



Implementation of the Fault Tolerance Module in PHOENIX CubeSat

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Outline

- Introduction
- Phoenix Nanosatellite
- Flight Software Design for Phoenix
- FDIR Module
- Conclusion



Introduction

- A **CubeSat** is a type of **Nanosatellite** (10x10x10 cm, weight 1 kg) which offers all the standard functions of a normal satellite.



Phoenix, 2U CubeSat

- **Command and Data Handling System(C&DH):**
 - Schedule Mission Tasks
 - Payload Operation and Data Handling
 - House-Keeping
 - Ground Command Handling

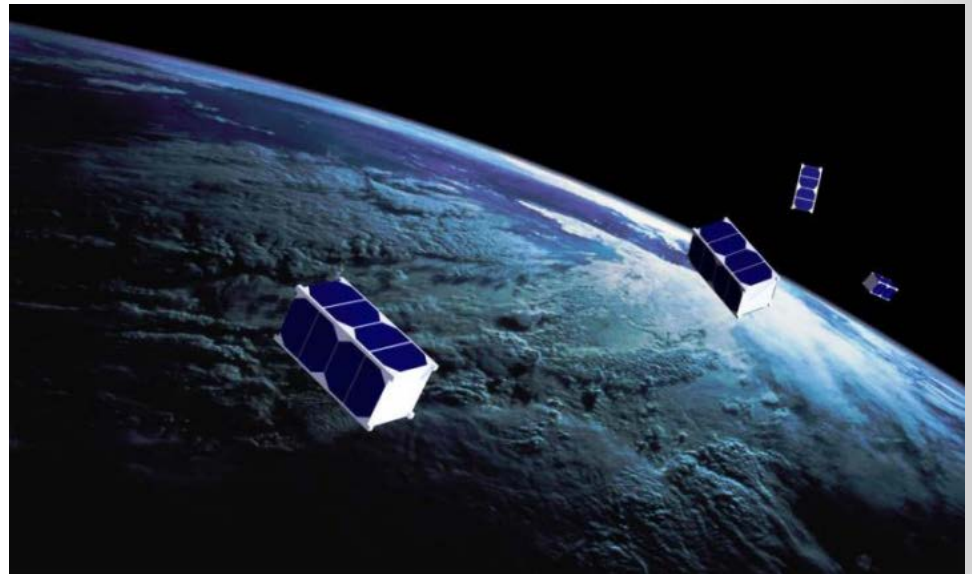


QB50 Mission



Images from VKI

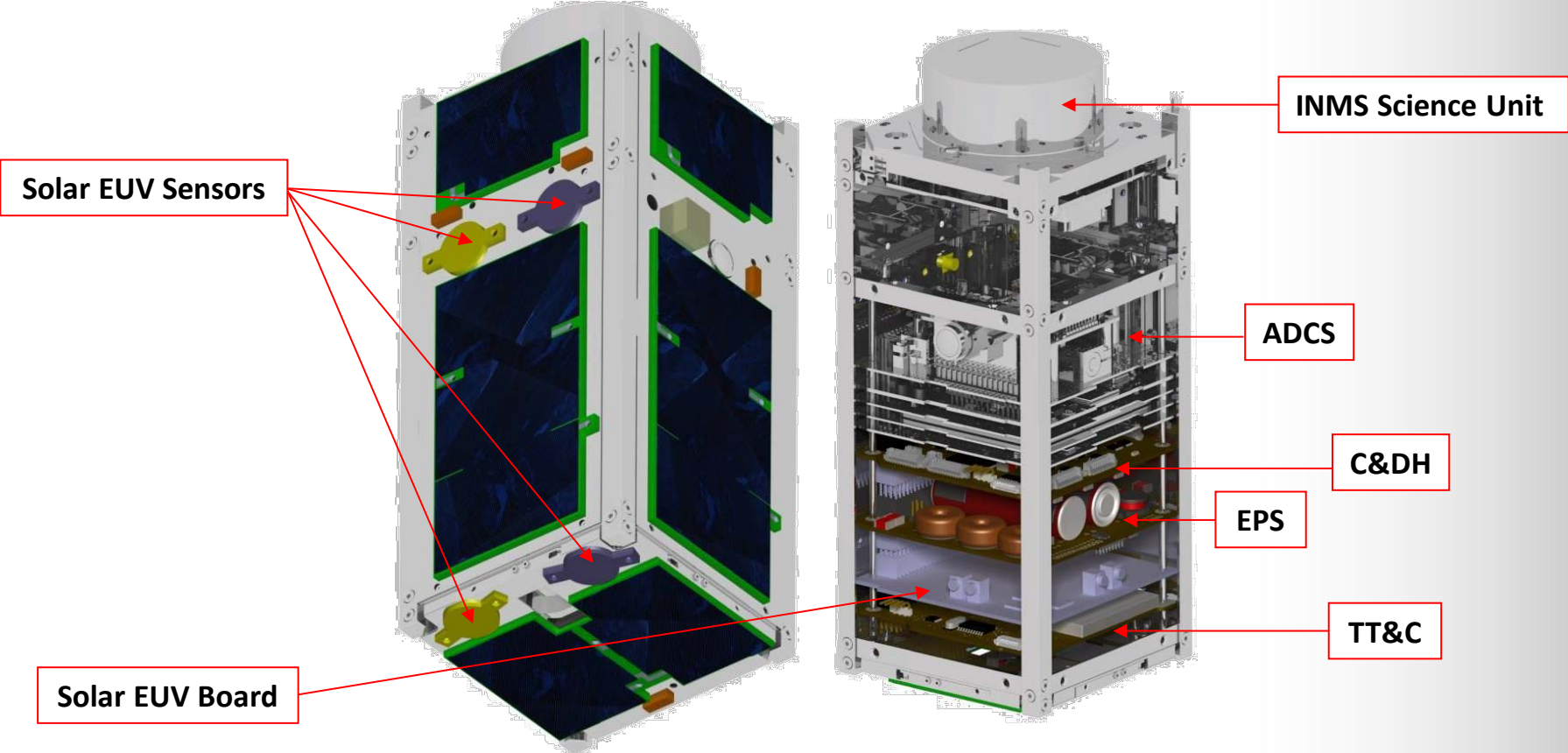
An international network of 50 CubeSats for multi-point, in-situ, long duration measurements and in-orbit demonstration in the lower thermosphere.





Phoenix Nanosatellite

Payloads: 1. Ion and Neutral Mass Spectrometer (INMS)
2. Solar EUV Sensors





C&DH Module

NanoMind A712D is a space proven COTS manufactured by GomSpace

- **Main Features:**

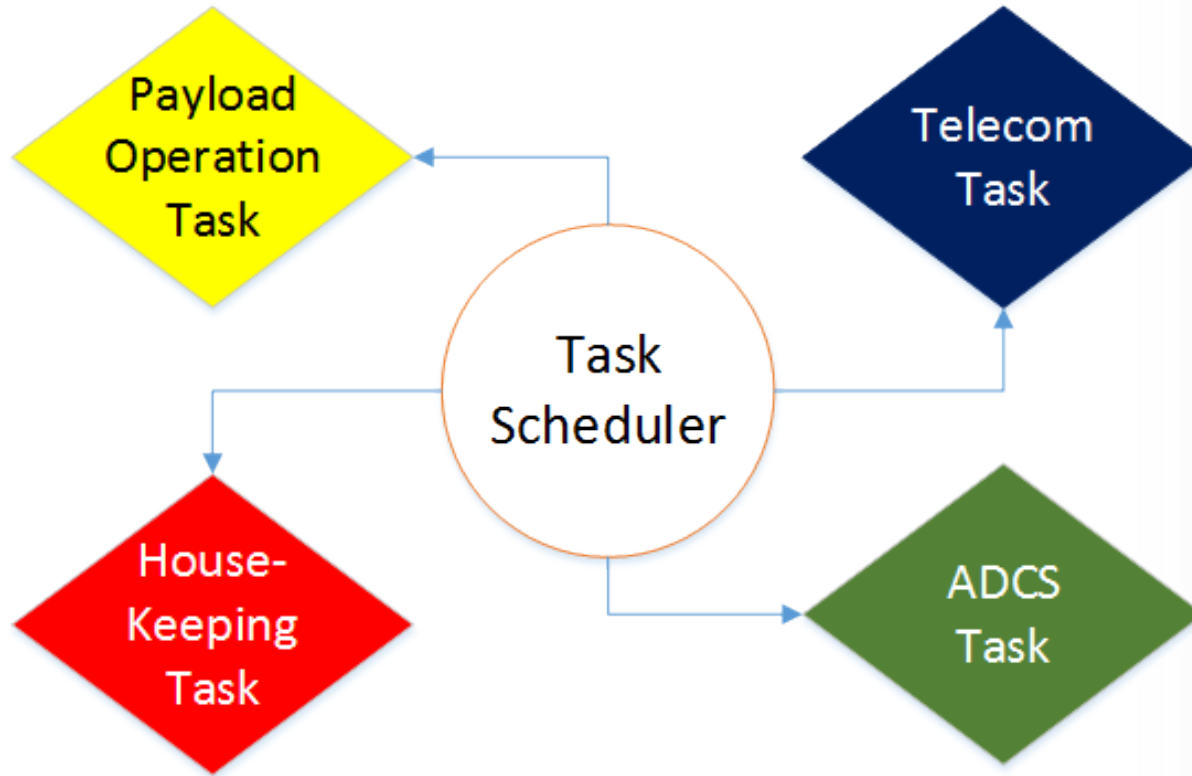
- 32-bit ARM7 RISC CPU
- Compatible with FreeRTOS
- 2GB MicroSD card
- I2C interface
- USART interfaces
- GPIO pins
- Real Time Clock



Images from
GOMSpace



Flight Software Feature





Failure Mode Analysis

Hardware Issue

- Hardware Damaged
- Single Event Upset(SEU)
- Single Event Latch-Up (SEL)

Software Issue

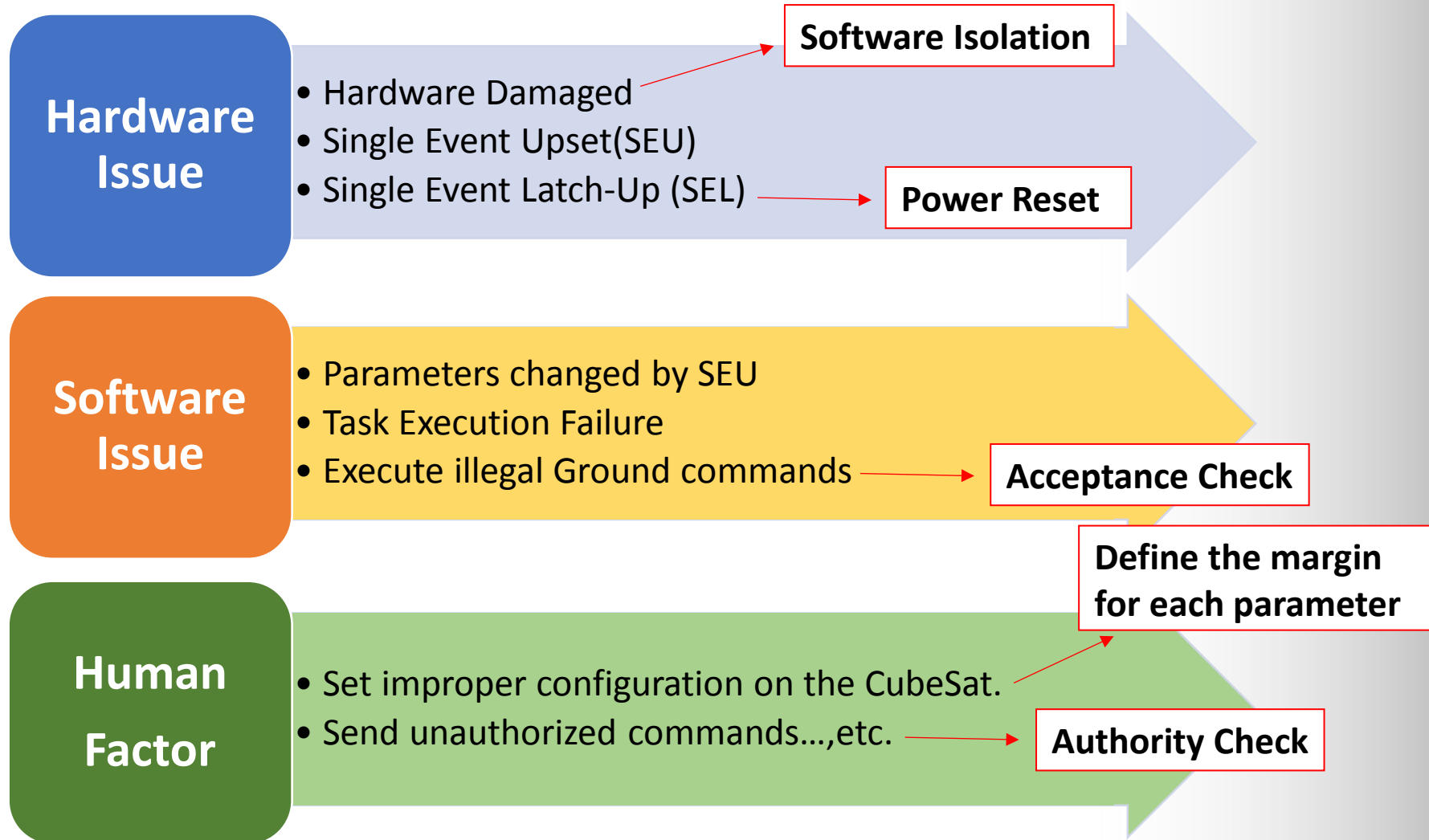
- Parameters changed by SEU
- Task Execution Failure
- Execute illegal Ground commands

Human Factor

- Set improper configuration on the CubeSat.
- Send improper commands...,etc.



Failure Mode Analysis





FDIR Implementation

**Data
Redundancy**

**Watch Dog
Timer**

**Software
Supervisor**



FDIR Module Implementation

**Data
Redundancy**

- **To against Single Event Upset(SEU)**
 - Cyclic Redundancy Check(CRC) algorithm in file-system
 - One additional backup copy



FDIR Module Implementation

**Watch Dog
Timer**

- **As the final defense**
- **Against communication latch-up**
 - Should be reset by software in a period
 - If somehow no one reset it, power reset the satellite.



FDIR Module Implementation

Software Supervisor

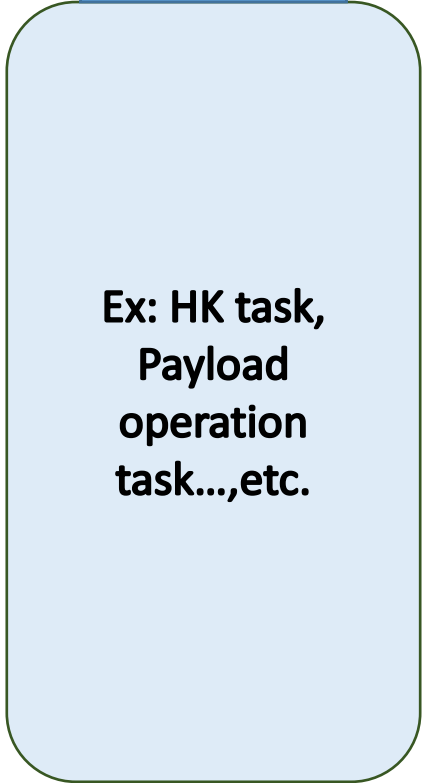
- **To against single events & Task Failures**
 - Routinely scan important parameters
 - Reset watch dog timer
 - Supervise target tasks
 - Recover failure according to library
 - Generate error report
 - Library can be updated by uploading scripts



Supervisor Operation Flow

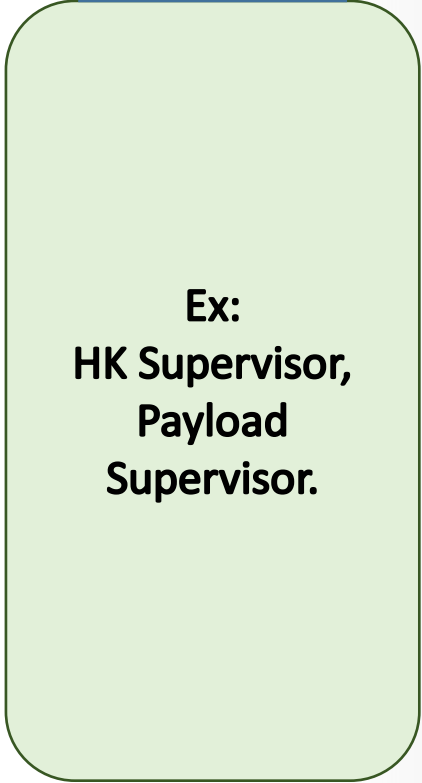
Activate by
Task Scheduler

Work Tasks



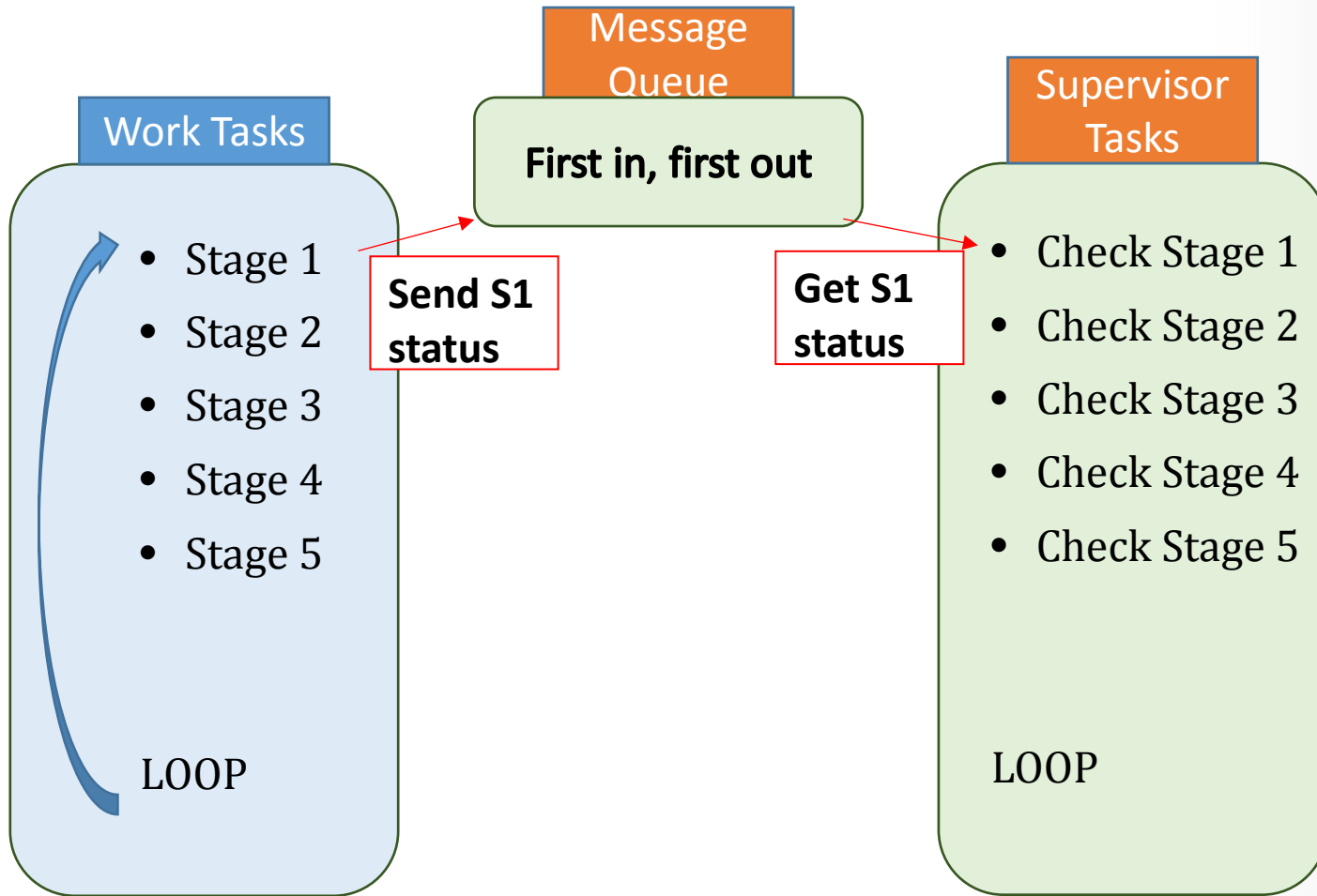
Supervisor
Tasks

Activate by
Task Scheduler
(option)



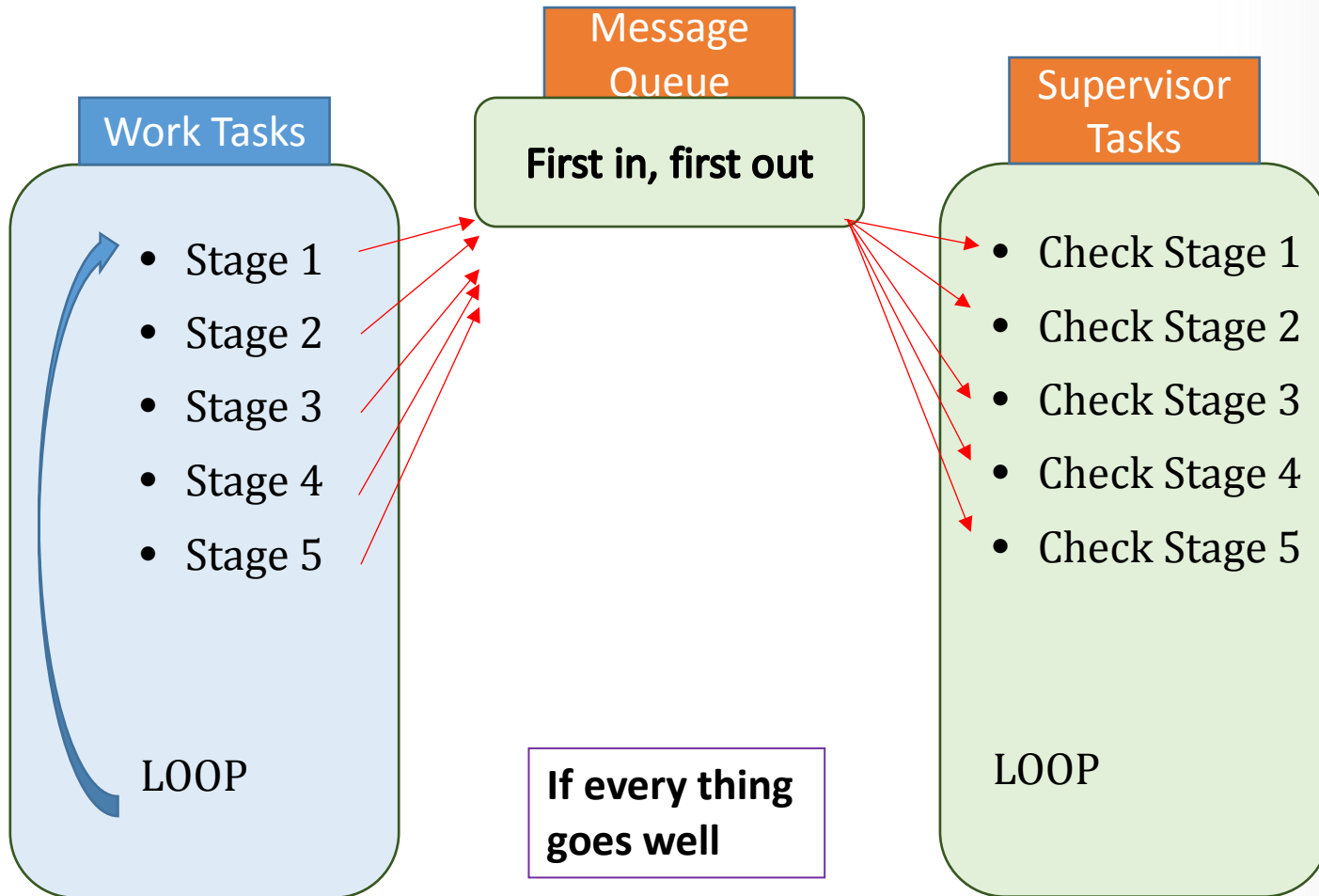


Supervisor Operation Flow



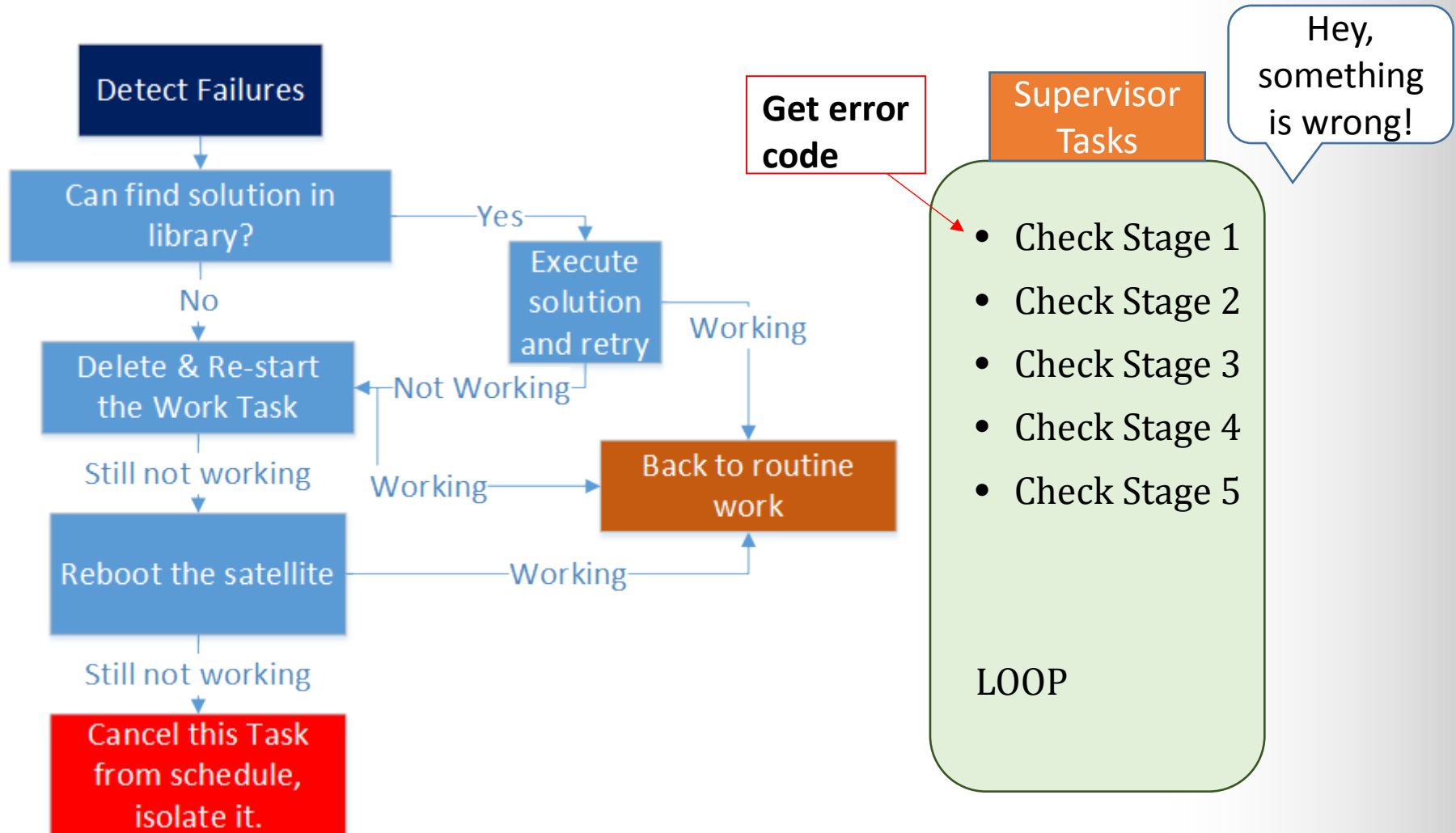


Supervisor Operation Flow





Supervisor Operation Flow





Error Recovery Script

- Library can be updated by uploading scripts

| Task ID | Stage | Error code | Solution ID | Solution command | Check sum |
|--------------|-------------------|-------------------------|------------------------|--|-----------|
| Work Task ID | The failure stage | Describe the error type | The steps of solutions | Ex: Reboot a Subsystem, Configure Parameters, Power control | CRC16 |



Conclusion

- Three FDIR methods are discussed here:
Data Redundancy, Watch Dog Timer and Software Supervisor.
- SEU can be detected and corrected by Data Redundancy and Software Supervisor
- Watch Dog Timer is the final defense.
- Solution library provides flexibility when dealing with failures.



THANK YOU FOR YOUR ATTENTION



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