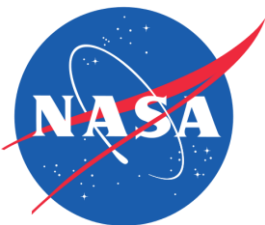


GSAW 2014 – Session 11C

Current and Future Ground Systems for CubeSats Working Group

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Agenda

- Welcome
- Panelist Introduction and Presentations
- CubeSat Mission Capability & Ground Systems
- Discussion
- Working Group Wrap-Up

Panelists

- Dr. Jamie Cutler – University of Michigan
- Mr. Bryan Klofas – SRI International
- Major Dave Illsley – NRO
- Dr. Charles Norton – NASA JPL-CalTech

CubeSat Mission Capability & Ground Systems

- What makes a CubeSat Mission different from a ground system perspective?
 - *Baseline of current CubeSat mission types*
 - *Examples of future missions*
 - Mission requirements
 - Ground system needs
- Ground systems used for current CubeSat missions
- Future ground systems?
- Outcomes:
 - *What are the issues that affect ground systems today?*
 - *What are the ground system issues that will affect future missions?*

CubeSat Mission Capability - TODAY

	Education	Science & Exploration	Flagship
Definition	Focus on education and gaining experience in developing a CubeSat.	Includes R&D	Advanced missions, Government (civil & military)
Communication Characteristics:			
Band(s)	UHF/VHF, ISM	UHF/VHF, ISM, S, X, Ka	UHF/VHF, S, X
Bandwidth	<10 Kbps, (9600 baud)	10 Kbps – 2 Mbps	10 Kbps - 10 Mbps
Mission Data (per day)	1 - 2 Mbytes	200 Mbytes	200 Mbytes – 2 Gbytes
Latency (end-to-end timeliness)	Best efforts	<24 hours	90 mins. or less
Security	none	Software AES	Software AES – Hardware Type 1
# of Spacecraft	1-2	1 – many (50)	1 – many (50)
Operational Control	Dedicated site and/or network	Dedicated site and/or network, Scheduled network with low priority	Scheduled network with higher priority
Mission Life	Weeks to months	Months to years	1+ years
Spacecraft Development Time	6 months or less	6 months – 2 years	18 months – 5 years
Geographic Diversity of Ground antennas	Best efforts	Mission Trade	Mission essential
Ground System Exemplars	GENSO \$ Individual Ground Station \$	Multiple sites networked (MC3) \$\$ Individual Ground Station \$-\$	AFSCN \$\$\$ USN \$\$-\$\$\$ NASA NEN \$\$-\$\$\$

CubeSat Mission Capability - FUTURE

	Advanced/Complex Missions (LEO)	Earth-orbiting beyond LEO	Lunar, Deep-Space Missions	Constellations & Swarms	Mother/Daughter Missions
Communication Characteristics:					
Band(s)	UHF/VHF, S, X, Ka, Ku, V, W, optical	S, X, Ka, Ku, V, W, optical	S,X, optical	UHF/VHF, S, X, Ka, Ku, V, W, optical	UHF/VHF, S, X, Ka, Ku, V, W, optical
Bandwidth	1 Mbps - 500 Mbps	1 Mbps - 500 Mbps	1 Mbps – 200 Mbps	1 Mbps - 500 Mbps	1 Mbps - 500 Mbps
Mission Data (per day)	200 Mbytes – 1 Tbyte	200 Mbytes – 1 Tbyte	200 Mbytes – 500 Gbytes	200 Mbytes – 1 Tbyte	200 Mbytes – 1 Tbyte
Latency (end-to-end timeliness)	Real-time (seconds)	Real-time (seconds)	Real-time (minutes – hours)	Real-time (seconds)	Real-time (seconds)
Security	Software AES – Hardware Type 1	Software AES – Hardware Type 1	Software	Software AES – Hardware Type 1	Software AES – Hardware Type 1
# of Spacecraft	1-20	1-40	1-20	20-200	2-40
Operational Control	Dedicated site and/or network, Scheduled network with high priority	Dedicated site and/or network, Scheduled network with high priority	Shared network with high priority	Dedicated site and/or network, Scheduled network with high priority	Dedicated site and/or network, Scheduled network with high priority
Mission Life	1-5 years	3-5 years	1-5 years	3-5 years	Months – 3 years
Spacecraft Development Time	18 months – 5 years	18 months – 5 years	18 months – 5 years	6 months – 2 years	18 months – 2 years
Geographic Diversity of Ground antennas	Mission essential	Mission Trade	Mission Trade	Mission Trade	Mission Trade
Ground System Exemplars	TBD				

Discussion

- What are the key issues from a ground system perspective to better support current and future CubeSat missions?
 - *Security for future CubeSat missions*
 - *Communication licensing and spectrum allocation*
 - *Identify and track (e.g. lessons learned from recent launches)*
 - *Coverage, priority, & scheduling (e.g. spacecraft emergencies)*
 - *Information sharing & access*
 - *Usage of standards - interoperability and reuse*
 - *Proprietary vs. government reference architecture*
 - *Enabling development of new technology*
- How to “share” or leverage current ground capabilities within community?
 - *Federated vs. stand alone communications approaches*
 - *Scheduling and management of contacts*
 - *Buying shared contact time*
 - *Changes to support higher data rate communications*

Wrap-Up

- Summary of working group discussions
 - *What did we accomplish?*
 - *Where to go from here?*
- Next steps
 - *Space Ops 2014*
 - *Other venues to continue the conversation?*
- Written Report

Backup

Examples of Current Ground Systems used for CubeSat Missions

	Type	Antenna	Frequency	More details
Individual Ground Stations:				
Morehead State University	Academic	21-m dish	L, S, C, Ku	http://www.moreheadstate.edu/content_template.aspx?id=11367
SRI International	Non-profit research institute	45.72-m dish	UHF, L, S, C, X	http://www.sri.com/research-development/specialized-facilities/dish-radio-antenna-facility
University of Michigan	Academic	Yagi	UHF, VHF	http://exploration.engin.umich.edu/blog/
Cal Poly San Luis Obispo	Academic	Yagi, Omni	UHF, VHF	http://polysat.calpoly.edu/
Networks:				
GENSO (Global Educational Network for Satellite Operations)	Academic/Amateur radio	varies	VHF, UHF, S, L	http://www.genso.org/
USN (Universal Space Network)	Commercial	3-m to 15-m dish	S, X, Ku, Ka, L	http://www.sscspace.com/about-the-ssc-group/ssc-companies/universalspacenetwork
AFSCN (Air Force Satellite Control Network)	Government			http://www.schriever.af.mil/library/factsheets/factsheet.asp?id=3916
NASA Near-Earth Network	Government/Commercial	varies	UHF, VHF, S, X	http://www.nasa.gov/content/near-earth-network/
NRL MC3 (Mobile Command & Control)	Government/Academic	Yagi	UHF, S	https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/colony-1

Future Ground Systems

- Discussion on new technologies or systems in the pipeline

Examples of Current CubeSat Missions

- Education
 - *University*
- Science & Exploration
 - *Aerocube*
 - *RAX*
 - *Mcubed*
 - *Genesat*
 - *QB50*
- Flagship
 - *Planet Labs – Dove*
 - *SMC SENSE*

CubeSats - TODAY

