

# FSG Academy 2020

## Formula Student Driverless Workshop



powered by



# HW Actuators Safety / Inspection

By Martin Stollberger



# How to build a successful DV:



Take the fastest car

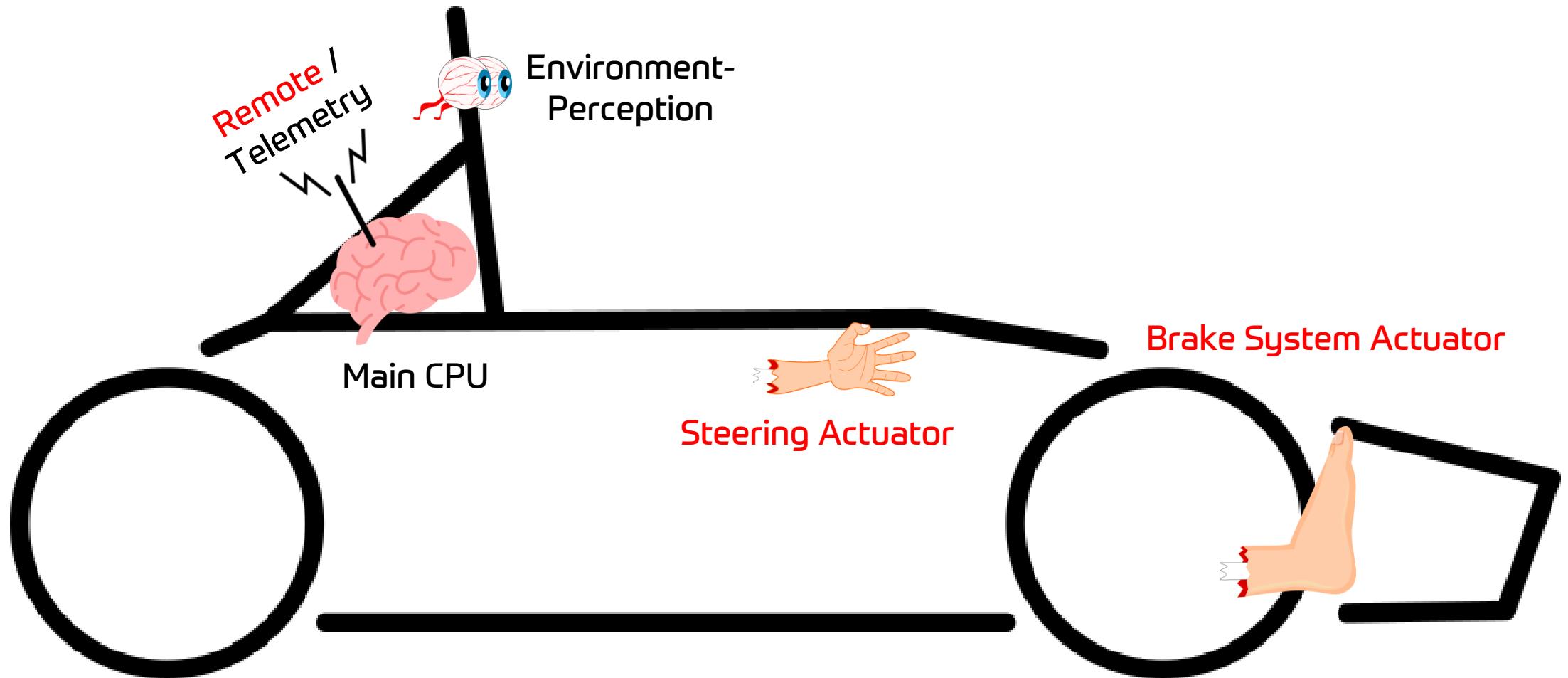


the best reference



and the right tools ;)

# and you'll get ...



# Safety measures

- ASMS (Autonomous System Master Switch)
  - Protection for the driver in manual mode.
  - Cuts the supply of the steering and braking actuators (DV2.2.4)
  - Must be fitted with a “lockout/tagout” to ensure that only the ASR enables the autonomous system (DV2.2.8)



# Safety measures



- **ASSI** (Autonomous System Status Indicator)
  - Used to display the actual state of the autonomous system (DV2.5.1)

AS Off	AS Ready	AS Driving	AS Emergency	AS Finished
off	yellow continuous	yellow flashing	blue flashing	blue continuous
  - The vehicle must be equipped with three ASSIs. One on each side of the main hoop and one at the back. (DV2.5.2/3)
  - It must also give acoustic feedback if the emergency state is entered (DV2.5.4)

# Safety measures

- RES (Remote Emergency Stop)
  - SIL 3 certified remote
  - Used to send the “go” signal remotely
  - Used to bring the vehicle to a safe condition remotely by opening the Shut-Down-Circuit => Tractive system / engine is deactivated and the emergency brake system is triggered.
  - A signal loss to the RES will lead to a safe state -> place your antenna properly.



# Steering Actuator Rules



- Steering system actuation must only happen if the vehicle is R2D. (DV2.3.1)
- It may remain active after R2D state was left, until vehicle is at standstill. (DV2.3.2)
- Manual steering must be possible, immediately after ASMS is switched off (DV2.3.3)

# Steering Actuator Important points

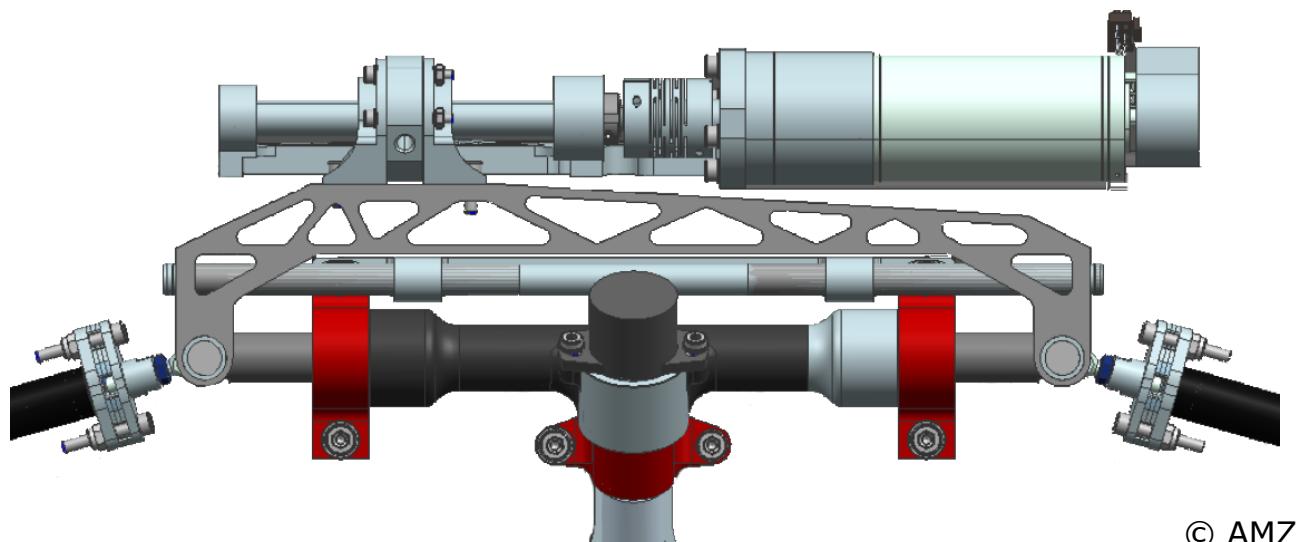
- Make sure that the cockpit template is fitting
- Cover moving parts from the driver
- Make sure your actuator does not need to move for position referencing, as this will only be allowed while the vehicle is R2D.
- Consider the impact to the steering forces while manual driving



# Steering Actuator Example (two of many)



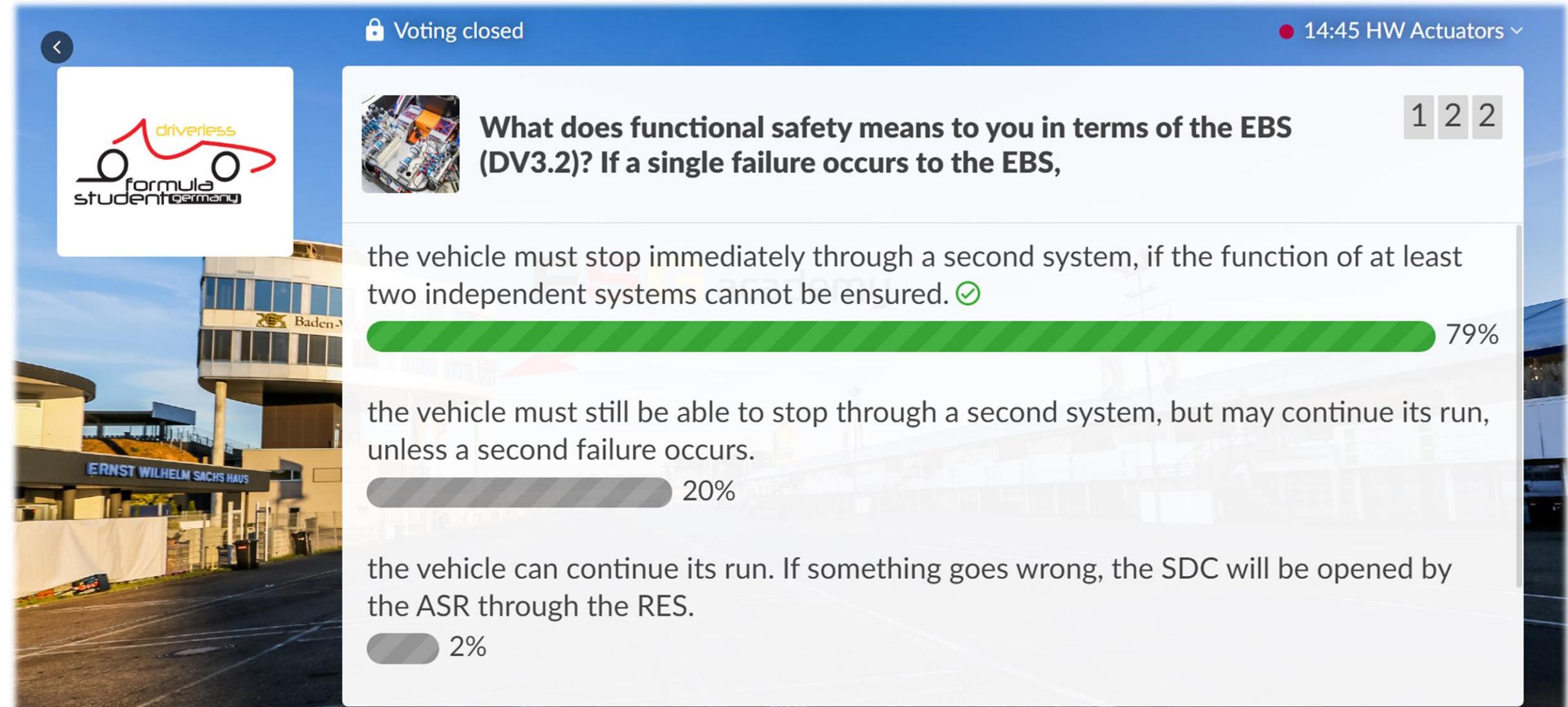
- Compact rotary steering actuation behind the steering wheel



- Linear steering actuation directly on the steering rack, by using a ball screw drive mounted outside the cockpit

# Slido Team Poll

Voting closed      14:45 HW Actuators ▾



**What does functional safety means to you in terms of the EBS (DV3.2)? If a single failure occurs to the EBS,**

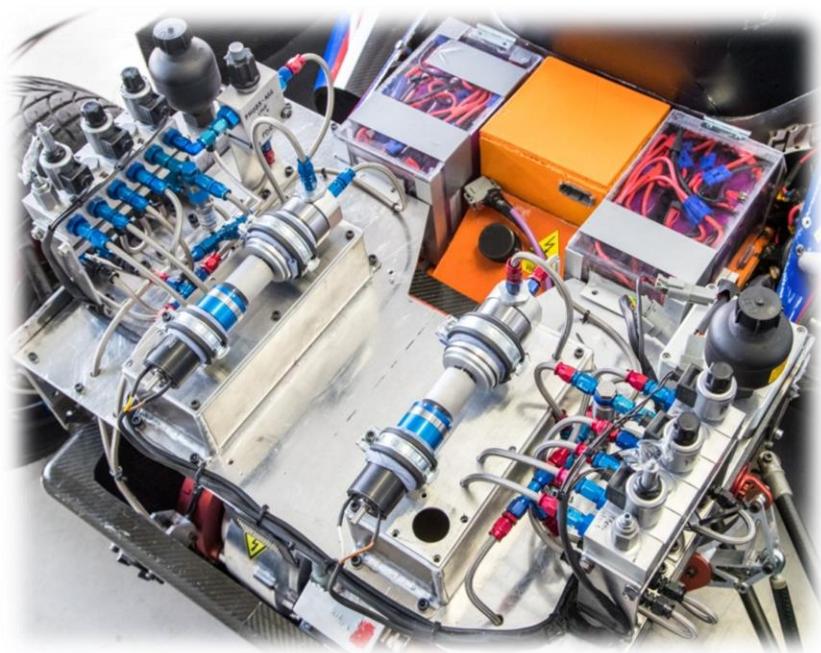
1 2 2

the vehicle must stop immediately through a second system, if the function of at least two independent systems cannot be ensured.  79%

the vehicle must still be able to stop through a second system, but may continue its run, unless a second failure occurs.  20%

the vehicle can continue its run. If something goes wrong, the SDC will be opened by the ASR through the RES.  2%

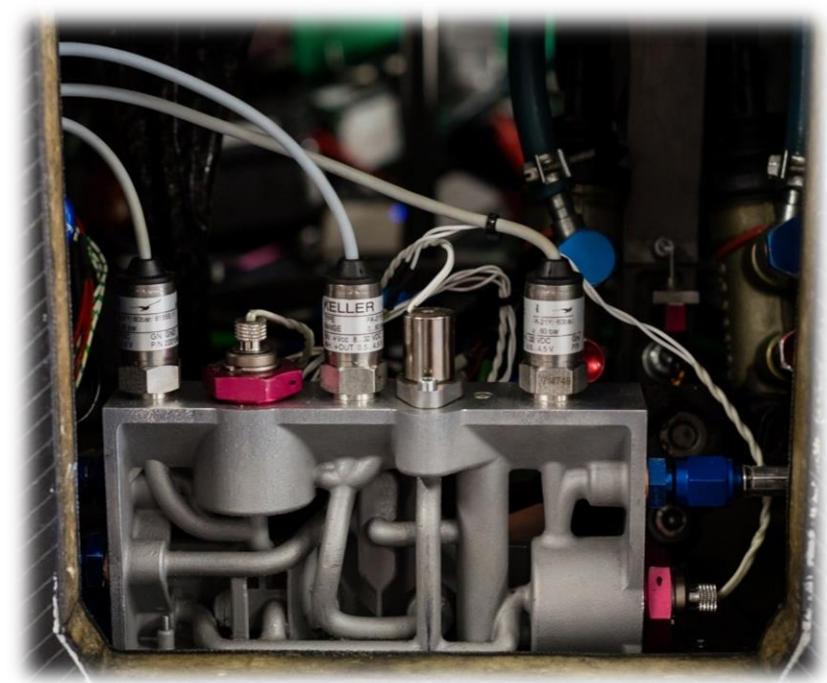
# EBS (Emergency Brake System)



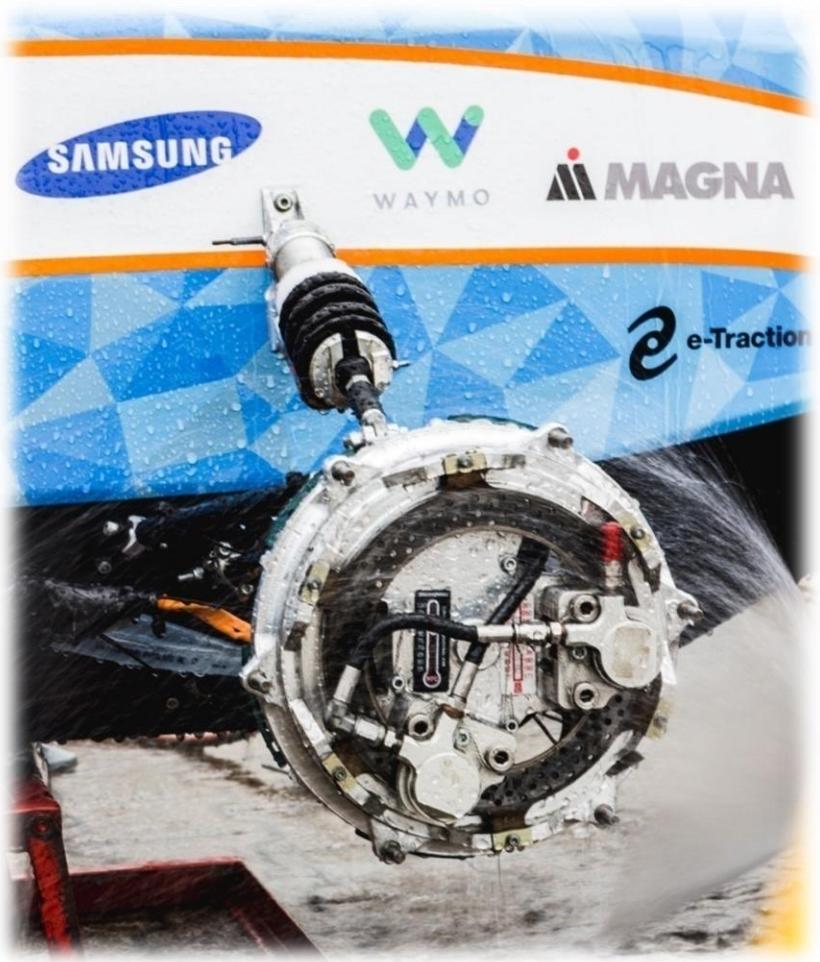
- The last chance to save your vehicle from a crash
  - Brings the vehicle to a safe state (standstill with brakes closed)
  - Must be designed under the aspects of functional safety (DV3.2)
    - Continuous monitoring for failures
    - Redundancy for single faults
  - Must work in absence of electrical power (DV3.1.3)

# Monitoring

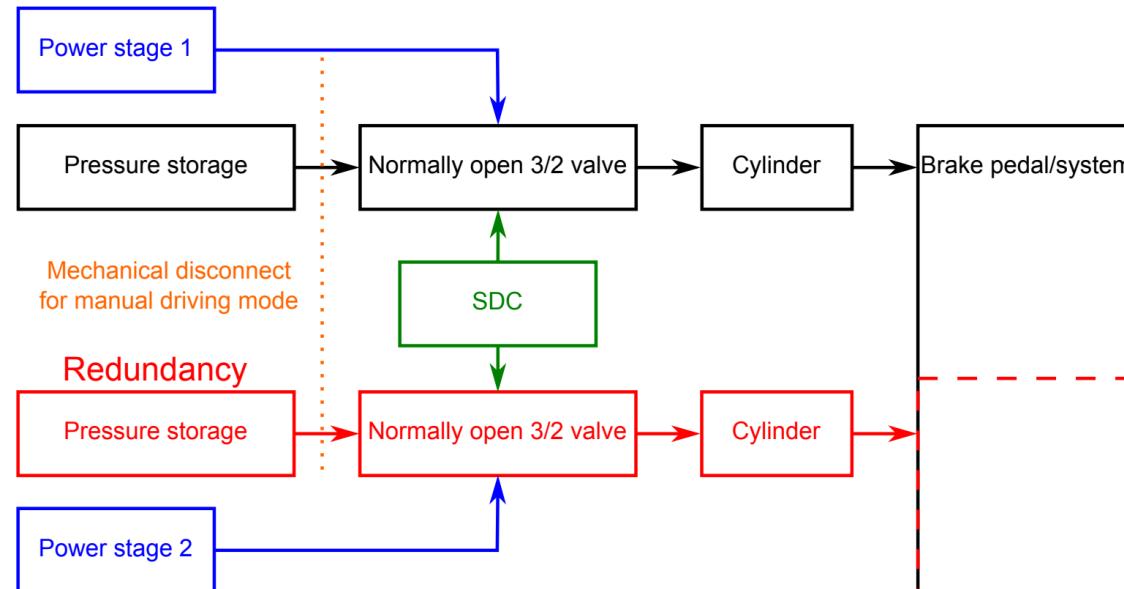
- The health checker (DV 3.2.1)
  - Initial checkup
    - Check all activation path to ensure proper function
    - Crosscheck different sensors for plausibility (e.g. pneumatic pressure vs. resulting brake pressure)
  - Continuous monitoring
    - Check the state of the energy storage
    - Check sensors for valid signals etc.
  - Redundant paths need to be monitored as well



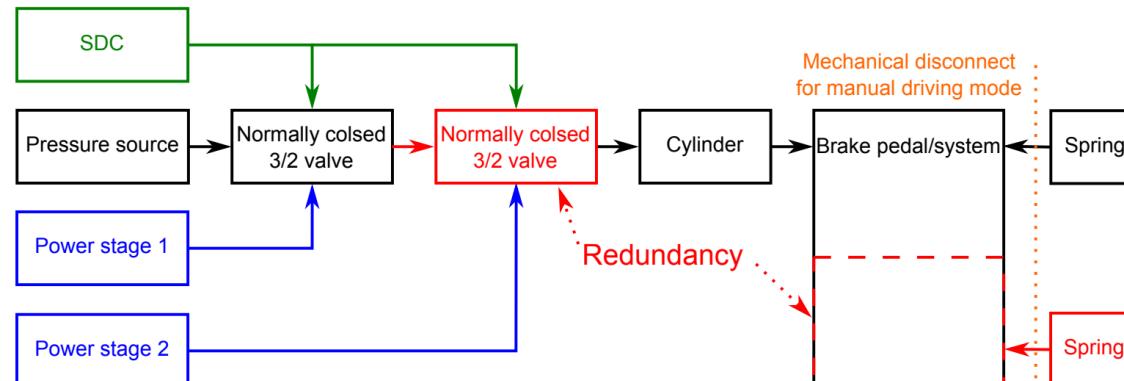
# Redundancy



## Actively applied braking energy



Removal of counterforce, which keeps the brakes opened

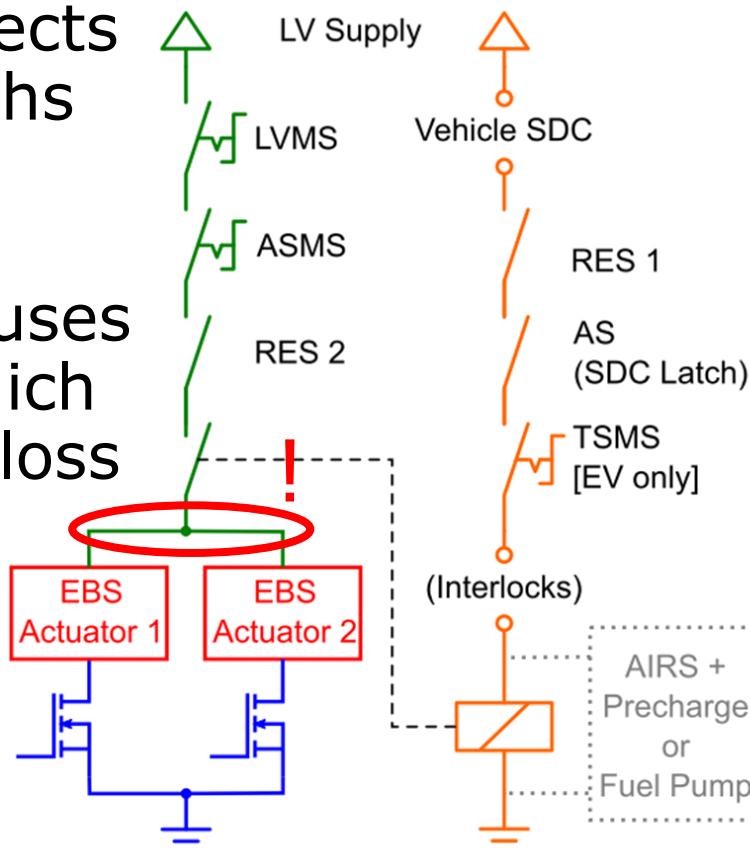


# Common Cause Failure

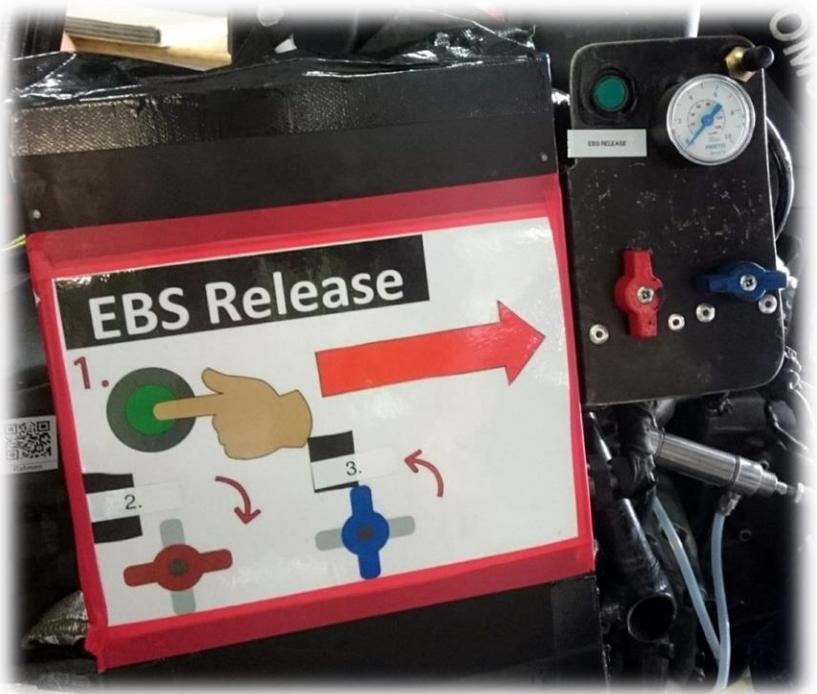
- The ones to keep an eye on

- One failure that affects both redundant paths directly.

- Or a failure that causes a chain reaction which will end up in total loss of function.  
(e.g. overpressure which destroys all actors at once)



# Deactivation



- The way to get your car off the track
  - The EBS must be designed so that any official can easily deactivate it. (DV3.1.6)
  - A pictographic description of the release points in proximity to the ASMS.
  - The necessary steps must be clearly marked
  - The release points must be marked by a red arrow of a given size with "EBS release" in white letters on it.

A funny video of HTW Berlin was here

# Service Brake



- For well controlled braking while driving
  - May use the same components as the EBS (e.g. a pressure regulation valve instead of an EBS activation valve on the second path)
  - Must be monitored for failure if it is used as redundant path
  - Will be removed on the next rules version 2022. There will be only a general brake system with EBS functionality, to avoid the confusion we had in the past.

# Slido Team Poll

Voting closed

14:45 HW Actuators

0 9 3

Have you already heard about the FSG EBS Reference Guide?

Response	Percentage
No	65%
Yes and we used it already	18%
Yes	17%

# Slido Team Poll

Voting closed

14:45 HW Actuators

0 3 7

How did you like it?

Score: 4.2

51%

32%

5%

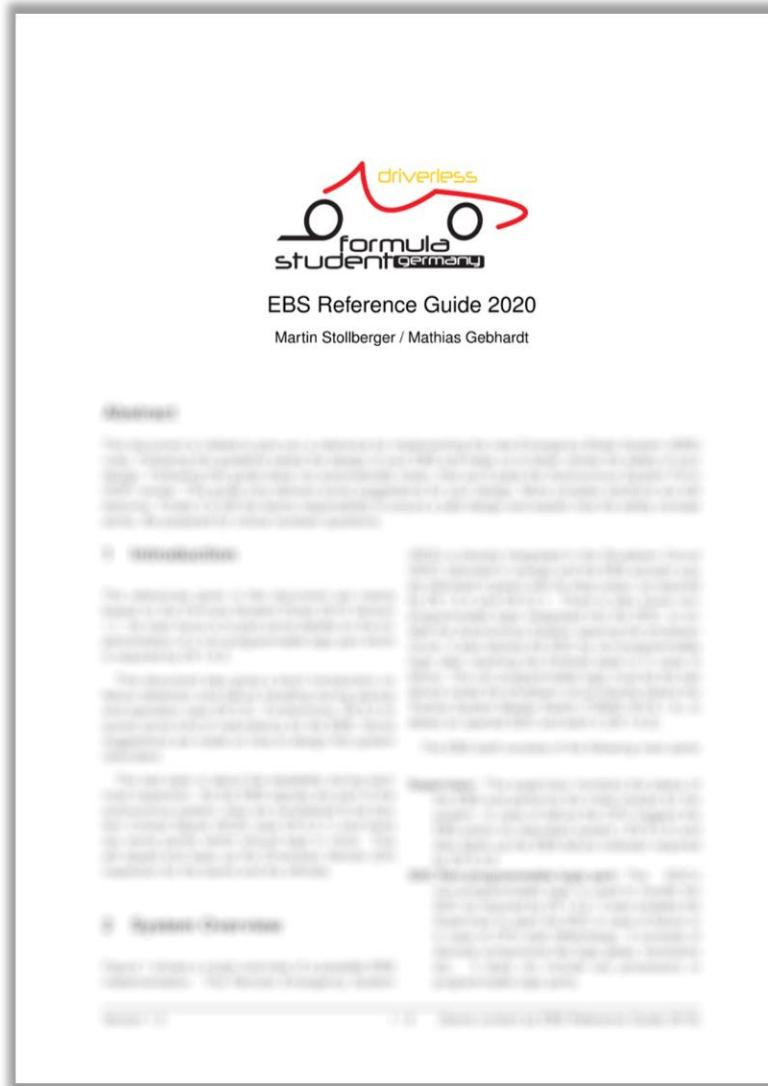
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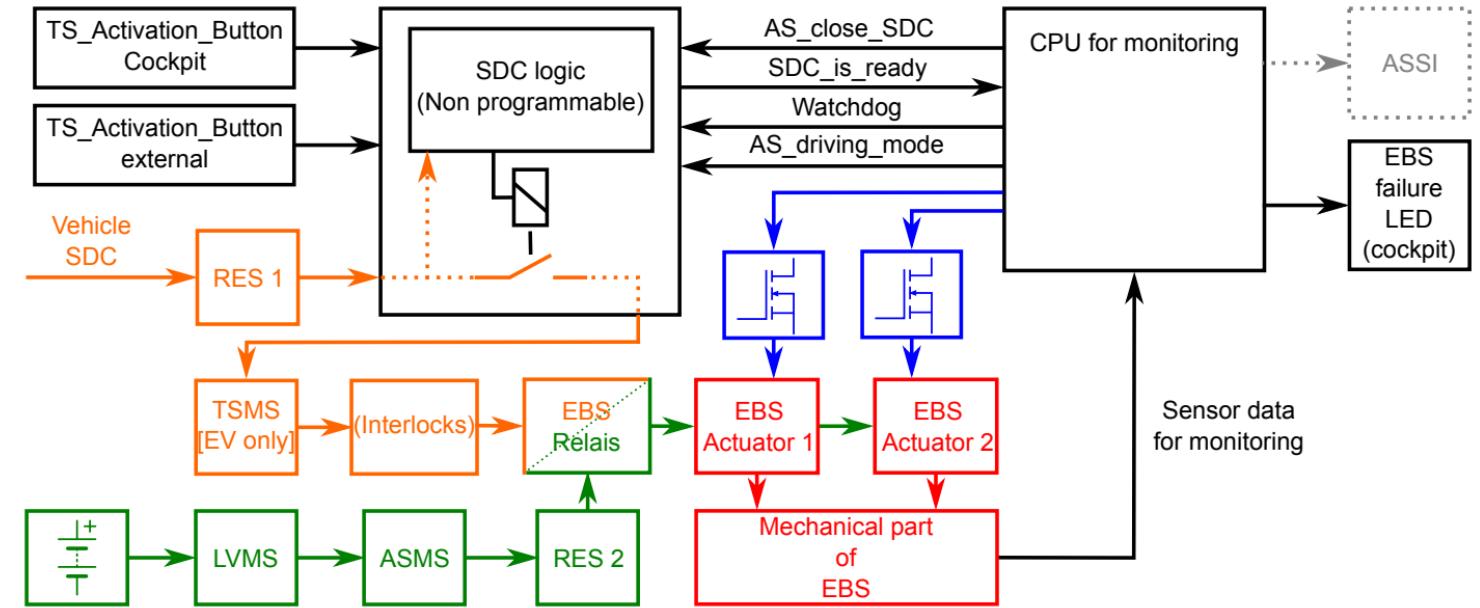
Category	Percentage
1	5%
2	5%
3	5%
4	32%
5	51%

1 2 3 4 5

# Reference Design Guide

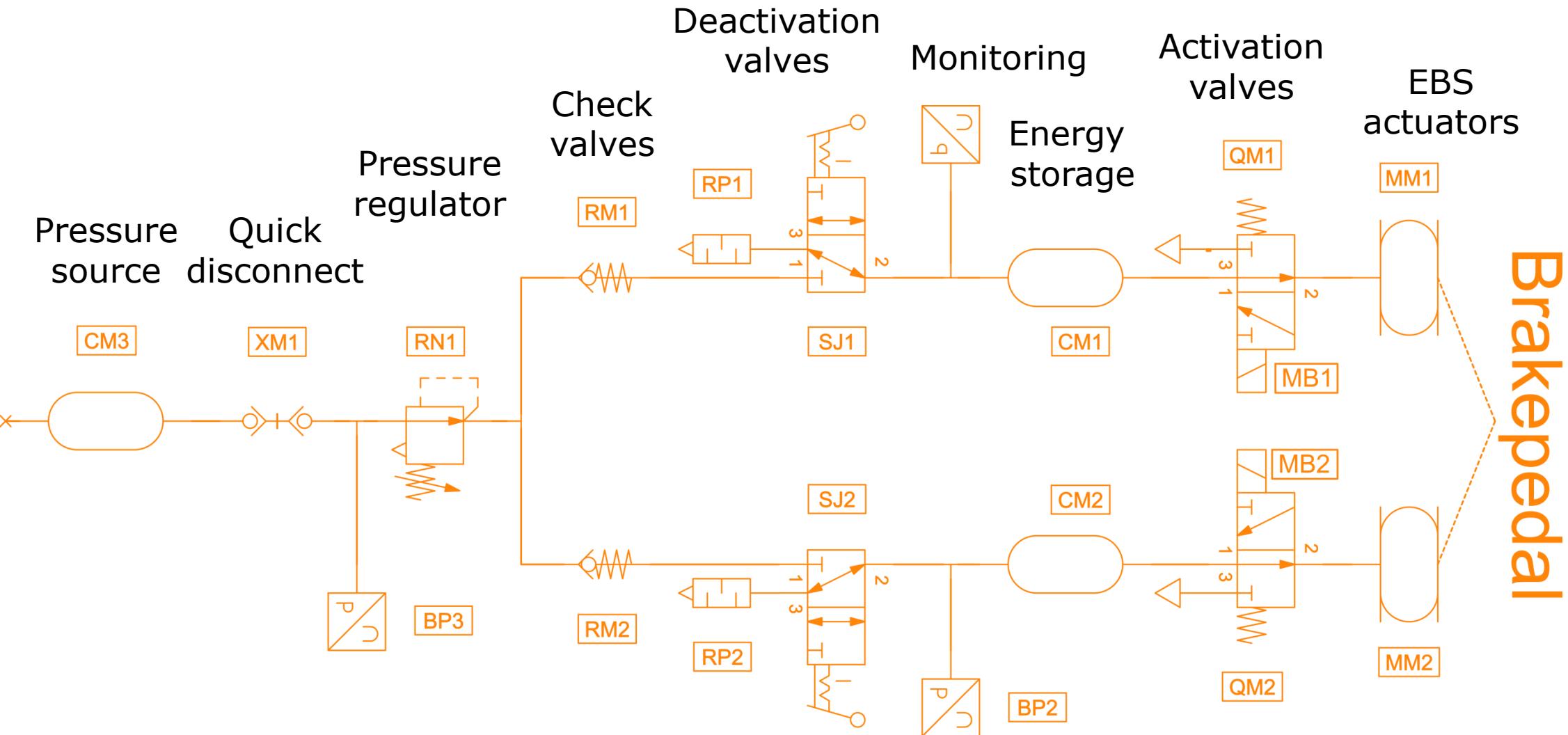


## ■ Example Implementation



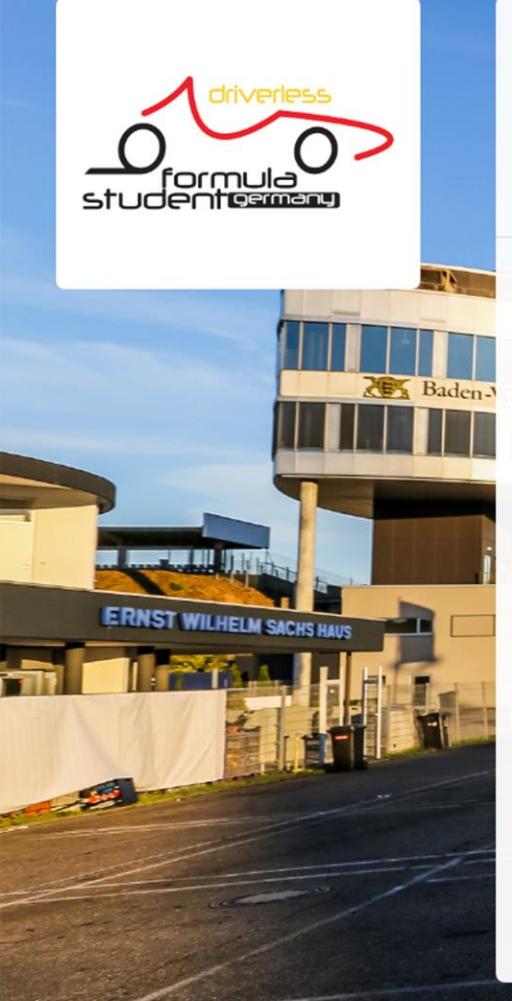
[https://www.formulastudent.de/fileadmin/user\\_upload/all/2020/important\\_docs/FSG20\\_EBS\\_Reference\\_Design.pdf](https://www.formulastudent.de/fileadmin/user_upload/all/2020/important_docs/FSG20_EBS_Reference_Design.pdf)

# EBS Examples (pneumatic circuit)



# Slido Team Poll

Active poll • 14:45 HW Actuators



**(Only for teams already building a DV) Which type of EBS brake actuation do you use on your DV?**

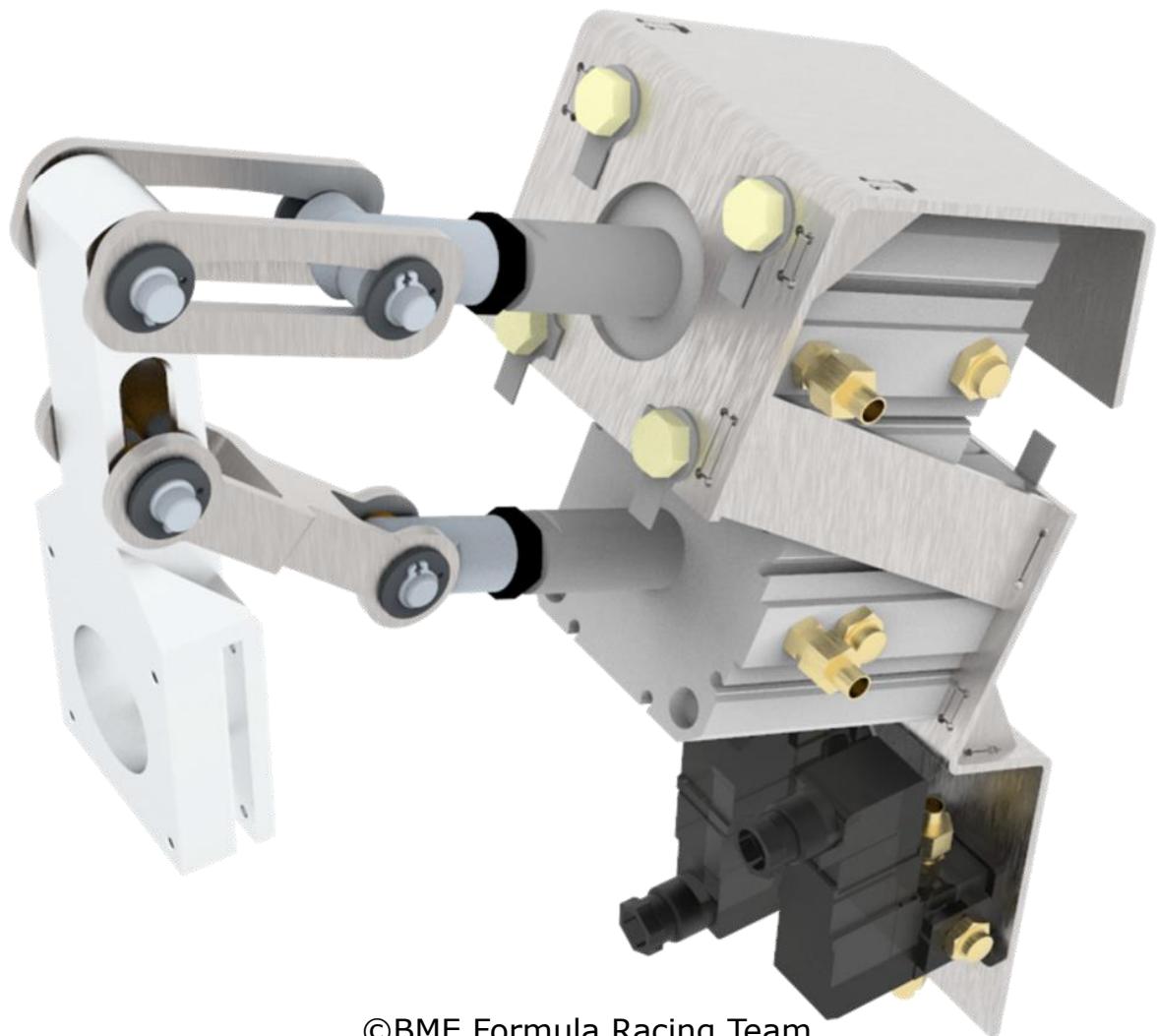
0 2 9

Option	Percentage
An actuator mounted to the brake pedal.	59%
An actuator which operates a separate master brake cylinder	28%
Others	10%
A pressure transducer between the EBS fluid and the brake system of the vehicle.	3%

**driverless formula student germany**

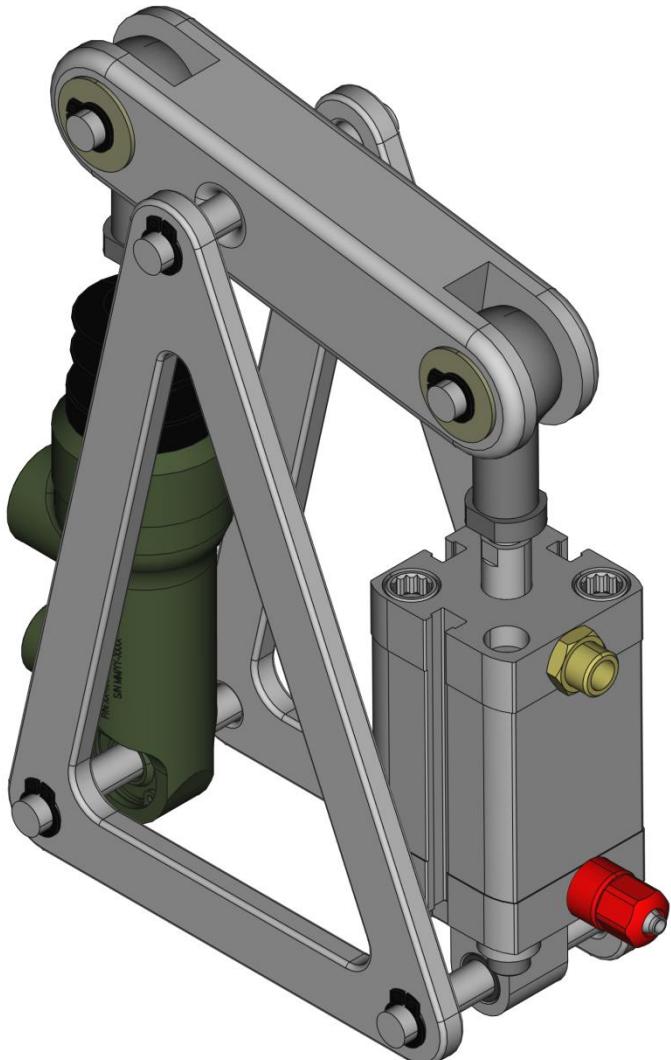
# EBS Examples (brake pedal actuator)

- The easy one
  - No modification of the hydraulic brake circuit needed.
  - Independency of the cylinders and of manual braking is ensured by slot holes
  - Can be designs as “plug on” for the brake pedal
  - The brake pedal and the connection points need to be designed sufficiently strong to avoid common cause failures.



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# EBS Examples (additional master cylinder)

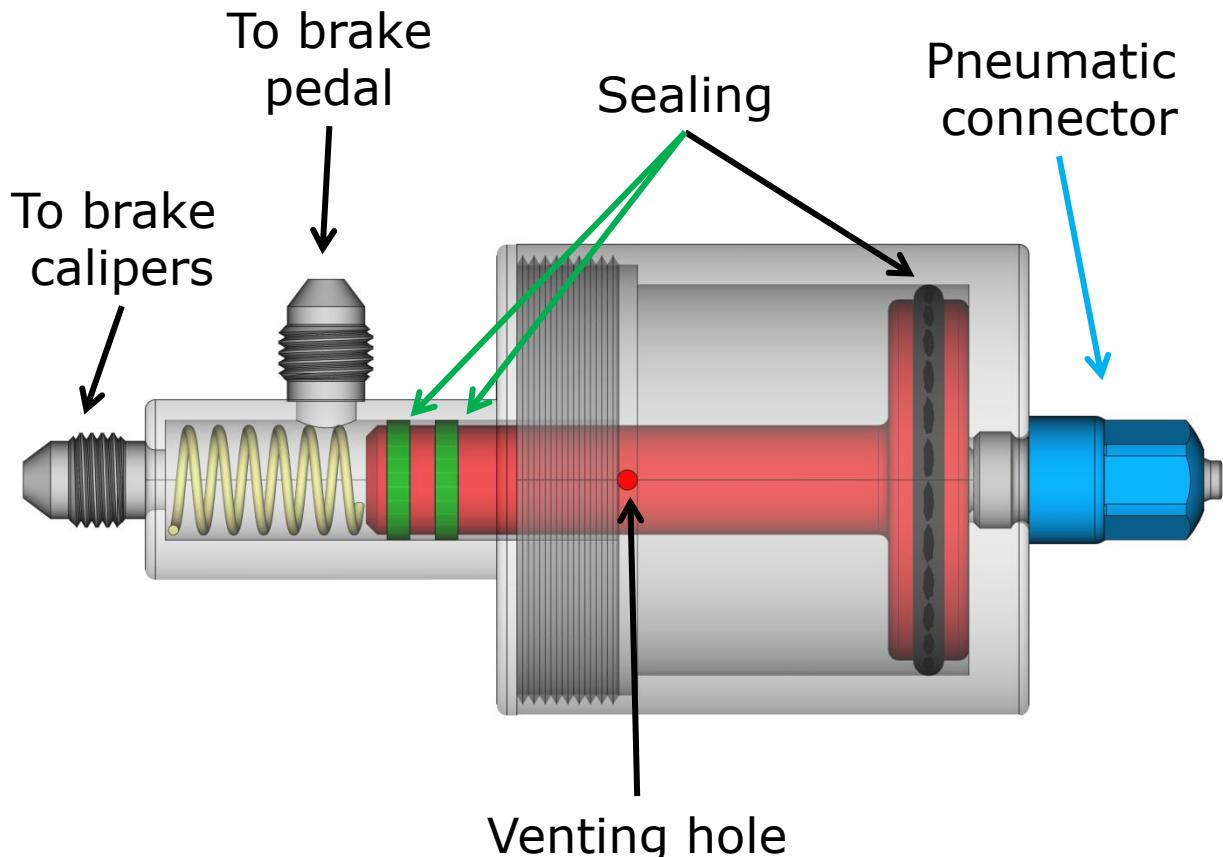


- The flexible one
  - A second master cylinder in series to the brake pedal cylinder, operated by the EBS actuator
  - Independent of the brake pedal assembly
  - Both redundant paths can be placed independently
  - No common point of failure like the brake pedal
  - Bleeding of the brake system may become more difficult

Caution: constructed by an electrical engineer: me ;). Just for visualization

# EBS Examples (pressure transducer)

- The smart one
  - Combined master cylinder and pneumatic cylinder.
  - Connected in series to the brake pedals master cylinder
  - Only brake fluid resistant material must be used (especially for the sealing)
  - Must be designed extremely carefully as a failure will also lead to a non working brake pedal.



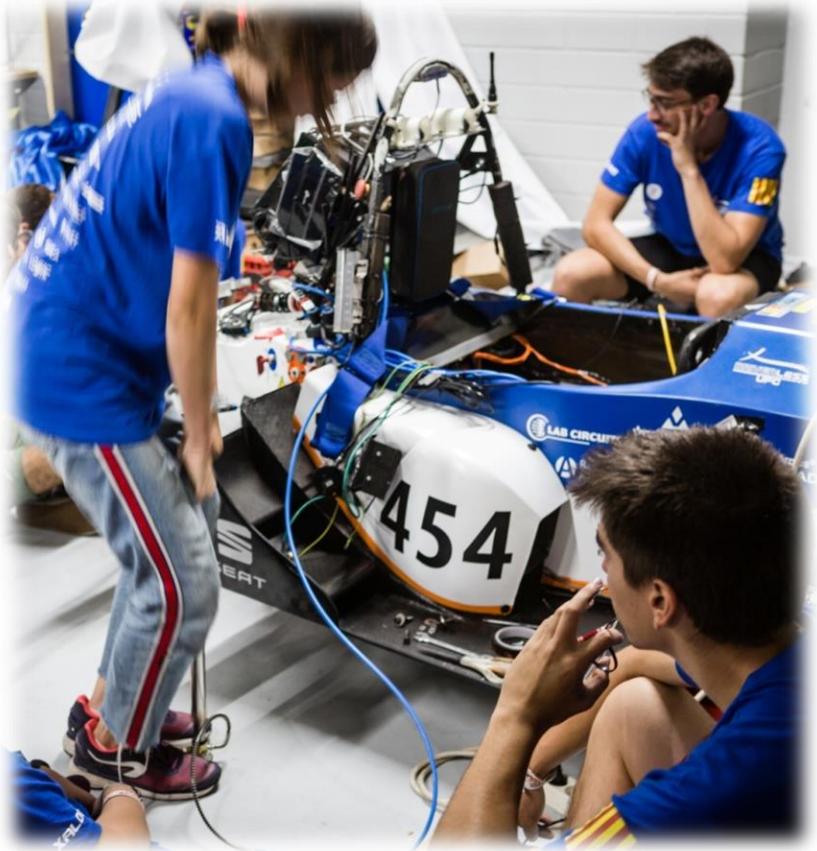
Caution: constructed by an electrical engineer: me ;). Just for visualization  
Inspired by e-gnition driverless team

# Inspection / Accessibility

- Be prepared and save time
  - Especially the EBS will be checked quite intense (failure detection / handling). -> Different sensors / actors will be unplugged to see the reaction
  - The vehicle will be restarted multiple times
  - Check all imaginable failure cases already at home
  - Be sure that all parts of the EBS are accessible without dismantling the whole vehicle



# Preparation before Start



- Keep it simple
  - No additional equipment is allowed at the staging/startling line. (D2.6.1)
  - The vehicle should enter "AS Ready" state within 1 min latest (D2.6.3)
  - The EBS may be armed already in the preparation area (D2.6.5)

# General Aspects

- Keep the rain test (EV) and bad weather in mind.
- Be aware of spots without GPS reception, especially during Tech Inspection.
  - Don't rely on a valid GPS signal to start the inspection mission.



# See you at the starting line



Presentation was based on [FSG Rules 2020](#)

# Thank you for your attention