Platforms Designed for Big Data Provisioning with Small Satellite Constellations

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ABSTRACT
Advances in commercial and public space imaging systems, SmallSats and CubeSats; commercial cloud computing, networking, and storage; and machine learning algorithms for computer vision and predictive model are disrupting the traditional government subsidized remote sensing market that follows an imagery as sales business model. As accessibility to space increases with the decreasing cost and lifecycle of SmallSat systems development, the quantity of available remotely sensed data will also increase, and large data procurers will surpass the US government as the primary consumer. In response, the remote sensing market is transitioning to an information-as-a-service market that delivers timely, relevant, and actionable information to users such as agricultural and financial companies as well as the US government. Descartes Labs will present the analysis, monitoring and forecasting cloud platform implementing a Living Atlas of the World and providing a basis for the rapid development of high-level global-scale business intelligence products powered by machine learning and remote sensing designed to support small satellite constellations.

INTRODUCTION
Advances in small satellites (SmallSats)- satellites measuring less than 180 kg in mass- are disrupting the traditional remote sensing market by greatly reducing the cost and lifecycle of satellite system development. These developments in conjunction with advances in commercial cloud computing, networking, and storage and the development of machine learning algorithms for computer vision and predictive modeling have fueled a transition into information-as-service business model in which large procurers of data surpass the US government as the primary consumer of remotely sensed data.

DEVELOPMENTS IN REMOTE SENSING
Space imaging systems, cloud computing, networking, and storage, as well as machine learning algorithms are all included in the system that analyzes, monitors, and forecasts data and trends of interest. Advances in these categories, particularly those relating to and supporting SmallSat constellations, can improve the accuracy and application of these analyses and forecasts.

Space Imaging Systems
SmallSats, and CubeSats in particular, are extremely low cost satellites that require only months to build. Miniaturization, interchangeability, and component standardization distinguish SmallSats from larger satellites that can cost millions/billions of dollars. A large satellite system can take on the order of 5-10 years to develop in a “waterfall style,” but CubeSat development is inherently agile and systems can be developed in just 1-2 years [2].

SmallSats can provide imagery consumers with 1-meter imaging, frequent revisits, and allow for customized tasking. This allows imagery users to gather high resolution with a temporal element that is appropriate to their application or operational need. Currently, TerraBella (previously SkyBox, then Google, now Planet), BlackSky Global, OmniEarth, Satellogic, and
DigitalGlobe (and others) have or are planning SmallSat missions that offer 1-meter or better resolution primarily in panchromatic and multispectral bands as well as in video. Similarly, Planet will have more than 130 satellites with 5-meter resolution in panchromatic and video [2].

**Cloud Computing, Networking, and Storage**

Traditionally, remote sensing required mainframe computing, but technological advances have shifted the requirements and capabilities of remote sensing to include cloud computing, high performance computing, and utilization of mobile devices and the Internet of Things [1]. Pricing decreases make compute power available to anyone who can access it.

**Machine Learning Algorithms**

Big data analytics that utilize machine learning algorithms for geospatial visualization are further advancing the analysis, monitoring, and forecasting system. The persistent coverage of SmallSats especially allows imagery and data streamed from satellites to be ingested into models or algorithms for visualization [1]. This model is particularly suited for an analysis/information-as-a-service business model where a data procurer is the intermediate consumer between the imagery producer(s) and the end user. In addition, Machine learning advancements allow an end user to access the real product or solution intelligence they need without having to be a data scientist or remote sensing analyst in order to prepare or interpret results.

**REMOTE SENSING MARKET**

From the 1980s through the 2000s, remote sensing was heavily subsidized by the US government, and the role of the government in remote sensing has started to decrease. Evidence of an evolving market can be found in next generation commercial systems that do not rely on federal resources and in the US government decreasing its position as premium customer to large data procurers [1].

**Consequences of Developments in Remote Sensing**

The miniaturization, interchangeability, and component standardization characteristic of SmallSats has changed the priorities of satellite systems. Assured systems performance is no longer a principal concern because system loss has been made affordable by low cost and short lifecycle development [1]. This affordability allows more systems to be orbited, enhancing system survivability and access opportunities, ultimately translating into a large increase in accessibility to space. Future systems engineering endeavors are expected to result in increased cosmic data collection, shrinking electronics and sensors, increased efficiency of satellite constellation management, and availability of flexible short-term/low cost missions [2].

The customized tasking ability that allows users to gather high resolution imagery in appropriate temporal intervals from a multitude of imagery vendors has allowed the commercial SmallSat market to outstrip the government’s ability to satisfy imagery consumption in commercial markets such as agriculture, finance and business intelligence, and energy [1].

**Market Disruption**

In 2015, the microsatellite market was estimated at $890 million and is expected to grow to $2.52 billion in 2020. As the commercial SmallSat market outpaces the US federal and global government subsidized remote sensing industry in meeting the operational needs of agricultural and financial companies, the remote sensing business model is transitioning from an imagery sales business model to an information-as-a-service business model [1]. An information-as-a-service business model delivers timely, relevant, and actionable information to users, allowing for swift and informed decisions to be made.

In an information-as-a-service business model, commercially owned satellites have many advantages for a government customer that only wants data. Under this model, the government can select, purchase, and procure only relevant data when it is needed without taking on any responsibility for long-term operation and maintenance on a satellite system. Diverse data ingestion can be ensured through data procurement from multiple commercial vendors; however, this data will be at premium since the government will essentially be passing on costs associated with systems development, maintenance, upgrades and personnel.

**Challenges**

New business models, engineering methods, and technology are disrupting the remote sensing market, and the US federal/civil and global government market space. SmallSats create even more disruption to old business models by approaching systems engineering and integration (SE&I) in a way that can be seen as radically different than the way the US federal government and global governments have always approached SE&I [1].

While SmallSat platforms are favored over large satellite platforms for their launch frequency, relatively low complexity, minimal extensive requirements, high near term technology demonstrations, and short
development length, large satellite platforms have an advantage in terms of their risk, capability, mission assurance, and ability to handle demanding missions [2]. To date, large satellite platforms are considered favorable for defense and intelligence missions.

Another challenge arises in terms of the consumption of remotely sensed data. As the market favors SmallSats in some industries such as energy, agriculture, finance, and insurance, the end user will shift from being a remotely sensed data consumer and data procurer to being a consumer of the information derived from data procurement. This will happen primarily in industries where SmallSats are favored. Keep in mind the user will know or particularly care about the difference between a large and small satellite constellation. They will purchase the product intelligence solution that meets their needs.

LIVING ATLAS OF THE WORLD
Descartes Labs provides global capacity at a spatial and temporal granularity, monitoring changes in near real-time, conducting global-scale historical analyses, and building predictive models that capture very-large scale scientific data and high-performance predictive models a Living Atlas of the World. The global-scale situational awareness and high-level business intelligence generated by this atlas has the potential to enable breakthroughs in a range of commercial sectors, from agriculture and other natural resources, to construction, transportation, energy and finance.

CONCLUSION
SmallSats are advancing to allow consumers to gather high resolution remotely sensed data that fits various temporal intervals through customized tasking. This turn to persistent surveillance is changing how remotely sensed data is consumed, shifting the market towards an information-as-a-service market. In this market data procurers take advantage of commercial cloud computing, networking, and storage and machine learning algorithms in order visualize remotely sensed data and create analyses and forecasts. The Living Atlas of the World supports SmallSat constellations by applying high-performance predictive models to very-large scale scientific data.

References