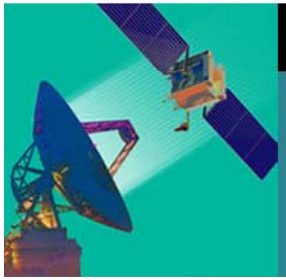
Working Group Out Brief

Ground System Architectures Workshop

Session 12F

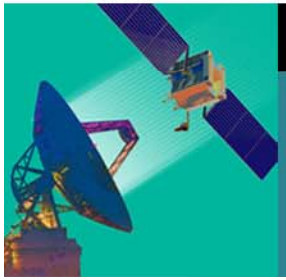
Cloud Computing for Spacecraft Operations

Ramesh Rangachar, Intelsat; Mark Walker, Integral Systems, Inc.



Session Goals

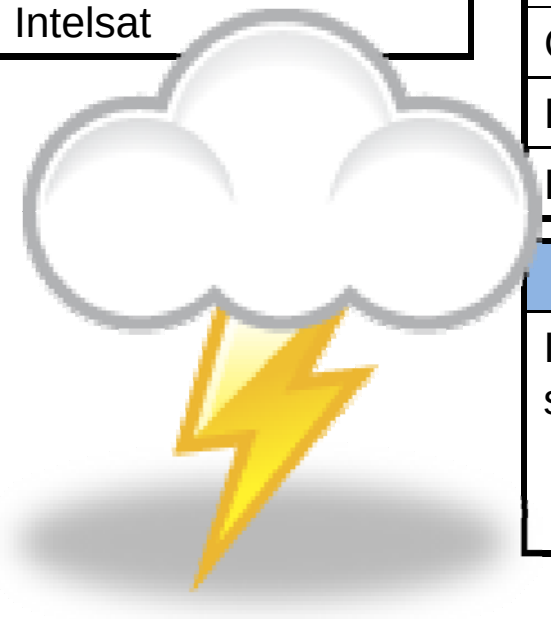
- To invoke lively discussions about cloud computing for spacecraft operations – including benefits and barriers
- To develop a roadmap for successful migration to a cloud environment in harmonization with the existing systems and processes
- To identify the top ten things to be considered for a successful cloud migration / implementation



Session 12F Cloud Computing for Spacecraft Operations

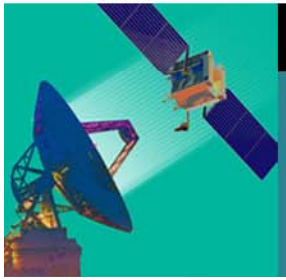
Presenters/ Panelists

Panelists	
Justin Boss	Integral Systems, Inc
Ted Hessler	Sirius XM Radio Inc
Brad Kizzort	Harris Corporation
Craig Lee	Aerospace
Knut Tjonneland	Intelsat



Presenters	
Doug Barnhart	General Dynamics C4 Systems
Jeremy Jacobsohn	GMV Space Systems, Inc
Emily Law	NASA JPL
Craig Lee	Aerospace
Bill Lowry	Terremark
Dan Mandl	NASA GSFC

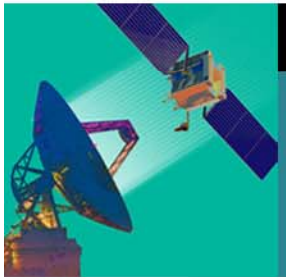
Terremark/ISI Demo
Implementation of Epoch ground control system on Terremark Enterprise cloud Demo by Bill Lowry, Terremark and Mark Walker, ISI



Key Points

1) Security / ITAR:

- Store only publicly available data on the cloud
- Host private data on local servers to eliminate potential security holes
- ITAR considerations must be made, but cloud providers are working to accommodate
  - Amazon EC2/S3 will provide an “ITAR Region” in Fall 2001
- Acquirers need to understand security provision that are available
  - Bring up concerns with vendors; they have solutions



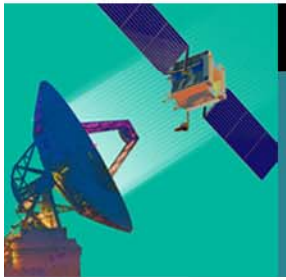
Key Points

2) Cloud standards are needed and necessary

- Customers want to be able to migrate from cloud provider to provider; they do not want to be locked in
- Tools and standards don't yet exist to do this
- Avoid using unique features to make migration simpler

3) New programming paradigms can optimize use of the cloud

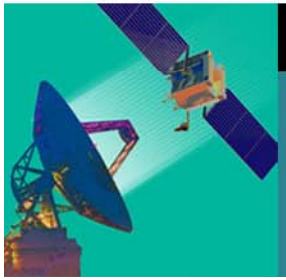
- Applications can be run as is in the cloud, but …
- Ground system software can be redesigned to take advantage of the compute capacity available on the cloud
  - E.g., retrieving long term telemetry may be sequential on servers today, but performance would be more optimal if the retrieval were broken into several parallel retrievals



Key Points

4) Incremental "Bolt-On" approach to cloud migration

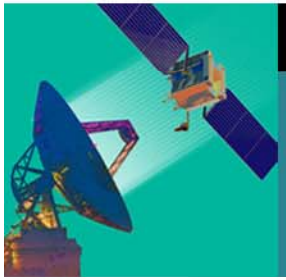
- Cloud computing is ready to provide external storage today
  - Operational archive data (e.g., archived telemetry and events) can be stored locally for recent data, but for long term storage it can be moved to the cloud
  - Payload and science data makes sense
- But, some space applications may not be cloud friendly
  - Commanding and command encryption interfaces
  - Graphic intensive applications (e.g., orbit visualization)



Key Points

5) Cloud business cases and strategies need to be refined

- Benefits to customers and providers are need to be clarified before migrating, identifying real cost savings
- Some business cases add up now (e.g., using virtualization for testing and configuration management); others need to be fleshed out
- Amazon EC2's rental model offers better performance per dollar than having to purchase and maintain local servers
  - More study is needed to see if this applies across the board
- Do proof of concept and prototyping actives



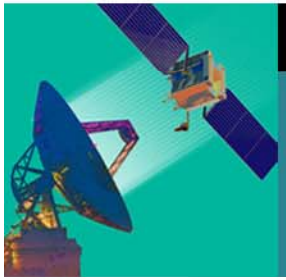
Key Points

6) Ground system suppliers need to revamp licensing schemes to be "cloud friendly" and effective for users

- Per seat licensing isn't effective as seats very

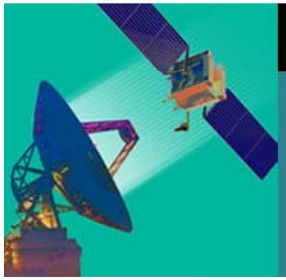
7) Cultural changes are required to take advantage of cloud technology

- Private vs. Public Cloud; private clouds are a good first step
- Procurement paradigms
- Training for IT professionals
- Address change and "fear of the unknown"
- Organizational reluctance to give up control
- Stakeholder buy in



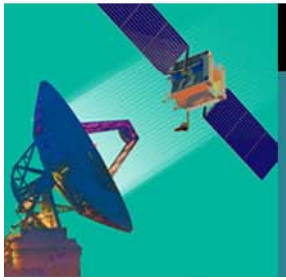
Key Points

- **8) Cloud capabilities improve upgrades and maintenance**
  - New versions/releases can be tested along side current versions
  - Operators can switch over when system is tested
- **9) Responsive 24 x 7 support required from cloud providers**
  - Responsiveness equivalent to network communication service providers can ease acceptance of “out of the building computing”

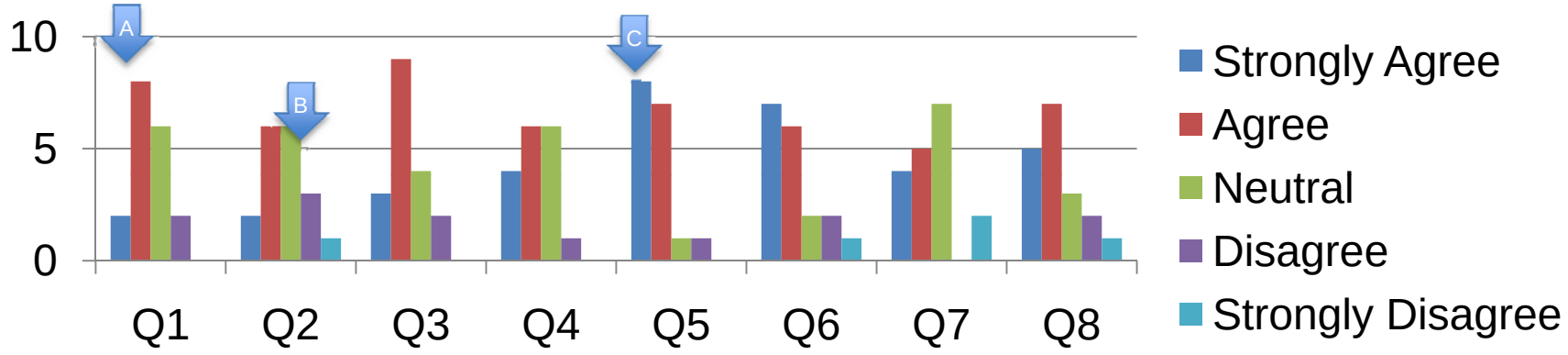


Key Points

- **10) Hold more workshops!**

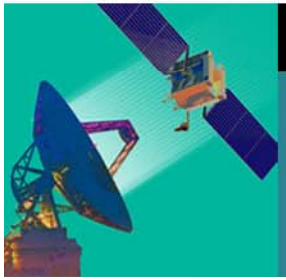


Cloud Computing Survey



Q1: I expect spacecraft ground systems to migrate to cloud computing platforms.
Q2: Cloud computing plays a major role in the future spacecraft ground system command and control and spacecraft operations.
Q3: Industry will overcome barriers to the use of cloud hosted ground system software.
Q4: Cloud computing plays a major role in remote access for spacecraft ground system data.
Q5: Requirements for remote access to spacecraft data will increase in the future.
Your Organization is…
Q6: Taking steps towards virtualization / virtual servers (rather than dedicated hardware).
Q7: Attempting to harmonize ground systems / reducing the number of ground systems.
Q8: Contemplating cloud-based systems

A, B, C: Command and control via the cloud makes us nervous, but remote data access is OK.



Conclusions

- Considering the cloud migration top 10 can:
  - Help develop a successful cloud migration strategy and roadmap that takes advantage of cloud computing can offer while avoiding pitfalls
  - Determines which functionality it makes sense to migrate now
- Survey results indicate attendees think cloud computing plays a role in the future spacecraft ground system command & control and spacecraft operations – but commanding is still *scary*
- More discussions are needed to address the “fear of uncertainty” associated with cloud computing
- *We look forward to continuing discussions at GSAW2012*