

CubeSats : New Opportunities for Small Experiments in Near and Interplanetary Space.

APS Meeting 2015

Far West Section

California State University - Long Beach

<http://meetup.com/smallsats>

Don V Black, Ph.D.

Digital ChoreoGraphics

drdon@digitalsats.com

1-949-548-1969

CubeSats : New Opportunities



APS Meeting 2015

Far West Section

California State University - Long Beach

<http://meetup.com/smallsats>

Don V Black, Ph.D.

Digital ChoreoGraphics

drdon@digitalsats.com

1-949-548-1969

Planet Labs ISS Launch





CubeSat Specs in a Nutshell

- Power (~2W - 57W)
- Temperature (-70 C to +70 C)
- Lifetime (depends on orbit, 2 wks – 25 yrs)
- Cost (<\$10K-\$50K/1U - \$500K/3U) ~\$150K
- Orbits (LEO, MEO, GTO, GEO)
- Launch Cost (\$8K - \$500K) ~\$150K
- Form Factor (examples follow)
- Payload (up to you)

Form Factors

- CubeSat (4" cubed – 10 cm on each edge)
 - 1U ... 3U – (P-POD deployable)
 - 6U – Interplanetary Candidate (10x20x30 cm)
- TubeSat – 3.52" diameter x 5.0" tube
- PocketCube (1/8 x CubeSat)
 - 1p (up to 3p) - 5x5x5 cm (up to 5x5x15 cm)
- ChipSat / Sprite – 5 x 5 cm PCB w/ chip(s)

Form Factors

- **CubeSat** (4" cubed – 10 cm on each edge)
 - 1U ... 3U – (P-POD deployable)
 - 6U – Interplanetary Candidate (10x20x30 cm)
- TubeSat – 3.52" diameter x 5.0" tube
- PocketCube (1/8 x CubeSat)
 - 1p (up to 3p) - 5x5x5 cm (up to 5x5x15 cm)
- ChipSat / Sprite – 5 x 5 cm PCB w/ chip(s)

Merritt Island High School

(near Cape Canaveral)

with P-POD, 3U, and 1U



1U (10x10 cm), 2U (10x10x20 cm),
and 3U (10x10x30 cm)

Form Factors



Six CubeSats with 2 P-PODs



Form Factors

- CubeSat (4" cubed – 10 cm on each edge)
 - 1U ... 3U – (P-POD deployable)
 - 6U – Interplanetary Candidate (10x20x30 cm)
- **TubeSat – 3.52" diameter x 5.0" tube**
- PocketCube (1/8 x CubeSat)
 - 1p (up to 3p) - 5x5x5 cm (up to 5x5x15 cm)
- ChipSat / Sprite – 5 x 5 cm PCB w/ chip(s)

Interorbital Systems TubeSat kit: (on left) plus LEO Launch for \$8,000



Form Factors

- CubeSat (4" cubed – 10 cm on each edge)
 - 1U ... 3U – (P-POD deployable)
 - 6U – Interplanetary Candidate (10x20x30 cm)
- TubeSat – 3.52" diameter x 5.0" tube
- **PocketCube (1/8 x CubeSat)**
 - **1p (up to 3p) - 5x5x5 cm (up to 5x5x15 cm)**
- ChipSat / Sprite – 5 x 5 cm PCB w/ chip(s)

Wren STADOKO

Launch
2013

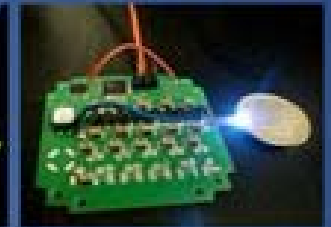
The German PocketQub "Just4You"

By: Paul Kocyla, Sacha Tholl, Bastian Döber, Matthias Stahrke

Attitude and Orbital Control



Reaction wheels



Pulsed Plasma Thrusters

Ground Control



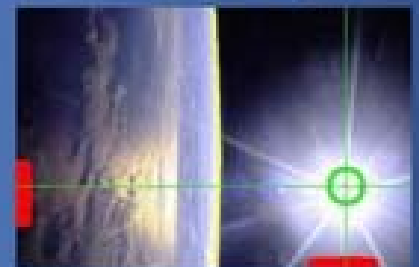
Mobile Ground Station



2 inch

2 inch

Navigation



Camera based determination
of sun and earth horizon vector

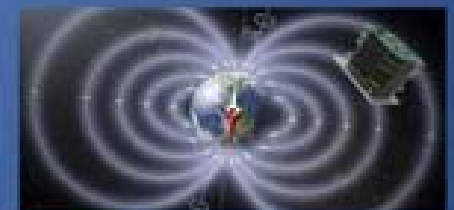


Intuitive Mission Control Software

PocketQub
privately funded
design matches proposal
from Prof. Bob Twiggs



3 axes rotation rate



3 axes magnetometer

\$50sat

FT-60 shown for size comparison



Freq.: 437.505 MHz.
TX Pwr: 100mW
Modes: CW, FSK, RTTY
Launched: Nov. 21, 2013 07:10 UTC
Dombrovsky, Russia

Confirming your reception Report:

CALLSIGN - DATE - MODE

Dk3WN

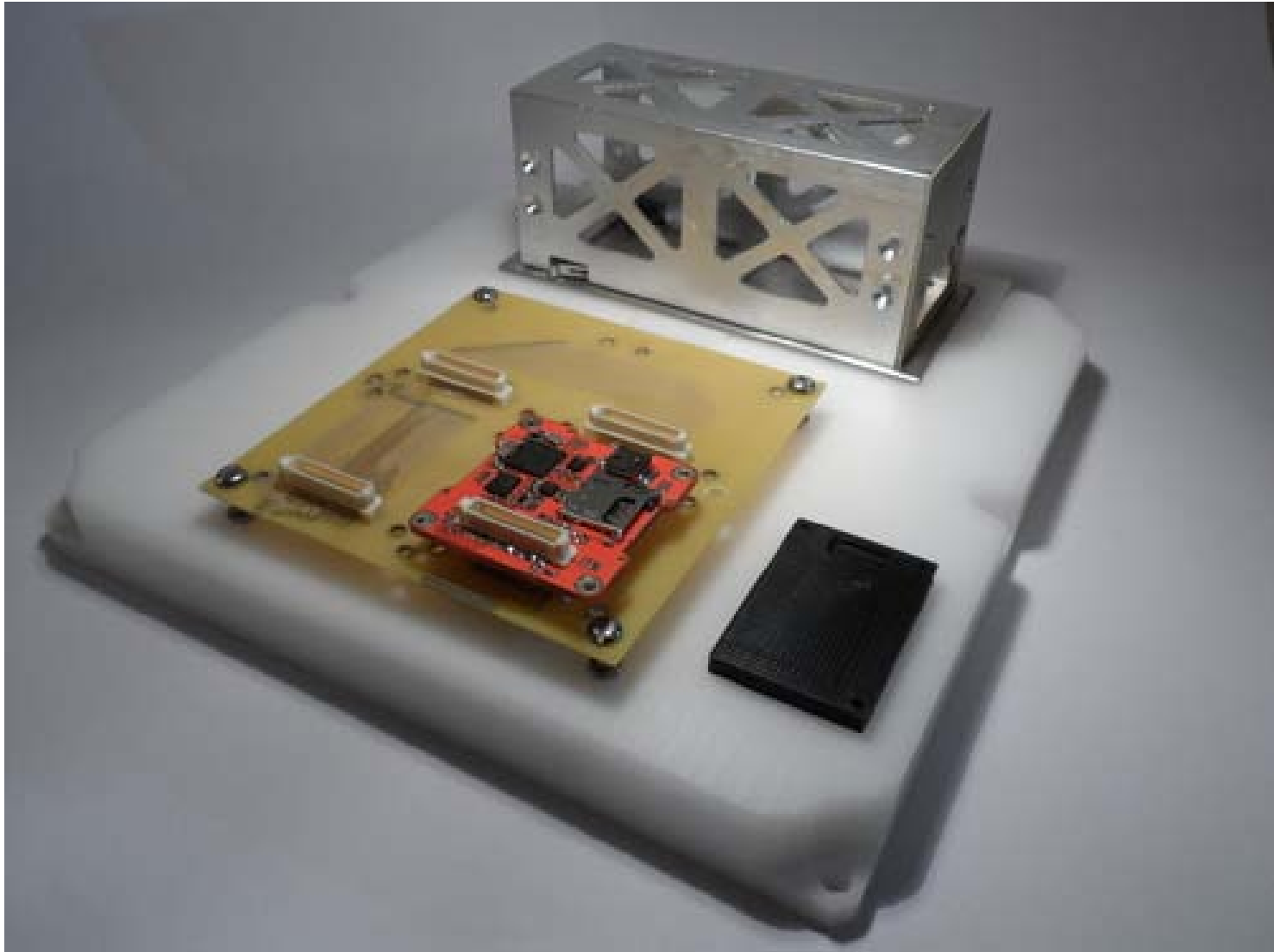
21/11/13

FAST
MORSE

www.50dollarsat.info

QSL card from Ham's Sputnik

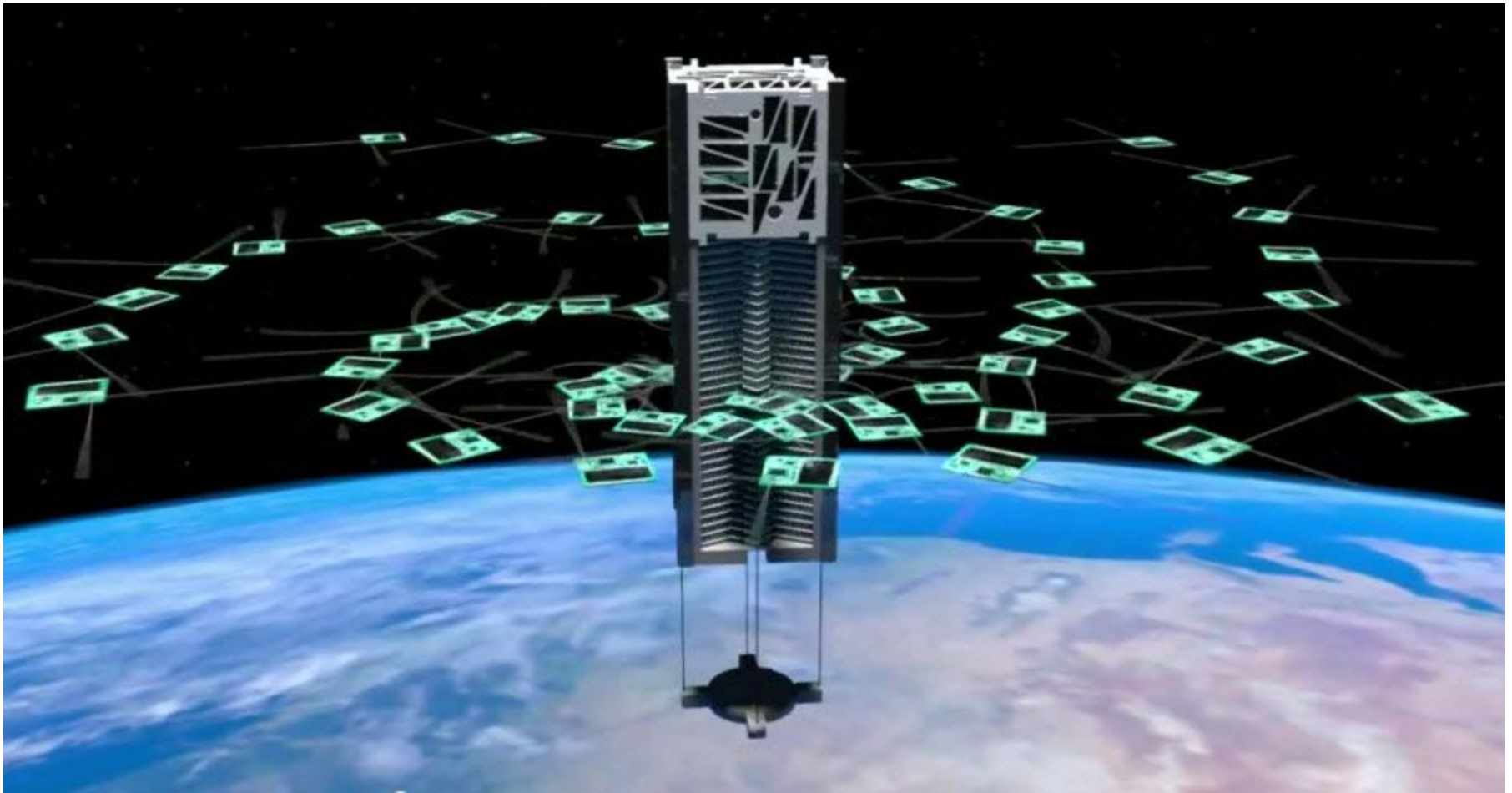
PocketQube Kit < \$6,000



Form Factors

- CubeSat (4" cubed – 10 cm on each edge)
 - 1U ... 3U – (P-POD deployable)
 - 6U – Interplanetary Candidate (10x20x30 cm)
- TubeSat – 3.52" diameter x 5.0" tube
- PocketCube (1/8 x CubeSat)
 - 1p (up to 3p) - 5x5x5 cm (up to 5x5x15 cm)
- **ChipSat / Sprite – 5 x 5 cm PCB w/ chip(s)**
 - **A 3U w/ 100 Deployable Chips**

KickSat 3U Deploying 100 Sprites





SmallSats Today & Tomorrow

- Lower Launch Costs
 - Many SmallSat Launcher Startups
- More Vendors
 - Ground Station Kit (Bob & Jann)
 - CubeSat & PocketQube Satellite Buses
- Useful Novel Payloads
 - Sensors: Atmospheric; Magnetic; Radiation; Solar; IR; Other Remote;
 - Optical & Radio Telescopes; GeoMag Surfers;
- Live on the Cutting Edge. Join SmallSats MeetUp

<http://meetup.com/smallsats>

CubeSats : New Opportunities for Small Experiments in Near and Interplanetary Space.

APS Meeting 2015

Far West Section

California State University - Long Beach

<http://meetup.com/smallsats>

Don V Black, Ph.D.

Digital ChoreoGraphics

drdon@digitalsats.com

1-949-548-1969

Introduction to a new Disruptive Technology

- Disruptive Technology – CubeSats and P-PODs Striking Parallels between the Microcomputer and the CubeSat Revolutions
 - Both have the capabilities comparable to contemporary commercial products costing 1,000 times as much.
 - \$4,000,000 IBM Mainframe vs. \$4,000 PC
 - \$855,000,000 Landsat vs. \$500,000 CubeSat
 - Both introduced by academia, yet subsumed by home hobby kits, industry, the military. Personal Sat next.



Emergent Satellites – A Brief History

- 1999 – CubeSat Spec introduced for students at Stanford.
 - Bob Twiggs, Morehead State (KY)
 - Jordi Puig-Suari , CalSate San Luis Obispo
- 2001 – Calpoly P-POD Spec (jack-in-the-box)
- 2003 – First launch on Russian Eurockot
- 2004 – Est. \$10K build + \$100K-\$120K launch
- 2007 – 1/11: Chinese Head-on destructive intercept.
- 2012 - 100th CubeSat Launched
- 2013 – 70 US companies; 50 US univs; 41 foreign univs
- 2014 – 160 more CubeSats expected?
- 2015 – OTS 1U: \$30K-\$50K; 3U: \$150K-\$350K

Mission Payloads

- Technology
 - Experiments
 - Demos
- Science
 - Remote Sensing (Planet Labs, Lunar Flashlight)
 - Earth Science (Geo Magnetism, Atmospheric Composition, Hyperspectral Surface Analysis)
 - Space Science (Planetary Resources)
- Commerce
 - Weather
 - Google Maps (SkyBox)
 - Global Transportation (Planet Labs)

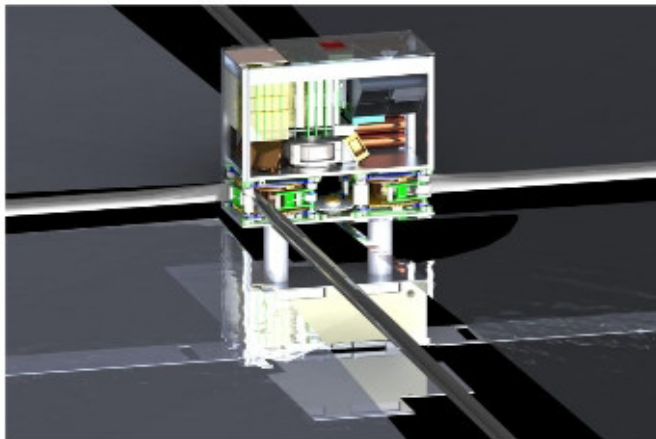
Form Factors

- **CubeSat** (4" cubed – 10 cm on each edge)
 - 1U ... 3U – (P-POD deployable)
 - **6U – Interplanetary Candidate (10x20x30 cm)**
- TubeSat – 3.52" diameter x 5.0" tube
- PocketCube (1/8 x CubeSat)
 - 1p (up to 3p) - 5x5x5 cm (up to 5x5x15 cm)
- ChipSat / Sprite – 5 x 5 cm PCB w/ chip(s)

First Interplanetary CubeSat Mission

Lunar Flashlight

LF Flight System Overview



Mission: Locating ice deposits in the Moon's permanently shadowed craters

Approach: "6U" Solar-Sail Propelled CubeSat (<12 kg)

Launch Opportunity: SLS EM-1 (Dec 2017 notional launch)

Bus: JPL Deep Space NanoSat Bus (leveraging INSPIRE)

Propulsion: MSFC ~80 m² Solar Sail (based on NanoSail-D)

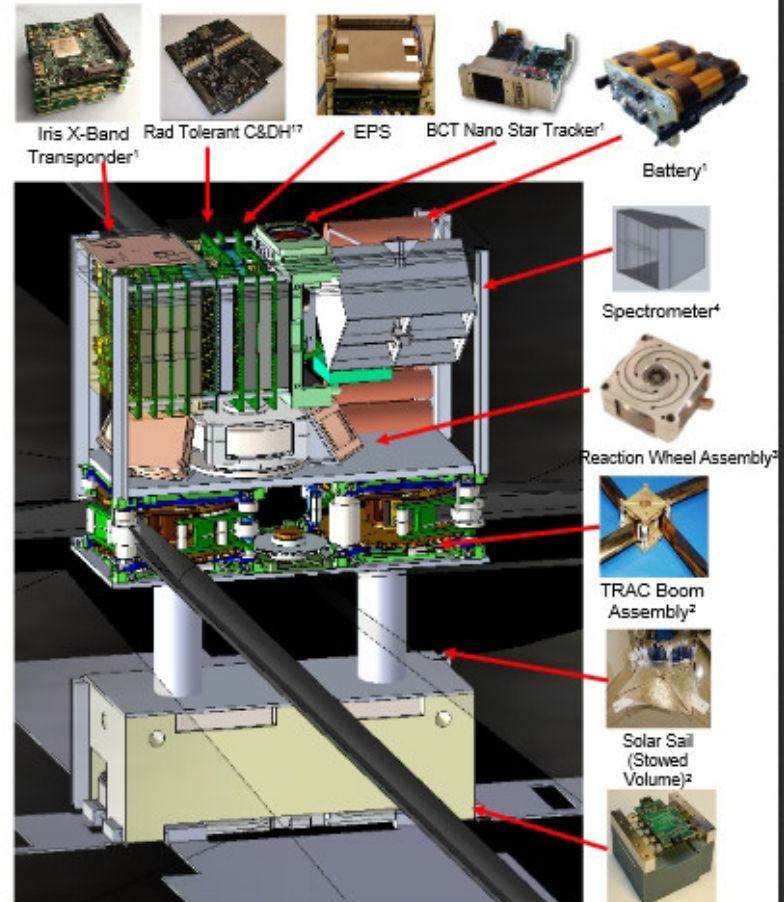
Payload: COTS 4-band spectrometer

C&DH: Rad Tolerant LEON-3 architecture, JPL Protos FSW

ADCS: COTS Cold Gas, RWA, SRU, IMU, CSS

Power: ~30W with gimballed solar panels

Telecom: JPL Iris X-Band Transponder + Patch Antenna (~1 kbps nominal @ Lunar Distance with Morehead State)



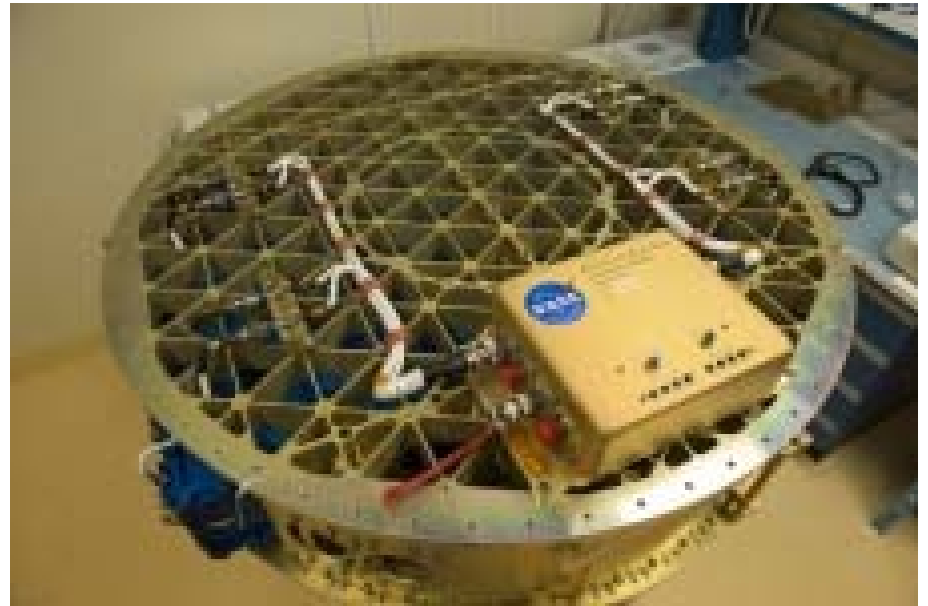
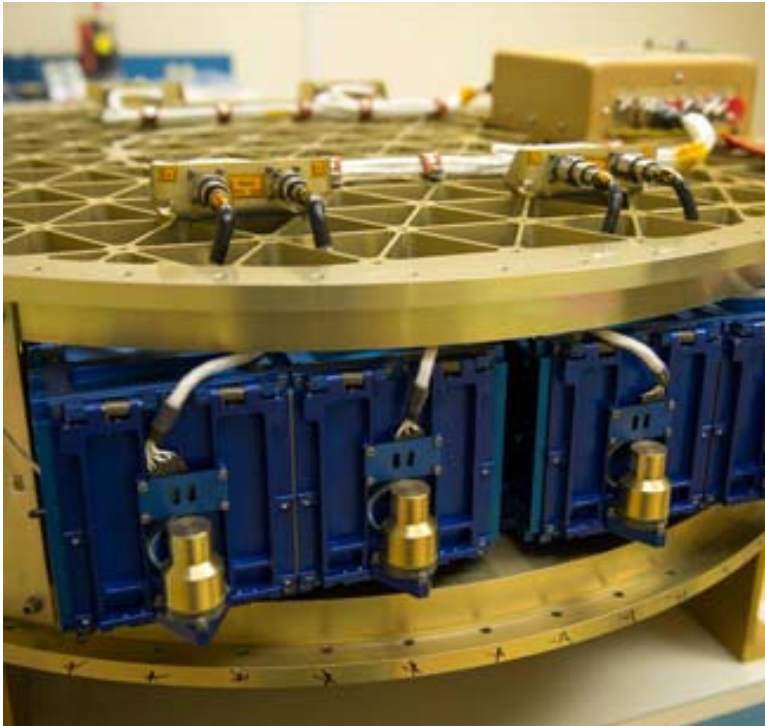
Launch Systems

- NanoRacks ISS Launch System via Astronauts
 - Russia to International Space Station (ISS)
 - SpaceX Dragon to ISS
- Rocket Deployment Collars
- Direct to LEO
 - SpaceX (SmallSat GEO Internet Constellation?)
 - Interorbital Systems
 - Garvey Spacecraft Corp
 - Rocket Lab
- Air Launch to LEO
 - Virgin Galactic
 - Generation Orbit
 - Boeing ALASA via F-15E

Planet Labs ISS Launch



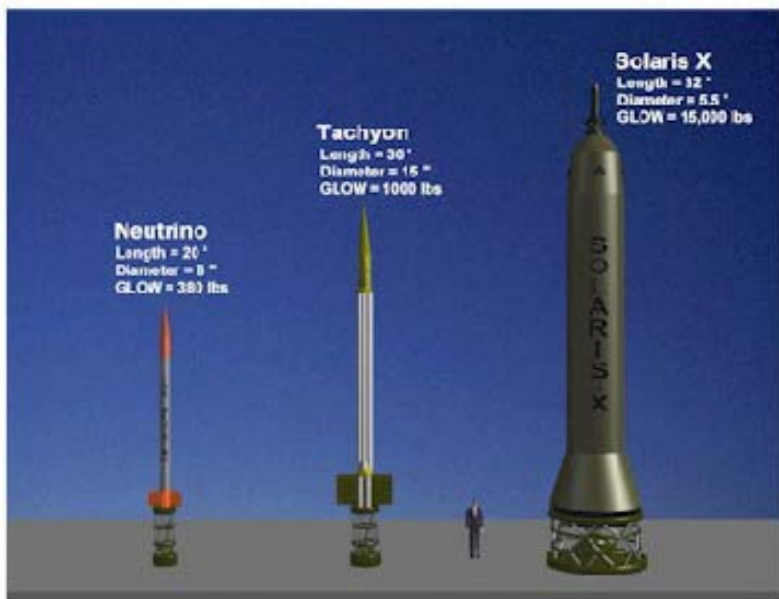
Rocket Collar Deployment System



SpaceX

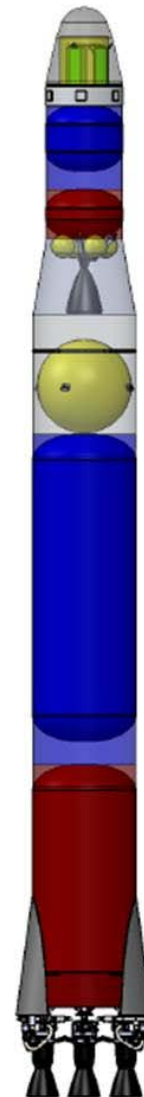


Interorbital Systems vision



IOS Suborbital Rockets

Garvey Spacecraft vision



11.4 m
(37 ft)

20 kg / 450 km
NLV

Air Launch Solutions





SmallSats Today & Tomorrow

- Lower Launch Costs
- More Vendors
 - Ground Station Kit (Bob & Jann)
 - CubeSat & PocketQube Buses
- Useful Novel Payloads
 - FirstLight, GeoMag Field, Radiation & SEU Honey Pots
- Join the Fray. Join SmallSats MeetUp

<http://meetup.com/smallsats>

CubeSats : New Opportunities for Small Experiments in Near and Interplanetary Space.

APS Meeting 2015

Far West Section

California State University - Long Beach

<http://meetup.com/smallsats>

Don V Black, Ph.D.

Digital ChoreoGraphics

drdon@digitalsats.com

1-949-548-1969

CubeSats, A Brief Introduction

A Brief History, State and Future
of the
Small Satellite Industry

<http://meetup.com/smallsats>

Don V Black, Ph.D.
Digital ChoreoGraphics

drdon@digitalsats.com

1-949-548-1969