MIST system test phase

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Table Of Contents

1. Basics of MIST integration & test

Hard Cubesat facts affecting integration and test.

- A Cubesat **can not be partially integrated**
- A single subsystem can not be removed from an integrated satellite **without partially disassembling the entire satellite.**
- It is **often impossible to reach the programming connector for** microcontrollers while the subsystem/experiment is integrated into the satellite. **Issue to be resolved: Only CUBES and OBC can reached?**
- The **OBC can be remotely reprogrammed** via umbilical (with some effort).
- Reprogramming after comms/deployment test only done in **dire emergency**.

Experiment programming connector reachability

- **NanoProp:** reachable.
- **CUBES-1/2:** reachable, debug via FlashPro 4 debugger.
- **LEGS:** reachable?
- **SiC:** **NOT reachable**.
- **SEUD:** **NOT reachable**, prototype version has debuggers pointing +Z dir, would be great to **”re-layout”** when manufacturing Flight version.
- **We will retest OBC SW Update via TC** on the EM & FM FlatSat to confirm this.

Separate vibration tests, bottom stack integration criterion, thermal test of experiments?

- All **newly developed units** (except NanoProp helper board) located in **the bottom stack**.
- **Newly developed units are not tested to qualification vibration levels. All other units are.**
- **Solution: Test the bottom stack** (integrated into flight structure) to vibration qual levels **separately as the first test in the system test sequence.** If there is a problem with an unqualified experiment the entire satellite does not need to be disassembled.
- This is the reason for splitting the vibration test into two (bottom stack and entire satellite).
- When to integrate the bottom stack and run the first vibration test? **When all bottom stack units are functionally checked out (See next slide).**
- What about NanoProp helper board? Run a separate qual vibration and thermal test for the board only – **spare units** available. **Issue to be resolved.**
- How about temp qualification? **Run funct. test on CUBES, SiC and SEUD, helper board in thermal chamber in air?** Or take the risk and leave it to the TVCT? **Issue to be resolved.**

Experiment basic functional test status

- **NanoProp**: **basics tested**, standalone operational partially tested (heaters, firing, state changes, valves), to test TM/TC when ready.
- **CUBES**: **basics tested**, TM/TC tested, **operations via TM/TC in progress**, **CUBES-1 issue still unresolved (HVPS)**
- **SiC: basics tested**, TC tested, **should try SiC - Request Payload? Otherwise ready.**
- **LEGS: basics tested**, TM/TC tested, operations is simply running LEGS. **Ready.**
- **SEUD: TBC.** Basic test (power) can be done in 3 hours, TM/TC test should be planned, perhaps via an "error generator" (hardware/software approach according to Johnny) if time allows.
- **Camera: TBC**, basic test should bundle with SEUD, operations should be verified via a simple photo-taking + downloading via TM/TC queues.

2. Exp tests during system tests

How to check experiment functioning and when?

- Is it reasonable to split experiments tests into two categories?:
  - **Basic Health Check** (RFT-see below) after Comms/deploy,Mag calibration, leak checks?
  - **Functional Check (**FFT – see below) after environmental tests (vibration, thermal vacuum).
- Is the Basic Health check just **ON/OFF, correct current drain and basic HK data**?
- What is the Functional Check (FFT) beyond the Basic Health Check (RFT): **sensor data**?
- Can PI's suggest scope and details of these tests? **Issue to be resolved.**

Footnote: RFT=Reduced Functional Test, **FFT**= Full Functional Test.

PI=Principal Investigator

3. System test sequence

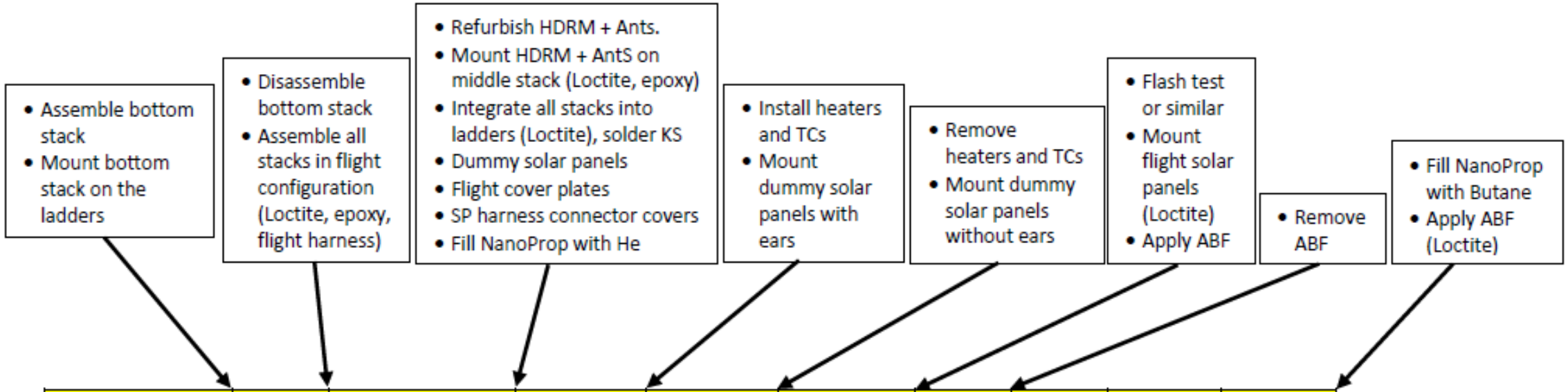
Overall Plan, summary

#	Title	Purpose	Test configuration	Location
1	**Vibration Test 1**	**Qualify** new units (Q levels, Acc duration)	Bottom stack, NProp Helper Board	**Facility TBD**
2	**Comms & Deployment**	Verify initialization & commissioning	AntS/HDRM separated from stacks	TR31
3	**NanoProp Leak check**	Check that NanoProp valves do not leak	No solar panels, body dummies used	TR31
4	**Thermal balance/cycle**	Check model/verify eqpt functions	No solar panels, dummies used	TVAC
5	**Magnetic calibration**	Needed for ADCS	No solar panels	SGU, Uppsala
6	**Vibration Test 2**	Flight **acceptance (ask L/V for levels)**	Complete satellite, threads locked	**Facility TBD**
7	**Mass properties**	For meeting L/V requirements + ADCS	Complete satellite	TR31 lab
8	**Thermal bakeout**	"Clean" satellite **(part of #4 ? check L/V req.)**	Complete satellite	TVAC?
9	**NanoProp Leak check**	Check that NanoProp valves do not leak	Complete satellite	TR31

Issue to resolve before fall 2025 semester

TEST LIST

Overall Plan, including actions between steps



Item	Vibr. 1	Comms/Deploy	Leak test	TBT/TVCT	Mag Cal.	Vibr. 2	CoM	Bakeout	Leak test
Solar panels	N/A	Mass dummies	Dummy	Dummy	N/A	Flight	Flight	Flight	Flight
Power supply	N/A	Battery	Umbilical	Umbilical	Bat &	N/A	N/A	N/A	Umbilical
Communications	N/A	G/S	Umbilical	Umbilical	Umbilical	N/A	N/A	N/A	Umbilical
Battery model	N/A	Flight	Flight	Flight	Flight	Flight	Flight	Flight	Flight
Test tool	N/A	G/S	Test Stand	Test Stand	Test Stand	N/A	N/A	N/A	Test
Location	TR8?	TR31-35	TR31	TVAC	SGU	TR8?	TR31	TVAC	TR31

TESTS, ACTION, LOCATIONS

System tests & preparation status

#	Title	Test (integration) eqpt status	Test plan/procedure id/status	Duration (d)
1	Vibration Test 1	• Vibration test adapter/plate/**Ready**	• Random vibration test procedure M632-041 **(incomplete)** • How to check experiment health after test?/**TBD**	3
2	Comms & Deployment	• MGSE/**Ready**	• Documents, **drafts** • Assembly manual Coms/depl M652-001 • AntS/HDRM Refurbishm. M53-001 • Comms/Depl Test plan M631-063 • Comms/Depl Test outl M631-068 (merge w063) • Commissioning phase simulation M631-061 • Handling of kill switch M631-064	6
3	NanoProp Leak check 1	• Cabling/**Ready** • He, pipes, valves/**pending**	• NanoProp leak check procedure M174-023/**draft**	3
4	Thermal balance/cycle	• TVAC suspension system/**ready** • TVAC umbilical/**ready** • Heaters + cabling /**ready** • Thermocouples/ **ready** • Dummy solar panels/**ready**	• Documents, **drafts** • TBT plan M632-026 • TVCT plan M632-038 • TVCT step-by-step procedure M632-044	10
5	Magnetic calibration	Minimum additional eqpt needed	At least two methods possible. Proc. to be written.	3
6	Vibration Test 2	See Vibration Test 1	See Vibration Test 1	3
7	Center of Mass	Equipment under development	• Where do we find requirements? • Procedure to be written	2
8	Thermal bakeout	To be defined **(make part of #4?)**	To be written **Check with L/V: 48 hours at max non-op temp?**	3
9	NanoProp Leak check 2	See NanoProp Leak check 1	See NanoProp Leak check 1	3

NB: All durations are ”guesses”

Work between system tests - 1

#	Title	Actions (Details will be in M630-008)	Tools/materials needed, procedure id/status	Duration
A		• Assemble bottom stack **(Locktite?)** • Mount bottom stack on ladders	• All experiments/ **Status=TBD** • Harness/**Status=TBD** • Stack assy M650-002	5
1	**Vibration Test 1**			
B		• Disassemble bottom stack (hopefully not) • Assemble all stacks in flight configuration (Loctite, epoxy, flight harness)	• All MGSE available/**ready** • Harness mostly OK. **(several cables incomplete)** • Epoxy application/**pending** • Documents-video, **drafts:** • Simplified test plan M600-009 • AIT Handbook M651-001 • Preps for sat integr M651-001 • Mounting mid stack on bottom stack • Stack assy M650-002 • Mounting AntS HDRM M650-004 • Ladder integration M650-005 • Epoxy handling M651-002 • Assy manual Coms/depl M652-001	14
2	**Comms & Deployment**			
C		• Refurbish HDRM + Ants. • Mount HDRM + AntS on middle stack (Loctite, epoxy) • Integrate stacks into ladders (Loctite), solder KS • Fill NanoProp with He	• Dummy solar panels • Flight cover plates **(surface treatment +/-Z)** • SP harness connector covers **TBD?** • **We have refurb kit for AntS. HDRM?** • Flight ±Z cover plates surface treatment **TBD** • AntS/HDRM Refurbishment. M653-001	21
3	**NanoProp Leak check 1**			

Work between system tests - 2

#	Title	Actions (Details will be in M630-008)	Tools/materials needed, procedure id/status	Duration
D		• Transport to TVAC • Install heaters and TCs • Mount dummy solar panels with ears	• Dummy solar panels ready (**add dummy connectors**) • Flight cover plates • SP harness connector covers • Assembly manual for thermal test M652-002	3
4	**Thermal balance/cycle**			
E		• Remove heaters and TCs • Mount dummy solar panels without ears • Transport to integration lab→SGU		2
5	**Magnetic calibration**			
F		• Flash test or similar • Mount flight solar panels (Loctite) • Transport to integration lab→test site • Mount ABF	• Solar panel test procedure **TBD** • Flight solar panels	2
6	**Vibration Test 2**			
G		• Remove ABF • Transport to integration lab		2
7	**Center of mass**			
H		• Transport to TVAC		1
8	**Bakeout**			
I		• Transport to integration lab		1
9	**NanoProp Leak check 2**			
J		• Fill NanoProp with Butane • Transport to launch site • Mount ABF (Loctite)		14

4. Factors in meeting launch date

Readiness of Experiments and OBCSW

- What defines the readiness of experiments for mounting in the bottom stack?
  - Communications with OBC verified on Flatsat.
  - Functionality verified on Flatsat. Estimate of date: **Can it be done NLT 31 August 2025?**
- What defines the adequate readiness of the OBCSW for integration of the bottom stack?
  - OBCSW support for experiment ready. Estimate of date: **TBD?**
  - Which new features may be added to the OBCSW to support experiments after bottom stack integration? None after the Comms/Deployment test? **Issue to be resolved.**
- Can the ADCS gain and filter parameters possible to be set by TC and are they then ”persistent” until changed by telecommand? **Issue to be verified, but appears to be true.**

Estimated length of the system test phase

Item	Description	Duration
A	Prepare for vibration test 1	5
1	Vibration test 1	3
B	Prepare for Comms Depl	14
2	Comms & Depl	6
C	Prepare for NanoProp leak check 1	21
3	NanoProp leak check 1	3
D	Prepare for Thermal Vac tests	14
4	Thermal Balance/Cycling	14
E	Prepare for magnetic calibration	2
5	Magnetic calibration	3
F	Prepare for vibration test 2	2
6	Vibration test 2	3
G	Preparations for Center of Mass	1
7	Center of Mass	1
H	Preparations for bakeout	1
8	Thermal bakeout	3
I	Preparations for Nanoprop leak check 2	1
9	NanoProp leak check 2	3
J	Prepare for launch	14
Total		**115**

So, if the net number of working days is about 115, and work on week-ends may not always be possible so we should perhaps add $(115/7)\cdot 2 \approx 33$ making **the total estimated test phase ≈148 days** long, ***barring technical problems.***

Then add delays due to exams… and public holidays and vacations. We need to navigate these matters somehow. **See penultimate slide**.

N.B. **No extra margins added to the schedule in the table on the left.**

NET DURATION OF SYSTEM TESTS

Moment to order a launch, Go/NoGo

1. Moment to order a launch.
2. Go/NoGo time before a booked launch

Christer's impressions after his talk with D-Orbit launch agent.
A "normal price" for a 3U satellite is 110-130 k€. Booking appears to flexible even as late as in 2027! Delivery of satellite for launch: "NET 45 days before launch" !!!.

Comments from Erik Hedenström: "100k€ may be possible, but not much lower Launch integration 1-2 months before launch. A student project I know about booked a launch 10 months before projected launch. They were allowed to delay one year free of charge, but only once. Proposal: Contact Exolaunch (for example) soon to get terms and requirements."

Other related internal matters

- How to keep a tight schedule with student manpower whose available time may be affected by exams, labs, lectures…? **Idea: For each major test task use two students – from different study programs – may help create continuity.**
- Some tasks may have been explored thoroughly in the past by students who have left the project long ago. **We could call such students back for a few days duty** (with ample warning).
- **Prepare tools, material and procedure ”kits”** well in advance. Make sure that students are ”read up” on the task they will work on well in advance and they know where all the tools and materials are. Maybe make **dedicated, labeled boxes** for each major test. (To a certain degree much of this work has already been done). These kits etc. could perhaps be listed in the **MIST Pre-Test Checklist, M630-008** (a skeleton draft at the moment).

Methods to handle necessary schedule margins

- There are many possible sources of schedule slip:
  - Technical problems,
  - Facility availability,
  - Staff availability.

1. Test facilities may be heavily booked and a delay from us may cause a major delay.
2. Our staff has strict schedule limitations due to exams etc..

- Changing the **order of tests** (when appropriate) may solve problem 1
- Scheduling major tests at **dates fixed** ”long” in advance may help mitigate problems 1 & 2.
- Fixed start dates of major tests require **margins <u>between</u> major tests**.
- Of course we need a **margin at the end** of the test sequence.