BEXUS

Experiment Integration Progress Review

REVIEW

Flight: BEXUS 30

Experiment: BoB

Review location: Cranfield University / United Kingdom

Date: 30 July 2020

1. Review Board Members

1 [redacted]

[redacted]

2. Experiment Team Members

[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	

1. GENERAL COMMENT

1. Presentation

- The presentation was clear and complete. All points needed for the review were covered and the next steps of the project were presented.

2. SED

- All CDR actions have been addressed and are identified in the document.
- The document quality is improving.

3. Hardware

- Components status:
  - The pressure vessel was sent back to manufacturing due to an issue.
  - The connector for the feedthrough was ordered.
  - The disc for the microfluidic system was received.
  - The DC motor & encoder were ordered.
  - The pump was received.
  - The valves were ordered.
  - The fan was received and tested.

- The camera was received and is being tested.
- The GPS was not received.
- The Raspberry Pi & microcontroller (Adafruit) were received.
- The connectors for E-link and power were received.

2. FOLLOW UP ON CDR ACTION ITEMS

- Cf. document "Addressment of CDR feedbacks_00"

3. PHOTOGRAPHS

4. REVIEW BOARD COMMENTS AND RECOMMENDATIONS

1. Science

- The biology team could access to the laboratory but 1 month later than expected.
- The imaging system is working correctly. The team is working on increasing the resolution. Even though the LED used for testing were too powerful the illumination was good enough to clearly observe the worms.
- The exposition duration of the camera can be modified.

2. Requirements and constraints (SED chapter 2)

- N/A

3. Mechanics (SED chapter 4.2.1 & 4.4)

- The security wires (figure 4-24 p81) have already arrived. Attachment holes are about 6 mm of diameter whereas the diameter of the cables is about 4 mm.
- ACTION 1: The team shall send to SSC the updated CAD **before the 5th of August**.
- The mountings to the gondola will be manufactured at the University. The aluminium has been purchased and should be received in week 32. The team estimated the manufacturing time to 3 weeks.
- ACTION 2: The position in-between the clamps may increase from 50mm to 75mm. The team should perform a first test on a trailer to determine the final distance between the clamps and later make another test with the full experiment (fully assembled and integrated).
- The team has decided to use O-ring instead of gaskets.

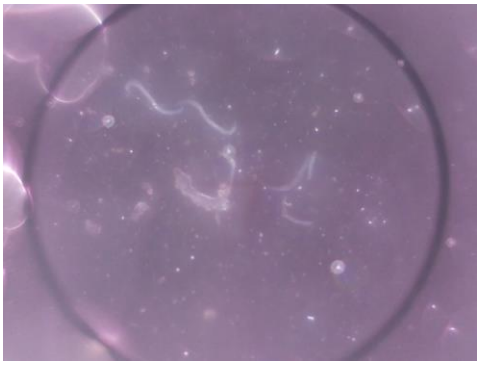
- In order to perform a pressure test, the only missing component is the valve. One lid has been ordered for the test (including a feedthrough for the pipe).
- The pressure vessel was manufactured by a professional company however due to an issue on it the pressure vessel has been sent back. The delivery date for the next pressure vessel should be around the first week of August.

4. Electronics and data management (SED chapter 4.2.2, 4.2.3, 4.5 & 4.7)

- ACTION 3: The experiment will embed a total of 24 sensors, the team should prioritize the sensors to be used and possibly de-scope some of them (i.e. IMU).
- The GNSS module is supposed not to be limited in altitude. However, the module has not been received yet.
- ACTION 4: The PCBs were not sent to manufacturing. An external company located in Asia should make them. The supply time is about 6 weeks. This is a MAJOR risk for the project. The team shall try to find a local provider to reduce the delivery time and order as soon as possible.
- The team will order spare PCBs.
- 3 members of the team are starting soldering components in order to gain experience however it is highly recommended to have an experienced person of the University or similar to review the soldering.
- 1 team member has experienced with cabling which is an advantage for the future integration. Nevertheless, it is recommended to add labels on your connectors and on your cables, ensure no naked wires, test no flat connection
- ACTION 5: The team shall test the ability to sustain a variation of the power supply (i.e. decrease the voltage to 25V), especially for DCDC converters and actuators.
- The camera is connected via a flat wire but the team has minimized the length to decrease the risk of breaking it.
- Breadboards status:
    - ACTION 6: The computer and the microcontroller have been connected but the script did not work. The team shall fix the UART connection.
    - ACTION 7: Photodiodes test has been done last week with test components. The same test should be done again with flight components.
    - The voltage regulator and surface mounted components are under testing on breadboards to determine capacitors and resistors values with LEDs.
    - Temperature test for the MSCD: [live demonstration]
        - ACTION 8: The team shall precise the resistance sensitivity to temperature compared with the calibrated thermometer. The resistance works well at 20 degC but it should be checked under flight temperature profile.

- The code is from the provider, from GIT HUB. The team is using a bang-bang controller with a set value found from testing and then from threshold.
- NOTE: the bang-bang controller works with an hysteresis loop.
- The risk with such controller is to have the thermal system continuing working turning ON and OFF quite often.

- Modulation module on raspberry pi [live demonstration]
  - The team used a kapton film heater in the 1U bus.
  - The duty cycle loop turns ON and OFF the transistors. The fan was working smoothly but when the sleep time was changed the fan started passing from the ON status to the OFF status accordingly to the duty cycle.
  - Similarly, the heaters had the same behaviour and were following the duty cycle.
- Imaging with LED [live demonstration]
  - Pictures have been taken.
  - Picture of the C elegans



For additional advises regarding optics, the team should have a look to the following resources:

https://en.wikipedia.org/wiki/siemens_star

https://www.image-engineering.de/support/chart-sizes-standards

https://www.thorlabs.com/_newproductlist.cfm?guide_id=2185

5. Thermal (SED chapter 4.2.4 & 4.6)

- The team relies on two thermal systems: passive (blanked, paint…) and active (heaters for the 1U and for the pressure vessel).
- Passive system:
  - The pressure vessel will be polished with metallic tape outside.
  - The pressure vessel will be painted in black near the fluid or the payload will be wrapped with a space blanket.

- Different configurations will be tested.

- Active system:
  - The team has implemented a heat sink with a thermal cement.
  - A 2nd heater will be placed close to the fluid.
- The last test will be done with electronics mounted and running.
- ACTION 9: The team shall make a final decision concerning the passive insulation **before the 14th of August**.
- ACTION 10: The team shall finalise the heaters configuration/location **before the 14th of August.**

6. Software (SED chapter 4.8)

- The software design has been frozen.
- The code has been prepared but not implemented to the electronics yet.
- Safe mode implemented:
  - Safe mode aims at maintaining a thermal control which is the critical part for the C. elegans.
- To test the control functions, some parts are missing:
  - Heaters: control the polyimide thin-film heaters
  - Geneva drive (code to be implemented).
  - Solenoid valves
  - Camera observations (code to be implemented)
  - Pump
- Communication and data functions:
  - Receiving and decoding data from the ground station (telecommands and heartbeat).
  - The data compression has not been tested yet.
  - Data storage on 2 SD cards.
  - The team is able to store and to transfer data from the ground station to the experiment.
- The ground station user interface is under development.
- The team can limit the data rate from the ground station to avoid the saturation of the E-link.
- ACTION 11: The team shall request on chapter 6 to have an announcement when 25 km is reached.
- E-link test [live demonstration]
  - Communication was working.
  - The test was done manually. The team is planning to perform it by using telecommands in week 32.

7. Verification and testing (SED chapter 5)

- ACTION 12: The team shall refine the test plans with the exact dates instead of "August". It is key that the team identifies interdependencies between the sub-system to have a realistic test plan.
- The delivery of the PCBs for system level tests is a critical point for the team. Furthermore a lot of components were not received yet (sensors and actuators).
- Thermal vacuum facilities are closed until the 15th of September. Re-opening after this date is still uncertain though.
- At University, the team has access to a vacuum chamber that could be inserted in a freezer.
- ACTION 13: The team should abandon the idea of performing a shock test on the flight model. The team should focus on static loads and vibrations instead.
- ACTION 14: The team shall re-plan T11.
- The team created a standard document for the tests. The team could send them to the organisers and include them in the SED.

8. Safety and risk analysis (SED chapter 3.4)

- The team provided an exhaustive list of chemicals inside the SED.

9. Launch and operations (SED chapter 6)

- The team will bring back the experiment to Cranfield however there are 2 different procedures (one for the experiment itself and one for the C. elegans.). The wroms will be frozen and then shipped to Cranfield. The ice box will be stored at Esrange for the shipment of the C. elegans.
- **INTERFERENCES:**
  - ACTION 15: The rubber may outgas and disturb O-Zone measurements. The point has been discussed with the O-Zone team during their IPR. BoB team shall send the datasheet of their rubber to rexus-bexus@esa.int that will follow the data to the O-Zone team.
  - ACTION 16: The team will provide a waste bag to cover the BoB box during recovering operation to prevent any risk linked to leakage. However the team shall verify that the waste bag is not corrosive.
  - The team has agreed to decontaminate the experiment with isopropanol.
- **LAUNCH SITE REQUIREMENTS**:
  - **BIOLOGY**
  - B1 – SSC will provide the team with the shipping address to send the biology hardware.
  - B2 – The required storage temperatures are:
    - Laboratory: 20 degC
    - Hardware storage: 12 degC

- B3 – ACTION 17: The team shall add the information concerning the team member joining before the official start of the campaign. In addition, due to COVID, new rules have been enforced at Esrange. Further information will be given in the following weeks.
- B5 – The team member will be granted the access to the laboratory before day 0 under the supervision of SSC staff. However after the start of the campaign the access to the lab will have to be coordinated with Stardust team.
- ACTION 18: The team shall bring VGA/HDMI adaptors to use SSC screens.

- **ACCOMMODATION REQUIREMENTS**
  - The team may need to feed the worms during the night before launch. It would be performed automatically but needs to be triggered by a telecommand. Power and E-link is needed for 20 minutes at least.
  - The experiment could stay on flight configuration during 38h otherwise the worms would need to be fed once more.
  - **The team is requiring to have the FCT as close as possible from the launch.**
- **PREPARATION ACTIVITIES**
  - The fit check with the gondola (clamps) will be done on day 1.
  - The individual check will be performed without the worms and flight fluidic environment.
  - ACTION 19: The team shall update the timeline.
- **TIMELINE**
  - The minimum number of participants to the campaign is 5 for the team.
  - There are several hours before the end of the FCT and the start of the countdown.
- Recovery sheet (already prepared):
  - The recovery team should have the skin covered when handling the box.

10. Organisation, project planning & outreach (SED chapters 3.1, 3.2 & 3.3)

- Finance:
  - The team has a grant which enables them to be confident on their capacity to afford travel costs.
  - The vacuum testing in Belgium is to be confirmed.
  - Missing at least 320£ but it might be more due to manufacturing so crowd funding necessary! Or help from the University -> Status? 2000£ without restrictions on-going
  - ACTION 20: The team is missing at least 320£. The team should seek additional funding from the University or start a crowd funding campaign as soon as possible.

11. End-to-end Test

5. FINAL REMARKS

1. Summary of main actions for the experiment team

- ACTION 4: The PCBs were not sent to manufacturing. An external company located in Asia should make them. The supply time is about 6 weeks. This is a MAJOR risk for the project. The team shall try to find a local provider to reduce the delivery time and order as soon as possible.
- ACTION 21: The team shall prioritize their tasks e.g. the team may think to remove the IMU.
- ACTION 22: The team shall update the chapter 6 (minor updates that could be done before EAR).
- ACTION 23: The team should contact ESA Education for accessing to the vacuum chamber in the CSF in ESEC.
- ACTION 24: The team should keep contact with STARDUST to coordinate the use of the lab during the campaign.

2. Summary of main actions for the organisers

- Provide the team with the shipping address.
- The list of chemicals will be sent to the Esrange Safety board.
- Section 4.4.3 with vibrations sources should be sent to ELFI.
- SSC will coordinate data downlink for pictures.
- Investigate the possibility for student to use the gas taps at Esrange as well as the availability of 4 glass bottles (1L) for autoclave and a vortex mixer (mg or g).
- G2 – SSC will check the possibility of a heated bath.
- A3 – SSC should investigate the possibility to use a 240V AC for the incubator.

3. IPR Result: pass / conditional pass / fail

- **CONDITIONAL PASS**

4. Next SED version due

Status report: The team shall send weekly status report before Friday 12:00 (London time). It could be simply done with a few bullet points in an email. Pictures and videos of tests are appreciated. Be sure to include information on ACTION 9 and ACTION 10 in the report on 14th Aug.

SED v4-0: One week prior to EAR (TBC).

6. INTEGRATION PROGRESS REVIEW – IPR

Experiment documentation must be submitted at least five working days (the exact date will be announced) before the review (SED version 3). The input for the Campaign / Flight Requirement Plans should be updated if applicable. The IPR will generally take place at the location of the students' university, normally with the visit of one expert.

The experiment should have reached a certain status before performing the IPR:

- The experiment design should be completely frozen
- The majority of the hardware should have been fabricated
- Flight models of any PCB should have been produced or should be in production
- The majority of the software should be functional
- The majority of the verification and testing phase should have been completed

The experiment should be ready for service system simulator testing (requiring experiment hardware, electronics, software and ground segment to be at development level as minimum)

Content of IPR:

- General assessment of experiment status
- Photographic documentation of experiment integration status, with comments were necessary
- Discussion of any open design decisions if applicable
- Discussion of review items still to be closed
- Discussion of potential or newly identified review item discrepancies
- Discussion of components or material still to be ordered or received by the team
- Clarification of any technical queries directed towards the visiting expert
- Communication and functional testing (Service system simulator testing and E-link testing for REXUS and BEXUS respectively)