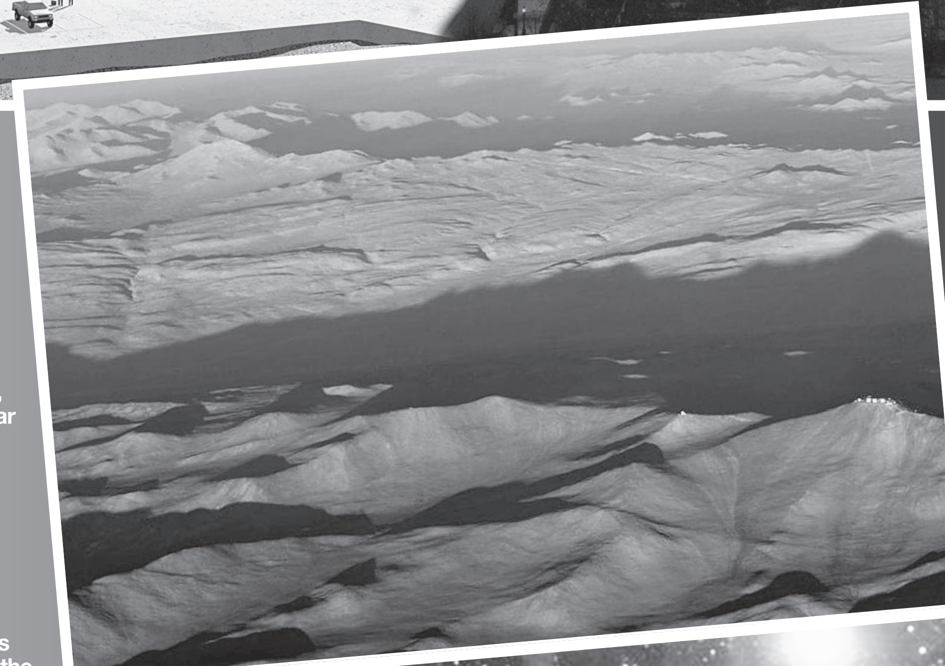
WEEKEND

PLANS FOR the world's largest telescope were unveiled last week. A joint project between 14 European countries with a budget of €1 billion, the European Extremely Large Telescope will use a 42 metre-wide lens to peer further into the cosmos than ever before. **Jack McKeown** talked to the project's UK lead, Edinburgh Royal Observatory's Professor Colin Cunningham, about the project's "holy grail" — finding an Earth-like planet capable of supporting life.

EYE on the sky



Above — an artist's impression shows the E-ELT next to the London Eye for scale. Left—Cerro Armazones mountain in Chile, where the telescope will be sited.

IT WOULD take Usain Bolt 4.5 seconds to run across and nearly 14 seconds to run around. The world's top shotputter could throw his 16lb ball barely halfway across it. Not that he would be allowed to, given the risk of smashing one of the nearly 1000 exquisitely-crafted mirrors that make up the €1 billion structure.

With a lens 42 metres in diameter and a massive 132 metres in circumference, the European Extremely Large Telescope is very aptly named.

Ambitions for what it can achieve are, if anything, even greater than its dimensions.

"We're hoping to see the 'first light' of the universe," explains Professor Colin Cunningham. "For millions and millions of years after the Big Bang, the universe was dark. Then the first galaxies were born and light entered the universe. But there was light emitted when the Big Bang happened.

"The radiation from that light still exists and people may have seen pictures of it from the Planck telescope in newspapers a few days ago. We want to look back further than that, almost to the very birth of the universe."

Incredible though that is, there's hope for an even bigger revelation, one that could potentially alter the way we see our place in the universe.

"We are also going to be looking for Earth-like planets that would be capable of supporting life — or may even contain it."

Professor Cunningham (58) is UK director of the European Extremely Large Telescope. An electrical engineer who specialises in creating scientific instruments, he worked for the Royal Botanic Gardens in London and the now-defunct Freshwater Biological Association in the Lake District before moving into astronomy.

He's been at the Royal Observatory, on Blackford Hill in Edinburgh, for the past 23 years. He was a systems engineer on the Herschel Space Observatory which went into orbit in May last year and has since sent back images of galaxies that formed just a couple of billion years after the Big Bang.

The European Extremely Large Telescope (E-ELT) has been seven years in the planning and involves 14 European partners, co-ordinated by the European Southern Observatory in Munich.

It's to be sited on top of Cerro Armazones, in northern Chile.

"It's a privileged zone for optical astronomy," Professor Cunningham continues. "Partly because it's very high — it's over 3000 metres — partly because it's very dark, but mostly because it's very dry. It only rains something like once every five years so you don't have cloud systems obscuring the atmosphere."

Readers may have noticed the almost comically obvious name given to the telescope. Professor Cunningham smiles as he explains its origin.

"The eight-metre telescope that is the biggest we currently have is called the European Large Telescope. The original plan was for a 102-metre diameter telescope called the Overwhelmingly Large Telescope. Its cost would have been prohibitive, so we've gone with the European Extremely Large Telescope for the 42-metre one."

The huge project does not yet have the green light, and the countries involved will meet in December to make a final decision. If it gets the go-ahead, construction will take the best part of a decade, with the E-ELT tentatively scheduled to begin searching our skies sometime in 2019.

Should it go ahead, it will be perhaps the greatest feat of optical technology ever attempted, and one of the greatest feats of precision engineering in any field.

The lens will consist of 984 hexagonal mirrors (with spares taking the number to over 1000) put together to create a surface area of nearly 1400 square metres. The engineering challenges involved are almost terrifyingly enormous.

"The margin for error across all 984 mirrors is around one 10 millionth of a millimetre," Professor Cunningham says. "A nice way of explaining it is that if you scaled the lens up until it was the size of the Atlantic Ocean, to remain within the margin for error, the waves would have to be no more than two millimetres high.

"The current biggest telescope has 36 mirrors. Each of those lenses takes around six months to manufacture.

"To make over 1000 in the time we've got we'll need to make around one a day for three years. We need to work out ways of vastly speeding up the manufacturing process."

Once the mirrors are completed they have to be transported — ever so gingerly — to Chile.

They will then be even more cautiously transported through the rugged mountain range and up the peak they'll be assembled on.

"There isn't a road to the mountain, so we'll have to build one. And we'll have to use explosives to blast the top off the mountain so it's flat enough to build on."

If and when all that is accomplished, the project's engineering worries are far from over.

"The mirrors will be attached to a steel frame. Once they're on the structure will weigh 4000 tons. There's no way we can make it strong enough not to sag when it moves.

"It will flex by about two millimetres. We've developed a sophisticated computer programme which calculates the flex and compensates to keep it in the one millionth of a millimetre range we need."

The reason for the project's vast price tag is that much of its technology is brand new.

"The biggest cost is the mirrors," Prof Cunningham continues. "The specification for them has to be incredibly precise. We're hopeful that it will be a company in the UK — in Wales probably — that manufactures them.

"Another big cost is the dome to protect the mirror. It's nearly the size of Wembley Stadium and it has to rotate and close if the weather takes a bad turn.

"Getting everything there and assembled isn't going to be cheap, either."

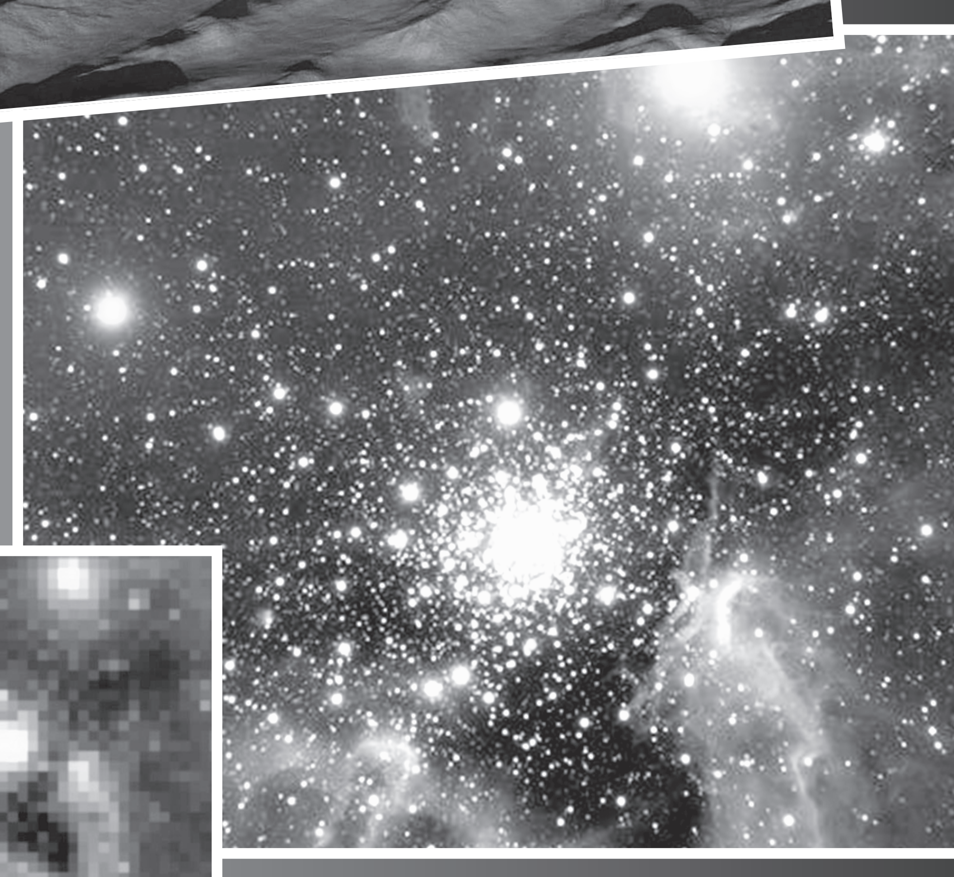
While €1 billion isn't small change, a big telescope is not the only thing the money buys. "The cutting-edge technology we're developing has applications elsewhere. For example, Adaptive Optics can be used to improve the imaging of retina scans. And the mirror arrangements we're using have possible applications for fusion energy, which could potentially create limitless clean energy."

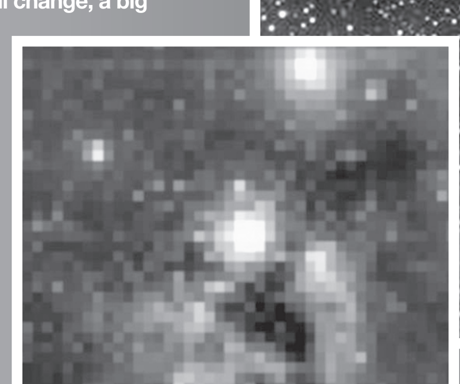
Over the last few decades astronomers have been launching telescopes into space — the Hubble being the most high-profile example — because of the extra clarity achieved once a lens gets beyond the distorting effect of the Earth's atmosphere. Yet the Earth-based E-ELT will be more powerful than any of them.

"We've got around that now. A system called Adaptive Optics measures fluctuations in the atmosphere and gets rid of them."

The result is quite incredible. On his computer, Professor Cunningham shows an image taken at the furthest limits of the Hubble's range. It's of a galaxy, but it's blurred and heavily pixelated.

He then opens another image showing what the E-ELT would be capable of. The same patch of sky is thrown into sharp contrast, with the blurred blocks replaced by stunning, swirling nebulae.





How the resolution of an image from the Hubble telescope (left) would compare with one from the E-ELT (above).

The telescope's power is enough that if it were built at John O'Groats it could zoom in on a bumblebee buzzing around at Land's End.

Much of Professor Cunningham's role in the project will be developing instruments to augment what the telescope sees. "We're making cameras and things called spectrometers that measure the quality of the light we're receiving. They allow you to do the chemistry that can work out what's going on in the universe."

Plans for the telescope were unveiled at the Royal Society's Summer Exhibition in London earlier this month. Prince Philip and Melvyn Bragg were among those who showed an interest.

If the project goes ahead and construction finishes in 2019, it will take another six months to a year before the first results are reported. "Finding and imaging any Earth-like planets will take another five or six years, because of the very complicated science involved in it," Professor Cunningham says.

"The light from a star is at least one million times brighter, sometimes 10 million times brighter, than the light from a planet. We need to get rid of the star's light so we can see the planet. That's very difficult."

It's worth persevering with, however, because of the possibility of finding out if we're merely a speck of dust – a one-off anomaly, floating alone in the universe — or whether we're one of thousands or millions of planets teeming with life.

"We know there must be billions of planets. We don't know if solar systems like ours are common. But given the huge numbers of galaxies, solar systems and planets it would be surprising if there aren't other Earths out there."

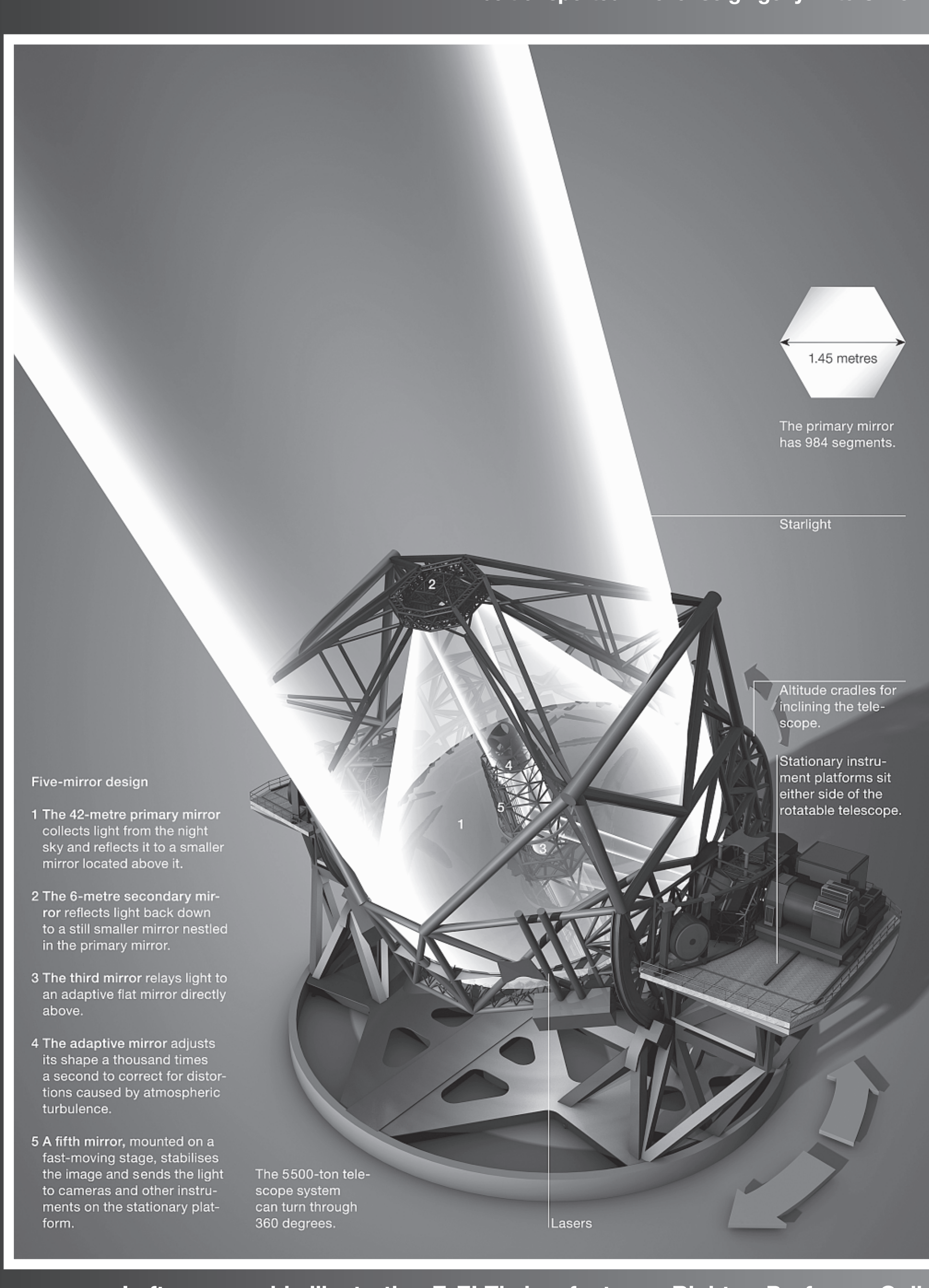
While finding a planet capable of supporting life is possible, finding one that actually contains life is unlikely in the extreme. The likelihood is any life will exist at the microbiological level. Even if a planet had been home to an intelligent species — as intelligent or even vastly more intelligent than us — the universe's 14 billion year age means the overwhelming probability is the life forms grew, thrived and died long before we dragged ourselves out of the swamps.

"Some of the light reaching us is 12 billion years old," Professor Cunningham says. "Any life forms looking at us from there would be seeing us as we were 12 billion years ago, and it would take at least that long to contact us."

However, the project's leaders do not need to actually find life elsewhere in the universe to add huge weight to the probability that it is out there.

"If we find another planet that is capable of supporting life out of the 400 or so that we can see, that means that — given the giant number of planets in the universe — there must be many planets where the conditions for life exist."

Of course, there is always that faint possibility that, while we don't know about them, they know about us. As the cartoon character Calvin from the long-running sketch Calvin and Hobbes once said, "Sometimes I think the surest sign that intelligent life exists elsewhere in the universe is that none of it has tried to contact us."



All images supplied by European Southern Observatory.

Left — a graphic illustrating E-ELT's key features. Right — Professor Colin Cunningham (l) receives a Fellowship from SPIE, the international society advancing light-based research, presented by SPIE President Ralph James (r).