How robots saved Britain's postwar photograph archive

By Tim Robey, Lucy Scholes, Chris Harvey, Simon Usborne, Charlie Metcalfe, Gabrielle Schwarz, Telegraph Culture Desk · The Telegraph · 9 min

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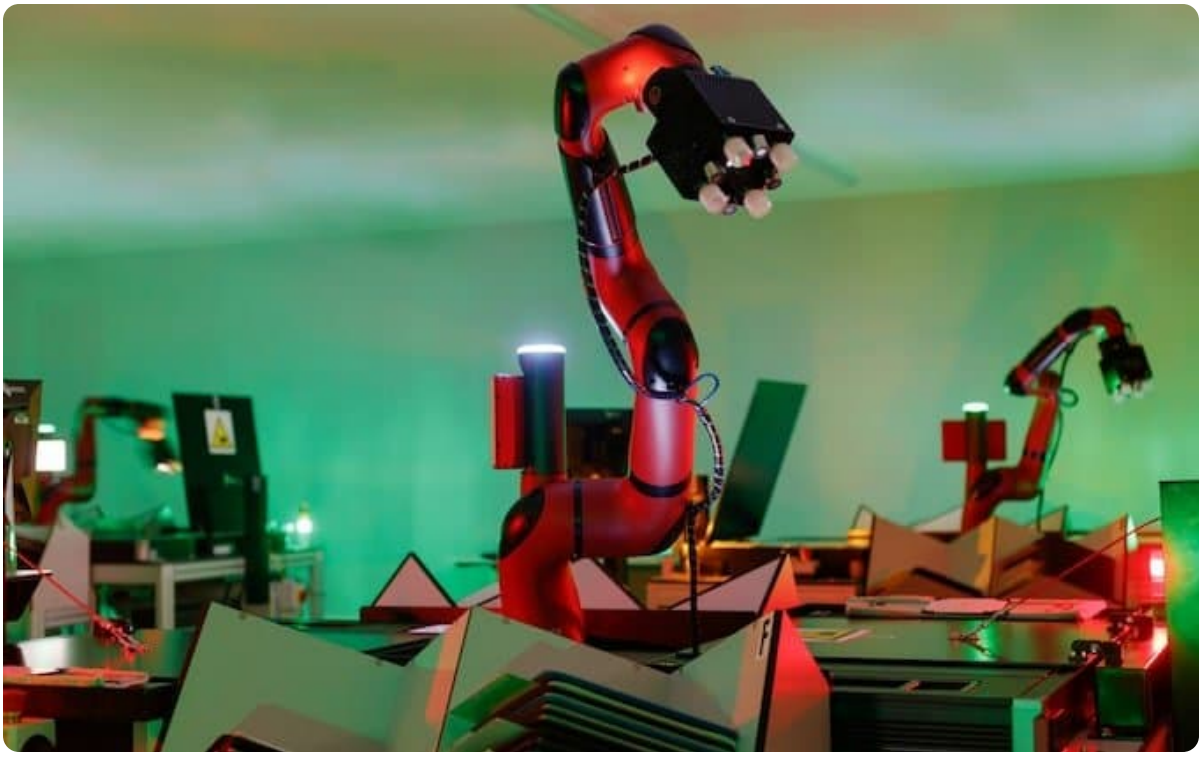


In a warehouse on one of Edinburgh's suburban industrial estates, I'm watching seven robots hard at work scanning a colossal archive of printed photographs. It's a Friday morning, and several women

sit at desks around the whitewashed room – alongside their large robotic colleagues – checking digital copies of the greyscale photographs as they appear on their screens. Each image represents a patch of postwar Commonwealth land as seen from the sky. In some, roads and rivers wind among tiny white buildings. In others, only the vast grey sweep of empty fields appears. The persistent hum of machinery fills the room.

The National Collection of Aerial Photography (NCAP), to which the archive belongs, commissioned the adaptation of the robots for this specific task. The archive, which contains aerial images of almost every square mile of the postwar Commonwealth, is made up of about 1.5 million photographs. These have a rich back story of their own: they were taken between the 1940s and 1980s as part of an extensive map-making project overseen by the British Directorate of Colonial Surveys (later the Directorate of Overseas Surveys, and DOS here) following the Second World War, eventually forgotten about, nearly destroyed, and then rediscovered – on which more later.

The oldest of the photographs predate even the first Landsat satellite images by more than 25 years, and they show the world's earliest extensive aerial view of our planet, and of a vastly different world that will soon pass out of living memory. The collection is a goldmine, but it would take someone a lifetime to scan by hand, the traditional method of digitisation. Enter the team of 'collaborative robots', or 'cobots', which can process almost 10,000 images a day – without needing to take a loo break.

Boxes upon boxes containing prints to be scanned

Dr Allan Williams, head of NCAP, walks me over to one of the robot-led systems. We watch as a 12kg automatic lid on a scanner opens, sending a signal to the black-and-red robot arm that it's ready for operation. The robot's optical sensor then assesses whether its jointed arm is directed at a photograph, or one of the interspersed weights preventing the prints from curling. When it recognises the dark colour of a weight, the arm picks it out of its hopper and places it in an adjacent 'complete' hopper. When it recognises the lighter colour of a print, it activates its vacuum nozzles to place it on the scanner's glass bed.

A rudimentary rope and pulley set-up then closes the lid, sending a signal to the system to start scanning. This takes about 45 seconds, during which time the robot operates a second scanner. Once each scan is complete, the robotic arm places the print in the 'complete' hopper and restarts the process. When a stack of around 500 prints

is complete, one of the women lifts it out of the hopper, places it in a drawer, and marks its barcode as ‘scanned’. This robot-human team will repeat the process until, some time in May or June, the entire archive is in digital format.

The archive itself is the product of advanced technological progress, albeit now out of date. At the end of the Second World War, much of the British Commonwealth remained uncharted. As a means of developing and managing it, the government embarked upon the extensive task of mapping the then Commonwealth and Empire (apart from Australia, New Zealand and Canada).

After its creation in 1946, the DOS set up a headquarters in Tolworth, Surrey, and hired hundreds of Britons to staff it. It also sent many young men abroad with the task of surveying the land – but advanced map-making methods, which Britain had pioneered during the war, required high-quality aerial images of the ground. So the DOS requisitioned a fleet of old Royal Air Force warplanes and their crews for the job, replacing armaments with cameras. These aircraft flew circles around radar beacons on the ground, taking photographs as they went. Meanwhile, ground-based survey teams took measurements using theodolites.

Vacuum nozzles allow the robot arms to lift prints and place them on a scanner Credit: Robert Ormerod

In total, the DOS surveyed 55 countries, from the Caribbean to Australasia. It continued updating the maps well into the 1980s too, when the DOS merged with Ordnance Survey, and replaced the RAF with commercial companies after its results proved apparently inconsistent. No other country had performed an operation on such a scale. Only decades after the DOS's work began would satellite images reveal earth's surface from the sky at such a resolution again.

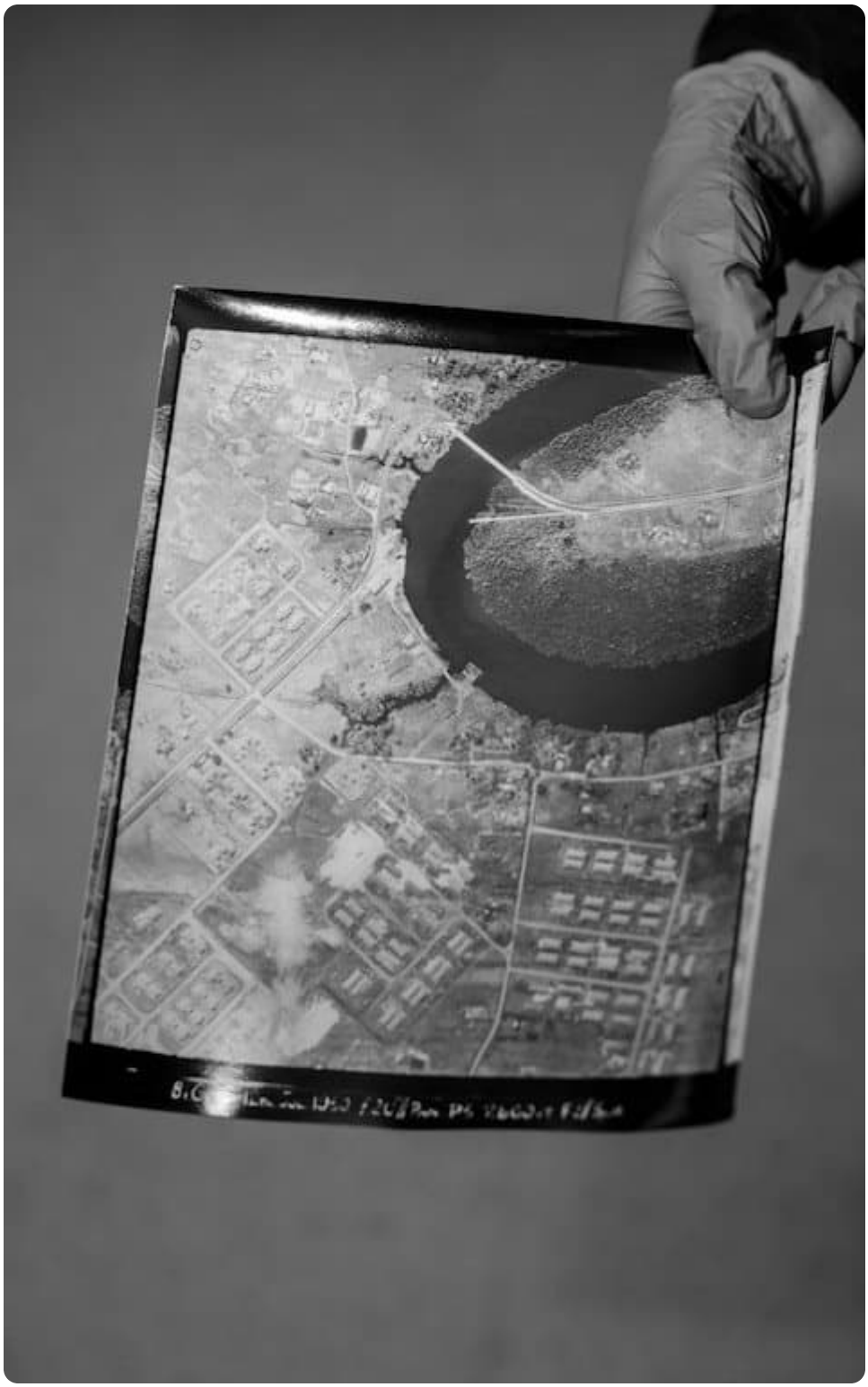
A 1969 government film about the project, called Framework for the Future, tells of a colonial approach that has long since passed out of fashion. 'Survey teams set out over country without road, to bring it under an order, to give it shape, and for the men who come later, a meaning,' the narrator reads. 'For these people, a charted world will offer opportunities they've never had before: a chance to understand and use the land they live on.'

Once the DOS had created its revolutionary aerial photographs, it filed them and related documents into 15,201 cardboard boxes (with 94 photos on average in each) at its Tolworth HQ. Malaysia alone accounted for 1,741 boxes. Kenya, Tanzania, and Zambia accounted for at least 1,000 each. Despite the photographs' inherent value, they had provided a means to a specific end: the maps. The images themselves quickly became forgotten.

In the early 2000s, the British Empire & Commonwealth Museum acquired the archive. It was held, according to one source, in the damp of Bristol Temple Meads station for some time, where mould crept in. After the museum announced its closure, the archive was almost destroyed.

But the ‘Doomsday Book of the Commonwealth’, as some call it, was saved at the last minute. Allan Williams at NCAP discovered it by chance while visiting the British Empire & Commonwealth Museum’s website for a book project. He arranged for NCAP to acquire it in 2012 and add it to its own collection, free of charge, as it still belongs to the Government. But again the collection faded into obscurity: it remained in storage, uncatalogued, where it was seldom used. According to Williams, fewer than 10 people were accessing it each year. ‘Here we had this dataset that recorded, systematically, the change over a large proportion of the earth’s surface over a long period of time, and yet it was essentially locked away in an archive unused,’ he says.

The archive’s salvation arrived in the form of an assistant professor in Stockholm University’s economics department. Anna Tompsett had heard about it, and recognised its huge potential as a unique resource to measure terrestrial change since the 1940s. So began a determined effort to digitise the images, led by Tompsett and Williams. Eventually, in 2017, in collaboration with the University of California, Berkeley, they won a £750,000 grant from the Bank of Sweden Tercentenary Foundation to digitise the collection – but they still had few ideas about how to proceed.



An original print, yet to be digitised

This problem was transferred to Alan Potts, NCAP's digital imaging manager. After some basic estimations (including one that involved the possibility of hiring 18 employees to work seven-hour shifts using 42 scanners, an inefficient, time-consuming process in which, once their salaries were accounted for, the grant wouldn't have stretched to cover equipment), Potts realised that they would need to find an innovative way to digitise the archive within the five-year time limit imposed by the terms of the grant.

That was when the idea of robots emerged. In early 2019, Potts and Williams chose a company near Leeds that promised to automate the scanning process. The company, called CBM-Logix, is referred to in the robotics industry as an 'integrator' – a company that takes off-the-shelf robots and adapts them with the necessary parts and software to complete a specialised task. In this case, its systems would digitise the DOS archive.

CBM-Logix developed the vacuum and magnet modules, and programmed the software, while Potts hired an assistant with extensive photographic experience, Sheila Masson. After a delay during the pandemic, Masson developed a 'workflow' for the prototype system, and tested it on The Gambia collection. With the process configured, albeit with some problems, Potts ordered five robotic systems from CBM-Logix. Together with workbench platforms (£20,000 per piece), each complete system cost £85,000.

The five new systems arrived in August 2021 and Potts hired six assistants, making Masson team leader. Scanning began, and the team started digitising the archive country by country, ordering relevant boxes from an off-site storage facility. NCAP had to deliver 1.2 million images by the end of 2022, according to the terms of the

grant. To achieve this, the team initially hoped to leave the systems running overnight. Problems, though, including mis-picks and software crashes, would often occur within an hour of staff leaving.

The team tinkered with the robots until they ran through to 9pm. Then a bit longer. In February 2022, one processed prints through the night without stopping. By the next week, several had done the same. When NCAP acquired another two robots in the summer, Masson and her assistants had them all running through the night. Once optimised, each robot could scan 54 images per hour (about 9,000 between them every day). On 22 December, nine days before the deadline, NCAP reached the project's 1.2-million-image milestone.

'It's a vast, vast amount of digitisation,' Williams says. 'We show colleagues, especially those who work with aerial photography from archives around the world. They are dumbfounded by what we've done.'

DOS collection assistant Nic Ruecroft works alongside a robot colleague Credit: Robert Ormerod

Despite the extent of NCAP's work maintaining reams of Ministry of Defence photography, the organisation receives no public funding towards operational or development costs. It must make its own money. Much of this comes from work with bomb-disposal units in Germany, which use historic reconnaissance images to locate unexploded ordnance. The digitised DOS collection will now contribute too, as each image will become available for a £30 licensing fee on the NCAP website. A subscription will provide access to an enhanced 'geo-portal', due to become active next year.

Meanwhile, a team of 10 scientists from Stockholm University and the University of California, Berkeley, are collaborating to analyse the images. The first step in this process is to combine the individual frames into larger images called 'mosaics'. Anna Tompsett, the Stockholm University researcher, says this is somewhat like arranging the pieces of a jigsaw puzzle. The DOS once did this manually, laying the physical prints out on a hangar floor. Today, it's a much faster process. The team at Berkeley developed special software that arranges the photographs automatically based on visual clues. Some manual tweaking is still required, though.

'Sometimes the algorithm goes wild and tries to connect images that just don't belong together,' Tompsett says. The team then removes any light imbalances before adding 'geo-references' for each image, which link them with specific locations on earth using modern satellite images.

These mosaics will become available for free under a Creative Commons licence through an online platform separate to that of

NCAP. The aim is to enable as much access to the archive as possible, Tompsett says, so people will be able to use it in a similar way to Google Earth.

Tompsett's team will extract further information using another specialised computer programme, which identifies specific patterns and textures on the black-and-white images to infer, for example, forest cover and agricultural land use. They can even begin to make leaps of theoretical faith by deducting population density and wealth.

'This is a giant knowledge gap,' she says. 'We just don't have data on these kinds of outcomes, going this far back in time.' Tompsett hopes the team will have finished its first academic paper by spring, although the entire archive will require years of work.

The final boxes of prints will be scanned in the coming months, bringing an unprecedented project to an end

These papers and the free online platform will, once active, provide scientists across the world with a unique and invaluable resource. The digital archive will enable analyses of deforestation, agricultural erosion, sea-level rise, desertification and urban sprawl. Environmental historians, geomorphologists, climatologists, archaeologists and many more will benefit as a result.

One of those scientists will be Solomon Hsiang, director of Berkeley's Global Policy Laboratory and a collaborator on the project, who studies climate change. Future-gazing, he says, requires information from the past. But that information is often unreliable.

'We sometimes forget that there are parts of the world that we know almost nothing about,' he tells me. 'So this [archive] is amazing. It's the one time we get to look in detail at everything that was happening in these parts of the world – very, very little was being recorded. It's a massive treasure trove of information, and the idea of being able to put it in a place where everyone can access it, and it can't be destroyed, is really exciting.'