Applications of Nano-Satellites & Cube-Satellites in Microwave & RF Domain

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Outline

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✧ Architecture & Communications Subsystems

✧ CubeSat Examples

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  – NASA's Earth Science Measurements

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Introduction

- Explorer-1 was the 1st American satellite that was launched on Jan 1958
- The 1st set of 6 Picosatellite were developed at Stanford University
- Measured 4 x 3 x 1 inch (4 Qty) and 8 x 3 x 1 inch (2 Qty)
- For deployment in space two launcher tubes compatible with the multiple payload adapter on the Minotaur rocket or launch vehicle were also developed
- The Picosatellites were launched in Jan 2000 & operated for several days on batteries & successfully accomplished their mission

4
3
1
(inches)

Picosatellite

Launcher Tube

Four Picosatellites
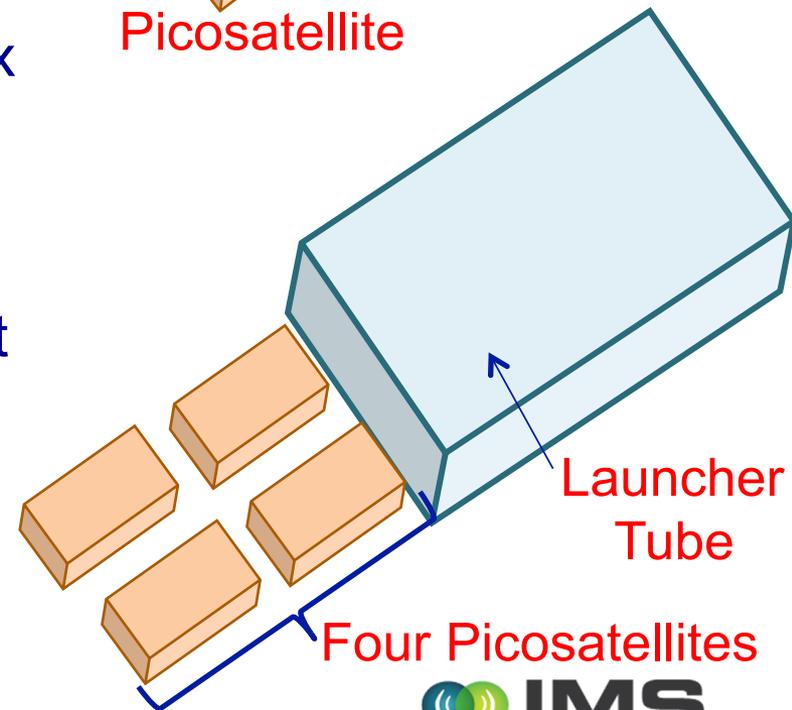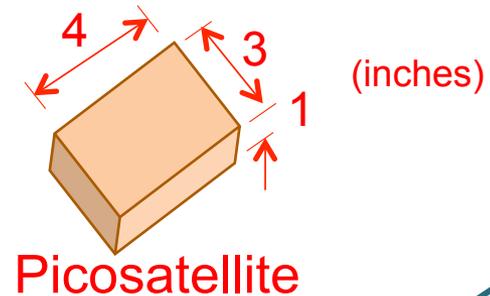
Evolution of CubeSats

✧ Experience gain with the Picosatellites indicated that a better size would be a cube that had enough surface area to generate at least two-watts of dc power with SOA solar cell technology

✧ A 3.5 inch cube could meet the above power requirement

✧ Experience with the launcher tube indicated that it was an efficient means for deployment

✧ To allow for room for the solar panels & room to contain the cube on rails inside the tube it was decided to design a cube with 4 inches (10 cm) on the side

✧ Thus the new Picosatellite called Cubesat & launcher tube to hold 3 Cubesats was conceived

Solar Cells

4.0

4.0

4.0

(Inches)
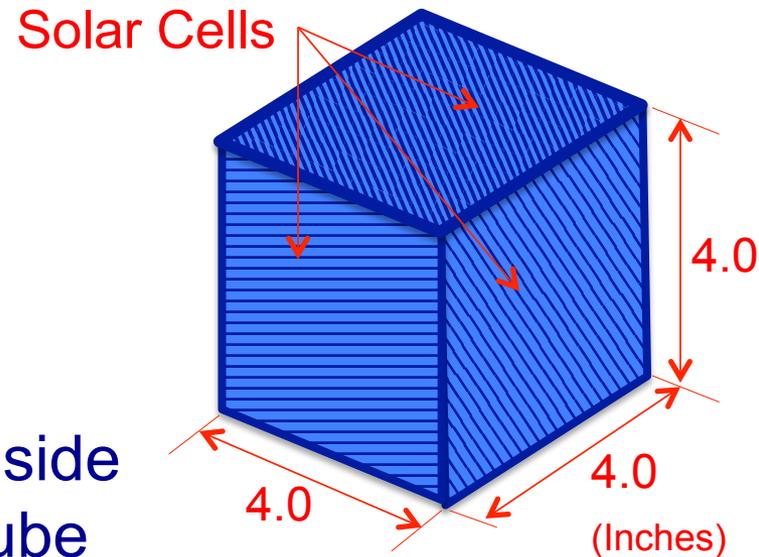
CubeSats

✧ A Cubesat measures 10 x 10 x 10 cm & weighs ≈ kg
   & assembled using COTS components

✧ This form factor is defined as a "1U" unit

✧ Stand alone or serves as a building block for
   a larger Nanosat or Microsat

✧ A "3U" Nanosat will consist of 3 Cubesats

✧ A "6U" or a "12U" is also a possibility

10 cm

10 cm

10 cm

1U (≈1 kg)   **2U**

3U
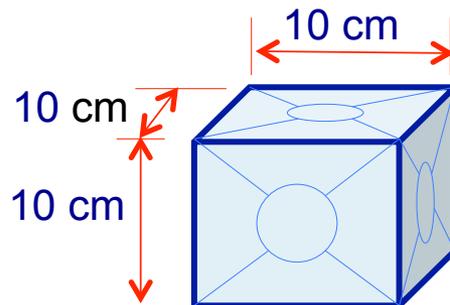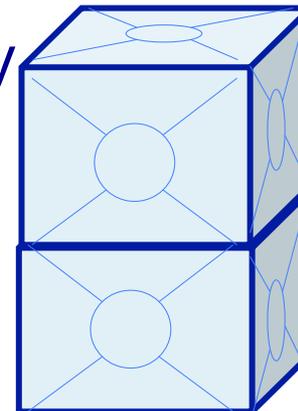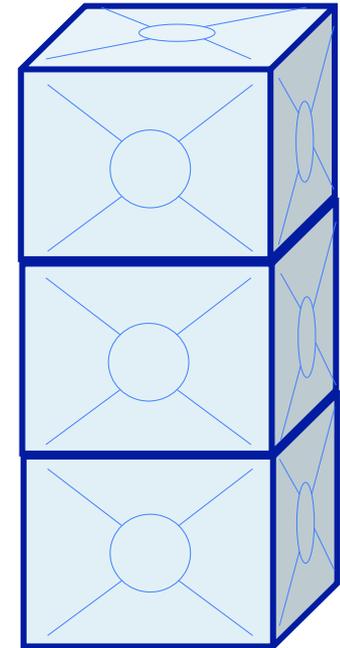
Challenges Facing the Small Satellite Industry

Challenges

✧ Radio Spectrum
– Typically UHF
– Migrate into Higher X-band and Ka-band

✧ Prime Power
– When Further Away from the Sun

✧ Life Expectancy
– Years Instead of Weeks

✧ In-Space Propulsion
– Trajectory Change
– Space Debris Removal - Mechanism to Deorbit

Challenges

✧ Instruments
  – Small Size and Mass
  – Making Meaningful Science Measurements

✧ Business Sustainability
  – Small Start-up Companies
  – Earth Multispectral Imagery
 – Other Applications

✧ Launch Opportunities
  – Affordable Cost

CubeSat Architecture & Communications Subsystem

Communication Subsystems
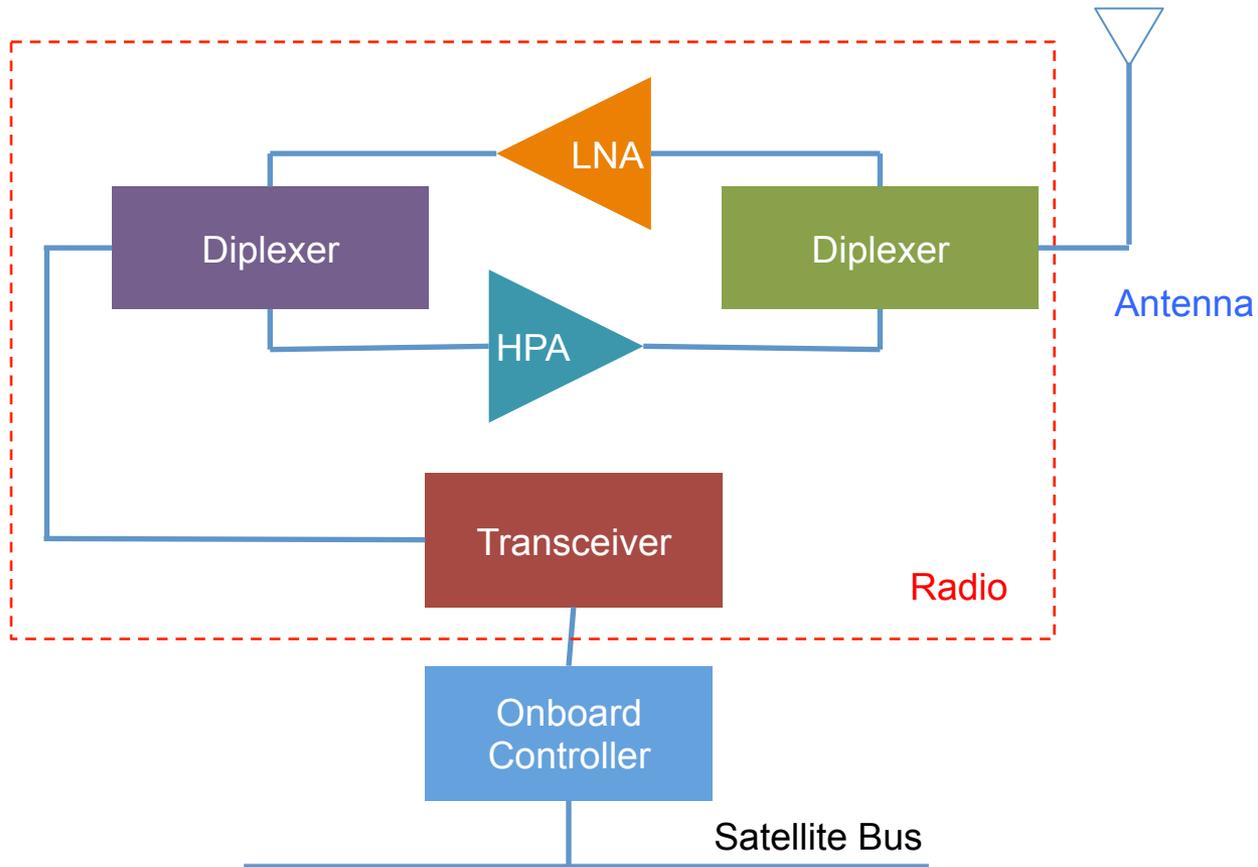
NASA's Small Satellite Communication Technology Missions & Demonstration Examples

Examples

✧ PhoneSat Mission

✧ Edison Demonstration of Smallsat Networks (EDSN) Mission

✧ Optical Communications and Sensor Demonstration(OCSD)

✧ Integrated Solar Array and Reflectarray Antenna (ISARA) for High Bandwidth CubeSat

✧ CubeSat Proximity Operations Demonstration (CPOD)

✧ Network and Operation Demonstration Satellites (NODES)

✧ High Rate CubeSat X-Band/S-Band Communication System

✧ Development of Novel Integrated Antennas for CubeSats

NASA's In-Space Validation of CubeSat Based Microwave Small Instruments & Subsystems for Earth Science Measurement Examples

Example

✧ Microwave Radiometer Technology Acceleration (MiRaTA) CubeSat

Conclusions

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✧ CubeSats, nanoSats and Microsats are an emerging disruptive technology area with a broad range/scope of applications in RF Communications

✧ While the scope of applications is still being studied, it is clear that this technology offers tremendous benefits in many space applications

✧ These benefits can be further enhanced through the use of 3D Printing, which has the potential to significantly reduce the Manufacturing cost, total time for the design cycle, and material waste