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CloudSat System Engineering:
Techniques That Point to a Future Success

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Topics

- Background & Introduction
- CloudSat Mission
- System Engineering
- Requirements
- Configuration Management
- Communications
- Responding to Change
- Summary
CloudSat has implemented a successful system engineering approach since the mission was selected in April 1999 as an official project.

The approach was developed through:
- Examination of advertised techniques
- Heuristic reasoning of past project performance
- Application of professional experience

What are some specific reasons for this success, and how can they help solve future problems?
CloudSat Mission

- NASA Earth System Science Pathfinder (ESSP) mission
- First global survey of cloud profiles and cloud properties
- First 94 GHz Cloud Profiling Radar (CPR) to operate in space
- Spacecraft will fly in formation with other cloud observing spacecraft, e.g. Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

- Launch: April 2002 from Vandenberg Air Force Base
- Mission Duration: 22 months
System Engineering

- Defining user needs
- Defining the required functionality of the system responsive to those needs
- Overseeing/directing the technical design and development effort to assure that the resulting system will deliver those needs

➢ System engineering must direct and oversee the project’s activities during the transition from one phase of development to the next
  - Has a sufficient level of maturity been reached?
  - Are all required work products completed?
System Engineering

➢ Extensive partnering arrangement = take maximum advantage of expertise/core competencies

ARM
Department of Energy

CIRA
Cooperative Institute for Research in the Atmosphere

JPL
• At project start
  – A preliminary system concept and architecture existed but no real detail about how to make this system concept work in an integrated manner
  – The engineers had only conceptual ideas about the overall designs and how their element fit in the “big picture”
  – An obvious need to develop a requirements hierarchy that flows down requirements from one level to the next
  – Ideally, the highest level requirements are defined first, then the next level, and so on...
    • Only in rare situations does this occur in a sequential manner
Invest early in requirements generation and analysis

- Project personnel briefed on what would be an iterative process and the tools used - get “buy in”
- The system engineers at all levels just started writing down the requirements
- Many of these statements were challenged, rejected, and/or significantly modified before they are finally accepted
- “Pit” sessions facilitated necessary interaction
- Review conducted at task completion
- Enabled next step, design, to be taken
Configuration management is traditionally under the purview of mission assurance at JPL.

On the CloudSat Project, it is an essential part of system engineering.

Management and control of project items, such as documents, hardware, software, and other key items are essential for managing an efficient project.

Also provides a system for evaluating and managing change.

Configuration management does not replace system engineering, but is a valuable tool.

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Utilize configuration management tools, but keep the number to a minimum

- CloudSat Docushare Electronic Library - serves as the main repository for most of the documentation and records for the project. The Library houses over 3000 files for 143 users.
- DOORS (Dynamic Object-Oriented Requirement System) - serves as the repository for all requirement documents.
- The JPL PDMS (Product Data Management System) - serves as the repository for drawings, schematics, change records and other items such as waivers.
- The JPL UPRS (Unified Problem Reporting System) - the official repository for problem/failure and ISAs (Incident, Surprise, Anomaly) Reports.
Communications

- In any team, various types of information must be communicated between project members
- Match communication method to the criticality of the information/data and the timeliness required
- Types of information communicated from least complex to most complex

1. General Status/Issues - Verbal
2. Schedule Planning - Verbal, with written follow-up
3. Cost Planning - Verbal, with written follow-up
4. Priorities and Goals - Verbal and written
5. Requirements - Written
6. Design Detail - Written

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Responding to Change

- Count on it - there will be changes
- Changes are usually driven by a better understanding of what is required, results of analyses or tests, or changing customer needs
- Design in flexibility and resiliency
- Conscious decisions made
  - understand the change
  - the intent of any recommendations
  - analyze the benefit
  - tailor the implementation approach all the while being sensitive to cost and schedule constraints
Example: Risk Management

- Directive requiring the use of risk management process and risk management techniques, including fault tree analysis and probabilistic risk assessment.

- Rather than waiting for a standard to be dictated, the project chose to complete a streamlined, system-level, relative rather than absolute-based analysis and assessment.

- In the end, the analysis and assessment confirmed the robust design of the spacecraft bus, and also lead to two design changes/enhancements to the payload instrument to increase reliability.
Summary

- **System Engineering**
  - Monitor and control phase transitions
  - Match work products to “doing” organization expertise

- **Requirements**
  - Invest the time and effort early to get this right

- **Configuration Management (CM)**
  - Utilize CM tools for effective system engineering

- **Communications**
  - Match methods to criticality and timeliness

- **Responding to change**
  - Change is inevitable - be flexible and resilient

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