HITTING ORBIT

The Easy Half Is Talking to Satellites Vs the Hard Half That Teaches You to Point

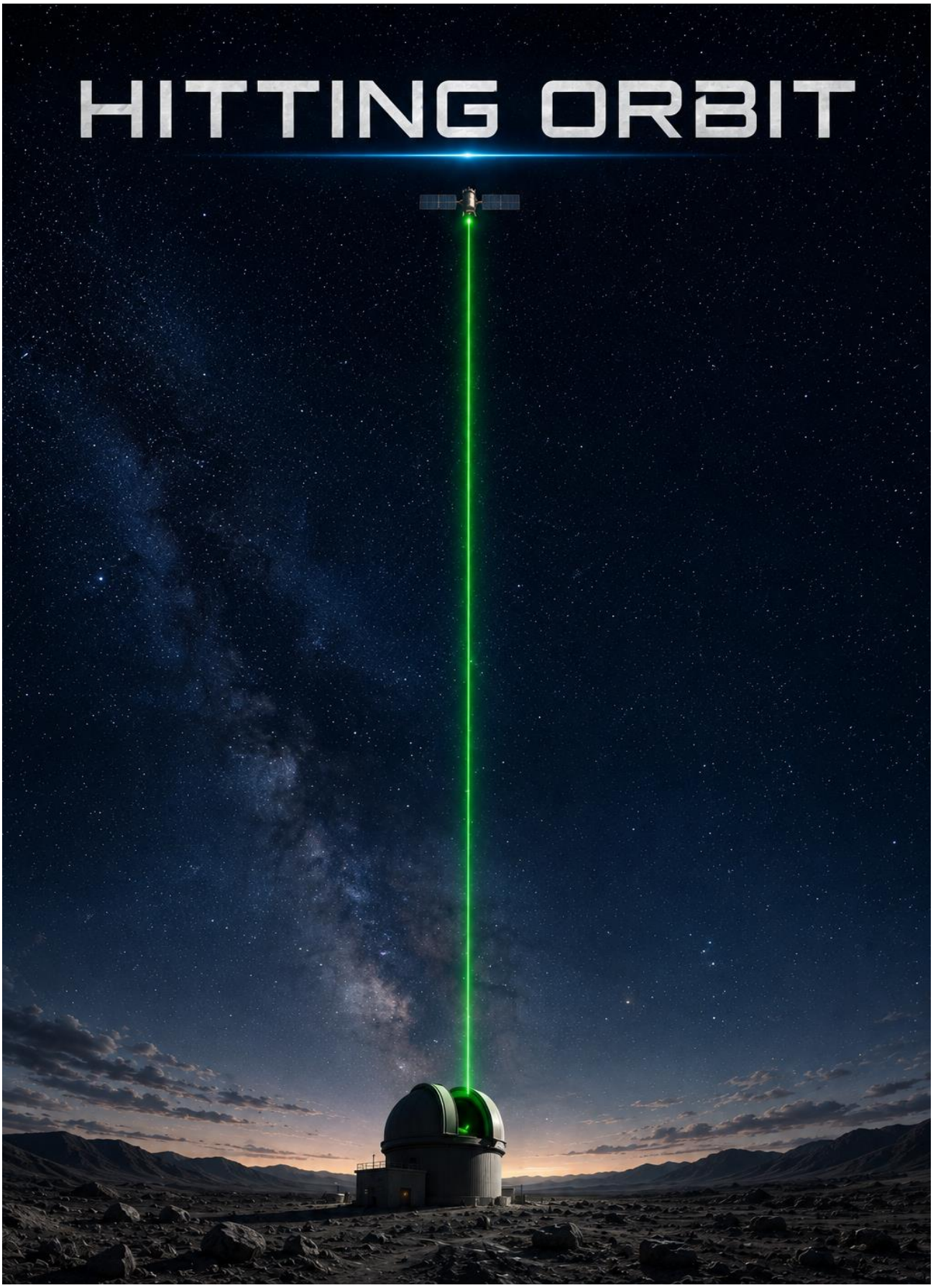
> ***The downlink is engineering.***
>
> ***The uplink is the examination.***
>
> ***And the skill it certifies is not only good for data.***

THE DIRECTION THAT ALREADY WORKS

We photograph satellites. We rarely photograph the telescope on the ground that makes them worth having.

In **May 2026** the UK's Defence Science and Technology Laboratory announced the country's first optical downlink from space, with Oxford firm **Archangel Lightworks**. In a single **90-second pass**, many gigabits fell from low Earth orbit into a deployable ground station in the Mediterranean. Dstl's own comparison: moving from a slow connection to superfast fibre.

The station, **TERRA-M**, needs no dome and no dedicated building. Its optical head stands about **3.6 feet tall**, travels by light vehicle or aircraft, and works from a rooftop. It ran throughout on the **U.S. Space Development Agency** laser standard — which matters more than the record itself, because it makes a British station interoperable with American terminals.The ceiling was set elsewhere. NASA's **TBIRD**, a package the size of a tissue box, downlinked at **200 Gbps** and moved **4.8 terabytes** in a single five-minute pass.


HITTING ORBIT

A York Space Systems satellite closed an optical link with an SDA ground terminal in September 2025. NASA ran optical service alongside radio during **Artemis II**, handing the link between ground stations mid-mission.

The physics is the attraction. Infrared light carries far more per second than radio, in a beam narrow enough that intercepting it means standing in it. Hard to detect.

Hard to jam. Largely indifferent to the electromagnetic congestion that now defines every contested environment.

The bill arrives as weather. Cloud and turbulence keep any single station well below the availability a commercial operator expects which is why every serious architecture is a **network** of dispersed stations rather than one prestigious observatory.

One point, because it is routinely blurred. None of this is kinetic, and not because the lasers are waiting for a bigger battery.

A telecom laser is a watt-class device engineered so that a distant receiver can **detect** it.

A weapon is a different machine end to end: different power, different optics, different cooling, different budget line. The laser communications build-out is not a weapons inventory in disguise.

> ***A telecom laser is built to be seen.***
>
> ***A weapon is built to be felt.***
>
> ***They are not the same machine waiting on a bigger power supply.***

NOW TRY IT THE OTHER WAY UP

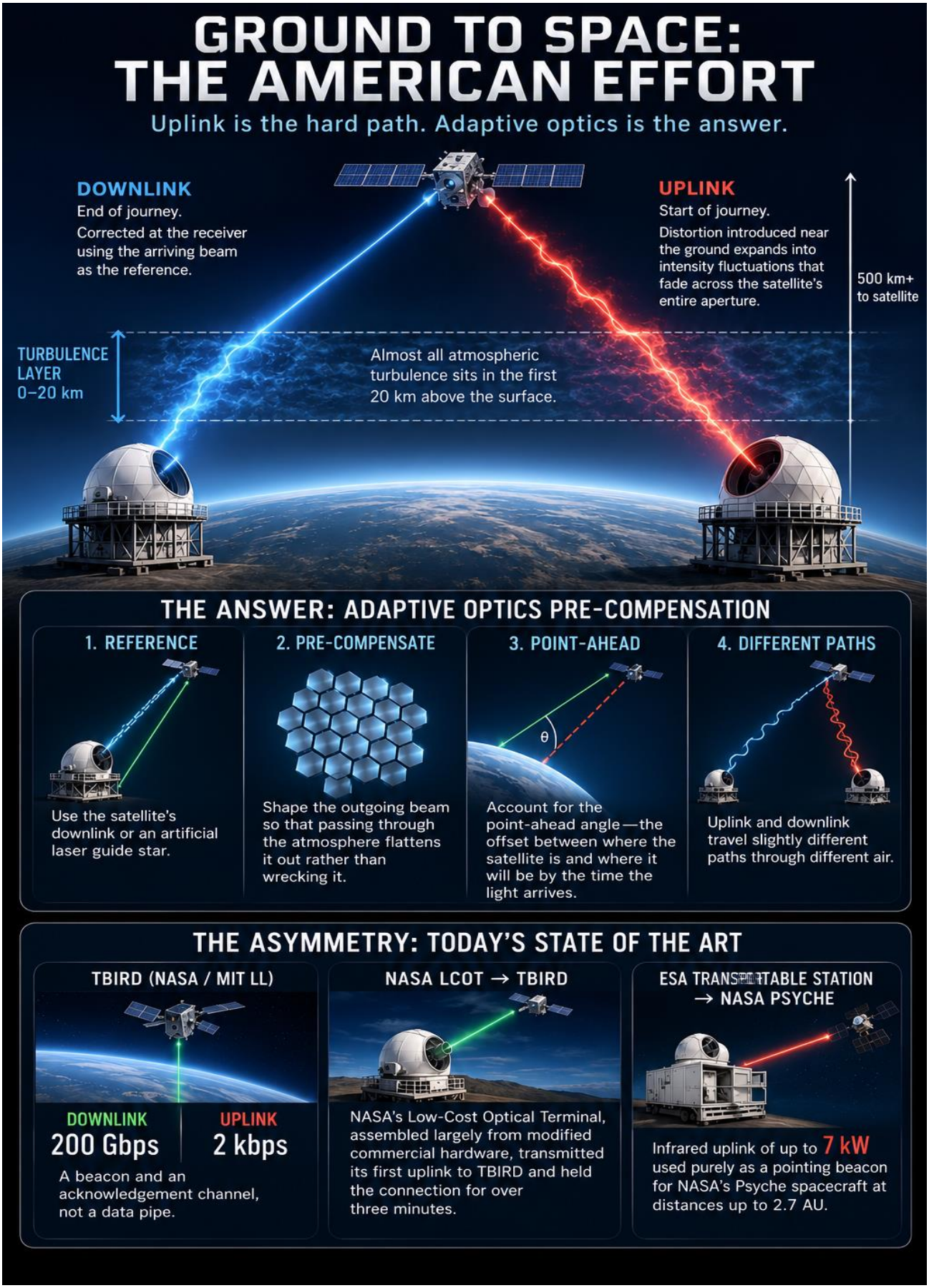
Reverse the direction and the problem changes character entirely. Almost all atmospheric turbulence sits in the **first 20 km**. A beam coming down meets it at the **end** of its journey, and the receiver can correct using the arriving light itself. A beam going up meets it at the **start**, then travels another 500 km or more so a wobble introduced near the ground blooms into fades across the satellite's entire aperture.

This is the governing constraint, and it is where the intuition about power fails. A ground station has grid electricity and can mount apertures no spacecraft could carry. **More watts do not unscramble a wavefront.**

The answer is adaptive optics **pre-compensation**: deliberately deform the outgoing beam so that the atmosphere flattens it rather than wrecks it. That needs a reference, either the satellite's own downlink or an artificial laser guide star, and it must allow for the **point-ahead angle** the gap between where the satellite is and where it will be when the light arrives. Up and down travel through different air.

The resulting asymmetry is the clearest signature of the state of the art. TBIRD's downlink ran at **200 Gbps**. Its uplink ran at **2 kbps** — a beacon and an acknowledgement, not a pipe. NASA's **LCOT**, assembled largely from modified commercial hardware, sent its first uplink to TBIRD and held it for three minutes. Where high-power uplinks do exist, they buy reach rather than force: ESA pushes up to **7 kW** of infrared purely as a pointing beacon for a spacecraft **2.7 astronomical units** away.

The American military ground segment is built on standardisation, not records. The SDA optical terminal standard fixes the rate at **2.5 Gbps** partly to widen the vendor pool, partly because Pentagon encryption requirements do not support more. Hold on to that figure.


GROUND TO SPACE:
THE AMERICAN EFFORT
Uplink is the hard path. Adaptive optics is the answer.
DOWNLINK
End of journey.
Corrected at the receiver using the arriving beam as the reference.
UPLINK
Start of journey.
Distortion introduced near the ground expands into intensity fluctuations that fade across the satellite's entire aperture.
500 km+ to satellite
TURBULENCE LAYER 0–20 km
Almost all atmospheric turbulence sits in the first 20 km above the surface.
THE ANSWER: ADAPTIVE OPTICS PRE-COMPENSATION
1. REFERENCE
Use the satellite's downlink or an artificial laser guide star.
2. PRE-COMPENSATE
Shape the outgoing beam so that passing through the atmosphere flattens it out rather than wrecking it.
3. POINT-AHEAD
θ
Account for the point-ahead angle—the offset between where the satellite is and where it will be by the time the light arrives.
4. DIFFERENT PATHS
Uplink and downlink travel slightly different paths through different air.
THE ASYMMETRY: TODAY'S STATE OF THE ART
TBIRD (NASA / MIT LL)
DOWNLINK
200 Gbps
UPLINK
2 kbps
A beacon and an acknowledgement channel, not a data pipe.
NASA LCOT → TBIRD
NASA's Low-Cost Optical Terminal, assembled largely from modified commercial hardware, transmitted its first uplink to TBIRD and held the connection for over three minutes.
ESA TRANSPORTABLE STATION → NASA PSYCHE
Infrared uplink of up to 7 kW used purely as a pointing beacon for NASA's Psyche spacecraft at distances up to 2.7 AU.

Space Systems Command's **Enterprise Space Terminal** programme, roughly **$100 million** since 2024, selected CACI, General Atomics and Viasat; on **31 July 2026** the Space Force paid K2 Space **$22.9 million** to fly two of them, concluding in **2028**.

The Tranche 1 laser mesh, meanwhile, is months late, an execution problem the GAO has tracked since 2025.

The vision was published years ago. At **Destination: Space 2050** in 2022, Lockheed Martin showed laser communications, power beaming and quantum applications more data per photon, at lower power beside self-adapting autonomy for spacecraft cut off from their controllers. Four years on, the communications half has left the concept art and entered procurement.

> ***Down is a receiving problem, and receivers can be fixed.***
>
> ***Up is an aiming problem.***
>
> ***Nobody has ever solved aiming by adding electricity.***

CHINA IS WORKING IN THE SAME DIRECTION

The useful comparison is on the hard leg not on downlink records, which measure something easier.

The record numbers can be handled quickly. China's Aerospace Information Research Institute reported a peak of **120 Gbps** in January 2026, reached by **software reconfiguration of an unchanged satellite**, up from 60 Gbps in 2025 and 10 Gbps in 2023.

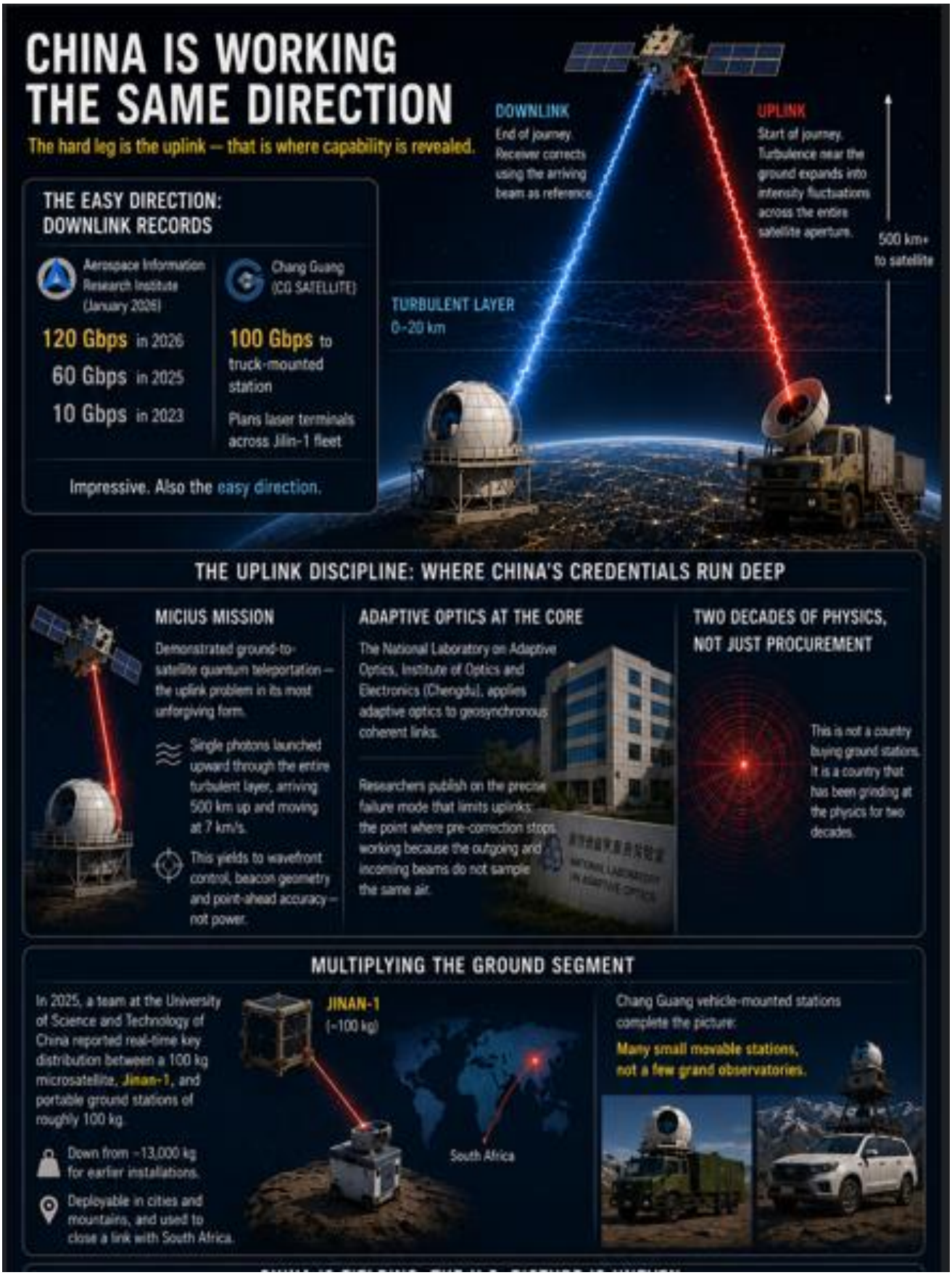
Chang Guang has reported **100 Gbps** to a **truck-mounted** station and intends to fit laser terminals across its Jilin-1 fleet. Impressive. Also the easy direction.

> ***The uplink is where capability is actually revealed, and China's credentials there are older than the headlines.***

The **Micius** mission did not merely send quantum keys down; it demonstrated **ground-to-satellite quantum teleportation**, which is the uplink problem in its most unforgiving form. Single photons, launched upward through the whole turbulent layer, arriving at a receiver 500 km up and moving at 7 km/s. Nothing about that yields to power. It yields to wavefront control, beacon geometry and point-ahead accuracy.

The discipline has an institutional home. The **National Laboratory on Adaptive Optics** at the Institute of Optics and Electronics in Chengdu has applied adaptive optics to geosynchronous coherent links, and its researchers publish on the precise failure mode that limits uplinks the point where pre-correction stops working because the outgoing and incoming beams do not sample the same air. This is not a country buying ground stations. It is a country that has been grinding at the physics for two decades.Then the ground segment itself begins to multiply. In 2025 a team at the University of Science and Technology of China reported real-time key distribution between a 100 kg microsatellite,

Jinan-1, and **portable ground stations of roughly 100 kg** down from about **13,000 kg** for earlier installations deployable in cities and mountains. Put that beside Chang Guang's vehicle-mounted stations and the direction is unmistakable: many small movable stations, not a few grand observatories.


CHINA IS WORKING THE SAME DIRECTION
The hard leg is the uplink — that is where capability is revealed.
DOWNLINK
End of journey. Receiver corrects using the arriving beam as reference.
UPLINK
Start of journey. Turbulence near the ground expands into intensity fluctuations across the entire satellite aperture.
500 km+ to satellite
TURBULENT LAYER
0–20 km
THE EASY DIRECTION: DOWNLINK RECORDS
Aerospace Information Research Institute (January 2026)
120 Gbps in 2026
60 Gbps in 2025
10 Gbps in 2023
Chang Guang (CG SATELLITE)
100 Gbps to truck-mounted station
Plans laser terminals across Jilin-1 fleet
Impressive. Also the easy direction.
THE UPLINK DISCIPLINE: WHERE CHINA'S CREDENTIALS RUN DEEP
MICIUS MISSION
Demonstrated ground-to-satellite quantum teleportation — the uplink problem in its most unforgiving form.
Single photons launched upward through the entire turbulent layer, arriving 500 km up and moving at 7 km/s.
This yields to wavefront control, beacon geometry and point-ahead accuracy — not power.
ADAPTIVE OPTICS AT THE CORE
The National Laboratory on Adaptive Optics, Institute of Optics and Electronics (Chengdu), applies adaptive optics to geosynchronous coherent links.
Researchers publish on the precise failure mode that limits uplinks: the point where pre-correction stops working because the outgoing and incoming beams do not sample the same air.
TWO DECADES OF PHYSICS, NOT JUST PROCUREMENT
This is not a country buying ground stations. It is a country that has been grinding at the physics for two decades.
MULTIPLYING THE GROUND SEGMENT
In 2025, a team at the University of Science and Technology of China reported real-time key distribution between a 100 kg microsatellite, Jinan-1, and portable ground stations of roughly 100 kg.
Down from ~13,000 kg for earlier installations.
Deployable in cities and mountains, and used to close a link with South Africa.
JINAN-1
(~100 kg)
South Africa
Chang Guang vehicle-mounted stations complete the picture:
Many small movable stations, not a few grand observatories.

Set against this, the American picture is uneven rather than behind. The United States owns the deep-space end decisively, and LCOT showed an uplink terminal can be built largely from commercial parts.

But the **military** ground segment reads differently: a standard fixed at 2.5 Gbps for reasons of encryption rather than optics, a laser mesh running late, a terminal programme still flying demonstrations until 2028. Capability sits in laboratories and in missions that have already ended. **China is fielding.**

The caveats are real. Chinese figures arrive largely through state media, peak rates are not sustained rates, quantum experiments are not throughput, and the United States still has far more optical hardware in orbit.

But the asymmetry worth naming was never about speed.

It is that a state which can **industrialise mobile optical ground stations** large apertures, adaptive optics, precise tracking of a fast-moving object, mounted on a vehicle has industrialised rather more than data links.

The Secure World Foundation now counts **thirteen countries** pursuing counterspace capability; U.S. Space Force intelligence has publicly projected that China may field ground-based lasers powerful enough to damage satellite structures by the **mid-to-late 2020s**. Separate systems, separate budget lines and not separate skills.

> ***A station that can drive out from under cloud***
> ***can also drive away from a targeting list.***
> ***Mobility is resilience, whichever way the beam is pointing.***

AND NOW, AN ASTEROID

One Chinese programme deserves its own heading, because it involves no lasers at all and belongs in the conversation regardless.

Beijing is preparing its first **planetary defence** mission. The concept, from a team under **Li Mingtao**, chief scientist for planetary defence at the China National Space Administration, is designed to surpass rather than repeat NASA's DART.

Where DART nudged a small moon around its parent asteroid a proof of principle the Chinese mission aims to alter an asteroid's orbit **relative to Earth itself**, and possibly to fracture it.

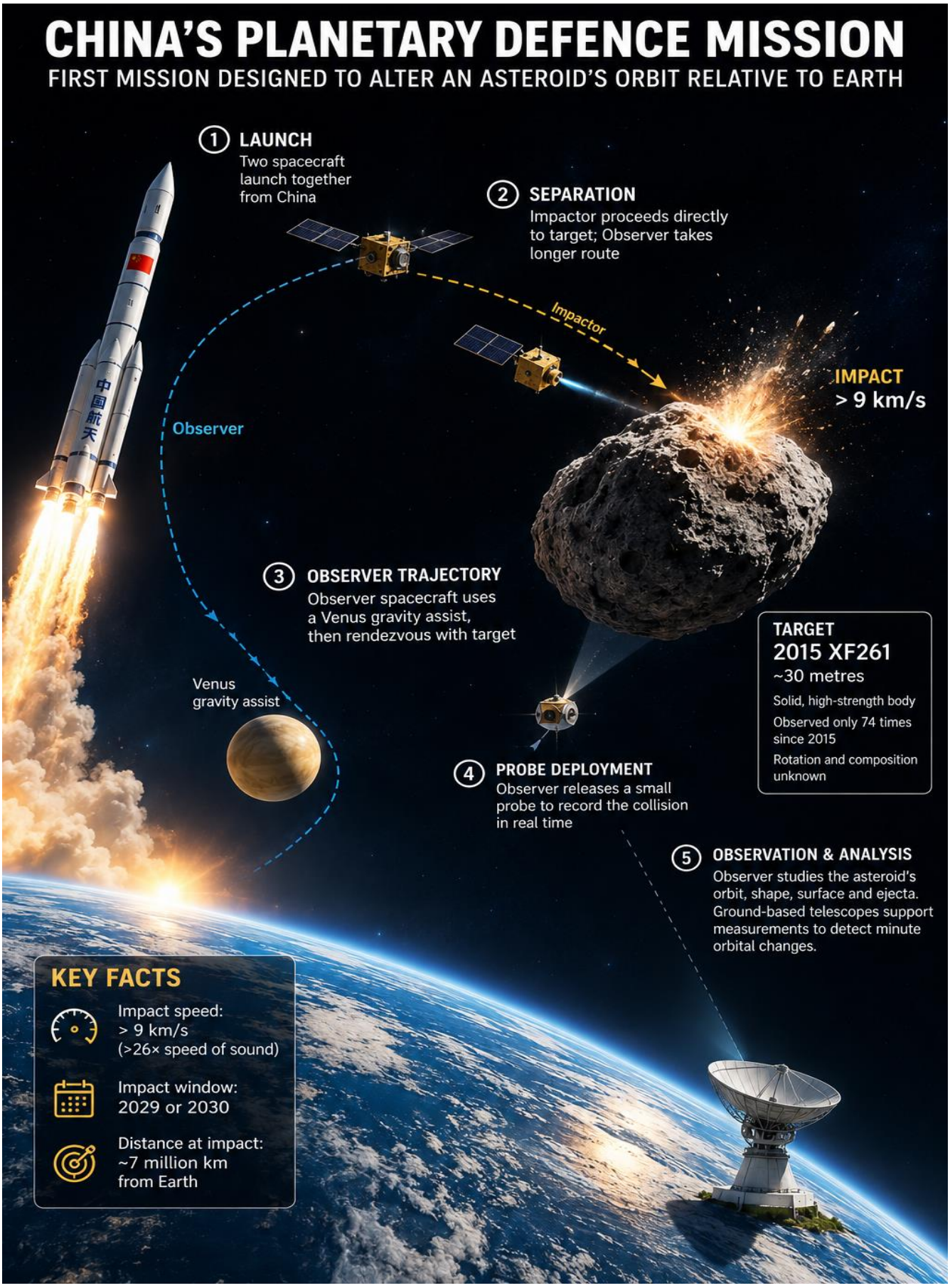
The impactor would arrive at more than **9 km/s**, against DART's 6.1, during a close pass some **7 million km** from Earth in **2029 or 2030**.

The architecture is the striking part. Two spacecraft launch together and separate: the impactor runs straight at the target while the observer takes the long way round via Venus, releasing a small probe to film the collision before tracking the changes in orbit, shape, surface and ejecta.

Europe needed a second mission, **Hera**, to find out what DART had done. China folds detection, deflection and verification into one campaign.

The target sharpens everything. **2015 XF261** is about **30 m** across far smaller than DART's 160 m rubble pile and probably solid. It is so faint

it has been observed just **74 times** since discovery; its rotation and composition are unknown and cannot be established until the final months.


CHINA'S PLANETARY DEFENCE MISSION
FIRST MISSION DESIGNED TO ALTER AN ASTEROID'S ORBIT RELATIVE TO EARTH
1 LAUNCH
Two spacecraft launch together from China
2 SEPARATION
Impactor proceeds directly to target; Observer takes longer route
Impactor
Observer
IMPACT
> 9 km/s
3 OBSERVER TRAJECTORY
Observer spacecraft uses a Venus gravity assist, then rendezvous with target
Venus gravity assist
TARGET
2015 XF261
~30 metres
Solid, high-strength body
Observed only 74 times since 2015
Rotation and composition unknown
4 PROBE DEPLOYMENT
Observer releases a small probe to record the collision in real time
5 OBSERVATION & ANALYSIS
Observer studies the asteroid's orbit, shape, surface and ejecta. Ground-based telescopes support measurements to detect minute orbital changes.
KEY FACTS
Impact speed: > 9 km/s (>26× speed of sound)
Impact window: 2029 or 2030
Distance at impact: ~7 million km from Earth

The terminal approach must therefore be **fully autonomous**, because radio commands from Earth arrive too late to help.

Now decompose the mission into its component skills. Detect and track a small, faint, fast object in deep space. Lock on autonomously, without ground guidance, in the closing seconds.

Strike at over 9 km/s with metre-level precision. Assess the damage afterwards, through a debris cloud, and confirm the object moved.

Delete the word **asteroid** from that list. Write in **adversary satellite**. You have, line for line, the requirement specification for an advanced kinetic anti-satellite weapon and against a far easier target, because a satellite publishes its trajectory, holds a known velocity and presents a surface that cooperates with sensors.

The obvious objection is that the same logic applied to DART, and it is a fair one.

But the Chinese formulation invites the reading more insistently: the declared ambition to deflect **or fracture**, the autonomous verification of effects, the folding of strike and assessment into a single campaign.

That reads closer to an employment doctrine than a research protocol. And the timing places the demonstration exactly as near-Earth space becomes the leading theatre of Sino-American competition.

The elegance is that none of it can be objected to. No treaty is broken. No target is designated. No orbital debris is created.

Humanity is the official beneficiary. It is the finest cover available: a capability tested in public, to applause.

> ***Beijing protects the Earth from asteroids.***
> ***It merely happens that the same hand, the same eye***
> ***and the same calculation would suffice, on the day,***
> ***to extinguish a satellite.***

ON THE RECORD: WHO HAS ACTUALLY DESTROYED A SATELLITE

Five destructive intercepts have succeeded to date.

The **United States twice**: an air-launched ASM-135A from an F-15 against the Solwind P78-1 observatory on **13 September 1985** at 530 km, and a modified SM-3 against the failing reconnaissance satellite USA-193 in **February 2008** at roughly 220 km, framed as a public-safety measure and known as Burnt Frost.

China destroyed its Fengyun-1C weather satellite on **11 January 2007** at 863 km — the worst debris event on record, with thousands of fragments still in orbit. **India** followed on **27 March 2019** against Microsat-R, deliberately low to limit debris lifetime.

Russia struck Cosmos 1408 with a Nudol interceptor on **15 November 2021** at around 480 km, generating more than **1,500 trackable fragments** and forcing the ISS crew to shelter.

Washington declared a unilateral moratorium on destructive direct-ascent testing in **April 2022**.

Note what all five have in common and what the asteroid mission conspicuously avoids: **a debris cloud in an orbit somebody else is using**.

THE GROUND, THE BEAM, THE ORBIT

Air superiority did not begin on the runway, and orbital advantage does not begin in orbit. It begins with a telescope on a truck, a deformable mirror, and somebody who knows where a satellite will be in four milliseconds' time.

The twentieth century counted satellites. The twenty-first counts ground stations, adaptive optics benches and the ability to put a beam exactly where it is aimed.

None of it photographs well. All of it decides the outcome.

> ***Two capabilities are being built at once.***
>
> ***The first talks to satellites.***
>
> ***The second learns, in the process, how to reach them.***
>
> ***Nobody has to choose between them ,and that is precisely the point.***

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