Small Sat Ground Systems

- Kratos has long tradition in building satellite ground systems
  - Created quantum product line for small satellites
    - Traditional functionality in software based solution
    - Flexible deployment
    - Reduced footprint
    - Scalable
  - Wanted to look at other options for small satellite ground architectures
Large Constellations

• Large constellations now feasible with small satellites
  – Cost to build, launch and operate traditional satellite negated concept of a large constellation
  – Small satellites now have companies looking at constellations in the thousands

• Traditional ground system architecture is not feasible
  – Stovepipe architectures and hardware reliance is too costly to operate constellations of hundreds much less thousands
Cloud Computing Services

• Deploy a ground system in a cloud
  – Eliminate hardware costs
  – Eliminate maintenance costs
  – Reduce floor space
  – Scalability
  – Collaboration
Kratos Cloud Study

• Study Goals
  – Is building a satellite ground system in the cloud realistic?
  – Will a cloud based architecture work for 1,000 satellite?
  – Are Kratos products favorable to operate in a cloud?

• Parameters
  – 1,000 satellite constellation
  – 30 simultaneous satellite contacts
  – 100 simultaneous system “Users”
Parameters

- Command and Control only
- 30 quantumCMD apps
  - C2 and M&C
- Fleet management tool for contact schedule
- 100 simulated web browser “Users”
- A test director using scripts to simulate “User” activity
• The scripts started each “User” individually, spacing them out randomly
  – Each “User” started at the Fleet management tool page for 10-14 seconds
    • Screen shot saved by Test Director for quality check to show page filled in correctly
  – “User” drilled down to assigned spacecraft page on quantumCMD for 8-10 seconds
    • Screen shot saved by Test Director for quality check to show page filled in correctly
  – The “User” increments s/c contact number by 1 and cycles through remaining 29 active contacts doing same process for each s/c
• Test Director script tracked all “Users”, logging times, events, and completions
• Image thumbnails were checked to ensure data filled in correctly for pages
  – Full size images were spot checked to ensure data was as expected
Lessons Learned

• VMs were easily imported to the cloud
  – This enabled us to import official quantumCMD virtual machines without having to recreate them
  – Updating instances running in the cloud is identical to traditional VM upgrades
• Largest performance concern was Fleet Management tool, maintains connectivity to 30 quantumCMD appliances, maintains a wide data set for all spacecraft, and receives frequent network traffic from “User” browsers
  – Running on a more powerful instance type helped address performance concerns
  – Tuning in a few software areas was also made to reduce latency and enable faster data access performance
What’s Next

• Include FEP & Ground Modem
  – Cmd/Tlm processing
  – Signal modulation
  – Digital RF from Cloud to Ground Station

• Use cloud-based ground system for end-to-end ConOps
  – Bench/compatibility testing
  – Launch & On-Orbit Checkout
  – On-Orbit Operations
Summary

• Satellite operations via a cloud is feasible
  – Significant cost savings versus building/maintaining physical ground system
  – Easily manage new applications or performance upgrades

• Trade offs
  – Importance of data security
  – Maintaining control over infrastructure
  – Access assurance