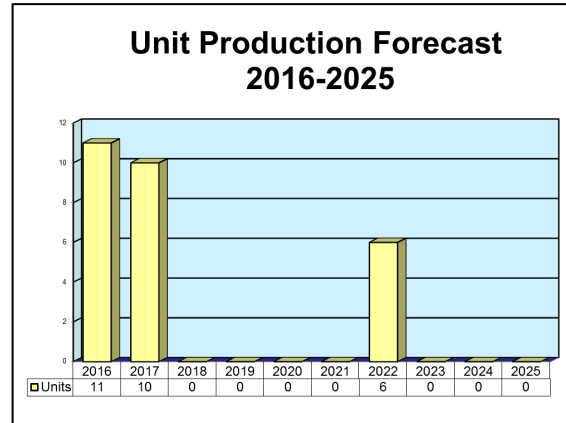


Terra Bella

Outlook

- SkySat-C1 launched aboard a PSLV in June 2016
- Name changed from Skybox imaging to Terra Bella in March 2016
- In June 2014, Google agreed to acquire Skybox Imaging for \$500 million, the deal was completed in August of that year



Orientation

Description. Terra Bella is a private remote sensing satellite operator.

Sponsor. Terra Bella, a private company based in Mountain View, California, is owned by Google, itself a subsidiary of Alphabet Inc.

Status. In development. SkySat C series satellites are being manufactured.

Total Produced. Terra Bella has taken delivery of three satellites.

Application. Terra Bella aims to collect imagery data of everyday human activities using a network of mini-satellites.

Price Range. Prices for Terra Bella's satellites have not been publicly disclosed. Forecast International estimates a cost of around \$5 million to build each satellite.

Contractors

Prime

Space Systems/Loral	http://www.ssloral.com , 3825 Fabian Way, Palo Alto, CA 94303-4604 United States, Tel: + 1 (650) 852-4000, Fax: + 1 (650) 852-5656, Email: lewisw@ssd.loral.com , Licensee
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Subcontractor

ECAPS	http://www.sscspace.com/ecaps , Torggatan 15, Solna, Sweden, Tel: + 46 08 627 62 00 (HPGP Propulsion)
Millennium Space Systems	http://www.millennium-space.com , 2265 E El Segundo Blvd, El Segundo, CA 90245 United States, Tel: + 1 (310) 683-5880 (RWA1000 Reaction Wheels)
Sinclair Interplanetary	http://www.sinclairinterplanetary.com/ , 268 Claremont St, Toronto, Ontario, Canada, Tel: + 1 (647) 286-3761, Email: dns@sinclairinterplanetary.com (Star Tracker)

Comprehensive information on Contractors can be found in Forecast International's "International Contractors" series. For a detailed description, go to www.forecastinternational.com (see Products & Services; Companies, Contractors, Force Structures & Budgets) or call + 1 (203) 426-0800.

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Terra Bella

Technical Data

Terra Bella (formerly Skybox Imaging) is currently building a fleet of satellites that will operate in a low-Earth orbit. The company would ultimately like to build a network of 24 satellites. Skybox Imaging designed the satellites and built the first two in-house, but outsourced the production of future satellites to Space Systems/Loral (SSL). The entire network, which operates in a sun-synchronous orbit, will be able to revisit any point on Earth five to seven times per day. Each individual satellite can view a single spot on Earth once every three days. Depending on specific orbital altitude, satellites will feature images with 0.75- to 1-meter per pixel resolution.

Terra Bella utilizes commercially available hardware and software whenever possible. For example, circuit boards were based on commercial off-the-shelf (COTS) components; however, the imaging sensor, camera, processor, and radio were designed in-house. Most

image processing will take place on the ground rather than aboard the spacecraft.

The satellites will provide imagery that is radiometrically corrected, panchromatic, multispectral, and pan-sharpened. The images files will also include comprehensive metadata.

A number of other uses of high-resolution imagery have been suggested by industry observers. Because Terra Bella will operate a satellite network that is much larger than those of current satellite operators, it will be able to detect changes on the ground on a daily basis. This could allow investors to forecast sales at a retail store by observing the number of cars in the parking lot, or to detect the release of a new technology device by the presence of trucks at a manufacturing plant.

Terra Bella will sell both raw data and analytics services.

Variants/Upgrades

SkySat-1 and -2 (also known as SkySat-A and -B). SkySat-1 was the first satellite designed by Skybox Imaging to be launched into orbit. The satellite operates in a polar orbit about 450 kilometers above Earth. SkySat-1 has a launch mass of 100 kilograms and a lifespan of six years. SkySat-2, already built but not yet launched, has similar specs.

The satellites have a 0.9-meter resolution in black-and-white mode and a 2-meter resolution in color mode. Swath width is 8 kilometers.

SkySat C Series. Space Systems/Loral (SSL) will build 19 SkySat C series spacecraft.

The satellites will have a launch mass of 120 kilograms. The slight increase over the earlier satellites is due to the inclusion of a propulsion module, which will enable Terra Bella to increase or decrease satellite altitude based on the types of imagery needed. The satellites will measure 60 x 60 x 95 centimeters.

Base altitude will be a similar 450 kilometers above Earth in a polar orbit. With propulsion, the satellites will have a 10-year lifespan.

According to SSL, the satellites it builds will have a 1-meter resolution, even in color mode.

Program Review

Background. Skybox Imaging was started in 2009 by a group of MBA students at Stanford. The company immediately began raising funds to develop and launch a network of small satellites. The concept behind Skybox is to rely on a network of satellites and develop a user-friendly data platform for customers. In fact, the company sees itself as an information company rather than a traditional satellite operator. About 60 to 70 percent of the company's workforce is focused on information products, while satellites are seen simply as a vehicle to provide that information.

Skybox's first satellite was launched on November 21, 2013, aboard a Dnepr launch vehicle. That satellite was built in-house using COTS components and machine

tools purchased at a discount from a nearby auto manufacturing plant that was in the process of closing. A second satellite, also built in-house, lifted off aboard a Soyuz on July 8, 2014.

The company originally planned to build all satellites in-house; however, it later decided to outsource manufacturing to Space Systems/Loral. A contract was signed in February 2014 and covers the construction of 13 satellites. Six more satellites were added at a later date. Outsourcing the manufacturing freed up Skybox to focus on the information end of the business and provided flexibility since SSL can produce satellites much faster than Skybox could. The satellites will launch between 2015 and 2017.

Terra Bella

In June 2014, Google Inc announced an agreement to acquire Skybox Imaging for \$500 million. When the acquisition was officially completed in August 2014, Skybox became a division of Google.

The most obvious use of Skybox will be to provide imagery for Google Maps and Google Earth, as well as sell higher resolution imagery and analytics services to users. Skybox will also provide imagery to important causes, such as environmental monitoring, education, and land mine removal. Furthermore, Google indicated

that it could use Skybox's expertise in satellite development and operations to develop other types of satellites, such as communications spacecraft to provide broadband Internet connections.

In March 2016, Skybox Imaging changed its name to Terra Bella and expanded its mission to include searching for patterns of change in the data it collects.

Three months later, on June 27, 2016, the first SkySat C series satellite launched into orbit, on board a Polar Satellite Launch Vehicle (PSLV).

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	2009	Skybox Imaging founded
	2010	Team designs satellites and data platform
	2011	Critical Design Review of SkySat-1 completed
Apr	2012	Skybox raises \$70 million in financing
Dec	2012	SkySat-1 completes thermal vacuum tests
Nov	2013	SkySat-1 launched
Jun	2014	Google agrees to acquire Skybox Imaging for \$500 million
Aug	2014	Google acquisition of Skybox Imaging successfully completed
Mar	2016	Skybox Imaging changes name to Terra Bella
Jun	2016	SkySat-C1 launched into orbit on PSLV

Forecast Rationale

Terra Bella is part of a wave of new remote sensing satellite operators that hope to utilize new technologies and business models to break into the Earth imagery business. SkySat satellites have a launch mass of between 100 and 120 kilograms, making them larger than those of some competitors, such as Planet (formerly known as Planet Labs), which is building 6-kilogram satellites. However, SkySats are still smaller than typical commercial remote sensing satellites, like DigitalGlobe's 2,800-kilogram WorldView-2. Terra Bella expects its satellites to offer a compromise between the two extremes, with resolution and lifespan better than that of extremely small satellites but revisit rates higher than networks that have only a few large satellites.

Terra Bella is building a satellite network that will eventually feature 24 satellites, each about the size of a mini-fridge. The network will be able to provide global coverage and update images of one spot between five and seven times per day with 1-meter per pixel resolution. Terra Bella has not revealed prices for its satellites, but they will cost much less than the larger, more complex satellites that are currently favored by commercial remote sensing operators. The small size and weight will also reduce launch costs.

Large fleets of satellites are enabled by modern computer technology, which allows miniaturization of components. Only a few years ago, small satellites made up only a handful of all satellite launches. In recent years, however, their popularity has grown. Their small size reduces manufacturing and launch costs, and improves network resiliency since the loss of one satellite would not be catastrophic. In the past, most small satellites were built for research institutions and universities to test scientific theories and develop technology. However, companies like Terra Bella and Planet hope to commercialize the new technology.

The biggest boost for Terra Bella came in June 2014 when Google agreed to acquire the company for \$500 million (the deal was completed in August 2014). Being part of Google will give Terra Bella enough cash to fund its capital expenditures and keep its satellite fleet up to date. It will also give Terra Bella a ready application, since its satellite imagery will be used to keep Google Maps and Google Earth current. The company will also benefit from Google's marketing abilities and global reach in selling its services to companies worldwide.

While companies like Planet and Terra Bella offer an innovative approach to remote sensing, their business

Terra Bella

models are largely unproven. So far, successful remote sensing satellite operators have relied on large satellites. Furthermore, sales have been largely dominated by government buyers. It remains to be seen if these new companies will be able to sign enough new customers to cover the costs of building a satellite network. Even small satellites can be expensive once launch and insurance costs are included.

That said, Terra Bella's focus on providing usable and current data to customers, aided by Google's deep pockets, will drive production of satellites for the foreseeable future. With the launch of the first satellite in the series in June 2016, all SkySat C series satellites are expected to be in orbit by 2017. Additional opportunities for new satellites will arise in the 2020s as Terra Bella replaces aging in-orbit spacecraft and expands operations.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program	High Confidence				Good Confidence			Speculative			Total	
	Thru 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024		2025
Space Systems/Loral												
SkySat												
	2	11	8	0	0	0	0	0	0	0	0	19
MFR Not Selected												
SkySat Follow-Ons												
	0	0	2	0	0	0	0	6	0	0	0	8
Total	2	11	10	0	0	0	0	6	0	0	0	27