The Advanced Instrumentation and Technology Centre (AITC)

ACSER CUBESAT2017: Launching CubeSats for and from Australia
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QB50 Test Campaign and CubeSat testing at the AITC

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Advanced Instrumentation and Technology Centre (AITC)

• National facility for the design, manufacture, assembly and test of precision instrumentation
• Suite of integration laboratories, cleanrooms, and environmental test facilities
• Staffed by personnel with significant instrumentation and space experience and expertise
Advanced Instrumentation and Technology Centre (AITC)

- Can provide technical support for all phases of CubeSat development cycle
- One-stop-shop for the AIT of both terrestrial and spaceborne instrumentation and small spacecraft
- A unique hands-on facility for AIT training.
- Spacecraft test team involvement encouraged
AITC Environmental Test Facilities

- EMC
- Vibration
- PyroShock
- Thermal Cycling
- Thermal-Vacuum
- Mass Properties
- EP Thruster Vacuum
- Mechanical Shock
AITC On-Site Test Support Facilities

- Electronics lab, general test & rework equipment
- Optical test & metrology equipment
- Full machine shop (modifications, jigs & fixtures)
- 3D printing capability (ABS and vacuum-compatible)
- Cleanrooms & clean work stations
- Adhesive preparation equipment
- Gross & precision cleaning facility
- Plasma processing facility
Australian QB50 Spacecraft

QB50-AU01
SUSat

QB50-AU02
UNSW-EC0

QB50-AU03
Inspire-2
Australian QB50 Spacecraft Testing

• Concurrent test campaign: AU01, AU02, AU03
• Undertaken over a 2-week period in late June 2016
  – ~5-days spacecraft test preparation
  – ~7-days testing
• QB50 flight acceptance tests:
  – Vacuum-bakeout;
  – Thermal-Vacuum cycling;
  – Vibration (Sine, QSL & RMV);
  – Pyroshock (deleted – waiver granted)
QB50 Thermal-Vacuum (TVAC) Tests

- All three spacecraft accommodated in S2F
  - Vacuum bakeout followed by 4-cycles +50/-20°C
  - Thermal cycling undertaken on 12-hour/day basis; paused at ambient
  - Free-space RF communications with AU01 (very low power)
  - GPS retransmission within chamber

- All tests successfully completed!
QB50 Thermal-Vacuum (TVAC) Tests

• Minor issues encountered and overcome
  – new TVAC test fixture – AU03 antenna deployment
  – RF communications with spacecraft
  – location of test temperature sensors
  – definition of when dwell starts/finishes
  – battery charging during cycling
  – battery power available for functional tests
  – GPS signals in test area and chamber
  – mechanism deployment at low-temperatures

• QB50 lessons-learned applicable to all testing
QB50 Vibration Tests

- ISIS 2U test pod (baseline) use had issues
- AU03 Z-axis testing completed OK
- Large resonance peak detected during initial sine sweep, X-axis
QB50 Vibration Tests

- Remaining tests completed with CalPoly test pod
- Shift in resonant peaks (CalPoly test pod) explained to launch provider
- 3 different RMV profiles were used across the three spacecraft (late requirements change)
Test Campaign Optimisation

• Test campaigns are expensive (costs underestimated)
  – test facility charges
  – test campaign logistics (travel, accommodation, subsistence)

• Efficient, effective & thorough planning will maximise success & minimise cost

• Start environmental test planning early - talk to us well before your test is due
  – understand test requirements (development or launch authority mandated)
  – advise us of your needs (required test(s) & window)
  – discuss AITC facility capabilities, interfaces & services
  – agree on a test baseline (test, ROM cost & schedule, window)
Reason for test

• Launch authority requirement
  – minimum usual tests
    • vacuum bakeout
    • vibration (swept-sine and RMV)
  – other requirements
    • additional vibration tests (Sinusoidal, QSL)
    • TVAC cycling
    • PyroShock (avoid with waiver if possible)

• Development tests
  – engineering analysis and risk mitigation
  – testing more involved
Test Cost Drivers

- AITC services provided on a cost-recovery basis
- Test price is based on AITC engineering effort (and consumables)
- Test price discounted for approved university research projects
- Facility access fee for test team operation
- Test work scope can vary widely
  - each test may have unique & specific requirements
  - wide range of ROM test prices
Test Cost Drivers

• We will work with you
  – provide technical assistance and guidance
  – allow you access to facility on 24/7 basis
  – allow test team operation of some facilities (after training)
  – help you to keep your costs down

• Remember
  – scope creep and changes will impact on cost!
  – delays may also impact

• **Minimise AITC effort to minimise test cost!**
Engagement with the AITC

• AITC facilities, capabilities, test guides and ROM pricing to be available online soon
• Engage initially by completing test questionnaire
• Follow-up telecon with AITC to discuss needs
• ROM test price for baseline scope provided
• Testing to be undertaken under a test services agreement
  – fixed-price (agreed and fixed work scope)
  – test-capped (limit-of-liability) based on ROM
  – takes time to get through university processes
TVAC testing – factors to consider

• Test facility capability
  – S2F suited to larger spacecraft (deployed mechanisms)
  – TBAL testing & TVAC cycling
  – consider UNSW Canberra for bakeout and stowed (launch configuration) thermal cycling (up to 3U)

• Test duration
  – TVAC testing normally undertaken on a 24/7 basis
  – 12-hour/day possible – takes longer, no cost saving
  – typically 3-4 days to complete bakeout & cycling
  – spacecraft thermal stabilisation drives overall test duration (and price)
  – spacecraft representative available on-site at all times
TVAC testing – factors to consider

• Test criteria
  – definition of when hot/cold dwell starts/finishes critical
  – test temperature sensor locations (internal/external)
  – battery charging during cycling creates drift

• Test preparation
  – spacecraft sensor instrumentation
  – spacecraft integration into chamber & end-to-end test
  – maximum amount of hands-on to spacecraft test teams

• Test fixtures
  – support spacecraft with appendages/deployables
  – separation switch type and locations
  – special fixture may be required (AITC or user-provided)
TVAC testing – factors to consider

• **Spacecraft communication**
  – direct cable connection
    • umbilical cable to spacecraft test connector
    • vacuum compatible harness
    • Standard vacuum feedthrough connector
  – RF comms
    • S2F is a Faraday cage – cable feedthroughs required
    • issues with free-space communications inside chamber
    • direct connection (bypassed) antennas or load caps
    • ground station required
TVAC testing – factors to consider

• Spacecraft power
  – battery charging
    • battery temperatures critical
    • trickle charging takes a long time
    • impacts on thermal cycling (battery temp rising)
    • limited windows for charging (battery temperature)
    • may impact on spacecraft functional tests (deployments)
  – ground power
    • consider external power supply via umbilical
    • external switching between ground and on-board power
TVAC testing – factors to consider

• **Spacecraft functional tests**
  – full functional tests before TVAC testing
  – abbreviated functional tests under vacuum at end of dwell
  – strongly consider automated test scripts to minimise time
  – deployments should be undertaken at the end of cold phase (worst case)
  – ensure sufficient battery power for functional tests
  – GPS repeater (inside S2F & Integration Hall) required

• **Materials vacuum compatibility**
  – vacuum-compatible materials only
  – significant S2F decontamination charges may apply
Vibration testing – factors to consider

• Test duration
  – spacecraft functional testing & inspection drives overall test duration
  – basic testing can be completed within a day
  – complicated testing - allow 1-day/axis

• Test preparation
  – test profiles need to be (re-)qualified before flight test item
  – profile change will require additional AITC effort
  – spacecraft preparation includes CAC & spacecraft inspection
  – AITC will provide training & reasonable level of support during spacecraft preparation
  – maximum amount of hands-on to spacecraft test teams
Vibration testing – factors to consider

• Spacecraft functional testing
  – may be undertaken on-shaker
  – requires bypass of separation switches and access to test connector port
  – ideally test item should not be removed between vibration axes
  – functional testing will add to schedule

• Test sequence axis by axis
  – all vibration exposures completed in one axis before moving to next
  – swept sine resonance search between vibration exposures
  – off-shaker functional testing after all axis exposures completed
Vibration testing – factors to consider

• Test pods & fixtures
  – CalPoly 3U test pod
    • 1U, 2U & 3U "tuna can" test items
    • multiple test items possible
    • enables testing in all 3-axes on slip table
    • clearance between spacecraft and pod
  – QB50 (ISIS 2U) test pod
    • clamped rail retains test item
    • necessitates shaker reconfiguration for Y-axis
  – Other test pods & fixtures
    • will require shaker interfaces fixtures to be fabricated
    • can be user-provided or by AITC
Vibration testing – factors to consider

- Test instrumentation & data
  - Flight acceptance test
    - test data demonstrates required test exposure achieved
    - minimum sensors and data logging
    - test pod instrumented; spacecraft not
    - logged data can’t be used for analysis
  - Development/qualification test
    - spacecraft internally instrumented
    - multiple miniature sensors required
    - DAQ system & analysis software
    - logging & processing by test teams
Contact us

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