



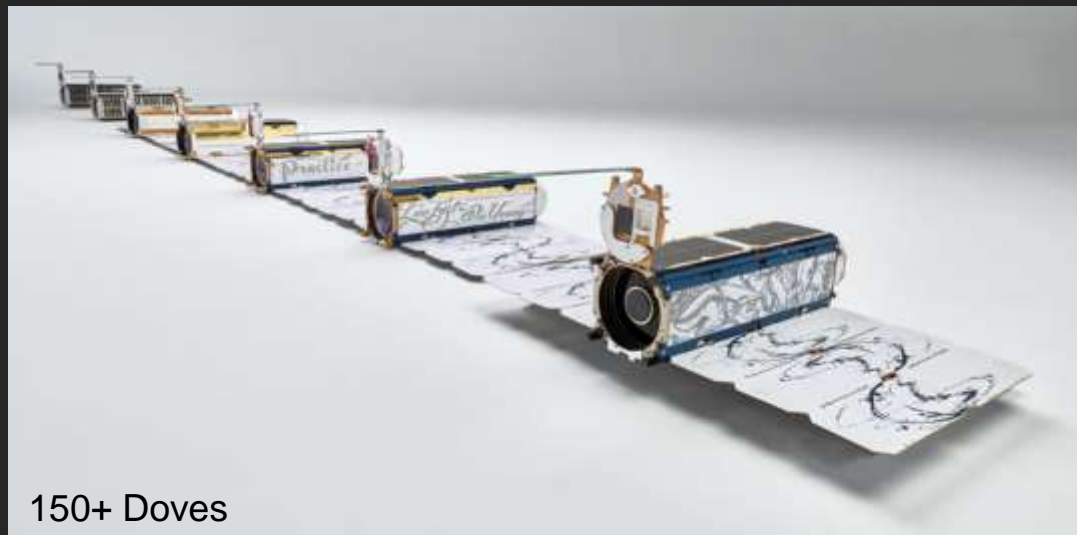
Launching Large Constellations

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OUR SATELLITES



5 x RapidEye evolved SSTL-100



150+ Doves



7+ Skysats



An aerial photograph of a sugarcane field. The field is divided into numerous rectangular plots by thin, light-colored lines, likely roads or irrigation channels. The sugarcane plants are a vibrant green, and some areas appear to be harvested, showing a lighter, brownish color. A black callout box with a downward-pointing arrow is positioned in the upper center of the image, containing the text 'SUGAR CANE HARVESTING' in white, bold, sans-serif capital letters.

**SUGAR CANE
HARVESTING**

An aerial photograph of a sugarcane field, similar to the one above. A semi-transparent black box is overlaid on the bottom left corner of the image, containing the text 'RIO GRANDE' in white, bold, sans-serif capital letters.

RIO GRANDE

JANUARY 18, 2016




An aerial photograph of a sugar cane field. The field is divided into numerous rectangular plots. Some plots are a vibrant green, while others are a brownish-tan color, indicating different stages of growth or harvest. A prominent black callout box with a downward-pointing arrow is centered in the upper half of the image, containing the text 'SUGAR CANE HARVESTING' in white, bold, sans-serif capital letters.

**SUGAR CANE
HARVESTING**



RIO GRANDE

MARCH 24, 2016



SYDNEY

MARCH 10, 2016





LARGE CONSTELLATIONS

1. PLANET'S EXPERIENCE

2. MISSION & SYSTEM DESIGN

3. LAUNCH & BEGINNING OF LIFE

4. OPS & END OF LIFE



PLANET'S EXPERIENCE

(Aug 2017)



19 launches

17 successful

2 failures (Falcon 9, Antares)

8 different rocket families (+2 soon)

284 satellites deployed

7 SkySats

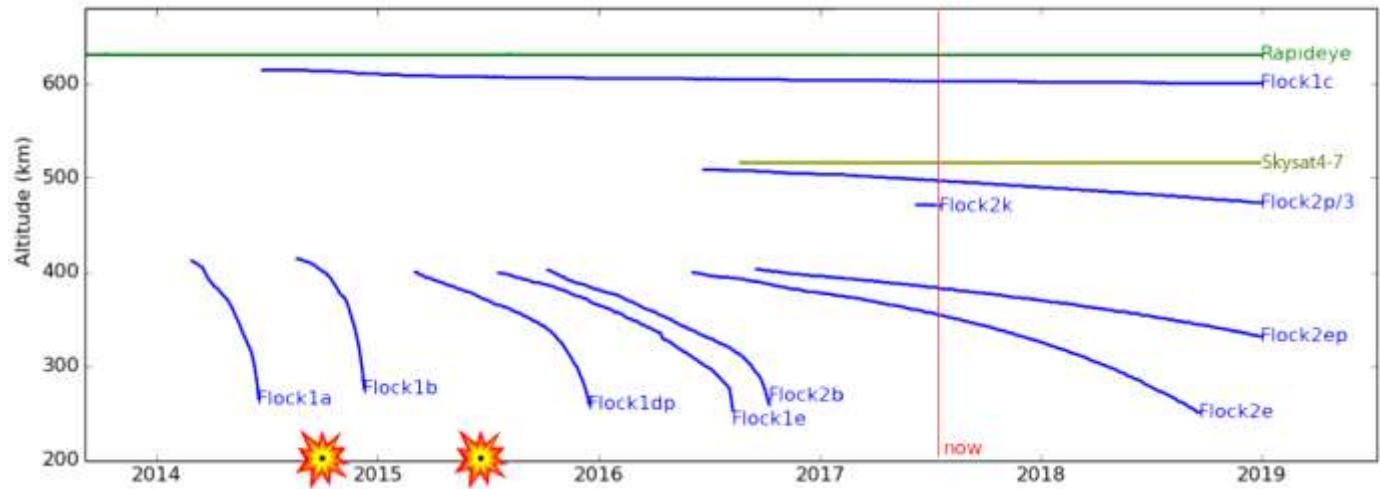
5 RapidEyes

272 Doves

170 operational



SYSTEM & MISSION DESIGN



| | |
|--------------------------------------|---|
| Launch as low as your mission allows | 475-525 km is ideal altitude For Doves |
| Satellite robust to neglect | A long-term-stable safe mode |
| Reliable, simple comms system | 30 deg beamwidth UHF, low power transceiver, broadcast option |
| Independent orbit determination | Time of flight ranging and GPS |



LAUNCH & B.O.L.



| | |
|--|--|
| Deployment strategy to reduce collision risk | Strive for maximum spread in along-track dV. ISS relatively easy for this. |
| Have good pre-launch orbit estimates | Triple check ephemeris formats and reference frames! Have a process for quick updates on launch day |
| Coordinate with other payload operators/JSpOC/LV operators | Know who is on your launch. Establish communications with them and talk as objects are sorted out. SSA sharing agreement with JSpOC |
| Have robust search strategies in place | Plane tracking mode |
| Plan for self-interference early on | Different RF channels Round robin comms |



OPS & END OF LIFE



| | |
|--|--|
| Maintain good ephemerides and make these available | Time of flight ranging, GPS Ephemeris made publicly available All ephemerides pushed to SDA |
| Minimize collision risks | Perform automated Probability of Collision assessments on all CDMs “Min interaction area” for high PoC collisions ($> 1e-4$) IN FUTURE: Integrate LeoLabs tracking data, differential drag avoidance maneuvers |
| Have a post mission disposal plan, and execute it | For Doves this is atmospheric reentry |





Conclusions

Plan for large scale ops from day one

Build satellites that can sustain neglect

Plan deployments: these are complicated and launcher dependent

Expect to lose satellites: have a robust search, ID, OD capability

Be transparent and communicative!

An aerial photograph of a rugged, mountainous landscape. The terrain is characterized by steep, rocky slopes and deep, winding valleys. A small town or village is visible in the lower central part of the image, nestled in a valley. The overall scene is captured from a high altitude, providing a wide perspective of the natural environment.

PUBLIC EPHEMERIDES

<http://ephemerides.planet-labs.com/>


Updated hourly, and pushed to Space
Data Association (SDA)

TEAM EMAIL

orbital-neighbors@planet.com

An aerial photograph showing a coastal city nestled between two rugged, mountainous landmasses. The city is visible in the lower center, with a grid-like street pattern and a harbor area. The surrounding terrain is characterized by steep, rocky slopes and deep, winding valleys. The sky is a clear, deep blue. The text "BONUS: PRETTY PICTURES" is overlaid in white, bold, sans-serif font in the upper center of the image.

BONUS: PRETTY PICTURES



**UNDATED
GOOGLE EARTH
IMAGE**

PULAU PINI, INDONESIA

UNDATED



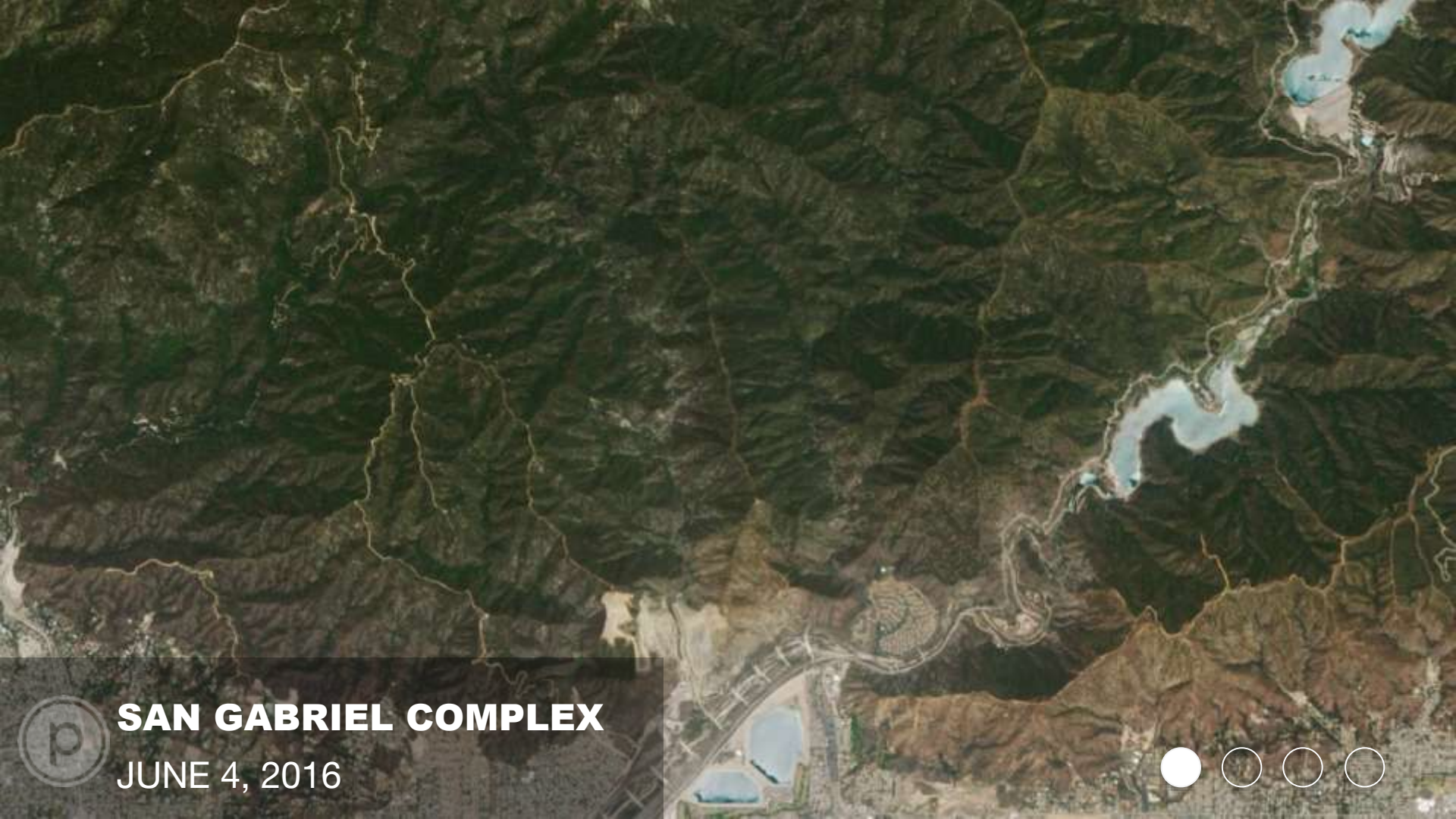


LOGGING ROADS

PULAU PINI, INDONESIA

JUNE 22, 2015





SAN GABRIEL COMPLEX

JUNE 4, 2016





SAN GABRIEL COMPLEX

JUNE 22, 2016





SAN GABRIEL COMPLEX

JUNE 22, 2016



CUPERTINO, CA

JUNE 15, 2017



VIRGIN ISLANDS

MAY 26, 2017

