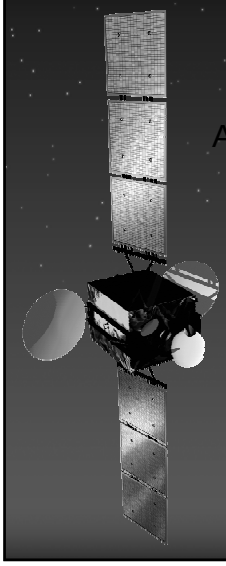

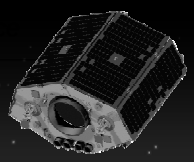

TechDemoSat-1:

A software test bed for CCSDS SM&C

Modern service oriented software for space

Nicholas Holt (SSTL)
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Mark Doyle (CGI)
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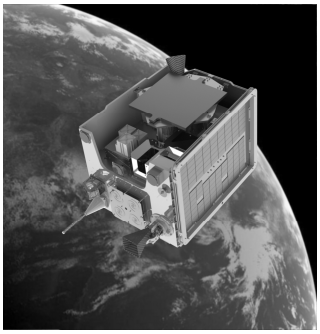
Topics

- TechDemoSat-1 (TDS-1)
- Software Experiments
- Test Bed System
- CCSDS SM&C
- Why SOA
- Next Steps

TechDemoSat-1

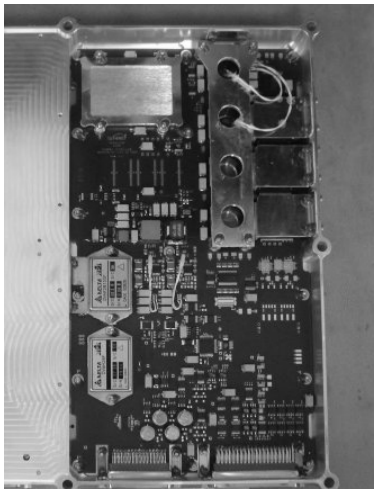
- Is a collaborative project to bolster the UK's thriving space industry by providing a low-cost opportunity for innovative commercial and research payloads under development in the UK to gain flight heritage.



- Launches Q3 2013
- Mission Operations managed through Satellite Applications Catapult at Harwell.

OBC750 & Software Experiments

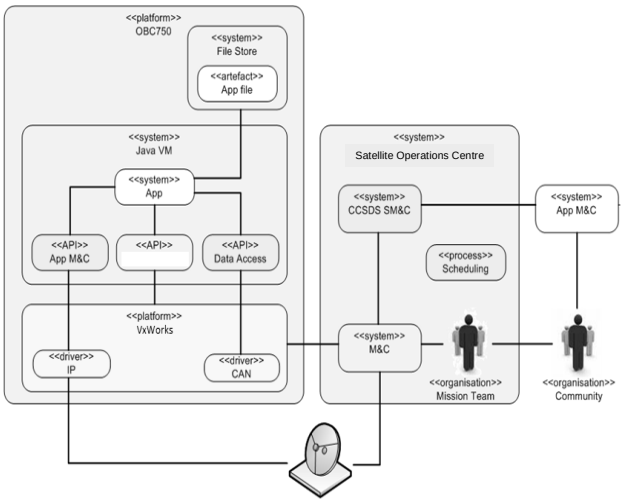
- TDS-1 flies SSTL's OBC750 next Generation On-Board Computer.
  - New Product Development
- High-performance OBC:
  - 1333 Dhrystone 2MIPS,
  - 296 Whetstone MWIPS
  - 16 MiBytes EEPROM for boot software
  - 256Mbytes RAM memory
  - IP comms with ground.
- On TDS-1 there are spare resources to operate the satellite and run software experiments:
  - OBC750 provides memory protection mechanisms in Hardware and Operating System
- Anticipated that operational time will be available to run software experiments after 1st year of operations
  - This will provide a unique test bed allowing approaches to be validated in orbit.
  - The aim is to reduce the barriers to fly novel techniques and promote innovation.



Test Bed System

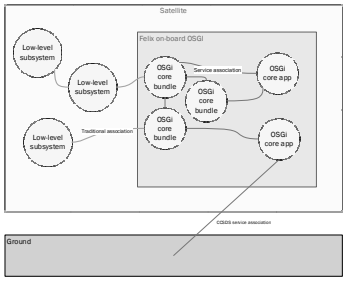
- SSTL and Logica (now CGI) have been working together on new approaches to Satellite System Software.
  - Next Generation On-Board Software (NGOBS) project
  - Aim to run on TechDemoSat-1
- Aims:
  - To use COTS open-source approaches and software where possible
  - Reduce barriers to development – e.g Avoid expensive toolsets.
  - Allow flexibility to easily move functionality around system.
  - To investigate mechanisms to implement CCSDS SM&C protocols.
- Initially looked at feasibility of flying Android on Satellites.
  - We successfully ran Android on OBC750
  - Chose alternative approach - Java Test-Bed using JamaicaVM
    - Lower risk approach as we wanted to run VxWorks together with Test-Bed.
    - Didn't need many of the Android functions
    - Development could still use Open-Source Toolsets.
- Ground System - Hummingbird Open-Source Mission Control System
  - Java Based

Test Bed System - TDS



Test Bed - OSGI

- The team chose to employ OSGI for Satellite Test-Bed System.
  - OSGi technology is a set of specifications that define a dynamic component system for Java.
  - Applications are (dynamically) composed of many different (reusable) components.
  - Advantages:
    - Service Modularisation
    - Service and Application Management
    - Resource Management
    - Service and Application Security
  - Technology exists and widely supported.
  - Already in use for Hummingbird.

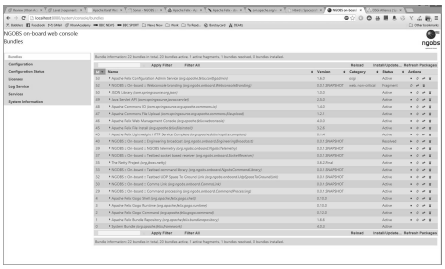


  - We chose to use 'Felix' implementation for on-board system
    - Lighter weight than Karaf used for Hummingbird

CGI

Test Bed: Services Implemented on board.

- Broadcast Telemetry
- Solicited Telemetry
- Telecommand:
  - Basic level to OBC tasks
  - Basic level to CAN (Satellite TT&C network)
    - Firewall layer incorporated to protect satellite.
- Messaging (socket comms) User defined
- Felix/OSGI provides:
  - Application Deployment
  - Web Services
  - http bundle
- File Transfer:
  - Saratoga protocol
  - Standard ftp



Felix On-board Web Console

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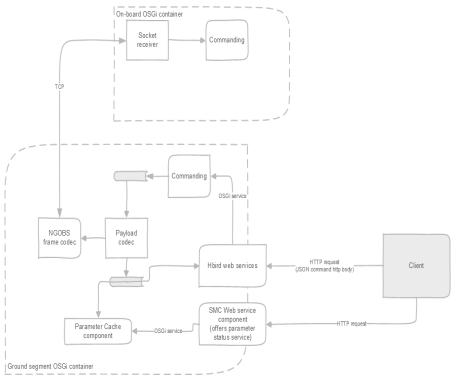
CCSDS SM&C

- The Team wanted to use the NGOBS project to explore CCSDS SM&C aspects
- Findings:
  - Difficult to find information on implementation details.
  - Standards incomplete with regards standardised services
  - Standards can be interpreted in multiple ways.
  - Goals of Standard was sound.
- Decision
  - Develop own services to satisfy SM&C goals.
    - Protocol and language agnostic.
    - Where possible match SM&C API implementation (Java)
    - Use COTS approaches and Tools

CCSDS SM&C approach

- Hummingbird provides SM&C proxy for Satellite
- Comms between Client and proxy to use HTTP, JSON and XML
  - Protocol and language independent.
- Implemented system for SM&C Parameter Service Status.
- OSGi Bundle created to brokers requests.
- This approach can then be expanded for other SM&C services



CCSDS SM&C: Deployment on-board

- On-Board system could service SM&C requests directly (without using proxy)
- Need to consider restricted link speeds to OBC
  - TDS-1: Uplink – 19k2 bit/s Downlink 38k4 bits/s
  - Using http, JSON etc… introduces overheads
- Recommendations
  - For routine services using more of link: Employ proxy
    - Also helps with flow control to/from satellite.
  - For services with lower data requirements and experiments quicker to develop based on Satellite servicing requests.
  - Note: More work in this area is necessary
- Because Satellite and Ground use common approaches, easier to adapt system!

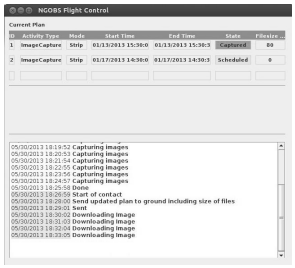
Why SOA? – Example Benefit to Mission

- Team wanted to ensure that there is a tangible benefit of SOA to mission in addition to potential cost savings.
  - Explain using example.
- Potential Benefit: Opens up new ways of autonomously operating Satellites!
  - Exchange of information can be much more dynamic and hence CONOPS can be evolved.
  - Approach to updating software makes it quicker to adapt system to optimise operations during service.
- Case Study: Imaging Payload Operations.
  - We identified that we can get more useful data from an Imaging Satellite in two ways:
    - Adjust Imaging Schedule to take account of actual compression ratios achieved.
    - Choose to discard Images for download based on Cloud Maps
- Current scheme.
  - No interaction between Planning System and Satellite during contact.
    - i.e. Telemetry received is processed and passed to MPS post-pass
    - Any change to plan is communicated on next contact.
  - This limits the potential benefits.

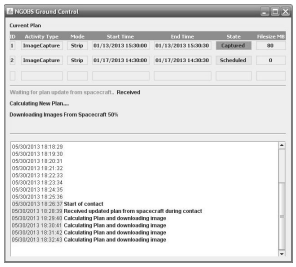
Why SOA? – Example Benefit to Mission

- Envisaged Scenario – Every contact:
  Pre-Contact
  - MPS receives Weather info (Web Services link)
  - MPS re-plans deciding not to download certain Images. (No point in downloading cloudy images)

  During Contact
  - At start of Satellite contact the MPS can delete the files & issues new download schedule
  - MPS requests file sizes of Images on-board
  - MPS re-plans using the received info to adjust Imaging Plan
  - MPS sends new schedule to Satellite.
- Result: We are getting more useful data from Satellite, by changing operational scheme.
- We have prototyped a demo showing this scheme in action!
  - Uses Test-Bed
  - Based on data exchanged for DMC satellites.



Demo: Progress Monitoring of OBC



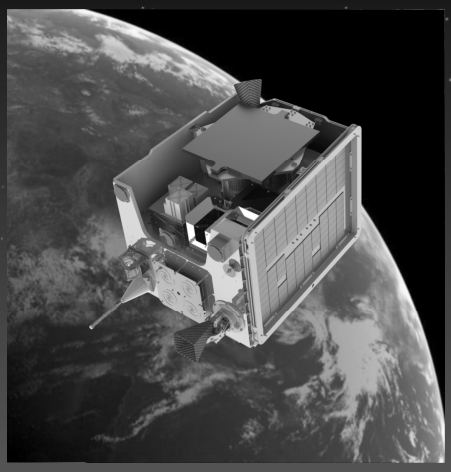
Demo: Progress Monitoring of GBOBC

CGI

Next Steps

- Launch & commission TDS-1.
- Commission payloads
  - OBC750 is a new product development.
- Call for Software Experiments
  - These don't have to use Java Test-Bed.
  - Expect operational time for experiments to be available after 1st year of operation.
  - Experiments will need to be co-ordinated with Satellite Applications Catapault.
    - See http://sa.catapult.org.uk/
    - Primarily for UK Industry and Academia
- Experiments expected to question classical separation of Ground and Space Systems
  - Test Bed for Space Software
    - E.g. CCSDS SM&C and file based operations.
- Use outcome of experiments for future missions!

CGI



Thank you

-Questions ?-