Dependability and Safe State

MDH Solar Car

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FLA 303
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Outline

- Dependability in a SVV
  - Redundancy
  - Parts
  - Design
- Modular System
- Safe State
  - Requirements
  - System Breakdown
  - Schematics
  - Components
- Conclusion

Dependability

Reliability: The solar car shall behave as expected with very few errors in its expected life time

Availability: The solar car system shall be available when needed. If down time exist, it shall be kept at a minimum

Safety: The system shall be safe for users and environment

Confidentiality: Data transferred between the solar car and follow car shall not be accessible for third parties

Survivability: The system shall be designed so that it can withstand the environment it operates in as well as withstand possible accidents

Integrity: The systems data shall only be able to be accessed by authorized user

Maintainability*:* Easy to maintain and repair

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Dependability in a SVV - Redundancy

Reliability of a system:

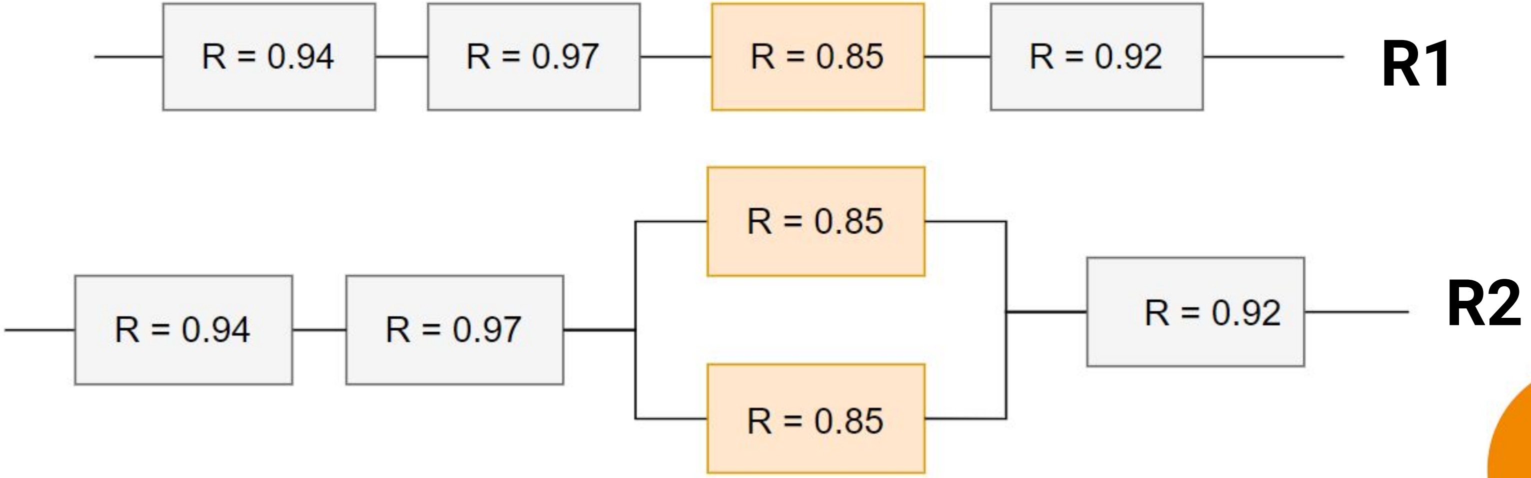
$$R = e^{-\lambda T}$$

Where T is an interval of time

λ = Number of faults / Time (fault intensity)

Dependability in a SVV - Redundancy

What is redundancy?



R1: 0.94*0.97*0.85*0.92 = **0.713**

R2: 0.94*0.97*(1-(1-0.85)*(1-0.85))*0.92 = **0.81998**

Dependability in a SVV - Redundancy

Redundancy

Advantages:

- Higher reliability
- System keeps working even with syúbsystem/component failure

Disadvantages:

- Extra weight
- Extra space
- Extra cost
- Higher complexity

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Dependability in a SVV - Parts

Does parts play a role in the dependability in a vehicle?

YES!

- Easy accessibility to parts makes for easilier repairs
- Open source
- Standard components - easy implementation
- Quality

In case of redundancy:

- Different brands

Dependability in a SVV - Design

Both in hardware and software

Needs to be planned, tested, reviewed and accepted

Important to design interfaces

Modular System

A modular system makes repair and maintenance easy and quick

Advantages

- Changing faulty components fast
- Maintenance can take place outside the vehicle
- Possible to have IP-classificated boxes

Disadvantages

- Need backup boxes - more components
- Takes more space
- Heat generation inside boxes

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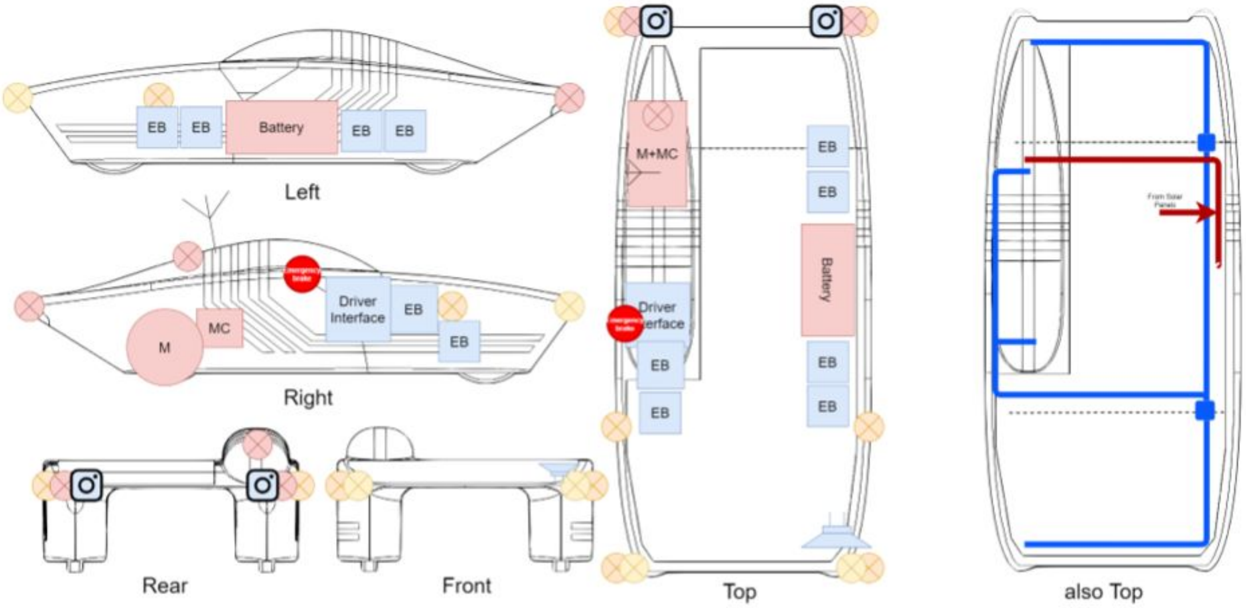
Modular System

Cable Channel and Component Placement



Symbols

⊗	Lamps	■	Cable Connectors	📷	Rear View Camera
EB	Electronic Box	Driver Interface	Dash Board + pedals	Y	Tx/Rx
╱	Low Voltage Channel	MC	Motor Controller	●	Emergency Brake
╱	High Voltage Channel	🔈	Sound Horn		

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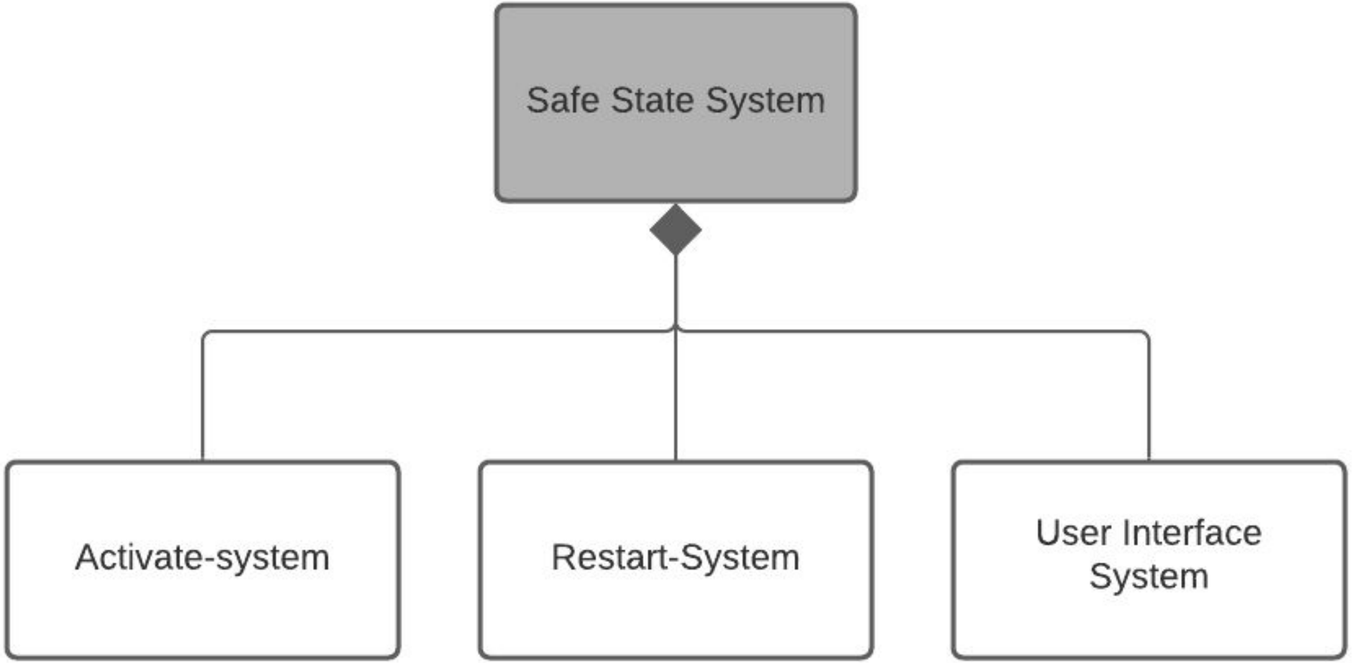
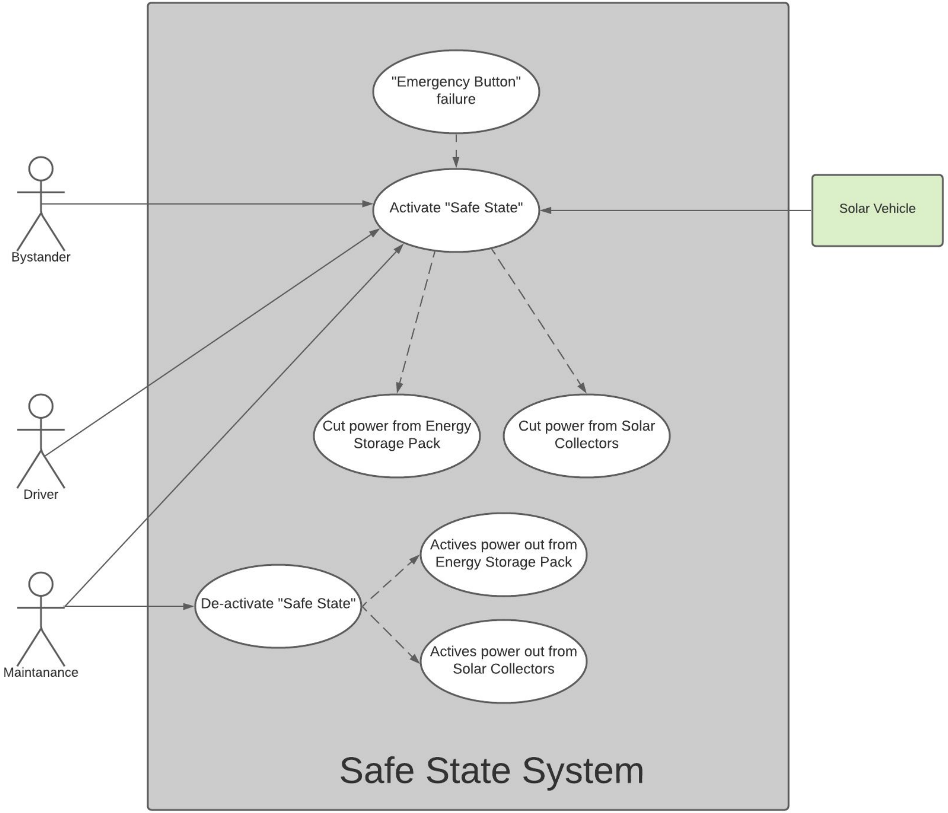
Safe State

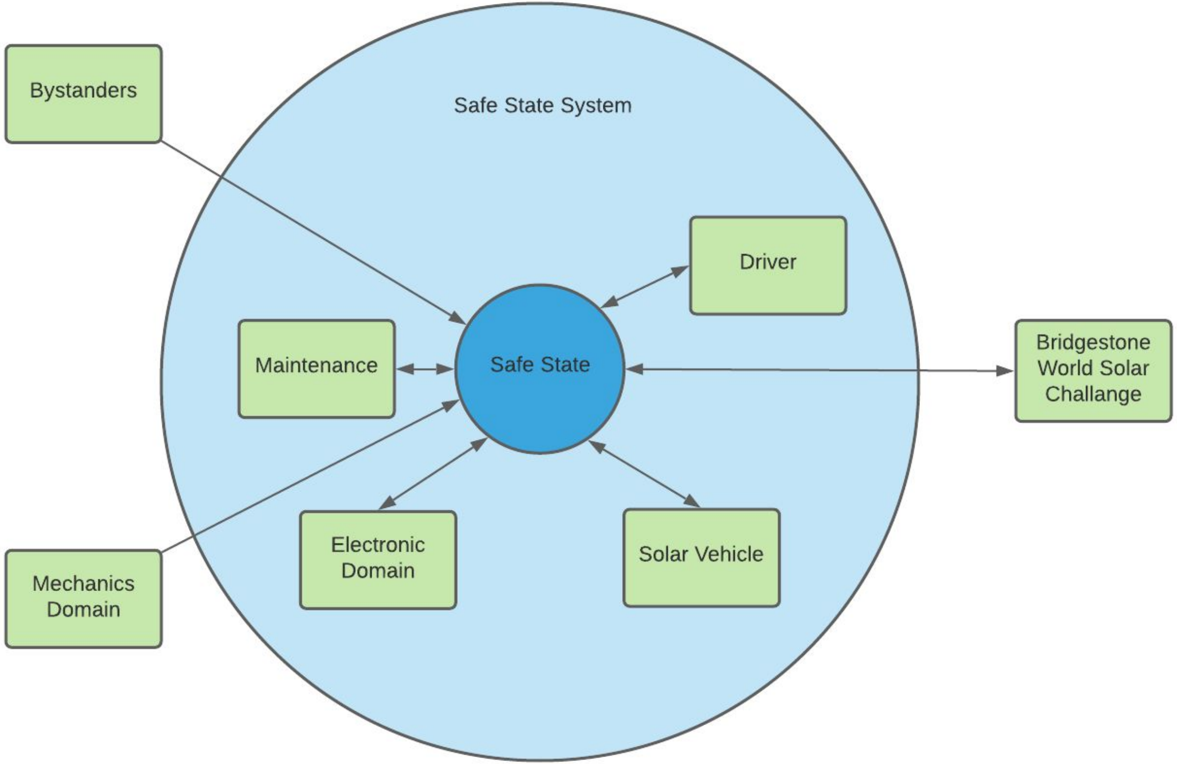
Safe State


Safe State System
Activate-system
Restart-System
User Interface System

Safe State


"Emergency Button" failure
Bystander
Activate "Safe State"
Solar Vehicle
Driver
Cut power from Energy Storage Pack
Cut power from Solar Collectors
Actives power out from Energy Storage Pack
De-activate "Safe State"
Maintanance
Actives power out from Solar Collectors
Safe State System

Safe State


Bystanders
Safe State System
Driver
Maintenance
Safe State
Bridgestone World Solar Challange
Electronic Domain
Solar Vehicle
Mechanics Domain

Safe State - Requirements (1)

- The solar car must have a ‘safe state’ which, in an emergency, minimises the risk of electrical fire and electric shock to occupants, team members, emergency response personnel, and bystanders.

  Safe state is for emergencies and for complete shutdown of the car. In addition to safe state, a solar car may have a “standby” state that provides power to some subsystems outside of the energy storage packs. An external battery is not necessary to bring the car out of safe state. Possible alternatives include:
  - *A switch on the energy storage pack*
  - *An air switch inside an energy storage pack, with an airline to a remote start button*
  - *A fibre-optic switch.*

- When in the safe state:
  - Every conductor emerging from each energy storage pack must be galvanically isolated from every energy storage cell.
  - No voltage may be present across any pair of conductors emerging from energy storage packs or the solar collector..
  - No current may be present through any conductor loop that is external to the energy storage packs or the solar collector.

    MOSFETS and other semiconductor devices are not considered to offer galvanic isolation.
- Any conductor that is more than 200 mm from the nearest PV cell is outside of the solar collector.

- All mechanisms for placing the solar car into safe state and maintaining safe state must be fail-safe; if an electrical activation mechanism fails, the solar car must automatically and immediately place itself into safe state and must remain in safe state indefinitely.

- Emergency Button placement Requirements

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Safe State - Requirements (2)

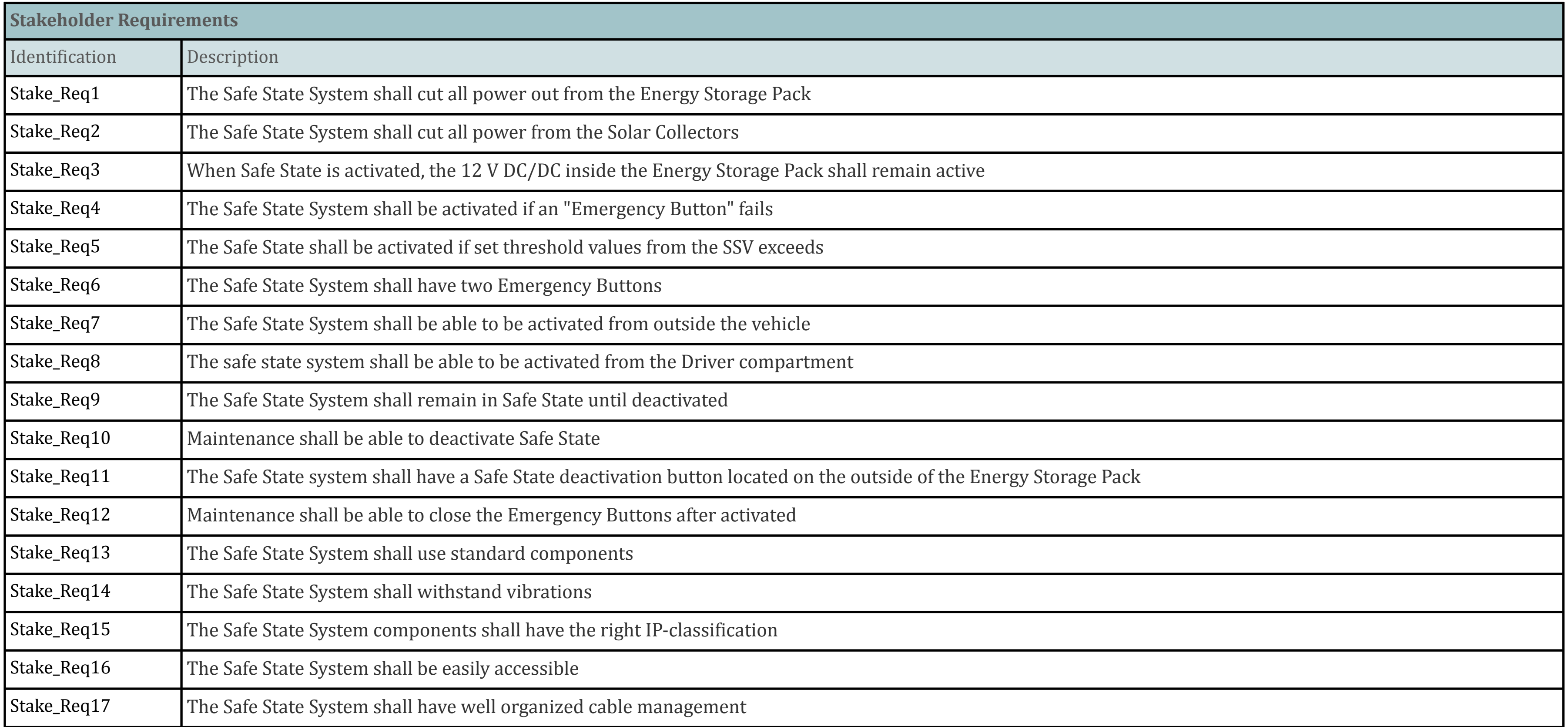
Stakeholders	
	Bridgestone World Solar Challenge
	Driver
	Bystanders
	Maintenance
	Electronics Domain
	Mechanics Domain
	Solar Vehicle

Safe State - Requirements (3)

Stakeholder Goals		
Stakeholder		Goal
Bridgestone World Solar Challenge		
	1.	Follow BWSC Regulations
	2.	Safe car for the driver
Driver		
	1.	Activate Safe State from Driver Compartment
	2.	Safe to driver the vehicle
Bystanders		
	1.	Easy activate Safe State from outside the vehicle
Maintenance		
	1.	Easy to activate Safe State
	2.	Easy restart procedure
	3.	Not being harmed by the vehicle

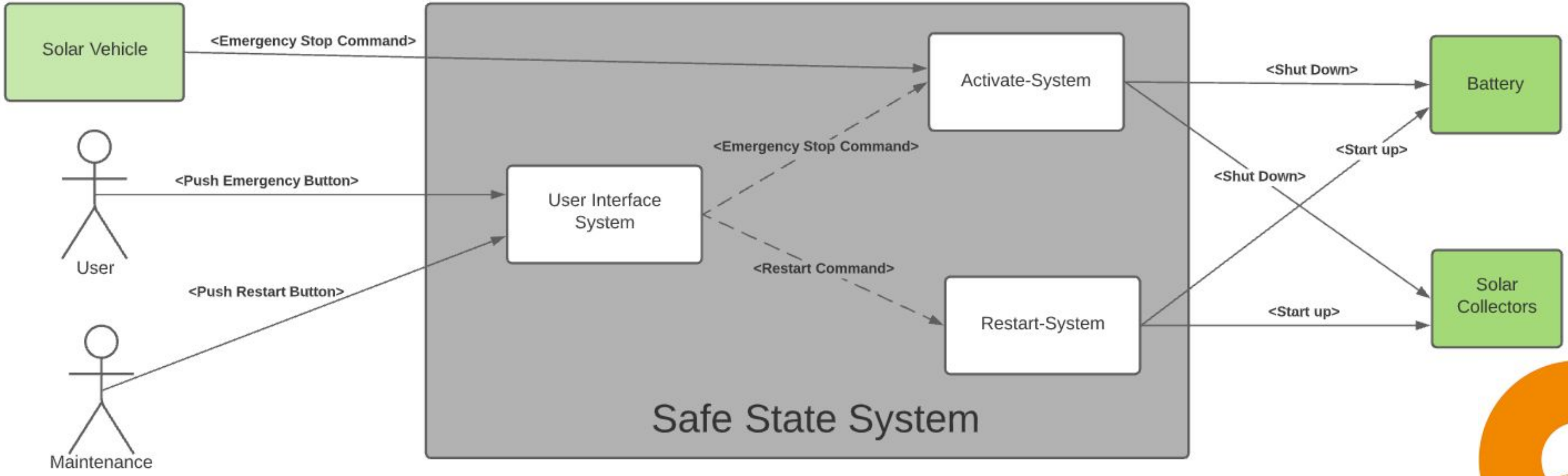
Stakeholder		Goal
Electronics Domain		
	1.	Follow BWSC regulations
	2.	Easy integration
	3.	Dependable
Mechanics Domain		
	1.	Incorporate in vehicle design
Solar Vehicle		
	1.	Enter Safe State
	2.	Protect the systems
	3.	Stay in Safe State until deactivated
	4.	Withstand operating environment

Safe State - Requirements (4)



Stakeholder Requirements	
Identification	Description
Stake_Req1	The Safe State System shall cut all power out from the Energy Storage Pack
Stake_Req2	The Safe State System shall cut all power from the Solar Collectors
Stake_Req3	When Safe State is activated, the 12 V DC/DC inside the Energy Storage Pack shall remain active
Stake_Req4	The Safe State System shall be activated if an "Emergency Button" fails
Stake_Req5	The Safe State shall be activated if set threshold values from the SSV exceeds
Stake_Req6	The Safe State System shall have two Emergency Buttons
Stake_Req7	The Safe State System shall be able to be activated from outside the vehicle
Stake_Req8	The safe state system shall be able to be activated from the Driver compartment
Stake_Req9	The Safe State System shall remain in Safe State until deactivated
Stake_Req10	Maintenance shall be able to deactivate Safe State
Stake_Req11	The Safe State system shall have a Safe State deactivation button located on the outside of the Energy Storage Pack
Stake_Req12	Maintenance shall be able to close the Emergency Buttons after activated
Stake_Req13	The Safe State System shall use standard components
Stake_Req14	The Safe State System shall withstand vibrations
Stake_Req15	The Safe State System components shall have the right IP-classification
Stake_Req16	The Safe State System shall be easily accessible
Stake_Req17	The Safe State System shall have well organized cable management

Safe State - System Breakdown (1)



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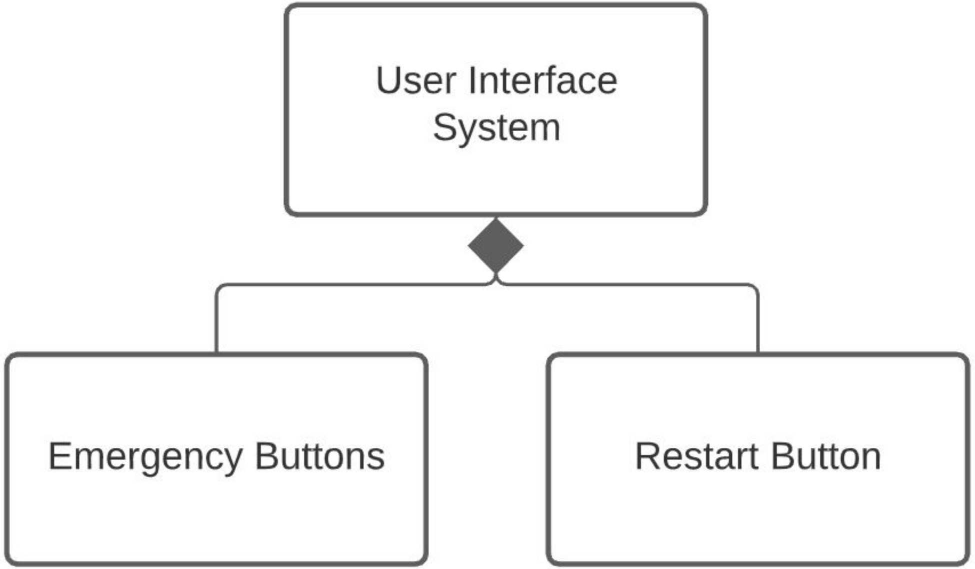
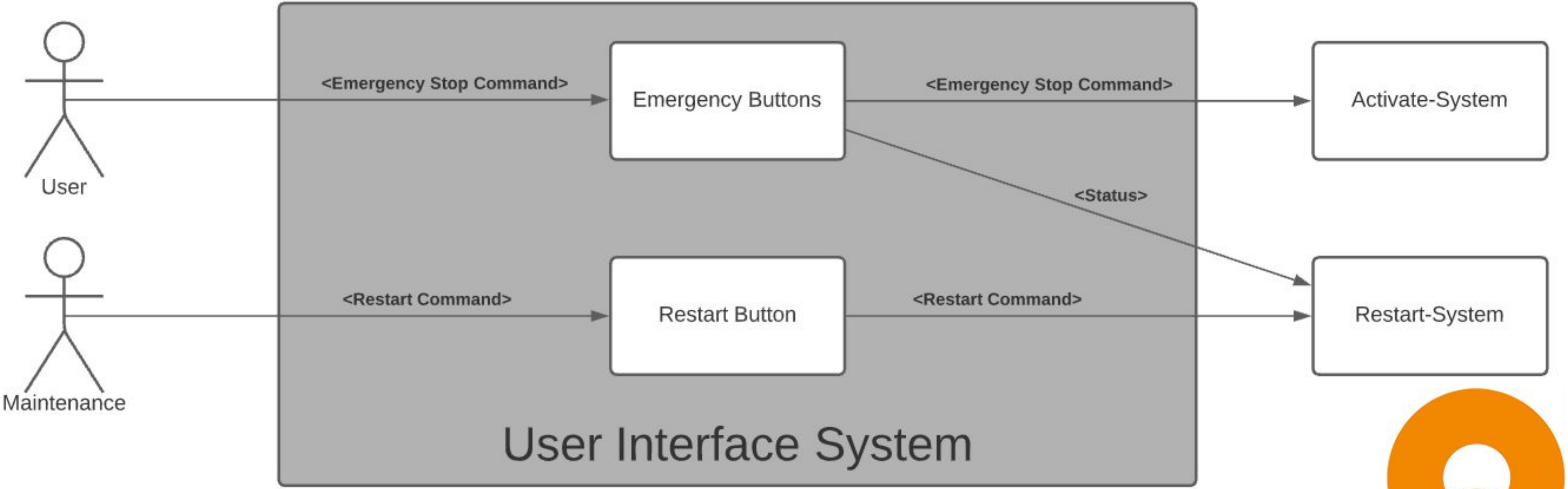
Safe State - System Breakdown (2)



Safe State - System Breakdown (2)



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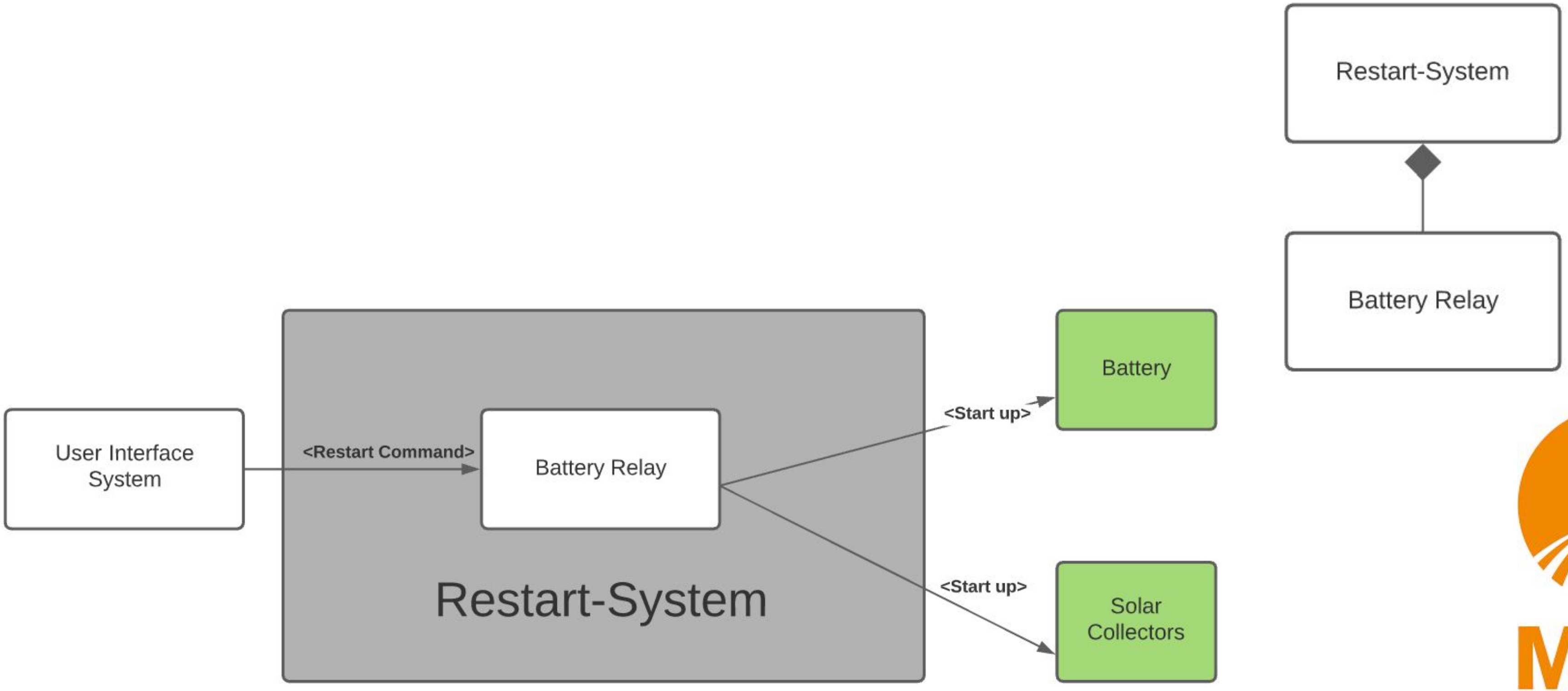
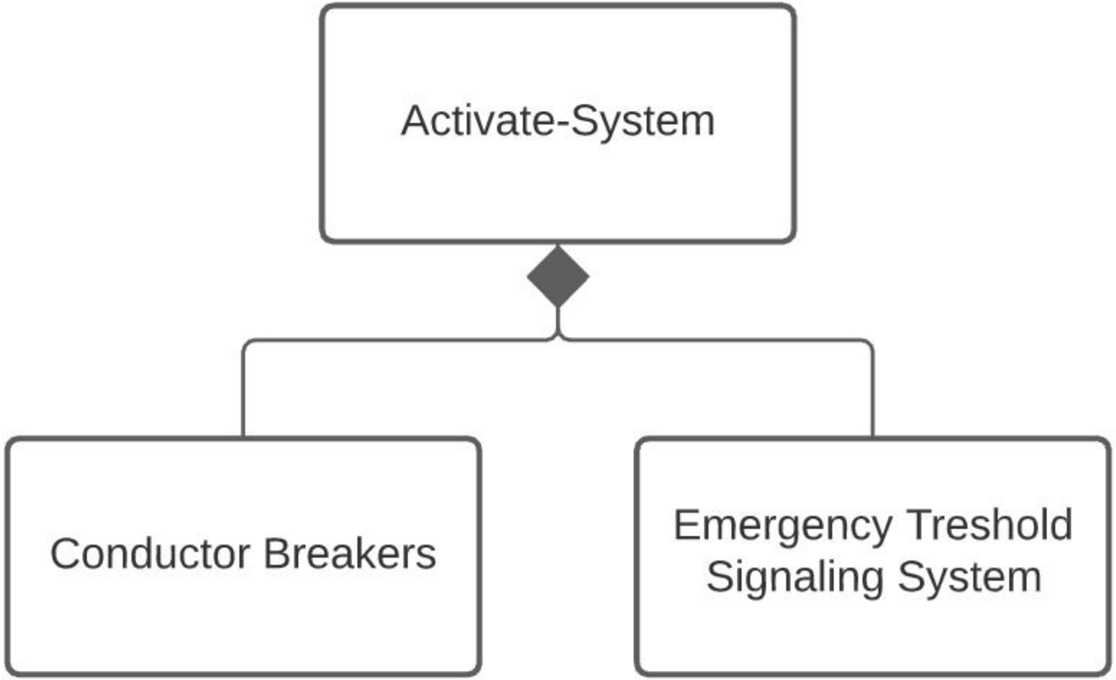
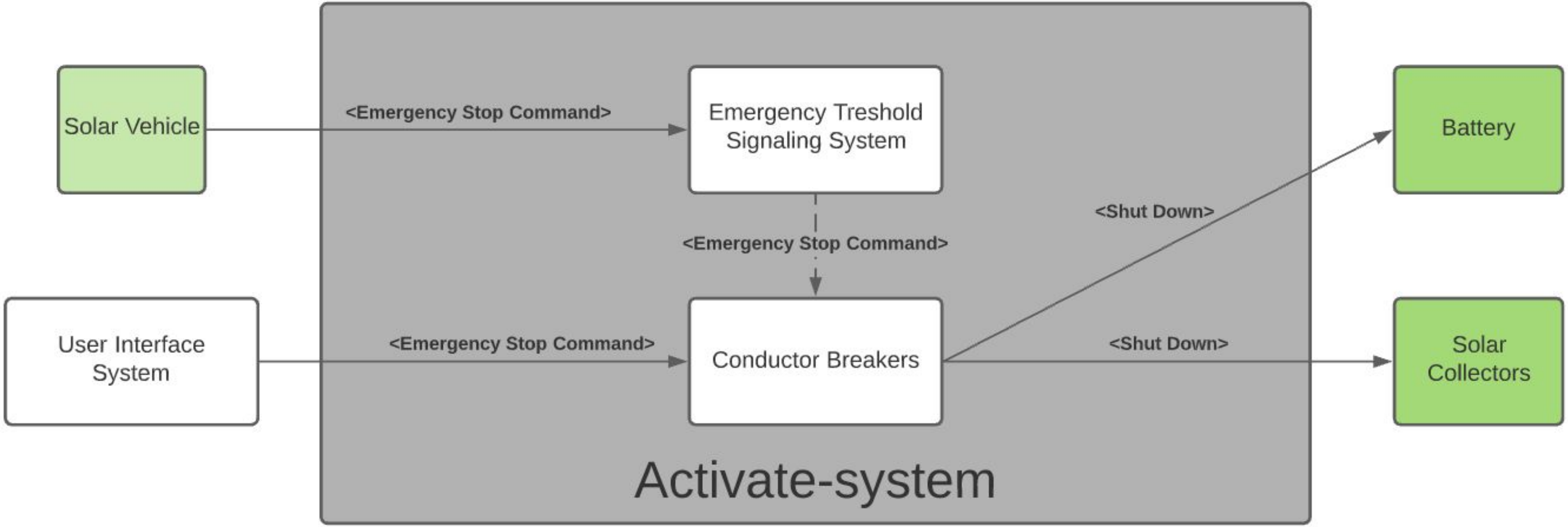
Safe State - System Breakdown (3)



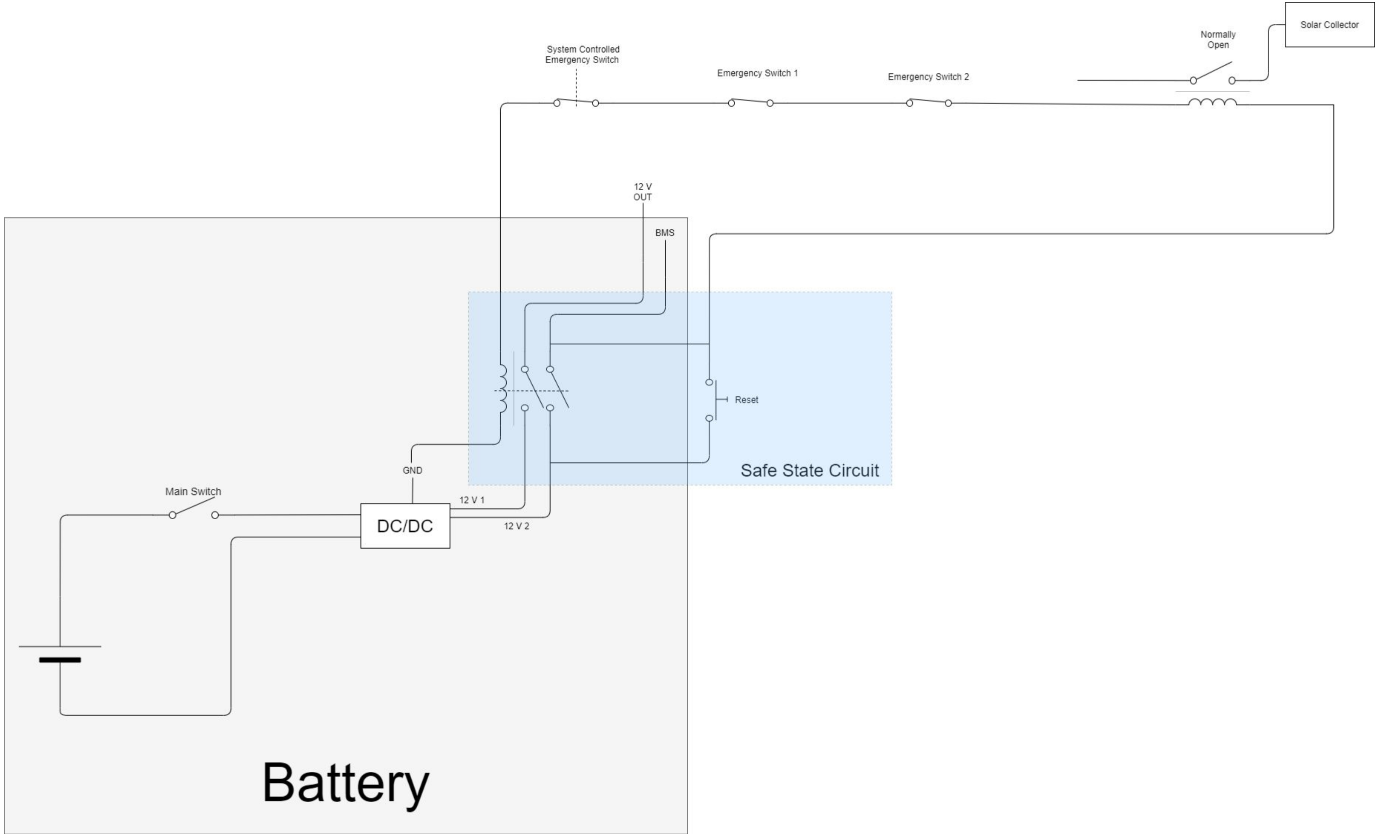
Safe State - System Breakdown (4)

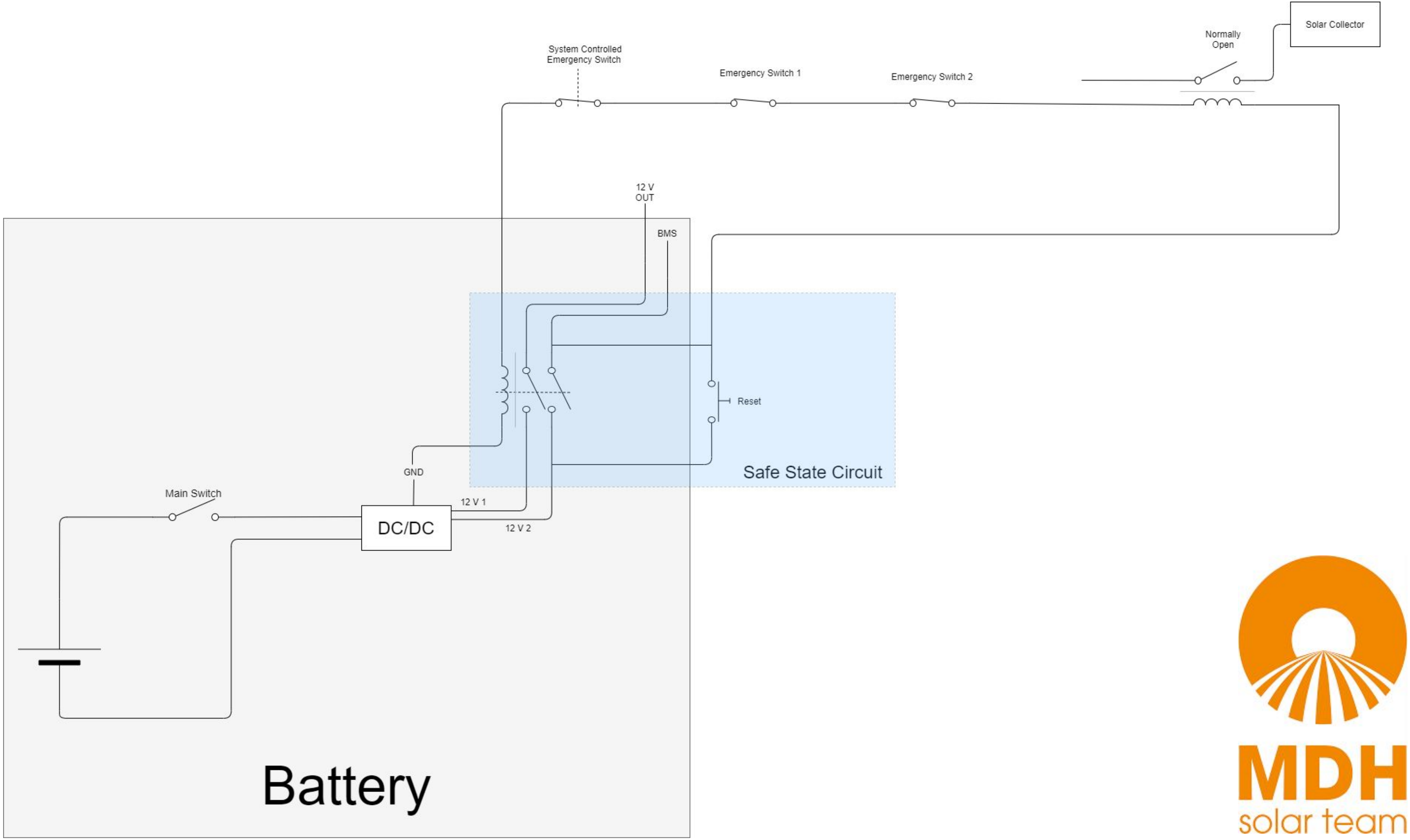


Safe State - System Breakdown (5)



Safe State - Schematics





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Safe State - Components

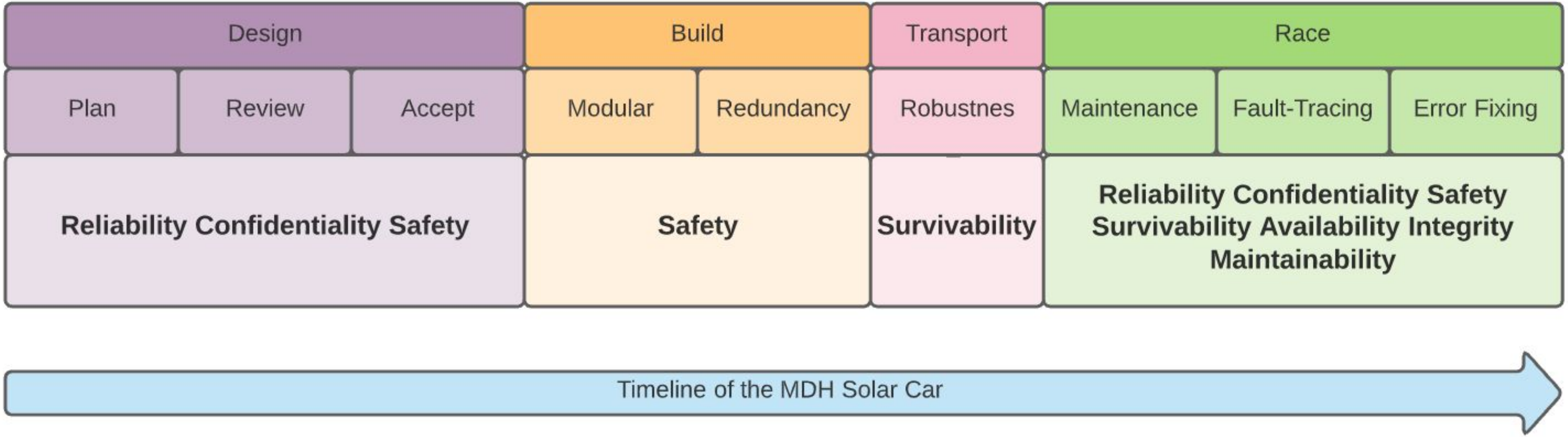
Battery

Emergency Switches

Relays

Software

Conclusion (1)



Design			Build		Transport	Race		
Plan	Review	Accept	Modular	Redundancy	Robustnes	Maintenance	Fault-Tracing	Error Fixing
Reliability Confidentiality Safety			**Safety**		**Survivability**	**Reliability Confidentiality Safety Survivability Availability Integrity Maintainability**		

Timeline of the MDH Solar Car

Conclusion (2)

The Safe State System fulfills following attributes for dependability:

- **Safety**
- **Survivability**
- **Maintainability**
- **Reliability**

Photo: Vattenfall Solar Team/Facebook