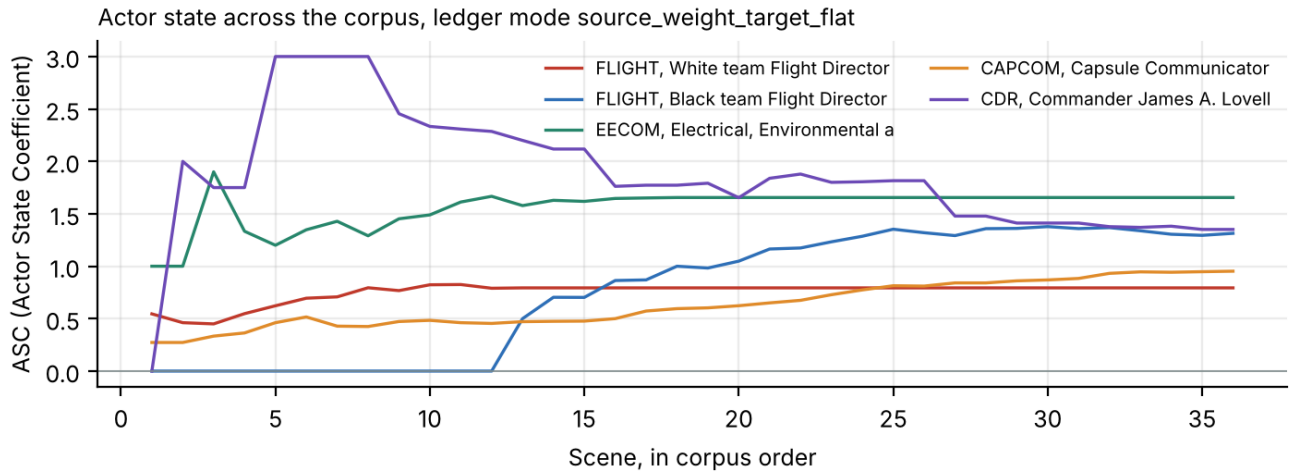
How to read. Each point is the change between one Scene and the next. Node churn (blue): how much the set of actors and objects changes; edge churn (green): how much the relations between them change; the rupture score (red) combines both. 1.0 = an entirely new picture.

What it shows. The peaks are the turning points: "we've had a problem" (01→02), Odyssey powered down with tracking lost (22→23, the maximum), the failed tracking test and the free-return decision (27→28, 28→29). The lowest point (06→07) is the mid-diagnosis lull, when the room was still working the same problem.



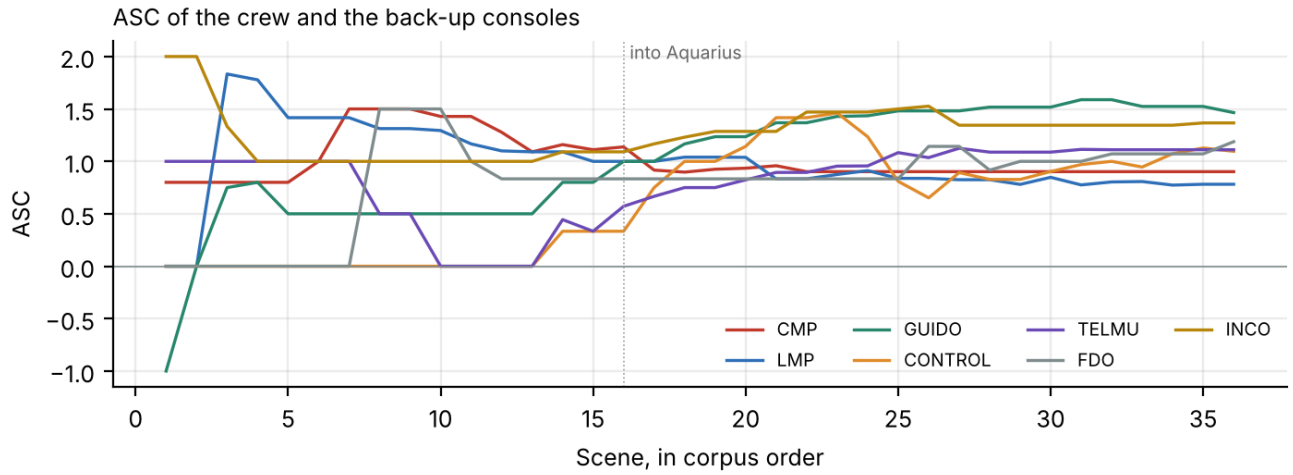
How to read. The corpus has three phases, named by where the crew lived. For each phase: how many actors were affected, how much their agency shifted and how much their relations changed; the black dot is the combined score.

What it shows. The world changed most while the crew was still in Odyssey (0.99): everything was being reorganised. The joint phase (0.87) changed who acted, but less who talked to whom. In Aquarius (0.57) the structure settled into routine.



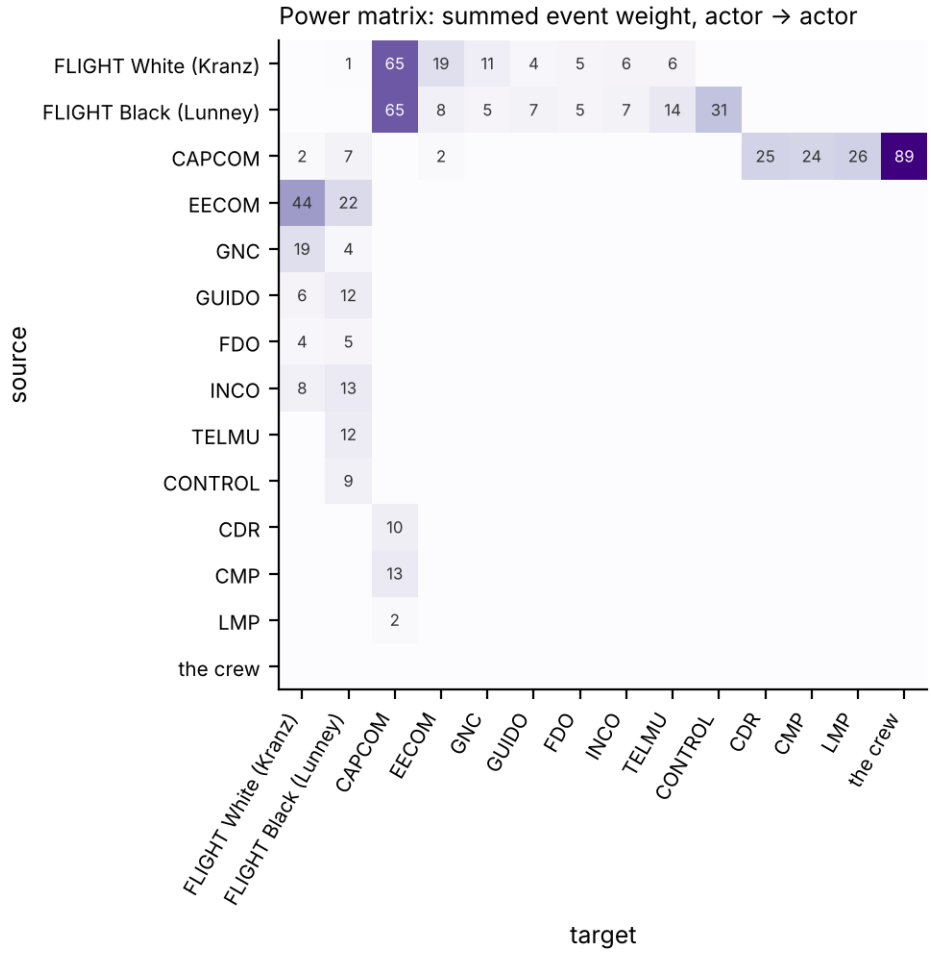
How to read. ASC of five key actors after each Scene. Above 1: their acts are taken further more than their presence alone would suggest. Lunney's line starts at 0 because his first acts fall in scene_13, after the 57:07 handover.

What it shows. Lovell jumps to 3.0 with the venting report and slowly returns towards 1.3. EECOM rises early and holds near 1.65, the most consistently "followed" console. Kranz stays under 1. Lunney climbs steadily to 1.31 as his decisions are carried out. CAPCOM rises slowly to 0.95 as a relay.



How to read. The same measure for the crew members and the support consoles. The dotted line marks the move into Aquarius.

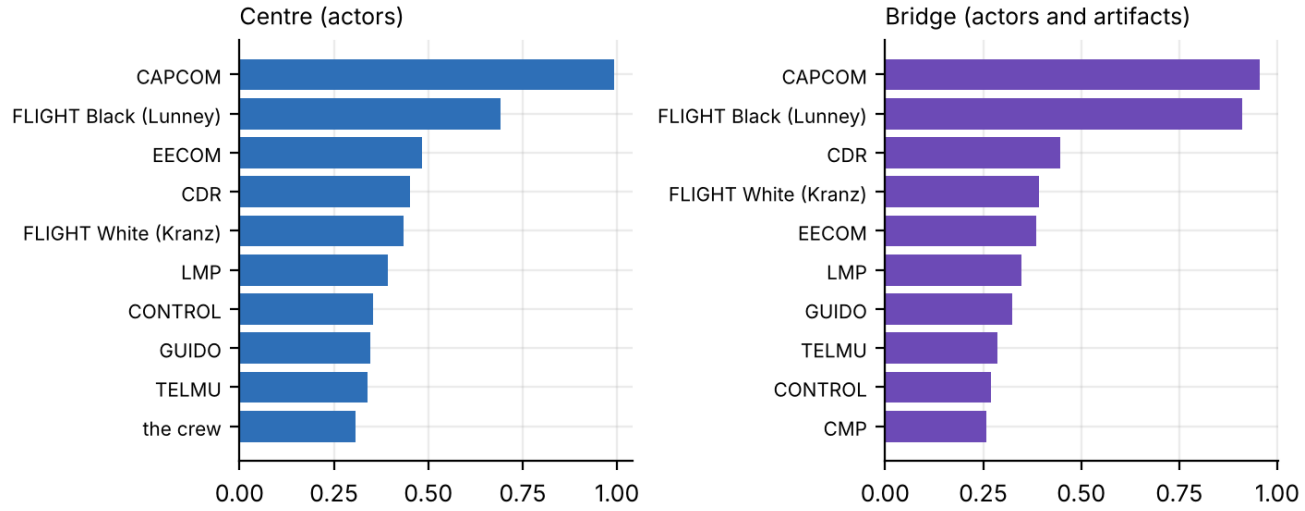
What it shows. After the move into the LM the support consoles that run it (GUIDO, CONTROL, TELMU, INCO) converge above 1: they become the people whose proposals are acted upon. The crew members settle just under 1: they mostly execute.



How to read. Rows are the actor who acts, columns the actor acted upon; each cell is the summed weight

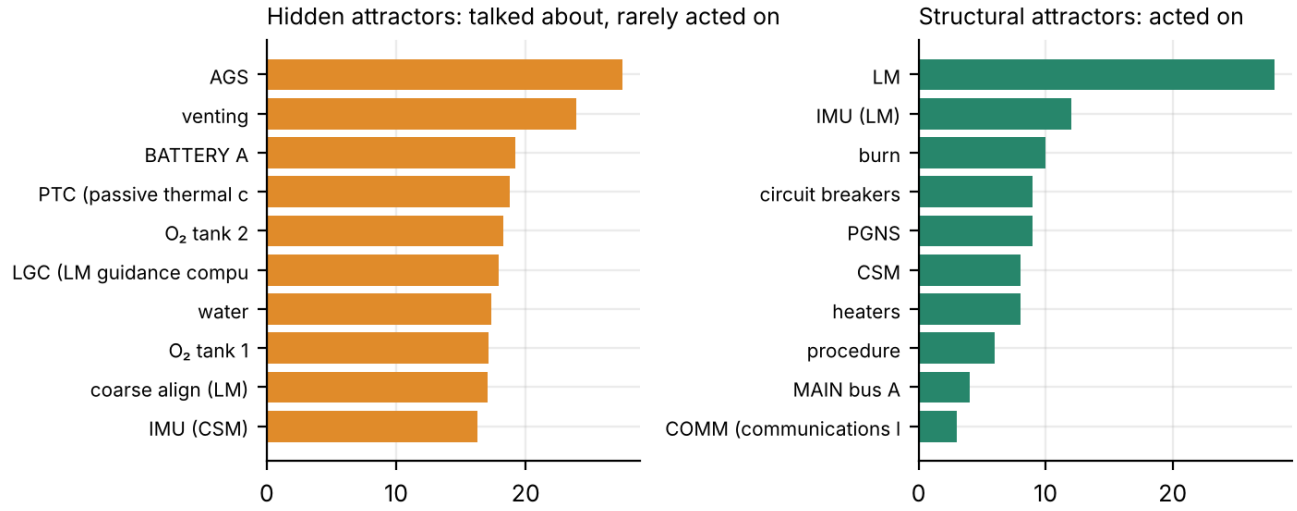
of their events. Darker = more.

What it shows. The shape of Mission Control in one picture. Consoles talk only to FLIGHT (left columns). FLIGHT talks to CAPCOM, and CAPCOM is the only voice to the crew (top right). The crew answers only CAPCOM. After CAPCOM, Kranz's busiest partner is EECOM (19); Lunney's is CONTROL (31), the LM console.



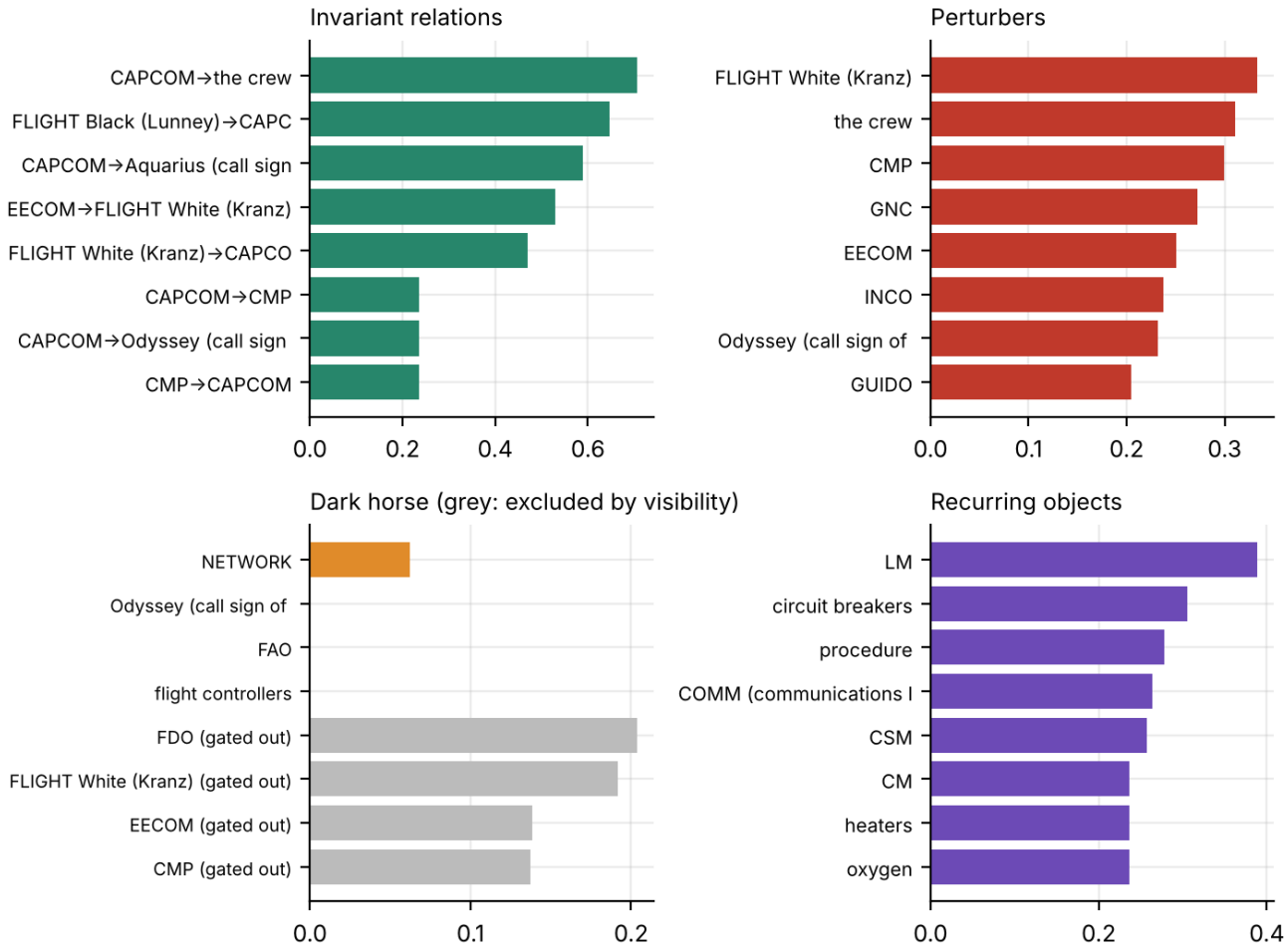
How to read. Left: who sits in the middle of the network. Right: who connects otherwise separate parts. Both are scored 0 to 1.

What it shows. CAPCOM wins both (0.99 and 0.95), with Lunney close behind as bridge (0.91): the network is a funnel through these two. Among objects, the LM is the most central (0.27).



How to read. Left: objects mentioned often but rarely acted upon. Right: objects that many events actually act on.

What it shows. The AGS tops the "talked about" list (27.5), followed by the venting, BATTERY A, the PTC rotation and the dead tank 2. The LM tops the "acted on" list (28) by a wide margin, then the LM platform, the burn and the circuit breakers.



How to read. Four smaller readings. Invariant relations: pairings that persist across the whole corpus. Perturbers: actors whose appearance tends to be followed by a change. Dark horse: influence larger than visibility (grey = dropped as too rarely seen). Recurring objects: objects that keep coming back across Scenes.

What it shows. The stable skeleton is CAPCOM → crew (0.71) and Lunney → CAPCOM (0.65). Kranz is the strongest perturber (0.33): when he speaks, the field shifts. The only gated dark horse is NETWORK, a weak signal; the gate drops FDO, Kranz, EECOM and Swigert, of whom FDO scores highest (0.20). The LM is the most recurrent object (present in 27 of 36 Scenes).

Qualifications

The Board and the corpus cover different things. The Board spent most of its report on the tank's history from manufacture to launch, and none of that is in this window. Inside the window it judged decisions; OptaCat counts dependencies. A Scene with large load is one that later events depend on, not necessarily one that was right.

The window truncates. The corpus ends at 62:06:53, about 25 minutes after the burn. Late Scenes cannot gather dependants that were never recorded, so the low load of scenes 30–36 is partly an effect of the cut. The same holds for the outcome: the burn itself carries load 4.

One annotator, who knew the ending. The events and callbacks were annotated by a single annotator (Claude), working Scene by Scene and knowing how the mission ended. The counterfactual reason for every callback is in `callback_audit.yaml`, and the Phase 5 decisions (three withdrawals, four re-admissions) are in `phase5_admission_review.yaml`. Anyone can remove them and rerun.

The loops are not the whole room. The back rooms, the telemetry displays and the crew's cabin are only present where someone spoke about them on these two loops. The masked alarm is absent for that reason, not because it did not matter.

Density. At 0.94 callbacks per event, the graph is far denser than the SVB or ExComm corpora. The relay chains are real, but they also inflate the load of whoever sits at the head of a chain: FLIGHT and the console that proposed the action.

Appendix: who and what

Actors in Mission Control (Houston). Each console position is one actor.

Actor	Who / what they do
FLIGHT, White	Flight Director Gene Kranz, in charge until 57:07
FLIGHT, Black	Flight Director Glynn Lunney, in charge from 57:07
CAPCOM	Capsule Communicator, the only voice that talks to the crew (Jack Lousma on this shift)
EECOM	Electrical, environmental and consumables in the CSM: power, oxygen, fuel cells (Sy Liebergot)
Maroon EECOM	EECOM back-room voice (John Aaron)
GNC	CSM guidance, navigation and control hardware, including the thrusters
GUIDO	Guidance officer: computers, guidance platform, state vectors and loads
FDO	Flight dynamics officer: the trajectory, burns and return paths
RETRO	Retrofire officer: return times and landing areas
INCO	Communications: antennas, data links, tracking
TELMU	LM electrical, environmental and life-support systems
CONTROL	LM guidance, control and propulsion
NETWORK, PROCEDURES, RECOVERY, SURGEON, FAO	Ground stations; procedures; ships and landing areas; crew health; flight activities and stowage
Guest CAPCOM, Tom Stafford, Jim McDivitt	Astronauts helping on the loop (John Young), in the simulator, or on power profiles

The crew (in the spacecraft): **CDR** Jim Lovell, commander; **CMP** Jack Swigert, command module pilot; **LMP** Fred Haise, lunar module pilot. Odyssey and Aquarius also appear as call signs when CAPCOM addresses whoever is in that vehicle.

Artifacts (the hardware and documents events act on):

Artifact	What it is
CSM / Odyssey	Command and Service Module: crew cabin, main engine (SPS), fuel cells, oxygen tanks
LM / Aquarius	Lunar Module, used here as the lifeboat
O_2 tank 1, tank 2	The two cryogenic oxygen tanks feeding the fuel cells and cabin; tank 2 failed
Fuel cells 1, 2, 3	Made the CSM's electricity from oxygen and hydrogen
Reactant valves	Valves feeding oxygen and hydrogen into each fuel cell; the talkback shows a striped "barber pole" when closed
MAIN bus A, B	The CSM's two main electrical distribution buses
BATTERY A, entry batteries	CSM batteries reserved for re-entry, only partly rechargeable
IMU, platform	Gyroscopic guidance platform; one in each vehicle (CSM, LM)
P52, coarse / fine align, REFSMMAT	Ways and reference frames for aligning the platform
AOT, COAS	LM telescope and sight for star sightings
CMC, LGC	CSM and LM guidance computers
PGNS, AGS	LM primary guidance system and its backup (abort guidance system)
DAP	Digital autopilot settings in the guidance computer
SPS, DPS	CSM main engine; LM descent engine (used for the burn)
RCS, thrusters, quads	Small attitude-control jets in groups of four
ATCA	LM attitude control electronics; its breaker had to be closed before the LM could hold attitude
Gimbal lock	An orientation in which the platform loses its reference
PTC	Passive thermal control: slow rotation to spread solar heating
PAD	A block of burn data read up to the crew
P30, P40, P47	Computer programs for loading a burn, flying it with engine steering, or flying it by hand
MCC-4, PC+2	Midcourse correction 4 (the burn here); the abort burn planned two hours after closest approach to the Moon
S-IVB / IU	The spent third stage and its instrument unit, whose radio interfered with LM tracking
Activation checklist	The LM book for powering the vehicle up
Water, LiOH, CO_2	LM cooling water; lithium hydroxide canisters that remove CO_2

Sources

- Apollo 13 Review Board, *Report of Apollo 13 Review Board*, NASA, 15 June 1970 — https://www.nasa.gov/wp-content/uploads/static/history/afj/ap13fj/pdf/report-of-a13-review-board-19700615-19700076776.pdf
- Apollo 13 Review Board, Appendices B–E — https://www.nasa.gov/wp-content/uploads/static/history/afj/ap13fj/pdf/a13-review-report-app-b-c-d-e-19700078726.pdf
- apollo13rt, Flight Director loop and air-ground loop transcripts (CC0) — https://github.com/issa-tseng/apollo13rt
- OptaCat v0.9.1 run files: `run/`, `step3/` audits, `step3_5/freeze_record.yaml`.