Distant Horizons

Smallsat Evolution in the Mid- to Far-Term

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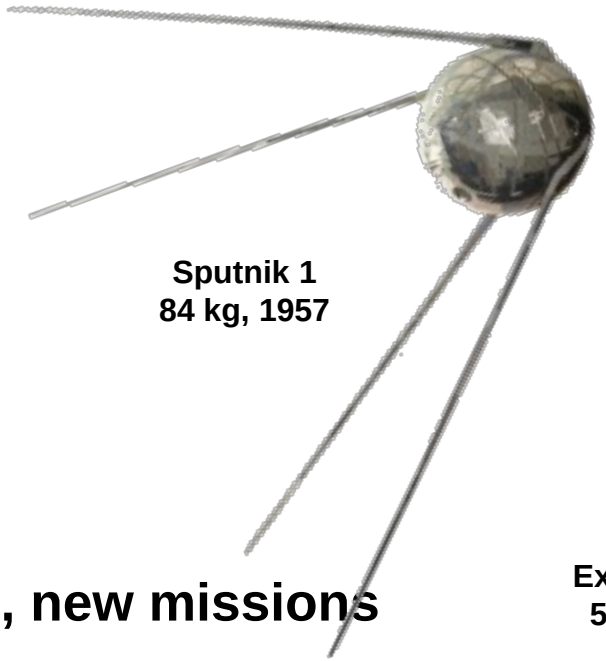
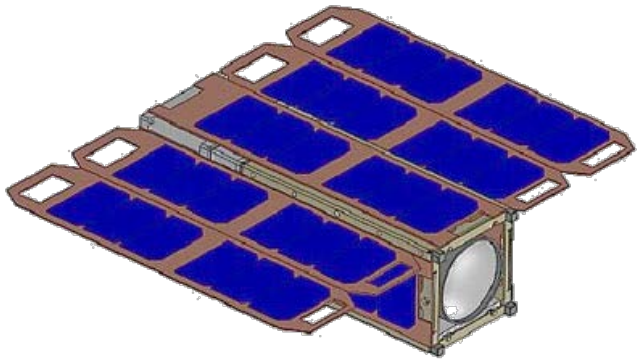
Introduction



Sputnik 1
84 kg, 1957

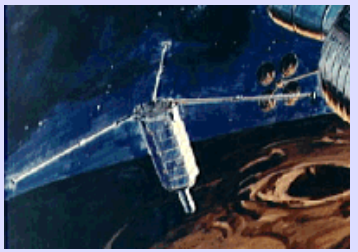
- The Microsat: Age 54
- Focus: 2020 and beyond
- Emerging: New forms, new functions, new missions
- The generation after next?

ExoPlanetSat
5.5kg, 2013



1957-2011: A Steady Rise

- Microsats achieved many space firsts (some of them forgotten)
- First wave – late 50s/early 60s
- Rebirth – late 80s/early 90s
  - Key experiments and demonstrations
  - New companies and new missions
- Enter the CubeSat
- Past the Tipping Point

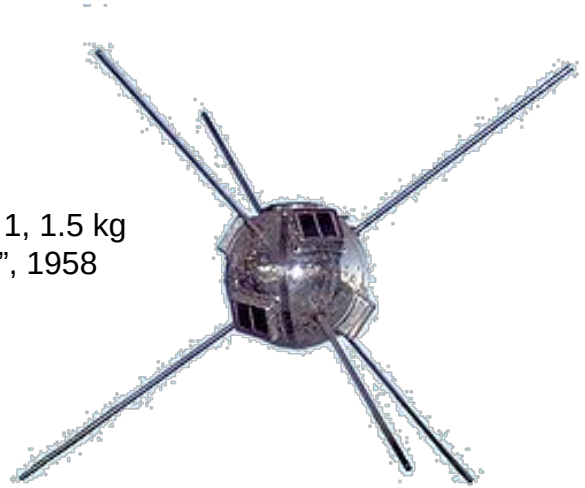


Apollo P&FS, 1971 (NASA)

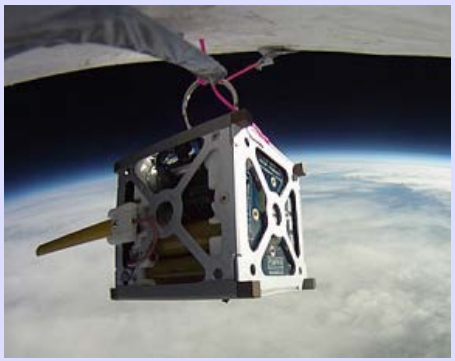
Space Technology 5, a.k.a. THEMIS, 2007 (NASA)

Small to Smallest

- **The march of technology**
- **Evolution and Conceptual Breakthroughs**
- **Pushing limits of physics**
- **Ideas from all sources (civil, military, commercial)**



Vanguard 1, 1.5 kg
“beeper”, 1958



Android ™ tested on balloon (NASA)

1-cm Chipsats ride the solar wind (Cornell)

IC with 9 JPL rechargeable microbatteries

Can We Solve Launch?

- Smaller Should Mean Easier
- Good Work Being Done
  - Rideshare
  - Incentives and Opportunities
- Thoughts In The Right Direction
  - Micro Launch Vehicles
  - Increased Technology and Utility

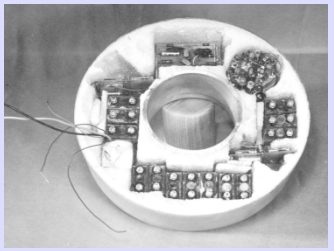
Microsat launcher, 1958

Microsat launcher, 1990 (NASA)

Microsat launcher : next generation?
(Images: SPG and Garvey Space)

Building a Better Microsat

- Satellites have gone from hand-built to… hand-built
- New techniques are making inroads in microsat production
- The future: mass production and fabrication on demand
- Newest Idea: Make it in space

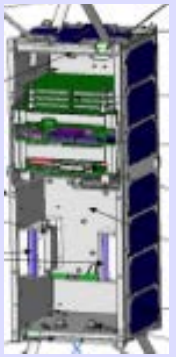


Microsat assembly, 1958
(Dick Boyd, NOTS)

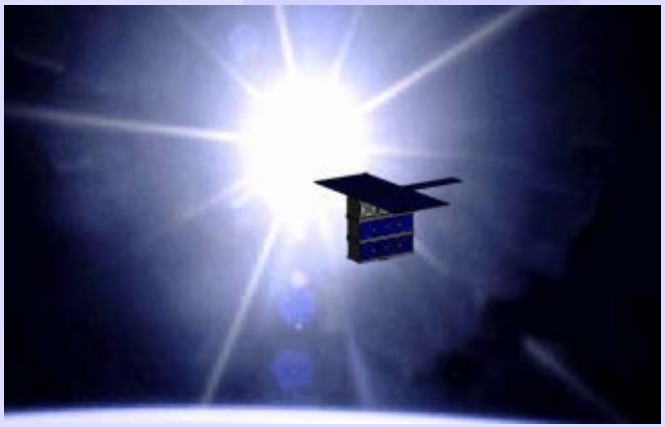
Microsat assembly, 2010
(U of Toronto AIS)

New Missions: Civilian and Military Applications

- **Military: fast response, more capability**
  - **Disaggregated Payloads**
  - **Data Exfiltration**
  - **Communications**
  - **On-orbit inspections**
- **Civil Apps: Expanding roles**
  - **Disaster monitoring**
  - **Tracking the environment**
  - **Education: Do it yourself**



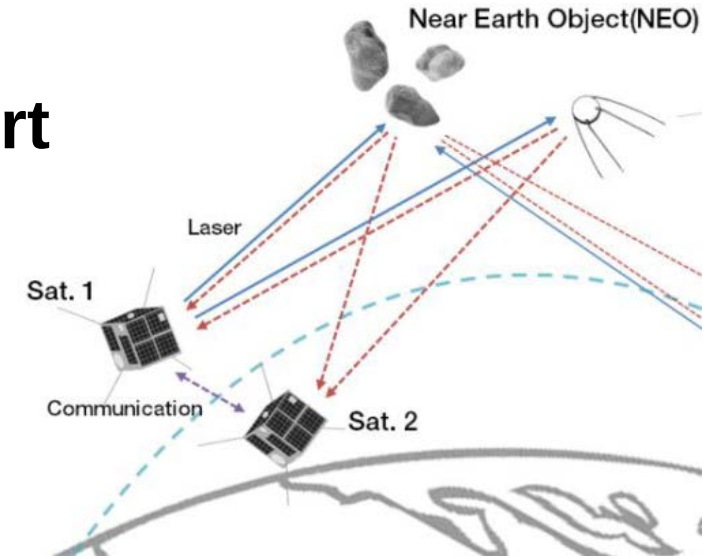
Army SMDC-ONE



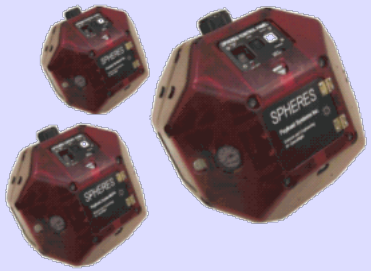
Surrey future Multi-spectral imager (15 kg)

New Missions: Science and Support

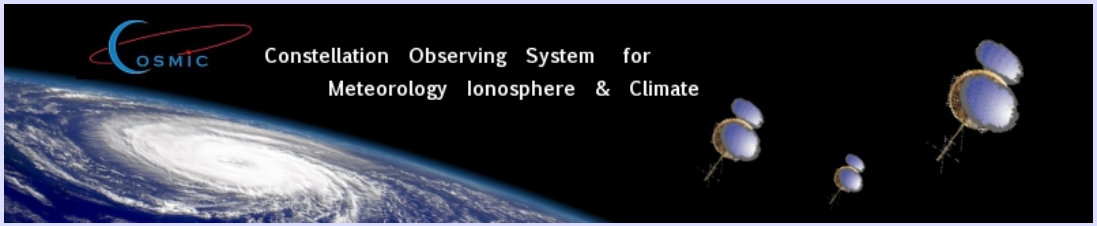
- Earth weather and space weather
- Finding NEO
- Helpers in Orbit



Nanosatellite interferometry (KAIST (Korea))



SPHERES (MIT)

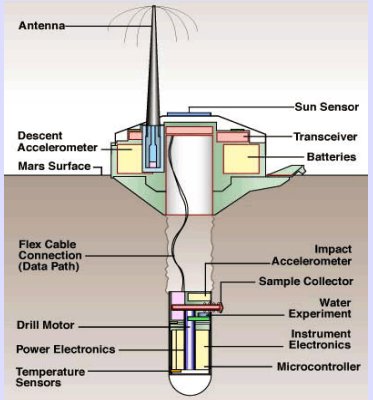


COSMIC Mission for studying Earth's Atmosphere

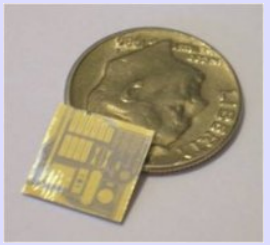
New Missions: Space Exploration

- **Long heritage, including Pioneer lunar microspacecraft, Apollo Particle and Fields Subsatellites, and Mars Deep Space 2 probes**
- **Current Trends:**
  - **Planetary probes: Sprite**
  - **Discovering Exoplanets**
  - **Micro robotics for planetary exploration**
  - **Navigation/Communication relay nodes**

"Exploration is where microsatellites will hit their home run." – Dr. Mike Griffin, former NASA Administrator



Deep Space 2 Microprobes (NASA)

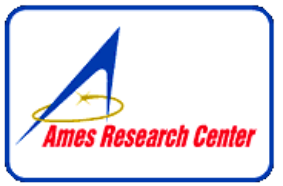


Sprite Integrated Circuit

Exoplanet Search

Trends

- More Nations, More Entrants
- Cooperation and Fractionation
- Into the Solar System
- “Large vs. Small” fight largely over
- Conclusion: Secure Present, Brilliant Future



The great age of microspacecraft has finally begun….

THANKS TO:

Booz | Allen | Hamilton

delivering results that endure

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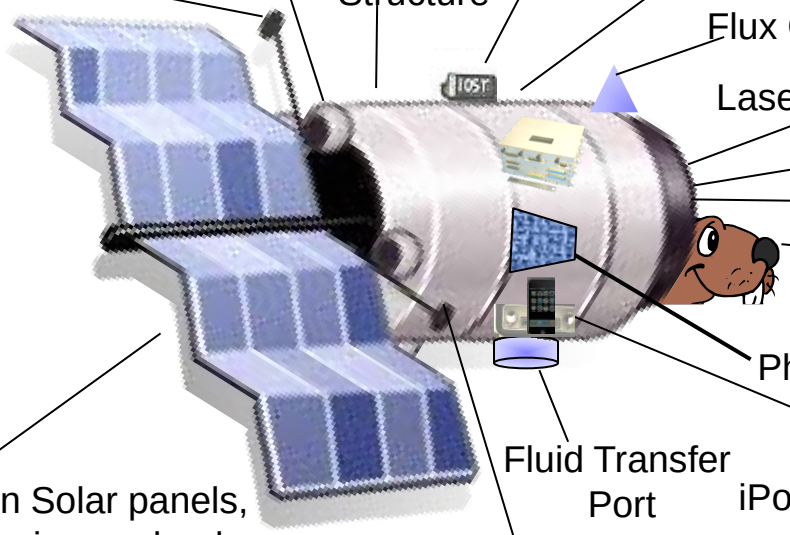
QUESTIONS?

If everyone gets their wish: the microsat of 2020

Amoeba
(Size Comparison)



Precision Pointing Thrusters
DirecTV
Unobtanium Structure
105 megajoule Capacitor
Cray™ Supercomputer
Flight Computer
Mass: 50 grams
Time travel Flux Capacitor
Laser rangefinder
Sensor module: Visual/IR/radar/ Sonar/ESP
Marman clamp
Marmot clamp
Phaser bank
Fluid Transfer Port
iPod™/iPhone™/iStarTracker™
Combination Solar panels, Gravity sensing payload, and BBQ grill
Microthrusters
Delta-V 200m/sec
Firing Duration 1.2 million seconds

Cartoon © 2011 by Matt Bille
(Satellite body: Microsoft Office)