Using observatory technology to improve eye surgery

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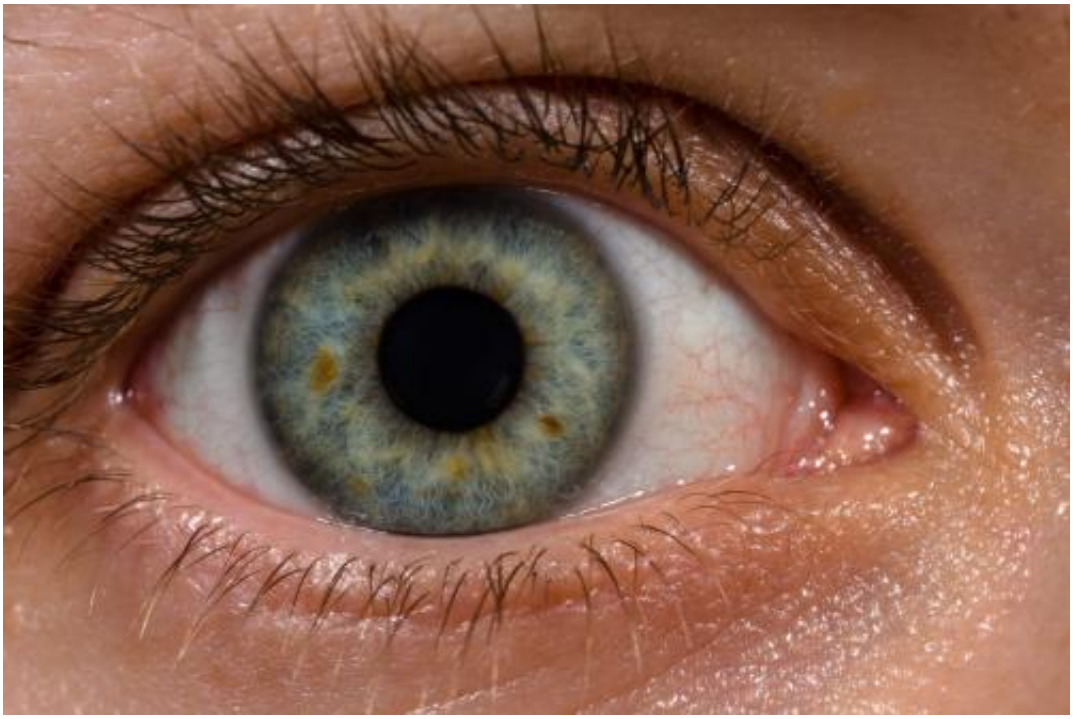


Credit: ROTFLOLEB/Wikipedia

Physicians in the Netherlands have turned to expertise from a planet-hunting telescope to steady their surgical microscope and save the sight of people threatened by blindness.

Doctors at the University Eye Clinic Maastricht found their microscope was quivering, making one in five sight-saving operations impossible.

The answer came in the form of the revolutionary Hummingbird device. Originally designed for testing Darwin, a potential space observatory, it enabled engineers to stabilise the microscope and unlock its full potential for preventing sight loss.

To magnify the eye, surgeons look through a powerful microscope mounted on the ceiling of the operating theatre.

"When you're working within less than 1 mm, a shaky microscope is not an option," says eye surgeon and head of the University Eye Clinic at the Maastricht University Medical Centre, Professor Carroll Webers.

"If a patient has retinal detachment, we must operate within a day or two to stop them going blind. The retina is barely half a millimetre thick and sometimes we have to peel back an 'epiretinal membrane', which is 10 times thinner.

"It's impossible to perform this kind of delicate surgery with a wobbling image."

Despite a lengthy investigation, including the removal of a speed bump from the busy road outside which shook the microscope every time a bus drove over, the trembling continued. So they turned to space via Dutch engineering company MECAL, who identified the culprit.

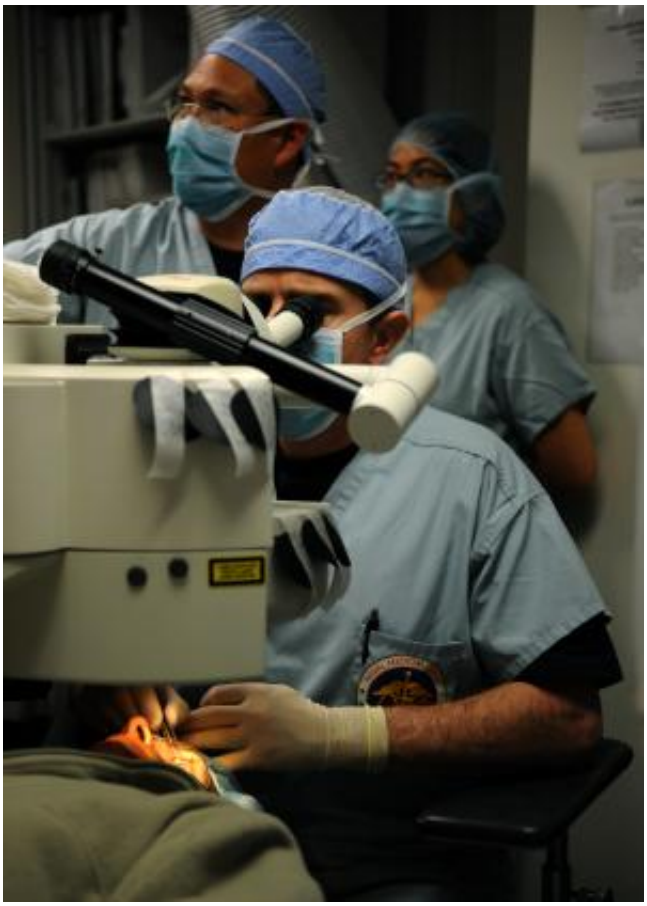
Wind blowing on the outside of the shiny new hospital was enough to vibrate the ceiling supporting the microscope.

"High buildings in glass and steel are popular," says Johan van Seggelen from MECAL. "They might be more attractive than concrete but they're also more sensitive to low-frequency vibrations."

Invisible to the naked eye, the vibrations were 100 times smaller than the

diameter of a human hair, but factor in the 20 times magnification of the microscope they often put the surgery at risk.

A steady-handed surgeon needs a steady microscope. "We had the idea of mounting Hummingbird between the ceiling and the microscope's arm in order to isolate it from the source of the disturbance."



Physician performing eye surgery with the help of a microscrope. Credit: Wikipedia/C.A.Bascom

In doing so, they created the first-ever active vibration damper to counter low-frequency vibrations in surgical microscopes – all thanks to

the pioneering work of a team of engineers testing crucial elements of ESA's Darwin telescope.

Born of our quest to seek planets like our own, Darwin was proposed as a constellation of four or five free-flying space telescopes designed to search for Earth-like planets around other stars and analyse their atmospheres for chemical signatures of life.

For this ESA project, the Dutch TNO research organisation developed an 'optical delay line', which combines the light seen from each of the telescopes in order to create a single detailed image.

"But we had problem" says Len van der Wal from TNO. "There were vibrations from the busy road outside our basement lab. We took all the measurements we could think of but it was impossible to fully test the delay line. So we had to devise a totally new environment that could cancel those vibrations: a vibration-free test bench."

Darwin did not progress beyond the study phase, but the TNO team realised the groundbreaking rig they had invented could have a life of its own.

Being part of ESA Technology Transfer Programme's network of brokers to spin-off space solutions, TNO often see how advanced technologies developed for Europe's space programmes provide intelligent solutions to problems in non-space terrestrial systems. Therefore, they took it to MECAL.

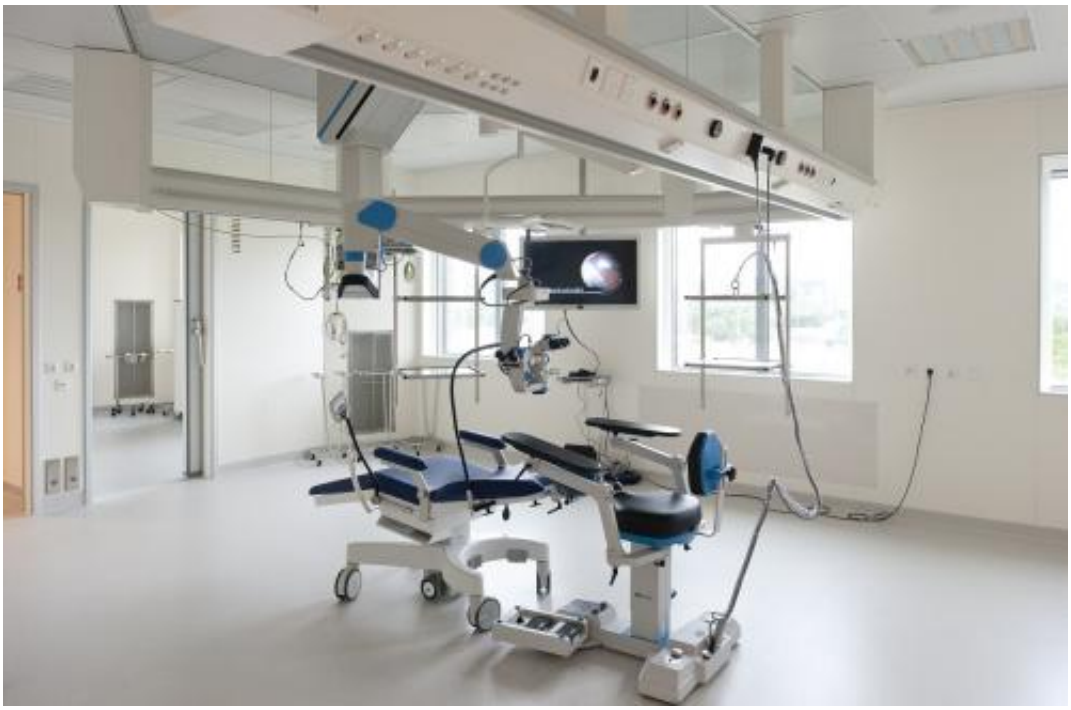
"There are two types of vibrations," explains Johan Van Seggelen. "High-frequency vibrations come from fast movements like a motor. We use springs or rubber to dampen them – that is passive isolation."

Low-frequency vibrations from slow movement such as traffic, wind,

waves on a beach or even people walking past a building are more difficult to eliminate.

"You can't use springs to stop a building swaying in the wind. What you have to do is counteract that movement. We call this active isolation."

Hummingbird senses the tiny vibrations and small actuators push the microscope in the opposite direction, effectively cancelling the vibration, just as if you were standing on a cliff with the wind pushing you one way and someone pushing you the other with the same force.



Operating theatre at the University Eye Clinic at the Maastricht University Medical Centre. Credit: Maastricht University Medical Centre

Countering vibrations is not new, but Hummingbird has a unique feature. The team invented and patented a 'horizontal coupling' mechanism,

which keeps horizontal vibration sensors level at all times and therefore prevents errors that normally occur when horizontal vibrations are countered at ultra-low-frequencies of one cycle every two seconds. Active systems without this technology will typically only work at more than five cycles per second.

"Everything moves within 'six degrees of freedom': up/down, forwards/backwards, left/right, roll, pitch and yaw," explains Johan. "Thanks to horizontal coupling, Hummingbird counters vibrations in all six."

This was vital when mounting the device on the ceiling of the operating theatre, which was moving horizontally.

"Hummingbird has changed our professional lives," says Prof. Webers. "Our patients can feel totally safe and at last we get to use our beautiful new building and operating theatre to the full."

TNO is delighted that their innovative work is paying off. "Looking at something created for space and wondering where this could land on Earth is a creative process," notes Len van der Wal.

"It's heartening that transferring our knowhow into a non-space world is helping people to see."

So what's next for the surgical microscope vibration damper? "It can be useful for all kinds of precision operations such as brain surgery, neuronsor tiny blood vessels," says Johan. "We already have interest from hospitals in Austria, Canada and the UK."

In the meantime, the team are about to release their latest version of the Hummingbird which will, just like the wings of its hovering namesake, beat up to 80 times per second – a feat of human engineering and a no-

less-impressive feat of nature.

Provided by European Space Agency