CSDC-5 CDR Feedback

October 9th, 2019

# Mission Overview

* “Gold Anodized” is not really gold
* Minimum pass time has no real meaning, will have very short pass times
* What is the angle to get a comm link with the ground station?
* The previous board we had died during radiation testing – we thought due to single event upset
  + Latch up can also kill an OBC from radiation – this is more likely than a single event upset
  + Make sure we know what happened, so we don’t buy one that does the same again
* **“Heat pipes, really?!” That’s a difficult solution, may not need that**
* Payload system counts as built, not buy

# Payload

* **Earth is at infinite focus ->** There’s no need for a focus motor or other mechanism for focus
* There’s a difference between focus and alignment
  + **Alignment will be the issue – This depends on how the lens and sensor are connected and secured to the bus**
  + Will be the driving factor in the payload’s performance
* Pixel dimensions – can’t have rectangular pixels?
* **If ground blur is less than ½ a pixel, It’s irrelevant**
* Not certain that CMOS is better than CCD – but still should work
* **Off-the-shelf DSLR lens**
  + Plastic is an issue
  + Rubber ring – and all rubber, plastic- will need to be removed
  + Potted with something not space qualified -> will outgas and deposit on lens and/or sensor – bad!
  + Focus motor has lubricants likely
  + Should remove all moving parts, focus by putting spacers in – basically make it a fixed focus at infinity
  + Will be tricky to get the lens to work
* Check how big the pixels are
  + Looked up: 3.8 microns pixel size
  + Therefore 11.26 m on the ground
* HUGE image sensor will need significant compression
* Bicubic compression is generally better but slower – but 1 image should be ok – there are some very good algorithms out there
* Put lens in a vacuum chamber to see the change in optics – can you still use it? How is the alignment? Could be messed up, need to confirm for use in a vacuum
* **How is the lens/sensor etc attached to the structure?** “Not as simple as you think it is”
* **How long will it take to calculate exposure time, ISO?**
  + Very, very important – can be km’s away by the time it’s calculated
  + Control sequence diagram has a lot of errors that need to be fixed
* How is the downlink budget calculate during orbit? ARO specs such as downlink budget is specified in rules – you don’t need to uplink this info to choose image compression method…
* Is there any windowing for image compression?
  + Sceptical that we will be able to compress enough to downlink in the time allowed
* **BE VERY CAREFUL about moving parts and materials in payload design**
* **Optics should be designed or modelled in MATLAB**
  + Estimate what the lens has inside in a simulation
  + Get the sensor/lens aligned properly in sim
  + Then change medium to vacuum and see how it changes
* **“TEC is a power hungry and thermal nightmare on cubesats”**
* **Where the discussion on heat pipes?** 
  + Filled with ammonium are much more expensive that plain copper
  + Copper tape is cheap and effective
  + Aluminum structure may even be enough to conduct heat away
  + Need to do a detailed thermal analysis in order to determine what solution is needed

# Structure

* First rendering slide – must better diagram than the first image showed in payload and earlier
* In drawing the lens include rubber ring – be careful!!!
* “Insane” number of elements in structure model
* Why non-linear model?
  + Can’t do a vibration analysis with non-linear
  + Could get away with 2D elements, but this is good
* Why 7075-T6? Reacts poorly with anodizing acids – usually -T73 is used – There is a specific type of aluminum that isn’t allowed… double check this
* What are the boundary conditions?
* Are the loads applied simultaneously in G study? One at a time = good
* **Ridiculously low stress result** – The simulation doesn’t include mass of components, which is a problem
  + The analysis of the structure alone doesn’t matter that much – with components is what you need to ensure works
* **Should test a less constrained model**
* **Deflection should be greater** – possibly used the wrong density?
* Why not beam and plate elements? Too few elements in through thickness
* **Model with 10,000 nodes using beam and 2D elements will just as accurately model the structure**
  + This way it will be much faster to run, so you can re-run and trouble shoot much more
  + Ask yourself if the deflection results actually makes sense (the one in the slides doesn’t)
* Numerical modes analysis: good. 150Hz is good, **but NO MASS included – need to redo with load**
* Which load step? (Slide Launch Vibration 1/3)
* **Boundary conditions are too optimistic**
* Represent deployable springs as springs, not forces
* 2mm pin ball radius – good, impressive!
* Don’t treat bolt holes as bonded – represent them as bolts – even bolts with washers will potentially chatter – use a beam or other stiffing joint or joint elements
* Launch vibration is actually quasi-static
* 0% margin is too optimistic
  + Use 5% if you’re pretty confident
  + **Should be 20% due to the estimation of components used**
    - Good to use comparable systems when you haven’t finalized design yet
    - Should indicate which elements are estimates in the table

# Thermal

* Primary/secondary systems are not sinks
* Margins – allowable
* Image sensor – to keep in focus need to have a better (smaller) range of temperatures
  + Same for batteries
  + Need a new list of target temperatures for components (data sheet range is not necessarily what you actually want)
* Sun sensors need work – thermal analysis margins
* **Not comprehensive power budget – No OBC, solar cells, PCB’s – NEED TO CONSIDER**
* **Batteries are particularly important – consider the thermal issues carefully**
* In 400 km orbit there will be days of constant sunlight – be careful estimating the hot case
* Heat will radiate – very little will translate into bus
* Need a weighted average for thermal analysis
* **Missing a # of components that generate heat – need to include a lot more**
* What is the attitude? Where is the camera pointing? **Telescope will alternate looking at space and earth – very bad for camera sensor and lens**
  + Heating and cooling repeatedly could break lens, kill or seriously damage sensor
* Build model around optics and batteries – these are the two biggest problems
  + Are there thermal gradients?
  + CTE misshape? (?)
* Why are cells deployed after de-tumbling? When panels/antennas deploy the sat will start tumbling again
  + **Deploy immediately, possibly, but pros and cons to both…**
* **Put a panel on the sides that don’t have cells – will** mitigate thermal issues and limit stray light that could affect images

# Power

* There are discrepancies between the CAD and power diagram
* Different voltages from cells on each panel
* How does EPS combine with the arrays? 4s2p helps, but there will still be a voltage difference
* Look at the EPS datasheet to see if it’s okay with those voltage differences
* Power generation slide: “This is the slide that had me worried”
  + Power is not W\*h – that’s energy
  + May get ~15 W in orbit in sunlight, for ~ 1 h = 15W\*h of energy in the best case
* ISS orbit is not always in these conditions – there may be more or less light
* **Redetermine power estimates – taking into account temperatures and sensor datasheet**
* **DOD 78% is completely unreasonable and irrelevant**
  + Use power simulations to find a DOD – as shallow as possible to maximize lifespan
* **Regulations! Safety is a big deal with battery packs**
  + There is a test plan set by nasa that needs to be followed
  + Cells will need to sourced from the same lot – need documentation to prove this
    - Tier 1 supplier only will do this (pansonic, LG, Samsung) but will be difficult to get because they don’t like selling them like this
* How are the batteries connected? Don’t solder directly to cells
  + Use a spot welder – find one in Kingston, probably too expensive to buy for just this
* **NEED DIAGRAM FOR DISTRIBUTION OF POWER IN SYSTEM**
  + Critical top-level system diagram
  + Great to hand out to new members, use as guideline while building
* Power budget: “A couple of scary things here”
  + TEC – no way
  + Orientation sensor – call this attitude sensor of magnetometer/gyro
* **Power in mech heat sinks??? Doesn’t make sense**
* 97W to reaction wheels? Can’t pull 100W from these batteries
* Enormous motors, antennas
* **Producing 24 W out of 18 cells? Completely wrong**
* Sun-synchronous orbit -> Not accurate to say the cells are always in the sun
* Orbit length – ISS is much shorter than sun-synchronous – need two estimates
* Power is reduced by amount of time in the dark
* POWER NEEDS WORK
* **Having each operational mode – very good! Only team so far to do that**
* Keep solar panels out of budget
  + Simulate each state step by step and determine how much power is generated, and if there is enough
* Account for seasons
* **Values don’t add up at the moment**

# ADCS

* **10% required accuracy -> needs to be considered in the range of uncertainty in power generation estimates**
* Choose one of 0 to 6.5 degrees accuracy
* FoV / 4 = accuracy on fine pointing
* Gravity gradient is irrelevant – balances throughout orbit, very small for a small satellite
* Drag coefficient is irrelevant – too small
* ADCS needs to include magnetorquers
* Position simulation
* **Sun sensors: get aluminum or glass with slit**
  + **Internal reflection is a big problem, will produce conflicting results**
* Need to know where you are to use magnetometers
  + Keep track of time and orbit position?
* Calibrating sun sensors: noise if in sun, get variable light levels -> Difficult to calibrate
* **Truth table: accuracy is optimistic** 
  + Especially gyroscope – it needs initial value – how do you get that? Uncertainty depends on the uncertainty in the initial value
  + Take picture – map to a known landmark -> Figure out attitude knowing the time and position – but this is complicated to do
* Gyro being better than every other combination except all combined – doesn’t make sense
* Magnetometer: field varies a lot, 1 degree is very hard to get – won’t in a cubesat
* **Reaction wheels: Shaft is a rotor – where are the motors? These motors have internal pcb’s w tracks, but no inertia**
  + Need to add inertia somehow
  + The manufacturer minimizes inertia by design – but we want to maximize
  + May have more momentum transfer than torque
* Stepper motors jitter = problem
* **Need a rotor: to design and build ourselves will be very hard and very likely fail**
  + **Statically and dynamically need to balance – otherwise sat will shake constantly**
  + Will need to buy

# COMMS

* “You better know…” is the ground station antenna vertical, horizontal or left polarized/right polarized (or something like that…)
  + Ionsphere will cause random rotation of polarization – circular on ground can be linear at the satellite
* Update table with loss of polarization – 3 dB okay
* Length of antennas will matter (?)
* What’s the elevation angle? Required 10 degrees
* Estimates are conservative in table – good
* **Recover sensitivity – always written for chips on earth, at 290 K consistently**
  + **Never like that in space… Consider signal to noise ratio**
  + #s in downlink table are not correct
  + UHF might be better than what we have down
  + Sky is cold in radio band - about 60-70k of galactic noise
  + At the horizon, or in urban areas, ~1000k of noise
  + Rain etc. is negligible at this frequency
* **Antenna: Why 4 wires? If 2 (1 long, 1 short) works, do that**
* **Really big image, 90s downlink with only a few minutes contact per day… will the compression ratio be good enough??**
* Are images also sent to control station? Yes – good
* Make an ARO link budget
* Need only to match initial link value (63.8 kB) to original image size (16 MB), in about 2.5 min = ~1min for processing

# OBC

* **Overview: A very small fraction of what the OBC actually does**
  + Run OS
  + Upload software
  + Control payload
  + Run ADCS System
  + Talk to ARO
  + Process images
  + Etc.
* **NEED A BLOCK DIAGRAM OF OBC**
  + The rest will follow
* Not comparator – exclusive OR
  + Need to decide ASAP between multi/single string system
* What kind of bus?
* What actual data is being compared?
* **Need something reliable to bit-shift – maybe a RAD tolerant CPLD**
* **How is the OBC talking to other systems?**
* Outputs need to be combined somehow (multi-string architecture slide)
* A lot of work still to do… need more people
* **Need USB to interface with camera** – computer systems MCU need help
  + Define protocol between busses
  + Need to know how everything interfaces
* Why is the ADCS on a separate computer? Does that computer have the same health checks?
* **How do you know when to point for ADCS and payload? RTC?**
  + **Currently don’t have a way to do that**
* ACDC computer must be ready ALL the time
* ARO must be able to control when and where the photo is taken

# AI&T

* **Need tests to test individual components** – not the whole satellite – it won’t be done in December to do that when you should be testing (lol)
* Typo in dates in AI&T payload
* Need different processor – an architecture and os that matches sensor and microcontroller
* **Tests are not well defined or clear**
* **DATES ARE NO GOOD** 
  + **Timelines are not integrated with each other**
  + Ie. Putting it in a vacuum chamber first is not a good idea – test it normally first
* **Need a gantt chart of critical path for testing**
  + Use Gantt Project – free, will track all dependencies, keep it up to date
* How will the Helmholtz cage be calibrated? Only will get rough estimate
* How will torques be measured to test magnetometers?
  + Be clear about what “functionality” means in a testing context – be specific
* Probably won’t be able to do a desaturation test

# Risk

* High vibration: this is a part of the environment, not a risk
* Low-off gassing is not related to high vibration…
* Radiation damage to sensor – also not a risk, it’s an environment thing
  + No lens aperture to close
* **A lot of these are DESIGN CHALLENGES, NOT RISKS**
  + Risks are program management related mostly
    - People not available
    - Supplies don’t ship in time
  + Technical risks
    - Analysis won’t converge
* Reaction wheel failure: good consideration, but mitigation is having 4 wheels, not what was written
* Single Latch-up: Power cycling won’t help hardware damage
* Watchdog, what is it? Use an external one
  + Use a window watchdog if possible
* **Worry about hydrogen particles for radiation** – cobalt is ok but won’t cover everything needed
* Comb through and take out “just fails”

# Anomaly

* Blurred image therefore buy lens: Doesn’t do anything. It’s a design challenge, not an anomaly
  + That’s not mitigating – it’s preventing

# CONOPS

* **Make sure every possible state or situation is on diagram**
* Can’t calculate desaturation events on the ground, ACDS should do that automatically
* Greedy algorithm – good
  + Take sun angle into account
  + Remember ARO must be able to request photo in real time
* **Consider ARO habits and preferences**
* Need to tell ARO if they get bumped – probably by email

# Program Management

* **Need critical path gantt chart**
* **Solar deploy, antenna deploy were not in CDR – should have been**
* Build a prototype at least once to find problems before the real thing is built
* Make a realistic schedule – then tell the customer when you’ll be ready (good luck telling larry that…)
* Technology risks – yep, all valid

# Outreach

* **Start keeping track of how many people attend each outreach event**

# Summary

* **Would debate that the thermal models presented are NOT compliant**
* **“3.9 km including margins” INCORRECT**
* Shouldn’t be any surprises on these summary slides – but there is
* Step 1 of OBC
  + Specify
  + Design
  + Build
  + Include the things that seem obvious on the diagram