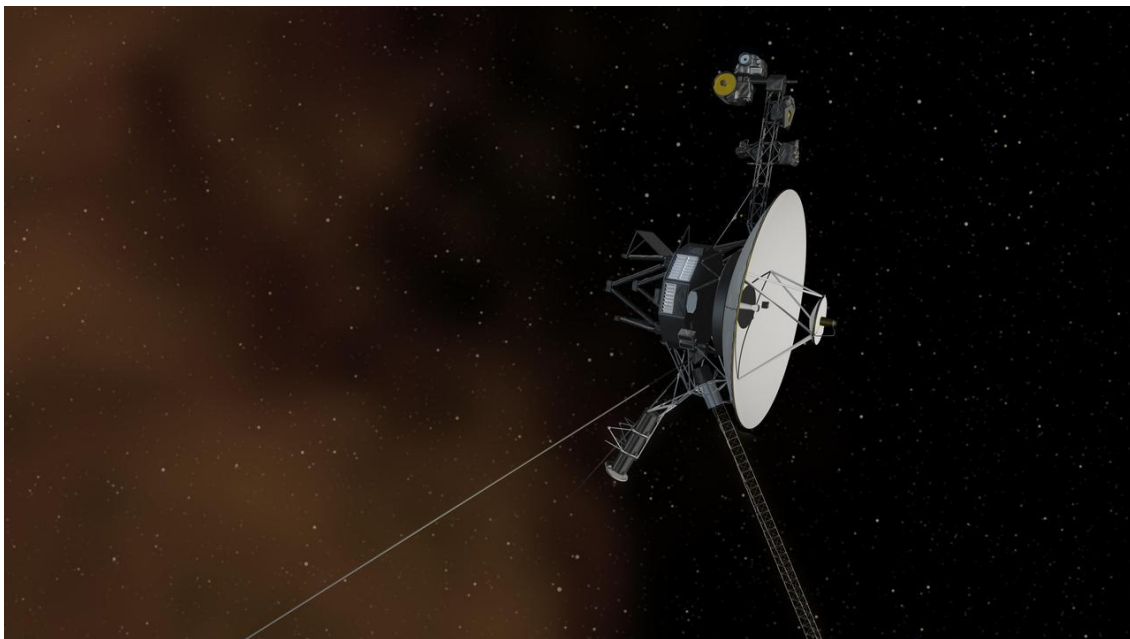


## OUR LONELIEST SPACE PIONEER

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Ken Tapping, 30th April, 2024

The most distant emissary we have sent into space is Voyager 1, now around 24.3 billion kilometres away. It is now well outside the Solar System, travelling in interstellar space. This great odyssey of space exploration began in 1977, when the USA launched two Voyager spacecraft to explore the outer Solar System. It just happened that the outer planets had arranged themselves in a convenient arrangement for a Grand Tour. Assuming one or both of the spacecraft survived the trip to the edges of the Solar System, they were intended also to provide data on the heliopause, the boundary between the Solar System and interstellar space. Voyager 1 crossed this boundary in 2012. It is amazing that the spacecraft has experienced the radiation and temperature extremes of interplanetary and interstellar space for about 47 years. Then, on 14 November, 2023, the data being transmitted back to Earth became unreadable. Luckily there was still communication, so there were possibilities of diagnosing and then fixing the problem.



When our home heating systems fail, we call in an appropriately skilled mechanic, who gets into the machinery, finds the failed components and either fixes or replaces them. Obviously this sort of repair process is utterly out of the question for a space probe out there in the depths of space. The first step is to do everything possible to ensure that components are as perfect as possible, and that they are not worked hard. Then, because there is no such thing as a perfect component, to the greatest extent possible, multiple backup components are included. Since no mechanic will be making a trip to remove old components and replace them with backup components, the on-board systems have to be designed with the backups included, together with arrangements and control systems for switching out the failed components and switching in the backups. Some of this can be automatic. Although the spacecraft should be able to take

care of itself to the greatest feasible extent, it is still necessary to be able to comprehensively monitor the spacecraft operation and to do some maintenance from Earth, using two-way radio communication. However, since it currently takes almost a day for the response to a command sent from Earth to arrive on the engineer's screen, this has to be done carefully. Reliable two-way communication system is critical. The attitude control system has to be working and the communications antenna has to be kept pointing at Earth. To provide the information the engineers need, there have to be monitoring devices throughout the system providing detailed information on how all the components are working. Then there has to be a means for controlling those devices. All these monitoring and control functions happen via the on-board computer system. This could be a problem, so you have three on-board computers, all running together and monitoring each other. If one fails, the others can vote it down two to one.

In the case of the Voyager 1 problem, it was a memory chip containing the code that formatted the data for sending back to Earth. So there was still two-way communication, but the data was garbage. Since nobody was around to unsolder the chip and install a new one, the engineers took the code from the chip and distributed it elsewhere in the computer system memory. The instructions were sent on 18 April. Imagine the suspense of the engineering team as they waited the 22 hours for the signals to reach the spacecraft, and another 22 hours to see if it worked. On 20 April they saw they had succeeded in solving the problem. It is amazing that we have a spacecraft 22 light hours away, and that engineers can fix on-board problems. A more sobering thought is that the nearest star after the Sun lies 4.3 light years away. Still, all journeys start with the first step.

Mars and Saturn lie low in the dawn glow. The Moon will reach Last Quarter on the 30th, and be New on 7th June.

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