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Exploring Space on a Small Satellite,
STSAT-2 : A Test Bed for New Technologies

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KAISTSAT-4 Mission

- Will be launched next month in Russia!
SaTReC Missions

KITSAT-1 (1992)
- Technology acquisition
- Manpower training

KITSAT-2 (1993)
- Technology verification
- Modification
- Enhancement

KITSAT-3 (1999)
- Technology development
- Engineering test
- Advanced payloads

- Technology Optimization
- Stabilize Technology
- Space Science Research

STSAT-2 (2005)
- Compact Design
- Technology Experiments
- Solar Observation

Technology Optimizations
- Compact Design
- Technology Experiments
- Solar Observation

Space Science Research
Contents

- STSAT-2 Mission Overview
- Mission Objectives of STSAT-2
- Science Mission Payloads
  - LIST (Lyman-alpha Imaging Solar Telescope)
  - SLR (Satellite Laser Ranging)
- Spacecraft Technology Experiments
  - Detailed Item Will be Introduced
- Overall Spacecraft Design
- Concluding Remarks
STSAT-2 Mission Overview

- Small Satellite of ~100 kg Launched by the 1st Korean Launch Vehicle (KSLV-1)
- Advanced Bus Technology Experiments
- State-of-the-Art Payloads Development and Operation
- Total Budget ~ $10M
Mission Objectives and Parameters

- Mission Objectives
  - Continuous Observation of Solar Lyman-Alpha (121.6 nm) Image in the LEO
  - Precise Measurement of Orbit Insertion Using Laser Ranging Technology
  - Development of Several Advanced Bus Technologies

- Launch

- Mission Orbit (Designated by KSLV-1)
  - Elliptical Orbit: 300 km (perigee) × 1,500 km (apogee)
  - Inclination Angle: 80°

- Mission Life Time
  - Less than 2 years
System Architecture

- **Space Segment**
  - Spacecraft
  - Payloads
- **Ground Segment**
  - STSAT-2 Ground Station
    - Satellite Operation
    - Image Data Reception
  - SLR Ground Stations
- **Launch Service Segment**

STSAT-2: Science and Technology Satellite – 2

LIST: Lyman-\(\alpha\) Imaging Solar Telescope

SLR: Satellite Laser Reflector
Orbit and Its Effects

- Not a Sun Synchronous Orbit
  - Irregular Ground Contact Time and Irregular Satellite to Ground Station Range
  - Orbit Analysis → 2.5 times/day with 5 minute contact time average → based on the X-band Science Data Download Link Budget (2,100 km range with elevation more than 10 degree)

- Full Sunlight Duration (No Eclipse Time)
  - ~ 23 days → Thermal Problem
  - Deployable Solar Panel and Heat Pipe

- Sweeps Lower Part of the Inner Radiation Belt
  - Radiation Shield on Memory and Critical FET’s
  - Software or Hardware EDAC Implementation

- Air Drag Effect
  - Mission Lifetime is Limited to 2 Years
  - Electric Propulsion is Considered
LIST : Science Mission Payload

- To Understand the Evolution of Structures in the Chromosphere
- To Improve Models of Solar VUV (Vacuum Ultra Violet) Variability
- To Study the Physical Properties and Processes in the Solar Active Region with Lyman-\(\alpha\) and Spectroscopic Data
SLR : Technology Mission Payload

- Satellite Laser Ranging
- Space Geodetic Technology
- Measure the distance between a ground station and a satellite most precisely in current method
- A very short laser pulse transmitted from a telescope retro-reflected by corner cube reflector array on a satellite
- The round trip time is measured and converted to the distance
Spacecraft Technology Experiments

- Frame-Type Satellite Structure
- Composite Material Solar Panel
- Dual-Head Star Tracker
- CCD Digital Sun Sensor
- Pulsed Plasma Thruster
- Compact On-Board Computer
- High X-band Transmitter

(CMOS CCD)
## CCD Digital Sun Sensor

**Specifications**

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOV</td>
<td>$128^\circ \times 128^\circ$</td>
</tr>
<tr>
<td>Accuracy</td>
<td>$&lt;0.03^\circ$</td>
</tr>
<tr>
<td>Weight</td>
<td>$&lt;1.0$ Kg</td>
</tr>
<tr>
<td>Power</td>
<td>$&lt;1$ W</td>
</tr>
<tr>
<td>Size</td>
<td>$150 \times 150 \times 100$ mm$^3$</td>
</tr>
</tbody>
</table>
Dual Head Star Tracker

- Use Similar Sensor Head of K4 Star Tracker
- Combination of CCD Processor Logic into One FPGA
- Increase Processing Power of DSP

- 10 arcsecond precision has proven through K-3 and K-4 mission
- But Limited to X, and Y axis
- Achieve ~5 arcsecond regardless of optical axis
Electric Propulsion Candidates

- **Pulsed Plasma Thruster**
  - Specific Impulse: 800s
  - Impulse Bit: 20uNs
  - Charge Voltage: 2000V
  - Discharge Rate: 1 Hz
  - Prototype has Developed
  - Propellant: Teflon

- **Hall Thruster**
  - Specific Impulse: 1600s
  - Thrust: 100mN (typical)
  - Propellant: Zenon
  - Commercial Product?
On Board Computer

<table>
<thead>
<tr>
<th>Item</th>
<th>Specifications</th>
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</thead>
<tbody>
<tr>
<td>CPU</td>
<td>PowerPC 603e</td>
</tr>
<tr>
<td>Program Memory</td>
<td>SRAM 2 Mbytes (H/W EDAC)</td>
</tr>
<tr>
<td>RAM Disk</td>
<td>SRAM 6 Mbytes (TBD, S/W EDAC)</td>
</tr>
<tr>
<td>Code Storage Memory</td>
<td>EPROM 1 Mbytes</td>
</tr>
<tr>
<td>Updated Code Storage</td>
<td>EEPROM 1 Mbytes</td>
</tr>
<tr>
<td>Memory</td>
<td></td>
</tr>
<tr>
<td>Watchdog Timer</td>
<td>1</td>
</tr>
<tr>
<td>Serial Port</td>
<td>UART:18, USART:2</td>
</tr>
<tr>
<td>Mass</td>
<td>900g</td>
</tr>
<tr>
<td>Size</td>
<td>225 x 200 x 15 mm³</td>
</tr>
<tr>
<td>Power</td>
<td>4W @ 5V</td>
</tr>
</tbody>
</table>

- OS : VxWorks
  - Efficient Task Management
  - Multitasking, Unlimited Number of Tasks
  - Fast, Flexible Inter-Task Communications
- Package Type : CGA
# Spacecraft Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>100 kg</td>
</tr>
<tr>
<td>Size</td>
<td>&lt; Φ1 m x 1 m</td>
</tr>
<tr>
<td>Power</td>
<td>152 W@EOL, GaAs/Ge</td>
</tr>
<tr>
<td></td>
<td>DOD &lt; 25% with NiCd 7AHr (Li-Ion)</td>
</tr>
<tr>
<td>Attitude Control</td>
<td>3-axis stabilization (0.5°/s Maneuver Capability)</td>
</tr>
<tr>
<td></td>
<td>Pointing Accuracy of 0.15° (2 σ)</td>
</tr>
<tr>
<td></td>
<td>Pointing Control Stability of 0.002° in 1 second</td>
</tr>
<tr>
<td>TT&amp;C</td>
<td>S-Band Tx (9.6, 38.4 kbps @ 2,252MHz)</td>
</tr>
<tr>
<td></td>
<td>S-Band Rx (1.2, 9.6 kbps @ 2075MHz)</td>
</tr>
<tr>
<td>PDTx</td>
<td>X-Band Tx (10 Mbps @ 8,127MHz)</td>
</tr>
<tr>
<td>Payload Data Storage</td>
<td>2 Gb SDRAM</td>
</tr>
</tbody>
</table>
Electrical Architecture

ACS

OBC

CDS

MMU

Payload

LIST

EPS

PDU

PSU

BM

Battery

MTQR

PPT

RWA

FOG

Solar Array (-Z)

Solar Array (Mount)

Solar Array (+x)

FDSS

DHST

GPSR

FASS

CASS

NMAG

Serial Link

Digital Status

Power Line

Bi-level Command

Analog Telemetry

AIAA/USU Conference on Small Satellites (2003-08-13)
Concluding Remarks

- **Major Milestones**
  - SDR : 2003.5. → Start of Prototype Development
  - CDR : 2004.7. → System Design Fix Through EM Test
  - PFM(2005.2) and FM(2005.7) Manufacturing and Environmental Test

- 100 Kg Small Satellite will be Launched by KSLV-1 in the year of 2005