1) Sharing of ground station resources throughout globe (mainly for bulk data up/down, but also for rapid as in next topic)

- international cooperation
- buy uplink/downlink time Vs collaborative arrangements
- S-band Vs. X-band
(~2 Mbit/sec)
availability and expense? geographic distribution?
- availability of specific ground stations

- SVOM is proposing to provide black-boxes. Security issues? Could we design sats to be compatible with that. Need to have agreements in place. This might be a useful starting point. How is SVOM doing this?
- This is only for downlink. The VHF emitter sends when it has something to send. Recurrent (every 30 seconds). 90 byte packets. Transmitted in 2 seconds. The satellite pushes. There's a sequence of alert packets. Including light curves. Some images. This is all pushed. If there's a station below it receives. Then they are collected and filtered in the french science center. Then there's an automatic alert distributed from there. You can subscribe to get them. Some alerts sent via GCN.
- Are you open to negotiation for people to join? How would we approach SVOM?
- We'll need to discuss this with you all. Then we can look technically feasible. Frequencies. We can't all transmit at the same time. Is it even possible to have a VHF antenna on a nanosat. How miniaturized can it be. The SVOM transceiver is 15 kg.
- Is there a document that describes this somewhere?
- There is.
- The packets are not encrypted.
- Need to put together information on a wiki about ground stations etc.
- Might also use the SVOM network for the Einstein probe. Will also use a network to send alerts. eXTP might also use it.
- Anyone have experience using VHF on cubesats?
  - Copper antenna. Extend in the orbit. 0.1W. It worked. CUTE1.7 was the mission. 1200 bit/s.
  - It's pretty normal for UHF for uplink and VHF for downlink.
  - Using VHF up as well.
- Should we develop a network layer? There was some discussion here.
  - The much as we make common the better. This is very details.
- Maybe we need a document at the high level about comms options. This is probably more important to get a first feeling for what options are out there. This is probably more important than the details about data sharing. The field is evolving rapidly. Michelle will add details to the wiki.
- Norbert is building a ground station with UHF and S-Band but is considering adding VHF because of the discussion we are having now.
- Need to add costs.
- Inter-satellite comms could be another option.
  - This is a risk and extra cost just to give us something that's not needed.
  - Less risk and less complications for this.

Michele went through a few slides using the sat phone networks. Main take away was the probability of getting a contact. All networks are not providing high coverage. This can be a challenge if you include a single modem for rapid triggers. Audyssey is promising 1 second latency with S-band. For 2020 should keep an eye out for this. Might be able take advantage of that. Audyssey has a high power.

What about cost? 10's and 100's of k$ per year depending on how many triggers. Some networks can deliver high data rates. For just SMS it's something like 10k range.   It's a low cost compared to the mission cost.

For Iridium and GlobalStar you need dedicated hardware. Inmarsat is very challenge for licensing and hardware.

Many missions are up there right now with globalstar modems. It's very expensive. Using it for short telemetry. For download it's prohibitively expensive.

Download you need.

Need to put together list of ground stations. Will put together a

What about polar ground stations? There is a commercial station in Svalbad. They cost a lot. Need to make sure we list some options for polar orbit missions.

IF A WIKI PAGE WERE ESTABLISHED, WOULD PEOPLE SHARE THEIR KNOWLEDGE REGARDING: STATION/S, LOCATION, TYPE, AVAILABILITY, BANDWIDTH, ETC. ?

2) rapid alerts and rapid data downlink
- TDRSS
- no guaranteed access, and requires modified antenna/code

- network of many S or X band ground stations
- how to coordinate widescale cooperation?
- cost?

- enlisting massive existing network HAM radio stations using UHF
- how to get it rolling?
- how rapidly can small burst of data be disseminated?

- VHF stations such as 45 stations for SVOM made by CNES
- SVOM has built a network of ~45 worlwide antennas that are simple kits elevated on a 3 m high platform; they would like to have more sites, and they are open to having people use the network for their own cubesat if they have a VHF antenna on the cubesat; low latency internet connection of data within minutes
- commercial satellite relay networks:
- e.g. GlobalStar, Inmarsat, Iridium, Orbcomm and Thuraya
- How-to and cost

IF A WIKI PAGE WERE ESTABLISHED, WOULD PEOPLE SHARE THEIR KNOWLEDGE AND DISCUSS AVAILABILITY

3) How to build a ground station on your own campus; cost
- UHF antenna ; fairly easy (~couple thousand dollars)

- S band antenna : could be done locally ??

- There something like a 100 euro. Includes software and everything else. SATNOGS.
- UHF mostly. It's in the amature part. There are options for commercial and S-band.
- Reliability? We're using it right now. There's a central database that you take data from.
- At Penn St. we have both a vhf and s-band. The s-band seems to always be down.

At israel (teknion?) we have UHF/S-band/VHF. None is amature. We are ready to share. It's easily buildable. They are based on software radio. Don't know the cost.

IF A WIKI PAGE WERE ESTABLISHED, WOULD PEOPLE SHARE THEIR KNOWLEDGE

4) lessons learned on various COTS comm boards
        CAN PEOPLE SHARE THEIR EXPERIENCE ON THIS ONLINE ?

No one will be unwilling to share?

5) Data compression to ease telemetry requirements ?
        specific experience and thoughts? factors of ~2? better?

        CAN PEOPLE SHARE THEIR EXPERIENCE ON THIS ONLINE ?

- We can get a lot out of this. Can share some of these algorithms from X-ray.
    - You have to be careful for packet loss. If you lose one bit you lose a lot.

6) Other topics?

        - GCN : adopt a common format (probably a discussion topic for
another sub-panel)

How can we gain access to a network?