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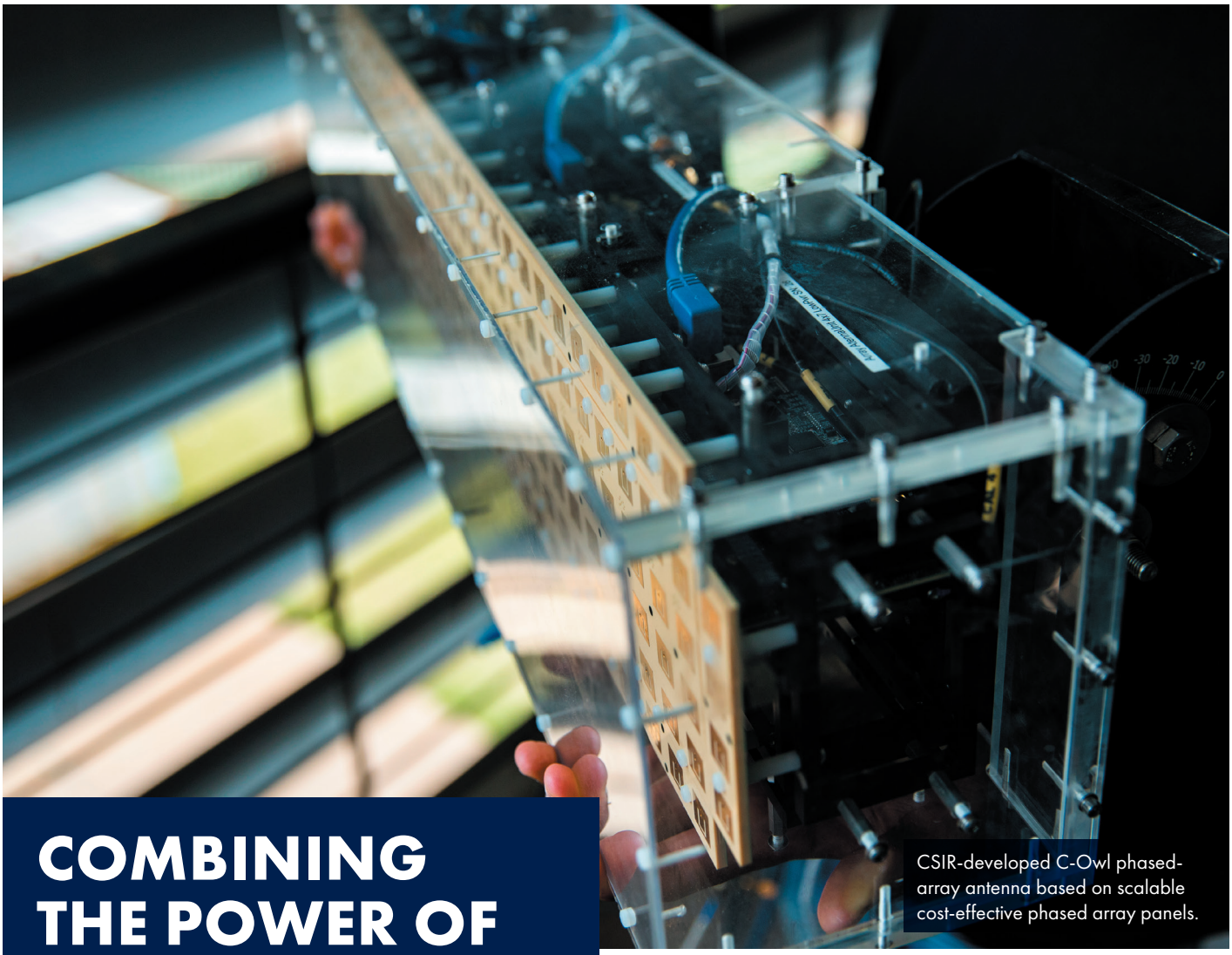


CSIR-developed C-Owl phased-array antenna based on scalable cost-effective phased array panels.

# COMBINING THE POWER OF ALL-WEATHER DAY-AND-NIGHT RADAR WITH THE SAFETY AND GO-ANYWHERE BENEFIT OF UAVS

## Synthetic aperture radar for unmanned aerial vehicles

*Addressing a problem and fulfilling a market demand*

### Detecting from a distance and acting in time

In the military and security domains, unmanned aerial vehicles (UAVs) and their applications have become the tool of choice to observe, decide and act – with the benefit of keeping operators out of harm's way. Able to carry everything from parcels, sensors, weapons and even lifesaving medicine, commercial and security markets for UAVs have grown significantly. From small drones used to inspect farm borders, to large fixed-wing UAVs that hover for days on end, these drones are providing valuable surveillance outputs to end users in various markets.

In many security and military applications, surveillance is required day and night, in all weather, over wide areas, and it must be able to detect fine changes that might have remained after an event of interest occurred. Synthetic aperture radar (SAR) sensors solve this challenge by imaging at wavelengths that penetrate cloud, fog, smoke and even foliage, making the activities of enemy forces deemed unseen, very clearly detected.

In many developed countries, long-endurance UAVs that carry SAR payloads have therefore become a de facto requirement for missions in

peace support, border control and maritime surveillance. The SAR sensor allows imaging over wide swaths from a standoff location – not alerting the perpetrator and allowing a prompt action or response.

*The technology on offer*

## C-band SAR payload family for UAVs

The CSIR is developing a family of SAR sensors to enable UAVs of different classes access to real-time, fine-resolution imagery. Ranging in size from 7 kg to 70 kg, and aimed at the low-, medium- and high-altitude UAV markets, these sensors are based on CSIR C-band (5.5 GHz) phased-array technology and – coupled with advanced ground-moving target indication modes – can provide day-and-night all-weather imaging, real-time processing and targeting.

The technology for the medium-altitude UAV was chosen as the starting point, given the significant number of medium-altitude long-endurance UAVs under development in South Africa and around the world.

The CSIR approach was to develop the sensor to be installed together with current optical payloads, to exploit the strengths of both by the same UAV.

The C-Owl demonstrator for UAVs has shown the ability to perform real-time high-resolution wide-swath SAR imaging as well as perform ground-moving target indication, with all information presented in real-time on a GIS map display, georeferenced to allow near real-time decision-making.

This payload technology enables imaging at resolutions as fine as 25 cm pixel size, with swaths up to 50 km for high-altitude long-endurance UAVs and with standard graphics processing unit-based real-time processing using modern back-projection techniques that enable imaging in VideoSAR modes, even in arbitrary flight paths.

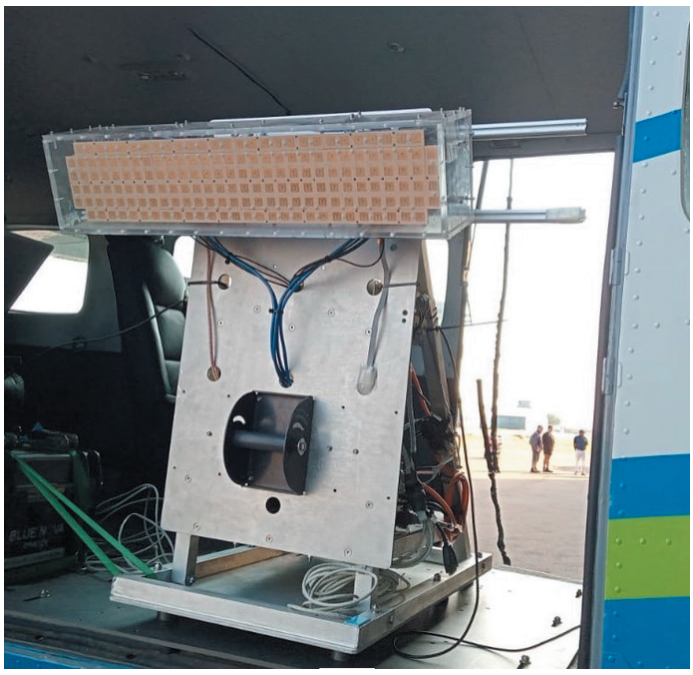
Designs for the smaller and larger class of UAVs have also been completed and the 7 kg class system is under development.

Coupled with the significant capability in imaging radar system design, development, integration and test capability, the opportunity exists to now adopt the technology from the airborne flight tests to the UAV market, to achieve even greater impact and generate economic benefit in the process.

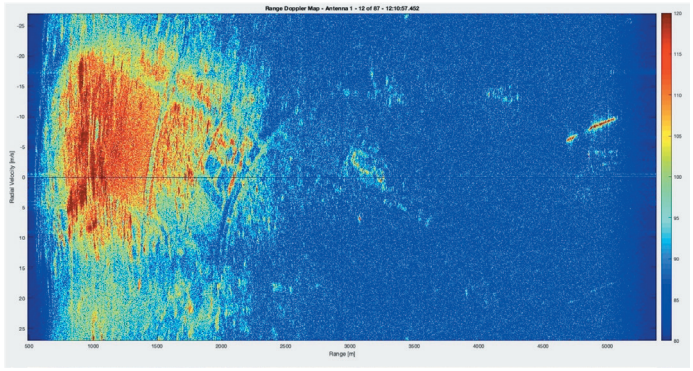
*Value proposition and competitive advantage*

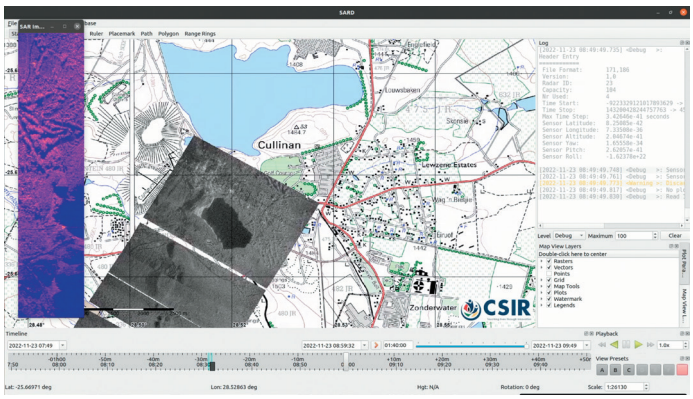
## Entering the UAV SAR market with the CSIR as partner

SAR sensors for UAVs can broadly be categorised into those designed as a replacement for the optical gimbal and those carried as a belly-mounted or under-wing pod. Removing the gimbal reduces the ability of the platform to collect evidence and investigate targets at ultrafine resolution from up close. Naturally, a solution that allows the optical gimbal to remain in



The CSIR C-Owl UAV synthetic aperture radar demonstrator installed on a Cessna 208 for flight tests.






Above and middle: Doppler map and real-time synthetic aperture displays captured during flight tests.

place will enable the UAV to achieve a greater spectrum of objectives. However, adding pod-based solutions often impact performance, due to the available size for antennas and processing in the pod.

The CSIR has developed customisable phased-array antenna designs which allow in-skin on-fuselage mounting of the antenna components, with processing and other components mounted inside the UAV electronics bay. This allows the addition of the SAR payload without adding significant extra drag and without affecting the optical gimbal operation.

As such, the CSIR's SAR technology base allows another entry point into the UAV market and addresses a gap for bespoke antenna solutions that do not require complete redevelopment for every UAV, but that can be adapted to fit a particular UAV's needs. Processing backends range from low-mass payloads with dual channel ground moving target indication to larger virtual path cross-connect options with up to eight channels of digital beamforming being available.

The flexibility allows customers the ability to choose the approach that fits their platform the best.

*Market opportunity*

## The UAV SAR market

According to a research report published by *Spherical Insights and Consulting*, the global SAR market size was valued at USD3.8 billion in 2022 and the worldwide SAR market size is expected to reach USD10.7 billion by 2032.

In South Africa and Africa specifically, UAV platforms are growing in applications and several small, medium and large platform providers are developing new platforms for niche applications. All of these platforms require SAR sensors for specific military and security missions and given that many of the foreign-supplied systems come with export restrictions, the CSIR sensor family is uniquely positioned to access this market.

*Investment and return on investment*

## Radar for medium-altitude long-endurance UAVs close to industrialisation

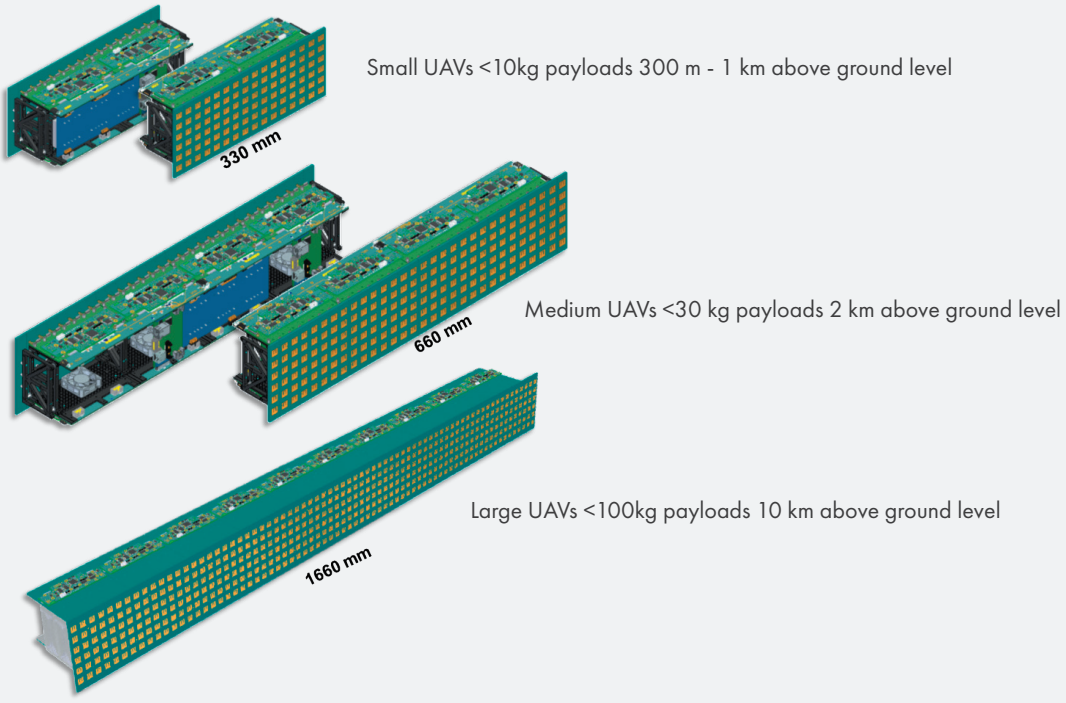
With the C-Owl demonstrator already developed, the CSIR technology for UAV SAR for medium-altitude, long-endurance UAVs and airborne platforms is very close to industrialisation. All elements, including ground stations and real-time processors, have been developed and tested in relevant environments, and the integrated sensor has been flight-tested. The next step is to produce the product baseline versions of the hardware and software.

For the high-altitude, long-endurance UAV market, an estimate of R40-50 million is set to produce the first products, ready to test and scale for production.

The low-mass 7 kg sensor will likely require a similar investment to complete the design, test and evaluation phase, while the high-altitude long-endurance UAV version with its more advanced modes of operation and much longer ranges, requires an investment of R80-100 million to achieve a product baseline.

The CSIR's technology catalogue for this opportunity offers flexibility and scope to pursue several commercialisation pathways and business models, ranging from partnering with industry on specific sensor payload segments, to the possible establishment, incubation and acceleration of a start-up to

### CSIR-developed lego-like building block C-band array technology




Scalable C-band array technology enables custom SAR payloads for small, medium and large unmanned aerial vehicles.

commercialise a specific payload product range. For example, where a SAR payload start-up is established using the CSIR technology base through licensing and specialising in the marketing, sale, installation and support of a family of SAR sensors in the small, medium and large UAV market, there may be potential to rapidly achieve annual sales in the order of R150 million that could generate profit of over R50 million per year, within five years from start-up of commercial operations, on a conservative base case of production, pricing and market uptake, with the scope to realise decent returns.

## Milestones and timelines

Development of the first payloads of the small and medium class will take approximately 18 months. The development of the payloads for high-altitude long-endurance requires an added step to produce higher-power amplifiers based on the design already performed for a surveillance radar product at the CSIR and will require a timeline of approximately two years to achieve the first product baseline.

## A seasoned team of radar and sensor experts

The SAR team is a diverse group of CSIR engineers with experience in radar, imaging radar, signal processing, radio frequency design, digital design, mechanical design, phased-array antenna design and more. The CSIR has access to specialised facilities such as radio frequency anechoic chambers and high frequency (up to 40 GHz) measurement facilities. The team has several years of experience in flight testing SAR systems and also has access to several experimental SAR systems which can be used for further development.

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View from the aircraft while flight-testing the CSIR C-band synthetic aperture radar airborne test facility.