

# PLANET: NEXT GENERATION SATELLITE IMAGING USING ARTIFICIAL INTELLIGENCE AND AGILE AEROSPACE

## EXECUTIVE SUMMARY

In 1959, a United States satellite photographed the first image of a small patch of Earth from space. It took almost an hour for the satellite to transmit a blurry photo of Pacific Ocean clouds to a ground station in Hawaii.

Today, Planet, the satellite imagery and geospatial company, routinely images 300 million square kilometers of the Earth's landmass every 24 hours. However, Planet's product isn't images, it is the data collected as it continually scans the globe, monitoring changes in landmass, from crops and forests to population activities like buildings and roads for customers across a variety of vertical markets.

This paper looks at the evolution of Planet from initial satellite deployment and imagery to an application ecosystem that incorporates agile aerospace. We will explore the strengths of Planet's approach and the challenges the company faces in the marketplace as well as the opportunities presented by global conditions, climate change, economic megatrends and a growing potential market. We also examine its potential to impact the future of business and societal attitudes.

## A SINGULAR PRODUCT TO SOLVE COMPLEX PROBLEMS

Planet offers a singular and unique data product that can monitor millions of kilometers of the Earth's landmass with a system of small satellites. This novel architecture of 200 small satellites is designed to deliver updated images to customer subscription feeds or be processed by artificial intelligence models. Insights from AI models can alert customers to large and small surface changes that affect global populations, organizations, and global economic systems.

Currently, no other company can claim these capabilities. Maxar and Airbus continue to employ traditional large satellites to image the Earth by capturing photos on a task-by-task basis as they have done for more than three decades. Cost prohibits large

satellites from being deployed in sufficient numbers to record and transmit images and data on the same scale as Planet.

## COMPETITIVE LANDSCAPE

Several small emerging satellite imaging companies entered the market within five years after Planet had launched its first functioning imaging system, but these have yet to complete their constellations or in some cases, generate revenue. These companies lag Planet’s technology by an estimated 5 to 7 years. According to Planet, these companies have deployed less than 25% of their projected number of non-scanning satellites. Planet has a significant head start on its competitors and we expect that advantage to widen as Planet continues to advance its capabilities in aerospace, data collection/processing and artificial intelligence

FIGURE 1: A DECADE OF PROGRESS<sup>1</sup>



Source: Planet

## PLANET’S UNIQUE VISION

Planet was founded in 2010 with the goal of capturing global changes and making them visible, actionable, and accessible to subscribers.

In a recent Planet conference for analysts, James Mason, senior vice president of Space Systems for Planet, described the company’s startup vision. “Even back in those

<sup>1</sup> This is an illustrative example of development of EO providers based on market research and Planet Company knowledge and experience. It includes comparisons against multiple North American satellite providers and several other international entrants. “ML analyzed” describes Planet’s machine learning capabilities.

early days, we knew that a data set like this would have a huge impact on the whole world. We also knew it would require hundreds of satellites to accomplish our mission and it was something that had never been done before.”

Planet engineers focused on building large numbers of shoebox-sized satellites that an automated system could manage instead of building traditional, larger multimillion-dollar satellites. A system comprised of multiple smaller satellites, with its built-in redundancy, provides greater reliability than a single, multi-purpose large satellite.

In addition, the distributed nature of Planet’s large constellation of small satellites makes it more resilient to most types of failures. Planet builds a constellation of small, simple satellites, a strategy that allows them to replenish as necessary instead of building a few expensive space craft. Historically, according to Planet, it has executed launches every year, accruing hundreds of person-years of cumulative experience in the process.

FIGURE 2: AGILE SPACE MISSIONS



Source: Planet

Planet’s low-cost manufacturing advantage originally evolved from a process designed to produce smaller satellites that are faster to build and easier to launch, resulting in more cost-effective deployments than what is required to lift a single, large satellite into orbit.

To support the mission and business plan around deploying large numbers of small satellites, Planet applies an accelerated and iterative development process called agile aerospace. A satellite is designed, rapidly built, and launched. Operating software is

upgraded in space as new features are developed. Individual satellites are retired and replaced as necessary.

Agile aerospace provides a significant competitive advantage for Planet. The process would take years for another company to duplicate and integrate into its culture fully.

Here are the key elements of Planet's agile aerospace:

1. **Design** - Space system engineers design and build Planet's satellites in-house using its proprietary technology stack. Ownership of the design allows Planet to perform faster iterations and complete more frequent upgrades. Planet is currently using the 18th generation of the Dove satellite.
2. **In-house manufacturing** - Planet designed its satellites to be manufactured quickly and maintains supplier and contract flexibility for quality-and cost-control as well as reduced dependency. According to the company, Planet can manufacture 40 SuperDove satellites in a single week, if needed. Traditional, larger satellites from competing companies require years to replace.
3. **Just-in-time manufacturing** - Planet's in-house, just-in-time manufacturing allows continuous upgrades on internal processes and software, giving them a competitive advantage.
4. **Launch and deployment** - Planet has launched over 460 satellites – with about 200 currently in orbit - on 33 different rockets. As a result, Planet can respond quickly to launch opportunities or rapidly deploy new satellites to respond to surge market demands or internal requirements.
5. **Ground stations** – Planet has a network of 43 ground stations located at 16 sites around the world. This provides a level of cost-effectiveness and operational reliability that is less expensive than outside contractors.
6. **Automated mission control** – Planet has designed a scalable and cost-effective automated control system. The system manages the complex interaction between satellites and ground stations and provides continuous software upgrades for satellites.

## HOW WELL DOES AGILE AEROSPACE WORK?

With agile aerospace, Planet has completed 18 design revisions and upgrades of Dove satellites, while improving overall system quality and performance.

Data download speed from satellites is currently 150,000 times faster than eight years ago. It is faster to download an image from a Dove satellite in space than to download it

over a gigabit fiber connection. In addition to increasing download speed, Planet has also increased the number of image pixels by more than tenfold, allowing higher processing resolution.

**FIGURE 3: PLANET AGILE SOFTWARE DEVELOPMENT**



*Source: Moor Insights & Strategy*

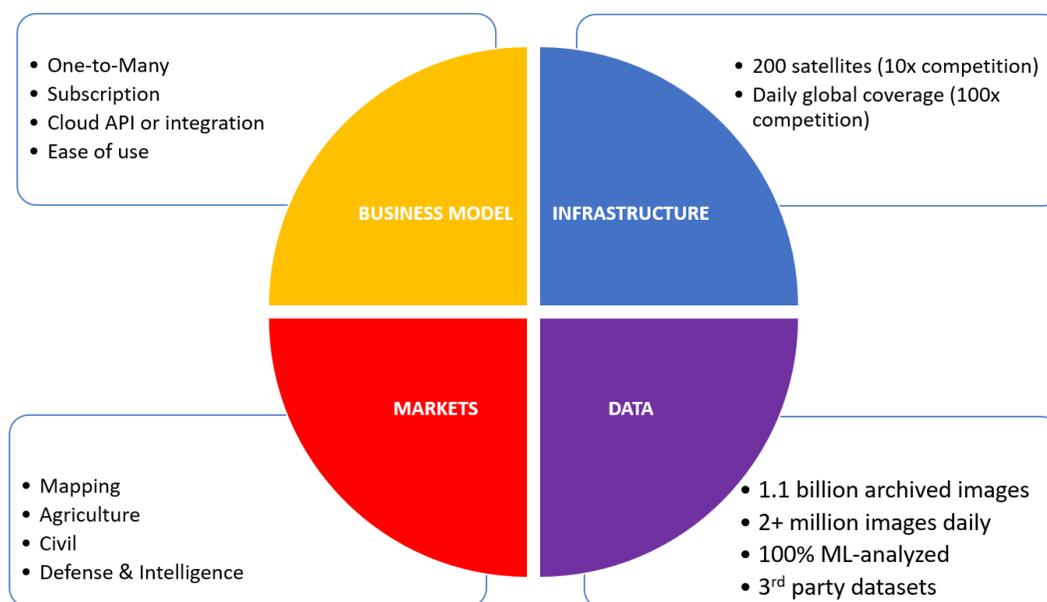
The use of agile aerospace has also improved critical satellite software development and updates required for over- the-air deployments.

The software development process begins with the identification and prioritization of new feature requirements. Once a feature is selected and the code has been written, it is then tested on the ground before undergoing a critical code review to ensure its integrity. Once developers are satisfied with the quality and functionality of the update, it is uploaded to a few orbiting test satellites, where its performance is subjected to real-world testing. Only after all those steps are successfully completed is the software deployed fleet wide.

## DON'T CALL PLANET A SATELLITE IMAGING COMPANY

Planet positions itself as a differentiated-cloud data and artificial intelligence company that uses a vertically integrated engineering stack, not as a satellite imaging company. Advanced satellite technology is only part of the complex sensor infrastructure Planet uses to collect and deliver its real product – actionable data about global changes and events.

Figure 4: Planet Components



Source: Moor Insights & Strategy

Just as Google indexes the world's information and makes it searchable, Planet is in the process of indexing every location on the Earth's surface to make it searchable or use artificial intelligence to provide insights on changes and conditions as they happen.

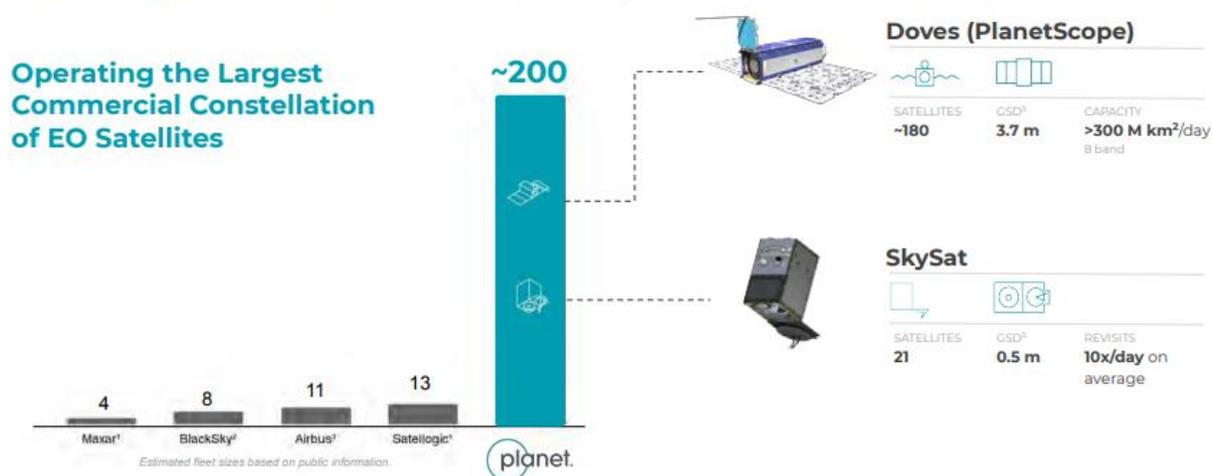
Planet optimizes all images for machine learning. It also delivers time stacks of images to its partners and customers that run machine learning algorithms directly on the stack. Some customers create their own training data sets from Planet images and use them to further train private machine learning models. Planet's archive of images means that any given location on the Earth has an average of 1,700 images to fuel machine learning model development. Planet does this internally and enables partners and customers to use the data to build their own models.

## THE SATELLITES

Planet has two fleets of orbital satellites, the Dove fleet and the SkySat fleet, for a combined total of about 200 satellites. According to public information, that is 10 times the number of its closest competitor.

### FIGURE 5: SPACECRAFT INFRASTRUCTURE

Satellite Fleets Designed for Cost Advantage and Operational Efficiency



Source: Planet

Planet’s Dove fleet consists of legacy Dove satellites and newer SuperDoves, the latter of which were launched beginning in 2019 to upgrade the constellation. Compared to Doves, SuperDoves have the same resolution but have higher image quality, additional spectral bands, and collect five times more data per day than legacy Doves. The entire Dove fleet has a resolution of 3.7 meters and photographs every location on the Earth’s landmass daily.

SkySat spacecraft are equipped with higher resolution 50-cm optics and can quickly zoom in on any area of interest on average of seven times daily, which is best in class in the market.

Planet plans to replace the SkySat fleet with the next generation of high-resolution satellites called Pelican. Like other fleets, the Pelican constellation will be designed and built in-house. Although Planet has yet to release detailed specifications, Pelican will have significantly better resolution and faster imaging than SkySat.

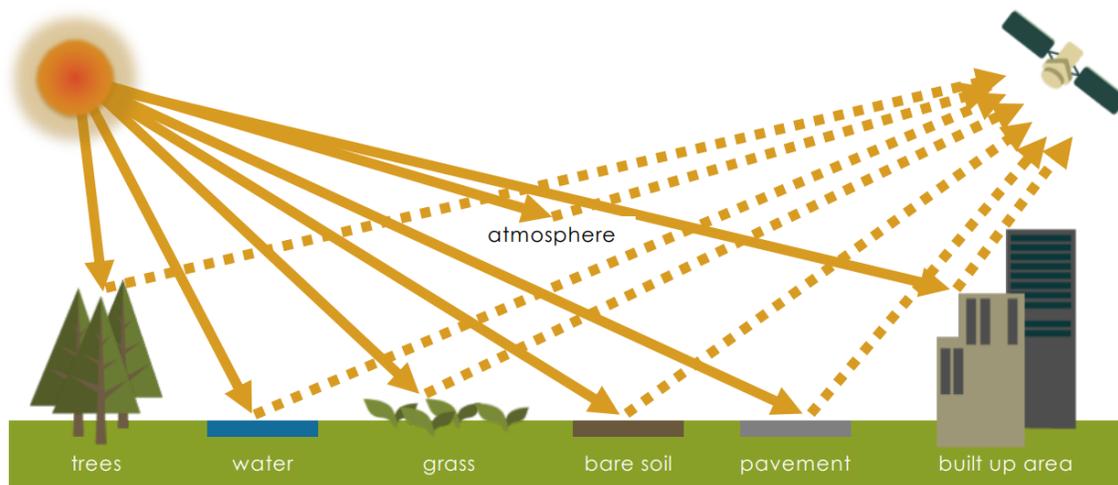
Together, both of Planet's constellations produce a differentiated data set unique within the industry. Over the past five years, Planet has accumulated more than a billion archived images. Planet optimizes its entire dataset for machine learning. This allows subscription customers to immediately create actionable insights with AI models.

Since trained machine learning models can recognize buildings, planes, ships, trees, roads, containers, and other objects, Planet intends to accumulate enough images to create a searchable database of these objects.

## SPECTRAL BANDS

Trees, buildings, land, water, and other objects absorb and reflect different frequencies of light that satellite images can detect.

**FIGURE 6: SOLAR SPECTRAL REFLECTIONS DETECTED BY SATELLITES**



Source: NASA.gov

A satellite image captures differing energy combinations and different wavelengths of light as bands. Images store these different wavelengths as data layers. Until last year, Planet's satellites only recorded four bands – red, green, blue, and near-infrared (NIR) light –reflected from objects on the Earth's surface. For example, chlorophyll reflects near-infrared (NIR) light, so imaging an area with plants detects the amount of chlorophyll. Analysis of that image can determine if the crop is healthy or not.

In 2019, Planet began upgrading its satellite constellation with SuperDoves, increasing its data from four spectral bands to eight bands. With the additional bands, satellites can capture light in additional parts of the electromagnetic spectrum, including near-infrared and coastal blue. The four new spectral bands support additional applications in agriculture, forestry, and science. Combined with machine learning, the new bands make it possible to determine the health of crops, the rate of deforestation, and many other indicators in real time.

## FUSION – INTEGRATION OF DATA SETS

Although Planet’s Dove satellites and public fleets such as Landsat have different imaging resolutions, Planet developed Fusion, a product that allows different data sets to be combined into a daily cloud-free dataset with ten layers of metadata. The combined data set can be used by customers to train machine learning models focused on crop growth, fertilizer optimization, water usage, and other agricultural applications. Fusion creates a seamless and accurate measurement of the surface better than a single data set.

Planet’s future roadmap calls for further development of Fusion and the creation of something that could be considered super data sets. Planet plans to fuse data with data collected by other technologies such as optical sensors, microwave sensors, and synthetic aperture radar (SAR). The combination of the new fused data sets could provide customers the capability to monitor biomass change as well as see through clouds. There are currently many ongoing sensor programs<sup>2</sup> and many more sensor missions planned.

## CARBON MAPPER

In a move that could extend Planet’s sensing capabilities and ultimately open the door for future revenue opportunities, Planet is a member of a public-private 501 c3 non-profit partnership called Carbon Mapper.

Planet is developing a new fleet of hyperspectral satellites capable of 400 simultaneous spectral measurements for agriculture, security, minerals, and coastal applications. Additionally, it will have the ability to measure the surface properties of many previously undetectable materials and analyze airborne gases.

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<sup>2</sup> <https://earthdata.nasa.gov/learn/remote-sensors>

According to Carbon Mapper<sup>3</sup>, “Carbon Mapper is designed to detect at least 80% of high emission CH<sub>4</sub> and CO<sub>2</sub> point sources on the planet through a combination of sensitivity, moderate spatial coverage (high-priority regions), and daily to weekly sampling provided by our constellation of multiple satellites. In doing so, Carbon Mapper will contribute to an emerging international system – other satellites and surface-based monitoring systems that will collectively provide global situational awareness of CH<sub>4</sub> and CO<sub>2</sub> emissions for many applications.”

Planet’s participation with satellite data collection in this program could help control climate-affecting emissions and lead to future commercial opportunities, including proactive monitoring of private locations for unintended greenhouse gases, analyzing ecosystem biodiversity, and proactively reading chemical emission fingerprints for industrial and military sites.

According to Planet, the Carbon Mapper platform is already under development, and, like the other fleets, it will consist of a constellation of many small satellites.

Planet expects Carbon Mapper technology to upgrade and strengthen its space infrastructure as it adds more product capabilities in the future.

## PLANET STRENGTHS

- In a short span of ten years, it has gone from a startup with an ambitious mission to a soon-to-be public company with a unique and defensible technology that is years ahead of its competition. Using agile aerospace and a robust development process, Planet has built the industry’s largest fleet of satellites, ten times larger than any competitor.
- By integrating artificial intelligence into its system, Planet has increased the value of its one billion archived images and over 600,000 multispectral images that are captured daily. AI provides timely, meaningful, and actionable insights to customers, and to some of them, this information is mission-critical. Insights include optimizing agricultural practices, monitoring deforestation, tracking urban growth and development, shipping container activities, and more.
- Planet’s competition uses a task-based one-to-one business model. This means customers specify locations that are imaged, and no other customer can purchase those images. Most of Planet’s business is the one-to-many subscription model. Planet sells data feeds to customers, and it can provide any

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<sup>3</sup> <https://carbonmapper.org/>

feed to multiple users. The incremental costs of selling to each additional customer are small, providing higher growth and higher margins than a one-to-one model.

- According to Planet, its revenue streams provide recurring revenue contracts that comprise over 93% of its book of business.
- With annual revenue of \$113 million in 2020, Planet's 700-plus worldwide customer base is well diversified across verticals – mapping, defense and intelligence, civil government, and emerging verticals such as forestry, energy, finance, and insurance. The symmetry of revenue distribution indicates that Planet's system has broad general industrial, commercial, and government appeal and utility. There is a high probability that future revenue growth can be fueled by scaling new product offerings to existing and new customers within established verticals. Moreover, the newer verticals such as energy, finance, insurance, and forestry, should prove rich in opportunities.
- During 2021, Planet established partnerships that can strengthen its competitive position and establish a broader foundation for future revenue growth:
  - The US Department of Agriculture will integrate Planet base maps into USDA datasets for surveys and reports critical to understanding food production fluctuations affected by natural disasters.
  - A new agreement was signed with Farmer's Edge to supply datasets for a new sustainable agriculture product. Planet will provide machine learning alerts for crop problems and provide help to maximize crop growth while minimizing environmental impact.
  - NASA expanded its contract with Planet to provide data access for nearly 300,000 federal and civilian researchers and all NSF-funded university researchers.
  - Google and Planet formed a partnership focused on developing joint go-to-market solutions in vertical markets that need Planet's data and Google's cloud platform. Sustainable supply chain tracking will be one of the first markets.

## THE FUTURE OF PLANET THE COMPANY

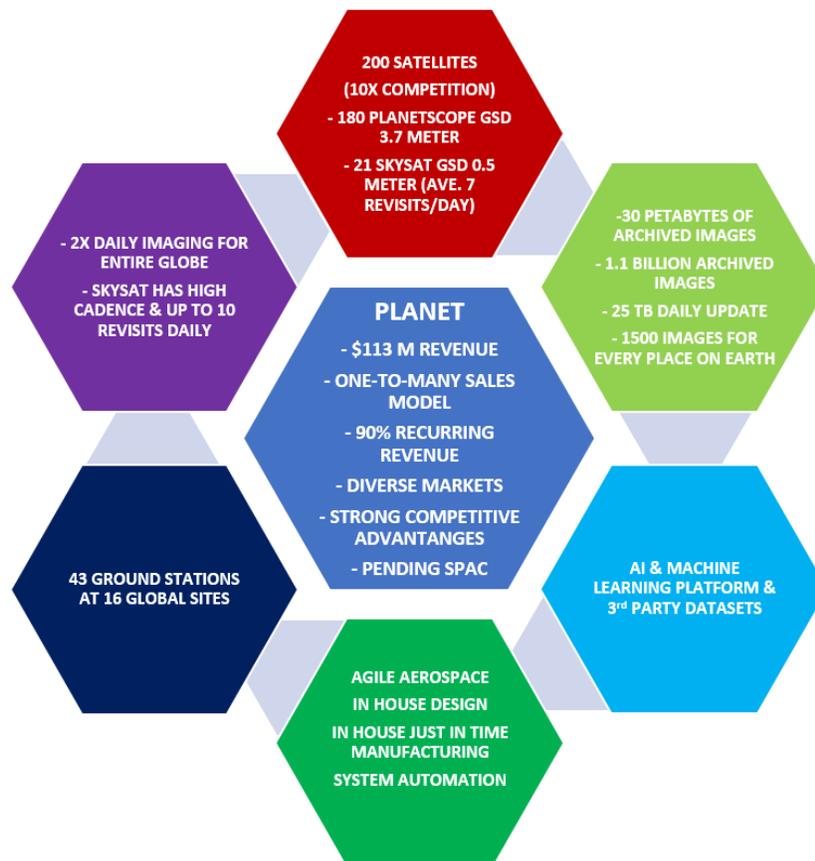
Global conditions, changing climate, and events will only become more complex<sup>4</sup> in the future as a growing population puts greater stress on agricultural and other food

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<sup>4</sup> <https://www.brookings.edu/research/the-challenging-politics-of-climate-change/>

sources and the corresponding need to produce more goods but with less environmental impact.

**FIGURE 7: PLANET’S BUSINESS MODEL**



*Source: Moor Insights & Strategy*

Planet’s data and analytics are foundational to two mega-trends: the digital and the sustainability transformation of the global economy. Planet believes these trends will result in a \$100 billion market opportunity in 2027. Even now, environmental, social, and governance (ESG) solutions are becoming part of the mainstream operation of companies and governments. Planet is at the forefront of capabilities to provide comprehensive ESG monitoring data and analytics for almost every industry and government across the globe. This is a realistic expectation, and it is reflected in Planet’s revenue growth projections.

Going public will provide Planet with funds for expansion. Although there doesn't appear to be a need for additional satellites in the foreseeable future, Planet needs to increase its sales force and double its software engineering headcount.

- Additional sales headcount will allow the company to increase its penetration in existing verticals plus drive adoption of its services in new verticals.
- Adding software engineers will permit Planet to partner with independent software vendors, solution providers, and business intelligence and analytics providers who are building vertical market-specific solutions on top of Planet's platform. More headcount in this area will also allow Planet to make its data more digestible and accessible to non-technical business users and build solutions to address more use cases and expand its addressable market.
- Planet expects that by making strategic investments in its sales, marketing, and engineering departments its compound revenue growth rate will increase to 44% over the next five years.

Planet considers itself to be a natural aggregator. Additional funds from the public offering will enable Planet to give serious consideration to new M&A opportunities. There are several smaller software and electronic companies in the satellite imaging space that, if acquired, could add significant value to Planet.

## THE FUTURE OF PLANET AND THE WORLD

Nature and humans have been changing the surface of the Earth for thousands of years. Prior to Planet launching its constellation of satellites, there was no way to timely monitor, measure, and interpret the impact to the ecosystem by the activities responsible for the changes.

It is important to realize that Planet is doing much more than just putting satellites in space to take more pictures. During the past five years, Planet has archived over 30 petabytes of satellite images, a data equivalent of recording about 100 years of around the clock HD video. Planet's three billion image archive grows by more than 25 terabytes every day. By applying artificial intelligence to its massive reservoir of images, Planet can utilize historical data to look back in time to better understand past trends that may help manage the future.

Research<sup>5</sup> shows that about 80% of all large companies issue corporate social responsibility (CSR) reports. Planet is currently the only company positioned to become a dominant player in the vertical created by monitoring and verifying corporate and government sustainability.

We expect Planet datasets to continue to grow as its system accumulates more data about the Earth and its changes. The availability of more information should increase demand for Planet's data feeds from an expanding number of subscribers and their AI applications.

As Planet continues to gather, catalog, and measure data at scale, operations will require many, perhaps hundreds, of large AI models to transform mountains of newly gathered data into actionable business intelligence.

By having so much influential ground-truth data readily available, not only is Planet likely to affect business change but it is also likely to promote change in societal attitudes about our ecosystem as well.

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<sup>5</sup> <https://www.epa.gov/smartway/resources-corporate-social-responsibility-csr-and-freight-sustainability-planning>

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