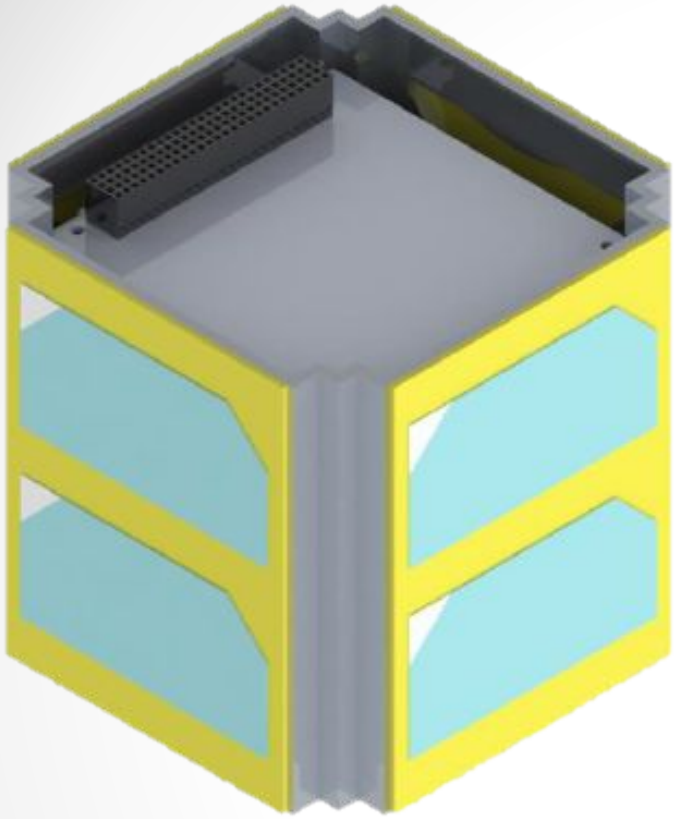


10/5/16

Principal Investigator: Michael Piccione
Energy Systems Lab Director
Thomas Jefferson High School for
Science and Technology

EMERGENT Space Technologies

THOMAS JEFFERSON HIGH SCHOOL FOR SCIENCE AND TECHNOLOGY

RAGNAROK INDUSTRIES
NANO SATELLITE COMPANY

Outline

- Mission of TJHSST
- Team Objectives
- Project Goals
- Meeting NASA Goals
- Proposed Outreach Activities
  - CubeSat Kits
  - Systems Engineering
  - Orbital Dynamics
  - Communications
  - CAD/Structural
  - CubeSat Testing
- Mission Strengths
- Accomplishments
- Conclusion

Goals of the Review

- CubeSat proposals must show scientific, technological, or **educational merit**
- Show how we meet NASA's Educational Goals
- Why we need this launch to fulfill the NASA goals

Mission of TJHSST

The mission of Thomas Jefferson High School for Science and Technology (TJHSST) is to provide students with a challenging learning environment focused on math, science, and technology, to inspire joy at the prospect of discovery, and to foster a culture of innovation based on ethical behavior and the shared interests of humanity.

Team Objectives

- Integrate teams working on distinct problems
- Apply for and be selected as a NASA CSLI candidate
- Engage in STEM outreach to the public and local students
- Prepare to design and construct a 3U CubeSat

Project Goals

- Train students in the basic parts of a 1U cubesat
- Develop and document the processes needed
- Develop possible payloads
  - Biological experiment with Micro Aerospace's Microlab
  - Test efficacy of different onboard radios and feasibility of ground communication methods

TJHSST CubeSat Background

First high school to launch a CubeSat

- Primary mission:
  - Provide educational resources to other K-12 education institutions
    - Foster interest in aerospace science
    - Previous Energy Systems Lab Director Adam Kemp
- Sponsored by Orbital

TJHSST CubeSat Background

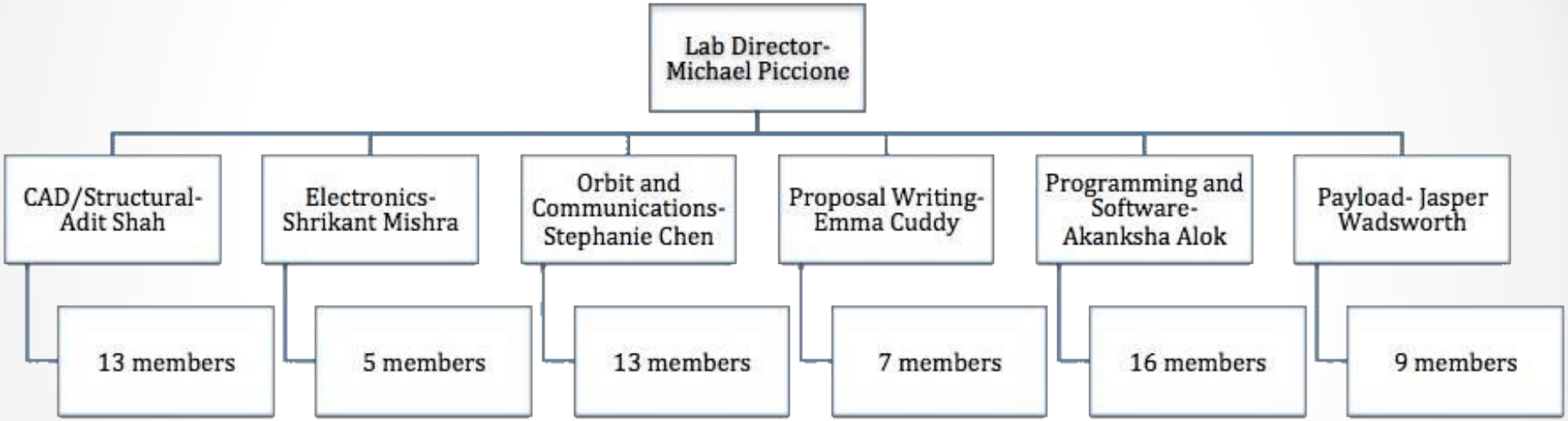
Mission accomplishments

- Raised awareness of CubeSat missions
  - Featured in the Washington Post and national news
- Functioning CubeSat
  - Launched on November 19th, 2013
  - Orbital Minotaur I rocket
- Power or radio failure
- Deorbit late 2015

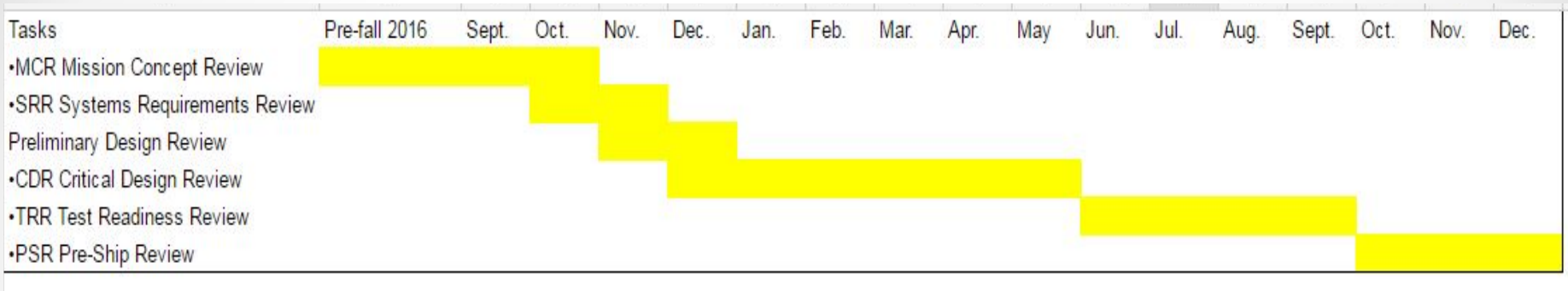
Mission Details

- The current mission is a joint operation between:
  - Thomas Jefferson High School for Science and Technology
  - Ragnarok Industries
  - Emergent Space Technologies
- Connections between current and previous projects
  - Expanded educational outreach
  - Shorter mission timeline
    - Transition to 3U project
    - Mentoring support by previous TJ Cubesat students
    - Additional support from corporate sponsors
      - Greater probability of success

Mission Details



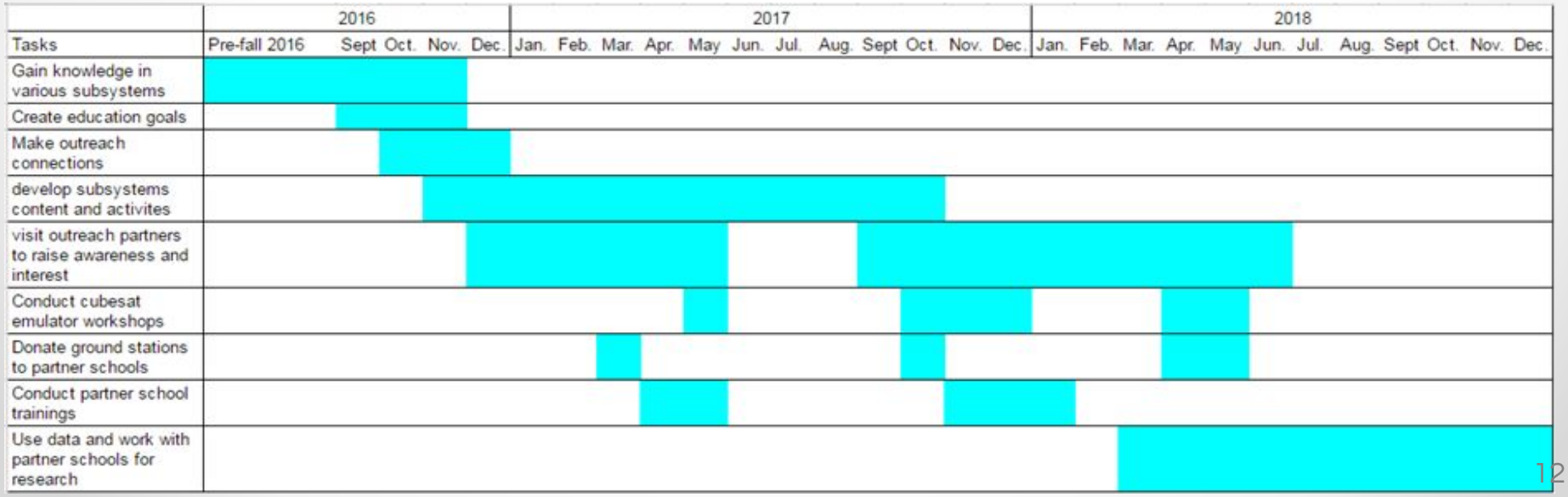
Project Timeline



- Mission Concept Review: Prior to NASA Submission
- Systems Requirements Review: Prior to NASA Submission
- Preliminary Design Review: Nov. - Dec.
- Critical Design Review: Dec. - May
- Test Readiness Review: Jun - Sept.
- Pre-Ship Review: Oct. - Dec.

Project Educational Goals

- Advance STEM career pipeline
- Expose STEM Students to Aerospace & Orbit Principles
- Implement student developed STEM educational materials
- Educate the TJ and local community
- Inspire other K-12 educational institutions



Meeting NASA Goals

Advancing the nation's STEM workforce pipeline

- Inspiration
  - Expose students to new challenges
  - Engage in outreach with local schools
  - Create ground stations with partner schools
- Fostering Skillsets
  - Develop student skills in specific subsystems
  - Encourage cross-collaboration of different subsystems
  - Teach systems integration throughout the project

Meeting NASA Goals

STEM Workplace Skills

- CubeSat project is student driven
  - Previous student led missions
    - Engineering expertise not found in classroom environment
  - Coordination of separate groups
  - Independent student research
  - Critical decisions for this unique project`

Meeting NASA Goals

Outreach Methods

- High School
  - Set up ground stations at US and international schools
  - Post educational materials on the TJ Cubesat Website
- K-12 stepped approach
  - Technology demonstration of assembling a CubeSat
  - Math and science activities using the CubeSat as a model
  - Utilize existing outreach methods (STEMbassadors, WISE, etc)

Meeting NASA Goals

Raising awareness

- Share the story with news and media outlets
- Sustain an active social media presence

Meeting NASA Goals

Advancing women in STEM

- 50% of our engineering team leads are female
- Less than 25% of STEM management positions in industry are filled by women (Beede et al., 2011)
- Activities outside school classes
  - Inspiring women in STEM

Advancing minorities in STEM

- Minorities make up a small fraction of STEM workforce
- After school programs have a strong minority representation (Mostache, Matloff-Nieves, Kekelis, & Lawner, 2007)

Proposed Outreach Projects

- Spread STEM and CubeSat activities to other schools and age groups
- Raise interest with CubeSat Kits
- Develop how to guides
  - Electrical Systems
  - Orbital Dynamics and Physics
  - Communication
  - CAD/Structural
  - Flight Readiness Testing

Build CubeSat Kits

- Teach the basics of assembling a educational CubeSat model
- Clear instructions, easy to understand
- Boosts confidence through successful STEM based activities
- Soldering skills
- Basic electronics theory
- Basic programming and sensor knowledge
- Tool usage
- Kits include: chassis, solar panels, Raspberry Pi, sensor board, battery, camera, switch

Electrical Systems

- Solar Cells & Lithium Ion Batteries
- Can be used to demonstrate properties of:
  - Batteries, resistors, and loads.
- Energy Flow Diagrams
- Soldering techniques
- Circuit design
- Physical Properties:
  - Ohm's Law
  - Kirchhoff's Loop Rule

Orbital Dynamics & Physics

- How to calculate:
  - Orbit speed and travel distance relative to Earth
  - Orbit period
  - Deorbit rate
  - Changes in orbit based on control components
  - Communication window
- Designing a orbital transfer

Communications

- Components
  - CubeSat: sensors, computer, transmitter (radio), antenna,
  - Ground station: antenna, receiver(radio), computers
- Steps in communicating
  - Data collection
  - Transmitting
  - Receiving
  - Processing
- Radio licensing
- Radio demonstration

CAD/Structural

- Different CAD Softwares
  - AutoDesk Fusion
  - OnShape
- Basic CAD Modeling
  - Assembly
- Uses of CAD
  - 3D printing
  - CNC Mill
- 3D simulation testing of frame
  - AutoDesk heat stress analysis
  - AutoDesk structural simulations

Flight Readiness Testing

- Confirmation of flight and space-readiness
  - TRL level 6
  - Simulate conditions of launch and space
- Testing types:
  - Radio Frequency Interference
  - Vacuum/Thermal
  - Physical stresses

Strengths of Proposed Mission

- Easily measurable participant outcomes
  - Degree choices that support national education and workforce needs
- Educational goals grounded in good practice or research
- Successful history of student managed complex projects
- Much of the selected hardware has flight heritage
  - NSL Fast Bus 1U kit (TRL 7-9)
- Robust mentor network
  - College students, companies, and engineers

Accomplishments

- Organized a team of 41 high school seniors into subsystem engineering teams
  - Leading underclassmen directives
- Internships with partner company
- Completed background research on individual subsystems
- Lab director developed cubesat educational emulator
- Lab director attended SmallSat Conference
- Mentors from the Naval Academy
- Mentorship with University of Michigan
- Established contacts and guest speakers
- Partnership with George Mason University on the 3U

Why Launch TJ?

- Higher standards of completion in a real project
- Orbiting satellite required to create partnerships for ground stations
- Educational outreach
  - Materials posted online more accurate
  - Greater credence for elementary and middle school outreach
- Impacts for successive team members
  - Monitor payload data
  - Develop future CubeSat projects

Conclusion

- Pipeline for STEM careers
  - Specifically NASA
- Project management skills outside of the classroom
- Four to five years of student research in aerospace
  - Hands-on experience with CubeSats
- Educational outreach
  - High-schoolers have a closer relationship to younger students than adults
- Enticing for students still finding their interests
  - Incorporates little known and specialised fields
- Unique payload due to varied interests of students

Thank You

Questions

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