

Understanding System Safety: Hazards, Controls, Inhibits, and Independence

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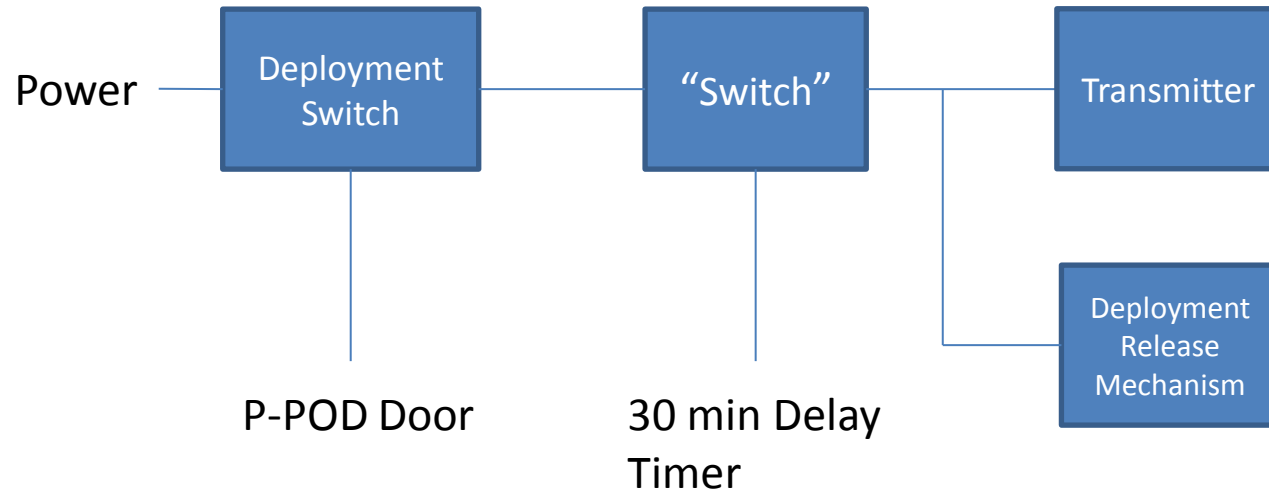


CubeSat Design Specification rev. 12

08/01/2009

- 2.3.1 No electronics shall be active during launch to prevent any electrical or RF interference with the launch vehicle and primary payloads...
- 2.3.2 The CubeSat shall include at least one deployment switch to completely turn off satellite power once actuated.
- 2.4.2 All deployables such as booms, antennas, and solar panels shall wait to deploy a minimum of 30 minutes after the CubeSat's deployment switch(es) are activated from P-POD ejection.
- 2.4.3 RF transmitters greater than 1 mW shall wait a minimum of 30 minutes after the CubeSat's deployment switch(es) are activated from P-POD ejection.

Compliant Architecture ?



Assess Hazard

Hazard Severity		Potential Consequences			Probability*					
Category		Personnel Illness/Injury	Equipment Loss (\$)	Unit Downtime	Data Compromise	A	B	C	D	E
I	Catastrophic	May cause death.	> 1,000,000	> 4 months	Data is never recoverable or primary program objectives are lost.					
II	Critical	May cause severe injury or severe occupational illness.	200,000 to 1,000,000	2 weeks to 4 months	May cause repeat of test program.					
III	Marginal	May cause minor injury or minor occupational illness.	10,000 to 200,000	1 Day to 2 Weeks	May cause repeat of test period.					
IV	Negligible	Will not result in injury or occupational illness.	< 10,000	< 1 Day	May cause repeat of data point, or data may require minor manipulation or computer rerun.					

Risk Priority: Unacceptable Waiver required Operation permissible

*Probability refers to the probability that the potential consequence will occur in the life cycle of the system (test/activity/operation).

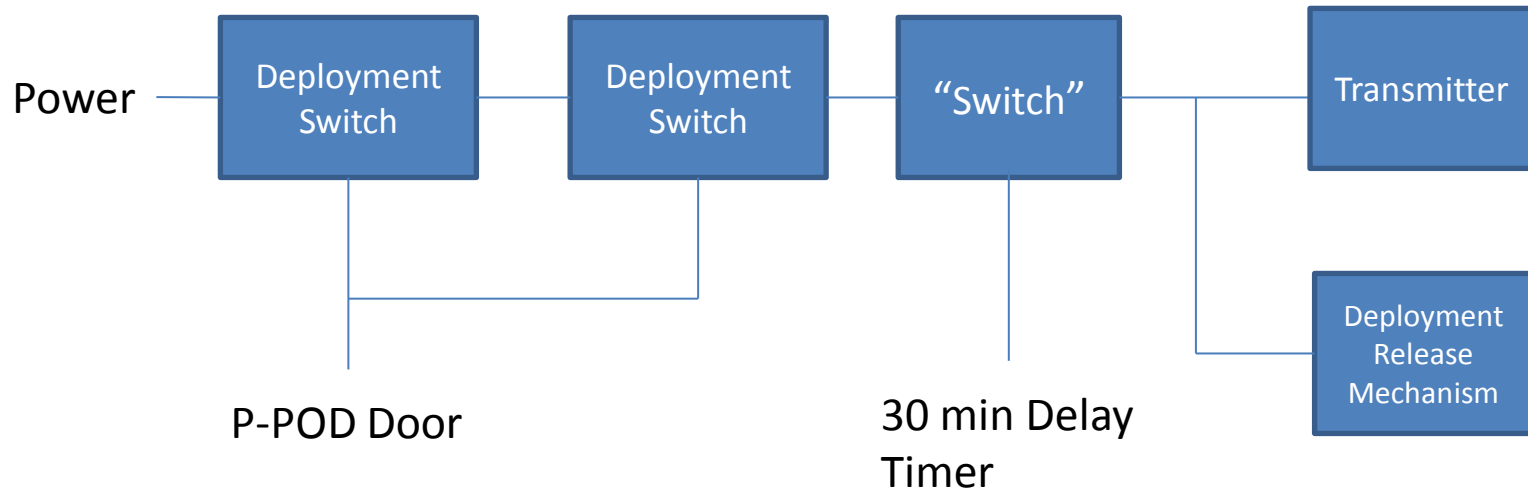
Use the following list to determine the appropriate Risk Level.

DESCRIPTION**	Threshold Level	Probability Value	Specific Individual Item	Fleet or Inventory***
A Frequent	----- 8X10 ⁻² -----	3X10 ⁻¹	Likely to occur repeatedly	Continuously experienced
B Reasonably probable		3X10 ⁻²	Likely to occur several times	Will occur frequently
C Occasional	----- 8X10 ⁻³ -----	3X10 ⁻³	Likely to occur sometime	Will occur several times
		3X10 ⁻⁴	Unlikely to occur, but possible	Unlikely, but can reasonably be expected to occur
D Remote	----- 8X10 ⁻⁴ -----	3X10 ⁻⁴	Unlikely to occur, but possible	Unlikely, but can reasonably be expected to occur
E Extremely Improbable		3X10 ⁻⁵	Very unlikely to occur, but still possible.	Unlikely to occur, but possible

Hazard Mitigation

- Hazard Control Precedence...
 - **Change design to eliminate or minimize hazards**
 - For example: Reduce transmitter power
 - Add engineered safety features
 - **Incorporate safety devices (inhibits)**
 - For example: Introduce Inhibits
 - Provide warning devices
 - Develop procedures and training
- Inhibits
 - Physical devices that interrupt the “power path” needed to turn on a potentially hazardous device

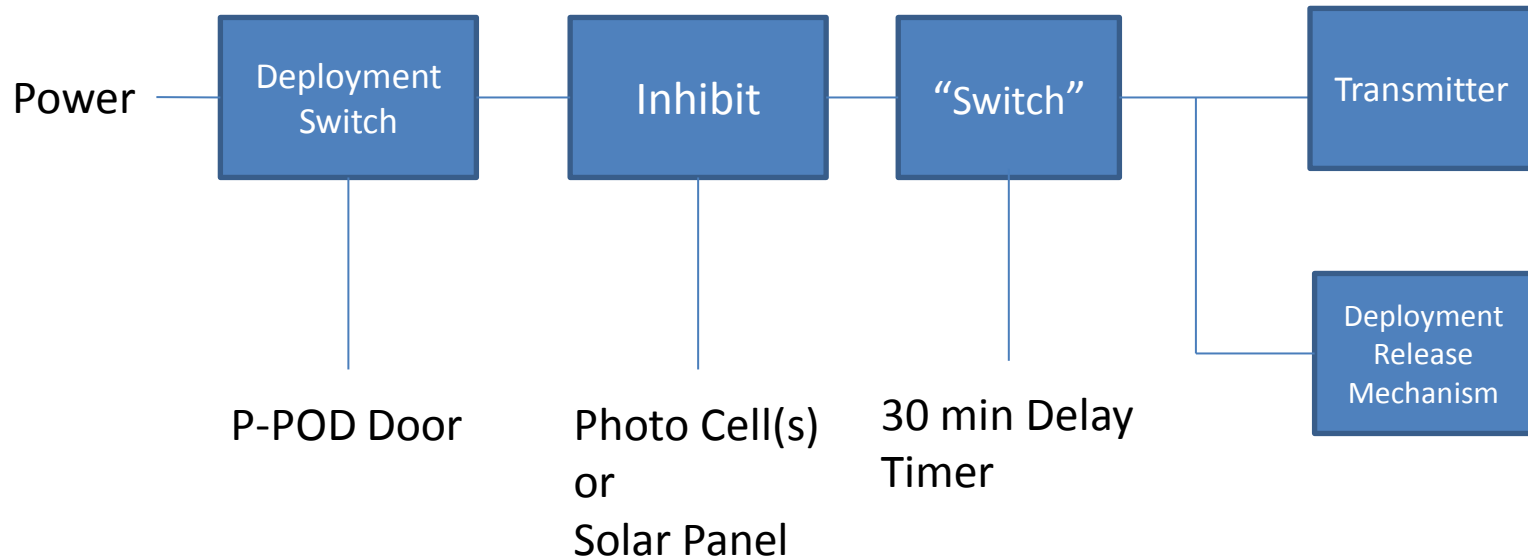
Two Series Deployment Switches



Two independent inhibits

- Increased safety
- Double jeopardy for power on

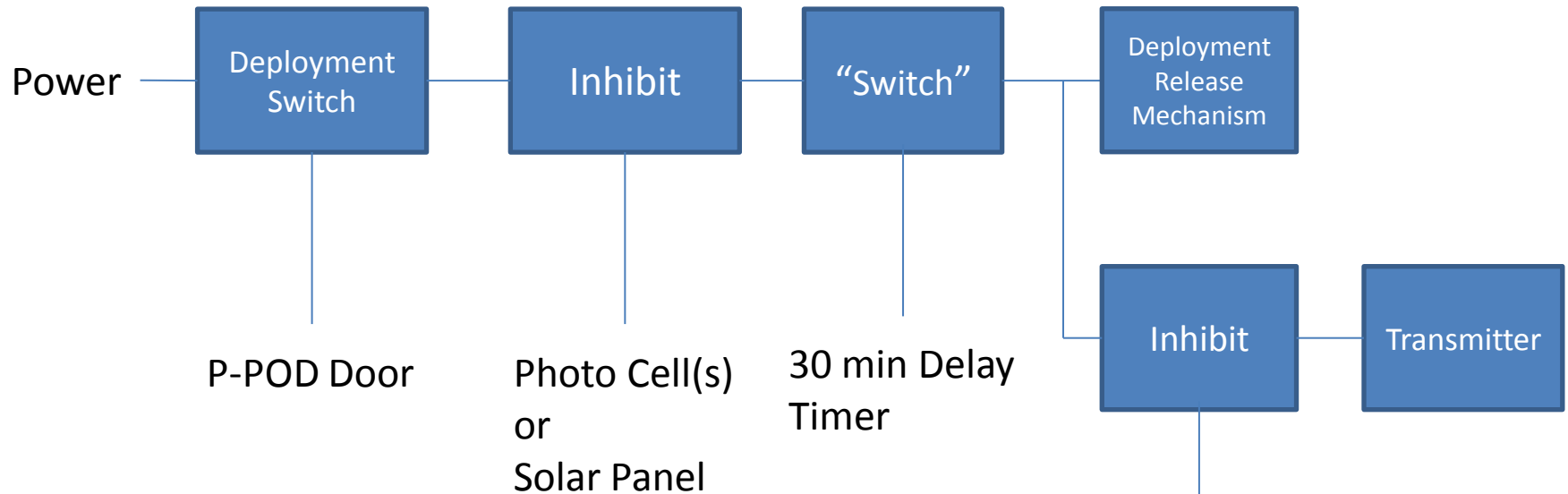
Two Series Deployment Switches



Two independent inhibits

- Increased safety
- Still single inhibit for power on

Transmitter Requires Additional Inhibit

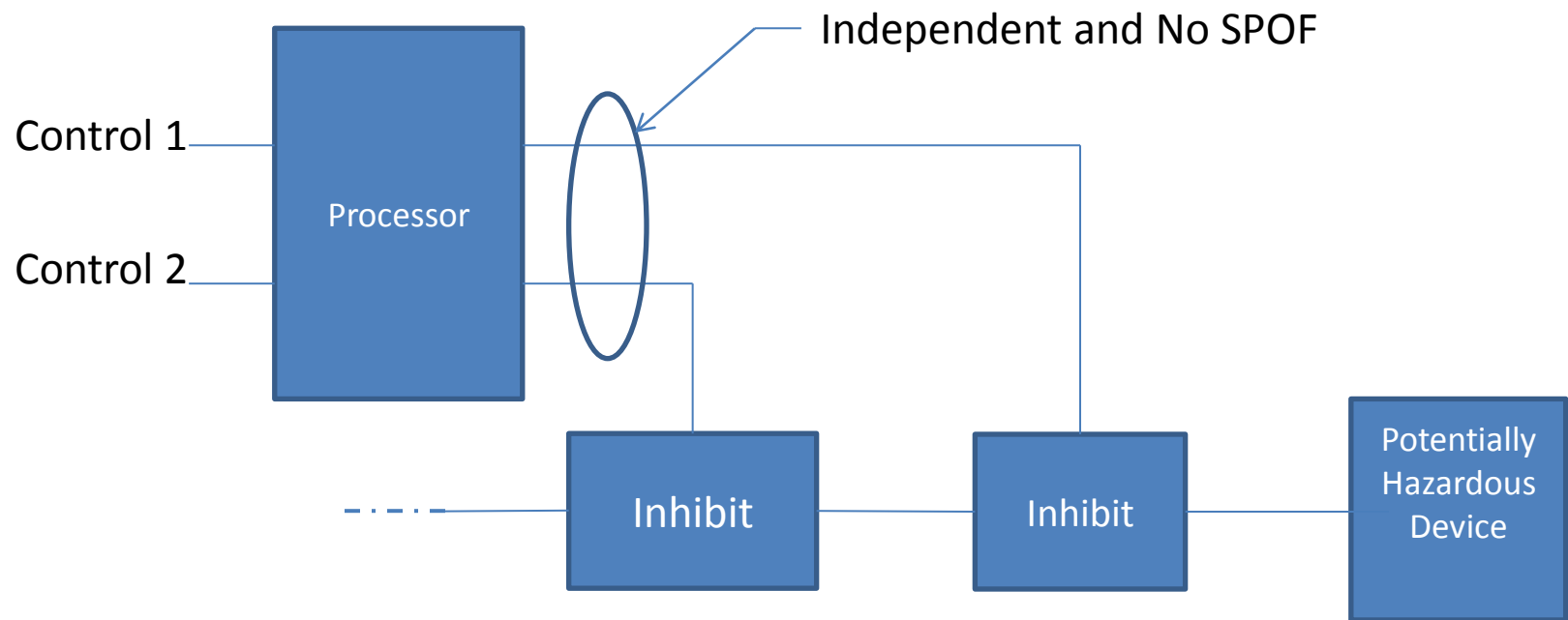


Two independent inhibits for deployables
Three independent inhibits for transmitter
Still single inhibit for power on

Confirm Antenna
Fully Deployed (Good Idea)
or
Ground Command

No Single Point of Failure

- Multiple inhibits controlled by a single processor could have common failure mode



Summary

Identify Hazards



Assess Hazard Risk



Identify Safety Measures



Reduce Hazards

1. Identify hazards and causal factors using a systematic approach.

2. Assess severity and probability of hazard mishap risk.

3. Identify mitigation measures (safety design requirements).

- Influence design, order of precedence

4. Reduce hazard risk to an acceptable level.

- Make inhibits work for both safety and mission assurance

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