

Integrating State Machine Analysis with STPA

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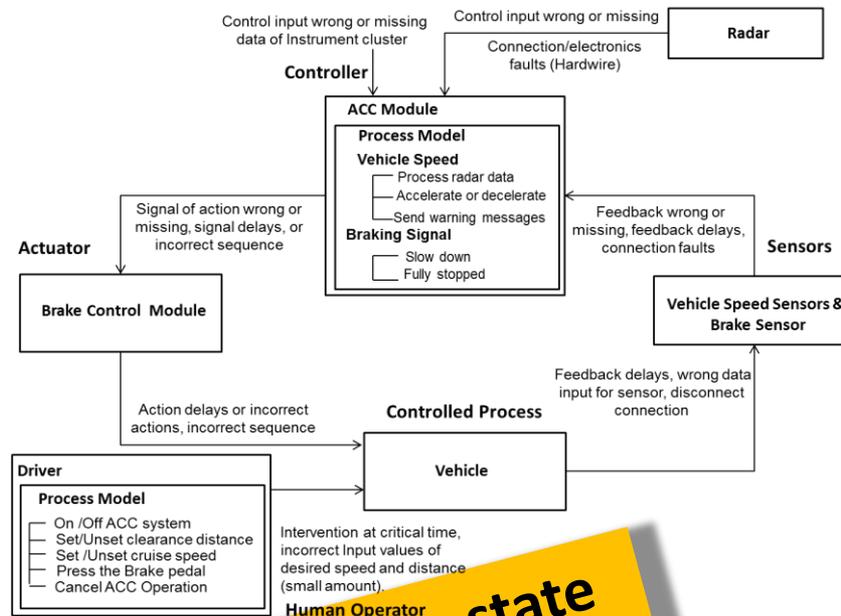
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Integrating State Machine Analysis with STPA

◆ Problem Statement:

- ❑ There is no systematic way to let the safety analyst know how to evaluate each control actions. Moreover, STPA does not represent system states, which have an effect on the safety of control action.

I have no knowledge and experience about the system.



◆ Research Objectives:

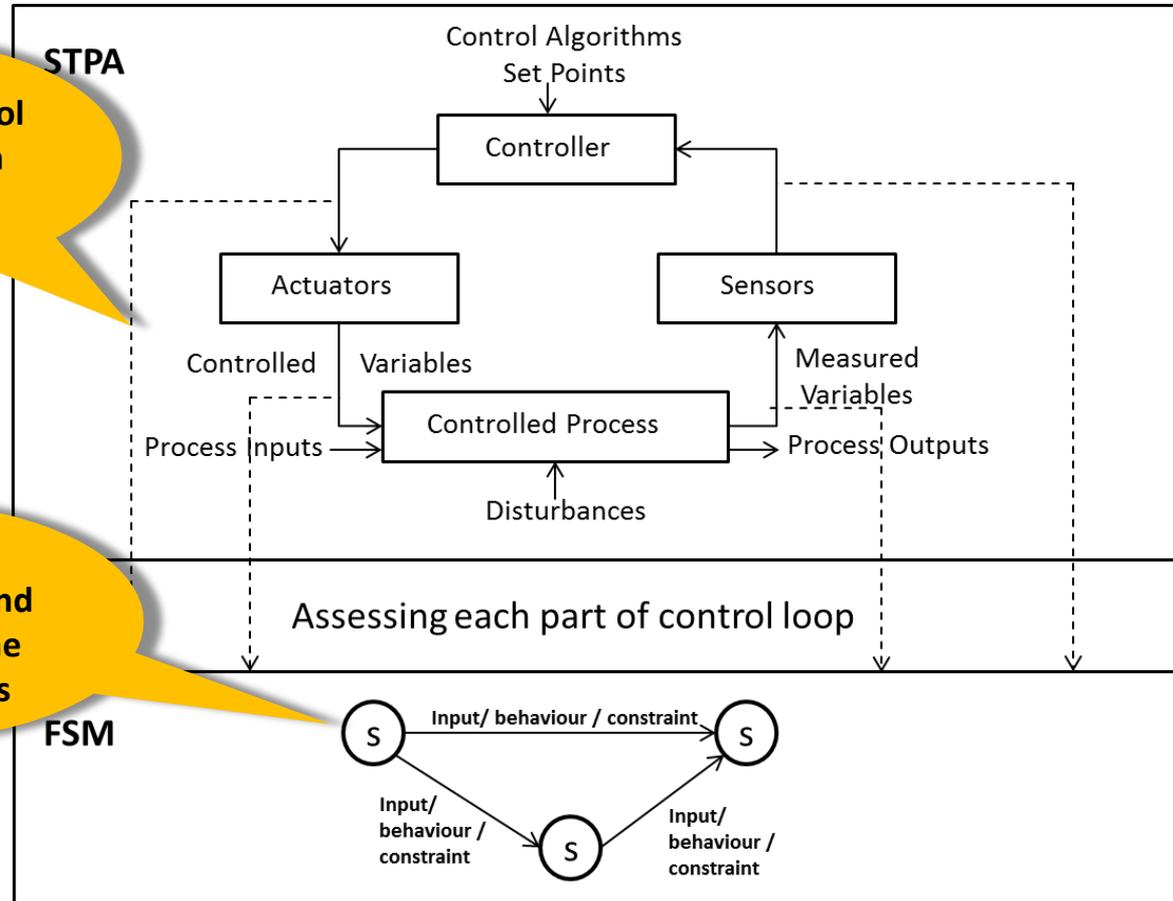
- ❑ Fill this gap and find ways to integrate state machine analysis with STPA for analysing the dynamic behaviour of systems during STPA.
- ❑ We plan to investigate the use of state machine modeling and analysis techniques.

For that, we integrated the state machine analysis with STPA.

Proposed Methodology

Assess each control actions based on system states.

Consider the system states and its effect on the control actions

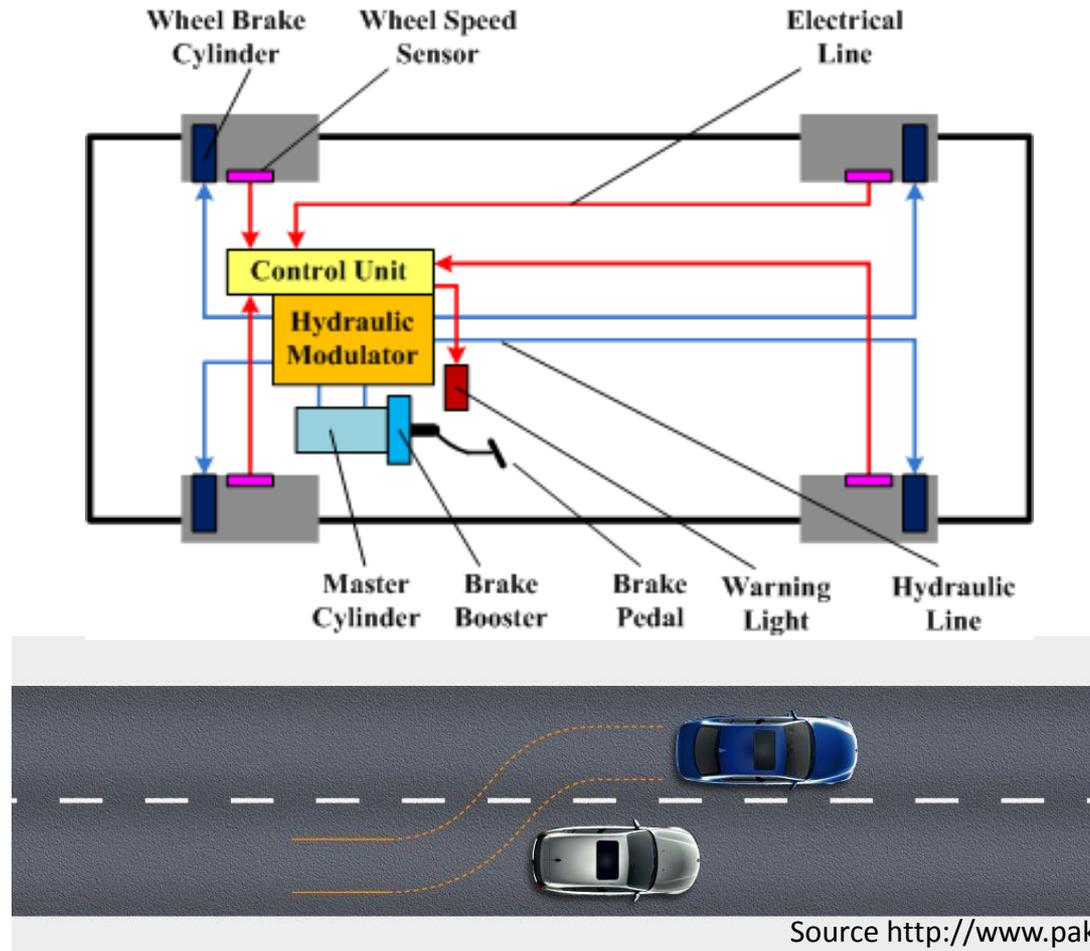


◆ Proposed methodology aims to:

- ◆ Use STPA to identify the potential for inadequate scenarios.
- ◆ Use Finite State Machine (FSM) to model the dynamic behaviour of the system.
- ◆ Assess each control action with FSM based on all the possible system states .

Study Object: Anti-Lock Braking System (ABS)

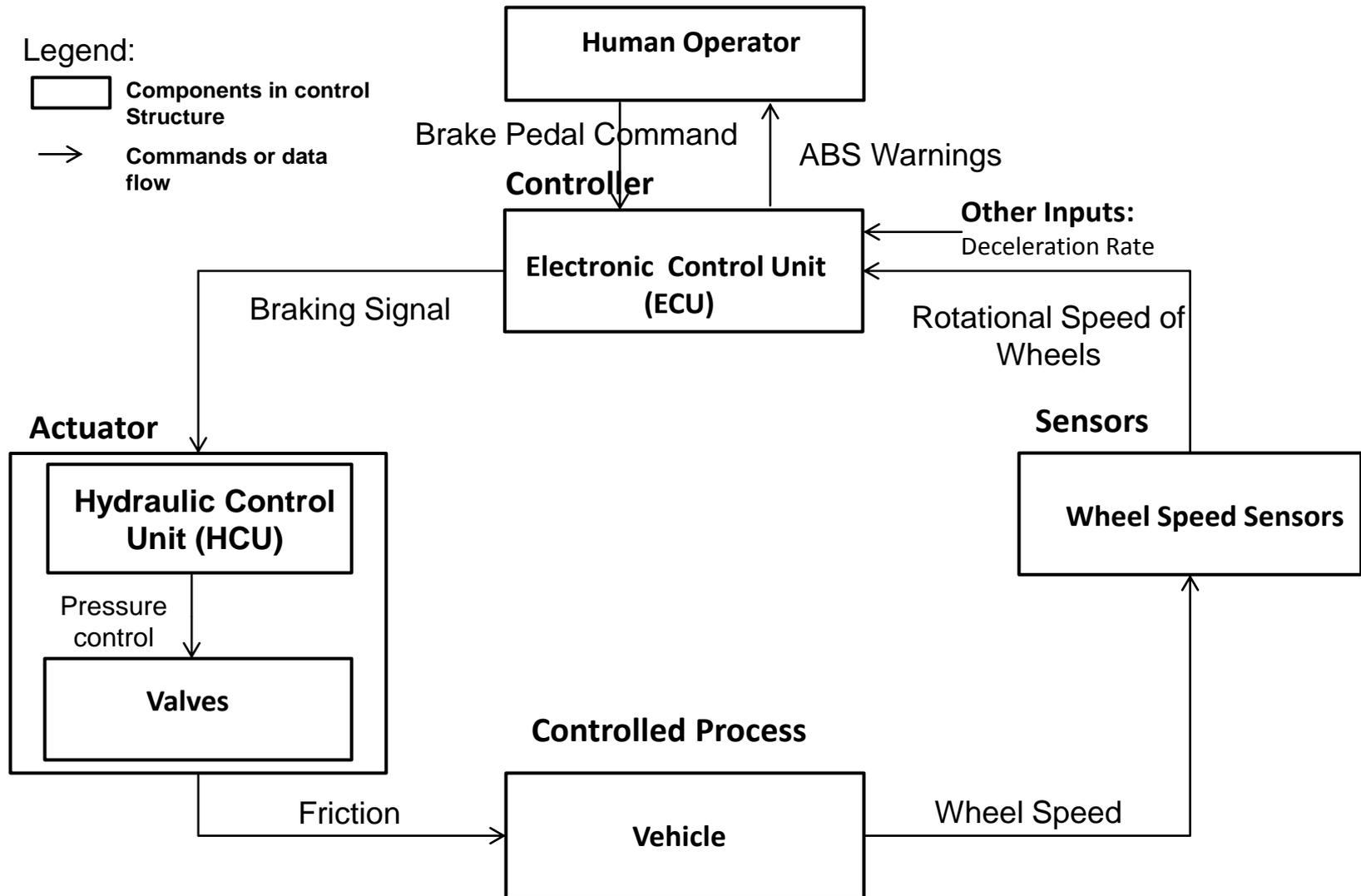
- ◆ **Anti-Lock Braking System** is a safety system on motor vehicles which prevents the wheels from locking while braking.
- ◆ **The ABS Architecture:**



Source <http://www.pakwheels.com>

Unsafe Control Actions (UCAs)

Unsafe Control Action: Brake event applied but not received by ABS



Unsafe Control Actions (UCAs)

◆ Examples of potentially inadequate control actions of ABS system:

Control Actions	Action required but not provided	Unsafe action provided	Incorrect Timing/Order	Stopped too soon
Brake Pedal Command	Brake event applied but not received by ABS [H.1]	Brake event is too short	Brake event provided too late	Brake event stopped too soon



I must evaluate each row to determine whether it is a hazardous state, but how?



You can assess them based on timing information, but what about other factors such as the states of the system?

FSM Construction

◆ In ABS example:

- ❑ ECU controller has four operating modes: **Inactive**, **handleLock**, **applyBrakePedal** and **reducePressure**.
- ❑ Valve component has three modes: **open**, **block** and **release**.
- ❑ HCU actuator has three modes: **Inactive**, **stopPump** and **openPump**.

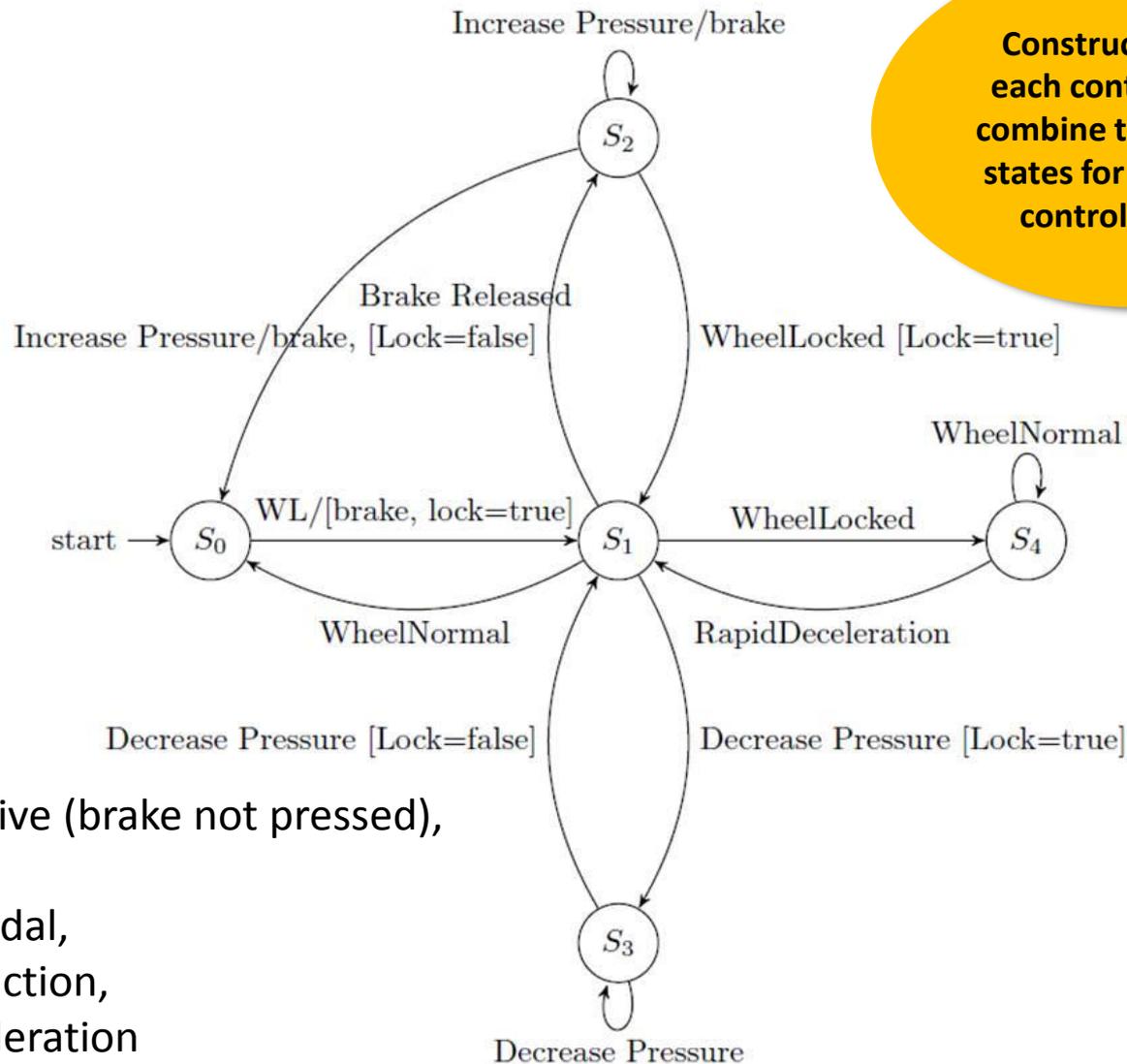
How to evaluate the control action whether it leads to hazard or not by considering all potential combinations of relevant states?



FSM can be used to determine the system states that affect the safety of the control action



FSM Construction of Controller (ECU)



Construct FSM for each controller and combine the relevant states for evaluating control actions.

Where: S_0 = inactive (brake not pressed),
 S_1 =handlelock,
 S_2 = applyBreakPedal,
 S_3 = pressureReduction,
 S_4 = MonitorDeceleration
and WL= WheelLocked.

The Extend Control Actions Table of UCA 1.

The control action table for the brake pedal command based on the potential combination of system states.

Control Actions	Wheel Status	Wheel Speed	Valve Status	Hazardous?
Brake Pedal Command	Locked	slow	open	Yes
Brake Pedal Command	Locked	fast	open	Yes
Brake Pedal Command	Locked	slow	close	No

E.g. Unsafe Control Action:

If we consider *the brake pedal command* that can be a hazardous control action, it consists of the values of the following process model state variables:

- ✓ The brake pedal is pressed.
- ✓ Valve is open.
- ✓ Wheel is locked.
- ✓ The wheel speed exceeded a preset maximum level.

E.g. Refine Safety Constraints: When brake pedal is pressed, the status of wheel lock should be false, the status of valve should be closed and the wheel speed should not exceed a preset maximum level.

Thank You!

