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CASE STUDY · MARLUC SYNOPSIS

NASA Goddard evolved structures

IMPLEMENTED 2022–2025 · GOVERNMENT AND PUBLIC SERVICES · US · BAND C · CLAIMED ONLY

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A NASA Goddard engineer uses commercial generative design software to produce one-off spacecraft and instrument structures that NASA calls evolved structures. NASA's own tests found the parts stiffer and stronger than human designs, and its 2025 presentation says the EXCITE balloon telescope, which uses a generatively designed part, flew an engineering flight in August 2024.

ABOUT THIS SYNOPSIS

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NOTICE WORDING LAST UPDATED 16 NOVEMBER 2026

AT A GLANCE

Frontier case: AI used for a scientific, medical or engineering breakthrough. The transformation is potential and unproven; MarLuc grades what has changed in practice so far.

AI and automation used: Commercial generative design software (Autodesk Fusion 360 Generative Design Extension) that NASA describes as AI; the underlying method is structural optimisation.

Implemented: 2022–2025. Grade: band C, Process change, Claimed only.

Headline result, as reported: NASA Goddard says AI generative design cut an instrument bracket's design effort from two days for two engineers to about 1.5 hours, with the part stiffer and stronger in tests

1 · The case

The facts, as reported by the 4 sources listed at the end. Where a source is silent, the field says "Not reported".

Organisation

NASA Goddard Space Flight Center. US space agency centre in Greenbelt, Maryland. The work was led by one research engineer and funded by Goddard's internal research programme and NASA's Space Technology Mission Directorate. Headcount: Not reported. Canvas block: 4. Operations and process. Also 6. Data and technology.

Business challenge

The challenge. By NASA's account, spaceflight instruments are expensive and NASA makes thousands of bespoke parts every year, so design, analysis and fabrication of each part is slow when done by separate people or organisations.

How it was addressed. Goddard research engineer Ryan McClelland developed a process using commercially available AI software, which he calls evolved structures. A CAD specialist defines the mounting surfaces, bolts and no-go zones, and the software generates a structure in as little as an hour or two; parts are then analysed with NASA-standard validation software and processes and made by commercial vendors. The paper names Autodesk Fusion 360 Generative Design Extension as the tool. NASA says the parts have been adopted by missions including astrophysics balloon observatories, Earth-atmosphere scanners, planetary instruments, space weather monitors, space telescopes and Mars Sample Return. [1] [2] [3] [4]

Who implemented it

In-house (In-house): NASA Goddard Space Flight Center: Developed and applies the evolved structures process.
Autodesk (Software vendor): Supplies the Fusion 360 generative design software named in NASA's paper.
Parts are machined or printed by commercial vendors, which the sources do not name.

Technology (SEAM pillar E)

SEAM types: T2 Embedded AI in existing software. Deployment: Not reported. Vendors and products: Autodesk, Fusion 360 Generative Design Extension.

Where it was built in: Used inside the CAD and analysis workflow: requirements and no-go zones go in, manufacturable designs come out, then standard finite element analysis, load and vibration testing and machining or printing by commercial vendors.

What changed

Before: a design engineer and structural analyst iterated on a part over days. After: one engineer encodes requirements and the software generates manufacturable options, and the part is checked with standard analysis, load tests and vibration tests. A human reviews the output, because by McClelland's account the algorithm can make structures too thin. [1] [2] [3] [4]

What it cost

Not reported

What it saved

By NASA's account: parts that save up to two-thirds of the weight of traditional components; a prototype in hand in as little as one week; for the EXCITE tip/tilt bracket, about 1.5 hours of effort against two days of effort by two engineers. Dollar savings: Not reported. [1] [2] [3] [4]

Governance and control

Parts are analysed with NASA-standard validation software and processes, and a human reviews the algorithm's output, by NASA's account. The paper reports load and vibration tests on fabricated brackets. Named risk owner and independent review: Not reported.

S2 · Accountable owner · Not reported
Not reported; the work was led by one named research engineer. [1]

A1 · Safe use · Not reported
Not reported.

A2 · Human in the loop · Claimed
By McClelland's account the algorithm needs a human eye because it can make structures too thin. [1]

A3 · Monitoring and assurance · Claimed
NASA says parts are analysed with NASA-standard validation software and processes; its paper reports load and vibration tests on fabricated brackets. [1] [2]

A4 · Vendor AI · Claimed
The paper names Autodesk Fusion 360 Generative Design Extension as the tool; vendor assurance is not reported. [2]

A5 · Agent controls · Not reported
No agents described.

A6 · Standards and regulation · Not reported
Not reported.

What worked, what did not, what is unproven

WORKED

– In NASA's tests of the EXCITE tip/tilt bracket, the AI designs were stiffer per unit mass (740 and 885 Hz/kg against 240 Hz/kg) and had 7 and 9 times lower maximum stress than the third human design.

– NASA's paper reports that tested parts were stronger than predicted and that standard analysis predicted structural performance accurately.

– NASA's 2025 presentation says EXCITE flew an engineering flight in August 2024 and describes its receiver as coupled to the telescope by a generatively designed transfer box.

DID NOT

– NASA's 2023 release said EXCITE planned a test flight as early as fall 2023; the engineering flight took place in August 2024.

– By McClelland's account, left alone the algorithm can make structures too thin, so a human review stays in the process.

UNPROVEN

– Which specific evolved parts have flown: the sources say EXCITE flew and uses a generatively designed part, but do not list flown evolved parts.

– Performance of evolved structures on Mars Sample Return and the other named missions, which NASA described as in design or construction in 2023: Not reported.

– Use on larger structures: the paper says only small to mid-sized metal parts (0.6 m maximum) have been demonstrated.

– Whether the method changes how spacecraft are designed across NASA: potential and unproven.

Timeline

2022 SPIE paper reports the EXCITE bracket comparison and tests, and 20 other applications [2]

Feb 2023 NASA announces evolved structures adopted by several missions in design and construction [1]

2025 EXCITE payload refurbished; 2026 to 2027 Antarctic science flight planned [3]

2 · Grade and SEAM assessment

MarLuc's opinion, made on the evidence above. How cases are graded: marluc.co.uk/case-studies/how-we-rate

Level of change and impact

Claimed: A. Grade: C, Process change. Proof: Claimed only. Level of change: Process change.

Process change (Level 2, band C) in instrument structure design at Goddard. Claimed as a paradigm shift (band A); that is potential and unproven.

A changed design process: one engineer defines requirements and the software generates parts that commercial vendors can machine or print, and the method has been used on about 20 further Goddard applications. That is a process change (band C, level 2). NASA's results come from its own tests and papers. NASA describes a wider transformation of spacecraft design, calling it a "paradigm shift" and "game-changing"; it is potential and unproven, since the sources describe small to mid-sized metal parts and no independent review.

The SEAM view and lessons learnt

The gain is specific: a defined part, a defined tool, repeat tests and a flown instrument. The sources are NASA's own, and the method is structural optimisation sold as generative design, so the case is marked as partly AI. The useful practice is the control around it: the same validation software and tests as any other part, plus a human reviewer.

1. Run AI-generated parts through the same analysis and tests as any other part.
2. Keep a human reviewer on generated designs.
3. Record which parts actually flew, not only which were designed.

Evidence

Score 2 of 4. Self-reported: NASA's own paper, release and presentation, with physical tests reported; relayed by press; no independent evaluation found.

Evaluation method. Agency paper and release with reported load and vibration tests; relayed by trade press; no independent evaluation or peer-reviewed trial found.

Sources disagree. NASA's release says the parts save up to two-thirds of the weight; the 2022 paper reports stiffness-to-mass and stress gains for one bracket and does not give a weight saving. The release said EXCITE would fly as early as fall 2023; the 2025 presentation says it flew in August 2024.

Status. Ongoing: EXCITE was preparing a 2026 to 2027 Antarctic science flight, per NASA's 2025 presentation.

3 · Original sources

Read these in full. To challenge a fact or a grade, use the contact form at marluc.co.uk or the link on https://marluc.co.uk/case-studies/nasa-goddard-evolved-structures

[1] NASA: NASA Turns to AI to Design Mission Hardware
https://www.nasa.gov/technology/goddard-tech/nasa-turns-to-ai-to-design-mission-hardware/

[2] NASA Technical Reports Server: McClelland, Generative Design and Digital Manufacturing: Using AI and robots to build lightweight instruments (SPIE 2022)
https://ntrs.nasa.gov/api/citations/20220012523/downloads/McClelland-Generative%20Design%20SPIE%202022.pdf

[3] NASA Technical Reports Server: Nagler, The EXoplanet Climate Infrared TElescope (EXCITE) presentation, 2025
https://ntrs.nasa.gov/api/citations/20250009023/downloads/Nagler_EXCITE_Heliotech25_revA.pdf

[4] The Register: Language, schmanguage: NASA's generative AI builds spaceships
https://www.theregister.com/2023/02/13/nasa_generative_ai_design/

NASA Goddard Space Flight Center website: https://www.nasa.gov/goddard/

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