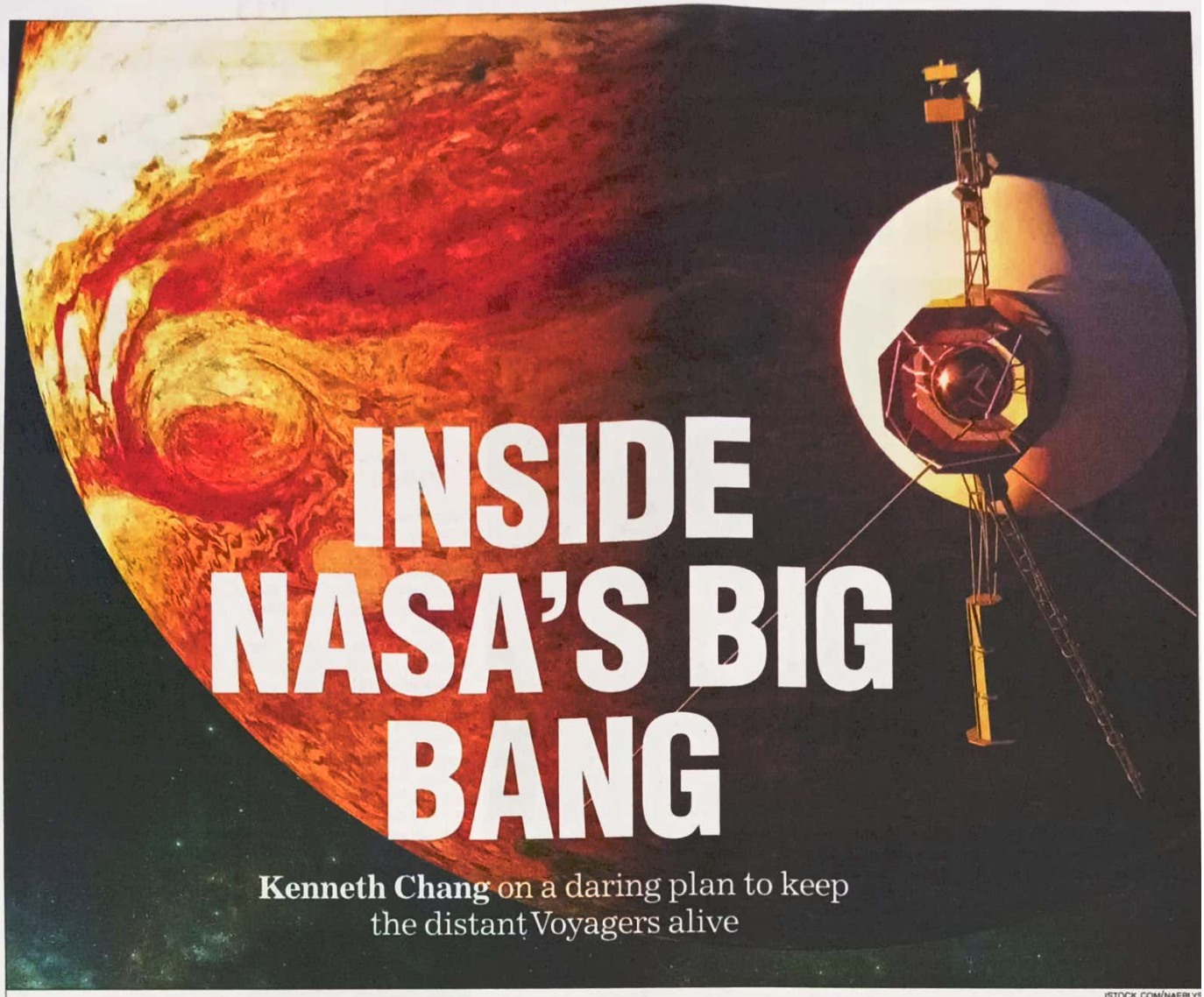

INSIDE NASA'S BIG BANG

Kenneth Chang on a daring plan to keep the distant Voyagers alive

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EYE SPY: It has been decades since the heyday of the Voyagers when they flew past the giant planets, sending back photographs of the reddish clouds swirling around the Great Red Spot on Jupiter as seen here

Nshan Kazaryan, the Nasa engineer responsible for communicating with the Voyager 1 and Voyager 2 space probes, is younger than the spacecraft he talks to. At 25, Kazaryan is among a new generation of engineers at Nasa's Jet Propulsion Laboratory in the US, working to keep the geriatric but resilient spacecraft going.

"Every time I talk about Voyager, I kind of treat it like my parents," he said. "As a human gets older, they have all these problems. A spacecraft is similar. The older it gets, the more the problems." (Kazaryan's parents were not yet born when the Voyagers launched in 1977.)

Working with the ageing spacecraft requires ingenuity, doggedness and Zen-like patience. Each time Kazaryan sends a command to one of the Voyagers, he has to wait a couple of days for a response. That is how long it takes a radio signal to make the round trip. Voyager 1 is almost 26 billion kilometres away; Voyager 2 is a bit closer — about 21 billion kilometres. But that is still more than four times the distance to Pluto.

It has been decades since the heyday of the Voyagers. Now, speeding away at more than 48,280 kmph, the twin spacecraft have travelled the farthest of any human creation. Voyager 1 entered interstellar space in 2012, and Voyager 2 crossed over six years later.

Space scientists want them to continue collecting observations about what lies between stars for as long as possible. There will not be another spacecraft venturing that far out anytime soon.

But that endeavour is becoming harder and, within a few years, will be impossible as the energy from the spacecraft's plutonium batteries diminishes. To keep the spacecraft alive, the engineers have to take risks that other missions would not dare. "We're like pirates," Kareem Badaruddin, the Voyager mission manager, said. "Nobody likes to be this close to the edge, but we've gotten quite comfortable with it because it's our only choice."

In a triumph in July, the team pulled off what it calls the "Big Bang" on Voyager 2 — a juggling of the electrical systems that saved about 10 watts of power. That tiny boost, enough to power a lightbulb or two, could extend the mission by about two years, well into 2031.

Diseases of Old Age

Three chronic conditions are slowly killing the Voyagers. One is that the fuel lines are clogging up with residue dissolved from a silicone bladder that pushes propellant — a liquid known as hydrazine — out of the tank to the spacecraft thrusters. Think of it as the spacecraft equivalent of cholesterol-clogged arteries.

If too many thrusters on a Voyager fail, it would be unable to keep its antenna pointed at Earth. With communications severed, it would be lost.

To slow the buildup of silicone, the thrusters have been fired less often over the past few years — the antenna is now allowed to drift farther out of alignment before being nudged back in the direction of Earth — and the lines that the propellant flows through are periodically switched.

A second challenge is keeping the fuel lines warm enough. Frozen hydrazine would also block the propellant lines and break the thrusters. There are heaters on the spacecraft designed to prevent that but they require electrical power.

And that — in the third chronic condition — is something the spacecraft are running low on. The plutonium batteries (what Nasa calls radioisotope thermoelectric generators or RTGs) generate the energy that the Voyagers run on by converting heat from the radioactive decay of plutonium into electricity.

The RTGs originally produced about 470 watts for each Voyager. As the plutonium decayed and power dwindled over the decades, one scientific instrument after another was turned off on the probes. On Voyager 2, which is down to 216 watts, only three of the 10 instruments are still collecting data. On Voyager 1, which is subsisting on slightly less power, there are just two.

The mission team investigated ways to cut back on power. For example, the digital tape recorder on Voyager 1 broke decades ago but engineers kept it on because it fortuitously warmed nearby propellant lines.

The designers of the Voyagers included a heater to keep the recorder warm in case it needed to be turned off. Why not turn off the broken tape recorder and turn on the heater, which uses fewer watts?

That carried some risks. The tape recorder had never been turned off, and the heater had never been turned on. More crucially, the heater produced less heat than the tape recorder. Analysis indicated that a thruster might become too cold for hydrazine to flow. "It wouldn't really help us," Badaruddin said.

The Switch

An engineer named David Woerner suggested that since piecemeal changes would fail, making a slew of such changes at once could keep the heat and power requirements in balance while reducing consumption.

This undertaking became the Big Bang, and after nine months of analysis, the Voyager engineers became convinced it could work. They decided the benefits outweighed the potential pitfalls. "Voyager is basically the path of least regret," Bruce Waggoner, the mission assurance manager, said. "There's no really right answer."

They started with Voyager 2 because it is healthier power-wise. The operation was performed in three steps, to minimise the danger of losing the spacecraft. "There's always that concern that it might not go correctly," said Suzanne Dodd, who has served as the project manager for Voyager since 2010.

First, in May, the spacecraft was told to switch to the new configuration for 40 minutes. That was to ensure that systems like the heater near the recorder, which had never been turned on before, indeed worked. A month later, Voyager 2 remained in the new configuration for six hours to check that the temperature predictions were accurate. Last month, the change was made permanent.

The 50th anniversary of their launches is just over a year away. "I'm pretty confident that they both will make it," Dodd said.

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