



Integration and Testing Challenges of Small, Multiple Satellite Missions: Experiences From The Space Technology 5 Project

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Agenda



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- ST5 Overview and Planning
 - Integration and Environmental Testing
 - Lessons Learned



S/C I&T - Overview



S/C 1 I&T including environmental testing was performed first, followed by S/C 2 & S/C 3 I&T in parallel, to maximum extent possible.

– S/C 1

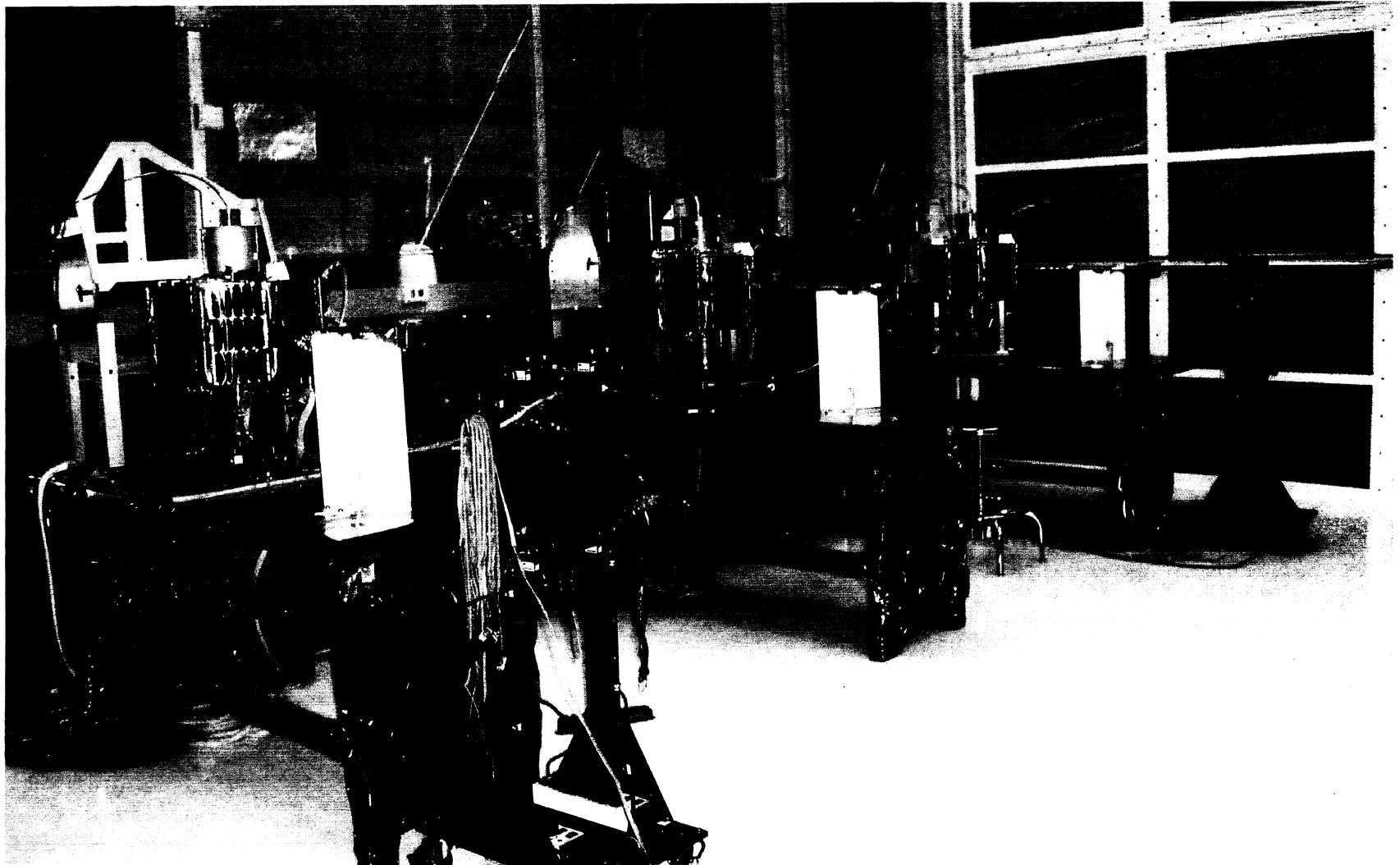
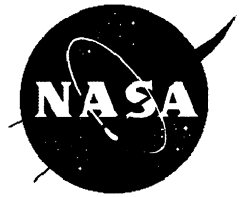
- One test conductor team integrated and tested S/C 1, led by Lead Test Conductor(TC)
- One electrical technician team and one mechanical technician team physically integrated S/C 1, led by the lead electrical technician

– S/C 2 & S/C 3

- TCs that supported S/C 1 integration and test were the lead TC's for S/C 2 and S/C 3 integration and test, with the oversight of the overall lead TC
- Overall lead TC performed other duties, supporting execution of S/C 2 or S/C 3 activities or planning future activities
- Electrical technician and mechanical technician teams physically integrated S/C 2 and S/C 3 in parallel, using the knowledge gained from S/C 1 integration, spacecraft S/C 2 and S/C 3 integrations more efficient

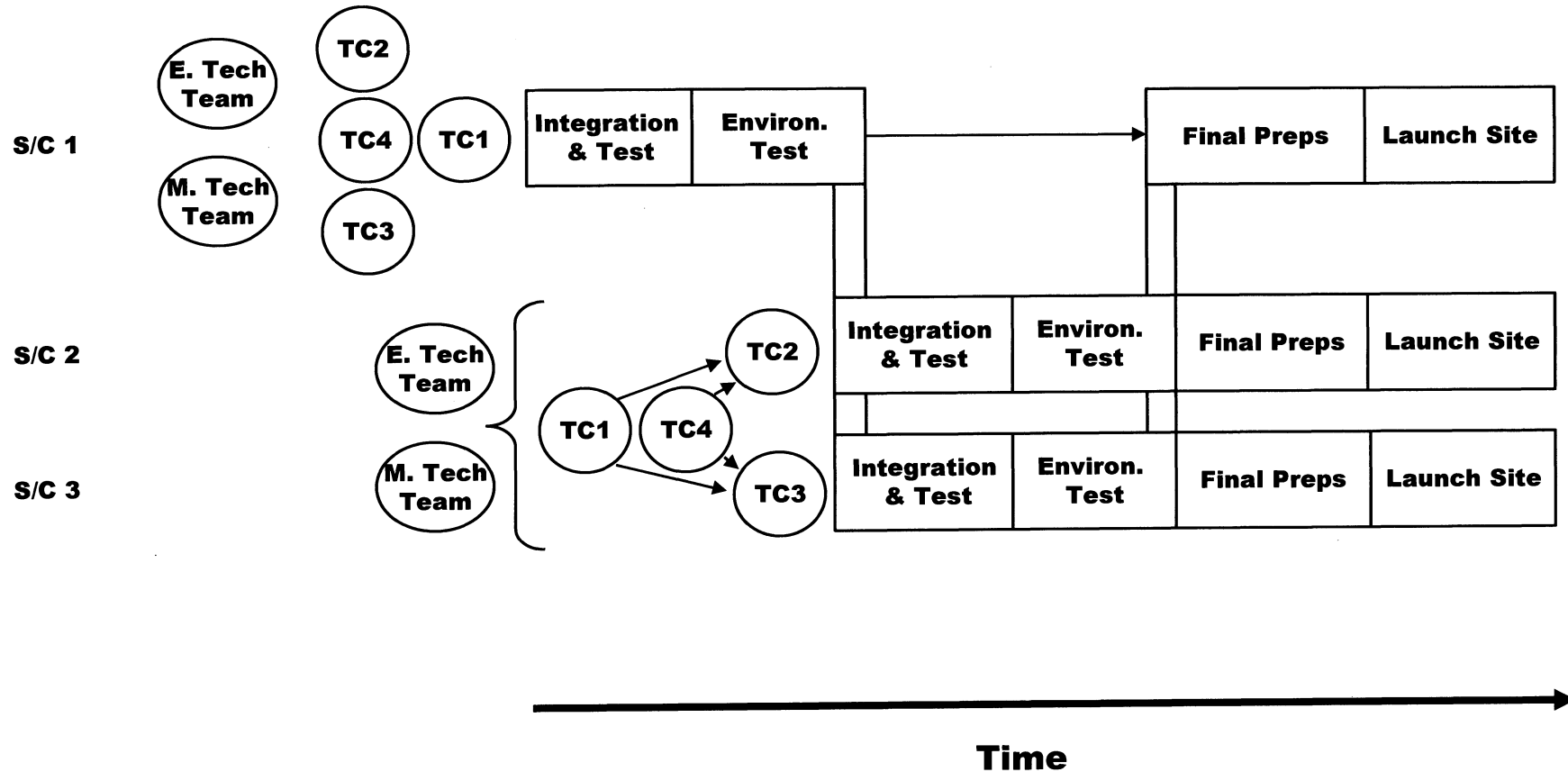


ST5 S/C I&T – Clean Tent





ST5 S/C I&T Staffing- I&T flow and Team Phasing





ST5 S/C I&T - I&T Planning



- Procedures
 - One set of integration procedures written for all three S/C
 - Procedures from S/C 1 integration had to be updated, reviewed, and signed prior to S/C 2 and S/C 3 integration
 - I&T person available to incorporate the redlines changes
 - On-site CM support dedicated to ST5 project
- Plan the work and work the plan, but always have a back-up plan, facilitated by:
 - I&T procedures ready before required
 - On-site Scheduler dedicated to ST5 project



ST5 S/C I&T - I&T Process



- Mechanical integration activities performed on one S/C at a time, enabled efficiencies gained through repetition
- Electrical integration activities involving different subsystems occurred concurrently on multiple S/C
 - Electrical integration repeated common electrical subsystems on other S/C
 - PDLs efficiently completed efforts at S/C I&T
- Minimized integration duration of successive S/C by efficiencies gained from repetition
- Allowed timely comparison of I&T data for similar subsystems

- Automated Test procedures to keep the test results consistent
- Used same test equipment, oscilloscopes, meters, and Break Out Boxes(BOBs) throughout integration to reduce variables in testing results
- Performed S/C Functional Tests and Comprehensive Performance Tests serially



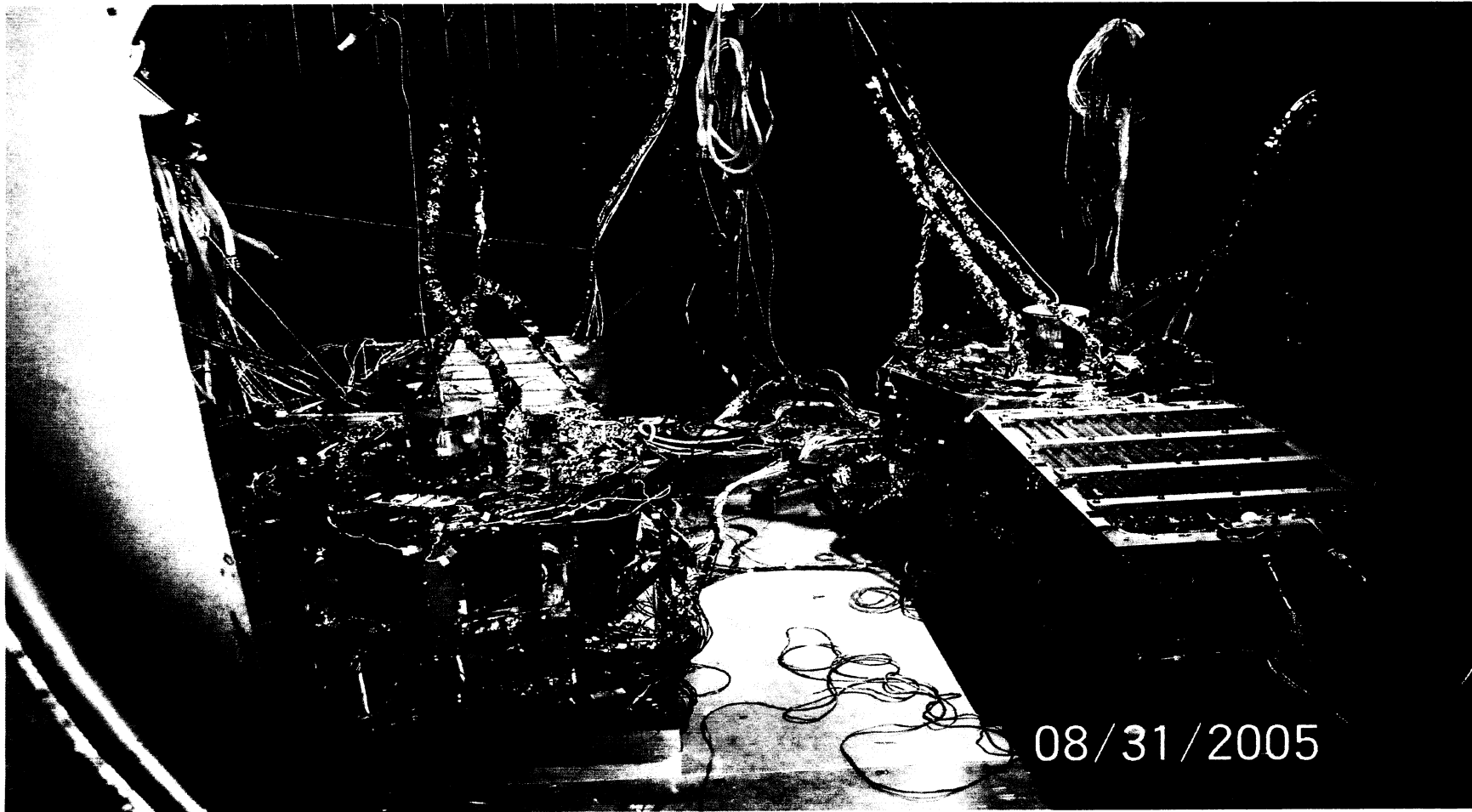
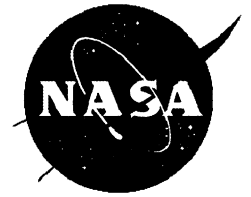
ST5 S/C I&T – Thermal Vacuum/Thermal Balance



- Two TV/TB tests performed, first S/C 1, then S/C 2 and S/C 3 together
- S/C 2 and S/C 3 Thermal-Vacuum/Thermal-Balance
 - S/C 2 and S/C 3 in the same chamber together
 - S/C 2 and S/C 3 tested independently with identical test configurations
 - Enabled control, monitor, and test of each S/C independently
 - Facilitated fabrication of GSE and planning for test configuration
 - Allowed for dynamic test re-planning and operating efficiency
 - One S/C was actively tested at a time, the other S/C left in quiescent state or specific test mode
 - Minimized support required and focused efforts on one S/C at a time, especially valuable for anomalies
 - ‘Hot Line’ and Blog website set up to give up-to-the-shift test status and information



ST5 S/C I&T – TV/TB Config for S/C 2 & S/C 3





ST5 S/C I&T - Lessons Learned



- Plan the work and work the plan, but always have a back-up plan
 - Have procedures ready to go prior to start of integration
 - With multiple S/C, there is always work to be done, prepare to dynamically re-plan
- Bring the I&T team on early to learn the system and cross-train on multiple functions
- Have an overall lead TC, lead electrical technician, and lead mechanical technician, who can also see the bigger picture
- Have a separate person/team responsible for each S/C, subsystem I&T procedure and environmental test
- Perform mechanical activities serially, to gain efficiency through repetition
- Perform electrical activities based on the level of subsystem expertise available.
- Use the same test equipment (oscilloscopes, meters, and BOBs) throughout integration to keep the test results from S/C to S/C consistent
 - Design items such as GSE and harnessing to be identical. Uniquely identify items, such as harnessing and GSE for a particular S/C.
- Have a physical integration layout for the clean tent and the control room that lends itself to multiple, separate integration activities
- If possible, take one S/C through I&T and environmental testing before building and testing more S/C



ST5 S/C I&T Team (at Launch Site)

