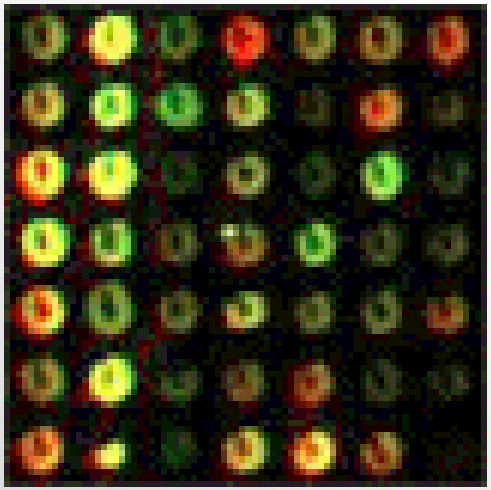
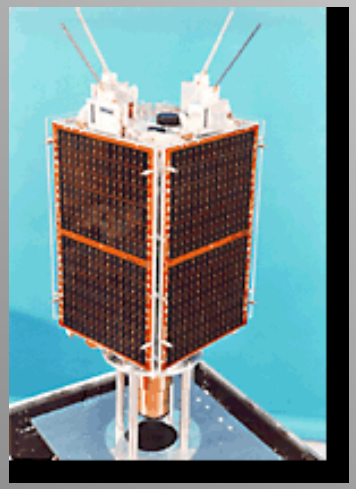
In Situ Genetics Experiments on Nanosatellites (ISGEN)

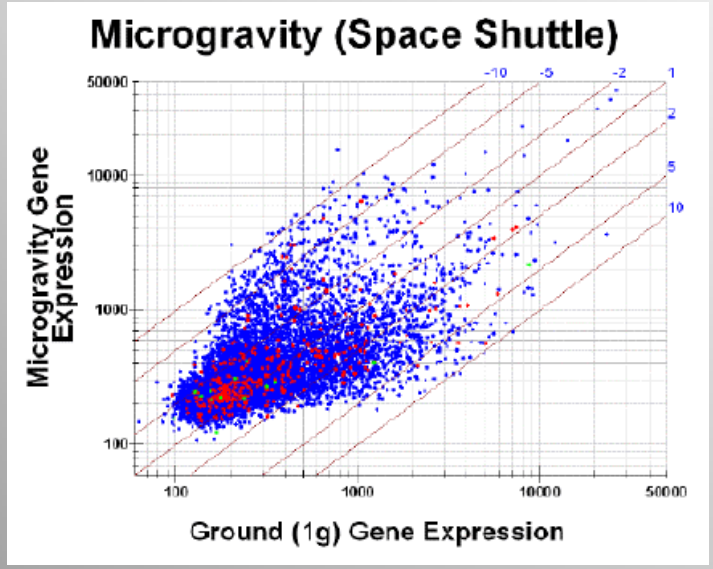
CubeSat Developer's Workshop

April 2004

ASTROBIONICS

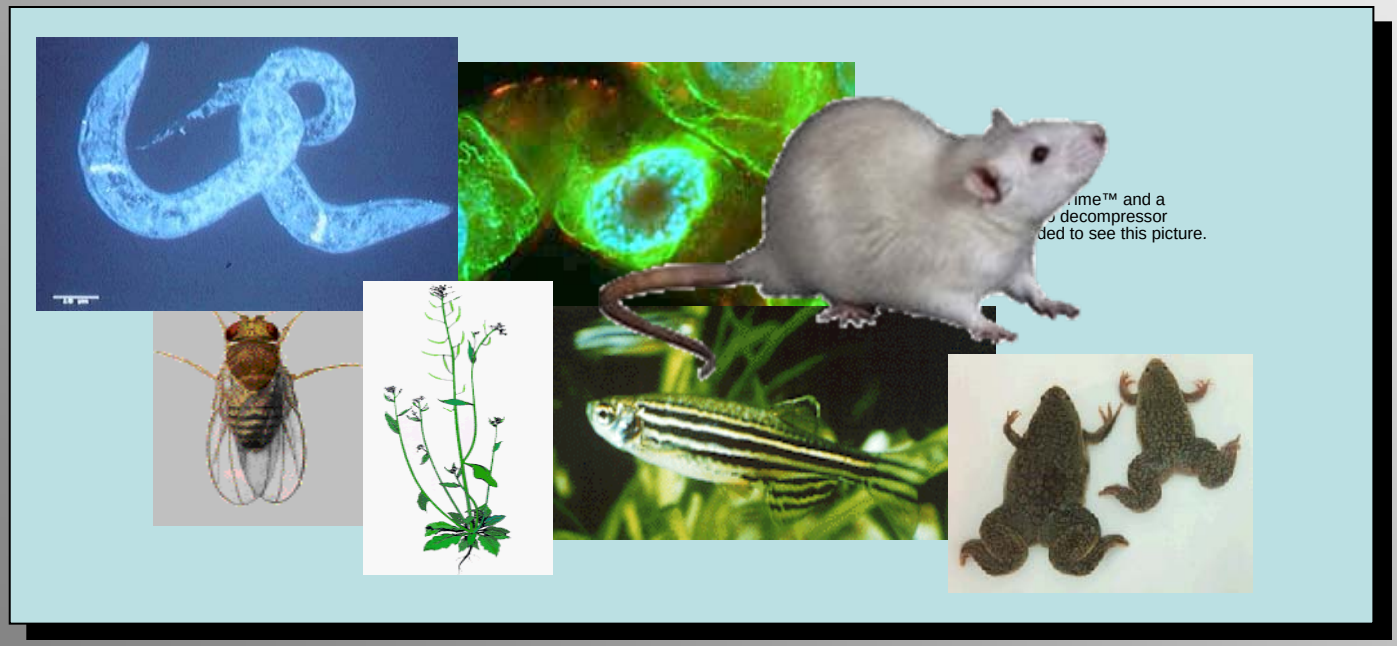






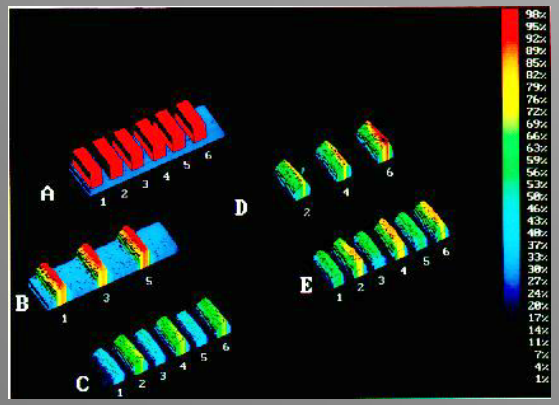
ISGEN Project Charter

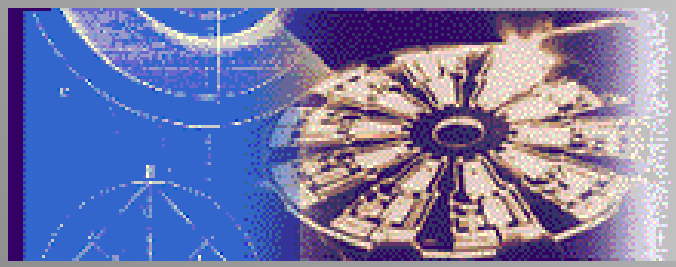
Develop, design, assemble, and test a flight-ready autonomous spacecraft as a technology demonstration platform which will accommodate genomic research.

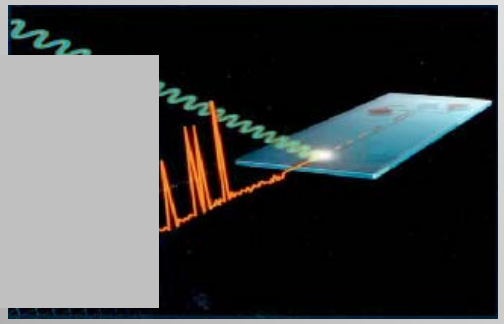


ISGEN Rationale - Why Genetics?

- **Powerful investigative tool(s) using small model organisms**
  - Large amounts of data from relatively modest investment into biology
  - Computational capabilities and related analytical methods available
  - “Broadband” versus discreet approach to cell biology very attractive
- **Genetics (genomics) is quickly becoming an accepted gold-standard for certain types of biological investigations**
  - Anticipate increased applications in support of NASA research goals
  - Excitement for understanding g-adaptation, radiation processes evident
- **Genetic research is highly compatible with small payload packages**
  - New operational mode for NASA Exploration research
  - Compatible with autonomous systems
  - *In situ* experiments produce information (vs. sample return)
- **Genetic research can directly augment and integrate rapidly into planned Exploration goals and objectives**







ISGEN Rationale - Why Satellites?

- **Access to alternative space environments**
  - Multiple flights possible - test, learn, iterate
  - Exploit unique space environments outside of 51° LEO (ISS)
- **Autonomous spacecraft technologies becoming available and capable**
  - Command and control, communications
  - Power generation
- **Relatively low cost**
  - Secondary payload model
  - Ideal for partnering and collaboration opportunities
- **Autonomous operations using small (miniature) systems**
  - Reduces reliance on human-tended architectures
  - Applies pressure to reduce mass, power, other resources
- **Rapid development cycle(s)**
  - Iterative process key to success
  - Consistent with commercial technology life cycles
- **Rapid technology migration to other (larger) platforms such as ISS, other FF platforms**

NASA GSFC

Orbital Sciences Corp.

SpaceX

SpaceDev

Mission Requirements (Summary)

*.Sat 1

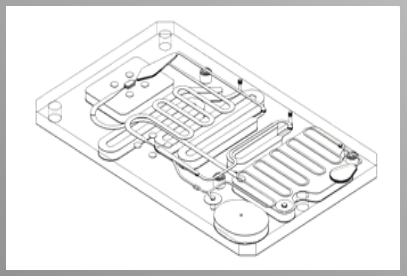
Total Payload Mass (does not include spacecraft)	1.5 kg
Payload Power (on-orbit average, excluding spacecraft)	2 W OAO
Payload Volume (does not include spacecraft)	~1.5 “cubes”
Science Data Downlink	Maybe 1 MB/day, X- or S-band OK
Launch Readiness Date	NET 10/05
Mission Duration (spacecraft design life)	$\geq$ 21 days
Orbit Altitude	Insensitive - prefer LEO
Orbit Inclination	Insensitive - prefer > 51°
Launch Vehicle	Prefer “soft ride”
Pre-launch Access	Late Access to payload desired

Not a compete set of requirements.

ISGEN General Technology Flow

Sample Management

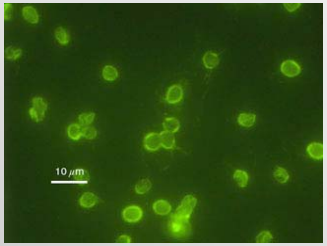
µwellplates



µfluidics

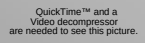
PCR

Imaging



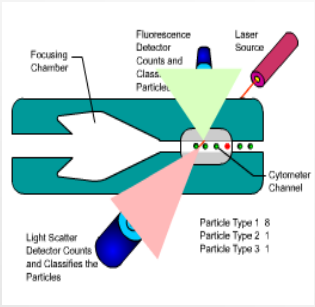
Fluorescence

Single wavelength

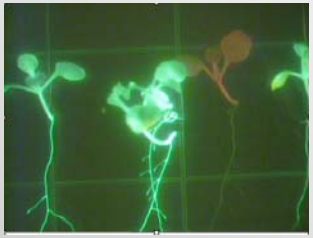


Multi-wavelength

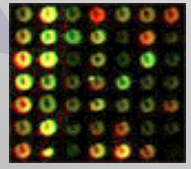
Detection and Analysis



Cytometry

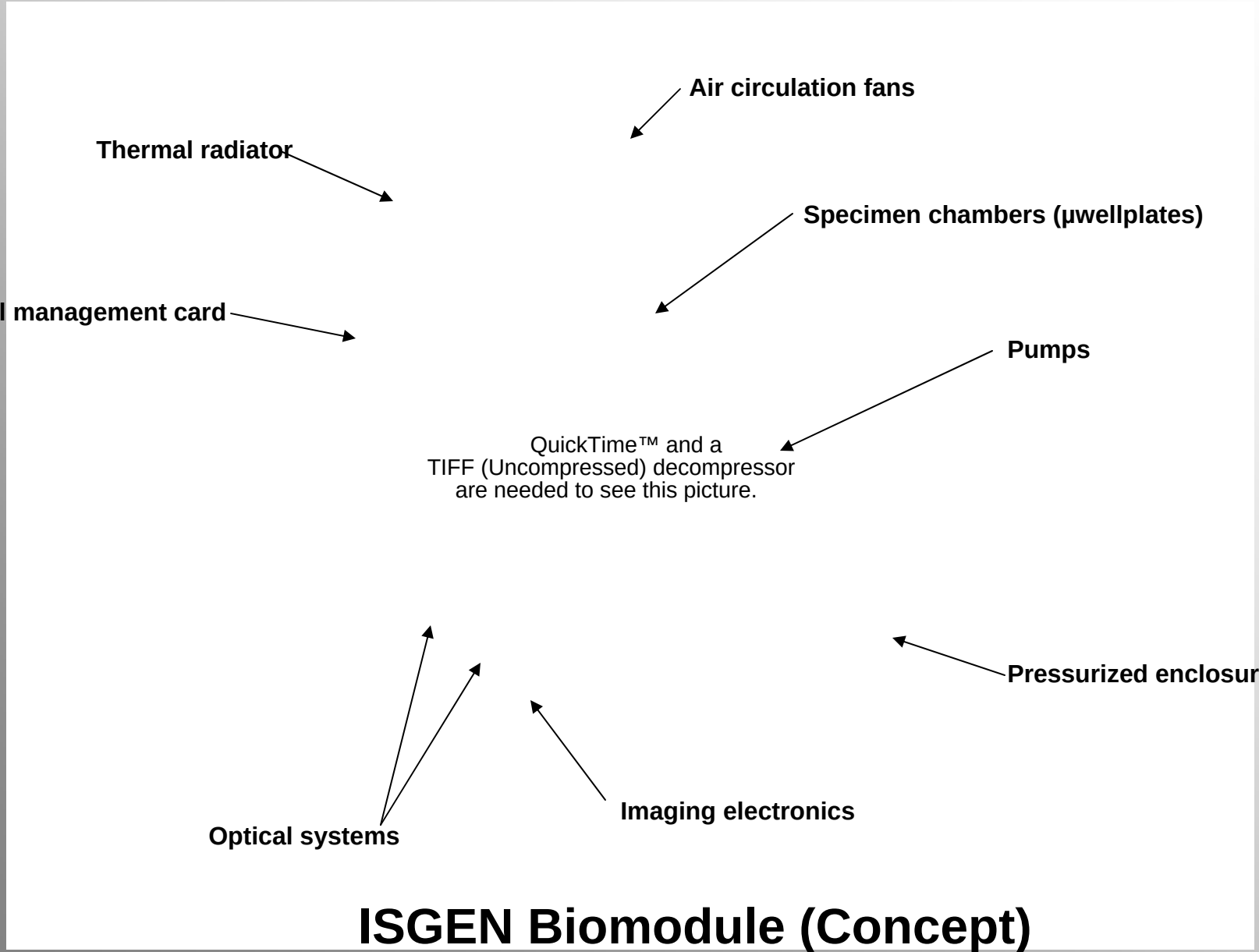


Spatial Imaging



Arrays (RNA, DNA, Proteins)

ISGEN Preliminary Technology Concept



ISGEN Biomodule (Concept)

*.Sat 1 Summary

Summary

- Universities developing *.Sat 1 spacecraft
  - Integration and launch site operations provided by CalPoly
- Payload technology provided by ARC
- *.Sat is launched on Dnepr late 2005
  - 2 flight opportunities/year
  - Multiple reflights possible
  - Other (domestic) opportunities may also be possible (?)

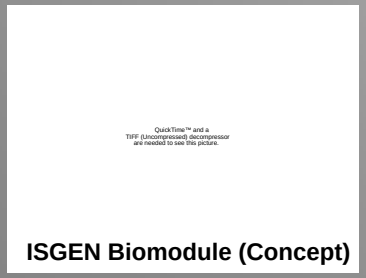
Dnepr

Benefits

- Excellent E&O opportunity
  - Potential to involve significant numbers of student and faculty
- Low cost for spacecraft and launch services
  - Russian launch services very competitive
- Rapid demonstration - 2005 launch a possibility
- Multiple spacecraft can be efficiently produced to accommodate multiple ISGEN technology configurations
  - Launch multiple times, evolve payload complement

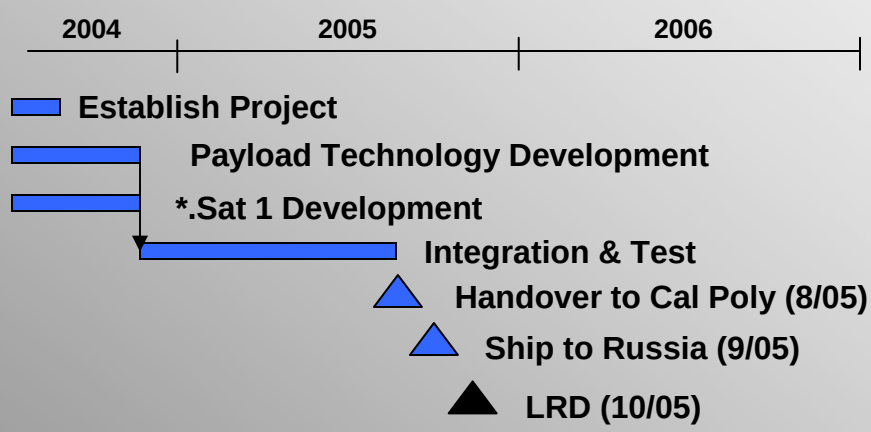
Issues

- Export and INA legal restrictions unclear
  - Issue in work at NASA HQs
- Schedule is very aggressive
- Challenge to payload for miniaturization



ISGEN Biomodule (Concept)

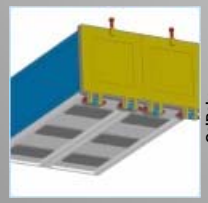
Project Schedule



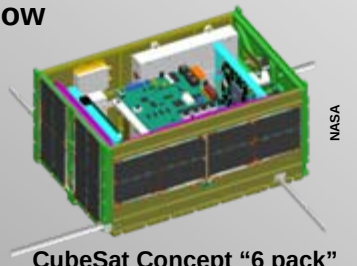
Foton M3

Summary

- Negotiate for 2 *.Sat accommodations on Foton M3 (LRD = 10/06)
  - Internal - recoverable (payload, only)
  - External - deployable - 2 X *.Sats
  - Other external configurations may be possible (under review)
    - BioExplorer - shown below



2 X PPOD



CubeSat Concept “6 pack” (External)

Benefits

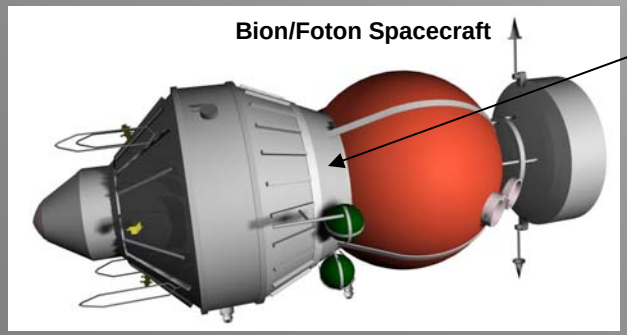
- High potential for success
  - Known, reliable spacecraft (Foton) and launch vehicle (Soyuz)
  - Experience on NASA side in flying on Bion/Foton
- Two mission types (internal + external) a plus
  - Compare results from both configurations
  - “Dissect” recovered payload/biology for performance data
- Potential to partner with peer-selected biology in ISGEN(s)

ISGEN Biomodule

(Internal)

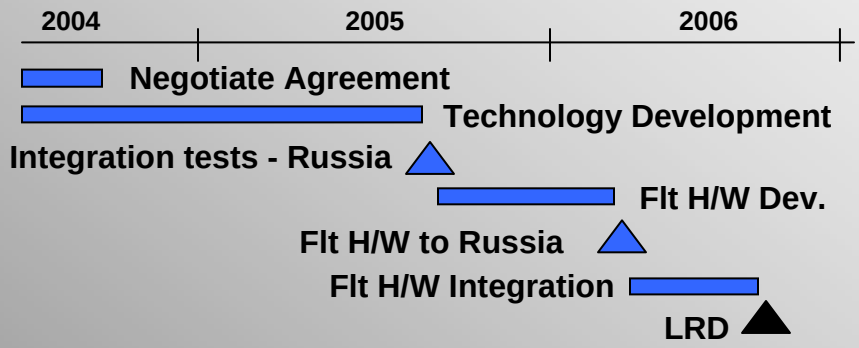
Issues

- Multiple agency interfaces may be required (ESA, RKA)
- (Peer reviewed) Science to be identified
- External attachments for *.Sats to be negotiated



PPOD Launcher

Schedule (Under Review)



Russian Launch Assets

- **Soyuz/Foton**
  - **ISGEN could be accommodated inside and/or externally**
  - **Returned system would allow for “after-the-fact” investigations**
  - **Foton M3 schedule (LRD = 10/06) is compatible with ISGEN development**

Soyuz/Foton

- **Other Russian vehicles (Eurockot, COSMOS, Dnepr, etc)**
  - **Cost effective**
  - **Smallsats heritage (Surrey, PPOD experience)**
  - **Larger range of opportunities, schedule flexibility**
  - **However: Cannot legally access these providers directly**

Cosmos

Domestic Launch Assets

Peacekeeper SLV

EELV (Delta IV)

Delta II

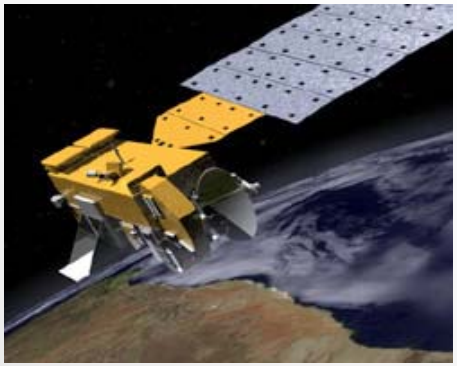
Minotaur

Falcon

SeaLaunch*

**Does not legally qualify as a US corporation.*

ISGEN Trailblazer for Exploration



- **Spacecraft Systems & Technologies**
  - Small spacecraft platforms (Nanosats, Microsats)
  - Rapid deployment architectures
  - Recoverable spacecraft technologies - future plans
  - Advanced command and control systems
  - Formation flying (tethers, artificial-g architectures) - future
  - Radiation measurement and mitigation technologies
- **Payload Systems & Technologies**
  - Miniaturized sensors and analytics
  - Life support technologies
  - Data acquisition and management
  - Automated systems

- **Access to Space**
  - Secondary payloads of opportunity
  - Rapid technology/platform validation and test
- **Education and Outreach Opportunity**
  - Platform of choice

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TIFF (Uncompressed) decompressor
are needed to see this picture.