



Mechanical System Integration of Spacecraft

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Objectives

- ❑ Through the case study of GrowingSat, discuss
 - Impact of other subsystems on mechanical system
 - Impact of mechanical system on other subsystems
- ❑ Integration and test issues

□ Requirements

- **Defined requirements**
 - e.g. Compatible with Atlas and Proton families of launch vehicles
- **Derived requirements**
 - e.g. Thermal environments for components

□ Typical road map

- **Trade Studies**
- **Design**
- **Analyses**
 - Mathematical models, test data, and engineering judgment
- **Test**
 - Simulate environments
 - Operation of equipment
- **Verification/Validation**
 - Correlate models with test data – not all conditions can be simulated
- **Launch support**
- **On-orbit support**

- ❑ **Mass properties**
 - Accounts for weight, inertia, and center of mass of the spacecraft
- ❑ **Spacecraft configuration & mechanical/structural design**
 - Oversees overall layout and mechanical and structural design
- ❑ **Thermodynamics**
 - Oversees thermal control system and perform thermal analysis
- ❑ **Mechanical analysis**
 - Performs stress and structural dynamics analysis and on-orbit analysis
- ❑ **Mechanisms**
 - Oversees mechanical moving assemblies, deployment analysis

All disciplines support manufacturing, assembly, integration, and test

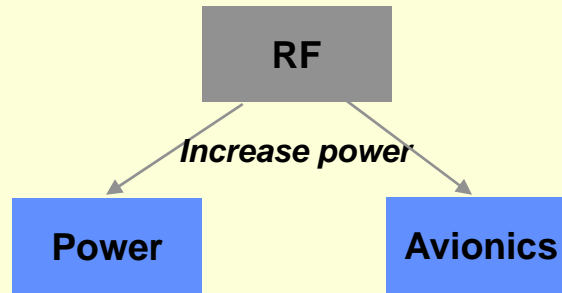
- ❑ **Coordinates and integrates mechanical design**
 - **Communicates issues beyond mechanical design team**
- ❑ **Owns mechanical system requirements**
 - **Ensures requirements are met, e.g. meet performance requirements in different thermal environments**
- ❑ **Provides presence in Configuration Change Board meetings**
 - **Ensures impact to mechanical system and vice versa are addressed**
- ❑ **Participates in mechanical team review boards**
 - **Leverage expert talents to resolve issues**
- ❑ **Performs overall pointing analysis**
- ❑ **Supports assembly, integration, and tests**

The Case of the GrowingSat

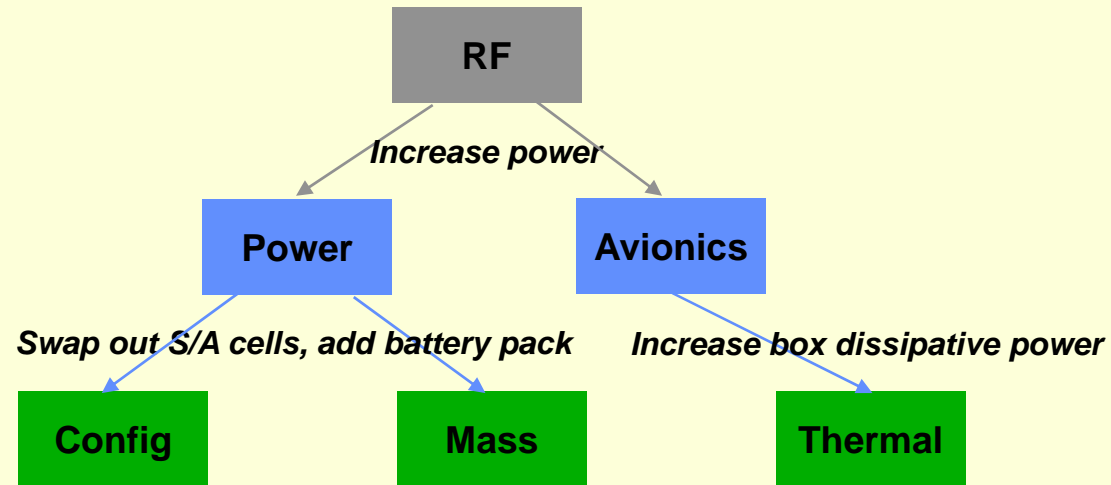
- ❑ **Finding after peer review of the design of GrowingSat**
 - **Need to increase the RF power to meet contractual requirements**

- ❑ **Recommendation of payload team after the design is scrutinized**
 - **Increase the total power**
 - **Overly optimistic design during proposal effort**

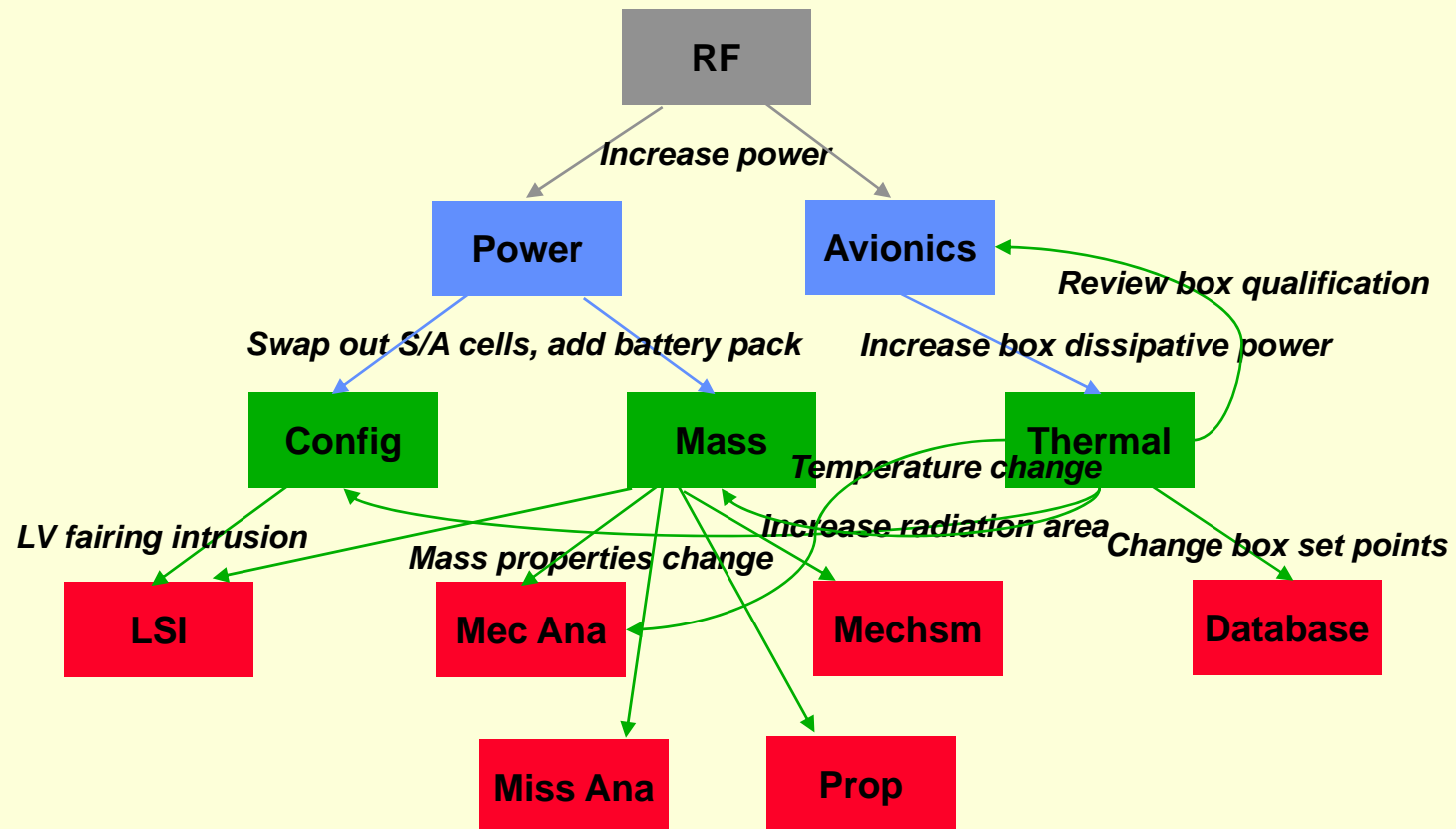
Selected Impact to the Design of GrowingSat



Selected Impact to the Design of GrowingSat



Selected Impact to the Design of GrowingSat



Headaches and 'Disaster' On-Hand



**Life cycle of a satellite very much resembles the life cycle of a human being –
With the passage of time, it becomes bigger and heavier.**

- **Spacecraft configuration and mechanical/structural design**
 - **Re-layout of boxes**
 - **Routing of harnesses**
 - **Physical access of components**

- ❑ **Mass properties**
 - **Model does not always predict CM exactly**
 - Use balance mass – part of contingency
 - Spacecraft engine needs to align with center of mass
 - Spacecraft ‘not clean’ during weighing
 - Test fixtures
 - Test harnesses

- ❑ **Spacecraft configuration and mechanical/structural design**
 - **Delivered hardware does not fit**
 - Interface control documents not correct
 - Exceeded tolerances
 - Design dropouts – require real time fixes
 - **Hardware replacement (boxes)**
 - Generate access paths (cut holes)
 - **Damaged hardware**
 - Drilled at wrong location

- ❑ **Thermodynamics**
 - **Model correlation after thermal tests**
 - **Out-of-tolerance tests**
- ❑ **Mechanical Analysis**
 - **Model correlation after static and dynamic tests**
 - **Out-of-tolerance tests**
- ❑ **Mechanisms**
 - **1-g (gravity) versus 0-g**
 - **Special Test Equipment (STE) are required**
 - **Model correlation for deployment tests**
 - **Out-of-tolerance tests**

❑ Compatibility issues

- Does the spacecraft fit in the container
 - Shock isolation devices, air conditioner, vent holes
 - Clearance
 - Environment sensors
- Does facilities have enough hook height

- ❑ **All members of design team**
 - **Possess system view**
 - **Be aware of your impact to others**
- ❑ **Always be ready to perform ‘damage control’**
- ❑ **Should let known of ‘hidden margins’**

System engineers need to perform damage control