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University of Oxford

Satellite Journalism – The Big Picture

Newsgathering applications of emerging satellite technology

by Mark Corcoran

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Acknowledgments

Journalism and Space are two very different fields undergoing enormous change at a rate that is difficult to quantify and analyse. I feel extraordinarily privileged that the ABC and Reuters Institute for the Study of Journalism, Oxford University gave me both the time and the place to grapple with the issues.

In an era of media upheaval and cutbacks, I am indebted to the ABC for its continued commitment to serious journalism and for the opportunity to analyse an emerging news-gathering capability. It was with some trepidation that I set off in the footsteps of a highly distinguished list of ABC colleagues, who have been heading to Oxford for more three decades, under a scholarship scheme that now bears the name of former ABC Chairman, Donald McDonald.

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Finally, I owe an enormous debt of gratitude to my family for encouraging me to embark on a project involving yet another extended absence, led by my fellow traveller in life and work, Helen Vatsikopoulos, an accomplished international journalist and journalism academic and a passionate advocate of our fast-changing craft.

Contents

Introduction

A billionaire dispatches a sports car towards Mars - to the strains of David Bowie's Space Oddity…a New Zealand rocket company launches a giant disco ball into low Earth orbit, spinning shards of reflected sunlight across the night sky…a Japanese start-up promises artificial shooting stars – on demand - for birthdays, parties, anything. The disrupters have arrived, and space may never be the same again (Malkin, 2018, Amos, 2018, AstroLiveExperiences, 2018).

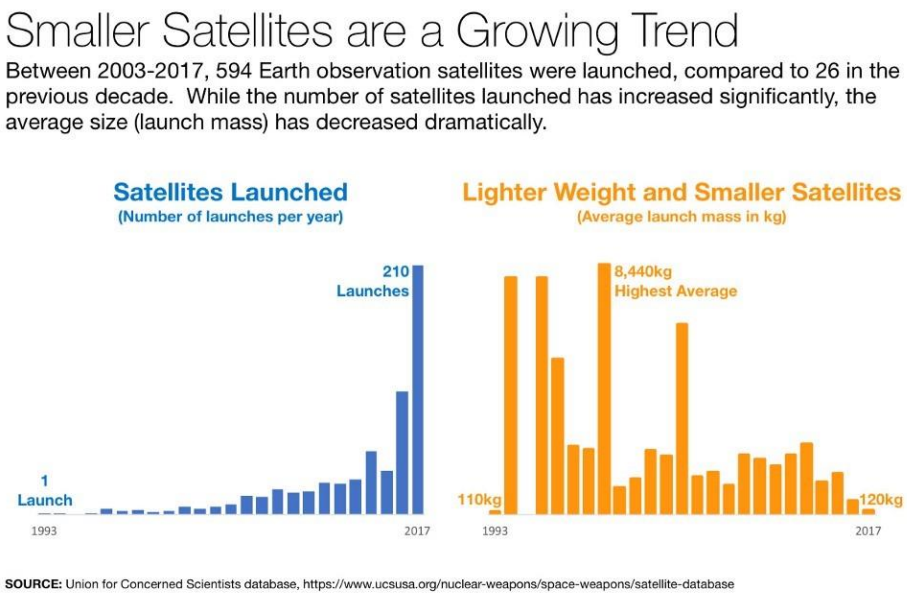
'The New Space Race', 'Space 2.0'; there are many labels for what is now occurring as a new generation of Silicon Valley-inspired tech disrupters challenge the long-established order of the space industry.

And at the heart of this space reboot is a revolution in satellites. Nearly 500 satellites and other space objects were sent into Earth orbit or beyond in 2017, nearly doubling the number launched in 2016 (UN, 2018).

Conventional satellites, the size of a bus, and costing up to half a billion US dollars, can take a decade to design, build and launch. By contrast, the disrupters offer an alternative to this enormously costly, complex capability - with cheaper, mass produced units the size of a shoebox. The trade-off – these new smaller satellites do not have the same capabilities of the larger ones.

There is extraordinary diversity in technical and business innovation being applied. The small-sat revolution is being fuelled by miniaturised componentry from smart phones, combined with advanced analytics, cloud computing, machine learning; all enthusiastically bankrolled by venture and private capital.

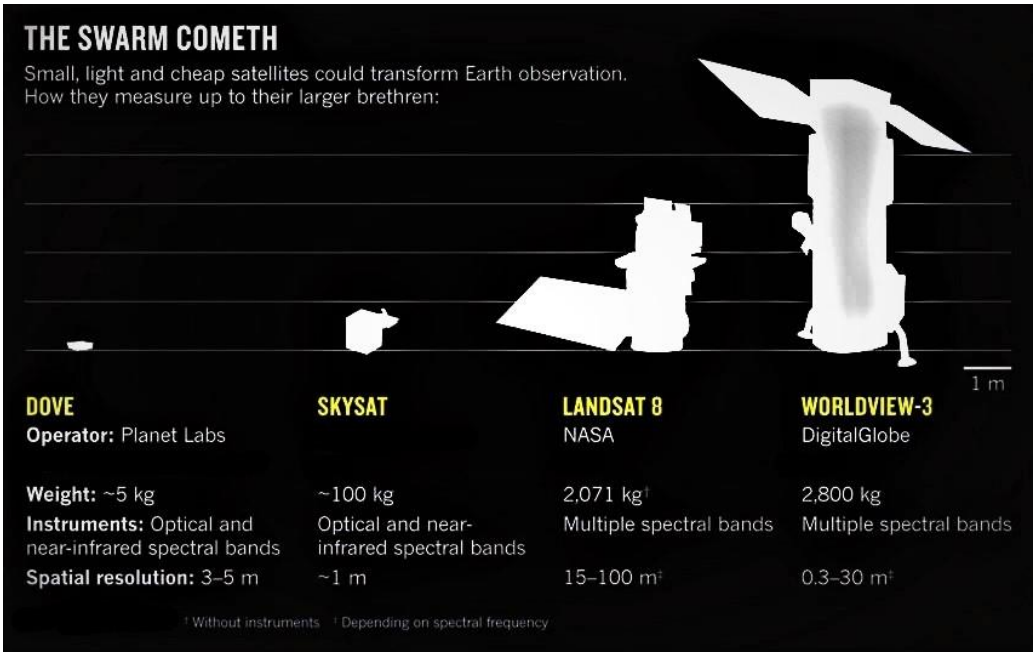
In response, the 'Big Space' corporations are rapidly adopting the can-do Silicon Valley mentality of the upstarts (Corcoran, 2017). Billionaire entrepreneur Elon Musk, whose SpaceX corporation pioneered the low cost commercial rocket business, has already launched the first test craft of what will ultimately be a 12,000-satellite space-based internet network (Scholes, 2017). To put this into perspective, in 2017 there were just 1,738 active satellites in orbit for the entire world, for all operators, in all countries (Grego, 2018).



(Infographic – courtesy Anne Hale Miglarese Radiant.Earth)

A key sector of this commercial satellite revolution is remote sensing, or Earth Observation (EO) – the business of watching us – with satellites imaging, measuring, even bouncing radar signals off the ever-changing visual patterns of life on Earth.

And there are dozens of EO applications including; scientific research, environmental protection, weather forecasting, precision crop monitoring, urban planning, forestry, human rights investigations, telecommunications, disaster relief co-ordination, maritime safety, business intelligence and of course military intelligence. By 2018 more than 30 corporations were either operating or planning to launch EO satellite networks (Erwin, 2018a).



(Image – Nature, international weekly journal of science)

The leviathan of the commercial EO industry is Colorado-based DigitalGlobe, with a fleet of five large, complex satellites, offering unprecedented 30cm resolution close-ups (Denis et al., 2017). Importantly, the satellites can 'see' and object that size or larger, and can locate that object's true position on Earth to within a few metres.

At the other end of the scale are the disrupters, with their constellations of small, cheap, mass-produced satellites that lack the capability of Big Space to zoom into a target. They specialise in the big picture, taking lower resolution images; observing crop changes, deforestation, natural disasters, or large man-made events such as the construction of refugee camps, or the destruction of cities.

Leading the disrupter pack in 2018 is California-based entity Planet Labs, operator of the world's largest constellation of about 200 EO satellites, most of them, shoebox sized 'Doves'. In November 2017 Planet announced that the Doves 'Mission 1' was complete: the ability to image the entire land mass of Earth – every day – at a resolution of 3-5 metres.

Mission 1 effectively started the clock on what Planet calls its visual "time machine". A rapidly growing database, pulling down more than 7 terabytes of data, 1.4 million images daily, giving customers a glimpse into the recently archived past - a snapshot of what happened, on any nominated day, at any land point on Earth.

Does size matter?

Big Space: DigitalGlobe's state-of-the-art Worldview-4, capable of 30cm resolution imagery, undergoes prelaunch checks, prior to launch in 2016 (Image -Lockheed Martin)

The Disrupter: Planet Labs co-founder and CEO Will Marshall holds a 'Dove'. Part of a constellation that now images the entire land mass of the planet daily, at 3-5m resolution (Image - The Times, UK)

So, what's in it for the media?

Journalists have been quick to exploit these new opportunities to cover events where it may be too difficult, dangerous or costly to put reporting teams on the ground. Media access to satellite company images data bases has resulted, in some cases, journalists gaining a near real-time reporting source for breaking stories.

Satellite imagery has already provided ‘smoking-gun’ evidence for award-winning investigative reporting of human rights abuses (Htusan et al., 2015). Digital, TV and print all carry growing numbers of satellite imagery-led exposes of environmental destruction in remote locations such as the Amazon (Weir, 2017), before and after imagery of natural disasters (Murphy, 2018), analyses of military build-ups such as China’s construction of artificial islands in the South China Sea (Wu et al., 2018), missile launches and nuclear testing in North Korea (Fifield and Taylor, 2018).

Satellite imagery has also become a compelling centrepiece for visual storytelling, the key element anchoring multi-media reports.

The emerging specialisation of data journalism also increasingly relies on satellite imagery as an important tool in verifying information and social media imagery collated on the ground (Bellingcat, 2018b).

For less time-critical stories, there is also a growing torrent of far lower resolution imagery (at 10-30 metres) coming from more established sources such as NASA, the European Space Agency, the US Geological Survey. Google, a variety of satellite-focussed non-profit groups, and journalism educators are now helping reporters make sense of it all, running workshops on the skills required to interpret, analyse and visually decode what can be a deceptively complex specialty.

Foreign correspondents and the production teams of the TV networks already have extensive expertise in satellite technology, but this capability has been about sending stories from the field and ‘live crosses’; answering the questions of the studio anchors back at headquarters. The march of technology has resulted in the capabilities of field satellite trucks being shrunk into laptop size units. Now, the option of using satellites to capture imagery from space, and not just re-transmit events recorded on the ground, opens up a whole new world of possibilities.

Planet and the other upstarts are intent on disrupting the very-high-resolution market of DigitalGlobe (Erwin, 2018b). As the two groups intensify their competition for paying customers and profitability, journalism is a beneficiary.

Planet and DigitalGlobe dominate the media imagery market, which has grown significantly during the past 3 years, largely because they give their imagery away to media for free, with some exceptions, in return for high-profile attribution.

Satellite companies proclaim these arrangements are part of a broader social contract, promoting ‘radical transparency’ and ‘democratisation of technology’ – nonetheless they also acknowledge such deals are marketing gold – prominent free ‘product placement’ to support their strategies to attract more user-pays clients in other industries.

And the most lucrative paying customer of all is still the US Government – mainly the intelligence agencies. As with the satellite-based Global Position System (GPS) that now runs so much of our daily life, from phones, cars and myriad other civil applications, commercial Earth observation satellites evolved from technology originally intended for military and

intelligence purposes. In the US, these satellite industry-intelligence community bonds remain strong.

America's intelligence agencies like what they see in this commercial satellite revolution and boundaries continue to blur as satellite companies simultaneously service the growing demands of intelligence gatherers and journalists.

In 2018 the US still dominated the commercial imagery market, so Washington's satellite policies have a global impact, but US dominance is rapidly diminishing, as small satellite technology proliferates internationally.

Censorship is still potentially an issue, but Washington is losing influence. Historically, the US Government has maintained tight control over access to US-produced high resolution commercial imagery through a regulatory measure called 'Shutter Control' that can ban American companies from distributing imagery deemed counter to US national security and foreign policy interests (NOAA, 2018).

Shutter control has never been formally imposed as there have been more subtle methods of censorship. US officials purchased all available imagery of preparations to invade Afghanistan in late 2001, to deny media access to those pictures (Campbell, 2001). And commercial pressure has also been applied. A former satellite company executive says that in 2007 the Bush Administration made unofficial phone calls to the key US imagery satellite providers – whose businesses depended on continued US intelligence contracts - to ensure pictures of an Israeli air raid on a suspected Syrian nuclear facility wasn't released to journalists.

The satellite technology genie is now out of the bottle, yet surprisingly, Washington still attempts to impose censorship, somewhat unevenly, over the release of high resolution satellite images of Israel and the Palestinian Territories (NOAA, 2018) despite these restrictions being rapidly made irrelevant by a growing number of satellites operated by companies in other countries. If customers want hi-res satellite shots of the West Bank, they can now shop elsewhere (Zerbini and Fradley, 2018).

As is the case with so many other tech-disrupted industries, the trajectory of this satellite revolution has left regulators, lawyers, privacy experts far behind, yet the satellite revolution has not triggered any meaningful debate on privacy or control.

This lack of public discussion is perhaps more surprising, given a popular misconception, inspired by Hollywood and 'Homeland'-style TV dramas, that satellites can easily read newspaper headlines or numberplates from space.

The exact resolution of America's state-of-the-art intelligence gathering satellites, remains a closely guarded secret, although the Washington Post recently cited one expert who estimated a resolution of 7cm per pixel in an image (Bump, 2017).

The highest resolution commercial imagery currently available (25-30cm under US licensing controls) can identify a vehicle but not a person. But what happens in 5-10 years, when as

some experts predict, we'll be watching live video from space of the world's major metropolitan centres? Will it ultimately make any difference in a world of Google street view, surveillance cameras and hobby drones hovering over backyards – all of which can easily record more detailed up-close-and-personal imagery?

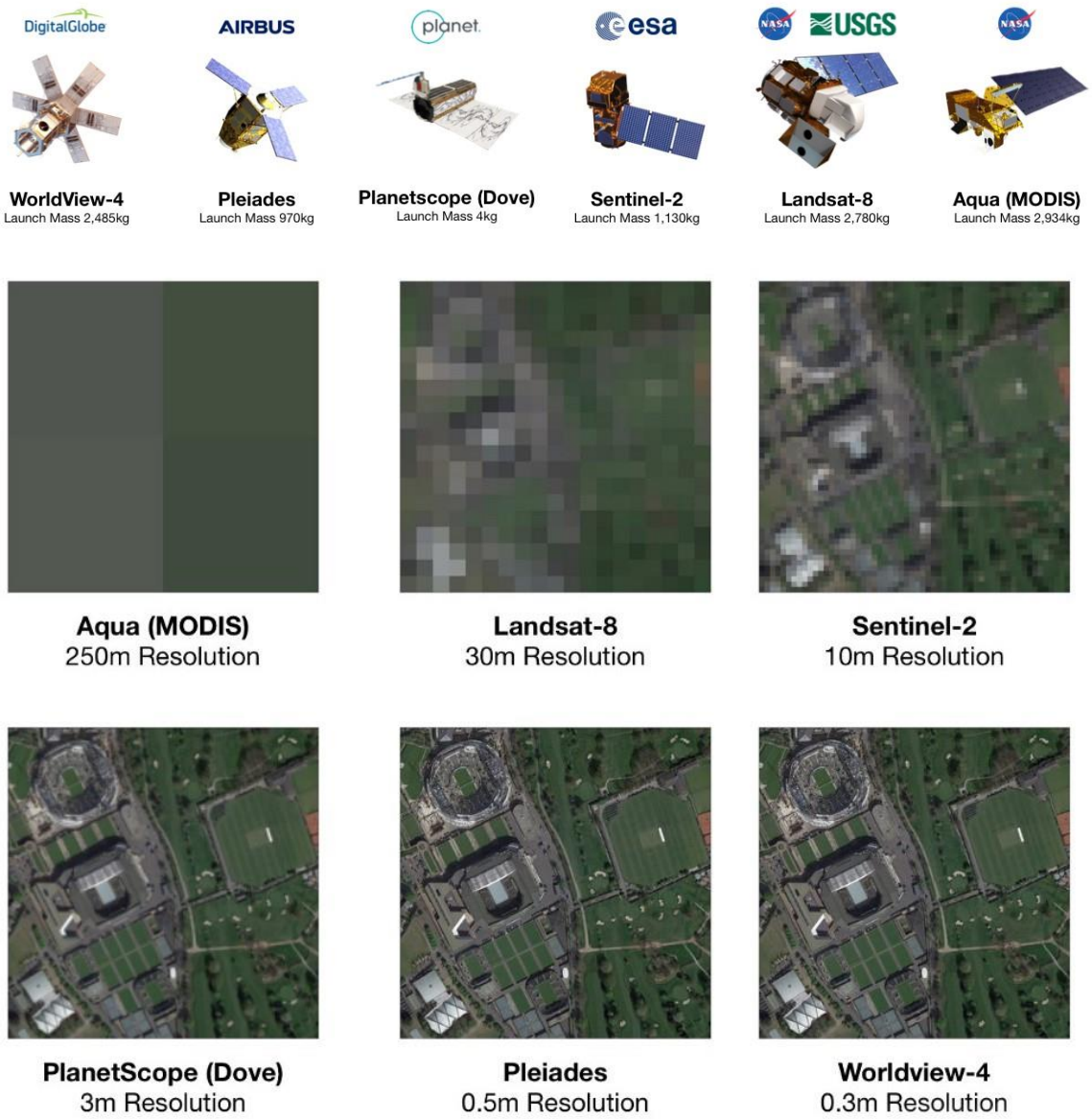
There are no complaints from commercial satellite imagery companies or media organisations. All appear content with the working relationships now evolving and few have the time or motivation for reflection.

This report is not an academic paper, nor does it delve into the highly complex field of satellite technology. It is intended as a big-picture introduction to an extraordinary newsgathering and story-telling tool. It examines media case studies, the two dominant US providers of commercial imagery to media and raises questions on the capabilities and complications.

What are the practical applications – and limitations - of satellite journalism? How can journalists independently authenticate images provided by a third party? What are the censorship issues? What technical proficiency is required to interpret images? In an age when anyone with a credit card and internet access can already download archived satellite imagery, what are the security issues and responsibilities of journalists? How will the satellite companies control the masses of data? As the recent Facebook controversy has shown, data companies rely on trust but in some cases are less transparent about what they do with the information they collect. And gazing into the not so distant future, what might satellite journalism look like 5 to 10 years from now?

In the picture

The key to satellite journalism is the quality of the image, or spatial resolution. This is measured by the size of an individual pixel within the satellite image. The lower the number (e.g. 1 metre), the sharper the image. Here is how the Wimbledon Tennis Complex in London appears at different resolutions recorded by some major government and commercial operators in the civil Earth observation business. DigitalGlobe (WorldView-4) and Planet (Planetscope-Dove) dominate the provision of media imagery:



All images were generated from a DigitalGlobe WorldView-4 image and resampled.
(Infographic – courtesy Anne Hale Miglarese, Radiant.Earth)

For further detail on spatial resolution, spectral resolution, temporal resolution, orbits and the different satellite sensor types, see **Annex A.**

The large NASA and US Geological Survey (USGS) satellites Landsat-8 and Aqua (MODIS) are designed for broad scale activities such as mapping, observing weather patterns and geological formations. With a single pixel in a Landsat-8 image measuring 15-30m, it would be difficult to determine where Wimbledon is, let alone who may be playing for match point.

There is a growing distinction between open and commercial satellite data. NASA and USGS satellites provide free open lower resolution archival imagery through public databases. This data is highly effective for stories where close-up detail or immediacy is not critical.

A notable earlier example was the 2014 collaboration between US news group ProPublica and The Lens on 'Losing Ground', an innovative environmental story, based around satellite imagery combined with on-the-ground reporting, that investigated the loss of Louisiana's coastline from accelerated erosion triggered by dredging and oil-well drilling. This pioneering project took five months to complete, with two months dedicated to the journalists and production team learning how to best utilise the data and production tools for visual storytelling (Bob Marshall, 2014).

Since 2014, the extraordinary advances in commercial satellite imagery have opened up many more opportunities for journalists. DigitalGlobe and Planet Labs are the two US satellite companies, with very different capabilities, that currently dominate the provision of high resolution imagery to the media.

Planet Labs

"Build it and they will come"

Will Marshall, Planet co-founder and CEO

In February 2014, Planet Labs Inc. launched its first flock of Dove nanosatellites into space. Shown are two shoebox-sized Doves being ejected into low-Earth orbit from the International Space Station (2 images – NASA)

The rise of San-Francisco based Planet Labs is a classic carport-to-corporation Silicon Valley success story. The company was founded 2010 in California by 3 young NASA scientists,

frustrated by the slow bureaucratic pace of US Government spacecraft research and development. They determined that technologies contained in smartphones could be adapted for tasks far more ambitious than taking selfies. As Planet co-founder and CEO Will Marshall told ABC-TV Australia's *Foreign Correspondent* program:

"We figured out how to miniaturise satellites, so satellites that will typically have been the size of a bus, sometimes a double decker bus, and we have taken that technology and tried to shrink it into tiny packages"

"When we were at NASA, me and my co-founders, we were thinking how could we leverage this cool technology that we're finding in our pockets for space? The unique moment was really when we had launched some smartphones into space. We just started building satellites in our garage in our spare time down in the south bay here in California, and it's a bit of a thing around here to just start building it in your garage. Build it and they will come" (Corcoran, 2017).

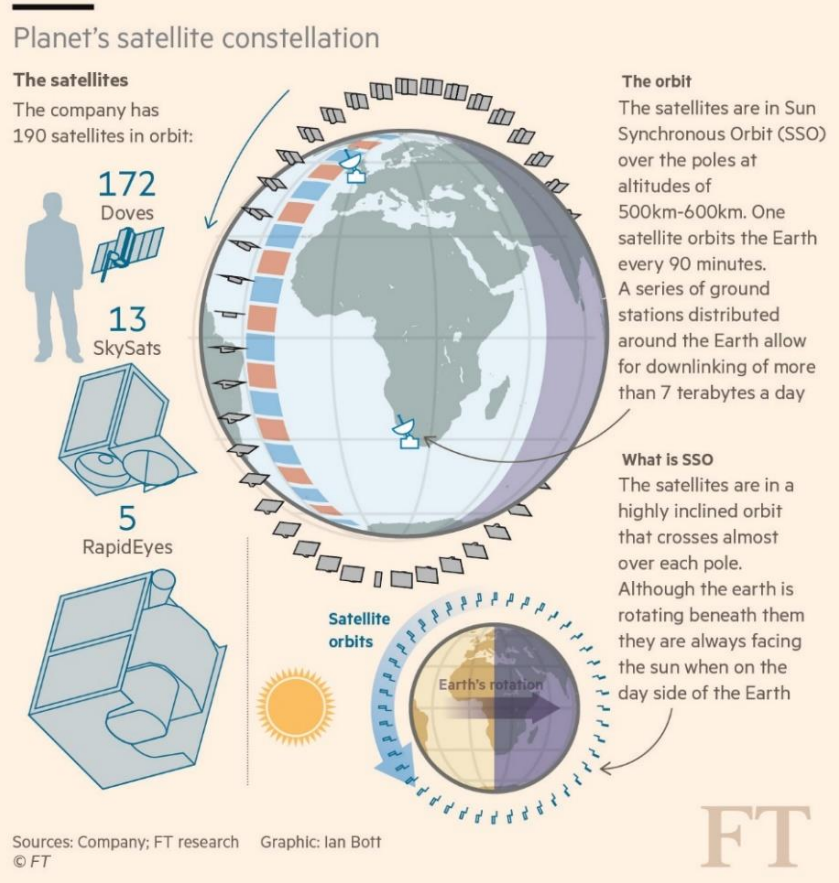
In 2010 the Planet team was launching smartphones into space on small amateur rockets. By 2018, the company operated the world's largest constellation of commercial satellites, capable of imaging the entire landmass of the Earth every day. Marshall projects a corporate philosophy of altruism, of using satellites to advance the human condition;

"One of the things about being a space geek is that we always approach things from the big perspective. And if you step back and look at the Earth, you think about it as a spaceship we have with seven billion astronauts hurtling around the sun. Well, we need the data that enables us to take care of that spaceship and so we need to monitor those changes on a fast enough timescale to stop our action where it's being harmful" (Corcoran, 2017).

The key to this success has been mass production of a small, relatively disposable constellation of satellites measuring 10 x 10 x 30cm, weighing about 4kg, and capturing imagery at about 3 metres resolution. In keeping with the Silicon Valley ethos, the Planet nanosats were branded as 'Doves' (Corcoran, 2017). Planet builds about 20 Doves a week in a workshop within the company's warehouse HQ in San Francisco (Vance, 2017).
So how much does it cost to build and launch each Dove? "That's about the only thing I'm not going to answer", laughs British-born Marshall, who has a PhD in Physics from Oxford University, "We don't go into details about that, it's some of our secret sauce" (Corcoran, 2017). Bloomberg Businessweek reports a per unit cost "well into six figures" (Vance, 2017).

Doves evolved from the standard building block of the small satellite industry – the CubeSat. In 1999, long before smartphones and digital disruption, two California-based university professors hit upon the concept of designing a miniaturised satellite using mainly commercial off-the-shelf components. The CubeSat was born - a 10cm cube weighing no more than 1.33kg (Mehrparvar et al., 2014). The low cost of the basic CubeSat, as little as $20,000USD, has made them popular with scientific researchers. Even universities and high schools are building CubeSats with significantly greater limitations compared to Planet's Doves, then hitching rides into space on other peoples' rockets (Gruss, 2016).

Planet also operates a fleet of 5 larger Rapid Eyes with 5m resolution, and 13 Skysat satellites; 7 acquired from Google in 2017, another 6 subsequently launched, in a deal that made Google a stakeholder in the company with full access to Planet imagery. SkySats can capture imagery down to .72m resolution and also record black and white video clips, up to 2 minutes duration (see Live from Space).



Planet's satellite constellation – February 2018
(Image – UK Financial Times/Ian Bott)

For further technical detail on the Dove and how Planet satellites effectively line scan the world every day, see **Annex B**.

Satellites are a high-risk business. Rockets explode on launch pads, expensive spacecraft malfunction in orbit. Planet incorporates failure into the business model by spreading the risk – launching its cheap, mass-produced batches or 'flocks' of Doves on many different rockets, American, Russian, *"basically anyone headed in the right direction",* quips Marshall;

"We didn't put everything into one big satellite that costs a billion dollars- when those things blow up that's really tragic but we spread our risk by putting our satellites on lots of different rockets and it's, it's not the end of the world if one blows up" (Corcoran, 2017).

The sector that puts these satellites into space is also facing the turbulence of disruption. First came billionaire innovator Elon Musk, in 2002 with his commercial rocket company SpaceX, and a declared goal “to revolutionise space technology” (SpaceX, 2018). SpaceX rockets routinely carry batches of Planet ‘Doves’ as secondary payloads on launch missions with a total cost upwards of $100M USD.

In turn, Musk now faces a new generation of usurpers, keen on a slice of the small satellite launch market, led by Rocket Lab, a New Zealand based start-up that builds much smaller rockets specifically designed to carry Doves and CubeSats for an all up per-launch price of $5M USD (Vance, 2017, RocketLab, 2018). Rocket Lab has already test launched a Dove and planned to start carrying full commercial payloads in 2018, with Planet at the front of the customer queue (Scholes, 2018).

Dove (Planetscope) 3 metre resolution

Skysat 0.72 metre resolution

Doha, Qatar November 11, 2017. oblique angle. Skysat (Images - Planet Labs)

"Tipping and Cueing" …Planet offers clients the option of monitoring a location with the broad-view 3m resolution Dove (Planetscope), then 'tasking' a close up with the 0.72m resolution Skysat (2 images – Planet Labs).

"If you're trying to track deforestation, for example, if you take satellite images every two years you wake up at the end of a few years and there's a bloody great hole in the Amazon, right? If you take images every day, well you can literally see any tree goes down when it goes down, and then stop illegal logging activity. That's just one example - there's many others, like tracking and stopping illegal fishing - helping with disaster response after floods or fires or earthquakes - quickly having data that helps responders go into those places"
(Corcoran, 2017)

Will Marshall, Co-founder and CEO Planet

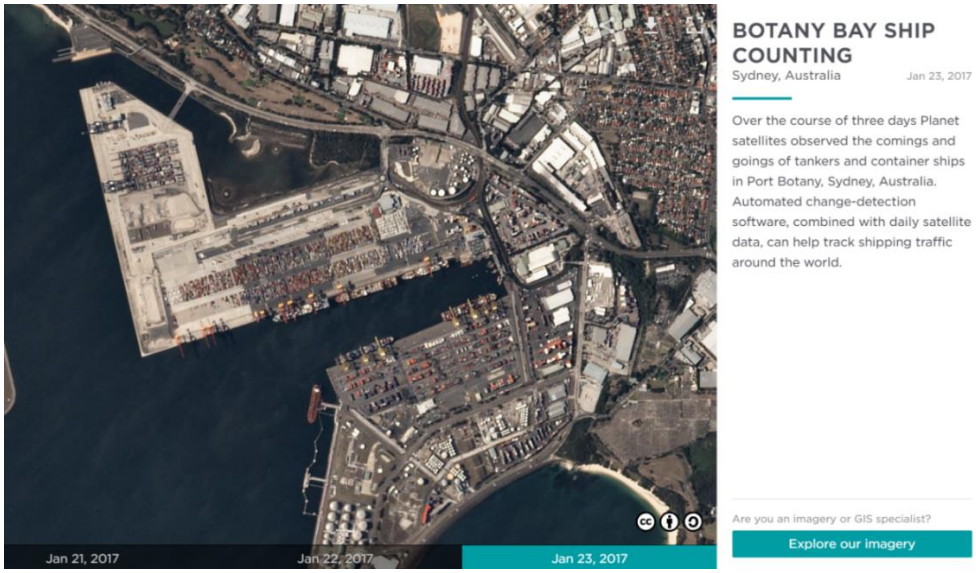
January 29, 2016

July 21, 2016

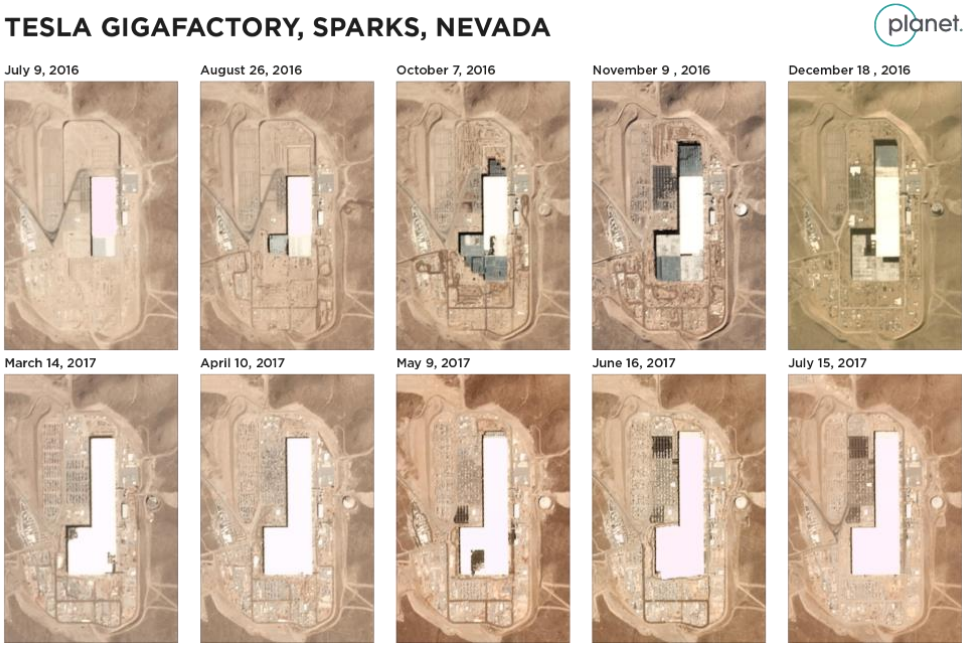
November 4, 2016

January 20, 2017

Environmental monitoring: The La Pampa gold mine in Peru. In 2016, mining operations were extended south of the Malinowski River, illegally entering the Tambopata National Reserve—a protected forest. The Amazon Conservation Association used Planet data to publish a series of alerts which tracked hundreds of hectares of illegal expansion and mapped alterations to the course of the Malinowski River. According to Planet, the Peruvian government intervened and actively targeted illegal mining operations inside the reserve (4 images – Planet Labs).



Commercial intelligence. Planet satellites can monitor and count the number of shipping containers moving through a port or calculate the volume of oil held in Saudi refineries awaiting shipment, providing a real time picture of commodity movements - accurate data to predict future prices (Image – Planet Labs)



Business story: Planet sells imagery to market analysts and businesses keen to monitor production and distribution of competitors. These images were provided to real-time market intelligence company Genscape during construction of the Tesla electric car Gigafactory in the Nevada desert and now monitors the ramp up of Tesla battery production (Spalenka, 2017) (Image – Planet Labs)

Planet's business model is based on selling subscription services to its imagery and claims to have customers in more than 100 countries in a wide range of sectors including agriculture, civil government, emergency management and disaster response, fisheries, forestry, business intelligence, insurance, mapping and intelligence agencies. The company also gives away imagery to NGOs and scientific researchers.

Planet does not divulge financial details or satellite operational costs, though the finance media has widely reported that since 2011, the company has raised $183M USD in funding and market value reportedly exceeding $1B USD (Morris, 2017) . The UK Financial Times noted; *"Some industry observers have likened Planet to a remarkable technological solution in search of a viable business model"* (Thornhill, 2018), a view reflect in 2017 by Micah Walter-Range, then Director of Research at US industry thinktank The Space Foundation:

"We'll see if Planet has succeeded or not, and this is one of the questions that the incumbents and other people like to raise about these start-ups, are they truly profitable? Are they building a sustainable business or are they simply burning up venture capital money, trying to pull far enough ahead that they will then eventually develop a sustainable business model?" (Corcoran, 2017).

While space is perceived as an exciting final frontier, ultimately the success of the commercial small-satellite revolution may be determined by unglamorous profit and loss margins here on Earth.

Media Relations

Planet has formal, first-tier 'terms of service' agreements with 10 major media groups including the New York Times, Washington Post, BBC and Financial Times. This provides free direct subscriber access through a portal to the Dove imagery database. Other media outlets and individual journalists are assessed on a "case-by-case" basis. Planet does provide imagery to news agencies, although this can be problematic due to copyright licensing and distribution complications *"because it's usually the wire services that sell their content to other media outlets",* says Trevor Hammond, Planet's Director of Corporate Communications.

3m resolution 'Dove' imagery is freely available to media, but 0.72 m 'Skysat' data is provided "on a request basis only". In 2018 80% of media requests were for Dove imagery, 20% for Skysat. Planet often anticipates media interest in a major news event, such as hurricanes or other natural disaster, by preparing imagery in advance. While the company supplies the data, Hammond says Planet will not provide in-house analysis, but can suggest external experts who may assist.

Planet operates under a corporate ethos of 'radical transparency' and 'democratisation of technology' and will not provide media with exclusive access to imagery.

"And it's important to us, and part of this program with the media that we don't give exclusive access to anyone. The historical norm of satellite imagery providers – the customers come in and say that 'I've got enough money to pay you to only get that image for me and no-one else" says Hammond.

"That's something we want to avoid and have never done and we've never provided our imagery exclusively to anybody and that's because it's really part of our ethics that we don't want there to be haves and have nots – people who have enough money to – people who

can buy stuff that others can't have – we really believe that imagery and the whole system should be one delivering a new level of transparency worldwide"

"So that's why journalists having it is important…. because there are things that governments of foreign countries don't want people to know but if it's there and we can access it - do what you will with it" (Interview 2018).

DigitalGlobe

"Satellite imagery is really visual truth serum and is an invaluable tool for journalists in understanding what is happening on the ground.

These satellites don't see borders or fears or hatred; the just see the planet Earth"

Mark Brender
former journalist and satellite company executive

DigitalGlobe (now part of Maxar Technologies) is the heavyweight of the commercial Earth imaging business. Founded in 1993, the Colorado-based company, with 6,500 employees, operates a constellation of five large, complex, satellites, fitted with multiple high-resolution sensors. DigitalGlobe provides imagery with a resolution down 30cm – in most, but not all regions.

Head of DigitalGlobe's, media liaison group, the 'Maxar News Bureau', Turner Brinton, says

"Everyone always wants to know, "What does a person look like? What can you tell about a person?" With 30-centimetre pixels a person is a speck. A person looks like not even an ant, just a dot on the beach or on the road" (Interview 2018).

In 2014, the US Government finally gave approval for DigitalGlobe to lower the threshold of imagery resolution it could sell internationally from 50cm, down to 25cm.

For many years, American providers were banned from distributing commercial imagery with a greater resolution than .5M, despite that capability being progressively matched, then exceeded, by non-US satellite providers and other new camera technology mounted on aircraft and drones. DigitalGlobe founder Walter Scott says this long period of "regulatory dysfunction" only ended after intensive lobbying by his company (Scott, 2016).

Former satellite imaging company executive Mark Brender, who maintains an unpaid position on the board of the DigitalGlobe Foundation, says the sharper imagery is more complex and costly to capture;

"The incremental costs of orbiting satellites with higher and higher resolutions, go up exponentially. A satellite company has to evaluate if the additional costs to able to 'see' more detail on the ground is worth it. For now, they have settled on 30-centimetre ground resolution. But they have approval from the US Government to go to 25cm if they want -and if there is market demand" (Interview 2018).

The DigitalGlobe constellation. Each satellite costs "several hundred million dollars" to build and launch (Images – DigitalGlobe)

WorldView-4

Introducing WorldView-4, a multispectral, high-resolution commercial satellite. Operating at an expected altitude of 617 km, WorldView-4 provides 31 cm panchromatic resolution, and 1.23 m multispectral resolution. WorldView-4 has an average revisit time of <1 day and is capable of collecting up to 680,000 sq km per day, further enhancing the DigitalGlobe collection capacity for more rapid and reliable collection.

(Images and infographic – DigitalGlobe)

Media relations

Turner Brinton says that while historically, there has been media demand for imagery of major stories, the concept of news organisations as lucrative paying customers never developed as with other sectors;

"I think it just goes back to the tight budgets and the struggles that the news industry is going through right now, and for the same reason that newsrooms don't have the budgets to keep the large staff that they had in years past and to send people all over the world to cover events and issues the way they did up until the 2000s" (Interview 2018).

DigitalGlobe intensified its media efforts after the 2015 collaboration with the US Associated Press on a Pulitzer-Prize winning investigation of slave labour in the south-east Asian seafood industry (see Seafood Slaves Case Study). Following this success, Brinton says DigitalGlobe founded the Maxar News Bureau in February 2017 and embarked on a roadshow offering free imagery:

“We went to visit first in New York and DC the largest domestic media organizations, The Washington Post, the Associated Press, The New York Times, CBS, ultimately BBC and a number of other outlets, The Wall Street Journal”.

“We briefed them on our capabilities and what we wanted to start doing with them and the response was overwhelmingly positive. Immediate they said, "This is amazing. When can we get started?" We said, "Right now." It snowballed from there”.

“Now on any given week we're probably fielding maybe half a dozen inquiries from reporters and editors that we've gotten to know and to work with…it might be two, three, four, five projects in any given week that end up being published” says Brinton.

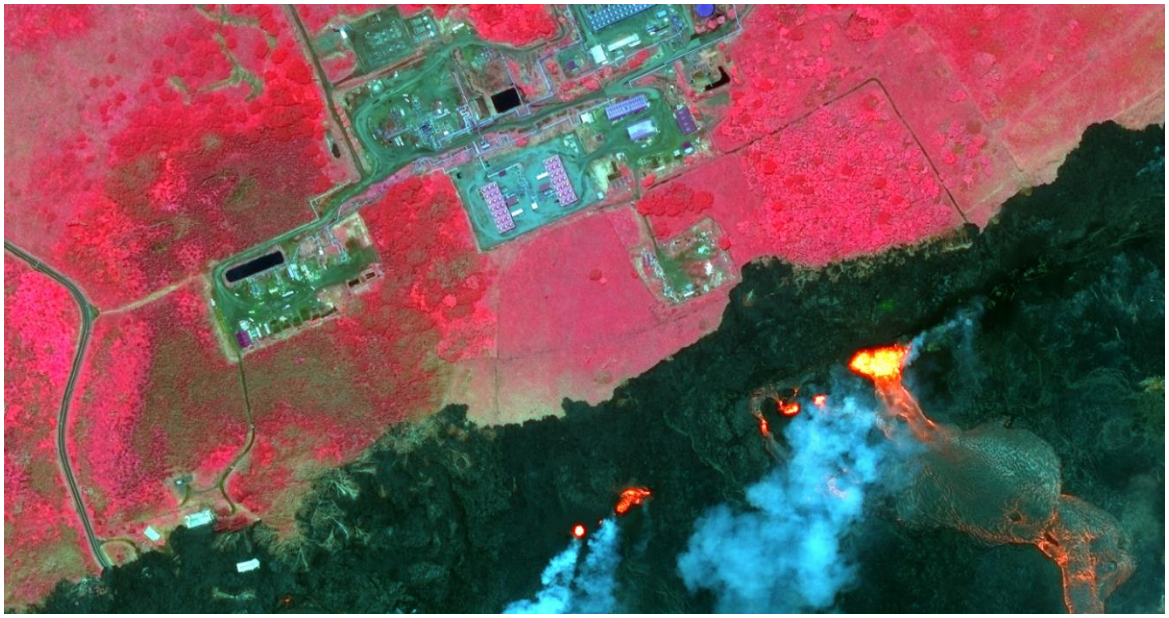
In contrast to Planet, DigitalGlobe provides in-house analytical support for selected media partners and will collaborate on exclusive investigations with journalists (See Seafood Slaves Case Study);

“At the other end of the spectrum are the exclusive, they tend to be the longer term investigative pieces that we might work with the reporter or an editor for weeks or even months at a time “

“We don't charge our media partners for our imagery or our time or our analytic services. We do it primarily to support our purpose of seeing a better world but also it's great for brand recognition and for differentiating our product in the market” says Brinton. (Interview 2018).

While DigitalGlobe provides selected major media outlets free imagery in return for attribution, the same deal is not always offered to freelancers or smaller media organisations. In 2017, a small team of foreign donor-funded Botswanan journalists were required to pay commercial rates for DigitalGlobe imagery, when investigating illegal construction at a compound owned by the President of Botswana, as the group did not fulfil the requirement of DigitalGlobe’s media support policy (see Botswana case study).

DigitalGlobe prepared this image and analysis for media release as a group of foreign journalists were granted permission to visit North Korea in May 2018 to observe the closing of the country's nuclear test site, a display of goodwill ahead of Supreme Leaders Kim Jong Un's Singapore summit with US President Donald Trump (Image – DigitalGlobe).

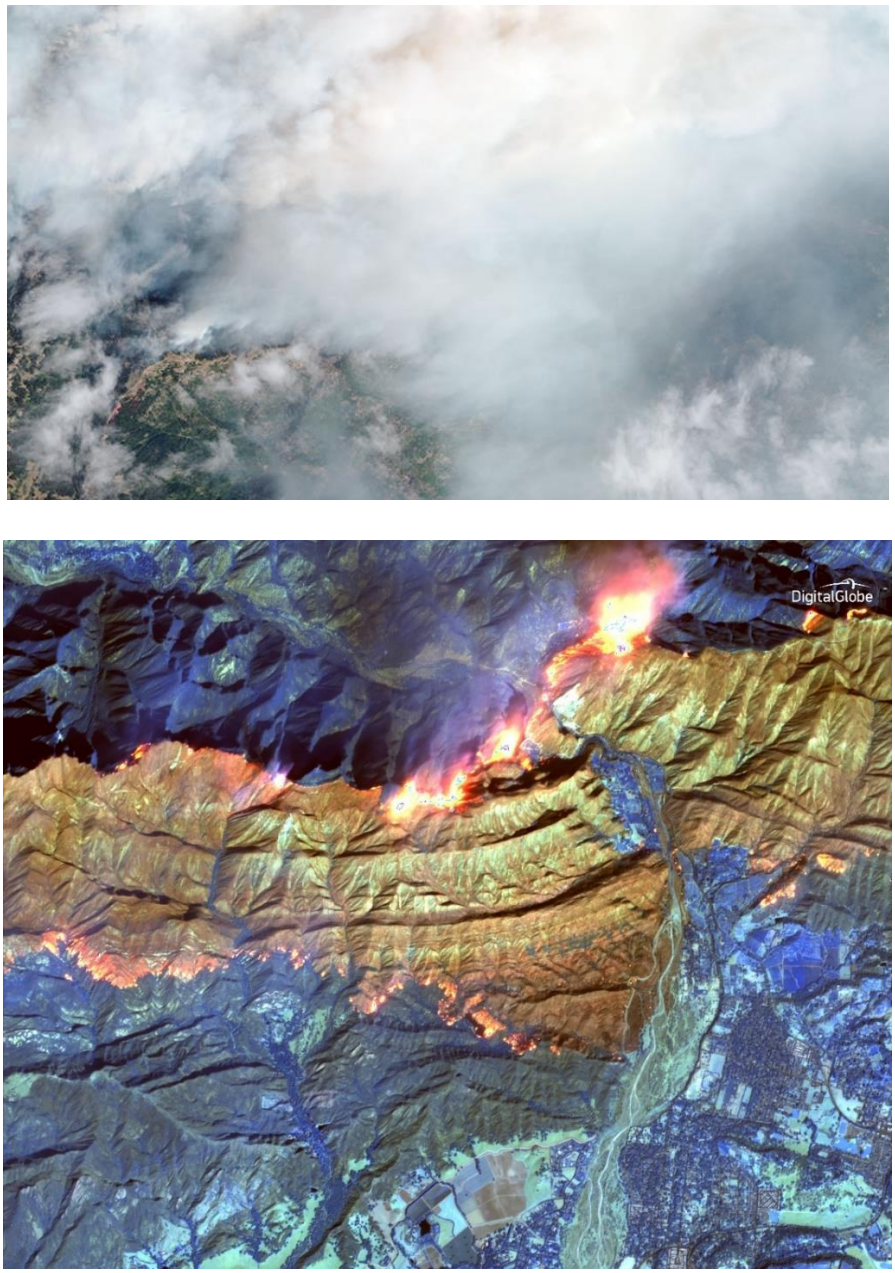


Infra-red image: Lava flow from Hawaii's Kilauea volcano threatens the Puna geothermal power plant. 23 May 2018. Healthy vegetation appears as red. Active lava is bright orange. Cooled Lava and burnt vegetation are black. (Image – DigitalGlobe)

The standard sensors on DigitalGlobe's satellites operate much the same way as a conventional camera, requiring good light and cloud and smoke-free skies to record imagery down to a resolution of 30cm.

DigitalGlobe also offers limited access to SWIR (Short Wave Infra-Red imagery) sensors on the WorldView-3 satellite that can penetrate smoke, haze and cloud, although with a reduced resolution of 7.5m. The company claims this capability offers a significant improvement on thermal imaging (heat sensitive) sensors with an image resolution of just 100m.

SWIR can distinguish man-made materials such as metals, plastics, fibreglass, road bitumen, differentiate between geologic minerals on the Earth's surface, such as clays and iron oxides, and determine soil moisture content.

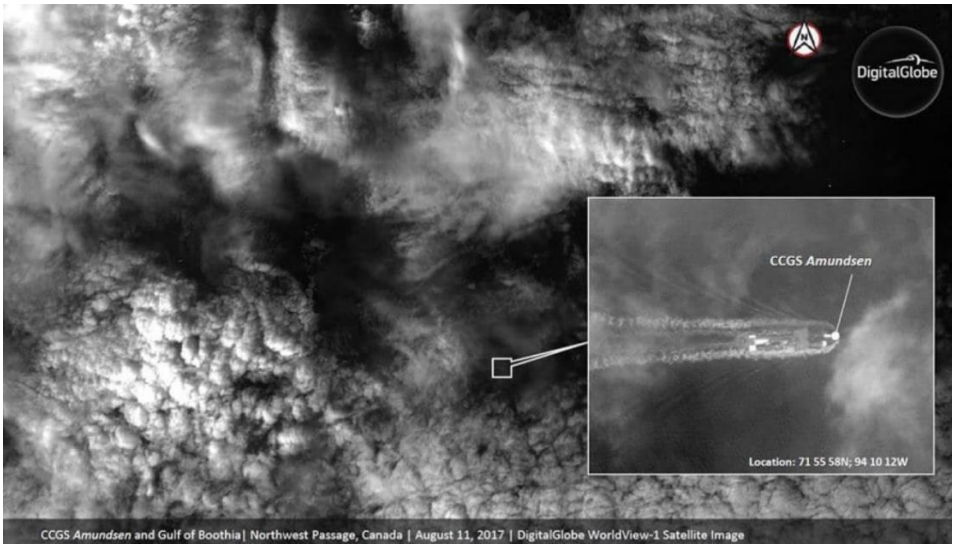


US forest fire at Mira Monte, December 7, 2017. Viewed through a standard EO (electrical optical) sensor (top) and SWIR (Short Wave Infra-Red) (bottom) (2 images – DigitalGlobe)

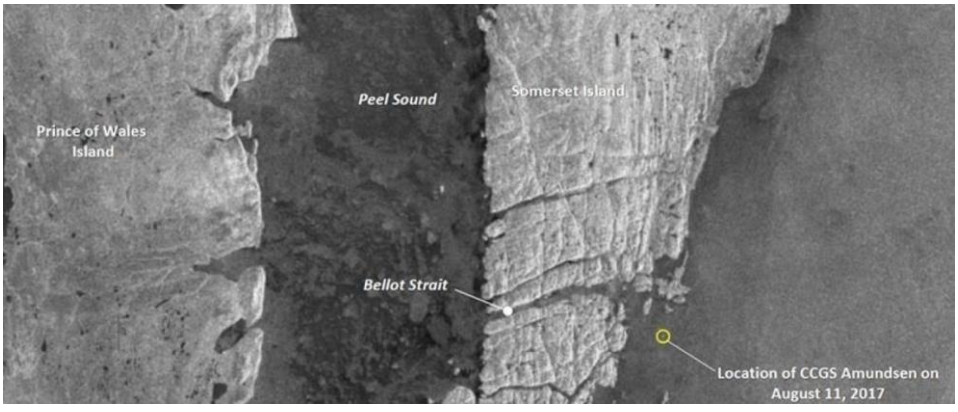
DigitalGlobe now also has access to new radar satellite technology from 'sister' company MDA in Canada, operator of RADARSAT-2. According to Brinton;

"It's still imagery of the Earth but it's a different phenomenology. The radar, it doesn't look like the natural colour imagery that we're used to seeing, it's black and white, it's not natural for our eyes to interpret it. What's really powerful about radar is it can image all day, all night, and it can image through clouds and bad weather, both of which are some limitations for electro optical satellites, the satellites that DigitalGlobe operates" (Interview 2018).

DigitalGlobe has already worked on a couple of media projects with this new capability including a 2017 Washington Post assignment on board a Canadian Coast Guard ship that transited the Northwest Passage in Canada (Mooney, 2017).



Electro optical sensors are standard on most Earth imaging satellites. They cannot see through clouds or smoke. In this Washington Post story, a Canadian coast guard ship transiting the North West Passage is briefly glimpsed through a break in the weather by a DigitalGlobe WorldView-1 satellite equipped with an electro optical sensor (Image Maxar/DigitalGlobe/Washington Post)



Also, from the Washington Post story, the ship and North West Passage as imaged by MDA radar satellite RADARSAT-2 (Image – MacDonald Dettwiler and Associates/Maxar/Washington Post)

Planet and DigitalGlobe initially focussed on very different capabilities, nonetheless the two major media providers through a process of acquisitions, mergers and strategic alliances are now increasingly in direct competition. As Space.com noted, this contest intensified following Planet's acquisition of Skysat higher-resolution satellites to complement the Dove constellation.

> *"(Planet) SkySat's 72cm imagery cannot compete with DigitalGlobe's 30cm images, but Planet is going after many of the same target customers, including the U.S. government, corporations and commodity traders who want access to high-quality imagery on a predictable schedule."* (Erwin, 2018b).

This competition is likely to deepen following the June 2018 announcement of a strategic partnership between Planet and Europe's dominant Earth imagery satellite provider, Airbus Defence and Space (Airbus DS), a branch of the Airbus aircraft manufacturing consortium.

Airbus DS operates a very high-resolution constellation, second only in capability to DigitalGlobe. According to Planet, Airbus DS operates "radar satellites ensure(ing) customers have access to any location whatever the cloud coverage" (Planet, 2018). Airbus DS is the third major provider of imagery to the media but has not pursued this market as actively as Planet and DigitalGlobe.

Case Study - Seafood Slaves

"You can't hide from space"

Jeff Tarr, DigitalGlobe CEO

Arguably one of the most successful applications of satellite journalism to date resulted in an extraordinary dividend; the release of 2,000 people held in slave conditions aboard fishing vessels. For 18 months an investigative team of four journalists from the US Associated Press (AP) had tracked ships and trucks across South East Asia in pursuit of their quarry; evidence of widespread slavery in the seafood industry that supplied stores throughout the United States.

AP reported that Thailand's $7B USD a year seafood business was built upon the labour of the poor who were "sold, kidnapped and tricked onto trawlers" (Mendoza et al., 2015). Establishing clear evidence of all the links in the slave fishing chain was extraordinarily difficult. The AP journalists interviewed recently returned slaves, fishing industry insiders and scoured government records and fishing licences.

Trawlers crewed by slave labour would stay out at sea for years at a time, periodically rendezvousing with refrigerated cargo ships, when the catch would be transferred, before ultimately making its way to US supermarkets. The AP investigative team had a lot of anecdotal evidence but lacked the smoking gun.

Interpol, the United Nations, and the US Defense and State Departments all told AP they did not have the authority to get involved.

Trawlers were routinely hidden from view, repainted, renamed, reflagged, and frequently switched off the on-board satellite location safety beacons. AP journalist Martha Mendoza says tracking the ship movements required months of investigation.

"We had through fishing registration and permits figured out that they were probably potentially in the area above Papua New Guinea, so then we wanted to go there but it was going to be logistically and financially almost impossible for us to do it" (Interview 2018).

Critical to the investigation was the transfer of slave caught seafood from the fishing boats to the refrigerated cargo ships that transported the catch to market. However, these rendezvous occurred well out to sea, away from prying eyes.

The AP team ultimately focussed on one cargo ship, the 2,300-ton refrigerated cargo vessel Silver Sea 2, after it dropped anchor off Papua New Guinea and turned off its Automatic Identification System safety beacon, that broadcasts its position via satellite.

"Analysts at SkyTruth, a West Virginia remote sensing and digital mapping firm, identified the Silver Sea 2 by its signals. However, they warned that getting photographic evidence of it collecting fish from one of the trawlers that fled Benjina (a remote Indonesian island base for slave fishing vessels) would be next to impossible" (Mendoza et al., 2015).

SkyTruth is a non-profit environmental group that utilises satellite imagery and remote sensing data to monitor threats to natural resources. In partnership with Google, SkyTruth runs 'Global Fishing Watch' a program to monitor the world's commercial fishing fleet in near-real time (SkyTruth, 2018).

SkyTruth handed the pursuit over to the satellite operators. Months earlier, Martha Mendoza had approached DigitalGlobe seeking assistance, except the satellite company didn't know if it could help.

"They came to us...they said, "We believe these ships are meeting up in this general area." I think it was an area about something like 800 square kilometres in the middle of the ocean." says DigitalGlobe's Turner Brinton.

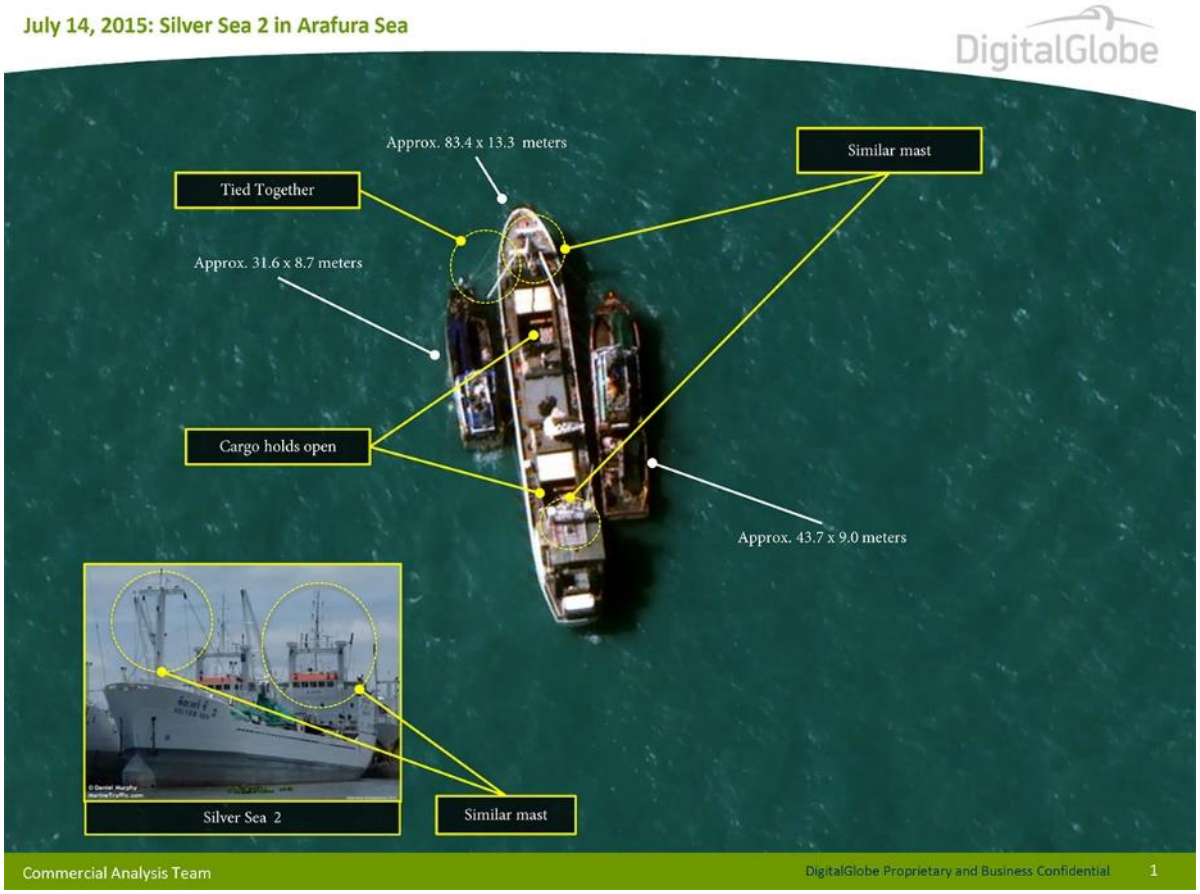
Brinton conceded it was a needle-in-a-haystack task requiring both technology and luck:

"It was luck in that we were able to get the satellite capacity that we needed. We always have many competing customer requests so for any given minute of satellite imaging time we could have one, two, dozens of different requests and we prioritize those based on a whole number of different factors" (Interview 2018).

DigitalGlobe's most advanced satellite at that time, WorldView3, was tasked to search for the elusive ships. The orbit could not be altered; although operators were able to change the direction the satellite was pointed as it tracked overhead at 27,000 kilometres per hour, 610 kilometres above the seas.

"The satellite would have been over that area for only a couple of minutes…passing the polar orbits, so travelling from the North Pole to the South Pole. They'll do about 15 laps around the globe each day, per satellite…our analyst said it jumped out at her right away and she was able to zoom all the way in to the image and see exactly the practice that we were hoping to see, which was these two slave trawlers tied up next to a refrigerated cargo vessel" (Interview 2018).

The trawlers appeared to be offloading fish to the large ship with distinctive cargo hatches and docking ropes, identical to the configuration of the Silver Sea 2 (Mendoza et al., 2015). According to Brinton; *"That was the start, that was the proof that the AP needed to go public with their investigation".*



The Smoking Gun – DigitalGlobe images refrigerated cargo ship Silver Sea 2 as catch is transhipped from slave fishing boats (Image – DigitalGlobe/AP)

AP caption: "Former Burmese slave fishermen Kaung Htet Wai, left and Lin, second left, point to a satellite image of a refrigerated cargo ship owned by Silver Sea Fisher Co., in waters off Papua New Guinea, while looking at a laptop screen at their home in Yangon, Myanmar, July 1, 2015. They said they were among the forced laborers loading slave-caught fish from their trawlers onto the Thai-owned vessel. They say hundreds of fishermen remain trapped at sea" (Mendoza et al., 2015).
(Image – AP/Gemunu Amarashinghe)

President Barack Obama, is applauded by senior law enforcements officials and members of the House and Senate after signing House Resolution 644, the Trade Facilitation and Trade Enforcement Act of 2015, in the Oval Office, White House, February 24, 2016
(Image – AP Photo/Carolyn Kaster)

The extensive AP investigation 'Seafood From Slaves', featuring the 'smoking-gun' satellite image, triggered an extraordinary chain of events (Htusan et al., 2015). The investigation ultimately led to the freeing of 2,000 slaves, dozens of slave fishing syndicate members were arrested, trawlers and refrigeration ships were seized and US Congress introduced

legislation creating greater transparency and accountability from seafood suppliers. The investigative team of Esther Htusan, Margie Mason, Robin McDowell and Martha Mendoza received the 2016 Pulitzer Prize for Public Service (PulitzerPrize, 2016).

DigitalGlobe declared that this was the first time a satellite had been used to capture human trafficking live (Mendoza et al., 2015). Leveraging this success, in 2017 the satellite company founded a specialist media liaison group, the Maxar News Bureau, to promote and distribute free imagery to selected major media organisations.

Ground Truth

'Seafood Slaves' was an outstanding example of the fusion between investigative journalism and technology. However, it should be noted that the critical information that enabled the orbiting satellite to target the right location, at the right time, came from an intensive 18-month investigation by a team of 4 journalists. Martha Mendoza;

"In the case of these boats, we would've just been chasing them around on the water…for a long time, so in this case, it did help us in our hunt a lot, but we had to know where to hunt by looking at the business registrations. Once we found that, we had to go talk to the people on the boats" (Interview 2018).

While satellite technology has become a powerful enabler, Martha Mendoza says it's important to emphasise that journalism is still ultimately a human endeavour:

"(Satellites) are a really cool tool in storytelling, but they're a tool just like a drone is a tool or ... a new type of software for database is a tool. It all enhances it, but at the end of the day you have to call people, go places, talk to people, be a news reporter" (Interview 2018).

Case Study - Botswana

President Khama's private airstrip -North East Botswana at 50cm resolution (Image: DigitalGlobe/INK)

In February 2017 Botswanan journalists with a non-profit, donor-funded news organisation, the INK Centre for Investigative Journalism (INK, 2018a), pursued a lead that the President of Botswana Ian Khama, was improperly using Botswana Defence Force (BDF) labour and government funds to secretly construct an elaborate multi-million-dollar private compound and airstrip at a prime tourist destination. For four years, the President's office had dismissed journalists' questions over the allegations and refused media access.

Location of the President's compound (Image – INK)

Three INK journalists, Joel Konopo, Ntibinyane and Kaombona Kanani drove 500 kilometres from Botswana's capital Gaborone to the President's remote compound, at Mosu in the isolated north east of the country. They were just 5 kilometres from the site when they were detained at gunpoint by security agents. The INK team's camera equipment and phones were temporarily confiscated, and the three were allegedly warned they would be shot dead if they ever returned to the location (AmaBhungane, 2017, OCCRP, 2017).

Obtaining visual evidence was critical to the success of the investigative assignment, so after returning to the capital, INK managing partners Joel Konopo and Ntibinyane (RISJ Journalism Fellow 2018), assessed the options. A search of Google Earth revealed old imagery dating back to 2012. Ntibinyane says this has been a common problem across Africa, where large areas of the continent that receive little online traffic from Google Earth viewers are not regularly updated or "refreshed";

"(Google Earth) wasn't helpful to us because it isn't showing that there were major developments taking place. We didn't see any vehicles or any earthmovers. So, we said, No, we can't rely on something that was last updated 6 years ago. We wanted a current thing, and that's why we're in the business of news. We want something new" says Ntibinyane (Interview 2018).

A proposal to deploy a small remotely-piloted drone mounted with a camera was discounted. While consumer-grade drones have been successfully deployed on many hazardous newsgathering tasks in recent years (Corcoran, 2015), the INK team concluded that the risks on this assignment were too great. The drone pilot would have been required to launch and control the craft from an exposed location - within a few kilometres from the President's compound - increasing the risk of detection by patrolling security forces. Hiring a helicopter was also ruled out as too expensive, costed by INK at $5,000 USD, and too hazardous; *"again you don't want to risk going there. Those are military guys. They can just shoot it down"* explains Ntibinyane.

The INK team then explored the option of obtaining imagery from an Earth observation satellite. The team was aware of the basic capabilities, as the local mining industry frequently tasked satellites for survey work. A Botswana-based imagery broker initially agreed to assist by contacting major US-based company DigitalGlobe, operator of the world's highest resolution commercially-available satellites, except two days later, the broker abruptly cancelled the agreement, claiming the location of the President's compound was defined as a "protected area". *"We only learned later that they were put under pressure by the security services",* says Ntibinyane.

INK finally secured the services of a remote sensing and mapping company in neighbouring South Africa that had no concerns in co-ordinating the task with DigitalGlobe. A topography expert concluded that satellite imagery resolution of 30cm – the highest available commercially – would be ideal for distinguishing details of the scale of construction in the compound.

Ntibinyane says INK was quoted a commercial rate of $8,000 USD for the task, using 30cm imagery, nonetheless this was too expensive for the small non-profit, non-governmental organisation largely funded by private international donors. A compromise was reached; DigitalGlobe would provide imagery at a lower resolution of 50cm, with the cost reduced to $5,000USD. While this arrangement was not ideal, Ntibinyane concludes it would provide just enough visual data to work with and the INK partners took significant pay cuts for three months to fund the satellite gamble:

"It was a lot of money, but we weighed up the idea of public interest. We said to ourselves this has a big public interest implication"

For three days in May 2017, DigitalGlobe's efforts to collect new imagery of the compound were defeated by cloud cover. Most Earth imaging satellites are mounted with electro-optical sensors that can only record imagery in daylight and with mostly clear skies. Faced with frustrating delays, high costs and fear of government retribution, the INK journalists worried that their significant investment would not pay off.

"Initially, we thought, well, this might not be much, maybe we are just troubling the guy, maybe he's not building an airstrip…or maybe there's no military…maybe we are going to be disappointed" concedes Ntibinyane.

The INK team examines the 'smoking gun' image
(L- R) Kaombona Kanani – INK reporter, Topographer (identity withheld) – back to camera, Joao Salbany - INK lawyer, and Ntibinyane - INK Managing Partner and RISJ Journalism Fellow 2018. (Image - INK)

Ntibinyane's doubts were swept away when a single, very high-resolution image was finally emailed to the INK office. *"When I opened it, I was so surprised, I was like, "Wow, this is just bigger than I thought".* It was the smoking gun; Incontrovertible visual evidence of the size of the project.

The scale of construction was confirmed when the new imagery was compared with Google Earth's archive from 2006, 2010 and 2012.

The DigitalGlobe image revealed a 15-hectare construction site, complete with earth-moving equipment, trucks, barracks accommodation for a significant number of soldiers labouring on the project, and a solar-panel power plant. INK had the story, and the President's office knew it, but they attempted one last legal obstruction;

"Before we published, we met with our lawyer. Because in Botswana, there's a law called Protected Areas and Places Act, so initially the government was saying the President's compound is protected by law" says Ntibinyane.

The challenge was dismissed, when it became clear that Botswanan law doesn't preclude satellite coverage. INK ran with the story, framed around the extraordinary amount of detail extracted from the single image;

"Completing the picture of a luxury eco-retreat outback is 79 square metre helipad and a tower jutting out of a sprawling housing complex of 22 buildings linked to a 45 hectares airstrip with a 1.6 kilometres runway" (Ntibinyane et al., 2017).

The investigation was published in Botswana's *Sunday Standard*, South Africa's Mail and Guardian, with a subsequent interactive edition on INK's website.

INK's investigation ran in South African and Botswanan publications with an interactive edition published on the centre's site (Image - DigitalGlobe/INK)

"They were caught. From there, we started receiving messages from senior government officials, including cabinet ministers and government administrators saying, "Guys, you did a good job. We know it won't do anything. The President won't be held accountable, but we are happy that the story came out" (Interview 2018).

As predicted, the INK expose did not bring down President Ian Khama, and he retired as originally planned, in April 2018. INK reported that a subsequent Ombudsman's investigation of the alleged misuse of public funds in constructing the luxury compound found the President to be "above the law" and "protected by the Constitution against being probed" (INK, 2018b). Despite a chronic lack of resources and ongoing threats and intimidation, the INK team demonstrated how satellite technology could be successfully applied in a well-planned and executed investigative story.

Ntibinyane notes that the team learned some critical lessons from the satellite investigation; the importance of specialist expertise, an appreciation of the cost and logistical complexity of commissioning satellite imagery and the issues of responsibility that come with using this powerful platform.

Requirement for expert analysis

Satellite imagery analysis requires a specialist skill set to interpret the data and it is extremely easy for journalists lacking these skills to misinterpret data and get the story wrong. DigitalGlobe provided a standard 21km x 19km very high resolution (0.8m) image. The President's compound and airstrip were located within the red box.

View from above. The standard 21km x 19km tile provided to INK – with the President's compound and airstrip in the red box (Image – DigitalGlobe/INK)

The INK team accessed the Google Earth Pro program with software for determining precise distant measurements needed to analyse the precise scale of construction, however they lacked the skills to effectively run the program. They consulted a local topographer with satellite imagery expertise, to examine the data, a decision that Ntibinyane believes

prevented a disastrous mis-interpretation that would have undermined the credibility of the investigation.

"…there were times when we thought, 'Okay, this should be an earth mover.' But when the topographer came and said, 'No, no, an earth mover wouldn't measure like that….it was something like a tower. Yeah, for us, we got it wrong. I'm sure if we'd gone with what we thought… we would have messed the whole thing up" (Interview 2018).

Cost

INK is a small non-profit investigative and advocacy organisation, largely dependent on international donors for funding, and the journalists struggled to raise the commercial rate of $5,000 USD for the imagery. This contrasts with DigitalGlobe's ongoing agreements with major media corporations to provide very high-resolution imagery free of charge, in return for company attribution, usually on the captions of the published images. It's a standard news attribution protocol, but for satellite companies jostling for business, this brand recognition is marketing gold.

Turner Brinton, manager of DigitalGlobe's Maxar News Bureau, says he was unaware of the Botswana investigation, nonetheless he explains that INK's exclusion from a media deal would have been in keeping with company policy.

"as much as we would like to support every organization that's doing good work, and there are so many of them, the news bureau is restricted to accredited media organizations. Even if it was an NGO (Non-Government Organisation) ...We do work with a lot of NGOs, but it's typically under commercial arrangement" says Brinton (Interview 2018).

There was no commercial incentive for DigitalGlobe to support the investigation, pro bono, a decision that frustrates Ntibinyane:

"It is quite astonishing that some big media organizations are getting images for free while non-profit organizations with an important mandate of holding power and the powerful to account are required to pay more to obtain the image.

" *What happened to social responsibility? Companies like DigitalGlobe with footprints all over the world including in Africa should support initiatives to support good governance by ensuring that non-profit organizations like my organization are supported to keep power in check*" (Correspondence with author, 2018).

Security

Ntibinyane predicts that observational satellites will become an increasingly valuable tool for journalists working across the vast, logistically-challenging spaces of Africa, but believes this capability comes with a social responsibility. Ntibinyane notes that neither the South African company that brokered INK's request, nor DigitalGlobe, formally requested identification. This casual approach greatly assisted in gaining quick access to imagery

central to the story, although upon reflection, he worries about the broader security implications:

"They never asked us anything about what we want to use the imagery for. Nothing. They were just saying, "OK, you want the image? Pay. You will get it".

"They just said "OK we want to help", which I think now with some hindsight…they should do more background checks, because imagine if we are like ISIS or warlords trying to get this image to only bomb the President's Palace" he adds.

"I think the whole thing should be regulated… and you should really do background checks before selling these images…It's an issue that will need individual countries to address it…and maybe at the UN level, because leaving it as it is…For now, it's OK, it hasn't really produced anything disastrous, but with time, I can tell you people are going to use this technology to do other things that are bad" (Interview 2018).

Case Study – Bellingcat

"Before the Arab Spring I knew no more about weapons than the average Xbox owner. I had no knowledge beyond what I'd learned from Arnold Schwarzenegger and Rambo"
(Weaver, 2013)

Eliot Higgins,
founder, Bellingcat citizen journalism group

Eliot Higgins, Founder - Bellingcat citizen journalism group (Image – Bellingcat)

Satellite imagery is an important subset of the emerging specialisation of data and open source journalism and one of most successful proponents of this genre has been 'citizen journalist' Eliot Higgins, founder of the UK-based investigative group Bellingcat (Bellingcat, 2018b).

Higgins is a highly unorthodox figure. A former administrative worker with a passion for computer games, he has no training in journalism, military technology or intelligence analysis, and has never set foot in a war zone, yet his Bellingcat group has broken an impressively long list of stories focussing on conflicts in Syria and Russia, weapons, organised crime and disinformation.

Higgins works from his home in the UK city of Leicester, connected by laptop to Bellingcat's far-flung team that has now expanded to nine full time staff, about a dozen volunteers and a wider group of website contributors. Higgins says he taught himself the skills needed for satellite imagery analysis over several years;

"To some people when you first look at it, it's like, 'Oh my God, that looks terribly hard.' It's not hard for me to judge because I've been doing it for six years, so I'm pretty used to doing it. It's stuff like knowing how to look at the shadows that had been cast by buildings so you understand the height of the buildings…or knowing to look out for things like the shadow cast by telegraph poles and stuff like that" (Interview 2018).

Higgins first came to international prominence in 2012-13, as he trawled through hundreds of videos and social media feeds, constructing accurate analyses of chemical weapons use in Syria's civil war. His results were at first met with surprise, then praise by human rights groups, war crimes investigators and experienced foreign correspondents.

While some have described his activities as a type of intelligence work, Higgins prefers the definition open source investigation.

"I'm often told, anecdotally by people who know people in the intelligence services of the world, that my work even going back to the early days of my blog was often used in the intelligence community because they weren't really using it in the same way that I had started using it" he says. Bellingcat's strength is to work quickly and accurately, unimpeded by secrecy or bureaucracy.

"Various government sources also found it very useful to understand what was happening on the ground because they weren't getting information from the intelligence community that was soft and as clear as what I was able to provide with actual videos and satellite imagery of what was happening"

"The idea of using YouTube videos for their intelligence gathering was alien for those kinds of organizations. It's a large bureaucracy. It takes a long time for those ideas to get to the point where someone actually reacts to it".

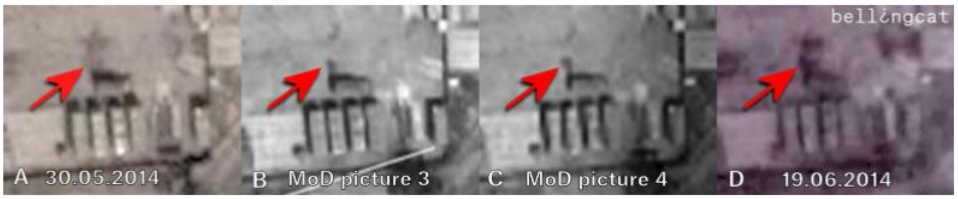
Not surprisingly, Bellingcat has few fans in the Kremlin. As the UK *Independent* noted; "In the global information war, Vladimir Putin's propaganda chiefs have an unlikely nemesis" (Burrell, 2015).

Bellingcat's most extensive, and controversial investigation followed the shooting down of Malaysian Airlines flight 17 over eastern Ukraine in July 2014, killing all 298 people on

board. The airliner was targeted while overflying a region where Ukraine government forces were battling Russia-backed separatists.

Russia was quick to blame Ukraine forces. However, in November 2014, Bellingcat published a 35-page response based on photos, social media, maps and satellite imagery that debunked Moscow's version of events. Bellingcat pointed to a Russian supplied and operated BUK anti-aircraft missile, launched from territory controlled by Ukrainian rebels loyal to Moscow, as being responsible for the attack (Tucker, 2015, Bellingcat, 2014).

Refuting the claims, Russia issued its own report, backed by the official satellite imagery, that the Kremlin said proved Ukraine's culpability. Bellingcat claimed Moscow had simply photoshopped the satellite pictures. Higgins then launched a crowdfunding campaign to purchase independent satellite imagery from DigitalGlobe, that combined with further forensic analysis, supported his conclusions that Russia had faked the imagery (Bellingcat, 2015).



Figures A though D – Picture 3 and Picture 4 from the MoD compared with satellite images from Google Earth

- Figure A: Area A – Satellite photo from Google Earth on 30 May 2014
- Figure B: Area A – Picture 3 from the MoD, dated 14 July 2014
- Figure C: Area A – Picture 4 from the MoD, dated 17 July 2014
- Figure D: Area A – Satellite photo from Google Earth on 19 June 2014

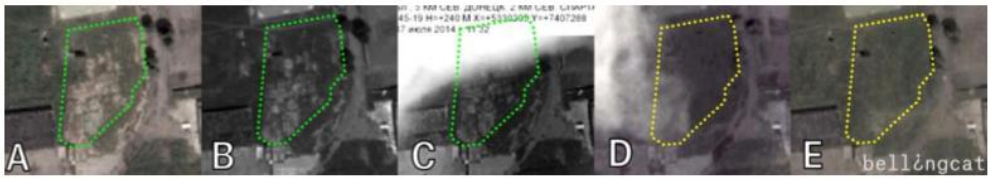
The red arrow in each of the figures above shows the location of the pool being formed by liquid leaking from the vehicle. In Figure A, the vehicle is present, but there is no leaked liquid visible. Figures B and C show the vehicle next to the leaked liquid, with the pool in Figure C already visibly larger. In Figure D, the pool has increased significantly.

There is also a remarkable change visible in the middle of area C in Picture 4:

Picture 4 - C marks the area to be examined

Note the changes in the vegetation in area C over time:

30 May 2014 MoD's Picture 3 MoD's Picture 4 19 June 2014 2 July 2014



30 May 2014 MoD's Picture 3 MoD's Picture 4 19 June 2014 2 July 2014

- Figure A: Area C – Satellite photo from Google Earth on 30 May 2014
- Figure B: Area C – Picture 3 from the MoD, dated 14 July 2014
- Figure C: Area C – Picture 4 from the MoD, dated 17 July 2014
- Figure D: Area C – Satellite photo from Google Earth on 19 June 2014
- Figure E: Area C – Satellite photo from Google Earth on 2 July 2014

The product of Bellingcat's crowdfunding campaign to buy satellite time from DigitalGlobe. The citizen journalism group made a compelling case that Russia had significantly altered satellite imagery of Ukraine, used in supporting Moscow's claim deflecting involvement in the downing of flight MH17 (multiple composite images – source Bellingcat/DigitalGlobe/Russian Ministry of Defence).

"We have seen cases where Russia has spiked satellite imagery. Once the fake is exposed, that's the kind of black mark on whoever does it, forever. Anytime Russia publishes satellite imagery now it's completely untrustworthy", says Higgins (Interview 2018).

In 2018, Bellingcat's conclusions were validated when a joint international criminal investigation confirmed the group's reporting; that the BUK missile that shot down MH17 came from a Russian anti-aircraft unit. Moscow continues to deny the finding (Walker, 2018).

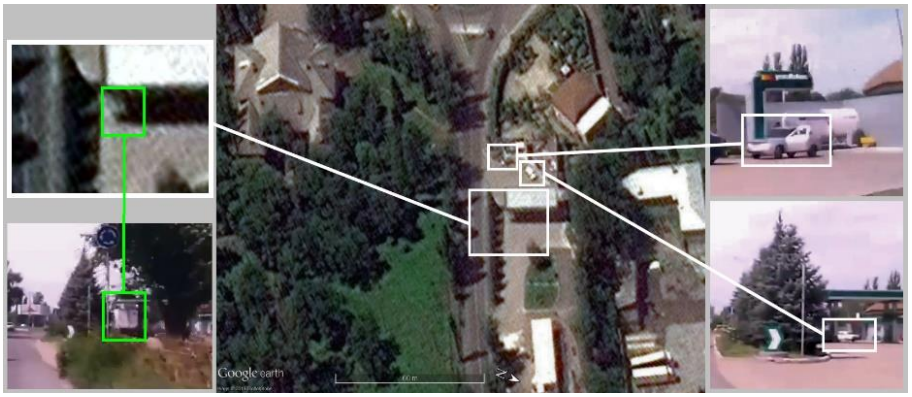
Bellingcat continues to utilise satellite imagery as a tool assisting in geo-location, verifying the location and authenticity of more detailed video and social media data recorded on the ground.

"We are looking to an execution that took place in Benghazi, Libya and that's a part of an International Criminal Court (investigation) at the moment. What we're able to find there is not only finding the exact location the execution took place, but on the satellite imagery, and we can actually see the blood stains from the execution and we can actually use the satellite imagery and line it up perfectly with the airframe of the video and show the bloodstains line up perfectly with blood stains in the video, which confirms where it took place."

"But it also then means we can confirm the camera position and use the shadows visible in the video to calculate the time of day by using a kind of like a sundial so you can get an awful lot of information just by figuring out where the images were taken." (Interview 2018).

"New Google Earth Satellite Update Confirms Presence of BUK in Eastern Ukraine" published by Bellingcat on June 22, 2016 was an example of using satellite imagery to verify the location, authenticity and timing of imagery and social media data on the ground. In this case the convoy escorting a BUK through Eastern Ukraine, the day flight MH17 was shot down.

Bellingcat caption: "After driving past the BUK and its convoy, the Makiivka dash-cam driver passes a gas station, where a few cars are parked. These cars are visible in the satellite image and easily identifiable by their diagonal parking angle"



Bellingcat caption: "With the updated satellite imagery, there is yet more confirmation that separatist forces transported a BUK from Donetsk to Snizhne in eastern Ukraine on the day of the downing of Flight MH17".

What Price Knowledge?

Higgins says Bellingcat accesses both DigitalGlobe and Planet, depending on the type of investigation and imagery requirement. Google Earth is often referenced as an initial source, but Higgins cautions the imagery can be several months, and sometimes years old and notes that in Iraq until recently, a significant amount of Google imagery dated back to 2000.

Bellingcat has a $300USD a year subscription to the Terraserver commercial imagery website, providing access to DigitalGlobe's high resolution archive, that Higgins says is typically 2-3 weeks old imagery, commissioned by other, paying clients. *"Sometimes…your fate is in the hands of whoever's got the money to task the satellites"* he notes (Interview 2018).

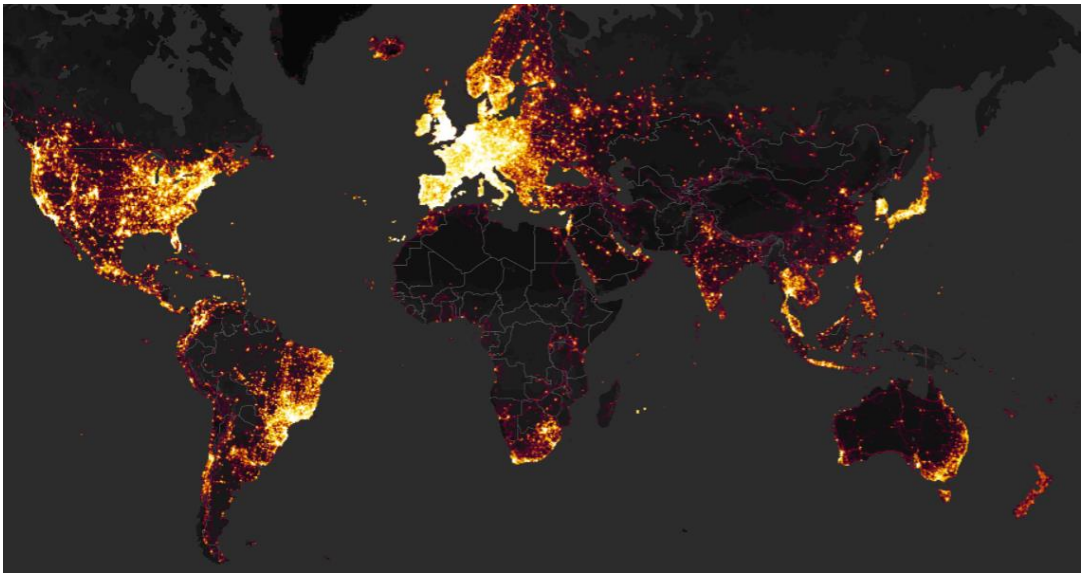
Recently, Bellingcat has begun accessing more of Planet's 3m resolution imagery;

"It's very good for tracking environmental damage. One thing we were using that for was looking at the black smoking produced by illegal oil refining in Syria and Iraq and ISIS territory. Because each one of those little refineries produced a lot of horrible black smoke which made it very easy to spot from space even at that resolution" (Interview 2018).

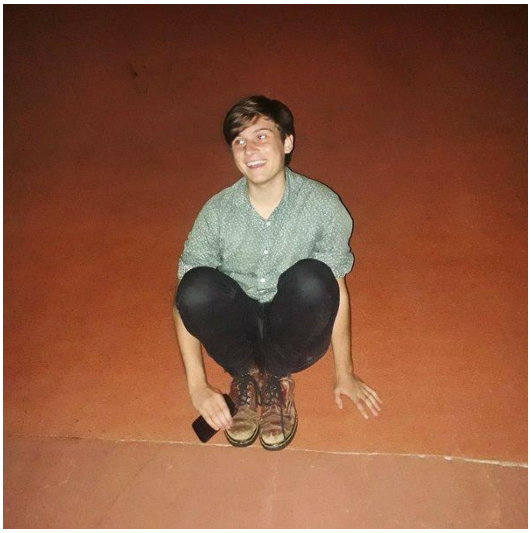
Higgins sees Planet's major advantage as frequency. DigitalGlobe satellites have significantly greater military-grade imaging power, but are few in number. Planet offers lower resolution, but has nearly two hundred satellites in orbit.

"DigitalGlobe is far less frequent…and is far more in a way, significantly affected by cloud coverage because with Planet, because it can sometimes take multiple images a day, sometimes the cloud moves and it gives you a clear view on the same day" (Interview 2018).

Satellite cross-referencing – the Strava fitness app



The Strava global heat map (Image- Strava)



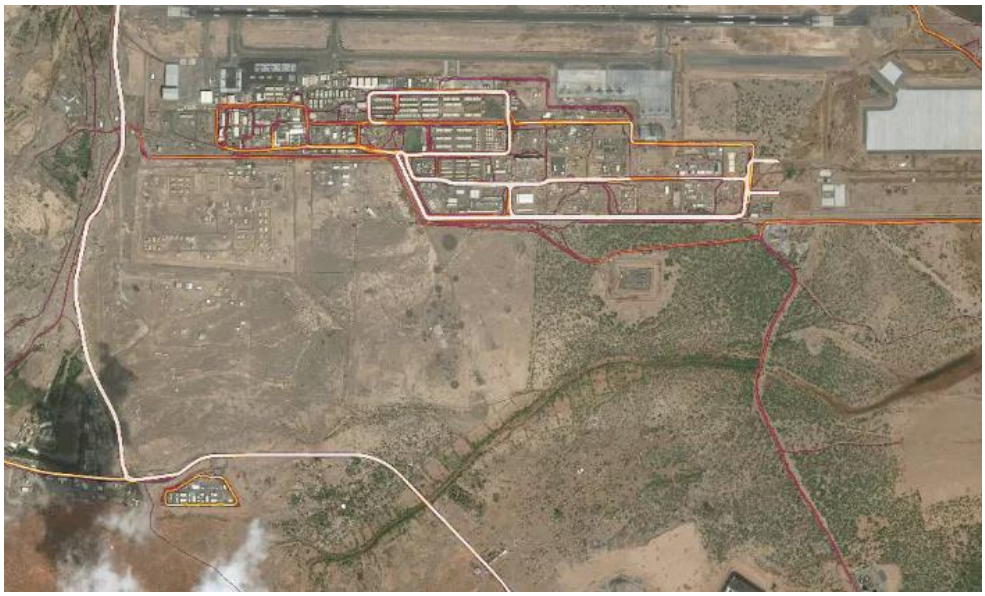
"Whoever thought operational security could be wrecked by a Fitbit?", remarked Nathan Ruser (Kwai, 2018) (Image – Jan Mark/New York Times)

In January 2018, Nathan Ruser, a 20-year-old student at the Australian National University made an extraordinary discovery. Strava, a company that had developed a fitness tracking app, released a global heat map, tracking the movements of those Strava owners who opted to make their posts public. The data unwittingly revealed the location of secret US military facilities, through the movements and exercise habits of thousands of soldiers and, presumably, some intelligence officers.

The Strava app , billed as 'the social network for athletes', tracks, via GPS satellite, the movements of wearers out jogging, walking or cycling (Strava, 2018). The app was popular with soldiers.

Ruser's social media posts on his discovery went viral, prompting the online community to trawl the world for more Strava patterns.

While well-known major US bases in Afghanistan were clearly identifiable through the concentration of Strava activity lines, there were, as the New York Times noted: "other airstrips and base-like shapes in places where neither the American-led military forces nor the Central Intelligence Agency are known to have personnel stations" (Perez-Pena and Rosenberg, 2018).



Camp Lemonnier (top right) and a suspected CIA base (bottom left) in Djibouti, with Strava activity indicated (Image – Strava heatmap/The Guardian)

For Bellingcat's Eliot Higgins, the Strava incident underscores how consumer grade smartphones and wristbands, enhanced by satellite links, are "just intelligence gathering units", which he notes will take personal security breaches to a new level;

"This Strava thing ... fitness tracking thing is cross referencing satellite imagery so you can see their little trails going in and out of military bases and you can see which buildings they're going into as well, if you know what's in their buildings (you) get (a) good idea what they're doing is their job. You can also see people say, "This person goes into this house and this other person comes out of the house. Is that their wife? Is that their children? Can we kidnap them? Can we kill them?

"And this information is all out there. Combining with satellite imagery gives a really good sense of exactly where people are going. You can see which entrance of the building they're using on a daily basis and they're just giving this information away for free".

Strava isn't the only app giving the US military a satellite-induced security headache. In July 2018, Bellingcat, in a joint investigation with Dutch journalism platform De Correspondent, reported on another fitness app that revealed personal movements in even greater detail.

Bellingcat detailed how the Polar app publicises more data per user in a more accessible way, with potentially disastrous results.

> *"…revealing the homes and lives of people exercising in secretive locations such as intelligence agencies, military bases and airfields, nuclear weapons storage sites and embassies around the world"* (Postma, 2018).

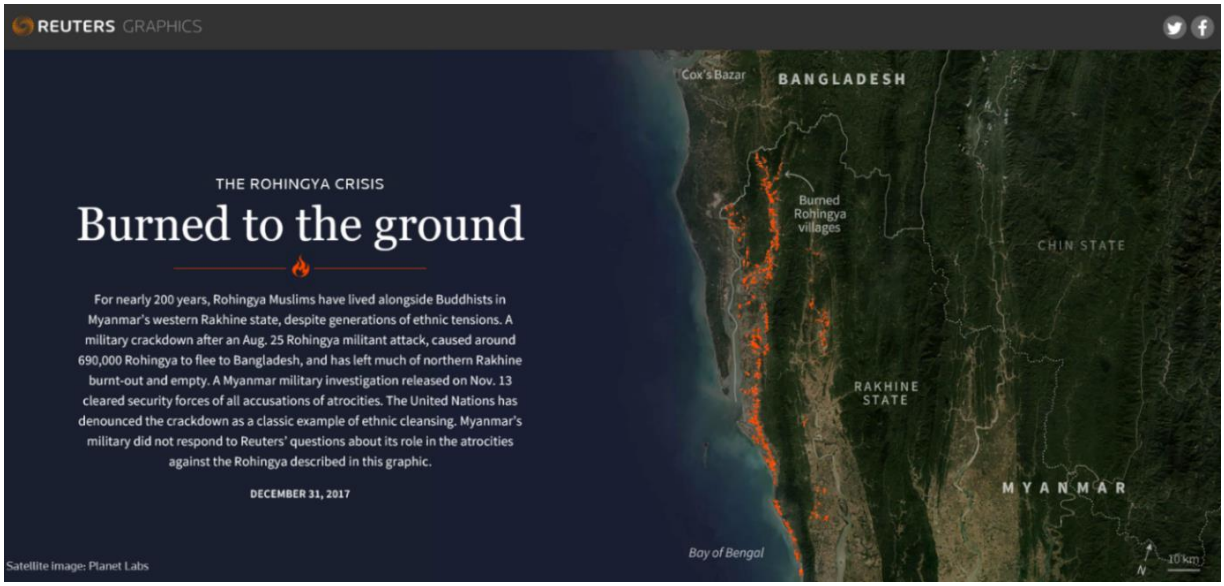
Polar app wearers often turn the device on or off when entering or leaving their residences, unwittingly providing a marker on the exact location of their home. Bellingcat notes that users often revealed their full names in the official Polar profile, accompanied by a picture.

More than 6,500 Polar users working at more than 200 "sensitive sites around the world", appear to have broadcast their exercise locations and routines. Bellingcat was even able to identify the name and routine of a high ranking US officer at an airbase hosting nuclear weapons (Postma, 2018).

Exercise tracked at a military base in Africa. Red squares with white dots indicate where multiple workouts commenced at a single location (Image – Polar/Bellingcat)

Case Study – Thomson Reuters

I. ‘Burned to the Ground’



Target area: Data from the UN Operational Satellite Applications Program (UNOSAT) showed scores of Rohingya villages in Rakine State that were burnt down. The dataset shown throughout the special report displayed burned areas from August 25 to November 25 2017. The area stretches 110 kilometres from the hills of Rakine’s northern tip, to beaches near the state’s southern capital, Sittwe (Image – Planet Labs/Thomson Reuters).

Link: http://fingfx.thomsonreuters.com/gfx/rngs/MYANMAR-ROHINGYA/010060630DW/index.html

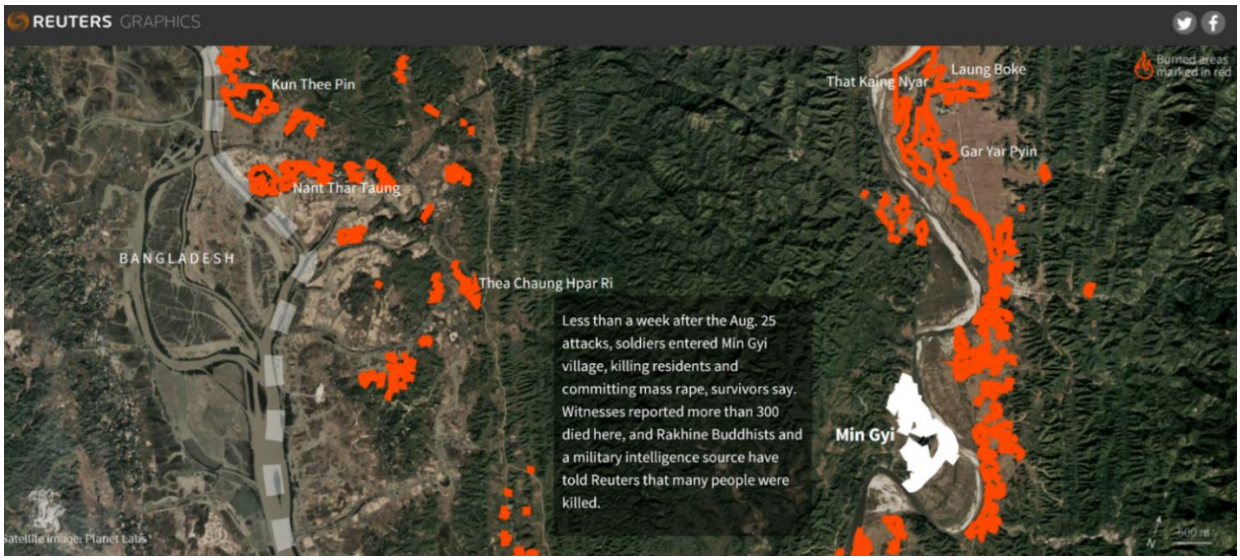
Satellite imagery has also become a compelling centrepiece for visual storytelling, the key element that anchors layered, multi-media reports. Thomson Reuters has published several outstanding examples of this genre.

Thomson Reuters is the largest news agency in the world with more than 2,500 journalists in 190 countries. Nonetheless there are still places the organisation struggles to access. The agency graphics team publishes up to a dozen news information graphics or data visualisations a day. Singapore-based Deputy Head of Graphics Simon Scarr says satellite imagery plays an increasingly important role in providing a window into remote or restricted locations. The agency has agreements with both DigitalGlobe and Planet, and Scarr says both companies have proved capable of meeting difficult requests and tight news deadlines.

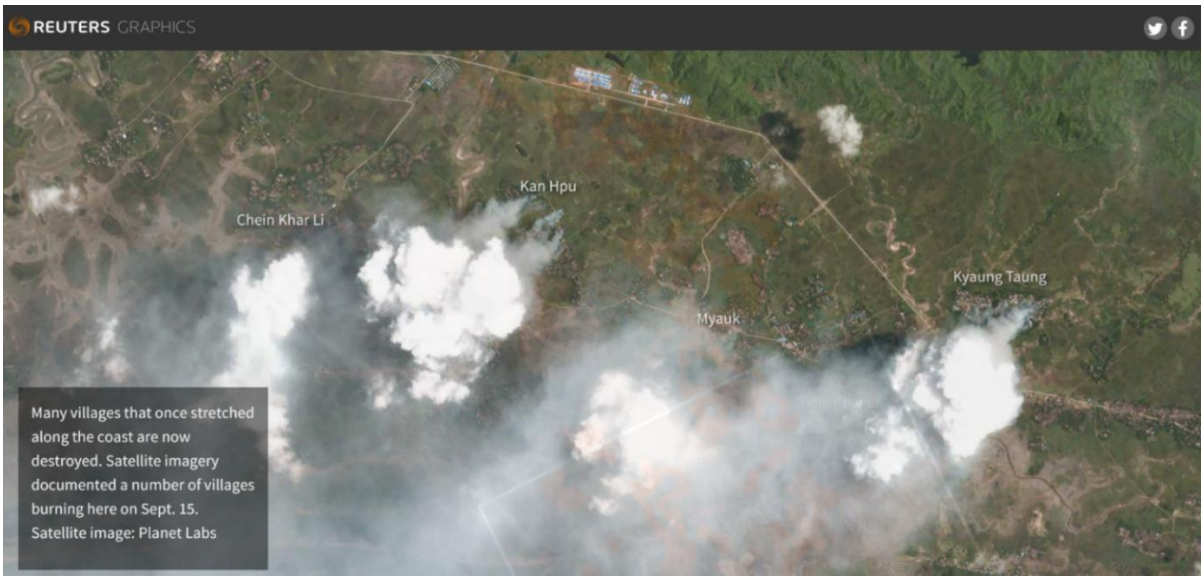
“We usually get a response within the next 24 hours and this can usually include the imagery we are looking for. Sometimes it needs a little more work on their side and could take a day or two. The speed in which our requests are dealt with is fantastic”.

In December 2017 Thomson Reuters published ‘Burned to the Ground’, a special report utilising satellite imagery and data to document the persecution of the Rohingya Muslim

minority living in Burma's Rakhine state. Multi-layered projects combining graphics and satellite imagery are highly labour intensive, and this project took nearly 3 weeks to complete, amid competing daily news demands. The story team comprised Simon Scarr and graphics journalist Weiyi Cai as main authors, with additional editing and fact checking from the Thomson Reuters Myanmar bureau and a Singapore-based news editor.



(Image – Planet Labs/Thomson Reuters)



Simon Scarr: "For this particular project we pulled composite imagery from Planet's Explorer interface. We did speak to Planet about one high resolution image we were aware of. It shows a cluster of villages as they were burning on Sep. 15. They provided the image later that day and we used it in the project"
(Image - Planet Labs/Thomson Reuters)

The team also accessed data from MODIS and VIIRS sensors on NASA's Terra and Aqua satellites that scan the Earth surface for fires each day. The older MODIS sensor has a 1,000m resolution, while the newer VIIRS has 375 metre resolution. And while they may not

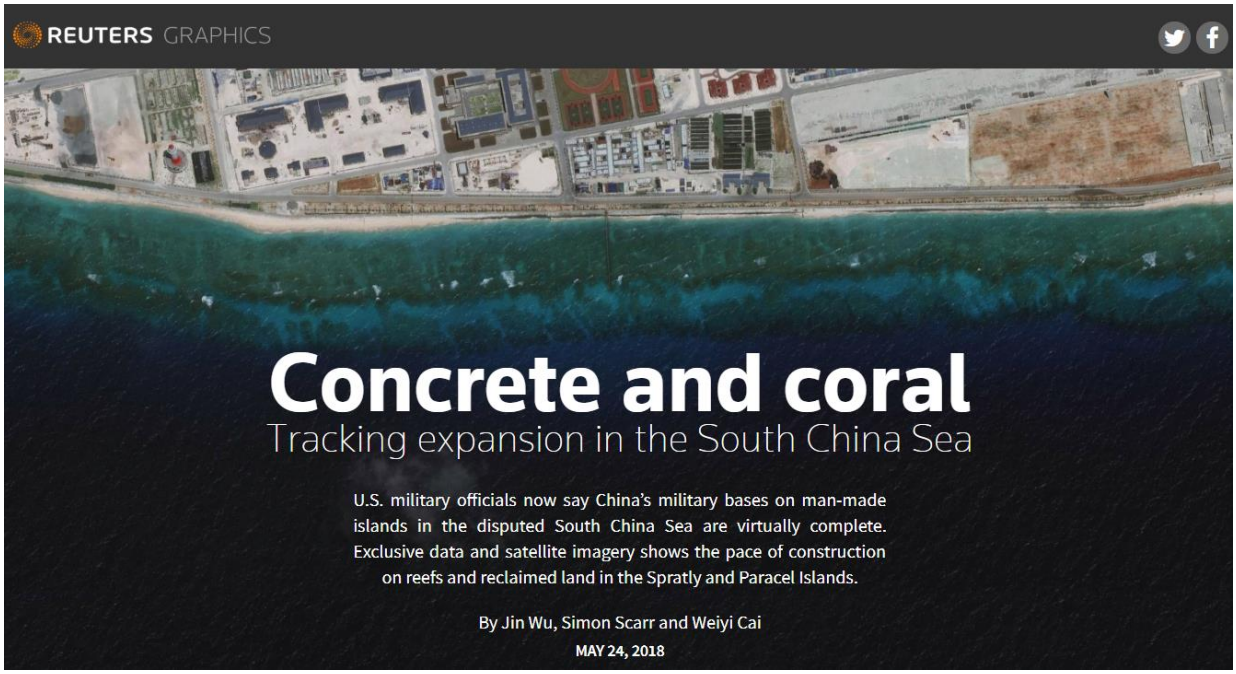
be suitable for close up imagery, the systems are ideal for detecting fires (UN, 2015). For the Burned to the Ground project, the data was processed by the UN Operational Satellite Applications Program (UNOSAT).

"We've used data from these sensors to visualise active fire hotspots. This was valuable when first reporting on this story back in late August and September (2017). Fires and thermal anomalies are just one of many subsets of data available from these valuable instruments," notes Scarr.

The burning of the village of Inn Din illustrates the Rohingya-Buddhist divide. Thomson-Reuters reported that Rohingya areas (marked reddish-brown, bottom of image) were completely reduced to ashes while the Buddhist area remained intact. Myanmar's army said security forces discovered a mass grave on the edge of the village. (Image DigitalGlobe/Thomson Reuters)

Simon Scarr says layering up the data and satellite imagery was actually the easier part of the project. The most difficult element was determining the sequence of events that took place on the ground and attributing that information correctly.

II. ‘Concrete and Coral – Tracking expansion in the South China Sea’



Link: http://fingfx.thomsonreuters.com/gfx/rngs/CHINA-SOUTHCHINASEA-BUILDING/010070760H9/index.html

Building on the success of projects such as Burned to the Ground, published in December 2017, Simon Scarr felt future satellite-based stories could be further enhanced by involving industry experts highly skilled in the analysis of visual data (Torode, 2018).

One of the most difficult stories to access and report is China’s military build-up in the South China Sea – an extensive complex of military bases being constructed on a chain of man-made islands, well away from the prying eyes of journalists.

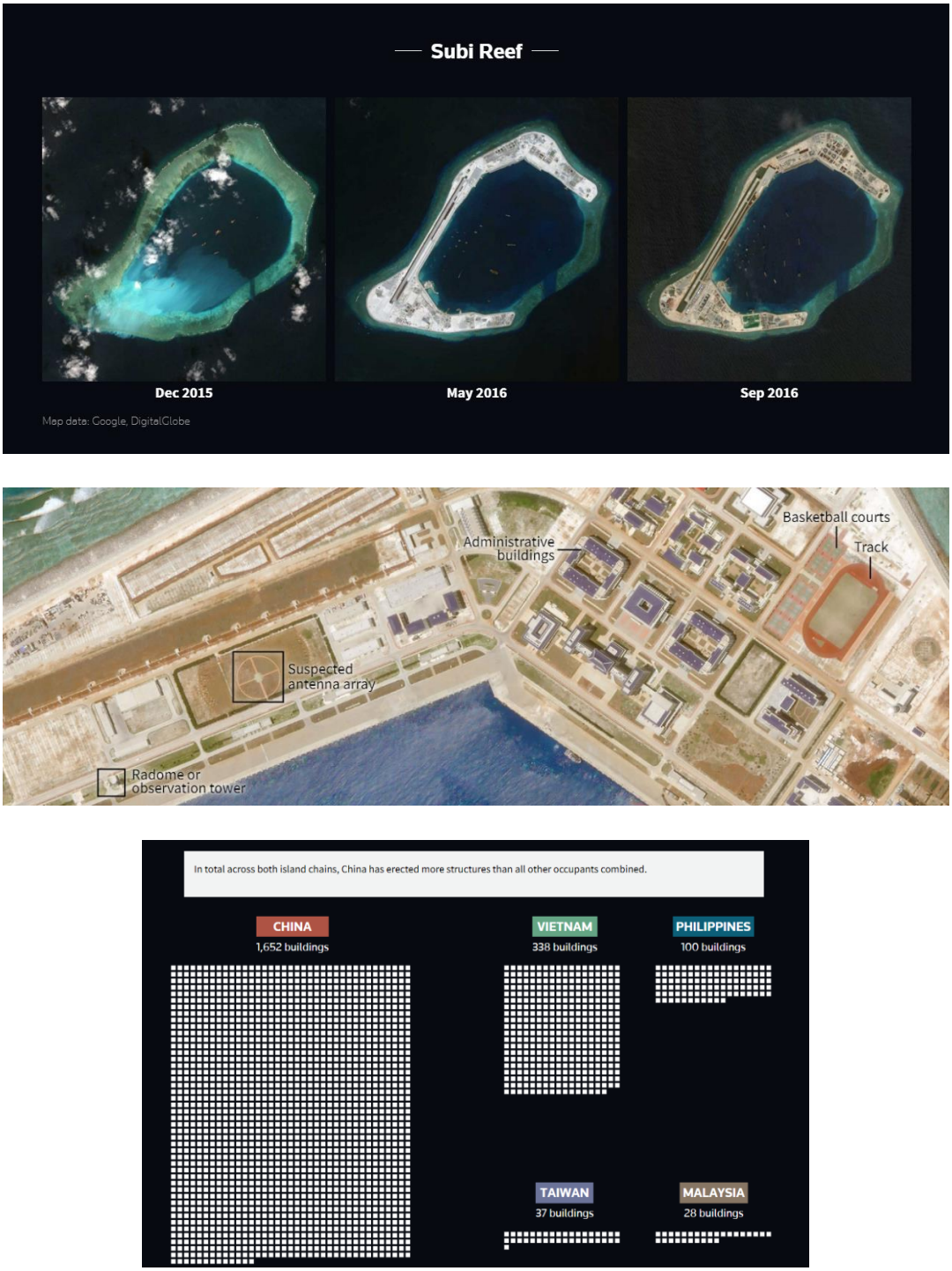
Scarr engaged the services of US-based Earthrise Media, an independent non-profit group supporting independent media to obtain and analyse imagery from commercial satellite companies (Earthrise, 2018).

Utilising satellite imagery for journalism can be a deceptively complex task (see Making sense of it all – Calling tech support). In response to a growing demand, a number of expert non-profit groups, including Earthrise, have emerged that are prepared to assist journalists with accessing the right satellite images for a story and the technically challenging job of analysing the visual data.

With US military officials saying China’s extensive project was nearly complete, Scarr asked Earthrise to analyse the scale of construction by counting buildings on China’s seven bases on the reefs and reclaimed land of the Spratly and Paracel Islands.

Earthrise spent six weeks “digitally scrutinising hundreds of images dating back to 2014 when China started rapidly building up those islands. Reuters journalists checked the data with a range of military and academic contacts” (Torode, 2018).

On a spreadsheet confirming extensive construction across the area, Reuters reported that one location stood out – Subi Reef - where nearly 400 buildings had been erected, far more than expected, and double the scale of construction on other islands (Torode, 2018).



Concrete and coral satellite imagery and info graphic of construction (Images- DigitalGlobe/Google/Reuters)

"It was great data to have and it really helped us build-up the webpage with imagery and information from other sources too" Scarr notes.

The satellite imagery, sourced from both Planet and DigitalGlobe, and Earthrise data analysis anchored the final Concrete and Coral package that was researched produced by Reuters journalists in Hong Kong, Beijing and Sydney.

The story provided a compelling challenge to Beijing's narrative that construction was "mostly civilian". The type and scale of new building on Subi and two other main islands matched military bases in China, and included "emplacement for missiles, 3km runways, extensive storage facilities and a range of installations that can track satellites, foreign military activity and communications" (Torode and Scarr, 2018).

Fake News in Space? Authentication of third party imagery

"In a world where there's so much misinformation and propaganda that can go around the world at the speed of light…journalists find it really helpful to know that if we collect it and it's our imagery, our name is on it and we stand behind the veracity of what that image shows"

Turner Brinton
DigitalGlobe

In 2018 no major media organisations were independently operating Earth observation satellites. The external provider market was dominated by two US companies: Planet Labs and DigitalGlobe, with Europe's Airbus Space and Defence also contributing content. This dependence on third parties for the provision of news material raises issues of authentication, interpretation and, potentially, censorship.

How can journalists independently validate images provided by commercial satellite companies? And what are some of the complexities involved in interpreting the imagery and related data?

And in times of war, what happens if US national security interests and the reporting requirements of news gathering organisations are in conflict? American satellite companies are required under US law to obey any directives to restrict or withhold imagery deemed counter to the national interest.

A decade before the 'satellite revolution', Major Sean McKenna, the author of a prescient 2006 US Air Force paper *"The Final Frontier: News Media's Use of Commercial Imagery During Wartime"* anticipated these potential complications and cautioned journalists against being seduced by the new technology:

"Misinformation and manipulation have been problems the news media have confronted from the beginnings of their existence. Whether the image or information came from outer space or from some stranger on the street, the prudent and responsible action is to confirm the information before reporting it. The media's social responsibility theory to provide truthful, comprehensive and intelligent information holds just as true with satellite imagery as it does with any other form of photography" (McKenna, 2006a).

Buyer beware, was the message. So, what is the likelihood of a commercial provider withholding or altering imagery, or providing misleading analysis without informing the media client?

"At the end of the day it boils down to you have to trust us" says Turner Brinton, head of DigitalGlobe's Maxar News agency that co-ordinates the provision of news imagery.

"If we were to alter our images or provide something that was inaccurate in some way we would lose all credibility

"We see fairly regularly the US Government releasing our imagery as a truly independent source. Following the Syrian missile strikes…we were collecting imagery on their behalf. We have a large contract with the US National Geospatial-Intelligence Agency. They released our imagery to show exactly that the nature and precision of those strikes" he adds.

"People came to us and they wanted to know, 'Do you stand behind this imagery? Is it as the government says it is?' We said, 'Of course it was, that's the original source imagery, it shows exactly what happened'" (Interview 2018).

Eliot Higgins, founder of citizen journalism investigative group Bellingcat (see Bellingcat case study) concurs;

"If anyone finds out any of their images have been doctored, then their reputation's effectively, completely destroyed forever. It will be terribly bad business for them to do that" (Interview 2018).

Higgins' group makes extensive use of commercial and government-supplied satellite imagery in their investigations. Self-taught at imagery analysis, with six years' experience, he finds verification of new satellite imagery relatively easy by cross-checking through open sources. He compares new imagery against archival satellite images, social media posts and other geo-linked material that provide a ground-based perspective. He's not aware of a commercial provider altering material, but Higgins says recent satellite imagery provided by the Russian Government failed that test:

"We have seen cases where Russia has spiked satellite imagery. Once the face is exposed, that's a black mark on whoever does it, forever…Anytime Russia publishes satellite imagery now it's completely untrustworthy, and …if Russia makes a claim or publishes satellite imagery, the first thing I do is check if that satellite imagery is genuine" (Interview 2018).

He points to imagery distributed after the 2018 nerve agent poisoning in the UK of a former Russian spy and his daughter. Moscow claimed the imagery showed new construction at a British chemical weapons facility – falsely implying the British Government involvement in the nerve agent attack:

"(in) the Skripal (UK nerve agent attack) case, they were trying to claim that there was this new building. That never happened. They misstated satellite imagery to make their case. And that was provable within five minutes" (Interview 2018).

Bleddyn Bowen is space security policy specialist at the University of Leicester and founder in 2017 of the UK Astropolitics Collective, a group of British academics who believe "space is about more than just rocket science". The collective aims to place greater emphasis on the political, economic and cultural consequences of space development (Astropolitics, 2018).

Bowen says a greater plurality of commercial imagery providers across more countries can assist journalists in both validating images and holding governments to account;

"You just need to understand who each provider is and what their relationship is in whichever country they're registered in. If you're going to be relying a lot on DigitalGlobe, then you need to understand, what is its exact relationship with the US Government.

"You just have to do your own intelligence work as (a media) industry there and get to know where you're getting your images from because there's no technical or legislative solution to that problem.

"That's not raw data you're getting. You're getting something that you've chosen to buy and has been made available for you to buy as well, so there's been choices made before you have access to that" (Interview 2018).

Interpretation of imagery – is seeing believing?

Satellite companies and imagery-skilled journalists agree that a far greater risk lies not in deception, but in journalists misinterpreting the data – an error that can destroy the credibility of a story. Historically, there have been notable examples where the media got it wrong, as the 2006 US Air Force study noted:

"One classic error occurred following the 1986 Chernobyl nuclear reactor disaster, when one of the major networks interpreted the infrared image's display of vegetation as raging fires simply because the vegetation appeared as red on the photograph. Another occurred when a British television news report aired a satellite image of a deadly 2003 North Korean train disaster when in fact the image was of a fire in Iraq taken a year earlier" (McKenna, 2006a)

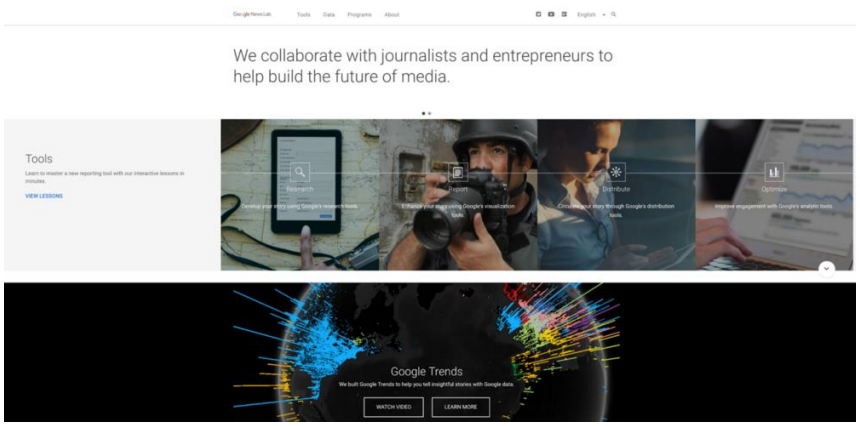
In the Botswana case study, a team of investigative journalists utilised satellite imagery to expose a massive illegal construction program at a compound owned by the country's President. When the journalists realised the complexity of the task they consulted a local topographer with satellite expertise, a decision that journalist Ntibinyane says prevented a disastrous mis-interpretation of the data that would have destroyed the credibility of the investigation (Interview 2018).

Satellite companies' policies differ on the provision of analytical support. DigitalGlobe provides in-house imagery analysis to selected media partners, while Planet supplies just the imagery, leaving analysis and interpretation to external experts engaged by the journalist. Some major media groups such as the New York Times have taken the capability in-house, by hiring imagery experts to join their investigative journalism and digital media teams.

Making sense of it all – Calling tech support

"We are moving from a world of data scarcity to a world of data abundance. So just have big is this rising tide? If we attempted to manually exploit the imagery we will receive over the next 20 years, we would need eight million imagery analysts"

Robert Cardillo
Director,
US National Geospatial-Intelligence Agency



Google: "Technology has made journalists jobs infinitely more complex…Two million blog post are written every day. 300 hours of video are uploaded to YouTube every minute. The world is awash with information" (Image – Google)

Utilising satellite imagery for journalism can be a deceptively complex task. The volume of data, while not comparable to the "rising tide" now immersing America's satellite spies, can still be overwhelming. Imagery has to be acquired by satellites, the raw data transmitted to ground stations for processing, analysed, then distributed to clients.

In response to growing demand from journalists, non-profit satellite industry organisations, Google, scientists and journalism educators are intensifying efforts to run media workshops on understanding the technology and skills required to exploit visual data. These workshops range from introductory sessions, through to more complex training that frames satellite journalism as a subset of the burgeoning 'data journalism' field.

In the United States, Columbia University's Tow Centre for Digital Journalism, the Center for Investigative Reporting, and the Global Investigative Journalism Network have all actively educated journalists on the technology and its applications.

"A picture can tell a thousand words, but it doesn't say the same 1000 words to the same people. You won't know what to look for, especially low-resolution images can deceive the eye. You need training and skills to able to tell you what the pixels are actually saying"

Bleddyn Bowen
Leicester University
The UK Astropolitics Collective

UK-based citizen journalism group Bellingcat runs workshops and has published a digital guide on investigative tools and how to conduct open source verification (Bellingcat, 2018a). Founder Eliot Higgins is keen to expand the citizen journalism model:

"*Bellingcat is training journalists in Lebanon in Palestine and all over. We're training journalists in Yemen and Iraq and all over the place. You're only going to see the use of this investigation spread"* (Interview 2018).

Non-profit organisations are also prepared to assist. US-based SkyTruth, an environmental group that utilises satellite imagery to monitor threats to natural resources, supported the Associated Press Pulitzer Prize-winning investigation 'Seafood Slaves" (SkyTruth, 2018).

Another American non-profit, Earthrise Media, partners several media groups including Thomson Reuters, NBC and the San Francisco Chronicle. Earthrise asks why commercial satellite imagery use should be dominated by the defence industry and commodity traders. The group's philosophy is to leverage "the half-trillion dollar investment in Earth observation satellites to surface environmental stories that are otherwise left untold and unseen" (Earthrise, 2018). Earthrise estimates that globally, there are between 100-200 stories each day that can be materially enhanced with satellite imagery.

Radiant.Earth is a Washington DC-based non-profit, whose funders include The Bill and Melinda Gates Foundation and the UK Space Agency. Specialising in applying satellite expertise to global development issues, Radiant.Earth also supports media projects. (Radiant.Earth, 2018).

Google no longer directly operates satellites, since selling its Skybox constellation to Planet in 2017 in a partnership deal that gives Google access to Planet's imagery. Nonetheless Google 'developer advocate' Christiaan Adams extensively supports journalists through the Google News Initiative and Google Earth Outreach programs (Google, 2018a, Google, 2018b);

"I help provide timely imagery for major disasters and news events. This includes working closely with the Google News Initiative to provide geo, imagery and online mapping expertise to journalists around the world" (email, 2018)

Adams says the most important free imaging tool for journalists is the Google Earth Engine, which is often also used by scientists and researchers;

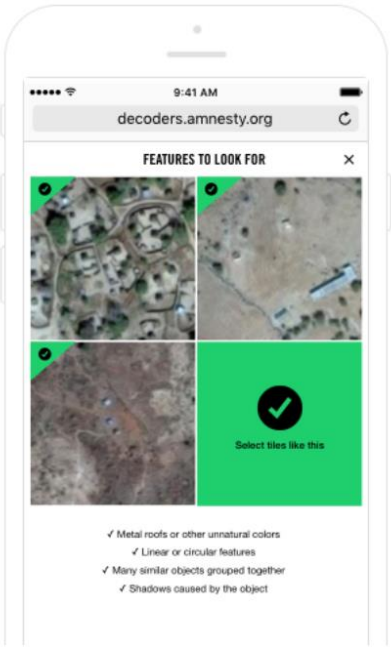
"Earth Engine includes a cloud-based repository of public satellite data (Landsat, MODIS, Sentinel, etc.) and other Earth observation data, co-located with massive computing power in our data-centres, and a browser-based API where anyone can perform very powerful and fast remote sensing analysis, machine learning image processing, and other types of analyses" (email, 2018)

Crowdsourcing

While satellite companies are developing a variety of automated analytics platforms that will greatly enhance the image interpretation process, for journalists in 2018 the task was still largely a labour-intensive process.

Crowdsourcing may be one solution for time-poor journalists working with limited resources. Human rights groups have refined successful crowdsourcing campaigns, harnessing volunteer labour to sift through large amounts of imagery data. In October 2016, Amnesty International called for 'digital volunteers' to join the 'Decode Darfur' project to map remote and vulnerable villages in Darfur. According to Amnesty, people had been shot while fleeing, raped, even subjected to chemical weapons attack (Amnesty, 2016a).

28,600 volunteers from 147 countries examined 326,066 square kilometres to provide data for a second Amnesty Decoders crowdsourcing project to identify home and schools in Darfur that were being destroyed (Amnesty, 2016b).



Human rights satellite crowd sourcing the 'Amnesty Decoders' (image –Amnesty International)

The crowdsourcing technique was also employed in a campaign organised by DigitalGlobe in the unsuccessful 2014 search for missing Malaysian Airlines flight 370. More than 8 million volunteers examined a search area of 340,000 square kilometres of the Indian Ocean that

was subdivided into map tiles, each one-eighth of a kilometre square. All tiles were reviewed by several people and volunteers were encouraged to tag any signs of wreckage. Some of the 18 million tags were submitted for further review by analysts, but the majority were assessed by computer programs (Partyka, 2015).

Can too much information be a bad thing? One expert worries that human rights investigators and journalists risk being swamped by the rapidly rising tide of data. Keith Hiatt, Director of the Human Rights and Technology Program at UC Berkley told the Columbia Journalism Review:

"There's little doubt that the use of new data is growing as part of reporting conflicts and human rights abuses. For journalists reporting during a humanitarian crisis, these sources provide relief by verifying facts and gathering information quickly and, more often than not, reliably. In the face of new and exciting ways to uncover human rights stories, however, there are also new challenges. As human rights reporting has changed drastically in a digital age from old-fashioned street reporting to work far more reliant on sophisticated data, there is a struggle to use these technologies in a smart, safe way"(Rajvanshi, 2016).

While acknowledging the capabilities of these extraordinary new newsgathering tools, Hiatt notes that there is no real substitute for 'ground truth'.

For one, the increasing reliance on open-source materials means that journalists do not always use witness testimony or boots on the ground, especially in high-conflict areas like Syria and Ukraine. Instead, the use of compelling evidence compiled by human rights organizations and citizen evidence on the internet is often seen as enough" (Rajvanshi, 2016).

Satellite companies and US Intelligence

> *"I don't think either one would be viable without NGA (US National Geospatial-Intelligence Agency) contracts, but each year they get better at selling imagery to commercial clients"*
>
> Mark Brender
> US Satellite imaging industry, executive consultant

As media organisations and individual journalists build relationships with the satellite industry it is useful to explore the close bonds and dependence of the commercial satellite industry on US military and intelligence contracts.

Earth imaging satellite companies are endeavouring to diversify their client base across a range of industries and also provide pro-bono support for human rights and environmental groups. Nonetheless the key 'anchor customer' remains the US Government, and the most lucrative client in Washington is the National Geospatial Intelligence Agency (NGA).

Dubbed America's "biggest spy agency you've never heard of", Barack Obama was reportedly five months into his presidency before he was made aware of the NGA's principal mission to collate and interpret satellite and drone imagery from around the world (Bamford, 2017).

The Agency has 14,500 civil and military employees and an estimated annual budget exceeding $5B USD (Corcoran, 2017). Two thirds of NGA's staff are based at the agency's enormous new headquarters in Springfield, northern Virginia. Leading US investigative writer on intelligence issues James Bamford summarized the NGA's mission;

> *"The NGA is to pictures what the NSA (National Security Agency) is to voices. Its principal function is to analyse the billions of images and miles of video captured by drones in the Middle East and spy satellites circling the globe. But because it has largely kept its ultra-high-resolution cameras pointed away from the United States, according to a variety of studies, the agency has never been involved in domestic spy scandals like its two far more famous siblings, the CIA and the NSA"* (Bamford, 2017*).*

Counter-terrorism is a key NGA activity, and the agency takes great pride in its role in locating Osama bin Laden's final hide out. A scale model of the Pakistan compound, where bin Laden was killed by US Special Forces in 2011, is displayed at the agency's headquarters.

In addition to its intelligence tasks, the NGA is also heavily involved in civilian support for mapping, navigation, scientific research and providing imagery assistance during natural disasters.

NGA's goal of 'persistent surveillance of the planet' is rapidly becoming a reality through the contract support of civilian imagery companies and the NGA has vigorously expanded these links with the commercial imaging world. In 2016, the NGA was DigitalGlobe's 'anchor' customer, providing 55% of the company's business (Denis et al., 2017), although since DigitalGlobe's subsequent acquisition by Maxar Technologies, that total percentage has been reducing.

As noted by Space News, the NGA's lucrative commercial imagery program 'Enhanced View' has one major contractor – DigitalGlobe:

"The agency in 2010 awarded DigitalGlobe and GeoEye $3.5 billion and $3.8 billion contracts respectively in a 10-year deal. DigitalGlobe acquired GeoEye in 2012 and now is the primary supplier of imagery to NGA" (Erwin, 2018a).

DigitalGlobe – Defence & Intelligence Programs product page (Image – DigitalGlobe)

DigitalGlobe already faces modest but growing competition from the disrupters for the lucrative intelligence market. In 2017 Planet was awarded a $14M one-year contract with the NGA, following a successful 7 month $20M pilot program (Henry, 2017). And as Mark Brender notes, DigitalGlobe's key multi-billion-dollar contract is up for renewal within two years:

"and it's going to be very interesting to see what happens once that mega contract is over, and if the NGA initiates multiple smaller contracts with companies like Planet" (Interview 2018)

So why does the vast US intelligence establishment, with the world's most sophisticated spy satellites, do business with a Californian start-up operating a fleet of shoe-box sized 'Doves'? The answer, according to Planet's Head of Data Visualisation Robert Simmon, is frequency:

"They get basically what the strength of Planet is, and that is that frequency - that every single day. So presumably the US military has a relatively small number, say 5 to 10 very high-resolution satellites. They can only look in one place at a time and so that's a really big limit on what they can observe, and with Planet Labs you get this much coarser view, but you're going to get it everywhere, every day" (Corcoran, 2017).

Interviewed in 2017 by the Australian Broadcasting Corporation program *Foreign Correspondent*, NGA Director Robert Cardillo enthusiastically endorsed Planet:

"Planet's advantage, in our view, and the reason why we've contracted with them to begin to explore what we could learn, is the fact that they repeat their sensing of the planet in a way that no-one else does today, at least not at that magnitude. I have to tell you, for somebody in my profession that's very exciting" (Corcoran, 2017).

The NGA subscribes to "Planet imagery coverage over specific countries... such as Iran, Syria, Iraq, North Korea, South Sudan as well as number of countries in South America". Planet emphasises that this contract doesn't constitute specific targeting by the company, as NGA is buying access to Planet's daily global imaging database (correspondence with NGA and Planet, 2017).

The NGA's head of commercial imagery, John Charles, says another key advantage in using Planet and DigitalGlobe imagery is that it it's unclassified, making it much easier for the NGA to share than images from highly classified reconnaissance satellites or drones;

"We are an intelligence agency and we certainly build products, of all types out of all of our sources, but the raw material that we get from the commercial imagery providers, such as our traditional partners, DigitalGlobe and their predecessors, is always unclassified. We're able to then share it with our foreign partners, coalition operations for humanitarian and disaster relief with non-governmental organisations" (Interview 2017)

Wrangling ever-increasing mountains amounts of satellite data is proving to be a challenge for both the private sector and intelligence gatherers. In 2018 Planet signed another contract to conduct analytics research for the NGA – looking for ways to shorten response times of "high value assets" i.e. spy satellites and drones, to closely investigate targets that may be flagged in Planet's lower-resolution global sweeps.

"NGA is the expert in geospatial analysis with decades of data, processing, and analysis. By partnering with Planet, they get access to foundational analytics that could transform their workflow and coupled with their data can extract early indicators and warnings to better respond and allocate their high value assets," announced Planet co-founder Robbie Schlinger (Marcus, 2018).

Intelligence Gathering-NGO-Media convergence?

The NGA has long pursued Public-Private Partnerships (PPP) with industry, not only to bolster intelligence gathering capabilities, but to also boost aid to civil society capabilities in scientific research, mapping and navigation (Clark, 2017).

In 2018 the agency sought to extend these civil partnerships to Non-Governmental Organisations (NGOs) specialising in investigation of human rights abuses. NGOs such as Amnesty International sift through a wide range of commercial and government supplied imagery seeking tell-tale signs of war crimes such as burned-out villages or freshly dug mass graves, which provide valuable evidence to war crimes investigators at the International Criminal Court. Amnesty also encourages public participation in crowd-sourcing of imagery.

The NGA initiative was first reported in a 2018 *Foreign Policy* report "US Spies to Partner with Human Rights Groups to Keep an Eye on North Korea". The magazine detailed NGA's intention to "provide raw imagery, expert review and the use of an already developed digital app and publishing platform to several non-profit organizations and think tanks" (Mclaughlin, 2018).

The NGA partnerships will focus on human rights abuses in North Korea – at a time when the administration of US President Trump is diplomatically grappling with the Pyongyang regime over dismantling North Korea's nuclear program.

This development is also highly significant for the media as human rights NGOs routinely share their satellite-based research and imagery analysis with journalists. As *Foreign Policy* notes: "The intelligence community often publishes declassified historical information, but that can take years. Doing something with current imagery is something new" (Mclaughlin, 2018).

Should this trend of mutually-beneficial satellite collaboration be defined as intelligence gathering, open source human rights research, newsgathering, or a combination of all these elements? In the converging worlds of satellite imagery, the boundaries are becoming blurred.

The Space Race for News – Censorship, control and complacency

'Democratisation of technology' and 'radical transparency' are the declared principles of a new generation of Earth observation start-ups, although these declarations need to be balanced with one important factor: government control.

While many countries restrict satellite access to varying degrees, this chapter focuses on the US Government because American companies still dominate both the media market and the broader international Earth observation sector. Often, other countries set their policies based on what the US does.

The recent increase in third-party provision of imagery has, to date, proved highly successful for both satellite companies and major media outlets. The US commercial space industry is governed by several agencies, with the National Oceanic and Atmospheric Administration (NOAA) responsible for licensing and controlling the activities of commercial Earth observation satellites under the Land Remote Sensing Act of 1992 (NOAA, 2018).

Both Planet and DigitalGlobe will decline media requests for imagery, if they are deemed to be in breach of licensing agreements under US law as Robert Simmon, Planet's head of data visualisation, elaborated;

"We're only allowed to sell to the people that the US Government grants us a licence to. So, there are some obvious countries that are not allowed to buy the data, if you have ties to a terrorist organisation you'd be on the forbidden list. So we actually count on the US Government to identify the bad actors and then we will abide by those rules one hundred per cent" (Corcoran, 2017).

Turner Brinton, head of DigitalGlobe's Maxar News Bureau, says his company has refused to support media requests determined to be counter to US national security interests or "frivolous" and cites two examples;

A request to monitor the development of a new US military installation and military operation, and;

A request to look at the many properties owned by a celebrity for a "frivolous purpose".

"We try to support projects that are meaningful. We don't want to be the paparazzi from space," says Brinton, declining to provide further details.

This limited form of editorial control over the supply of third party content appears to be a workable compromise, particularly when coverage of major international events in hotspots such as North Korea, Syria, Ukraine, the South China Sea and Myanmar is generally favourable to US Government interests.

Nonetheless as Eliot Higgins, founder of citizen journalism investigative group Bellingcat asks, what will happen when the international news agenda turns to issues that significantly embarrass Washington, or are deemed counter to US national interests?

"...and it's going to be interesting when we start seeing if that focus is on Israel and Palestine and Yemen and other countries, where the West and its allies might not want so much close attention paid to it" (Interview 2018).

"Precise pictures from space will revolutionise television news, both by freeing reporters from relying solely on government-provided information and by freeing viewers from relying solely on what reporters tell them" (McKenna, 2006a)

Mark Brender, ABC News Producer
Testimony to the US House of Representatives,
Subcommittee on Space and Aeronautics,
July 24, 1996

Satellite-based news reporting is a good idea that's been a long time coming, according to Mark Brender, who has enthusiastically advocated satellite news-gathering for more than three decades. The former US Navy Public Affairs Officer worked for the US ABC network for 18 years as an assignment editor, producer and radio correspondent, before joining satellite company Space Imaging in 1999, where he rose to become Vice President.

As a former journalist and satellite imaging corporate consultant, Brender is uniquely placed to provide historical context to the politics and tensions between the US intelligence community, satellite companies and media groups now shaping the nascent satellite journalism world.

In the beginning

It was in 1960, during the darkest days of the Cold War, that the first US military reconnaissance or spy satellite Corona was secretly launched. It was capable of imaging Soviet military activities down to a resolution of 7.5 metres (CIA, 1995). Classified multi-spectral photography and infra-red systems were also developed to see in the dark and detect camouflage (McKenna, 2006a).

Satellite imagery was a strategic asset. The civil capability, when it emerged, would never be permitted to match cutting-edge military satellites.

Publicly-accessible remote sensing was launched in 1972 with NASA's Landsat, with a much lower resolution of 80 metres per image pixel, although by 1980 this had improved to 30 metres (McKenna, 2006a).

Until this time, the media publication or broadcast of imagery largely relied on declassified, often blurred or obscured spy satellite pictures, usually released by Washington or Moscow to underscore developments in a major military conflict or diplomatic dispute.

Brender quickly realised the potential of commercial Earth observation satellites for journalism, and he proposed to launch a satellite dedicated to news-gathering, but the project was grounded by a lack of funding;

"I created a company in 1984 called MediaSat International Inc. and I felt one day there'd be a media consortium or a media company that would want a competitive edge. They'd get access to satellite imagery over areas of breaking news on Earth and get it first. But I'm not an Elon Musk or a Bill Gates or a Steve Jobs that will just go and fund a satellite, so there never was a MediaSat" (Interview 2018).

Brender also had trouble selling the concept to his news executives, whom he says didn't appreciate the value of satellites as an integrated news-gathering tool;

"And I hate to say it, but there was very little intellectual curiosity by the news media at the executive level to better understand it. Especially as (the staff supporting satellite-based news stories were) buried down in the IT department, or the computer department, or the graphics department" (Interview 2018).

With Brender's project grounded, it was left to a French company SPOT (Satellite Pour l'Observation de la Terre), to launch the world's first commercial imagery satellite in 1986, with a resolution of just 10 metres, capable of "clearly photographing a sports stadium".

"It was through SPOT that international media first began to make significant use of remote sensing. In April 1986, news agencies around the world used SPOT and Landsat images of the Chernobyl nuclear disaster region to show television viewers out-of-control fires and spreading radiation in an area sealed off for a 100-mile radius"(McKenna, 2006b).

SPOT's images were expensive, and logistically complex to co-ordinate. In his paper "*Satellite imagery, the ethics of a new technology"* Adam Powell notes that Brender, working as an ABC news producer, quickly capitalised on the opportunities created by SPOT;

"ABC World News Tonight began showing pictures of secret military installations in North Korea, weapons plants deep inside Iran and mysterious laboratories in the Russian heartland" (Powell, 1998).

The US Government was willing to permit media experimentation with this new tool, as long as the satellite stories didn't threaten America's perceived national security interests.

During the 1991 Gulf War, as the US-led coalition massed in the Saudi desert preparing to attack Saddam Hussein's forces, SPOT declined to sell images to the American ABC network and all other clients, "amid reports the United States suggested it might disable the SPOT cameras with lasers if they tried to televise the battle" (Powell, 1998).

Following the end of the Cold War, the US relaxed controls on commercial satellites and embarked on an 'Open-Skies' policy. The passing of the 1992 US Land Remote Sensing Policy Act enabled American companies, for the first time, to commercially operate Earth observation satellites (Florini and Dehqanzada, 1999).

Tim Brown, a US researcher specialising in commercial satellites with GlobalSecurity.org told World Politics Review this policy change was primarily a strategic move to maintain control of the emerging civil sector:

> *"The law was meant to encourage firms from the US space industry that built the reconnaissance satellites of the Cold War to enter and saturate the market, thereby deterring foreign firms from doing so. That way, the US would not face significant foreign competition or threats to its security. The logic was, 'If we build it first, they won't come'"*(WorldPoliticsReview, 2011).

America launched what was then the world's most powerful commercial high-resolution satellite, Ikonos, in 1999. Operated by Colorado based Space Imaging, a company that was ultimately absorbed by DigitalGlobe, Ikonos offered an unprecedent leap in civilian capability, with imagery down to 1 metre resolution. While France's first SPOT satellite could identify a football ground, Ikonos could distinguish objects the size of a car or park bench.

But where media viewed opportunity, the US military and intelligence services saw a threat, and the solution to that threat was Shutter Control.

Shutter Control

Shutter control is the industry term for a regulation by which the US Government can restrict or prohibit the release of commercial satellite imagery due to foreign policy or national security considerations. Shutter control's primary intention is to prevent 'hostile players' from gaining access to imagery, but it undoubtedly serves a secondary purpose of preventing media access to information (Nardon, 2002, Jones, 2004). While Washington has never directly invoked shutter control, it did engage in what amounted to 'chequebook shutter control' in late 2001 as the US prepared to invade Afghanistan (McKenna, 2006b).

Concerned that preparations for Operation Enduring Freedom would be compromised, the Pentagon's National Imagery and Mapping Agency (NIMA) approached Space Imaging, operator of the one-metre resolution Ikonos, the only commercial satellite capable of detailing troop movements, to buy up exclusive rights to all imagery of Afghanistan and Pakistan for three months (McKenna, 2006a, LaFleur, 2003).

By this time, Mark Brender had left ABC and was an executive for Space Imaging:

> *"…and the Government called then-Space Imaging and said, "We want to buy all of your satellite imagery over Afghanistan and buy imagery collected from every orbital pass. We're not going to impose shutter control, but we're going to buy all of your product all the time". So, they did that, for about three months and spent about $8 million (USD), and finally*

someone said, "Hey, this is crazy". And so, all that imagery was then available for sale to the public" (Interview 2018).

By this stage, US-led forces had secured all the initial objectives in Afghanistan and the value of the imagery as news material had passed. Writing at the time in the UK *Guardian* newspaper, Duncan Campbell, a journalist specialising in intelligence issues, argued that the deal provided no military value beyond media censorship:

"The US military does not need the pictures for its own purposes because it already has six imaging satellites in orbit, augmented by a seventh launched last weekend. Four of the satellites, called Keyholes, take photographic images estimated to be six to 10 times better than the 1 metre resolution available from Ikonos" (Campbell, 2001).

Campbell concluded that the Pentagon sought a commercial solution rather than invoking shutter control, as a formal ban would have been challenged in court by US news organisations as a breach of press freedom, as guaranteed under the First Amendment of the US Constitution (Campbell, 2001). His analysis has been subsequently confirmed by Mark Brender (Interview 2018).

Barbara Cochrane then-President of the US Radio-Television News Directors Association (RTNDA) lodged a protest over the government action denying media access to the imagery;

"No news organization would risk the disgrace that would
come from putting out information that costs the lives of American fighting men and women.
No journalist worthy of the name would give away troop movements or strategic plans. Just as in previous military conflicts, journalists have already shown in this one [Enduring Freedom] that they will keep sensitive information secret until it can be safely disclosed."
(McKenna, 2006a).

And what Washington couldn't buy, it sought to control by diplomatic means. The US reportedly pressured France to withhold the release of high resolution commercial satellite imagery, with "President Bush, convincing the French Defense Ministry to ban sales of SPOT images over Afghanistan in 2001" (McKenna, 2006b).

However, by early 2003, as US-led forces massed to go to war against Iraq for a second time, the Pentagon's space censorship efforts were overwhelmed, as Israel, France, Japan and India had all launched a new generation of high-resolution satellites in quick succession. At the time Mark Brender noted the futility of continuing the 'buy-to-deny' approach;

"It would be difficult for the U.S. Government to enter into enough contracts to keep all that imagery off the shelf…and with 600 embedded journalists, why shutter control a commercial imaging satellite that's overhead every three days?" (LaFleur, 2003).

The Pentagon abandoned chequebook shutter control, and instead embraced the new capability. In a memo to the Pentagon satellite imagery agency NIMA, then CIA Director

George Tenet said: “It is (now) the policy of the Intelligence Community to use US commercial space imagery to the greatest extent possible” (LaFleur, 2003).

America’s spies wanted to harness the burgeoning commercial satellite sector, but according to Brender, there were tensions;

“The concept of outsourcing overhead imagery has been an anathema to the intelligence community for a long time.

“There are still those in the federal government who feel that commercial remote sensing is competitive to the capabilities of the spy satellites, though presumably the spy satellites have much better ground resolution. They're much more agile; they can pivot on an axis to shoot at angles and they can be lowered up and down to get higher resolution imagery. They weigh tons. They cost billions of dollars. But there are those in the government, the cold warriors, that still see so much value in spy satellite technologies, that they look at commercial satellite imagery as a stepchild” (Interview 2018).

But the nascent satellite imaging industry was a well-remunerated stepchild. In 2003-4 contracts totalling $1B USD were awarded to the DigitalGlobe and GeoEye companies to develop the next generation of commercial imagery satellites (McKenna, 2006b). This freed up the National Reconnaissance Office’s powerful spy satellites for more urgent tasks (Campbell, 2007).

While Brender states that the US satellite imagery industry is getting better at selling imagery to commercial clients, he notes that none of the companies would be economically viable without government contracts, primarily with intelligence and defence agencies. And this makes them vulnerable to another method of government censorship beyond ‘shutter control’ and ‘buy to deny’.

Brender says US officials have applied commercial pressure to satellite companies to keep imagery out of the public domain:

“There have been times the government has called the companies individually and said, ‘We'd prefer, as your biggest customer, for you not to image a certain part of the world for a certain period of time’. And it's done on the QT and it's down over the phone and it's done quietly, and the companies say OK” (Interview 2018).

He details one incident in September 2007, when he was a satellite company executive;

“I recall when Israel attacked a nuclear reactor in Syria when Bush was President. The government called both satellite imagery companies (DigitalGlobe and GeoEye) and asked them not to release any imagery publicly over the site”.

“And that was done informally”.

"And once the US talked about it, and it became knowledge that Israel did in fact attack that plant, then companies were allowed to release the historical imagery of it." (Interview, 2018).

Photos Show Cleansing of Suspect Syrian Site

By WILLIAM J. BROAD and MARK MAZZETTI OCT. 26, 2007

Satellite imagery of a facility in Syria collected on August 10, 2007, left, and October 24.
Satellite images from Aug. 10 and Oct. 24 by DigitalGlobe

On October 26, 2007 The New York Times publishes the first DigitalGlobe satellite imagery of the Syrian airstrike location - 50 days after the Israeli air raid destroyed a suspect nuclear facility at the location (Image – DigitalGlobe/New York Times).

Open Skies and the Israel lobby

While the United States has progressively relaxed restrictions on commercial high-resolution imagery in most areas, Washington is still prepared to impose satellite censorship on behalf of close ally, Israel.

Tensions first rose in 1992, when the United Arab Emirates applied to purchase imagery from a US firm. That application was ultimately rejected, reportedly after lobbying by Israel. In 1994, a US satellite company that has since merged with DigitalGlobe, applied to build a ground station in Saudi Arabia, which would have given the Saudis access to high resolution imagery of the entire region, including Israel (Zerbini and Fradley, 2018, Brunngraber, 2001).

In 1995, US President Clinton authorised the declassification and release of 860,000 high-resolution Cold-War era images, recorded between 1960-71 by the first-generation Corona spy satellites. Initial Corona imagery had a resolution of 12m, although technological advances later improved this to 1.8m (USGS).

Included in the Corona release was a detailed image of Israel's Dimona nuclear reactor, that was published on the front page of Israel's high-circulation newspaper Yediot Aharonot. Israel claimed national security was threatened by the release of the Dimona image, and intensified lobbying efforts to limit further disclosures. In 1997, the space industry was stunned when the US reversed the Open Skies policy by banning American companies from

distributing high resolution imagery of Israel and the Palestinian Territories (Zerbini and Fradley, 2018).

Israel's Dimona nuclear weapons production facility. Side by side comparison of Corona US spy satellite image from 1971, declassified in 1996, and the much lower resolution image by French commercial satellite SPOT, recorded in 1996 (Images – Federation of American Scientists/US Government/SPOT)

The Kyl-Bingaman Amendment

The ban was imposed under the Kyl-Bingaman Amendment (KBA) to the US National Defense Authorization Act. Named after US Senators Jon Kyl and Jeff Bingaman, who promoted the 1997 amendment, US satellite companies were restricted from providing imagery of Israel and the Palestinian Territories with a resolution greater than two metres. The amendment was still in force in 2018, and applies only to US companies, although, "as this country dominates the commercial market for satellite imagery, its impact is global" (Zerbini and Fradley, 2018).

In 2018, Oxford University archaeologists Andrea Zerbini and Michael Fradley called for the KBA to be overturned and for implementation of an Open Skies policy over Israel and Palestinian Territories. They advocated greater public access to high resolution imagery to locate and monitor archaeological heritage sites across the Middle East and identified at least six non-US commercial satellite operators capable of delivering sub one metre imagery of the region:

"Since 2012, the KBA has become increasingly anachronistic, as non-US satellite firms, utilizing ever more sophisticated satellite technologies, have begun retailing high-resolution imagery of Israel and Palestine" (Zerbini and Fradley, 2018).

Zerbini and Fradley's research highlights the growing ineffectiveness of the US policy. Rebuffed by American providers, imagery customers can simply shop elsewhere. They note that Google has simply chosen to ignore the KBA amendment:

"quiet resistance to US regulation, particularly from Google Earth, where high-resolution images covering areas of the West-Bank, Golan Heights and the border areas of Israel, provided by (European consortium) Airbus, are already available on the platform"(Zerbini and Fradley, 2018).

In July 2018, US commercial satellite regulations were under review, but there was no immediate indication that the KBA restrictions would be lifted. Former DigitalGlobe consultant Mark Brender sees no point in the industry directly taking on the US Government over the amendment:

"I think the commercial companies, because Israel is only 0.02% of the Earth's surface, they're not going to spend the time and effort to fight that law and get it changed. It's just not worth it to them to do that. And they realize that the law will eventually crumble anyway" (Interview 2018).

However, it's not just the US satellite companies that have struggled with the perceived national security threat posed by commercial satellite imagery.

In this image reproduced from Zerbini and Fradley's paper, dated 18 April 2016, Egypt is on the left of frame, Israel on the right, with the border closely following the yellow boundary line. Note the blurring effect on the Israeli side (Images courtesy of CNES/Airbus via Google Earth)

Google Earth, censorship and the CIA.

> *"So the next time you are exploring a new land from the comfort of your laptop or snapping pictures with your lithium-battery-powered digital camera, take a moment to think about some other ways CIA technology may have improved life outside its walls" (CIA, 2014)*
>
> 'CIA Impact on Technology'
> US Central Intelligence Agency website

There are numerous examples of late 20th century commercial technology that evolved from investment from US military and intelligence agencies, but perhaps few outside the defence and tech sectors would be aware that the prototype for the now ubiquitous Google Earth was developed with CIA funding. The official publication of the National Geospatial-Intelligence Agency (NGA) noted that in 2001, its predecessor organisation, NIMA:

"collaborated with In-Q-Tel, the CIA's private non-profit venture, to fund a start-up called Keyhole, a software development company whose signature application, Earth Viewer, superimposed maps onto satellite images.

NIMA immediately employed Keyhole technology to support US troops in Iraq. In 2004, Google acquired Keyhole, and in 2005 re-launched Earth Viewer as Google Earth" (Alderton, 2014)

Former US ABC producer and satellite industry executive Mark Brender believes this was good for journalism. In buying and upgrading Keyhole, he says Google propelled satellite imagery into the public consciousness as a consumer product and easy-to-access news gathering tool:

"It wasn't really until Google Earth, that came about in 2005, and Google Earth provided the commercial remote sensing industry a megaphone. It created a sonic boom that rippled through societies, and it gave journalists and people around the world a strong tailwind in the use of commercial remote sensing" (Interview 2018).

Google may be a pioneer of 'democratising technology', but the company was immediately accused by several governments of unwittingly enabling terrorism. Following Google Earth's 2005 launch, Lt. Gen. Leonid Sazhin, analyst for the Russian Federal Security Service, proclaimed: "Terrorists don't need to reconnoitre their target. Now an American company is working for them" (Stahl, 2010).

China, Sudan and Jordan all attempted to block Google Earth. Even "Sweden was caught doctoring satellite photos of its National Security Headquarters by replacing buildings with

trees" (Stahl, 2010). As Stahl noted, the initial official US response to Google Earth was also erratic. The West Point Military Academy and Pepsi Cola's headquarters were targeted for "pixelated censorship", yet sensitive military sites and nuclear facilities were not.

Nonetheless, there were other incidents that bolstered supporters of the Kyl-Bingaman imagery restrictions over Israel and Palestinian Territories. A 2007 UK Guardian report "Google Earth used to Target Israel", detailed how Palestinian militants were using the online mapping tool to determine targets for rocket strikes (Chassay, 2007). In response, Google pointed out that Earth and Maps imagery was not unique:

"Commercial high-resolution satellite and aerial imagery of every country in the world is widely available from numerous sources. Indeed, anyone who flies above or drives by a piece of property can obtain similar information" (Chassay, 2007).

In 2009, GlobalSecurity.org satellite expert Tim Brown warned there were several cases of satellite imagery falling into the wrong hands;

"China tried to buy sub-metre-scale images of Taiwan but ran into trouble with US government regulations. By going through a supposedly benign environmental monitoring project, they got 60 cm-resolution images of the entire island from DigitalGlobe." He told the Guardian.

"North Korean agents tried to purchase imagery of the DMZ [demilitarised zone] a couple of years ago through a dummy company based in Australia but were caught. There's a guy in a cubicle somewhere checking all this" (Bloom, 2009).

The Ethical Implications

The democratisation of small satellite technology and the imagery it produces raises some interesting ethical and civil liberties issues.

On the positive side of the ledger, earth observation imagery has enabled human rights groups such as Amnesty International to collate irrefutable evidence for war crimes investigations. Amnesty first used satellite imagery in 2004 in Darfur and since 2006 has dedicated staff and resources for satellite-based human rights research. Amnesty's Washington-based Crisis Response Team routinely uses open-source intelligence by analysing commercial satellite imagery, verifying YouTube videos and Twitter posts when investigating human rights abuses during armed conflict.

Planet's head of Data Visualisation Robert Simmon also notes numerous examples where satellite imagery has done "unambiguous good", and he cites satellites being used to verify the decommissioning of nuclear weapons stockpiles of the United States and the Soviet Union.

Nonetheless seeing events doesn't always equate to decisive action or intervention. Simmon has experienced the difficulties of observing a conflict, where people were being harmed in near real time and being unable to intervene:

"In Iraq, for example, we had, a series of oil well fires that had been set by ISIS and the smoke was actually basically hovering over these cities day after day for months at a time. And, and to know how miserable it must be to be underneath those smoke plumes and not be able to do anything about it... I mean, you can raise awareness, but it's an area where we really have no ability to affect things directly, and so that is a little frustrating and a little sad" (Interview 2017).

Planet cites its published Code of Conduct as providing the company's key ethical framework (Interview 2018). In 2017, the company's head of data visualisation, Robert Simmon, told ABC TV Australia's Foreign Correspondent program that Planet was required to comply with US law and only permitted to sell data or licences to clients approved by the US Government.

Simmon emphasises a strong internal staff culture at Planet, where ethics weigh heavily in operations and planning.

"I think about the ethical side all the time. So, our strategy is…basically radical transparency, and make the access to the data as easy as possible and so hopefully that will basically prevent the powerful and the wealthy from monopolising this type of data" (Corcoran, 2017).

While Planet projects an image of corporate responsibility, there are growing concerns that other new players in the burgeoning small satellite sector may not. Space industry analyst Micah Walter-Range points to an industry-wide failure to address this issue;

"I think one of the concerns with Planet and this ability to image the entire Earth is to do with what people will do with the information" (Interview 2017).

While Planet is acutely aware of the issues and responsibilities, Walter-Range says a problem lies with other start-ups that have emerged with a Silicon Valley culture where they view themselves not as space or satellite companies, but as big data companies that happen to collect data from space, without fully appreciating the implications of what that satellite data can be used for.

"So, when you take all of these new capabilities and wrap them up, you're approaching something very much like real time intelligence as to what's happening everywhere that people are active. That can be a very good thing, there are lots of positive uses…(but) what if someone is using that information for criminal purposes or trying to harm another person?" he asks.

'Democratisation of technology' is also creating unease in the US intelligence community. Long accustomed to being the watchers, America's security establishment is deeply unsettled by the prospect of being the watched;

"There was a time, you know, the good old days in which we could control, broadly speaking, what happened in space and what was imaged and what wasn't - because we had the

joystick," says Robert Cardillo, Director of the US National Geospatial-Intelligence Agency (NGA).

"The fact that you can go on the internet today, swipe a credit card or in some cases not, get a free application of satellite imagery anywhere on the world, is a wonderful opportunity in the sense of connecting the planet and commerce and all that. It also is a risk in the sense that it can expose activities that you'd rather not have exposed" (Corcoran, 2017).

Cardillo is less concerned about journalists than others he defines as *"non-state actors"*. An increasing part of the NGA's brief is what he calls *"the warning business"*- educating US military and intelligence units that all outdoor activities can be monitored. The issues raised by the Strava fitness app heat map, being a recent example (See Bellingcat Case Study).

However, satellites still need rockets to be launched into space, and Bleddyn Bowen, space security specialist and founder of the UK Astropolitics Collective, says the fact that even civilian rockets are internationally classified as restricted munitions technology can act as a barrier:

"The missile technology control regime is signed up to by most rocket capable countries. To put anything in space, you have to buy a launch service from a state or a launch company, but those launch companies are so integrated into the national security architecture of a big space power that they would be able to put a stop to anyone going, trying to launch something by proxy or undercover (Interview 2018).

Bowen concludes there would be a way for 'non-state actors' or rogue journalists to circumvent these controls, but that would require the collusion of a national government:

"What will be interesting is if a country like Iran develops good enough launch capabilities that if they start launching satellites and feed their information to such groups without any sort of filters or shutter controls. Non-state actors could get stuff in space but they will need a state sponsor of some kind to do it" (Interview 2018).

There are also some decidedly low-tech security gaps. Botswanan investigative journalist Ntibinyane, who tasked a satellite to image the President of Botswana's private compound in 2017, noted a lack of basic vetting;

"They never asked us anything about what we want to use the imagery for. Nothing. They were just saying, "OK, you want the image? Pay. You will get it.

Which I think now with some hindsight…they should do more background checks, because imagine if we are like ISIS or warlords trying to get this image to only bomb the President's Palace" says Ntibinyane.

"I think the whole thing should be regulated… and you should really do background checks before selling these images…It's an issue that will need individual countries to address it…and maybe at the UN level, because leaving it as it is…For now, it's OK, it hasn't really

produced anything disastrous, but with time, I can tell you people are going to use this technology to do other things that are bad" (Interview 2018).

As ethicist Joshua Hampson posits:

"What is the liability, legally or morally, of a US space company if its remote imaging was used to commit war crimes halfway around the world?" Hampson argues that the perception of a problem can be a potent driving force for regulation – whether it is required or not, although he acknowledges there are no easy solutions;

"Like the debate around encryption, these will not be easy issues to solve. Encryption allows dissidents to survive under tyrannical regimes but can also allow the planning of terrorist attacks on innocents."

Achieving this balance between enabling journalists and human rights activists access to this emerging technology - while preventing exploitation by those broadly defined as 'bad actors', will require significant deliberation by the space industry, media and government.

The problem is this discussion hasn't even started yet.

Case Study - The Space Detective Agency

"We've had maybe 100-200 inquiries from journalists about what we do…we've had 40 offers from TV companies…for our own TV series"

Ray Purdy,
Co-founder and Director
Air and Space Evidence

The Space Detectives… L-R Jon Carver, Peter Hierp, Ray Purdy, Ray Harris, David Tellett. (image- Odine Open Data Incubator Europe)

Air and Space Evidence (ASE), established in the UK in 2014, claims to be the world's first space detective agency (Purdy, 2018b). The founders combined their extensive backgrounds in military intelligence, imagery analysis and environmental and space law to create a consultancy that utilises imagery from satellites, drones, aircraft, and map data, to provide evidence for clients.

Co-founder and director Ray Purdy says the media has displayed an ongoing fascination with the business, to the point where the 'Space Detectives' have become the story. Despite this intensive media attention, ASE failed in an initial campaign to attract paying media clients. With the news industry in a state of constant upheaval amid shrinking budgets and staff cuts, Purdy says media companies were unwilling to pay for a specialist imagery service.

ASE sources imagery from a wide range of providers. While the company does not engage in media work, the company's investigative processes and experiences can provide highly valuable insights for journalists. ASE specialises in satellite monitoring of environmental crime, with cases have ranged from identification of illegal deforestation in Fiji, to examining changes to a shoreline of a UK lake following dredging activities (Purdy, 2018b).

Ray Purdy is also a Senior Research Fellow at the Law Faculty, University of Oxford. His key expertise is on the use of satellite imagery as evidence in courts and its capacity to monitor and enforce laws and he has conducted research for the UK Space Agency, the European Space Agency and the United Nations Committee on the Peaceful Uses of Outer Space (Oxford, 2018).

According to the head of the UK Environmental Agency, waste crime is "the new narcotics", offering massive illegal profits to syndicates operating well ahead of authorities attempting to control the problem (Carrington, 2016). Purdy says ASE has been contracted by EU Governments and UK regional authorities to investigate illegal dumping of waste, a growing environmental problem with some additional, unexpected risks for on-ground investigators (Purdy et al., 2017).

"We've developed the detection model to find illegal waste crimes. Because it costs I think it's about 80 billion (Euros) in Europe. So, it costs us, just in the UK alone, over a billion (GBP) a year. But some of these sites, they're run by organized gangs. Criminal gangs. And they're also involved in drugs and people trafficking. And it makes sense to get the lay of the land and what's happening from a distance first" (Interview 2018).

(Image- screenshot Google/The Conversation -UK)

Figure 1

Purdy estimates that in a 7,000 square kilometre test area in the UK, ASE identified 207 waste sites that were classified as suspicious. *"A countrywide monitoring programme would be expected to identify potential tax penalties in the hundreds of millions of pounds"* (Purdy, 2018a).

The Space Detectives also engage in another specialisation; investigation of property boundary disputes. Purdy says there is a growing acceptance of satellite imagery as evidence in UK courts and this often quickens the resolution of cases.

"It's affordable now. And if you've got a property dispute with your neighbour, it's worth paying 300 quid, 500 quid to get an image proving one way or the other, rather than spend 10, 20 grand going to court. Makes much more sense" (Interview 2018)

Boundary disputes can initially be investigated by accessing cheap or free archive imagery databases, although Purdy cautions against using Google Maps or Google Earth in forensic cases.

"You can't really rely on Google…you can't rely on the date. Because it's imagery taken from many different sources. And, some of it is stitched together. So, some of it might be from one satellite, another might be from another satellite, another might be from an aerial photograph".

"So quite often they (Google) don't actually put the dates. And if they do put the dates, sometimes it will be the first of January. Which we take it as- they don't know. But where they do put the dates, we find in our forensic examinations when we're looking at things that they're quite often wrong" (Interview 2018).

As Earth observation satellites proliferate and more commercial imagery sources become available, costs will decrease, although in 2018, the fees were still significant. When ASE tasks a satellite for an investigation, Purdy says there is a wide international variation in pricing, although in the UK:

"You're heading more towards the 1000 pounds for the 30-centimetre type resolution…The other thing is a lot of them are booked up by the military and it's finding a time to actually take them when they're not already specifically tasked to do something" (Interview 2018).

Purdy and several other satellite experts interviewed for this paper noted a widespread public assumption to over-estimate the capabilities of Earth imaging satellites. While the technology is evolving at an extraordinary rate, the ability to read numberplates or newspaper headlines – remains firmly in the realm of 'Homeland'-style TV fiction. ASE receives frequent requests to investigate old-fashioned, terrestrial-based crime. However, Purdy notes that many potential clients have unrealistic expectations, framed by this Hollywood notion of an all-seeing, all-powerful monitor from space:

"We maybe have had 500 inquiries about murders, beatings, rapes, disappearances, kidnappings, all sorts of things like that. But finding the image of that exact time is pretty

much impossible. We've only been able to do it once so far, and that was a murder in Texas" (Interview 2018).

In the Texas case, Purdy says ASE was able to demolish the chief suspect's alibi, proving through satellite imagery that the suspect's car was not at home in the driveway, as claimed, at the time the murder occurred at another location. This case was the exception. As Purdy notes, even 30cm resolution imagery, the highest currently available commercially, has its limits:

You can see a manhole cover, you can see house obviously, very clearly…You can see people, but you wouldn't be able to identify them".

"You get a snapshot image, it's very unlikely it would be much help. Because you might be able to see somebody standing there with a knife and somebody on the floor. But it's just two figures that are very blurry. That's all it really offers you as an investigator".

"Many of these cases have highlighted that what remote sensing technology can offer is not always going to be compatible with investigatory needs. It can often be too imprecise to provide the specific legal data required (e.g. identifying people) or can be too inflexible or temporally unsuitable to react to specific events (e.g. an abduction)" (Interview 2018).

Are satellites eroding the concept of personal privacy?

"I remember I got a letter from (an Australian) farmer asking if the satellite could see him in his outside toilet. And he was genuinely concerned about that. But most of them are quite savvy about what the satellites could and couldn't do. They were just anti the satellite monitoring program and government interference with what they were doing"

Ray Purdy
2011 Satellites and Privacy Study
University College London

To date, surprisingly little quantitative or qualitative research has been conducted on the privacy implications of the growing capabilities of Earth observation satellites. Ray Purdy an imaging legal expert and director of a private satellite investigative agency noted;

"Governments have focused on how these developments can create opportunities for businesses. More debate is needed about what should be considered acceptable and what constitutes intrusive monitoring from above" (Purdy, 2014).

In 2011 Purdy led a University College, London, research project seeking the privacy views of British and Australian farmers who had already been subjected to regulatory inspections by satellite monitoring for more than a decade. In the UK, satellites checked farmers for subsidy fraud under EU agricultural support schemes. In Australia, satellites monitored landholders' compliance with highly controversial environmental laws on native vegetation clearance (Purdy, 2011).

The survey found that 58% of Australian farmers and 75% of UK farmers agreed that satellite monitoring could be an invasion of privacy and only 15% of landholders in both countries disagreed (Purdy, 2011). The extraordinarily rapid improvement in what the satellites could image, with commercially available resolution reducing from 30m-80m to under .5m in just ten years – was not a key issue for farmers.

What mattered was the perceived covert and intrusive nature of satellite surveillance, with numerous references to '1984' and 'Big Brother'. According to Purdy, a common survey response was that satellite monitoring was fair, as long as farmers knew it was happening;

"A lot of Australian farmers actually use monitoring satellite data themselves to help on their own land anyway…so they were embracing technology. And it seemed to me that their problem was that they were being caught. There's a law they didn't agree with and some of them were being caught doing the wrong thing. And they didn't particularly like that. There were privacy impacts of what they were doing" (Interview, 2018).

UK farmers broadly supported the satellite monitoring program because it helped eliminate fraud and made it easier for them to receive their EU subsidies. In both Australian and the UK, given a choice, farmers preferred satellite monitoring to on-the-ground inspectors (Purdy, 2011).

"Because they didn't really want people poking around. And I think they thought it would take up their time and they were busy, having to show the inspectors around. If it could be done by satellites, they were quite happy about that" (Interview 2018).

In Australia, the New South Wales (NSW) Office of Environment and Heritage is one of several state bodies that routinely uses high-resolution satellite imagery as part of its remote surveillance program to monitor illegal land clearing.

The sensitivity of farmers to visiting inspectors was tragically highlighted in 2014 when an NSW environmental inspector was murdered by a landowner. In a trial that received national prominence, 81-year old farmer Ian Turnbull was sentenced to a minimum of 24 years jail for the shooting murder of inspector Glen Turner on a country road near Turnbull's property. Turnbull had been facing prosecution in the Land and Environment Court over illegal land clearing, which he continued to do after officially being told to stop (ABC, 2016). Turnbull died in jail, of a heart attack, in 2017 (Kidd, 2017).

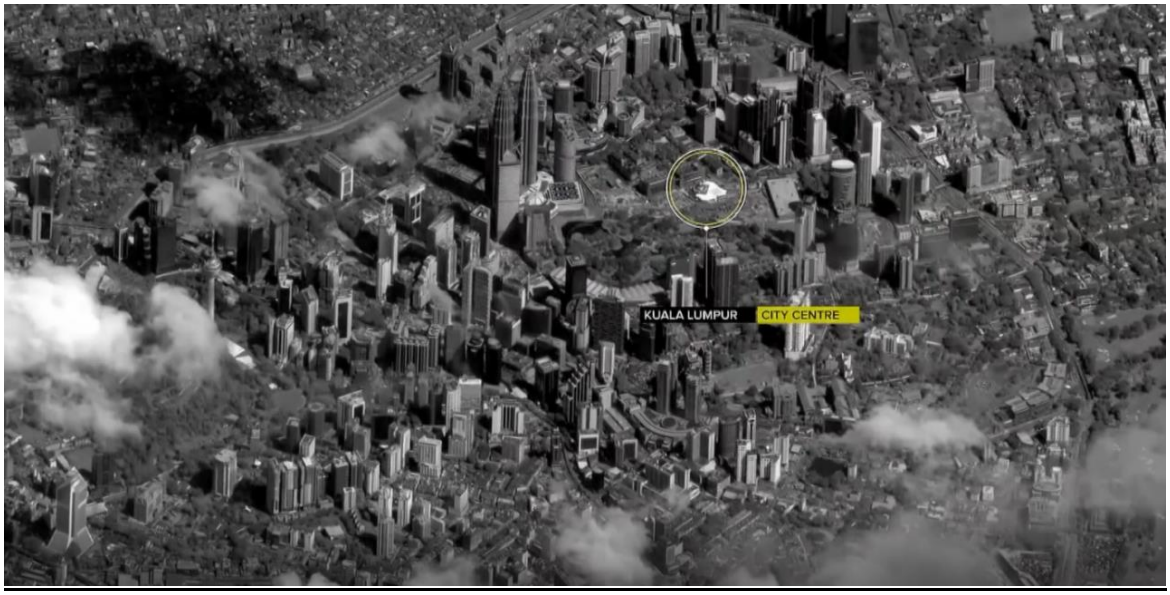
The UCL farmers study underscored the grey area of how we define the term 'reasonable expectation of privacy'. In a world where personal data is routinely harvested or hacked and facial recognition software in public areas is becoming the new normal, are society's

assumptions on privacy set too high? Facebook founder Mark Zuckerberg certainly thinks so, declaring back in 2010 that expectations of privacy had disappeared in the digital age (Johnson, 2010).

In an essay for the US Center for Digital Ethics and Policy, Kate Baucherel noted that the declared opinions of farmers - and other sections of society- on satellite monitoring may not be matched by their ready acceptance of surveillance in other aspects of their lives.

"In common with most of us in this fast-moving digital world, British farmers are increasingly likely to store digital photos in the cloud and share news with family and friends online through social media and other channels. Their movements are already tracked by some of the 1.85 million CCTV cameras in the U.K (in 2015), with the average citizen caught on camera up to 70 times a day" (Baucherel, 2015).

Live from Space?



Screenshot of video of Kuala Lumpur, recorded by Skysat-1, January 6, 2014 (Image – Planet Labs)

Live video from space is one of the looming goals in commercial Earth imaging that deeply divides opinion, on both the technical feasibility and the broader societal implications. In 2017, US space industry analyst Micah Walter-Range estimated that "within another five years and I would say almost certainly within ten, we can expect live video or close to live video of the Earth's major metropolitan areas" (Corcoran, 2017).

Planet currently maintains a limited HD black and white video capability from its fleet of 13 Skysats. According to CEO Will Marshall, the .72m imagery and the ability to shoot video should not raise privacy concerns. *"(Skysat) still can't see a person or identify a person with this sort of imagery, but you can see more detailed things about buildings in urban areas"* (Corcoran, 2017). While Planet has released short promotional clips of Skysat video, Director of Corporate Communications Trevor Hammond says providing video on demand is:

"(It's) still a fair way away because video remains a very intensive process to collect. So that's black and white, and a paid model at this point. There are certain instances where we will go and collect video pro-actively and share it widely with media" (Interview 2018).

Screenshot of video of Yongbyon, North Korea, collected by Skysat-1 December 28,2013 (Image – Planet Labs)

Other competitors have now joined the race for space video. British company Earth-i released its first full colour videos from space from its VividX2 prototype satellite in April 2018 (David, 2018). Travelling overhead at 6.4 kilometres a second, VividX2 constantly reorients its camera on a fixed position, to capture a two-minute video clip, with an image resolution of 60cm.

Screenshot of video from VividX2 prototype satellite (Image – Earth- i)

Also, in April 2018, another start-up EarthNow, backed by a powerful investor syndicate that includes Bill Gates and the European aerospace corporation Airbus, announced plans to launch “hundreds” of satellites “that will deliver real-time continuous video of almost any spot on Earth”. EarthNow envisages a “live Earth video” mass market to be accessed instantly from a smartphone or tablet. “With EarthNow, we will all become virtual

astronauts" declared company founder and CEO Russell Hannigan (EarthNow, 2018). Airbus proposes to mass produce the EarthNow video satellites alongside another fleet of nearly 900 satellites being constructed for the OneWeb satellite internet consortium (Gates, 2018). Earth Now has not disclosed its launch schedule, or the specific technical capabilities of the proposed video network.

However, the world's largest satellite imaging company, DigitalGlobe, is sceptical of the live video concept. Turner Brinton says it is an inefficient use of satellite capability.

"These satellites, they're only over one point for a couple minutes. They could potentially spend those entire minutes focused on one area and shooting either still image after still image after still image or full motion video as some do. Really when they're doing that they're using up a lot of valuable time that could be spent imaging a lot of different places in that region"

"We're never going to get to a point where you can have video of anywhere anytime…that would require a number of satellites that would be just economically infeasible in my opinion" says Brinton (Interview 2018).

Nonetheless other industry experts and journalists with satellite imagery experience are convinced that live video streaming will eventuate, and while there are numerous positive applications, there is concern that the new capability will be misused. Eliot Higgins, founder of Citizen Journalism group Bellingcat, has pushed the boundaries on exploiting satellite imagery for investigative journalism projects, yet he worries about the implications of giving the public access to live satellite video:

"Imagine being able to look at North Korea nuclear sites 24 hours a day on the live stream anytime you want…(but) that's where it starts becoming an issue of controlling what people can actually access. Maybe one day we will have live streaming satellite imagery of the entire planet. That will be good for my job. But I think being able to watch people drive back and forth to work again, will be a stalkers' paradise as well, so that may not be completely ideal" (Interview 2018)

Ray Purdy has effectively worked on both sides of this debate. As a law academic he conducted extensive research on satellite privacy. In the commercial arena, Purdy has been engaged as a satellite investigator for private clients. Given the rate of technological evolution and implications of what's coming, he is struck by what he perceives as a distinct lack of public discourse:

"I think there's a limit to what science can do…in terms of what the satellites can and can't see, but I think the better they get, and the more videos that are going to be out there, the more chance there will be for privacy breaches. And it seems crazy to me that nobody wants to discuss it. It's a case of industry burying their heads in the sand. And governments. For me, they take more and more short-term views" (Interview 2018).

If I was a satellite company I could see why I wouldn't want privacy being raised, because it might affect my business. But at the same time, if I'm putting 300 million pounds (GBP)

satellites up into space, I'd quite like...to know the risks that somebody's not suddenly going to regulate this" (Interview 2018).

Former journalist and satellite imaging company executive Mark Brender also doubts the viability of live video satellites. The next realistic goal he says, is about harnessing the data to predict the news:

"The key question is how artificial intelligence can be integrated with high resolution imagery, so you'll be able to predict the news and predict where something may happen next based on repeated collects of imagery over the same location, integrated with current and historic news, social media, tribal, societal and economic data and the human geography of an area. While you may not predict the future, you could certainly make some assumptions about it".

"And one day there may be a predictive news division in a company, where you are predicting where the news is going to happen next so you can deploy your news gathering tools, deploy your journalists, or be ready to order up imagery over a certain area" (Interview 2018).

The Satellite Revolution: Who's in charge?

So what rules and regulations should govern the new generation of imaging satellites, and the related issues of journalism, privacy and government attempts at control?

Steven Freeland, Professor of International Law, Western Sydney University, who has also advised the UN, Australian and New Zealand governments on space law, says currently there are five major international treaties, starting with the Outer Space Treaty, regarded as the Magna Carta of contemporary space law when enacted in 1967 (Freeland, 2004). These treaties are complemented by another five sets of governing principles, and many nations including the US and Australia also have national legislation governing space related activities. Commercial satellite operators have to comply with their own national laws and the laws of the countries where the rockets are launched.

None of these international and national space laws do not have a privacy or personal surveillance component,

Freeland notes that the rate of technological change "is far outstripping the ability of the law to deal with the specifics. That's absolutely right and it's absolutely right to say there are gaps and ideally you need to upgrade" but he argues that international space law has served society well over the past 60 years (Interview 2018).

Other space lawyers regard the international framework, drafted between the 1960s and 80s, as an outdated "hodgepodge" (Green, 2018), and the 120 nations participating in UN Committee on the Peaceful Uses of Outer Space (COPUS) have begun the long, arduous process of reform. Although none of these proposals will incorporate laws on the recording, dissemination or sale of satellite imagery. Freeland says there's one very good reason why control of satellite data will not be included:

"Space law is premised on freedom of access to space".
It's not the role of space law to restrict the access to space, because it's all premised on the fact that there's freedom of access to space. You don't want to turn that on its head"
(Interview 2018).

Satellite privacy and dissemination of the data, he says, is not a space law problem, but a question for nation states;

"The issue of controlling the use of information is not the domain of space law, but of terrestrial agreements and treaties and national laws".

Mark Brender agrees that space should remain non-sovereign, as embodied in the UN Outer Space Treaty of 1967. His concern centres on one very specific "terrestrial agreement" and "national law" - the potential implications of Washington's efforts to maintain censorship over imagery of Israel and the Palestinian Territories:

"In itself the Kyl-Bingaman Amendment was a dangerous precedent, because it (increased) the ability of a country, to reach up into outer space, and control, through the licensing or legal process, what can and cannot be taken of their territory."

"And if every other country in the Earth wanted to do that, it would be very difficult for commercial remote-sensing companies to operate, if you had to fly a patchwork quilt orbit around the Earth and be concerned about every nation having some type of rule about collection".

"I believe other countries tried, but the State Department pushed back on them, because they did not want to hurt the new and growing commercial remote-sensing industry" (Interview 2018).

The difficulty, says Air and Space Evidence co-founder and legal specialist Ray Purdy, is that nation states already have widely varying interpretations on recording and dissemination of commercial imagery:

"Different people will have different expectations of privacy. And how the hell do you actually regulate it? Because if we regulate the privacy side, whether it be on the resolution limits in one country, there's nothing to stop India from selling resolutions at a completely different level…So you start figuring out, can we solve this problem, and how do we solve it before it kind of gets too late?... Who takes the lead of that? Is it an international body like the UN? I don't know" (Interview 2018).

Mark Brender disagrees, arguing that less bureaucracy is more; that a free market approach engenders global transparency:

"So right now, it's not the Wild West, but it's certainly appropriate for these satellites to be able to overfly countries and take imagery, and make that imagery publicly available, as long as the satellite companies are allowed to sell that imagery to the sensed state if they request it. That's sort of the underlying constitution for overhead imaging. And once you get an UN-type environment to try to re-examine it, you're going to get more regulation, more hand-wringing, more concerns, and more regulations" (Interview 2018).

Bleddyn Bowen of the Astropolitics Collective says the major powers, fearing greater intrusion on secretive activities, may bypass any international framework and directly collaborate in limiting commercial imagery;

"What if we have sort of Planet Labs with Chinese characteristics? What if there's a high-resolution version of Planet Labs but it's a Chinese company? I don't know how this is going to go but I think a tendency would be that since China and Russia and America and all these big space powers have a shared interest in making sure the most interesting (military and nuclear) sites they have are not revealed on the open market, they'll have an interest in mimicking America's shutter control policies to make sure that they protect each other's secrets during normal peace time relations"

"We saw this example with Russia in the 1990s… I don't know who exactly they were selling the images too...They were desperate for hard cash… The Americans were not amused when the Russians started selling their best imagery on the open market and diplomatically pressured Russia to put a stop to it" (Interview 2018).

Ultimately, journalism can benefit greatly from the capabilities of the small satellite revolution, but the implications of 'democratisation of technology' and 'global transparency' run far deeper than satellite companies may have anticipated. Broader societal questions of how we will define personal privacy in the age of 'persistent surveillance', and even issues of national sovereignty, will need to be addressed. But as Ray Purdy concludes:

"You should actually start having those discussions now, about what the implications might be in five years' time, because it's really hard to get the genie back in the bottle afterwards. (Interview 2018)

Conclusions

- Satellite imagery provides journalists with a powerful storytelling tool. Effective story telling applications include:

  Coverage of events in remote, high risk, or inaccessible locations. Examples: North Korea nuclear weapons development, China's construction of bases in the South China Sea, destruction of Rohingya communities in Myanmar.

  Investigative reporting. Examples: AP's Seafood Slaves expose, the INK group's investigation of Botswana's president.

  Providing verification for data, imagery and social media content gathered on the ground, as a subset of the growing specialisation of data journalism. Example: the investigations of the Bellingcat citizen journalism group.

  'Pattern of life on Earth' observation; Stories on environmental destruction, weather patterns, natural or man-made disasters, urban development. Examples; ProPublica's Losing Ground, Peru's La Pampa Amazon gold mine.

  Political 'pattern of life' stories; Destruction of major cities/infrastructure in conflict, construction of refugee camps.

- Satellite imagery also has some restrictions.

  Most Earth observation satellites mount electro- optical imaging systems that provide high resolution pictures, but cannot shoot through cloud, smoke, and have poor low light capability. The exception is the relatively few satellites equipped with infra-red or radar imaging systems that provide imagery data that is more complex to process and interpret.

- Current commercial imaging technology does not have the capability to record identifiable shots of individuals, which may alleviate some, but not all, privacy concerns.

- Privacy issues surrounding satellite newsgathering have not become an issue of public debate. Industry analysts and imagery experts say this is largely due to lack of public awareness of emerging satellite capabilities and more immediate community privacy concerns over personal data security, social media, drones, street cameras.

- Technical innovation by start-ups imbibed with the Silicon Valley tech culture have contributed significantly to the 'small satellite revolution'. This technological upheaval has greatly increased the capability and numbers of satellites tasked with remote sensing or Earth observation capabilities.

- Competition between ‘Disrupters’ and ‘Big Space’ providers has led to greater availability of free high-resolution imagery for major media organisations and some individual journalists.

- Earlier attempts to create a viable commercial media market for satellite imagery failed, largely due to the unwillingness of news organisations to pay for the product. With the media industry in a state of long term disruption, amid constant restructures, budget cuts and staff reductions, satellite imagery has not been perceived as a priority.

- A major factor in the significant increase in media use of satellite imagery over the past 2 to 3 years can be attributed to two major US satellite companies providing their product for free and seeking to build stronger relationships with select media organisations and individual journalists.

- Another significant contributing factor in the uptake of satellite imagery by journalists has been the extraordinarily rapid development in the resolution or sharpness of the imagery, enabling a greater range of stories to be told.

- Improved speed and reliability of service to media has also contributed. Satellite companies now provide select media clients with a near real time news source via direct access to imagery databases. Additional specific requests for imagery are frequently met within 24-48 hours.

- Copyright issues can restrict access to free imagery, particularly for news agencies that syndicate stories, imagery and graphics.

- Provision of free imagery is largely conditional on the level of attribution or credit provided by the publication or broadcast. Freelance journalists and those working for small circulation organisations, or under NGO auspices, may be charged commercial rates.

- News organisations are unlikely to develop in-house satellite journalism capabilities in the near future, given that satellite companies currently provide imagery for free. Another major disincentive is the high cost and complexity of stand-alone satellite imaging operations, and the requirement for multiple ground stations to capture and process the data.

- Utilising satellite imagery for journalism can be a deceptively complex task. It is very easy for journalists to get it wrong and undermine the credibility of a story. A growing number of non-profit satellite industry organisations, Google, scientists and journalism educators are intensifying efforts to run media workshops on understanding the technology and skills required to exploit visual data. These workshops range from introductory sessions, through to more complex training that frames satellite journalism as a subset of the burgeoning open-source ‘data journalism’ field.

- As is the case with many 'disrupted' industries, regulation, control, and public awareness of the capabilities of the satellite revolution is trailing behind technological innovation and application.

- Managing and processing ever increasing amounts of data from Earth imaging satellites is becoming a progressively more difficult. Satellite companies are researching ways to increase levels of automation in the imagery analysis process.

- Live video from space is viewed by some analysts and imagery experts as the next objective, that may be achieved within 5-10 years, with journalists becoming major beneficiaries of this capability. However, the technical viability of this capability remains unresolved, with some specialists concluding that the technological complexity, combined with low Earth orbit patterns and optical physics make the live video proposal commercially unworkable.

- As US imaging companies still dominate the international commercial market and provision of imagery to the media, US national laws and policies on commercial imagery continue to have significant impact beyond US borders.

- Globalisation of Earth imagery satellite technology will progressively diminish US dominance of this sector.

- US satellite media providers maintain a form of third party editorial control over the supply of imagery to media outlets. The relationship between providers and media is largely built on trust.

- The US Government, through a licensing process, maintains control over the resolution of the imagery that American companies can disseminate and who can receive that product.

- The US Government reserves the right to block or restrict dissemination of imagery deemed to be counter to national security interests through a regulation known as "shutter control". Though shutter control has never been formally enacted, historically the US has engaged in more subtle methods of censorship, such as 'chequebook shutter control' or buying imagery to deny media access, which occurred in Afghanistan/Pakistan in 2001. The US Government has also demonstrated a willingness to put unofficial pressure on satellite companies – that still rely on US Government contracts to maintain economic viability - to withhold imagery from release.

- The US still attempts to maintain control over resolution and dissemination of commercial imagery of Israel and the Palestinian Territories. This restriction is becoming increasingly irrelevant as the technology proliferates and non-US satellite companies provide imagery prohibited under US law. Google discreetly defies this restriction on its Google Earth app.

Annex A

Earth observations satellites are launched into different orbits, depending on the task.

Geostationary Orbit: Used for weather monitoring satellites that appear to be in a fixed position in the sky, about 36,000 kilometres above the Earth. Good picture quality (high spatial resolution), is difficult at this altitude.

Medium Earth Orbit (MEO): is the zone 2,000 – 36,000 kilometres above the Earth, commonly used by navigation, communications and scientific research satellites. The Global Positioning System (GPS) constellation of 30+ satellites are in MEO and typically take about 12 hours to complete one orbit of the Earth.

Low Earth Orbit (LEO): The vast majority of earth imaging satellites, including those tasked for media work are in LEO, at an altitude of about 600-2,000 kilometres. The International Space Station orbits at an altitude of 400 kilometres. Planet says its shoe-box sized Doves are deployed in Very Low Earth Orbit at 400-500 kilometres, which means after about 3 years services the satellites "degrade' by being pulled back to Earth by gravity and burn-up upon re-entering the Earth's atmosphere.

Basically, Earth observation satellites carry three types of sensors; Electro-optical (EO) sensors collect data based on reflected light, comparable to taking a photo. Typically, only used during daylight and cloud cover will obscure images. EO sensors take the sharpest images and are usually the easiest to interpret as they most closely resemble photo. The most widely deployed type of sensor on Earth observation satellites (Sleeth, 2004).

Infrared (IR). Sensors collect electromagnetic radiation emitted or reflected from the target, producing images that show temperature gradients. IR sensors can be used to monitor heat sources such as industrial exhaust, vehicle engines or rocket motors. Cloud cover also degrades IR images (Sleeth, 2004).

Synthetic Aperture Radar (SAR). Regarded as the only true day/night all weather imaging capability. SAR images are usually more difficult to interpret (Sleeth, 2004).

A key to satellite journalism is the quality of the image, or spatial resolution. Spatial resolution refers to the size of an individual pixel within the satellite image. The lower the number (e.g. 1 metre), the sharper the image. Other important factors are the temporal resolution, or 'revisit time', how often a satellite returns to a specific location to record follow-up images, and the spectral resolution – the wavelengths of light used to record an image, broadly categorised as visible, infrared or ultraviolet light.

Spatial Resolution

Spatial resolution refers to the pixel size of the satellite image. The lower the number (e.g. 1 meter), the finer the clarity of image.

Here is how the Wimbledon Tennis Complex (London, UK) appears at different resolutions associated with several of the satellites highlighted. All the images below are generated from a Worldview-4 image and resampled to be representative of the different spatial resolutions represented.

Aqua (MODIS)
250m Resolution

Landsat-8
30m Resolution

Sentinel-2
10m Resolution

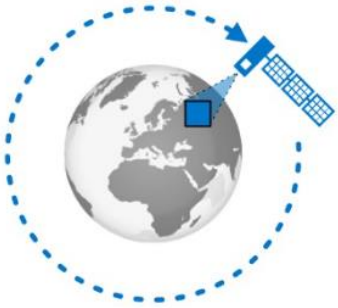
PlanetScope (Dove)
3m Resolution

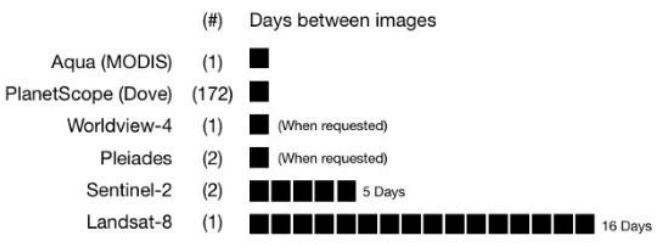
Pleiades
0.5m Resolution

Worldview-4
0.3m Resolution

Temporal Resolution

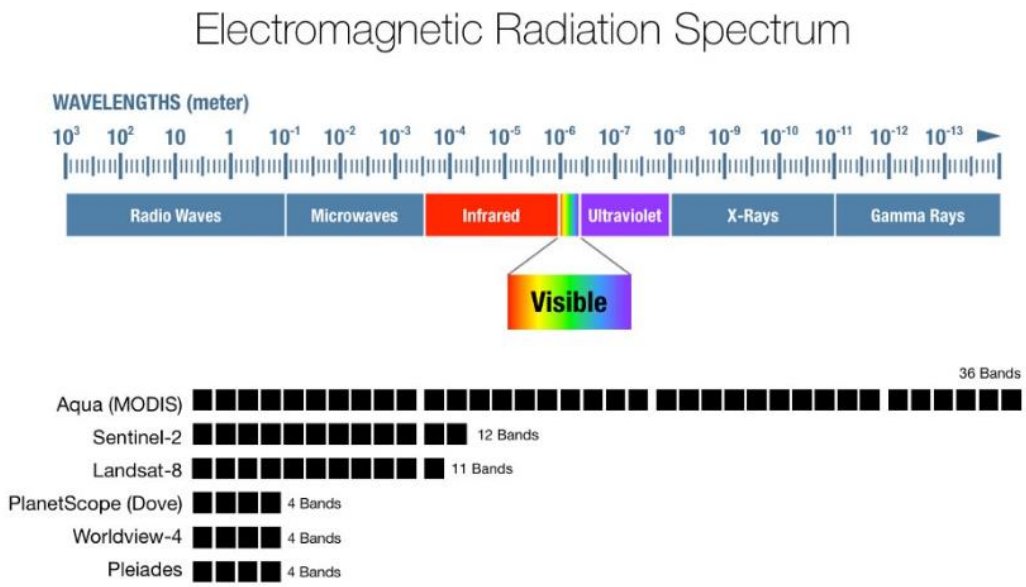
Temporal resolution varies by satellite and describes the time it takes for an individual satellite to orbit and revisit a specific area. Some satellites operate as a constellation with multiple satellites working together to increase their global coverage daily.





Spectral Resolution

The number of bands of radiation in the electromagnetic spectrum that a satellite can sample (visible, infrared, ultraviolet, microwave, x-ray, etc.)



Passive vs. Active Sensors

Most Earth observation satellites are passive, only receiving image data from reflected sunlight, but a few utilize active image capture by transmitting their own signal.

PASSIVE Earth Observation Satellites

Passive satellites detect radiation reflected off the Earth's surface, such as visible light and infrared. In general, passive satellites are not able to work through clouds.

ACTIVE Earth Observation Satellites

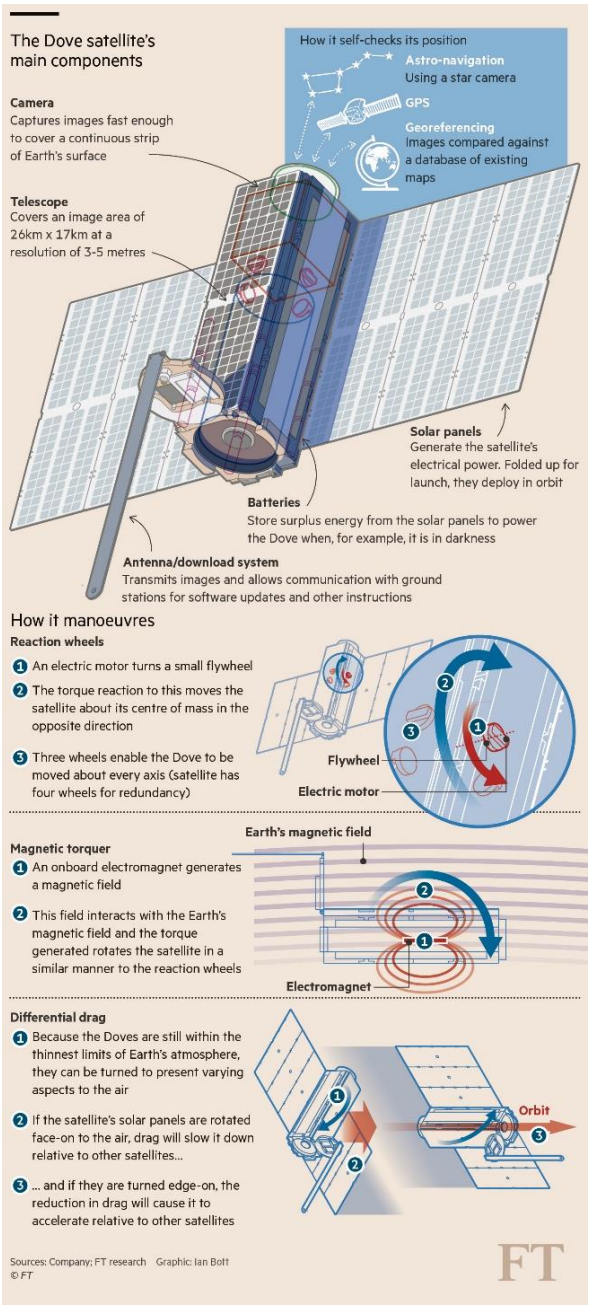
Active satellites transmit energy towards the Earth and measure the returned signal which provides information about the Earth's surface. In general, active satellites can see through clouds.

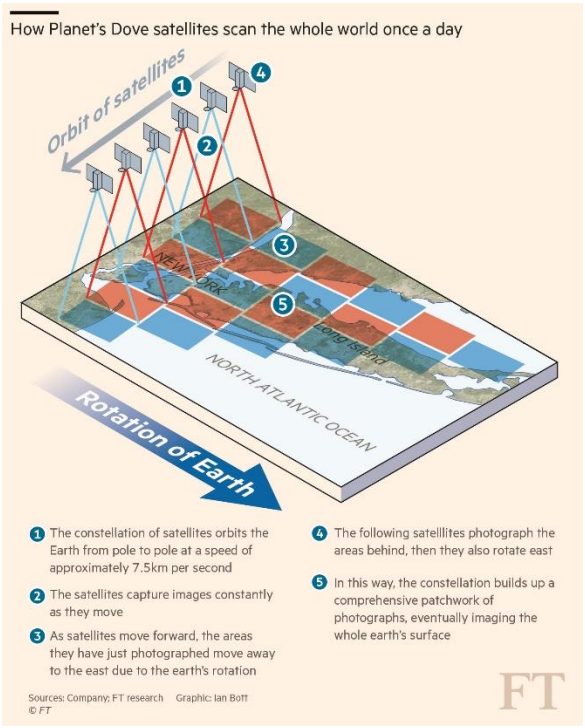
SOURCE: http://satellites4everyone.co.uk/technology/earth-observation/

Radiant.Earth
Earth Imagery for Impact

4 infographics courtesy of Anne Hale Miglarese of Radiant.Earth

Annex B


The Dove satellite's main components
How it self-checks its position
Astro-navigation
Using a star camera
GPS
Georeferencing
Images compared against a database of existing maps
Camera
Captures images fast enough to cover a continuous strip of Earth's surface
Telescope
Covers an image area of 26km x 17km at a resolution of 3-5 metres
Solar panels
Generate the satellite's electrical power. Folded up for launch, they deploy in orbit
Batteries
Store surplus energy from the solar panels to power the Dove when, for example, it is in darkness
Antenna/download system
Transmits images and allows communication with ground stations for software updates and other instructions
How it manoeuvres
Reaction wheels
1 An electric motor turns a small flywheel
2 The torque reaction to this moves the satellite about its centre of mass in the opposite direction
3 Three wheels enable the Dove to be moved about every axis (satellite has four wheels for redundancy)
Flywheel
Electric motor
Earth's magnetic field
Magnetic torquer
1 An onboard electromagnet generates a magnetic field
2 This field interacts with the Earth's magnetic field and the torque generated rotates the satellite in a similar manner to the reaction wheels
Electromagnet
Differential drag
1 Because the Doves are still within the thinnest limits of Earth's atmosphere, they can be turned to present varying aspects to the air
2 If the satellite's solar panels are rotated face-on to the air, drag will slow it down relative to other satellites...
3 ... and if they are turned edge-on, the reduction in drag will cause it to accelerate relative to other satellites
Orbit
Sources: Company; FT research Graphic: Ian Bott
© FT
FT


How Planet's Dove satellites scan the whole world once a day
Orbit of satellites
NEW YORK
Long Island
NORTH ATLANTIC OCEAN
Rotation of Earth
1 The constellation of satellites orbits the Earth from pole to pole at a speed of approximately 7.5km per second
2 The satellites capture images constantly as they move
3 As satellites move forward, the areas they have just photographed move away to the east due to the earth's rotation
4 The following satelllites photograph the areas behind, then they also rotate east
5 In this way, the constellation builds up a comprehensive patchwork of photographs, eventually imaging the whole earth's surface
Sources: Company; FT research Graphic: Ian Bott
© FT
FT

Interviews

(Directly cited in the report or provided extensive on-the-record background)

Christiaan Adams, Developer Advocate, Google (questions answered by email), June 2018

Bleddyn Bowen, Lecturer International Relations, Leicester University, UK Astropolitics Collective, April 2018

Mark Brender, Satellite imaging industry executive consultant, July 2018

Turner Brinton, Manager Maxar News Bureau, DigitalGlobe, June & July 2018

Robert Cardillo, Director, US National Geospatial-Intelligence Agency, February 2017

John Charles, Senior GEOINT officer, Commercial Imagery, US National Geospatial-Intelligence Agency, February 2017

Christine Chan, Graphics Editor -The Americas, Thomson-Reuters, May 2018

Steven Freeland, Professor of International Law, Dean of Law, UWS, UN Space Law adviser, May 2018

Trevor Hammond, Director Corporate Communications, Planet Labs, May 2018

Eliot Higgins, founder, Bellingcat Online Investigations, citizen journalism group, May 2018

Christoph Koettl, Crisis Response Team, Amnesty International, February 2017

Donna Lawler, Assistant General Counsel, Optus Satellites (Australia), May 2018

Marth Mendoza, journalist, Associated Press, June 2018

Will Marshall, Co-founder and CEO, Planet Labs, February 2017

Anne Hale Miglarese, Radiant.Earth, June 2018

Ntibinyane, journalist, INK investigative group, Botswana, April 2018

Ray Purdy, Co-Founder and Director, Air and Space Evidence, May 2018

Simon Scarr, Deputy Head of Graphics, Thompson Reuters (questions answered by email), June & July 2018

Robert Simmon, Head of Data Visualisation, Planet Labs, February 2017

Micah Walter-Range, Director of Research, Space Foundation, February 2017

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