



Essential Failure Modes and Effects Analysis (FMEA) and the Design Influence of Space Launch Vehicle Avionics Systems



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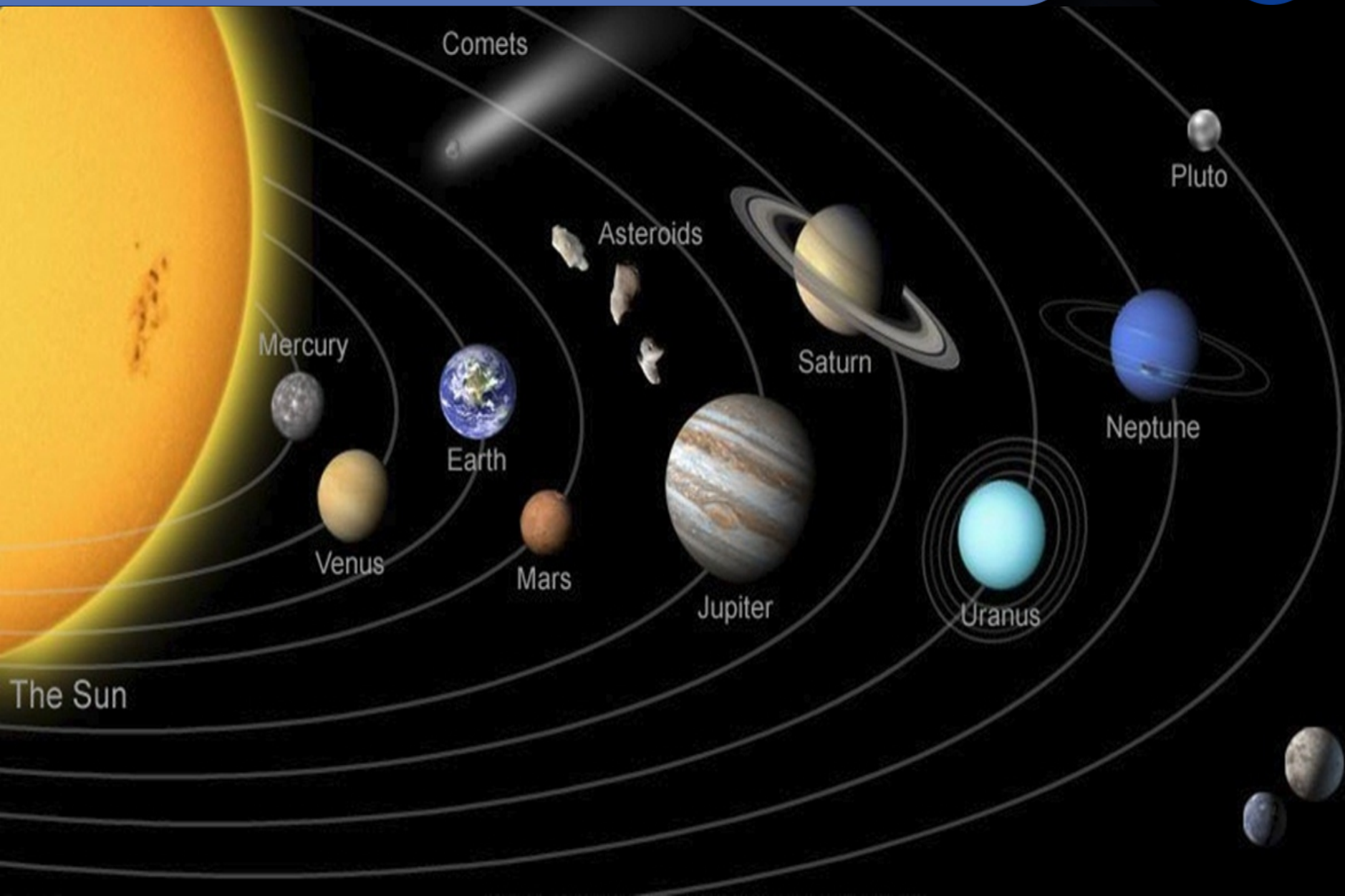
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Background



- Sophisticated electronics are prevalent in modern launch vehicle avionics system
 - Such as flight control computers and engine controllers
- Schedule, cost and safety risk constraints result in increased reliance on analysis over integrated testing
- Avionic system circuits use plenitudes of passive and active electrical components
 - such as resistors, capacitors, inductors, transistors, amplifiers, etc.
- The cost of single electrical components is small compared to entire space exploration missions.
- FMEA can effectively influence design and reduce loss of mission risks

Our Solar System



Presentation Outline



- Background
- Electrical Component Review
- Electrical Diagram Tutorial
- Circuit-Level FMEA
- Design Solution

1. Electrical Component Review



- **Passive Components**

- Does not require a power supply to perform its intended function
- Includes resistors, capacitors, inductors, transformers, etc.
- Includes RC, RL, and RLC filters

- **Active Components**

- Requires a power supply to perform its function
- Includes diodes, transistors, operational amplifiers, etc.

1.a Passive Components Cont.



- Resistors have several functionalities and can be utilized as:
 - Current Limiter
 - Voltage divider
 - Wheatstone Bridge Circuits (Gage Strain)
 - Heat-sense application (photoresistor)
 - Light brightness
- Capacitors store electric charge to be available the charge when needed for immediate use
 - The reactance nature of capacitors is utilized in signal noise filtering

1.a Passive Components Cont.



- Filters are used in circuits to be responsive to certain frequencies
 - Very effective at filtering noise from signals
- For instance, an RC filter can be designed for a specific cutoff frequency, and comes in two basic types:
 - Low-pass filter (Filters AC signals)
 - High Pass filter (Filters DC signals)

1.b Active Components



- Transistors are semiconductors doped with impurities to manipulate current flow
- Mostly used as electronic on/off switches and amplifiers
- They come in different types:
 - BJT (N-P-N and P-N-P)
 - FET
 - MOSFET



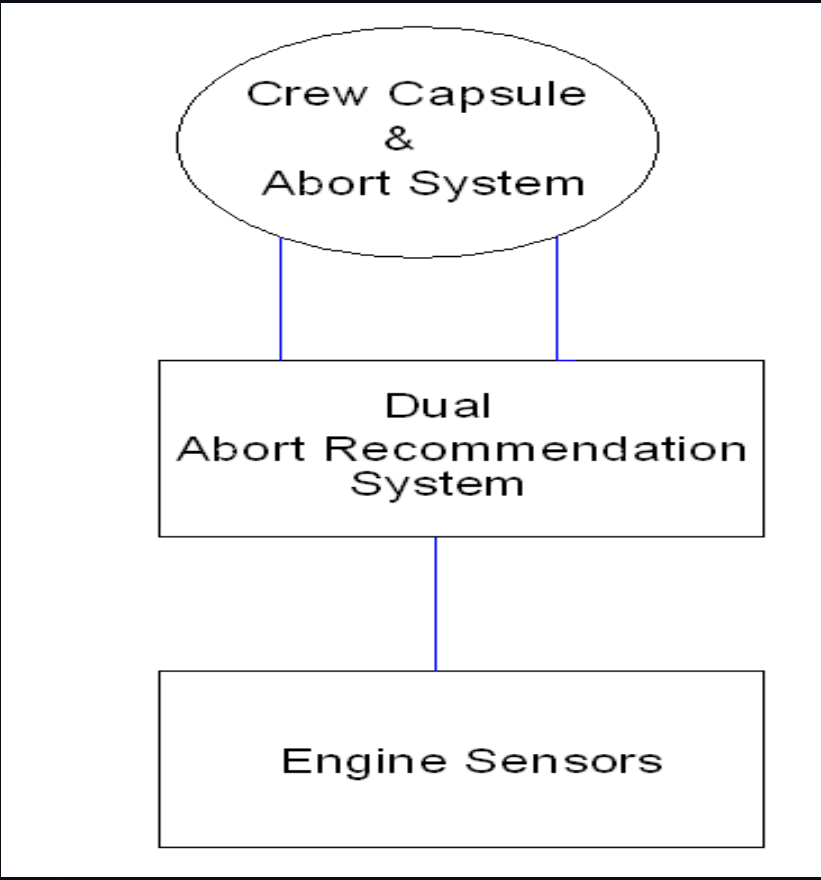
1. c Integrated Circuits

- A chip containing discrete electronic components (passive and active) functioning together as a larger circuit

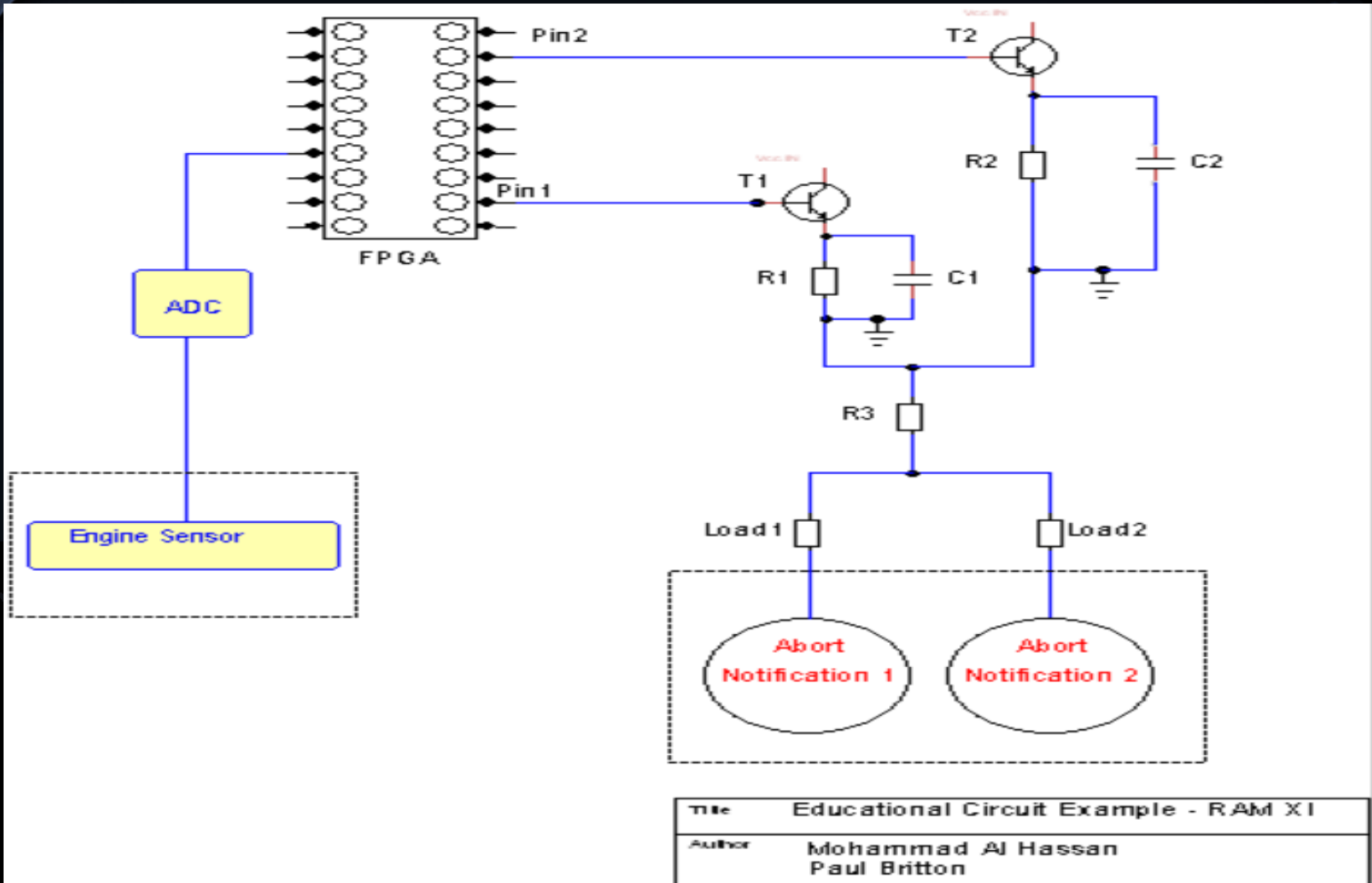




2. Notional Vehicle Block Diagram



2. Reading Electrical Diagrams

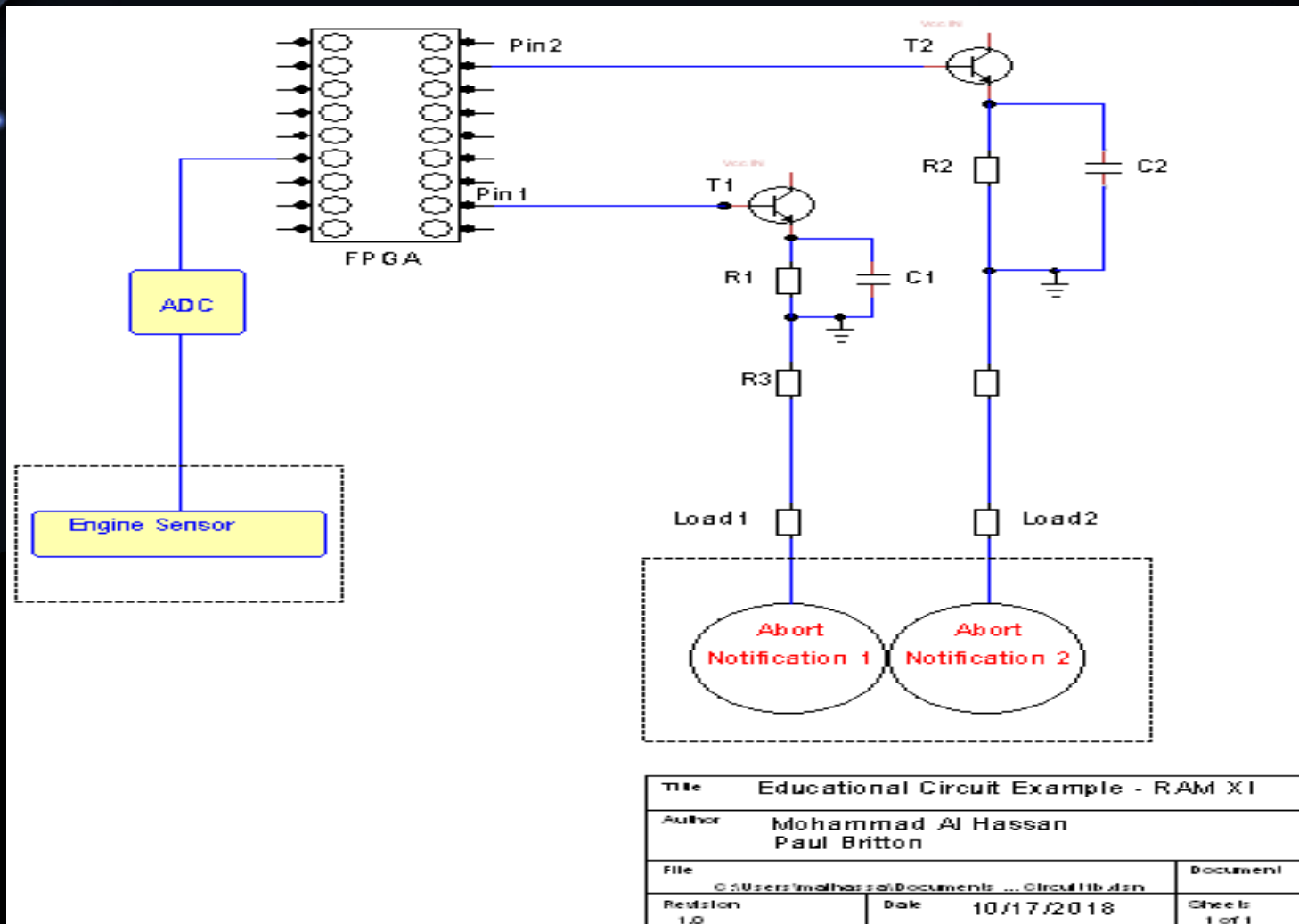


3. Circuit Level FMEA

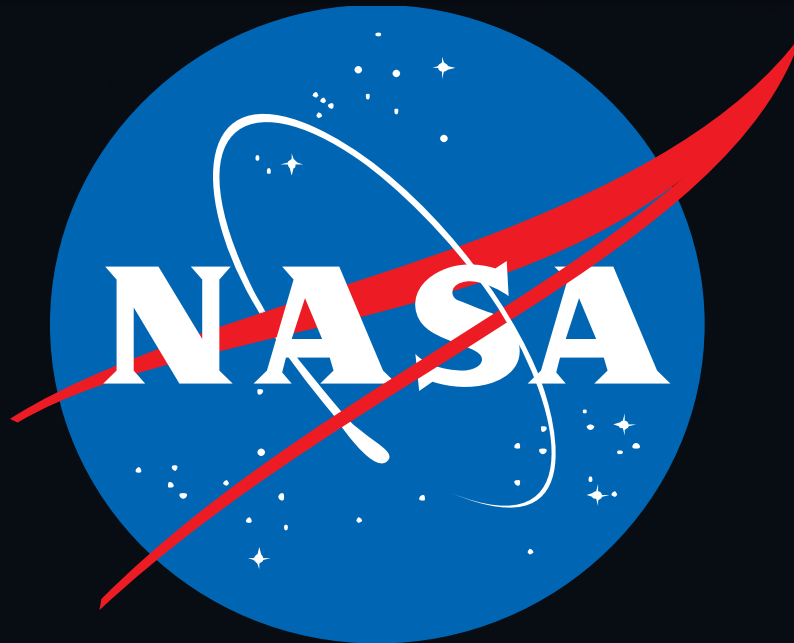


Component	Failure Mode	Immediate Effect	Next Effect	Final Effect
Transistor 1	Fails short	Collector-to-emitter shunts (makes), allowing Vcc to supply power to R1	Load 1 energizes, as well as Load 2 due to common wiring. False-positive Abort recommendation is sent to crew	Loss of mission, vehicle and crew
Transistor 2	Fails short	Collector-to-emitter shunts (makes), allowing Vcc to supply power to R2	Load 2 energizes, as well as Load 1 due to common wiring. False-positive Abort recommendation is sent to crew	Loss of mission, vehicle and crew
FPGA - Pin1	Fails high	Pin1 supplies power to the base pin of Transistor1, collector-to-emitter shunts, allowing Vcc to supply power to R1	Load 1 energizes, as well as Load 2 due to common wiring. False-positive Abort recommendation is sent to crew	Loss of mission, vehicle and crew

4. Design Solution



Questions



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