



# CubeSats

**Inpressions from 15<sup>th</sup> Annual AIAA/USU  
Conference on Small Satellites,  
Logan, Utah, 13 – 16 August 2001**

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**Find the presentation at:**

**[http://www.dsri.dk/roemer/pub/Presentations/CubeSat\\_Presentation\\_20\\_Aug\\_2001.ppt](http://www.dsri.dk/roemer/pub/Presentations/CubeSat_Presentation_20_Aug_2001.ppt) and \*.pdf**

**Danish Space Research Institute**

**Danish Small Satellite Programme**

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## **CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 1**

**See conference programme at:**

**<http://www.sdl.usu.edu/conferences/smallsat/2001FinalProgram.pdf>**

**General impression on Cubesat activities: Many start-ups groups with no or little experience in satellite design, little flight experience – but this is what the Cubesat concept is all about.**

**Both universities, NASA centers, military units and private enterprises are active in Cubesat building.**



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**CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 2**

**The following CubeSats are scheduled for the launch in May 2002:**

- 1 – California Polytechnic State University**
- 6 - Government – NASA Ames Research Center**
- 1 - Leland High School - San Jose, CA**
- 1 - Montana State University**
- 1 - Private**
- 1 - Stanford University**
- 2 - Taylor University**
- 1 - Tokyo Institute of Technology**
- 2 - University of Arizona**
- 1 - University of Tokyo**
- 1 - Wilcox High School - Santa Clara, CA**



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## **CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 3**

### **Technical Session VIIIb: CubeSat Missions**

**Chair: Professor Robert Twiggs, Stanford University**

- 1. The APRS Satellite Mission and CUBESAT DESIGN Notes**, B.Bruninga -Naval Academy Satellite Laboratory
- 2. Nihon University CubeSat Program**, Y.Miyazaki,H.Isobe,T.Kodama,M.Uchiki,S.Hinuma -Nihon University,Japan
- 3. Cubesats: A Technology and Science Mission Low-Cost Test Bed**, V.Aguero -SRI International
- 4. TU-Sat 1 CubeSat**, J.Oehrig, N.Schutt, J.Schea, D.Voss, J.Lee, B.Gerig, C.Fennig, J.Wilhelmi, D.Gall, J.Bryson, A.Becker, C.Herron, J.Weisenburger, E.Grashorn, J.Nussbaum, J.Rodriguez, G.Chase, J.Voss, D.Prentice, A.Platt, W.Holmes, Dr.H.Voss -Taylor University
- 5. CubeSat: The Development and Launch Support Infrastructure for Eighteen Different Satellite Customers on One Launch**, R.Twiggs - Stanford University SSDL; Prof.J.Puig-Suari, Prof.C.Turner - California Polytechnic State University



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**CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 4**

**Technical Session VIIIb: CubeSat Missions, continued**

**6. Getting Started: Using a Global Circumnavigation Balloon Flight to Explore Picosatellite (CubeSat)Technology, K.Bennett,M.Swartwout - Washington University**

**7. Project Aria: Progress in the Development of a Sustainable Student-Focused, Project-Based, Research, Education and Public Outreach Program, M.Swartwout,K.Bennett -Washington University in St.Louis**

**Alternates**

**DARTSAT: A Modular Approach to Educational Satellite Design, A.Parashar,A.Moore -Thayer School of Engineering, Dartmouth College**

**University of Tokyo's CubeSat Project - Its Educational and Technological Significance, Y.Tsuda, N.Sako, T.Eishima, T.Ito, Y.Arikawa, N.Miyamura, A.Tanaka, S.Nakasuka -University of Tokyo**



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## **CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 5**

### **Cubesat project presented in session III-2**

**“The Montana State University NASA Space Grant Explorer-1 Science Reflight Commemorative Mission - MEROPE”.**

**To commemorate the discovery by Prof. James van Allen of the Earth’s radiation belts by flying a Geiger counter on a Cubesat similar to the one flown on Explorer-1, launched 1 Feb. 1958.**

**Project start: Jan. 2001**

**Project completion: End July 2001**

**Launch: Mid-May 2002.**

**Interesting project !!!**

**Danish Space Research Institute**

**Danish Small Satellite Programme**

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**CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 6**

**Special Cubesat Meeting, Tuesday 14 Aug. 2001, 18:00 - 19:00**

**50-60 attendees**

**Chairmen:**

**Bob Twiggs, Stanford Univ.**

**Jordi Puig-Suari, Cal-Poly**

**Mike Woods & Jay Smith, OSSS**

**Launch cost for next launch May 2002:**

**USD 49000 per Cubesat (1 kg satellite + 1 kg for dispenser etc.) on Dnepr. Price is expected to go up for following launches.**

**OSSS aims at launches in mid-May and mid-November.**



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**CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 7**

**Special Cubesat Meeting, Tuesday 14 Aug. 2001, 18:00 - 19:00**

**Vibration qual test requirements: 125% of launch loads**

**Short thermal vac test required**

**The dispenser (P-POD w. 6 Cubesats) incl. Cubesats will be vibration and shock tested after integration.**

**There will be no access to Cubesats after integration in P-POD.**

**Kits: OSSS, SpaceQuest (check this)**

**Aluminium feet shall be coated (teflon, kapton) to prevent cold welding. The entire aluminium structure shall be Alodine coated or anodized.**

**Discuss allocation of amateur radio frequencies for satellite communication with AMSAT-OZ**

**A Cubesat e-mail list server will be set up shortly at GSFC.**



**CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 8**

**Meeting after Cubesat session Wednesday 15 Aug. 2001, 17:00 - 18:00**

**30 - 40 attendees**

**Chairman: Bob Twiggs, Stanford Univ.**

**Repeat presentation of "Frequency Licensing Options for Small Sat Missions", Session II-8, by K. Ryan, Comsearch.**

**Jan King, AMSAT member #2, Ecliptic Enterprises Corp., presented frequency allocation issues regarding amateur radio frequency bands.**

**Frequency allocation issues are very important regardless if amateur frequency bands or commercial frequency bands are used !!!**



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## **CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 9**

### **Meeting with Bob Twiggs 16 Aug. 2001**

**Bob Twiggs would like very much to visit Denmark, but as he must undergo cardiac surgery in the fall of 2001, he declines to go until spring of 2002. He could recommend Prof. Jordi Puig-Suari, Cal-Poly or Mike Obland, Montana State Univ. as replacements.**

**Latest: E-mail from Bob Sunday 19 Aug. recommends Prof. Jordi Puig-Suari, Cal-Poly to come to Denmark**

**FH urged Bob Twiggs to create a Cubesat community, which could lobby towards governmental bodies e.g. for frequency allocations and act as a Cubesat standards body. The standardization process could be modeled after IETF, where anyone may suggest a standard and eventually get it accepted.**



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## CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 10

### Meeting with OSSS, Ogden, Utah

Mike Smith, Marketing Manager

**Delivery of flight-ready Cubesat to OSSS: 4 - 6 months before launch**

**Optimistic schedule:**

**To - 4 months:**

**Delivery to OSSS, shipment to Cal-Poly, integration in P-POD, functional tests.**

**To - 3 months:**

**Shipment to OSSS, integration into carrier, environmental and functional tests.**

**To - 1 month:**

**Shipment to launch site, integration onto launcher, last tests.**

**(Launch campaign: typ. 20 days)**

**To: Launch**

**Kosmotras uses a 90 day launch window for Cubesat launches.**



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**CubeSat Activities at 15<sup>th</sup> Annual AIAA/USU Conference on Small Satellites - 11**

**Meeting with OSSS, Ogden, Utah, contiued**

**Price for Nov. 2002 launch: USD 75000 (conservative estimate)**

**Lead time for Cubesat kits: 30 - 60 days.**

**Payment terms:**

**Up front at contract signature: 10%**

**At CDR: 40%**

**At final integration in P-POD: 50%**

**The customer commits the launch at To - 9 months.**

**OSSS commits the launch at To - 8 months.**



## CubeSat Concept

The CubeSat concept has been developed at Space Systems Development Laboratory (SSDL), Stanford University by Prof. Bob Twiggs and his colleagues and students in conjunction with California Polytechnic State University (Cal-Poly).



The original idea was to build a picosat 100 x 100 x 100 mm, mass below 1 kg and power consumption below 1 W to a standard Interface Control Drawing (ICD) and deploy it together with a number of CubeSats from a dedicated dispenser for less than USD 50000 total.

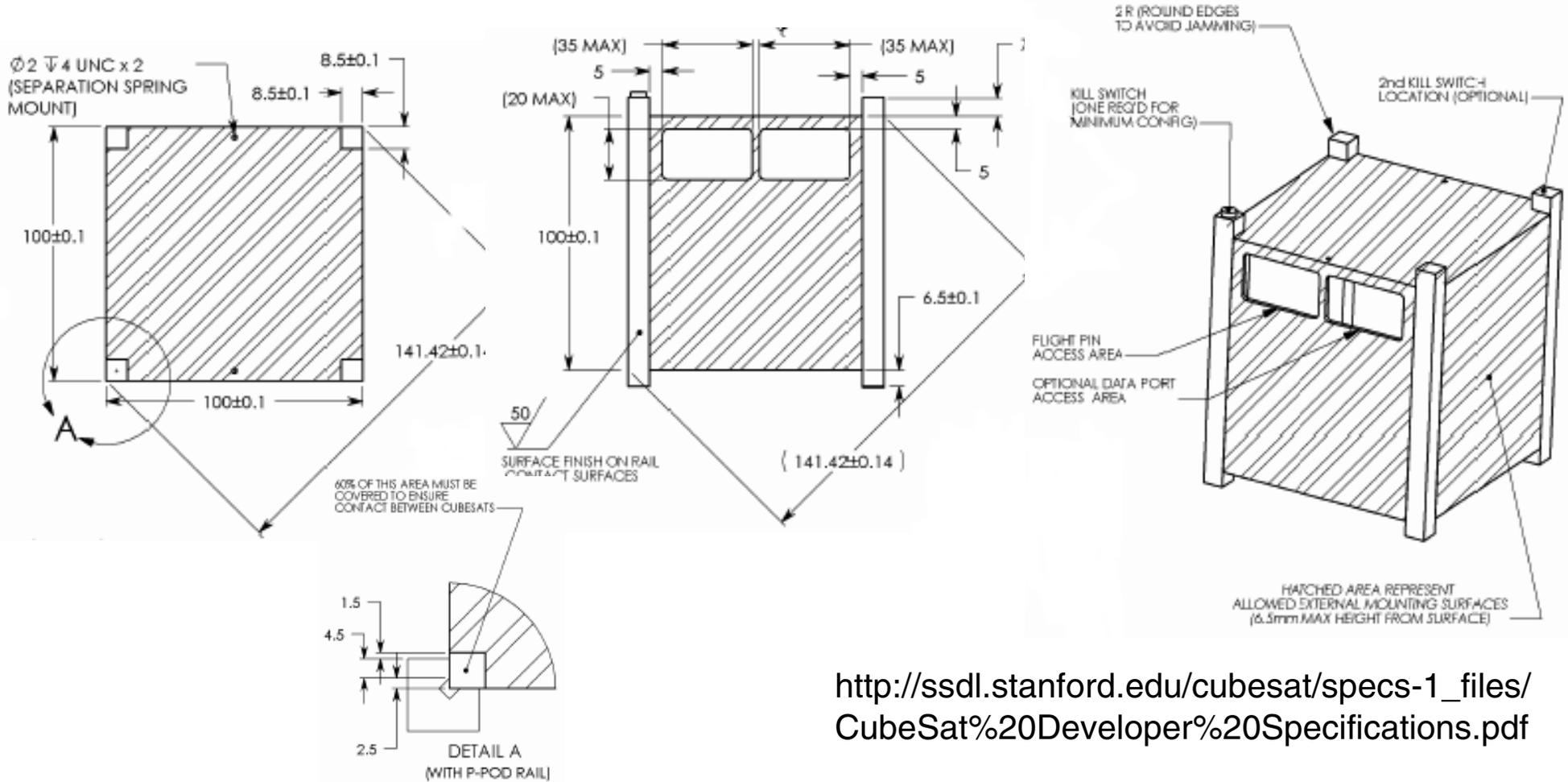
Unfortunately, the launch costs have increased sharply, and a launch in November 2002 is expected to cost USD 75000, in addition to the cost of the spacecraft.



**CubeSat Home Page:** <http://ssdl.stanford.edu/cubesat>



# CubeSat Interface Control Drawing (ICD) – New issue 2001-03-19



[http://ssdl.stanford.edu/cubesat/specs-1\\_files/CubeSat%20Developer%20Specifications.pdf](http://ssdl.stanford.edu/cubesat/specs-1_files/CubeSat%20Developer%20Specifications.pdf)



## **CubeSat Launch**

**One Stop Satellite Solutions of Ogden, Utah, USA (<http://www.oss.com>) plans to launch up to 18 CubeSats using a Russian Dnepr launcher (Converted SS-18 ICBM) provided by Kosmotras in November 2001 followed by regular launch opportunities every mid-May and mid-November in the 2002 - 2007 time frame.**



**OSSS will deploy the satellites from its Multi-Payload Adaptor (MPA):**

<http://www.oss.com/products/mpa.html>

**Launch Requirements:**

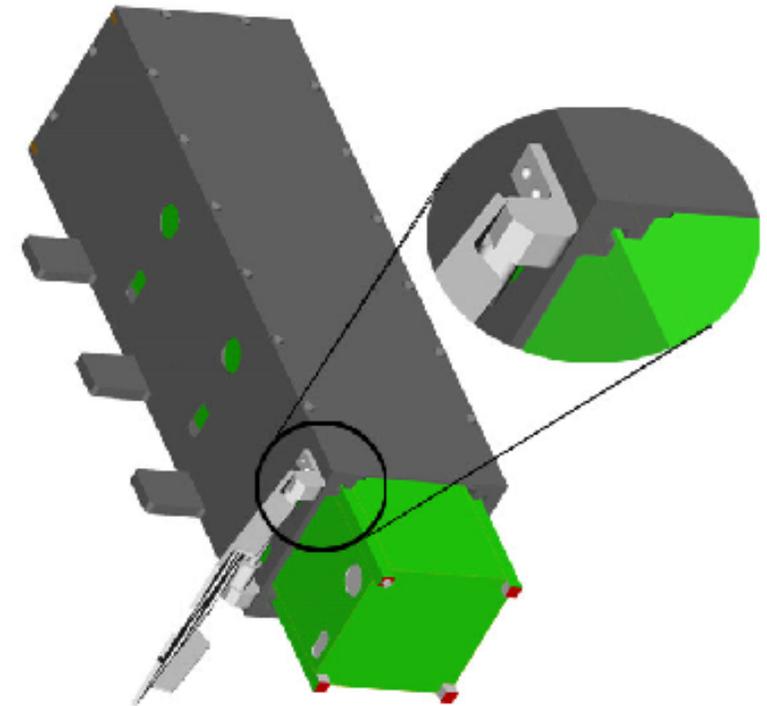
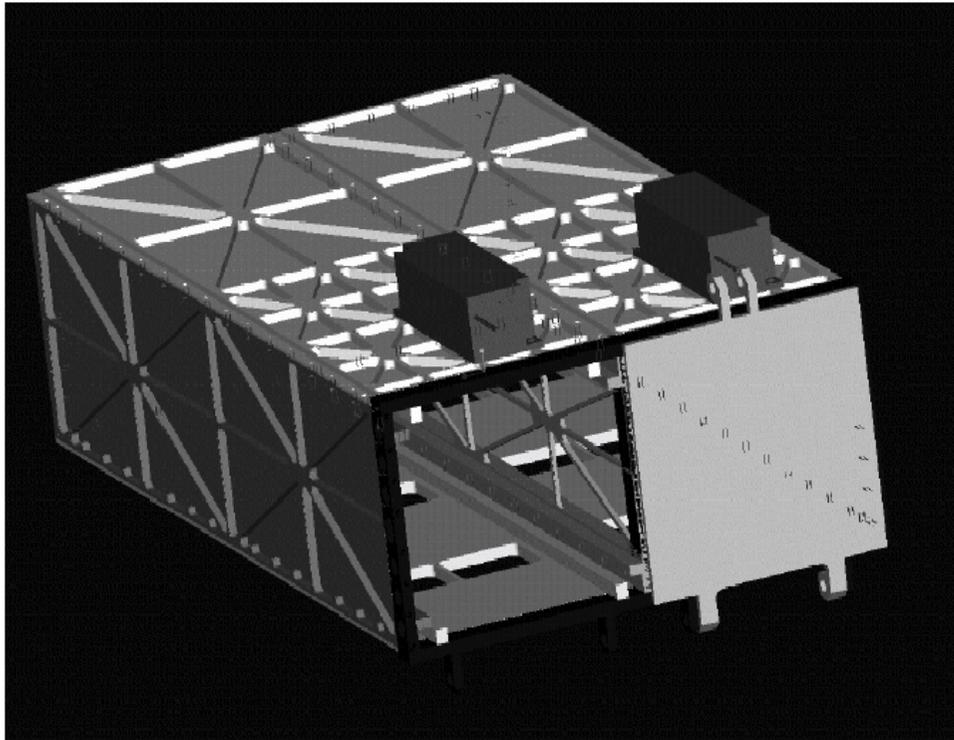
[http://ssdl.stanford.edu/cubesat/specs-1\\_files/CubeSat%20Launch%20Environment.htm](http://ssdl.stanford.edu/cubesat/specs-1_files/CubeSat%20Launch%20Environment.htm)



## **Multi-Payload Adapter on US Minotaur Launcher**



## CubeSat Deployment



P-POD Deployer with Rail Detail

**Excerpt from CubeSat Design Specifications Document:**

[http://ssdl.stanford.edu/cubesat/specs-1\\_files/CubeSat%20Developer%20Specifications.pdf](http://ssdl.stanford.edu/cubesat/specs-1_files/CubeSat%20Developer%20Specifications.pdf)



## CubeSat Kits by One Stop Satellite Solutions - 1

### Cubesat Modular Frame

Price: USD 4500 for 6-module kit

(Note the picture shows a non-Cubesat frame of similar design)



### Specifications

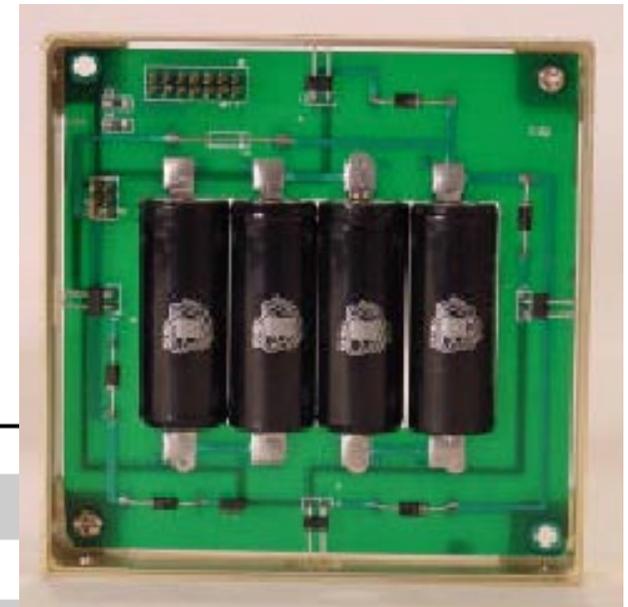
Feature	Data
Configuration	Vertical-stacking, independent compartments with standard connectors
Material	7071-T3 Aluminum
Dimensions	10cm x 10cm x 1.783 cm
Connectors	DB-9, DB-15, DB-25, DB-36, or NTSC



## CubeSat Kits by One Stop Satellite Solutions - 2

### Cubesat Power Module

Price: USD 2000 - 5000 for solar rechargeable system



### Specifications

Feature	Data
Battery Type	4 NiCd Cells
Power	2 x 4 Pin Header, 2.54 mm/0.100" centimeters
Nominal Voltage	4.8 Volts
Nominal Storage	1.5 Ah
Solar Specifications	Panel Voltage- 9 Volts DC Panel Current- Nominal 80 ma

## CubeSat Kits by One Stop Satellite Solutions - 3

Cubesat Computer Module  
Price: USD 5000



### Specifications

Feature	Data
Processor	Motorola MC68HC705B16
Storage	1Megabyte x 8
Power	Approximately 5 volts at 30 ma
Data Acquisition Rate	Programmable Interval
TTL	4 Input, 4 Output, 4.8 bit Analog Channels
Connectors	Debug- RS-422, port 115KBD, N,8,1 Expansion- Dual Row 2.54 mm connector Sensors- Bus Voltage, CPU Temperature, Current



## CubeSat Kits by One Stop Satellite Solutions - 4

### Cubesat UHF Communications Module

Price: USD 5000

#### Specifications

Feature	Data
UHF Transceiver	Frequency Bands- 430 to 450 MHz or 450 to 470 MHz Transmitter Power Output-2 Watts @9.6 VDC Transmitter Modulation- Varactor Controlled Direct FM
VHF Receiver	Frequency Band- 140 to 150 MHz Data Rate- 9600 Baud Power- 12 VDC @1 Amp
UHF Transmitter	Frequency Band- 430 to 440 MHz Data Rate- 9600 Baud Power- 13 VDC @ 650 mA





## Other CubeSat Kits Suppliers

SpaceQuest Inc. is said to supply  
Cubesat Kits, but no information is  
found on their web-site:  
<http://www.spacequest.com>





## How to get going with CubeSat – Status – 1

Review of checklist presented in March 2001

- **Arrange a workshop with Bob Twiggs in Denmark**  
(The Danish Small Satellite Programme would sponsor the workshop)  
**Bob Twiggs would like very much to come to Denmark, but due to cardiac surgery in the fall of 2001 he declines to go to Denmark earlier than spring 2002.**  
**Bob recommends Jordi Puig-Suari from Cal-Poly.**  
**Small Satellite Programme Office at DSRI will arrange visit ASAP.**
- **Decide a mission** (Science, technology demo .....) - ?????????????????????????????????
- **Decide if the CubeSat concept is useful – Yes, Done !!!**
- **Build a team** (DTU and AAU independently, DTU+AAU together, all engineering schools ???)  
**DTU and AAU each builds own Cubesat - Done !!!**
- **Find sponsors** (Danish Small Satellite Programme, public funds, private funds .....)  
**Ongoing via Small Satellite Programme Office at DSRI and at DTU and AAU !!!**



## How to get going with CubeSat – Status – 2

Review of checklist presented in March 2001, continued

- Decide what to procure from outside and what to build here in DK  
????????????????????
- Build the satellite
- Launch it



**Links:**

<http://ssdl.stanford.edu/cubesat>

<http://www.cubesat.org> (= <http://www.cubesat.net>)

<http://www.amsat.org>

<http://www.ssel.montana.edu/merope>

**Read more:**

**Hank Heidt & al.: “CubeSat: A new Generation of Picosatellite for Education and Industry Low-Cost Space Experimentation”, 14<sup>th</sup> Annual AIAA/USU Conference on Small Satellites,**

**21 - 24 August 2000, Logan, Utah, Paper SSC00-V-5 21 - 24 August 2000, Logan, Utah, Paper SSC00-V-5**