Group 2: Hardware Development and Mission Formulation

Chair: Riccardo - Minutes: Jeremy

Define the topic: each NanoSat has a specific choice of detectors, so a common hardware design is not possible. On the other hand, operating a set of different satellites as a constellation will increase the science output.
Open Questions:

- Some library of available hardware technologies? E.g. readout ASICs for scintillators?
    - Should this be public or not?
        - It's important to be able to be able to be honest about this. So we can say what we want about vendors.
        - If it's public then the vendor's can defend their record.
        - Public has an advantage for people that are not part of the community.
        - Platform? Riccardo will work on this. Look into getting a wiki going.
    - Can we provide details on the hardware that can show how to implement specific hardware solutions.
        - Several people are happy to share things.
        - Solutions for GPS in space?
            - Are people are doing open-source stack for GPS?
                - There might be legal issues here.
            - RR bought a board for space qualified testing. There is a firmware update that you have to agree to the license.
        - There are difficulties for US collaborators with ITAR/EAR. There was a discussion about what can and what cannot be shared. We need to be cognizant of this.
    - Space qualification? This is something that we could share. We could also share hardware. Validation, qualification and so on. - can't remember who volunteered for this.
    - GAGG in orbit? Radiation testing on the ground? There's a good paper from a Japanese group.
    - Lot's of cheap parts that just work.
- Compatible time binning (counters etc.)
    - Overlap with data sharing people. Needs to do this so we don't do rebinning.
    - Is it possible to have an absolute 0 timing? 1 second? Is this even needed? Do we need to do it at a specific UTC?
    - Everyone can make a photon list that's for a trigger (a few times a day). Is this something that they can all do? Probably need a lot of storage. Data consist of time stamp and energy.
    - The science goal is for making a coherent network.

    - Could have a table on the wiki that details minimum requirements. An individual cubesat might not meet them but they can particilpate in part of the effort.
    - Need to figure out what these requirements are.
    - Side Discussion on figuring out which cubesat is which cubesat.
    - Is there an issue with telling people where your sat is? Don't think it's a problem.
    - Good to have absolute timing on some level. Might not do less than a second but something would be doable.
    - Maybe if we do it all the same way. Even on earth would be fine.
    - If we had 20 different instruments, it would be difficult to keep them straight. We need something like a table to determine what instruments can do what.
    - If you want to do time difference, then you need millisecond.
    - Could put together a list of capabilities with ways to implement them. Sats could pick and choose what parameters to meet. This is a way to direct people to do specific things. This needs to be driven by the science.
    - Could have another table for specific missions that describe what each mission can do
    - For triangulation we need to go below 1 millisec. You need one order of 1 millisecond or you wash it out. To combine stuff you need to be precise in time. You need to know where your satellite is in time.
    - There was a discussion about reconstructing the position of RXTE after the fact to really good accuracy. This was an analysis. This should be brought up to the software group. It's straightforward for sats to get to less than 1 millisecond. This is in LEO.
    - Jeremy will look at developing a requirements/suggestions table.
- What to make available in Telemetry?
    - Location. GPS position every given spot.
    - Orientation (pointing of instrument boresight).
        - Attitude of the satellite. Is important if your instrument is not symmetric. Need two axis.
        - 2 line element and quaternion. This is the standard.
    - Instrument status.
    - Can merge this into the requirements.
    - 2 line is on ground but quaternion is done by the ACS system in real-time.
    - The data group will need to work on this. Will need to ask for someone from the data group.
- Alert capabilities, including responding to triggers from outside (e.g. GW). Is repointing necessary (depends on FOV)?
    - Do we provide the alerts to all the cubesats.
    - Need space available for TTE data and to do sub-threshold alerts.
        - There's a trade between continuous data and asking for TTE for specific times.
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- Coordinate and optimize sky coverage

    - This is an issue if you have to sacrifice your own observing plan for the good of the group.
    - But if we publish sky coverage would you be willing to point in the gaps?
    - Most of these projects have prototype and then full development. Sky coverage is simple. You use lots of sats. If you're using a prototype then you are forced to look at a specific patch of the sky. You'll have a list of targets. But if you're mature then you can optimize.
    - It also depends on the different cubesats. Doesn't mean you can't go on a best effort basis. Can upload an observing plan. And people can follow on a best effort basis.
    - This is probably too early but we should keep a place-holder in the wiki.
- High data volume tends to be difficult for nanosats. How to obtain high temporal (esp.) and spectral resolution data for GRBs? 1) triggering, or 2) commanded download of stored data. #2 provides data for sub-threshold GRBs and GW events.
    - What can we coordinate here?
    - Ground network? No one has enough resources to cover the whole earth. Each project could build a world-wide ground network.
    - SVOM?
    - We have a good model with eduroam. Could we think about a similar network of university networks. S-band? Resource sharing? This would be very useful for all missions that require high-data transfer rates. Contact times could be minutes a day.
        - What about hogging the bandwidth?
        - This could be something that university can do.
        - What about security? The main thing would be downlink only. Not use uplinks.
        - What about doppler? This is not an issue.
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    - Example of many universities having antennas not being used.
    - What about standards?
        - If you have an s-band radio then you can communicate with an s-band grounds station.
        - The data-block is not standard but you make that available to the data sender.
    - What about inter-sat communications?
        - Very complicated business. Small target, huge distances.
        - Some people have demonstrated this.
        - Relaying is a better way.
    - Might be a discussion for the communications session.
        - We can continue this discussion in the commes session.
    - Could also be a general project.
- There was a discussion about requirements and making sure that cubesats do not have the requirements that a larger mission does. This is important to keep the price down.
- THis could help each other a lot.
    - Can we share hardware? Like test boards.

- Sometimes you can’t share prices.

Probably need to spin up a server somewhere with issue trackers, wiki, git, mailing lists, etc.