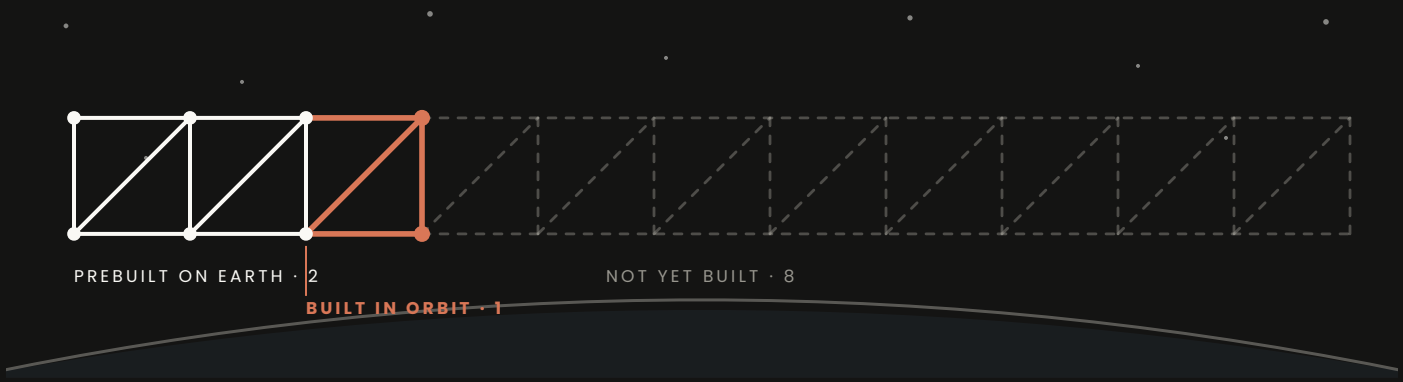
INFLECTION.

THE WEEKLY MAGAZINE OF INNOVATION

ISSUE 02 · FRIDAY, 20 NOVEMBER 2026 · DEEP DIVE — BUILDING IN ORBIT



THE DEEP DIVE

Space Will Be Built, Not *Launched*

A Caltech robot has just assembled the first structure ever built autonomously in orbit — and finished one bay out of eleven. The unfinished part may be the most valuable thing it did.

- Why a fifteen-minute radio window, not the robot, is the real design constraint
- The twin machine in a Pasadena lab that may be the actual product
- Signals: AI that simulates lasers in milliseconds · diamond defects as molecules · a refinery filter that thrives on fouling

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THE DISPATCH

Every instrument we have ever put in space is a packing problem.

> *The container is the constraint.*

Look at the great space telescopes and antennas and you are looking at origami. Each one was designed on the ground to fold into a rocket nose cone and unfold, flawlessly, a million miles away. The mirror you can build is the mirror you can fold. Engineers rarely say so, but the fairing, the cone of metal at the top of a rocket, has been the silent co-author of every spacecraft design.

This week a robot built by Caltech and funded by DARPA tried to break that rule. It did not unfold a structure. It assembled one, strut by strut, in orbit, with no astronauts. It built one section of an eleven-section antenna truss and then ran out of time. Most coverage treats that as a footnote. This issue treats it as the story, because what stopped the robot tells you more than what it achieved.

The lens for this issue is a question we will keep asking: *what do you treat as a law of physics that is really a container?* Once you see the fairing, you see containers everywhere. A data-centre power envelope. A regulatory category. A release cadence. Our three Signals each hide one too.

— THE EDITORS

THE FEATURE

One Bay of Eleven

Caltech's ASTRA robot did something no machine has done: assemble a structure in orbit with no human hands on the build. It also did not finish. Read the gap between those two sentences carefully.

BY THE INFLECTION DESK · RESEARCH DRAWN FROM CALTECH, DARPA AND SCIENCEDAILY REPORTING · 9-MINUTE READ

On 30 March 2026, a cube about one metre on a side left Vandenberg Space Force Base aboard a SpaceX Transporter-16 rideshare. Inside it were two finished sections of a truss, a robotic arm, and motorised dispensers of struts and joints. Six months later, Caltech announced that the machine had done what its designers hoped: it built a third section, in orbit, on its own. DARPA describes the task as playing with a high-tech K'Nex set. The hard part, as every parent of a toddler knows, is that the pieces are never where you left them.

The problem: the nose-cone ceiling

There are two ways to put something big in space. You can fold it, as the James Webb Space Telescope's mirror was folded, and unfurl it after launch. Or you can send up pieces on several launches and have astronauts bolt them together. Both methods, Caltech's release notes, set practical limits on the size and complexity of what you can build.

Folding means every large aperture must be designed to survive being crumpled and then reborn. Crewed assembly means every large aperture waits for a rare, costly spacewalk. Neither scales to what DARPA says it wants from its NOM4D programme: structures "hundreds of meters or kilometers in scale." In the program manager's words, "nothing approaching that scale can be achieved today."

The bet: stop shipping shape, ship parts

NOM4D, launched by DARPA in 2022, bets on a third option: ship compact raw material and manufacture or assemble on site. Caltech's ASTRA (Autonomous In-Space Tensioned Reflector Assembly) is one of only two projects that reached the programme's third phase, small orbital demonstrations. The other, from the University of Illinois Urbana-Champaign, tests hardening carbon tubes aboard the International Space Station.

The idea is plain to state and brutal to execute. A robot arm picks a strut, picks a joint, joins them into a repeating cell called a bay, and pushes the finished bay outward. Then it does it again. A full ASTRA truss is eleven bays. The antenna it frames is a mere 1.4 metres across, a deliberately small proof for a very large ambition.

What actually happened up there

A kit of one cubic metre

ASTRA rode as one of ten payloads on Momentus Inc.'s Vigoride 7 orbital vehicle. It occupied roughly one cubic metre and carried everything it needed: two prebuilt bays braced with diagonal supports, an arm-like manipulator, and spare composite fibre tubes and aluminium joints to build the rest. Eleven cameras watched the work.

Build, push out, repeat

Once in orbit, the team released the launch restraints, extended the two prebuilt bays, and ordered the manipulator to build the third on an assembly plate. When a bay is done, the arm attaches a reflective film and pushes the section out. A complete ASTRA truss has eleven bays; the robot finished one in orbit and the mission cannot complete the rest before it ends in December.

A film that lets the structure be lighter

The reflective surface is a perforated film co-invented by Caltech and the University of Pennsylvania (Igor Bargatin's group), assembled into two cable nets pre-stressed against each other by springs. Compared with the knitted metal mesh used in foldable reflectors, it needs less pre-stress, which allows lighter supporting structure. In space engineering, mass saved is launch cost saved.

> *"Once you get to the size limit where structures cannot be prebuilt on the ground and unfolded, you have to think about how to build them in space."*
>
> SERGIO PELLEGRINO · CALTECH, ASTRA TEAM LEADER

The operations nobody photographs

The team could talk to ASTRA only seven or eight times a day, for about fifteen minutes each. So a human could not drive the robot like a crane. Instead engineers uploaded commands, checked photographs when the robot came back into range, and, when something went wrong, reproduced the fault on an identical flight spare in Pellegrino's lab, tested a fix, and relayed it. "Every time we confirm there is an issue in space, we come to the laboratory and try to mimic the problem on the ground," said systems engineer Charles Sommer.

Team member Jaden Suh called the unforeseen problems "little surprises." That is the sound of proof-of-concept working as intended. The payload was completed, tested and delivered to its host in under twelve months, an unusually quick development for flight hardware.

FROM LAB TO MARKET

What it means, and what it does not

Be precise about what was proved. ASTRA showed that a robot can pick, place and join structural parts in orbit and that the concept is, in Caltech's words, "scalable to very large perimeter trusses." It did not show that it can do so quickly, cheaply or without a team of engineers watching. Caltech says the work revealed ways to "simplify and refine" the design; that is the honest next step.

Where the value could land

Telescopes and radio apertures. Mirrors and antennas limited by fairing diameter could instead be limited by how much material you ship and how long you wait.

Space solar power. Pellegrino co-directs Caltech's Space Solar Power Project, which aims to collect solar energy in orbit and beam it to Earth. Such arrays would be vast and repetitive, an ideal fit for a robot that builds identical bays.

Defence and communications. DARPA funded the work, and larger antennas mean more capable communications, a point the agency's own program manager highlights.

For the CTO. The transferable lesson is architectural. ASTRA separates a cheap, repeatable unit (the bay) from an expensive, slow one (the human feedback loop). Any system that must operate through narrow, intermittent communication, from deep-sea rigs to factory robots on a flaky link, faces the same design choice.

Timeline: NOM4D launched 2022 → ASTRA lab proof → payload delivered in under 12 months → launched 30 Mar 2026 → mission ends December 2026.

FIELD NOTES · HOW A SPACE TRUSS BUILDER WORKS

1. **Dispense.** Motorised dispensers hold composite tubes and aluminium joints. The arm picks a strut and a joint.
2. **Assemble.** On an assembly plate it joins the parts into one bay, a repeating cell of the truss.
3. **Extend.** It attaches the reflective film, pushes the bay outward, and starts the next. Eleven bays complete the truss.

GLOSSARY

Fairing. The protective nose cone around a rocket's payload. Its width caps the size of anything launched whole.

Bay. One repeating section of a truss, like one span of a bridge.

Perimeter truss. A ring-like frame that holds a reflective surface taut at its edge.

Flight spare. An identical twin of the flown hardware, kept on the ground to reproduce and fix faults.

THE CONTRARIAN

The Failure Is *the Product*

Everyone is watching the robot. Watch the telephone line instead.

The unfashionable read

Seven or eight windows a day at about fifteen minutes each is roughly 105 to 120 minutes of contact in 24 hours (our arithmetic). The robot spent the other twenty-two hours alone. Its builders therefore did not so much operate a robot as operate a *loop*: observe, reproduce on the ground twin, test a fix, uplink, wait for the next window.

That loop, not the arm, is the scarce capability. Arms can be bought. A discipline for diagnosing a fault you cannot touch, rehearsing the cure on an identical twin, and shipping it across a thin radio link is rare, and it generalises well beyond orbit.

A product hiding in plain sight

Our inference, not Caltech's claim: the investable asset is an **operations twin as a service** for remote robotics. A vendor would keep a certified ground replica of every flown unit, rehearse every command package against it, and sell the confidence that an upload will not brick a machine worth millions. The robot is a one-off; the rehearsal stage is a recurring subscription, and it works equally for lunar, subsea and mining robots.

Why a half-finished build is good news

A demo that completes on schedule proves a plan. One that stalls at one bay in six months proves where the plan's bottlenecks are, and hands the team a precise list of what to simplify. Caltech says it will refine the design, which is exactly what a first flight is for.

WHY THE CONSENSUS DISAGREES

01 **The scale gap is enormous.** A 1.4 m reflector against a kilometre-class ambition is nearly three orders of magnitude. Reliability that holds for three bays may not hold for three thousand.

02 **"Autonomous" has asterisks.** The robot executed the assembly, but engineers sent the command sequences and judged results from photographs, repeating steps when things failed.

03 **Folding still works.** Foldable structures fly today. Bigger launchers and larger fairings also chip away at the problem robots are meant to solve.

04 **The numbers that decide economics are missing.** We found no published cost, robot mass or total build time for the demonstration, so "cheaper than launching it whole" remains unproven.

COMPUTE

250×

AI replaces the slowest step in simulating X-ray-laser optics

Researchers at Stanford, UCLA and SLAC trained an LSTM neural network to model how light changes frequency inside nonlinear crystals, a step in the laser chain at SLAC's LCLS-II X-ray facility. The conventional method accounts for about 95% of the processing time in the full simulation. Batched on GPUs, the AI needs a few milliseconds per run. ScienceDaily's headline figure is 250×; the release itself speaks of "orders of magnitude." It was tested on one process, so treat it as a promising technique, not a general solution. The goal: live digital twins of laser systems.

SOURCE · ScienceDaily / SPIE, 13 Nov 2026 · sciencedaily.com/releases/2026/11/261111005913.htm · Advanced Photonics 8(3), doi:10.1117/1.AP.8.3.036004

QUANTUM MATERIALS

16–30

Treat a diamond defect like a molecule, and the search gets cheap

At the DOE's Princeton Plasma Physics Laboratory, John Mark Martirez carves out just 16 to 30 atoms around a diamond defect and models them with mature chemistry methods. "The cost of calculating these defects is equivalent to the cost of just modeling a simple molecule," he says. The technique flagged boron and oxygen defects as new qubit candidates, emitting ultraviolet and blue light rather than the red of the familiar nitrogen-vacancy centre, which could let different qubits be addressed separately. This is a computational prediction; no device has been built.

SOURCE · ScienceDaily / Princeton, 13 Nov 2026 · sciencedaily.com/releases/2026/11/261111005855.htm · ACS Central Science 12(10):1578, doi:10.1021/acscentsci.6c00548

ENERGY

31.6%

A refinery filter that gets better as it clogs

Distilling crude oil uses about 1,100 TWh a year, by the researchers' estimate. A KAIST and Georgia Tech team passed real crude through a bare, cheap polyacrylonitrile membrane. Heavy hydrocarbons deposited in the pores and narrowed them to channels under 2 nm, so the fouling itself created the sieve. The membrane ran 28 days with a flow about 23 times that of earlier crude membranes. Used ahead of distillation, simulations show 31.6% less energy and 37.6% less CO_2. These are process simulations, not plant results. Published in *Nature* in June and widely re-covered in November.

SOURCE · KAIST news release via EurekAlert, 24 Jun 2026 · eurekalert.org/news-releases/1133507 · Nature, doi:10.1038/s41586-026-10677-3

1 of 11

Truss bays built by the robot in orbit. Two more flew prebuilt; the other eight remain unbuilt as the mission ends in December.

1.4 m

Diameter of the demonstration reflector antenna. DARPA's target is hundreds of metres to kilometres.

7–8 × 15 min

Daily communication windows with the robot, each about fifteen minutes long.

<12 months

Time from lab concept to a delivered, tested flight payload.

250×

Headline speed-up for AI-based modelling of laser frequency conversion (single process tested).

16–30

Atoms in the "carved-out" cluster used to model each diamond qubit defect.

31.6%

Simulated cut in refining energy using a membrane pre-treatment step, from a 1,100 TWh-a-year distillation burden.

Constraints are architecture wearing a disguise

Three stories this week, one pattern. In space, the nose cone fixed the size of every telescope ever flown; ASTRA says that is a decision, not a law. In laser physics, a Fourier step dominated the runtime, and a neural network quietly turned it into milliseconds. In refining, fouling, the thing engineers fight, became the mechanism of separation.

Each is a case of changing the unit of the problem. Not a better folded mirror but a robot that ships parts; not a faster solver but a learned surrogate; not a cleaner filter but a self-assembling one. The honest caveat is that all three are early: one bay, one process, one simulation. The cost of being early is risk. The cost of ignoring the pattern is waking up to find the container was optional.

Watch for the boring signals that will say whether ASTRA-style assembly is real: published cost and mass, bays per day, and how much of the human loop disappears. Until then, hold the idea lightly and the lens firmly.

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THE LENS · A QUESTION FOR YOUR WEEK

What do you treat as a law of physics that is really a container?

NEXT ISSUE · FRIDAY, 27 NOVEMBER 2026

A fresh deep dive from a different domain, three new Signals, and a contrarian column that argues with the consensus.

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