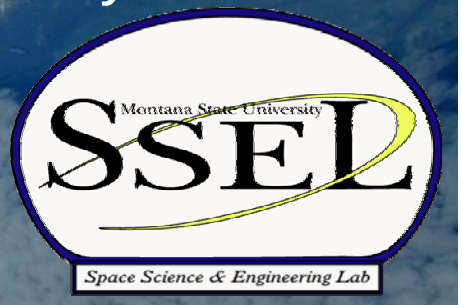
# Simplified Configuration Management and Qualification Testing for CubeSats

Keith Mashburn

Space Science and Engineering Laboratory
Montana State University
August 11, 2008

# Agenda

- Overview of Configuration Management
- Example Configuration Management System
- Overview of CubeSat Qualification Testing
- Example CubeSat Qualification Program

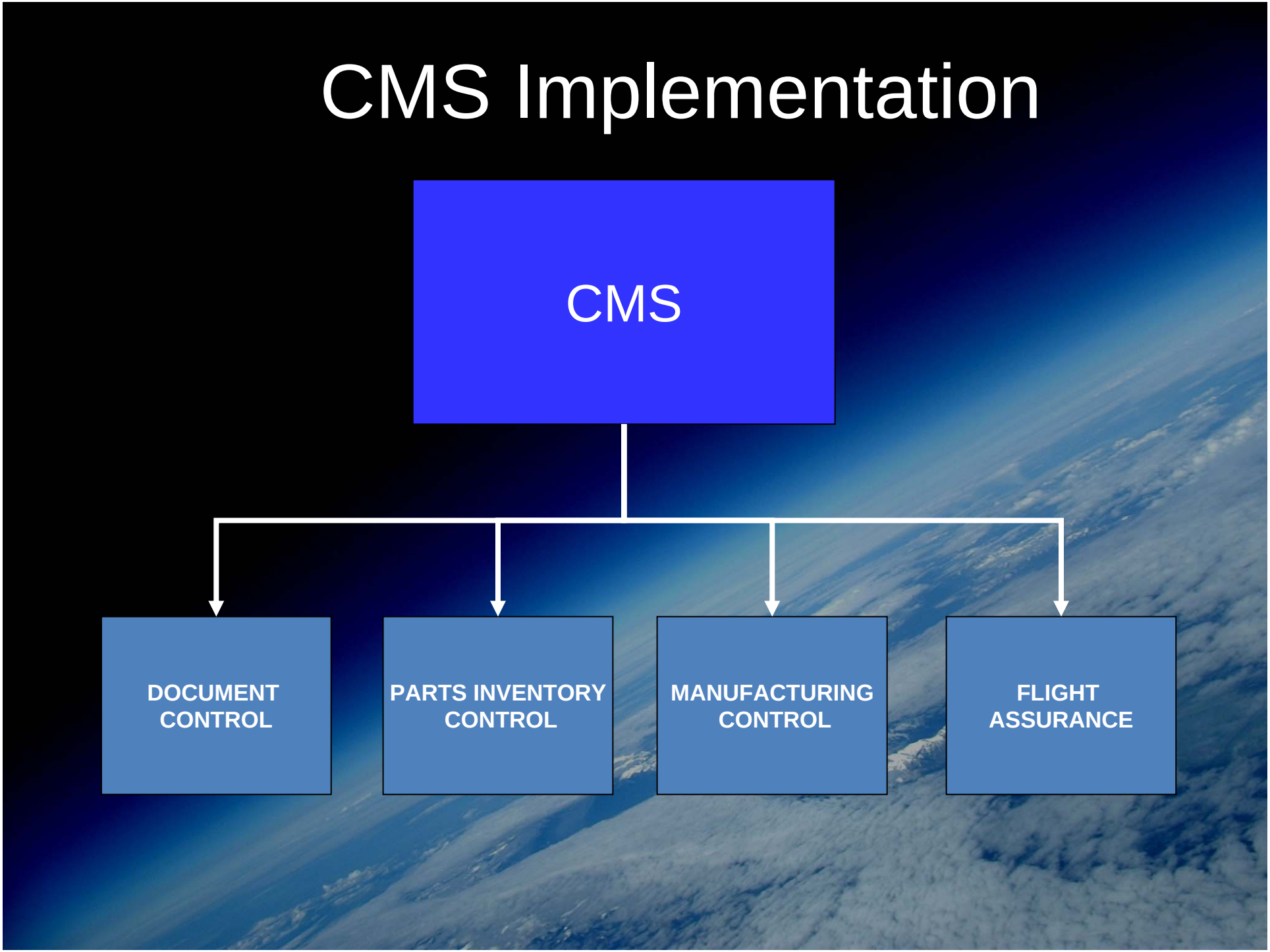
# Overview of Configuration Management

- Configuration Management (CM) is the process of organizing and maintaining engineering data

- Components of a simple Configuration Management System (CMS)
  - Document Control
  - Inventory Management
  - Manufacturing Control
  - Flight Assurance

- Dedicated staff members devoted to CMS activities is a must

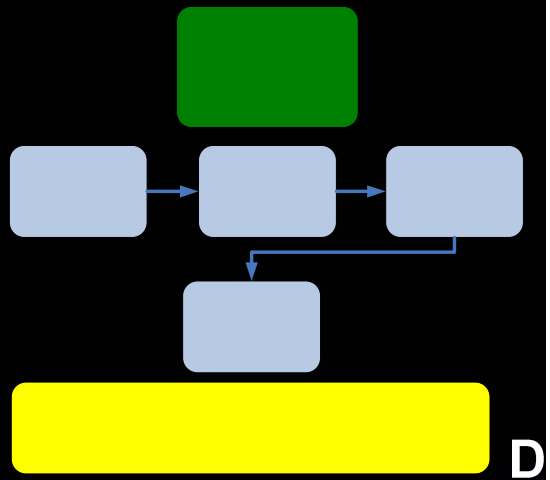
# CMS Implementation

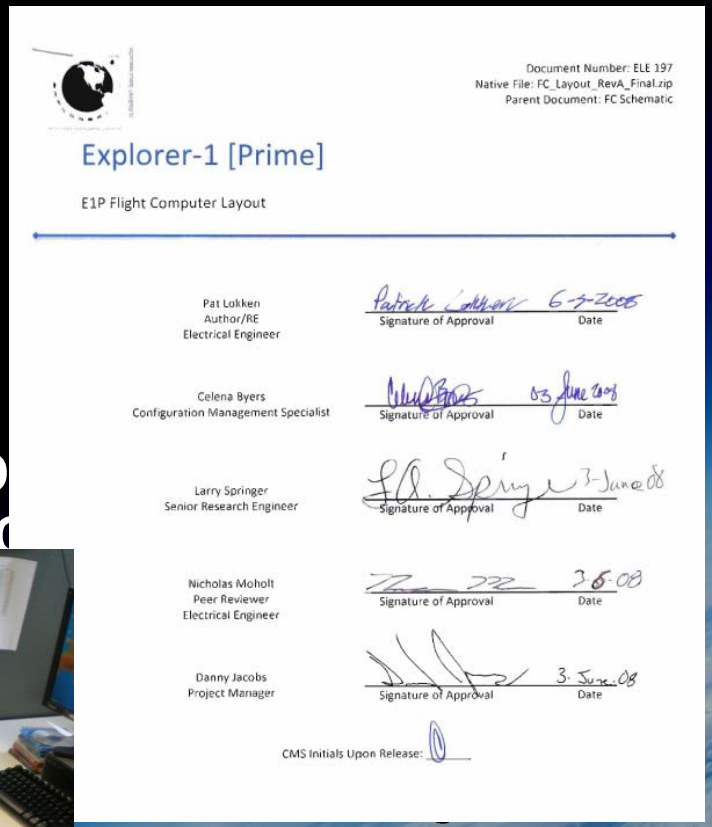


# Document Control

- Each engineering document issued a sequential number
- All documents undergo a peer review process to ensure quality
- Each document contains a coverpage for review signatures and a revision log to track changes
- After all approval signatures are obtained the document is formally released
- Changes to released documents tracked using Engineering Change Order (ECO)

# SSEL Document Control





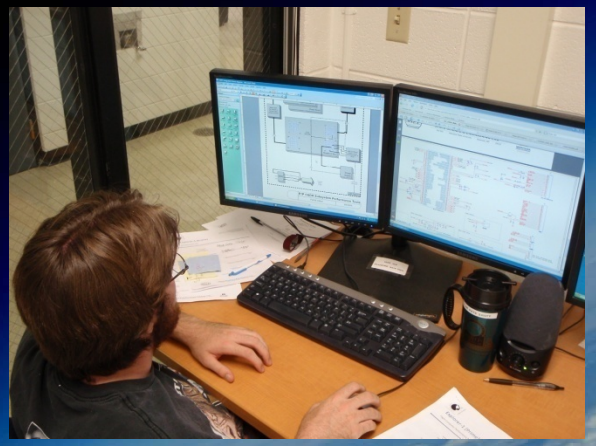
Document Number: ELE 197
Native File: FC_Layout_RevA_Final.zip
Parent Document: FC Schematic

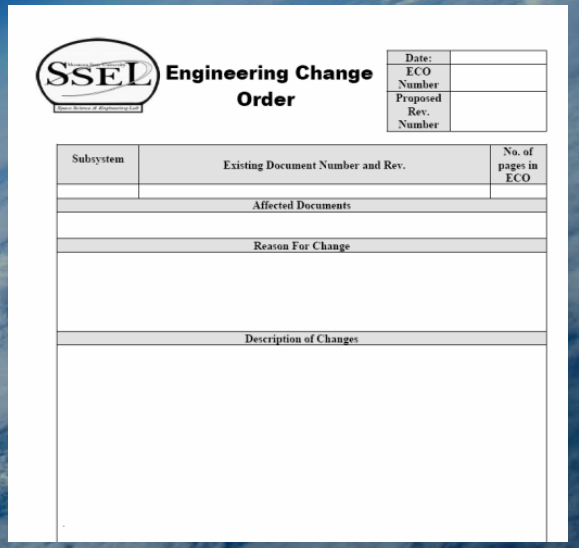
Explorer-1 [Prime]

E1P Flight Computer Layout

| | | |
|---|---|---|
| Pat Lokken<br>Author/RE<br>Electrical Engineer | Signature of Approval | Date: 6-3-2008 |
| Celena Byers<br>Configuration Management Specialist | Signature of Approval | Date: 03 June 2008 |
| Larry Springer<br>Senior Research Engineer | Signature of Approval | Date: 3-June-08 |
| Nicholas Moholt<br>Peer Reviewer<br>Electrical Engineer | Signature of Approval | Date: 3.6.08 |
| Danny Jacobs<br>Project Manager | Signature of Approval | Date: 3. June.08 |

CMS Initials Upon Release:





SSEL **Engineering Change Order**

| | |
|---|---|
| Date: | |
| ECO Number | |
| Proposed Rev. Number | |

| Subsystem | Existing Document Number and Rev. | No. of pages in ECO |
|---|---|---|
| | | |

Affected Documents

Reason For Change

Description of Changes

- Released documents can be accessed using an online database
- All document originals are locked in a secure filing cabinet

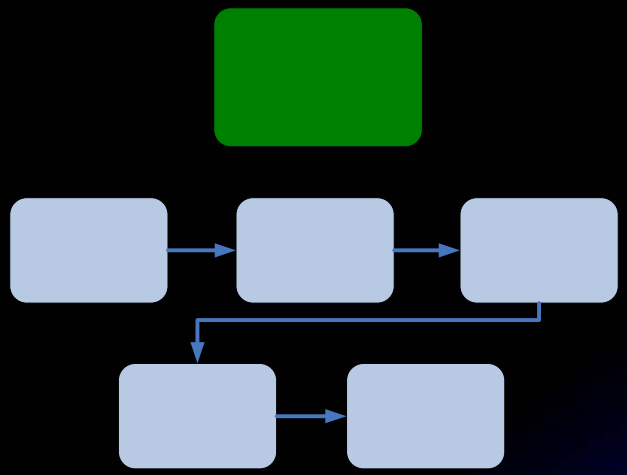
**Document release**

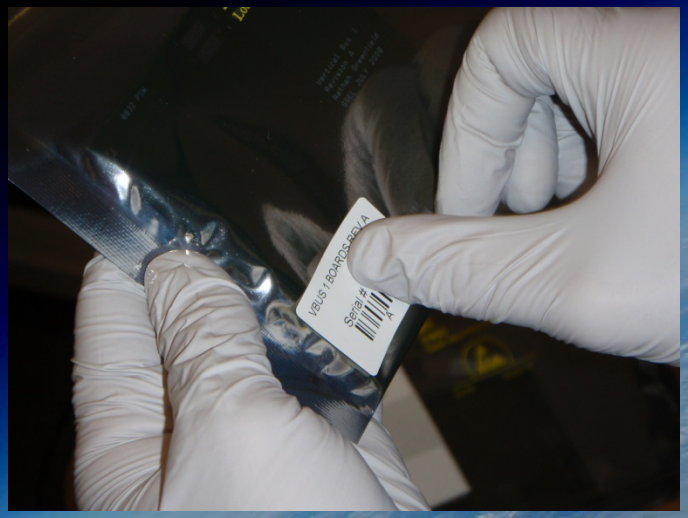
**Changes to released documents tracked using Engineering Change Order (ECO)**

# Parts Inventory Control

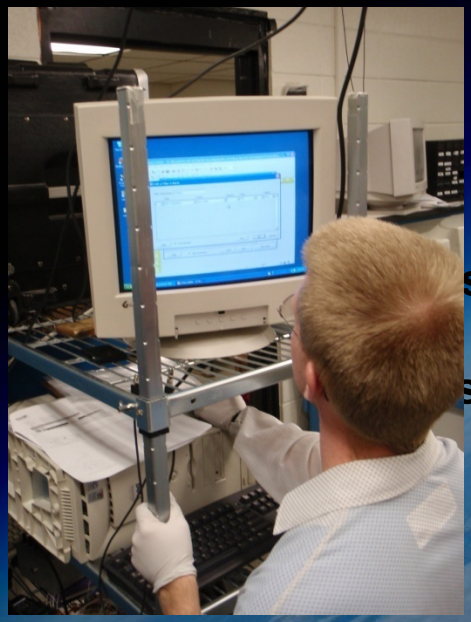
- Verify parts meet outgassing requirements
- All parts purchased from commercial vendors
- Maintain detailed records of all flight parts in stock
- All electrical parts stored in ESD safe containers
- All flight parts stored in locked cabinets

# SSEL Parts Inventory Control





**PARTS INVENTORY CONTROL**





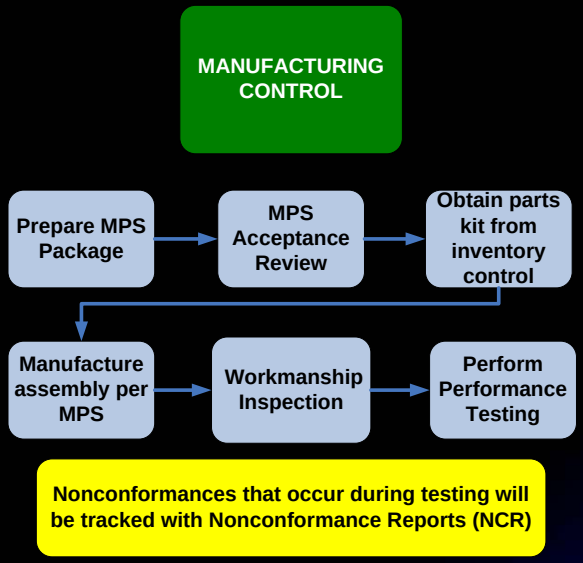
**added to flight inventory**

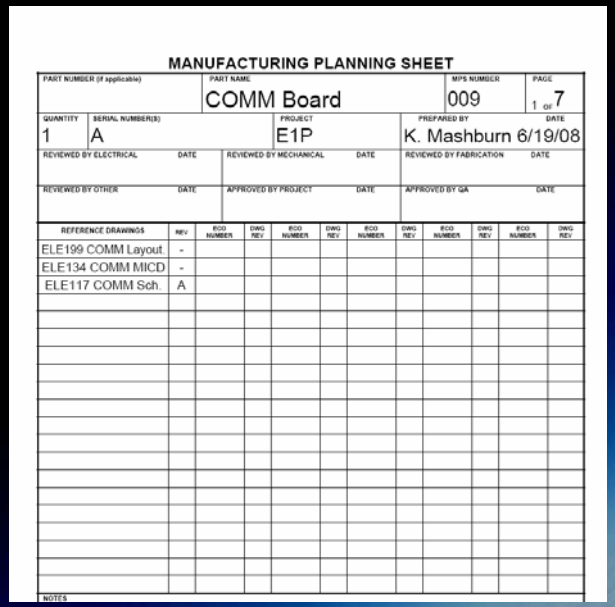
**Kit parts for flight assembly**

# Manufacturing Control

- Manufacturing Planning should start early in the design phase of the mission
- Inspection and other hold points should be identified early in planning stage
- Identify the necessary fabrication, assembly, and testing procedures for all flight hardware and related ground support equipment (GSE)
- Personnel involved in flight fabrication and testing should be trained in the application area (ESD, Soldering, Polymerics, etc.)
- At least two persons are required during all flight hardware operations

# SSEL Manufacturing Control



MANUFACTURING PLANNING SHEET

| PART NUMBER (if applicable) | PART NAME | MPS NUMBER | PAGE |
|---|---|---|---|
| | COMM Board | 009 | 1 of 7 |

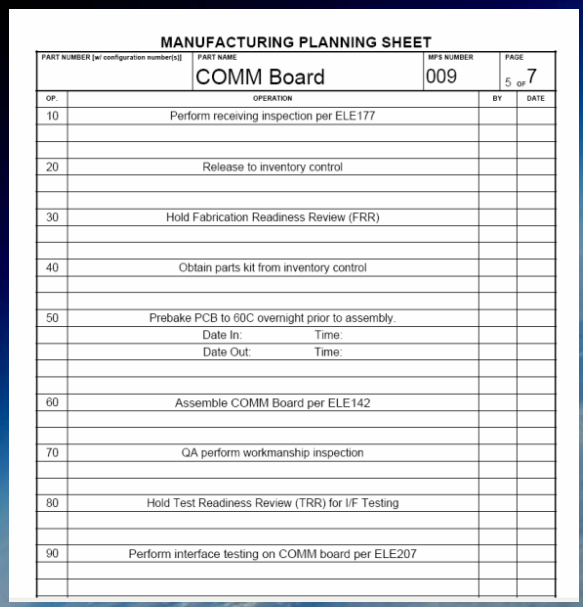
| QUANTITY | SERIAL NUMBER(S) | PROJECT | PREPARED BY | DATE |
|---|---|---|---|---|
| 1 | A | E1P | K. Mashburn | 6/19/08 |

| REVIEWED BY ELECTRICAL | DATE | REVIEWED BY MECHANICAL | DATE | REVIEWED BY FABRICATION | DATE |
|---|---|---|---|---|---|
| | | | | | |

| REVIEWED BY OTHER | DATE | APPROVED BY PROJECT | DATE | APPROVED BY QA | DATE |
|---|---|---|---|---|---|
| | | | | | |

| REFERENCE DRAWINGS | REV | ECO NUMBER | DWG REV | ECO NUMBER | DWG REV | ECO NUMBER | DWG REV | ECO NUMBER | DWG REV | ECO NUMBER | DWG REV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELE199 COMM Layout | - | | | | | | | | | | |
| ELE134 COMM MICD | - | | | | | | | | | | |
| ELE117 COMM Sch. | A | | | | | | | | | | |

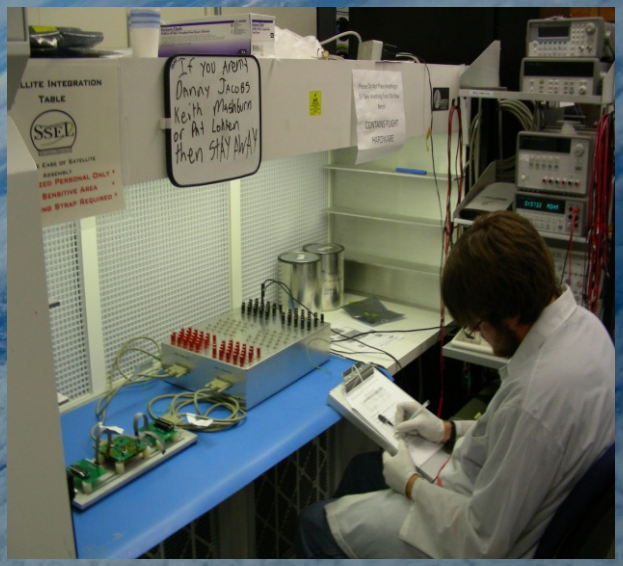
NOTES



MANUFACTURING PLANNING SHEET

| PART NUMBER [w/ configuration number(s)] | PART NAME | MPS NUMBER | PAGE |
|---|---|---|---|
| | COMM Board | 009 | 5 of 7 |

| OP. | OPERATION | BY | DATE |
|---|---|---|---|
| 10 | Perform receiving inspection per ELE177 | | |
| 20 | Release to inventory control | | |
| 30 | Hold Fabrication Readiness Review (FRR) | | |
| 40 | Obtain parts kit from inventory control | | |
| 50 | Prebake PCB to 60C overnight prior to assembly.<br>Date In: Time:<br>Date Out: Time: | | |
| 60 | Assemble COMM Board per ELE142 | | |
| 70 | QA perform workmanship inspection | | |
| 80 | Hold Test Readiness Review (TRR) for I/F Testing | | |
| 90 | Perform interface testing on COMM board per ELE207 | | |



# Flight Assurance

- Provide oversight during all phases of the integration and test program to ensure the work is performed according to specifications
- Perform workmanship inspections during fabrication and assembly activities
- Certify equipment/GSE setup prior to execution of all qualification tests
- Maintain detailed records of all non-conformances that occur during I&T
- Verify test records and data are adequate to meet test requirements

# SSEL Flight Assurance


FABRICATION READINESS REVIEW CHECKLIST AND RECORD

| | | | | | |
|---|---|---|---|---|---|
| | | Project | | | - |
| Fabrication Item: | Part Number | Part Name: | | | |
| MPS Number(s): | | | | | |
| Attendance: | Names | | | | |
| Responsible Engineer* | | | | | |
| Fabricator(s)* | | | | | |
| QA* | | | | | |
| PM* | | | | | |
| Inventory Control | | | | | |
| Other | | | | | |
| *Attendance required | | | | | |

Agenda

| Items | Considerations and Comments |
|---|---|
| Review MPS | Known unusual or difficult process or inspection issues; special hold points; closure status of MPSs, ECOs, or ARs/PFRs that affect fabrication; response to unexpected events |
| Parts kit status | Status; known shortages and anticipated work-arounds |

SSEL

**Nonconformance Report**

| | |
|---|---|
| Incident Date: | |
| NCR Number | |

| Subsystem | Part/Document Name | No. of NCR Sheets |
|---|---|---|
| | | |

| Brief Description |
|---|
| |

| MPS Number | MPS OP Number | Hardware Type |
|---|---|---|
| | | ☐ Flight ☐ Flight Qualification ☐ Non-Flight ☐ ETU |
| **Quantity** | **Procedure Number** | **Found During** |
| | | |

| Reference Documents |
|---|
| |

| Analysis (Attach additional pages if necessary) |
|---|
| |

TEST READINESS REVIEW CHECKLIST AND RECORD

| | | | | | |
|---|---|---|---|---|---|
| | | Project: | | | - |
| Unit Under Test: | Part Number | Part name | | | |
| MPS Number(s): | | | | | |
| Test Procedure(s): | | | | | |
| Attendance: | Names | | | | |
| Test Conductor* | | | | | |
| Responsible Engineer(s)* | | | | | |
| Technician(s)* | | | | [Names, Technician(s)*] | |
| QA* | | | | | |
| PM* | | | | | |
| Other | | | | | |
| *Attendance required | | | | | |

Agenda

| Items | Considerations and Comments |
|---|---|
| Review MPS and test procedures | Test sequence; known unusual or difficult processes or test issues; special hold points; closure status of MPSs, ECO, or ARs/PFRs that affect testing; response to unexpected events |

# CubeSat Qualification Testing

# Overview of CubeSat Qualification Testing

- Qualification testing ensures that design is acceptable and that the satellite will function in the expected environments
- Qualification begins with the completion of the flight hardware and software and ends with the satellite ready for shipment to CalPoly for acceptance testing
- Qualification testing consists of a series of functional and performance tests, followed by a sequence of environmental exposures
- The requirements for qualification testing are derived from a variety of sources including the individual mission requirements, the CubeSat program requirements, and the designated launch vehicle requirements

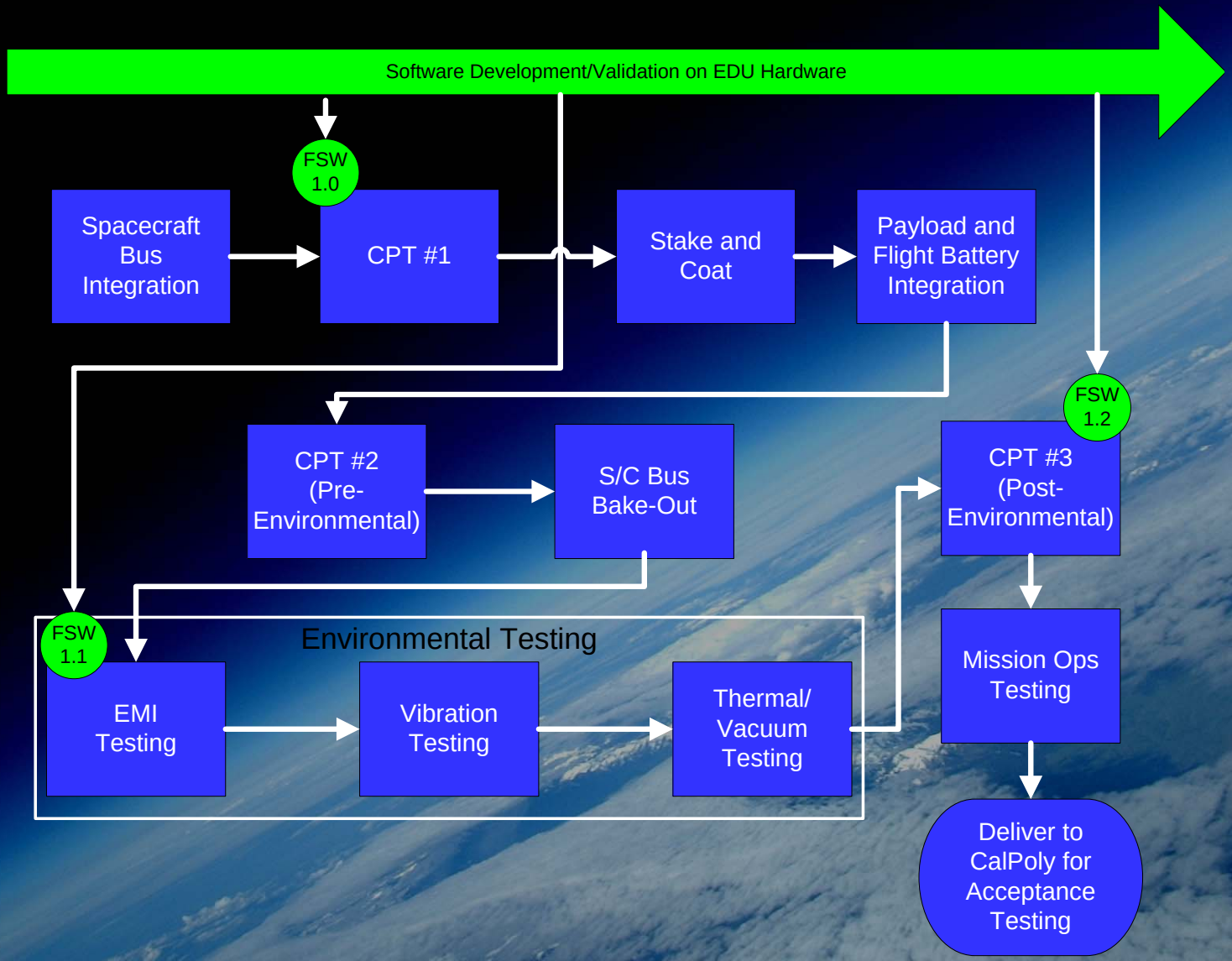
# Example of CubeSat Qualification Program (1 of 3)

lopment/Val

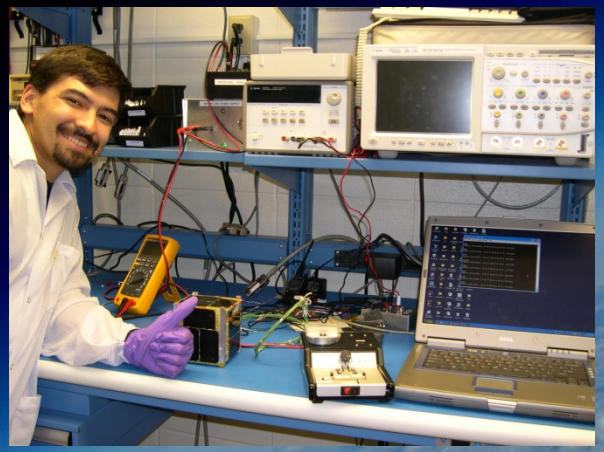
PCB Board Manufacturing

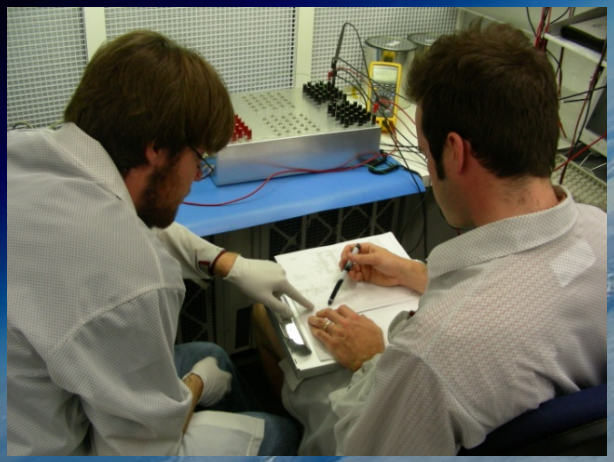
PCB Receivin Inspection

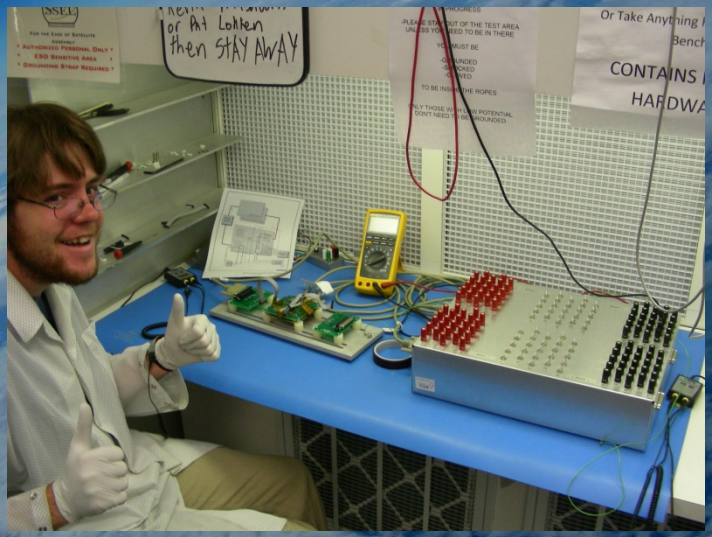
# Example of CubeSat Qualification Program (2 of 3)



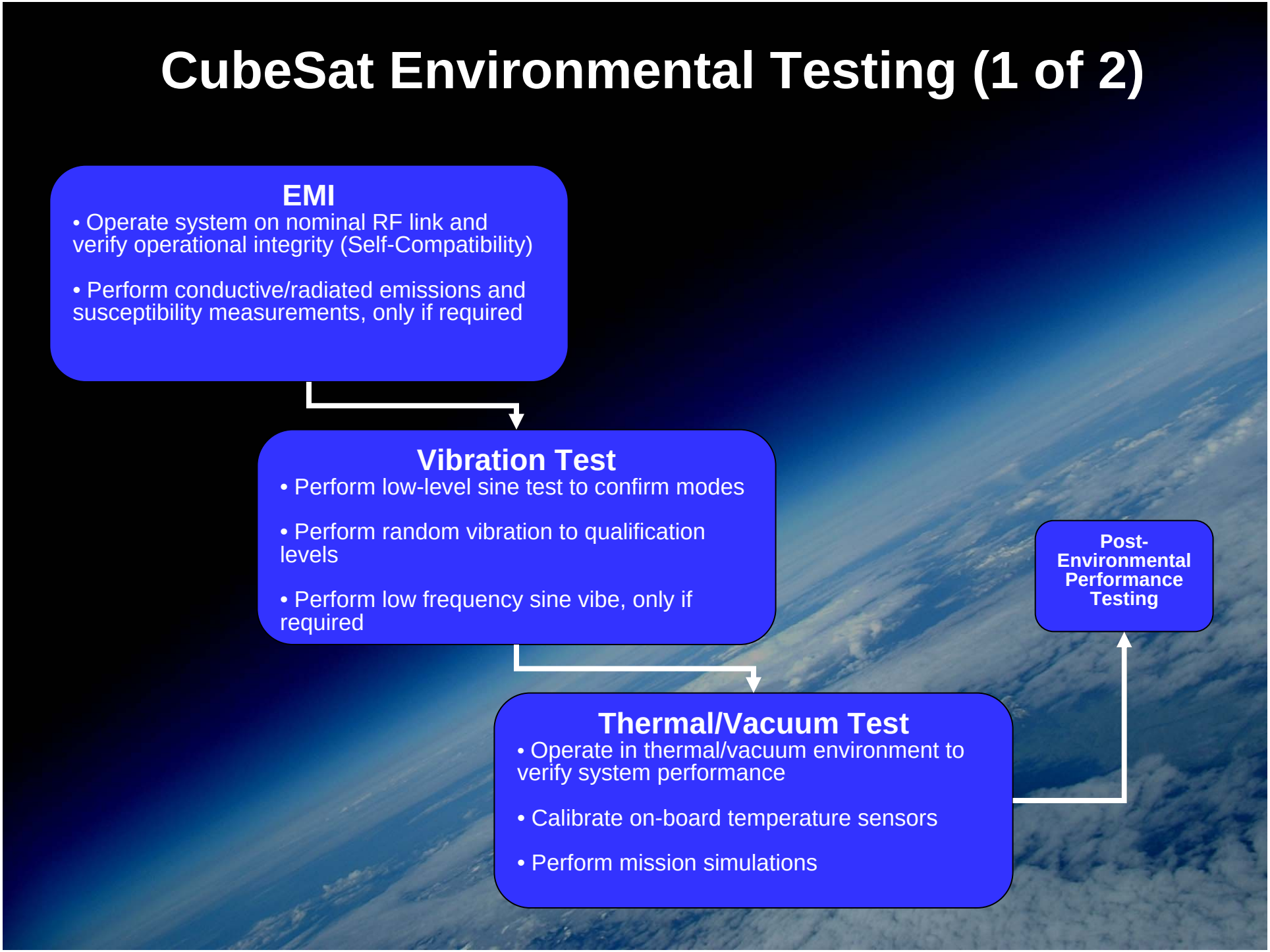
# Example of CubeSat Qualification Program (3 of 3)

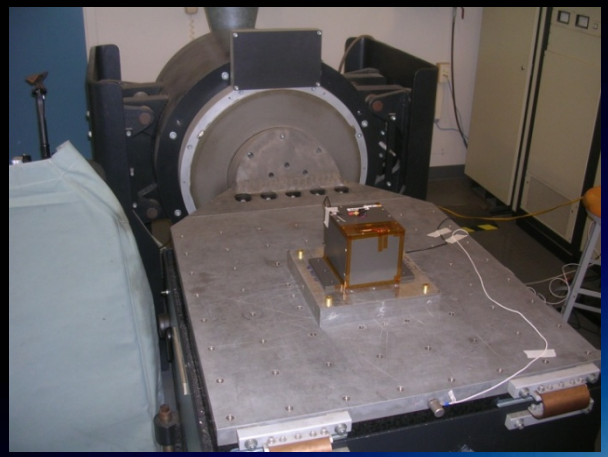


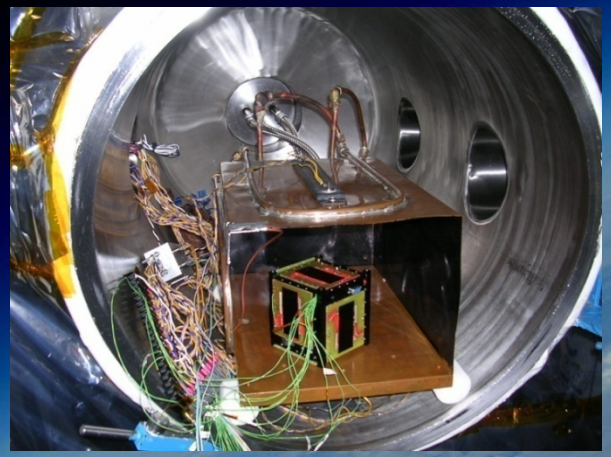


# CubeSat Environmental Testing (1 of 2)

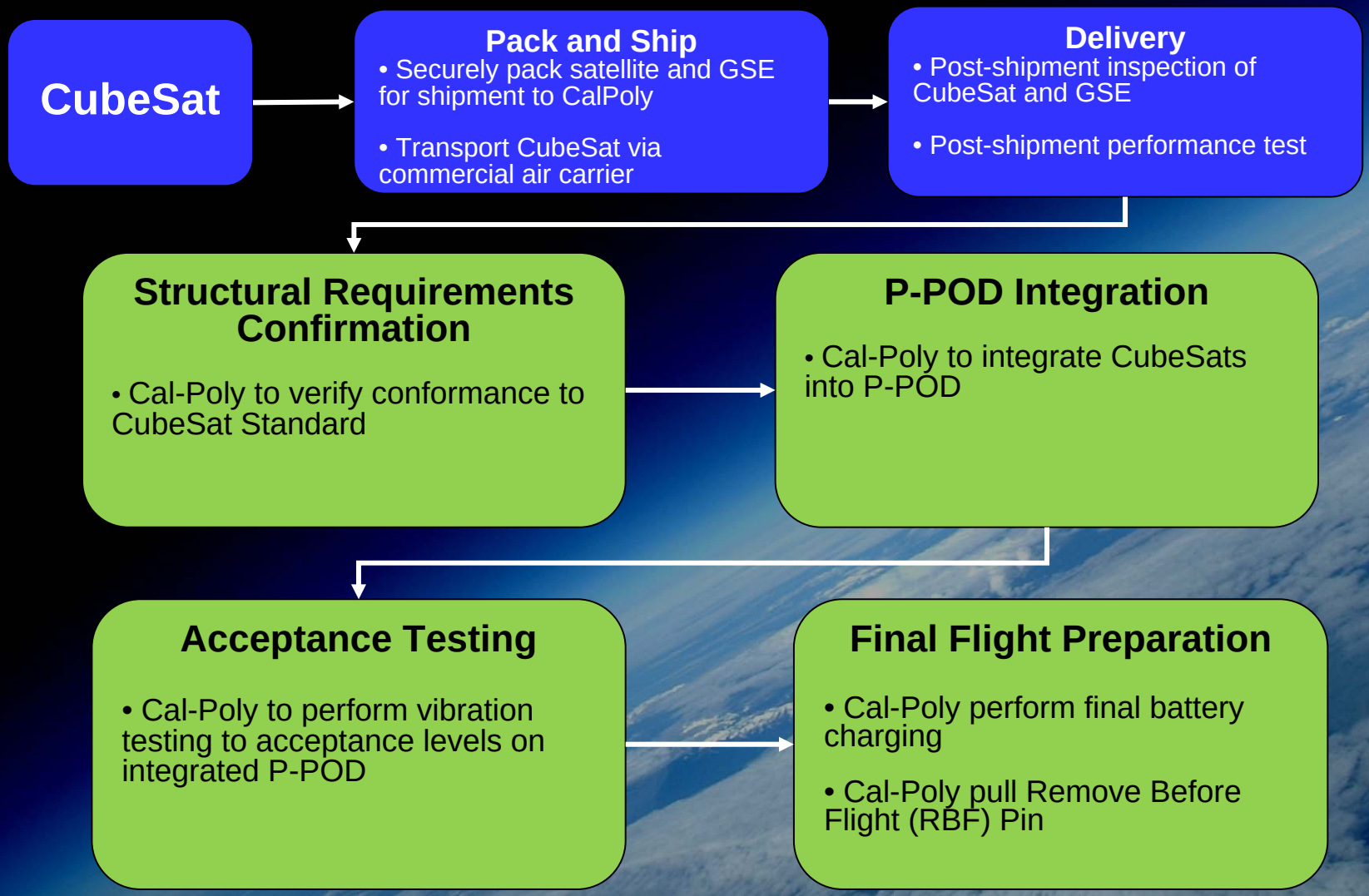


# CubeSat Environmental Testing(2 of 2)






# CubeSat Delivery and Acceptance (1of 2)



# CubeSat Delivery and Acceptance (2 of 2)

# Acknowledgements

I would like to thank Ms. Celena Byers for all of her hard work on the implementation and maintenance of the SSEL Configuration Management System.

# Contact Info

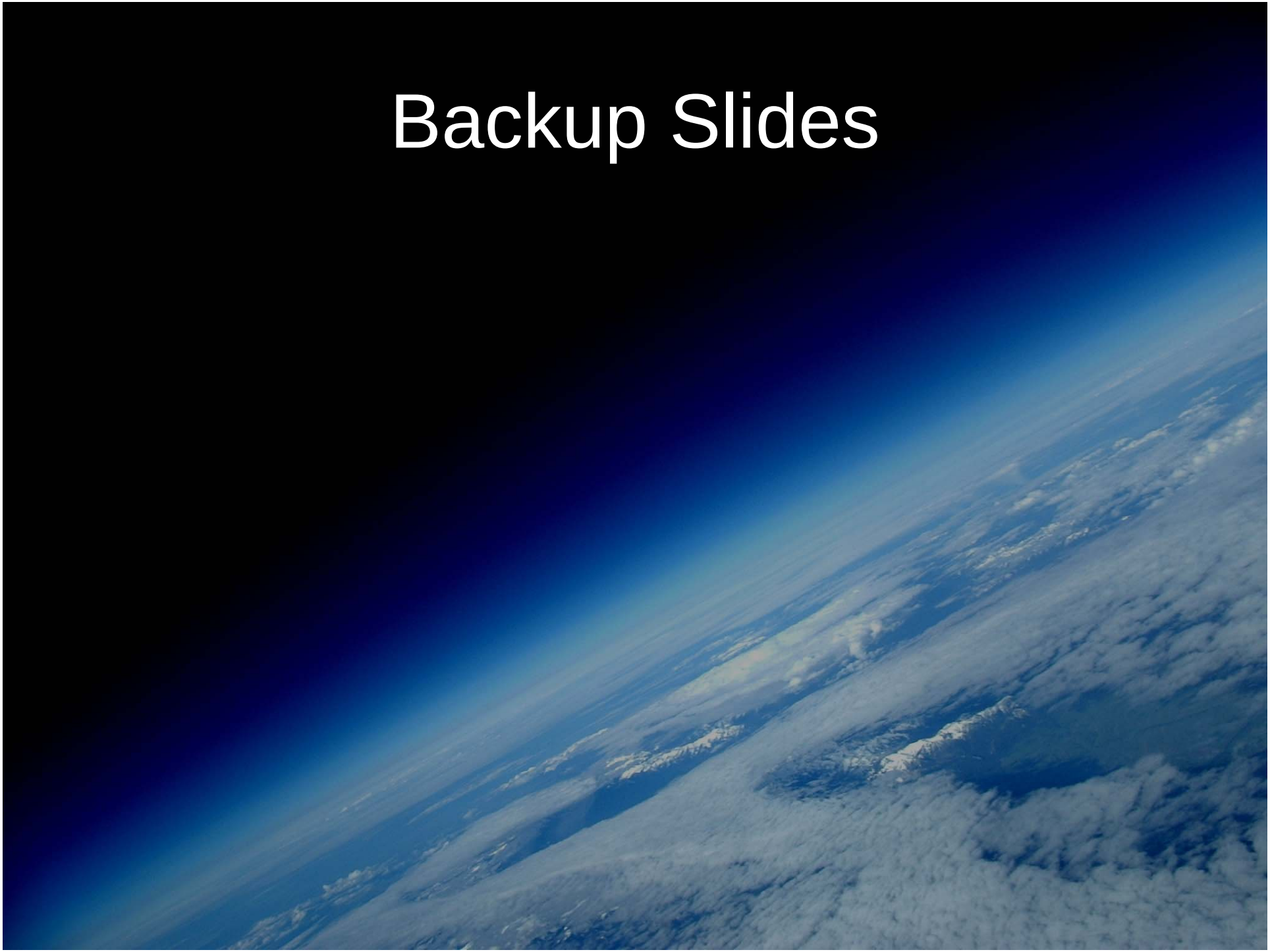
Keith Mashburn – I&T Team Lead:

kwm@ssel.montana.edu

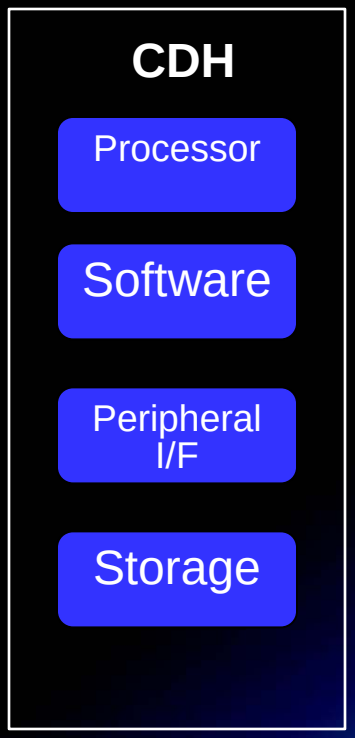
Celena Byers – SSEL Configuration Management Specialist:

Celena@ssel.montana.edu

# Backup Slides

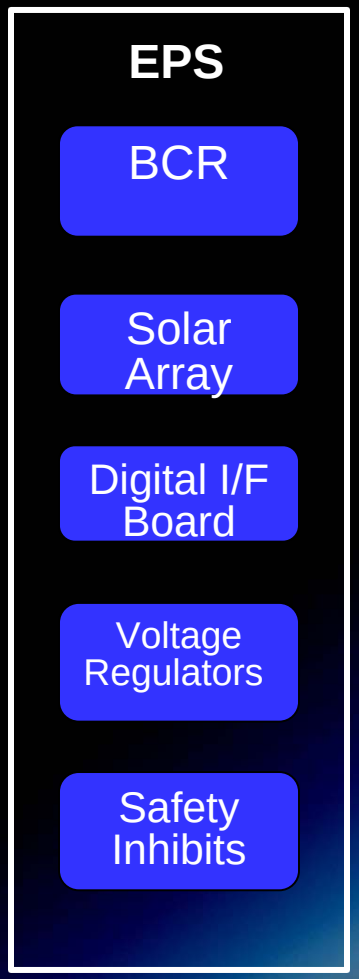


# CDH PCB Integration and Test



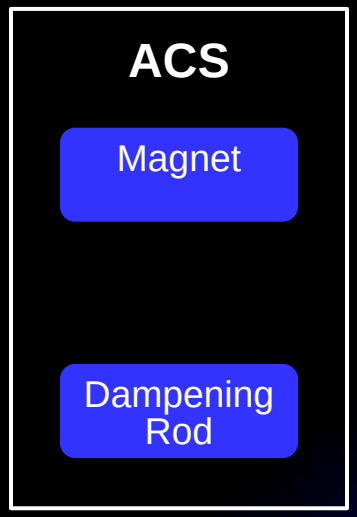

- Perform PCB Assembly
- Perform workmanship inspection
- Electrical interface testing
- Initial Power-up
- Oscillator measurement or calibration
- Watch dog functional check
- Memory read/write verification tests
- Verify S/W loading capability
- Perform initial checks of the peripheral I/F

# EPS PCB Integration and Test




- Perform PCB Assembly
- Perform Workmanship Inspection
- Electrical interface testing
- Initial Power-up
- Voltage regulator functional testing
- Safety inhibit functional testing

# ACS PCB Integration/Verification




Perform PCB Assembly

Perform Workmanship Inspection

Electrical interface testing

Battery charge/discharge testing

# COMM PCB Integration/Verification

- Transmitter
- Receiver
- Antennas
- TNC

Perform PCB Assembly

Perform Workmanship Inspection

Electrical interface testing

Initial Power-up

Transmitter/Amplifier functional testing

Receiver functional testing

RF link test and power measurements

Watchdog functional testing

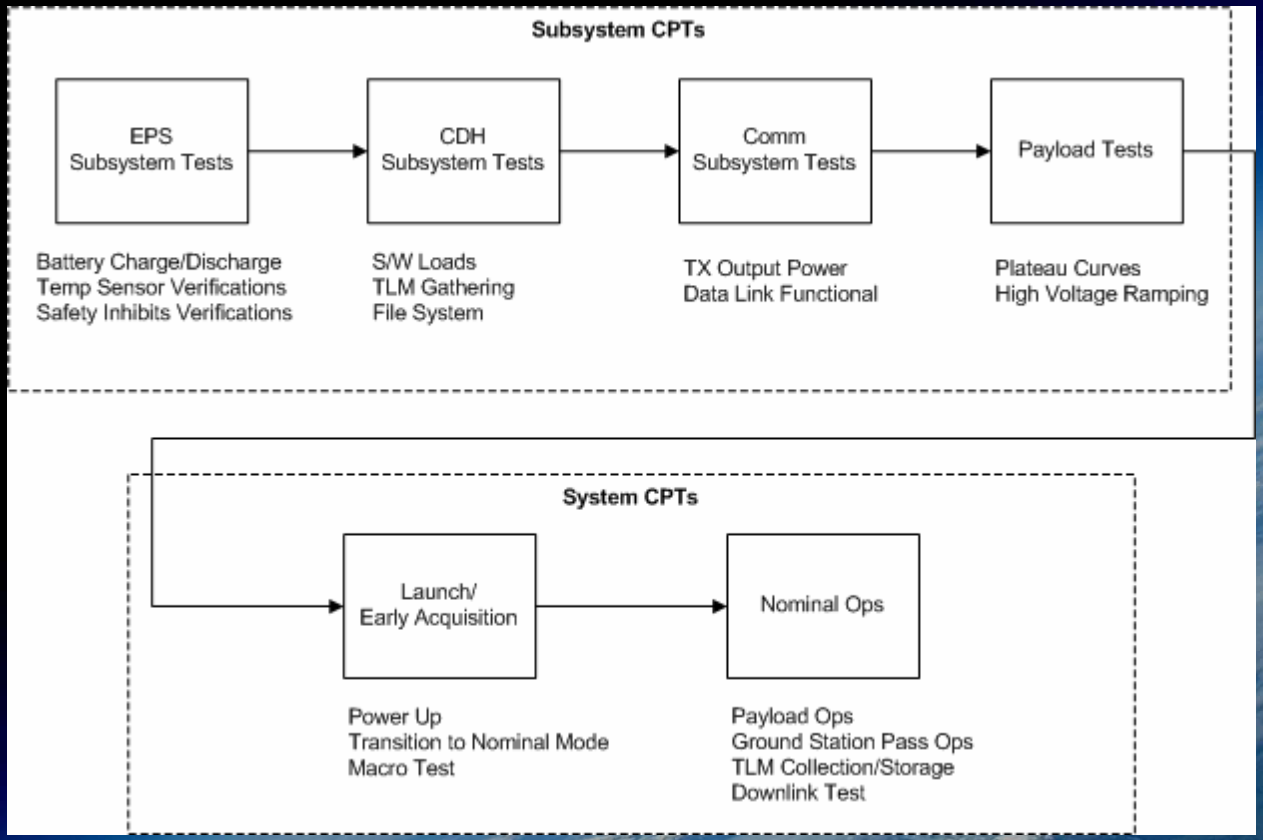
# Payload PCB Integration and Test

**Payload**

Particle Detector

- Perform PCB Assembly
- Perform Workmanship Inspection
- Electrical interface testing
- Initial Power-up
- Preamp noise measurements
- I2C Interface functional
- Payload Plateau Curves

# Backup Slide: System CPT Plan



# Backup Slide: System Environmental Test Plan