

TJ³Sat – Unique Challenges of Building a Small Satellite within a High School Environment

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A High School Satellite



- Can a High School design and build their own satellite rather than simply be involved as a recipient of an “outreach” program?

Conventional wisdom: **NO**

Lacking knowledge base

Insufficient resources

Unqualified faculty

Visionary Response: **YES**

Create a structured program

Use existing standards and COTS components

Simplify the process

Provide solid mentoring



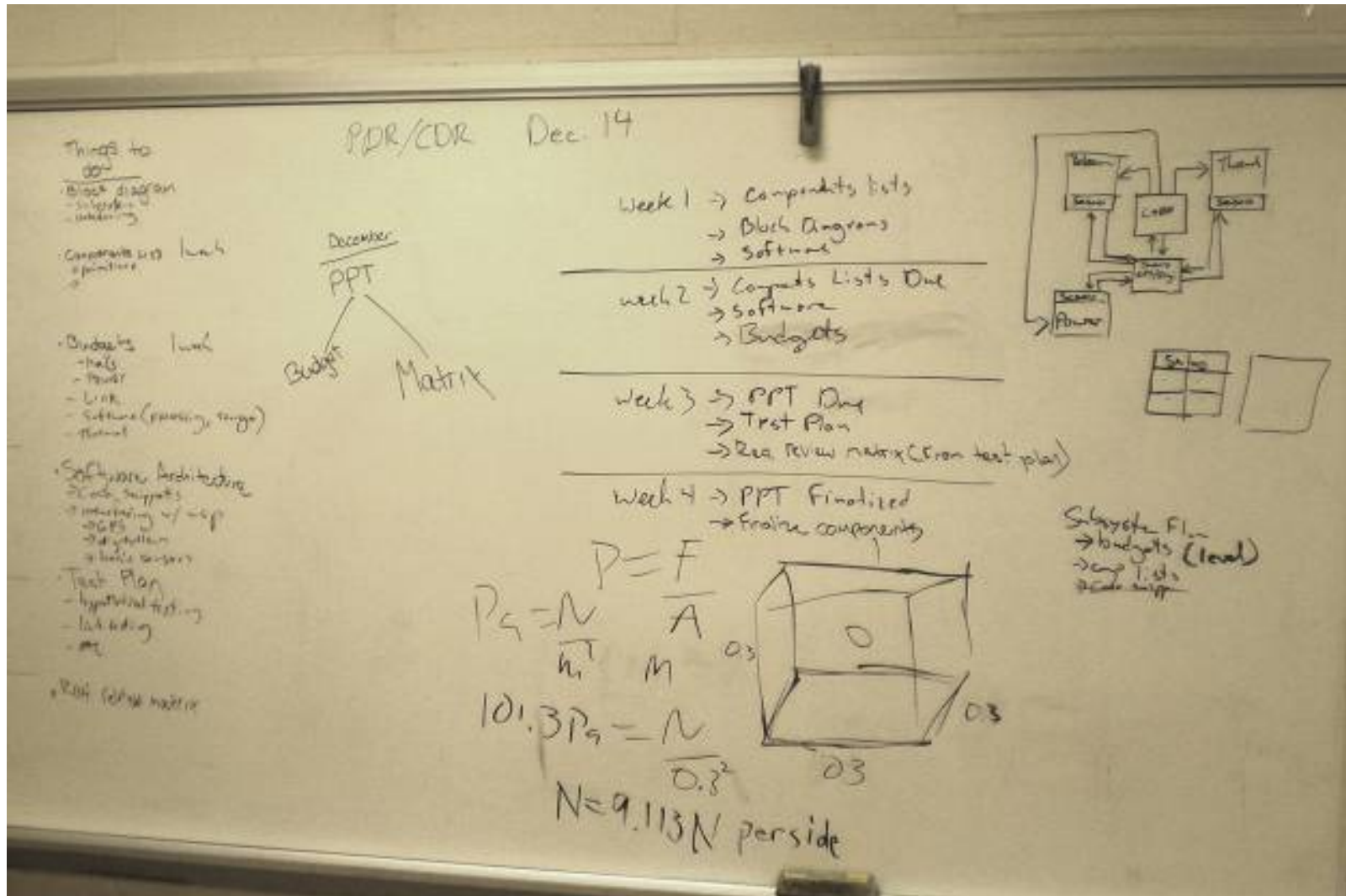
TJHSST – Systems Engineering Program *Orbital*

- *Key to Success* – Do not simply start a spacecraft program; Create a curriculum around the concept
- TJHSST established a system engineering course aimed at Sophomores, Juniors, Seniors
 - Introduce the art of engineering to the students
 - Bring the students together in a collaborative team environment
 - Center efforts around a large scale project (build a satellite!!!)
- Focus the curriculum on both technique and process
 - Formulate potential missions and justify their validity
 - Bring in industry experts to provide insight and answer questions
 - Follow proper system engineering techniques – establish requirements, create budgets, decompose functionality into subsystems

"We want students getting their feet wet and muddy doing fun things with science in a vigorous way" –Principal Evan Glazer



Not a Typical High School Blackboard...



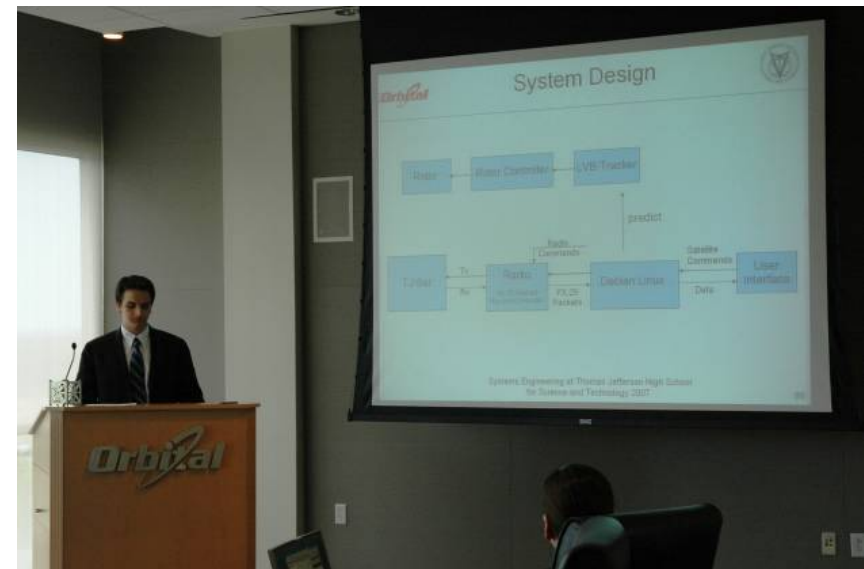


Reviews, Reviews, Reviews



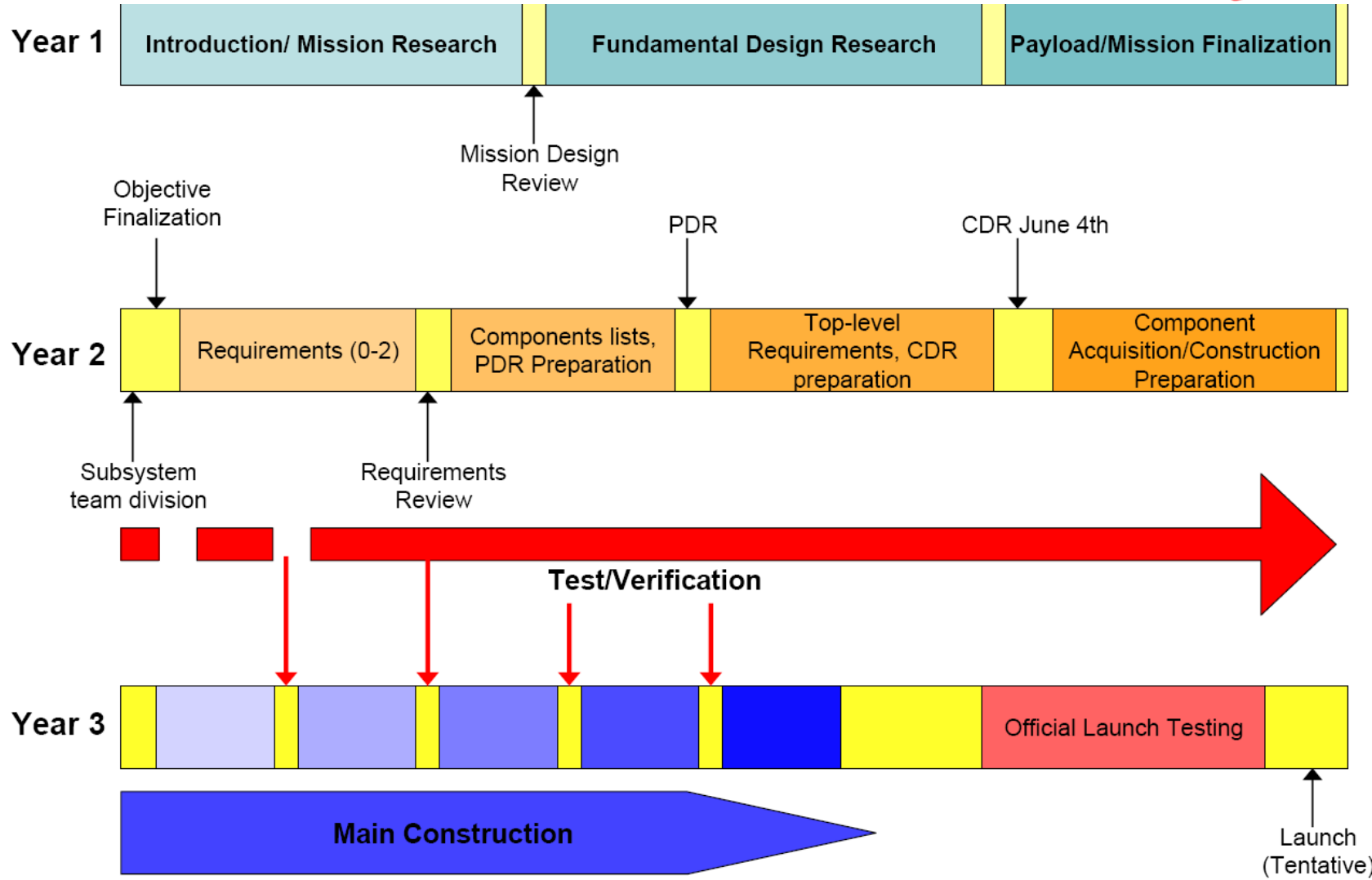
- Provide students with independent feedback on the progress accomplished
- Instill communication and presentation skills
- Permit students to “regroup” and reassess the project on a regular basis

- Reviews designed to mirror those of industry
 - *Mission Concept Review* – Students reported on variety of missions of possible interest
 - *Systems Requirements Review* – First cut at top level requirements derived from the mission options
 - *Mission Concept Review (2)* – Provide details of final downselected mission. Led to descoping of secondary payloads
 - *Preliminary Design Review* – Present level 2 requirements and initial design concepts, block diagrams and budgets
 - *Critical Design Review* – Culmination of second year of effort. Evolution of design concepts, report on first prototyping efforts





Project Timeline



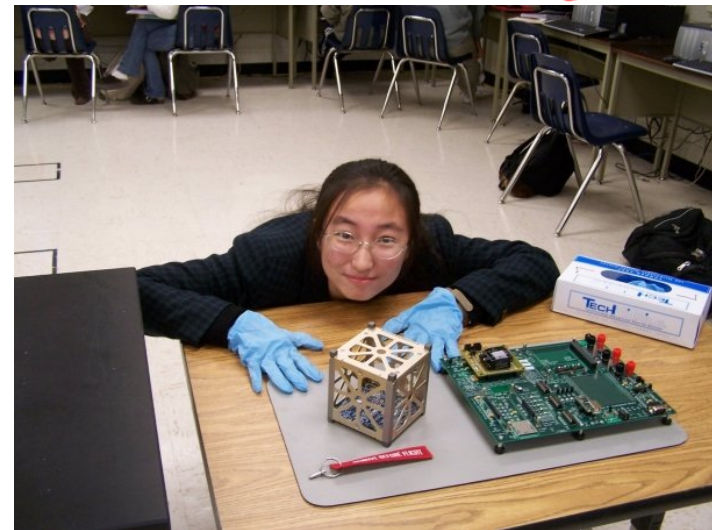


TJ³Sat Mission



- *Primary Mission* – develop primary educational resources in the fields of science and technology through the design, construction, and flight of a picosatellite.
- *Secondary Mission* – collect data on satellite systems, produce an operational satellite to substantiate the educational resources, provide educational resources to third parties and will use a voice synthesizer to broaden the scope of the global resources.

- *Platform* – Pumpkin CubeSat Kit
- *Primary Payload* – TTL-03 Voice Synthesizer
- *Communications* – Standard amateur radio frequencies

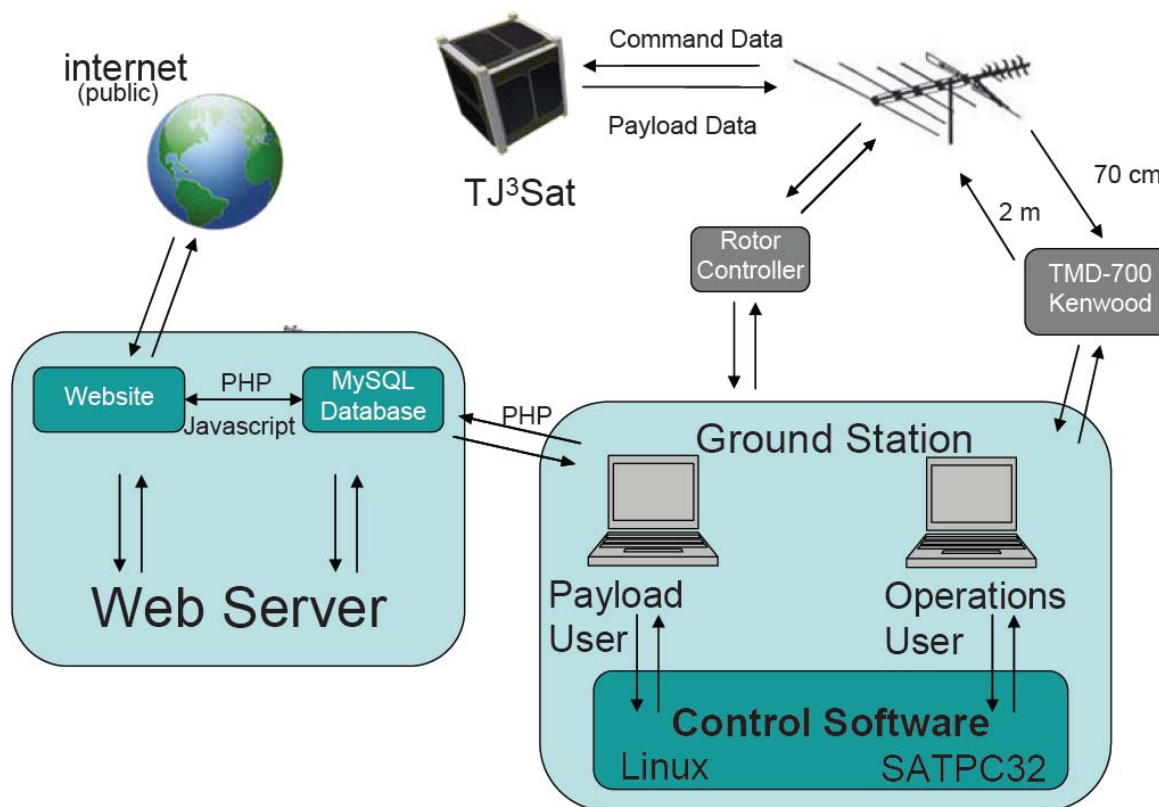




TJ³Sat Concept of Operations



- Simple command and telemetry system
- Remote operation of voice synthesizer through the internet
- Voice recordings can be picked up using a handheld amateur radio





Unique Challenges for the Students



- “What is Systems Engineering?”
 - Students are not sure what the course they are signing up for is
 - How is a broad topic introduced in a manner that makes sense?
- Constraints of the High School environment
 - Project team split into different class periods
 - All work must be conducted during these periods
 - Staying late requires special transportation arrangements
- Student turnover
 - Lack of continuity and loss of previous leaders to graduation
 - Competition from other courses and extra-curricular activities
- Communication Skills
 - Students must learn a new set of intra and extra team communication skills
 - Presentations matter!

“Unfortunately, due to this nation’s emphasis on testing, most of the time TJ³Sat must sit in the back row, while the AP courses take center stage. ”



Collaboration with industry



- Normal corporate-school relations revolve around directed research or recruiting activities
 - No formal mentorship programs in place, at least within Orbital
 - Majority of relationships are with university-level institutions
 - Most relationships with primary and secondary education involve class speakers or science fair judges
- Challenging corporate logistics
 - How should any expenses be accounted for?
 - ITAR constraints – if there are foreign nationals in the student class export restrictions may apply
- Obtaining mentor time
 - Over 50 employees signed up as mentors
 - Yet only 10 or so actively involved on a regular mentoring basis
 - Common constraints: lack of time, long commutes, working within the student schedule constraints
- Good engineers do not necessarily make good teachers
 - Even the most “fundamental” topic needs to be simplified when the student has never been exposed to the subject before
 - Engineers find it too easy to fall into jargon and assume what is or is not known



Learning Lessons Early in a Career



When asked about the important lessons they have learned, the students working TJ³Sat are particularly insightful

- How to acquire relevant information to accomplish a complex objective
- Find out what needs to be learned, learn it, and know why one is learning it. Self-initiated learning doesn't receive enough credit.
- Good communication skills are critical
- Independent thinking must be valued
- Technical jargon is often a hindrance
- The Internet is like a dog: your best friend but doesn't always do what you say
- Progress comes in spurts – periods of incredible accomplishment with bouts of extreme laziness, partially evidenced in somewhat rushed design reviews.

“This program has provided me with many great opportunities, meeting inspirational people and talking with intelligent, experienced professionals”

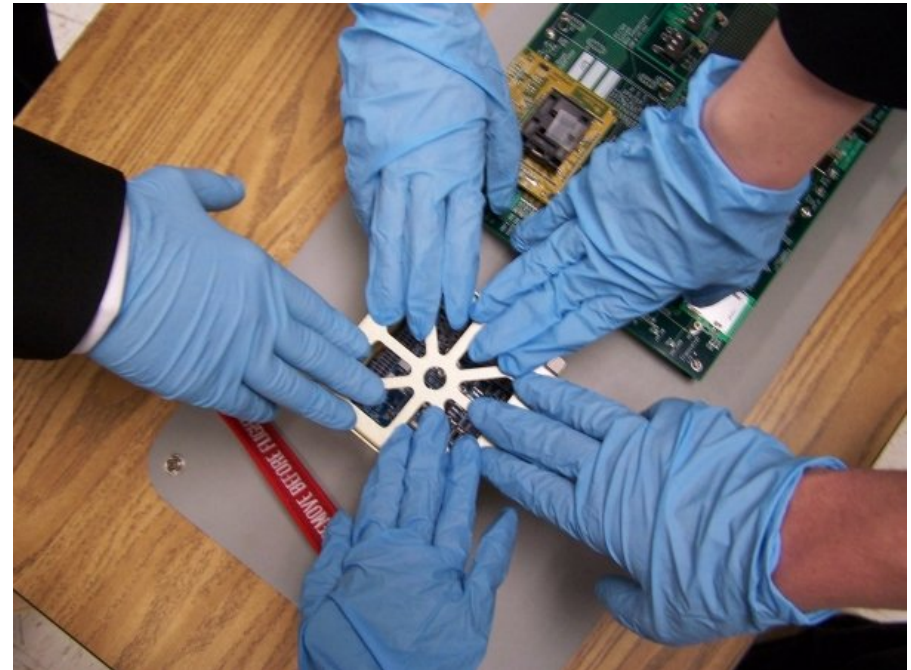


Bringing It All Together



- Building a satellite is a great catalyst to instill students with a sense of discipline, teamwork, and accomplishment
- Systems Engineering is not just a discipline, it is also process, coordination, and continuous learning
- The students are learning important lessons in the most formative years of their future careers

SmallSat 2009 – Stay tuned for an update of TJ³Sat's orbital operations!





Acknowledgements



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