

SETI on the SKA

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Astronomers have listened for signals from the planetary system around the red dwarf star Gliese 581, just 20.3 light years away, but heard nothing but terrestrial interference. Credit: ESO

Can the Square Kilometer Array - a network of thousands of radio antennas to be based in South Africa and Australia -- be used to hunt for extraterrestrial signals?

It was a vision of the [search for extraterrestrial intelligence](#) that was never meant to be. In 1971 [NASA](#)'s Ames Research Center, under the direction of two of SETI's great heavyweights – Hewlett–Packard's Barney Oliver and NASA's Chief of Life Sciences, John Billingham – sponsored a three-month workshop aimed at coordinating SETI on a large scale. While laying the groundwork of much of what was to follow for SETI in the subsequent decades, such as the existence of the 'water hole' between 1420 and 1666MHz, it also investigated what SETI could

do if money and resources were no option. By the end of the three months they had come up with Project Cyclops, which detailed plans for an immense array of radio dishes, up to a thousand in all, each dish 100-meters across with a total collecting area of up to 20 square kilometers. Cyclops would have been able to hear the faintest whisper, the quietest murmurings from ET, capable of picking up rogue leakage from their civilizations or being deafened by the blaring signal of a deliberate beacon.

Cyclops was never built of course; it was never intended to have been. Rather it was a thought experiment, a look at what was possible if SETI scientists had carte blanche to build whatever they wanted. Indeed, 100-meter dishes are just about the largest we can build before they become structurally unstable. They're also expensive, but crafty radio scientists have realized that linking many smaller and cheaper radio dishes together in a process known as interferometry can create a combined collecting area equal to or larger than those single dishes, and far more efficiently.

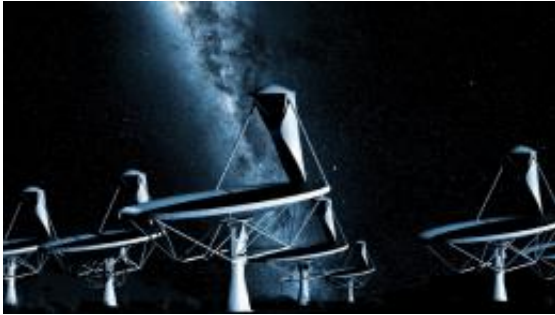
As such, today we stand on the cusp of a new era in radio astronomy, one that could give SETI the boost it needs to discover that we are not alone. In May 2012 it was announced that the Square Kilometer Array (SKA) – an ambitious network of thousands of [radio antennas](#) – would be based in both South Africa (in addition to neighboring countries) and Australia. Assuming funding is in place, construction on phase one is set to begin in 2016, phase two in 2019, with the whole venture to be complete by 2024. [South Africa](#) will get the majority of radio dishes, each one 15 meters across, designed for targeted observations, while Australia will have the low frequency antennas and mid-frequency phased array dishes for wider-field survey work. It's not quite on the scale of Project Cyclops but, overall, the size of the SKA is still enormous, with initial baselines (the widest distance between telescopes in the interferometer; the longer the baseline, the greater the angular

resolution) of hundreds of kilometers, with phase two expanding that to 3,000 kilometers. A veritable forest of radio antenna on two different continents, listening to the stars.

Whereas Cyclops was designed to be a SETI-dedicated array upon which other astronomical projects could piggyback, the SKA is the mirror image, an instrument primarily for seeking neutral hydrogen in the early Universe, for examining emission from pulsars and black holes and exploring cosmic magnetism. Yet the search for life and its origins has never been far from the SKA's priorities, with plans to probe the interiors of planet-forming dust discs around young stars to search for the building blocks of life in those planetary construction yards. There's also SETI and the possibility that the SKA could chance upon an artificial radio signal from another world. So would SETI experiments be welcome on the SKA, perhaps piggybacking at no extra cost on other astronomy experiments as SETI does on Arecibo?

That's an affirmative, confirms Dr. Michiel van Haarlam, the SKA's Interim Director General. "It's not been put to the test yet but it is definitely being considered," he says. "It's on our list of science cases so I think it will be there, in competition with all the other proposals out there."

So, what could SETI do on the SKA? Suffice to say, alien searches have rarely been attempted on very long baselines. More often than not SETI has been performed on single dishes and when interferometry has been utilized, such as on the Allen Telescope Array (ATA), it's rather localized with short baselines, but very long baseline interferometry (VLBI) is finding itself increasingly in vogue. How does SETI perform on telescopes of such size?



An artist's impression of the SKA's 15-meter dishes, staring up at the Milky Way. Credit: SPDO/TDP/DRAO/Swinburne Astronomy Productions

The bane of SETI is terrestrial interference from the likes of television and radio, cellphones, orbiting satellites and airport radar. With a long baseline array of so many telescopes across such a wide stretch of land, is it feasible to eradicate all interference? It turns out you don't need to, says Hayden Rampadarath of the International Center for Radio Astronomy in Perth, Australia. He led a SETI VLBI experiment to listen to the Gliese 581 system – a red dwarf with at least four orbiting terrestrial planets – using the three telescopes of the Australian Long Baseline Array. The report on the experiment, to be published in *The Astronomical Journal*, describes how, despite no extraterrestrial signals being received, the system did detect and successfully identify 222 narrow and broadband signals of terrestrial origin.

“Because of the large separations of the individual telescopes, hundreds to thousands of kilometers, the same radio frequency interference would usually only be seen by one or two telescopes and, as such, would not be correlated,” says Rampadarath. “However, sometimes this might not be true and interference that does correlate would instead experience a geometrical delay – and hence a phase delay – that arises due to the radio emission arriving earlier at some of the telescopes than at others.”

This phase delay could then be used to rule out any rogue emission – the point being that long baseline interferometry on the SKA need not worry about interference from terrestrial signals, therefore making the array an excellent tool for targeted SETI operations.

Whereas our interference is an obstacle for SETI, extraterrestrial radio interference may provide an opportunity. The SKA’s promotional literature has frequently talked about being able to eavesdrop on ET’s own terrestrial radio signals, neatly sidestepping the issue of whether ET would spend the resources on deliberately beaming a signal to us. Certainly our own rogue radio signals have been permeating space for almost a century, but they’re weak, dropping off with distance following the inverse square law; the SETI Institute’s Seth Shostak has previously pointed out that we couldn’t even detect our radio signals with our current equipment at the nearest star, Proxima Centauri, 4.2 light years away. What hope then do we have of detecting ET’s version of tacky reality television and soap operas?

It depends on whom we ask. “For phase one of the SKA, we can detect an airport radar at 50 to 60 light years,” says van Haarlam.

Professor Abraham Loeb, Chair of the Astronomy Department at Harvard University, goes even further. In 2006 he wrote a paper with his Harvard colleague Matias Zaldarriaga that was published in the *Journal of Cosmology and Astroparticle Physics*, describing how upcoming radio observatories such as the SKA could eavesdrop on radio broadcasts.

“Military radars in the form of ballistic missile early warning systems during the Cold War were the brightest,” he tells *Astrobiology Magazine*. “We showed that these are detectable with an SKA-type telescope out to a distance of hundreds of light years, although TV and radio broadcasting is much fainter and can be seen to shorter distances.”

It is undisputed that our over the horizon radar has powerfully leaked out into space. However, those early warning radars are in most cases, like the Berlin Wall, a relic of a past time, used for only a few decades before becoming obsolete. Today they have been mostly replaced by broadband radars that hop across frequencies, making them untraceable to extraterrestrials, a theme that's been latched onto in a paper published in *The International Journal of Astrobiology* by Dr. Duncan Forgan of the University of Edinburgh and Professor Bob Nichol of the Institute of Cosmology and Gravitation at the University of Portsmouth. They worry that, if extraterrestrial civilizations followed our technology curve, with the move over to digital broadband signals, they would have reduced their radio leakage and made their planets 'radio quiet', leaving a window of only about a century where we can eavesdrop on them.

“If we are able to improve our technology so that our signal does not leak out into the Galaxy and if we improve it on a certain timescale, then our estimates suggest that even if our Galaxy is well populated but with human-like intelligence that decides to drastically curb its signal leakage, then it becomes very difficult to detect them,” says Forgan. If that's the case, then the chance of the SKA's existence coinciding with one of those relatively short time windows of extraterrestrial leakage is going to be small.



A representation of the giant Cyclops array from NASA's 1971 SETI study.
Credit: NASA

It gets worse. Although Forgan accepts that radar will still be directed into space to probe potentially hazardous near-Earth asteroids, this use of radar is random and non-repeating, points out Dr. James Benford of Microwave Sciences, Inc. who, along with John Billingham, assessed our own civilization's visibility in a paper presented at the Royal Society's 'Towards a Scientific and Social Agenda on Extraterrestrial Life' discussion meeting in October 2010. They calculated that a transmission deliberately beamed into space by the 70-meter Evpatoria radio antenna in the Crimea, far more powerful than our TV and radio leakage, would only be detectable as a coherent message by a SKA-sized receiver out to 19 light years, and as a raw burst of energy containing no information out to 648 light years.

Worse still, they argue that Loeb's calculations for our TV and radio leakage being detectable out to 75 light years – calculations that are based on very long integration times on the order of months – are not feasible because radio stations will rotate over the limb of a planet, preventing locking onto the signal for a prolonged period of time to facilitate detection (Benford levels the same criticism at van Haarlam's estimate of detecting airport radar out to 50 light years).

Furthermore, in response to Seth Shostak's claim that a receiver the size of Chicago could detect our radio leakage out to hundreds of light years, Benford and Billingham respond by pointing out that such an antenna, with a total collecting area of 24,800 square kilometers, would cost \$60 trillion, of similar order of magnitude to the planet's entire GNP (for comparison, the SKA is projected to cost around \$1.5 billion). If ET is going to hear us, they're going to have resources far in advance of our

own, meaning that our own efforts to eavesdrop with the SKA are going to be futile.



An artist's impression of the SKA's low frequency antennas that will be located in Australia. Credit: SPDO/TDP/DRAO/Swinburne Astronomy Productions

The picture painted by Forgan and Nichol, Benford and Billingham is pretty bleak for eavesdropping with the SKA. However, Loeb counters, “The periodicity due to rotation of a planet is a big plus that can help in identifying the artificial nature of the signal.” He adds, “In addition to planetary rotation, one could search for periodicity due to the orbit of the planet around its star.”

Benford isn't convinced by Loeb's arguments. “Absence of signal [as the planet rotates] means absence of detection time and the signal-to-noise ratio is reduced,” he says.

However, we've been assuming that our aliens are planet-bound. Suppose they have spaceflight. That could change things quite a bit. Radio communication between satellites, space stations and spacecraft would not be subject to planetary rotation. Duncan Forgan admits that he hasn't factored spaceflight or interplanetary colonization into his vision of a radio quiet Universe, but cautions, “It's unclear exactly how much radio

traffic would result from a civilization that has multiple planets around multiple stars.” There are other methods of communicating, he says, such as lasers or even ephemeral neutrino beams. On the other hand, notes Jim Benford, a planet-faring civilization may use microwave beaming to power their spacecraft, dramatically increasing their leakage signature.

Ultimately, whichever side of the debate you fall on, there are a lot of unknowns and assumptions built into each argument that renders neither of them entirely persuasive. Maybe the SKA won’t be able to eavesdrop on ET, but there’s certainly no harm in trying. If it fails, there is always more traditional SETI to fall back on, namely the search for deliberate beacons.

Benford imagines the existence of transient beacons, designed to be cost efficient, flashing our way only once in a given timeframe. These, he says, look a lot like pulsars, something that the SKA is primed to search for; perhaps a transient beacon will manifest itself in one of the SKA’s pulsar sweeps? It’s the potential for this kind of serendipitous discovery that could make the SKA such a powerful tool for SETI, as long as the manpower and resources are there to search through all the raw data that the SKA will produce. Certainly, there will be lots of it: in order to process all the data covering millions of one hertz wide narrowband channels, exaflop computers that are capable of performing on the order of a million trillion operations per second will be required. There’s only one problem: such powerful computers have not been invented yet, but Moore’s Law and recent advances in computing tell us that they are on their way and will be ready by the time the SKA is online.

Jim Benford suggests making things even simpler. Searching for transient beacons is going to require a lot of watching and waiting, staring unblinkingly in the hope of catching the brief burst of a transient signal in the act – something like the mysterious ‘Wow!’ signal, perhaps.

According to Benford, a small array of radio dishes, each tasked with observing a particular patch of sky non-stop, would do the trick. There's no need to use the entirety of the SKA, he says; the small array of dishes that form ASKAP, [Australia's](#) SKA Prototype, would be sufficient and far more efficient at a fraction of the cost of using the entire SKA.

Regardless of the SKA's true ability to detect extraterrestrial leakage, it is still vastly superior to anything we have conducting SETI right now, including the Allen Telescope Array that has struggled for funding. What the SKA does prove is that, even if the ATA shuts down, it's not the end of SETI itself. "Radio SETI is going to get a real boost because we have fantastic telescopes coming like the SKA that are game-changers for radio astronomy," says Forgan. "It's a very exciting time."

And there's certainly no harm in looking, just in case. "The nature of SETI research is exploration," says Loeb. "We should act as explorers and make minimal educated guesses, simply because extraterrestrials might be very different from us and our experience might not be a useful guide."

On the other hand, if they are like us and do have leakage that is predominantly from military radar, then we might want to steer clear, warns Loeb. "The conclusion I would draw is that militant civilizations are likely to be visible at greater distances than peaceful ones, and we should be very careful before replying to any detected signal."

But that's a debate for another time.

Source: [Astrobio.net](#)

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