DeMoor Orrery

A 240-year-old orrery provided the inspiration for Chris de Moor's stunning planetarium project. **David Crookes** takes a look

MAKER

Chris de Moor

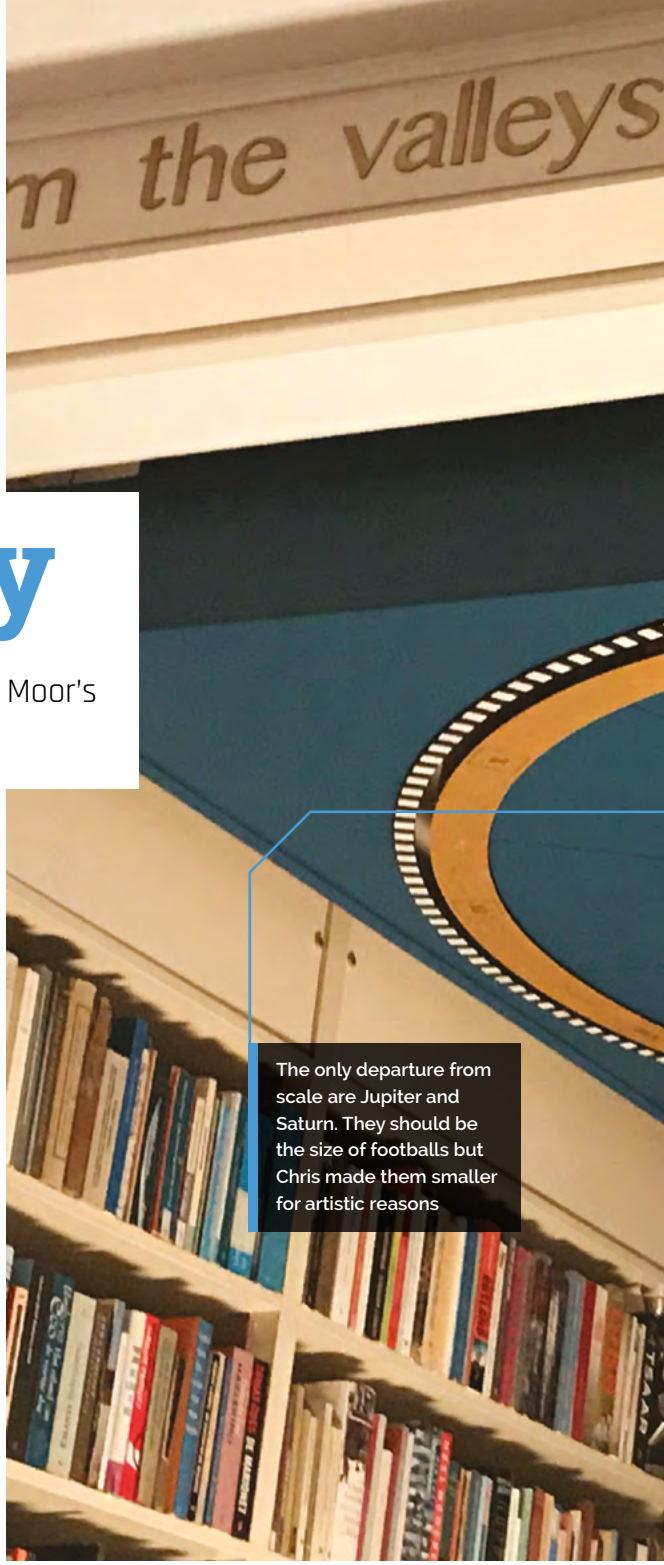
Former programmer and enthusiastic maker, Chris founded and ran a digital agency called Est Digital until earlier this year. His website links to the required GitHub files.

demoor-orrery.com

Many people have a keen interest in astronomy, but before Chris de Moor created a project that's truly out of this world, he didn't count himself as being among them. "I didn't know anything about astronomy and that sort of stuff," he freely admits. Yet after visiting the Eise Eisinga Planetarium in Franeker in the Netherlands, he was inspired.

"Eise Eisinga completed an orrery in his house in 1781," Chris says, of the oldest working orrery in the world, created by the Frisian amateur astronomer. "I saw it on the ceiling and thought I wanted one just like that, thinking it would fit perfectly in my living room. At first I believed it would be a weekend project – a simple art piece – until I decided it should work as well. And then the rest came." Indeed, what followed would take him a year!

Chris set about building a replica, one that is similarly coloured and with planets fitted to copper tracks. But while Eisinga's orrery was driven by a pendulum clock driving a host of mechanics in the space above the ceiling, Chris went one better: he used six Raspberry Pi Zero computers – one for each of the six planets he decided to concentrate on.



The only departure from scale are Jupiter and Saturn. They should be the size of footballs but Chris made them smaller for artistic reasons

Planetary planning

"My first question was about scale and how big my orrery should be," Chris recalls. Ultimately, he worked out that he only had room for Mercury, Venus, Earth (plus the Moon), Mars, Jupiter, and Saturn. The next step was then figuring how spaced apart they should be, the size of each representative planet and how they would move into position in real-time.

"I'd heard about Raspberry Pi computers so I decided to experiment with them," Chris says. "I also know how to program and, while Python is not my favourite language, it was easy to learn. What I didn't know was how stepper motors worked. They were new to me. But once I bought one Raspberry Pi Zero and a stepper motor and played around, I realised what was possible."

Even so, there were lots of technical challenges along the way. "I got some plywood and started sawing, but a lot of things went wrong," he laughs. "Trying to saw perfect circles by hand is impossible, so I had to go to a store that had a CNC cutting machine, which meant I needed a drawing and DXF vector file. I ended up in areas where I didn't know anything."

Each planet is controlled by a Raspberry Pi Zero. A Nema 17 stepper motor and Adafruit Motor HAT driver are connected to it to drive it along the track

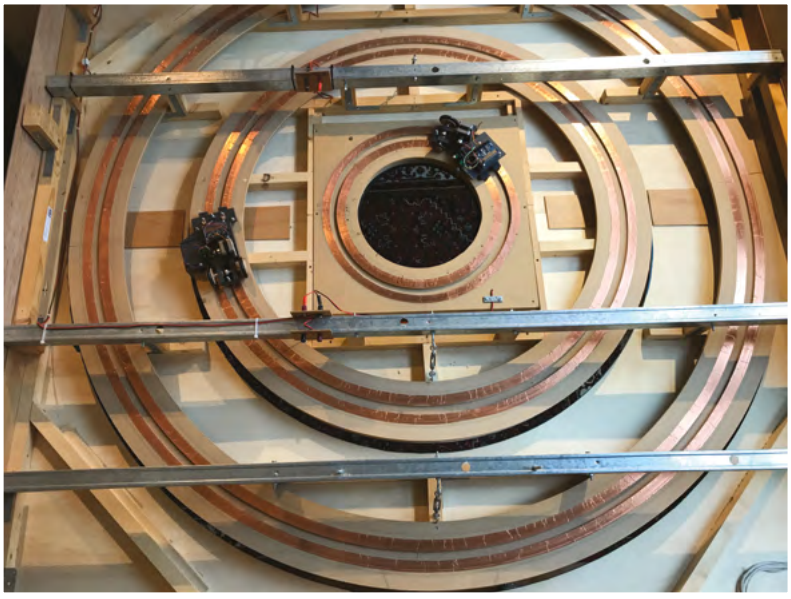
The inner planets (Mercury, Venus, and Earth) are on their own system that can be removed from the rest of the orrery

Quick FACTS

- The orrery is created to scale
- It cost Chris €4500 to make
- It weighs 83.2 kilograms
- The dimensions are 2.20 × 2.20 metres
- Six Raspberry Pi Zero computers are used

Raspberry Pi in the sky

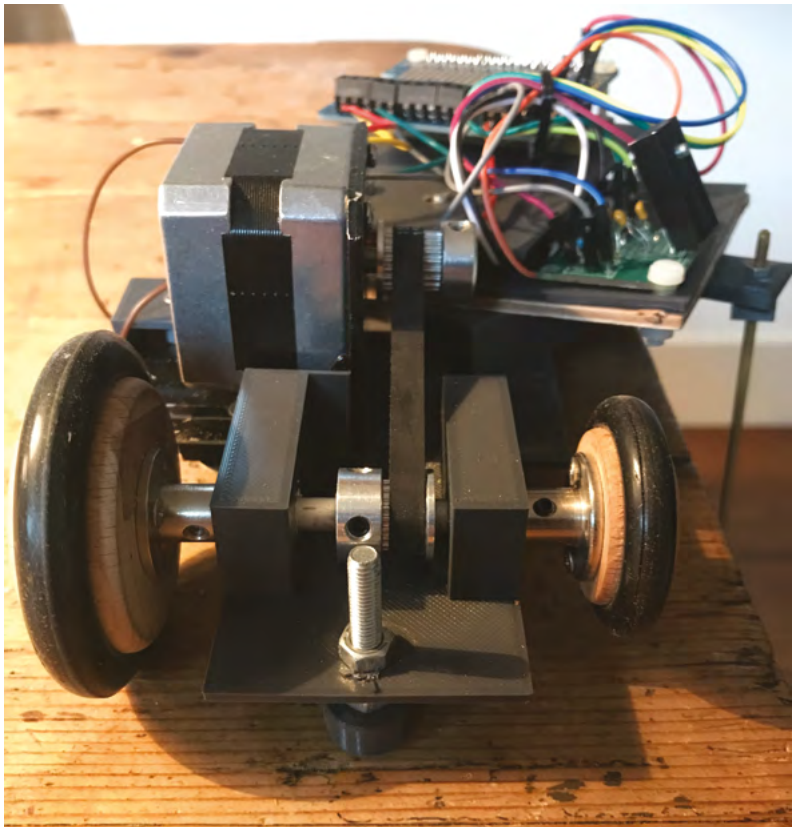
Even so, he persevered and learned, ending up with two ways of moving the planets, each of which is connected to a Raspberry Pi Zero computer. Mars, Jupiter, and Saturn are attached to front-wheel drive, 3D-printed cars which run on tracks on the non-visible side of the project. The inner planets, Mercury, Venus, and Earth, are mounted to dishes. "The inner system is so small, you can't have tracks there, so I mounted those planets on dishes and even connected Mercury directly to the axle of the stepper motor."

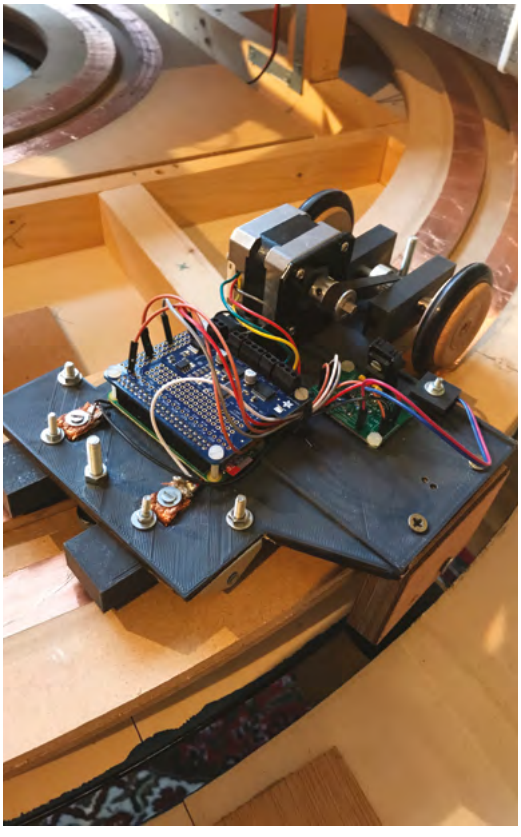


▲ To discover its position, each Raspberry Pi Zero computer detects when it passes a magnet placed on the track. This sets its counter to zero so it can work out how many steps the stepper motor must take to get a planet into position

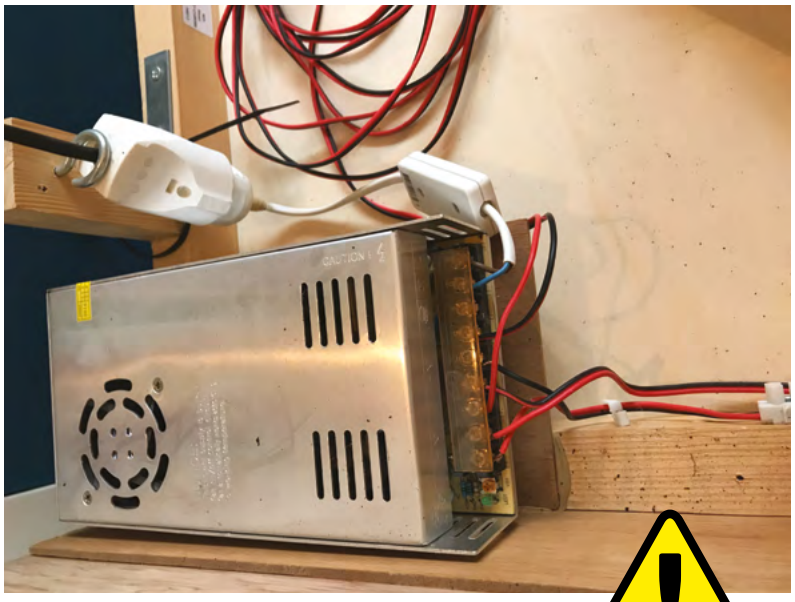
◀ The orrery is 30 centimetres high and suspended from the ceiling. Chris has attached it to a winch which allows it to be lowered for easy maintenance. A winding mechanism from a vacuum cleaner is used to ensure the power cord doesn't get in the way

▼ This car drives Jupiter around its circular track (in reality, orbits are not perfect circles). It gets electricity via two sliding contacts mounted on the back





▲ Here's a close-up view of the front of the Mars car with a Raspberry Pi Zero mounted on top



Warning!
Electrical Safety

Please be careful when working with electrical projects around the home. Especially if they involve mains electricity.

magpi.cc/electricalsafety

This is a view of the inner planets attached to their propeller dish. The Sun is drawn on the ceiling, otherwise it'd be 2.85 metres in diameter!

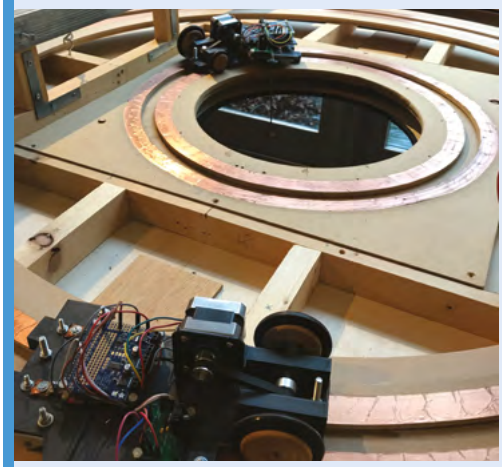
The driver runs on 12 volts and the Raspberry Pi Zero computers on 5 volts. The power supply is firmly attached to the frame

The biggest headache was working out the planetary positions. "I looked into the mathematics of NASA, and the exact positioning of Mercury is a mathematical equation, with more than 40 pages of data. It's very, very complex," Chris says. "I had to make it more simple, and I found a beautiful JavaScript library called JSOrrery which is installed on a server. You give it a date and it plots the planets. Raspberry Pi computers are then connected by wireless LAN and they read their position before moving their connected planets to it."

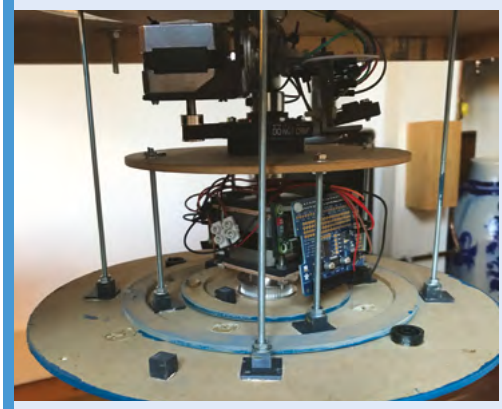
It's not 100 percent accurate. "If you want to travel to Mars and you let yourself be guided by my orrery, then you're definitely going to miss it," Chris laughs. But as a working showpiece, it's stunning and, what's more, it has been made open-source so that anyone can try to make their own. "Maybe it will lead to something – perhaps people will contact me and it'll involve some travelling and meeting new people," he says. "If not, I've got a beautiful ceiling and that was the whole point."

Recreating Eise Eisinga's historic orrery

01 Eise Eisinga spent seven years creating his orrery in the 18th century. Bought by King William I of the Netherlands in 1818, it was very detailed and also kept track of the phases of the moon. Credit: Erik Zachte, Wikipedia



02 Chris de Moor opted for a simpler system because of the smaller space he had. The outer planets are connected to 3D-printed cars running on tracks, controlled by a Raspberry Pi Zero.



03 Inner planets Earth and Venus, meanwhile, are connected to a viewing dish that's mounted to a propeller dish. Mercury is mounted directly on to the stepper motor. It allows for tighter circling.