Understanding Block Diagrams

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Open loop (feedforward) versus closed loop (feedback)

Open loop (feedforward) control

is a “time-table”

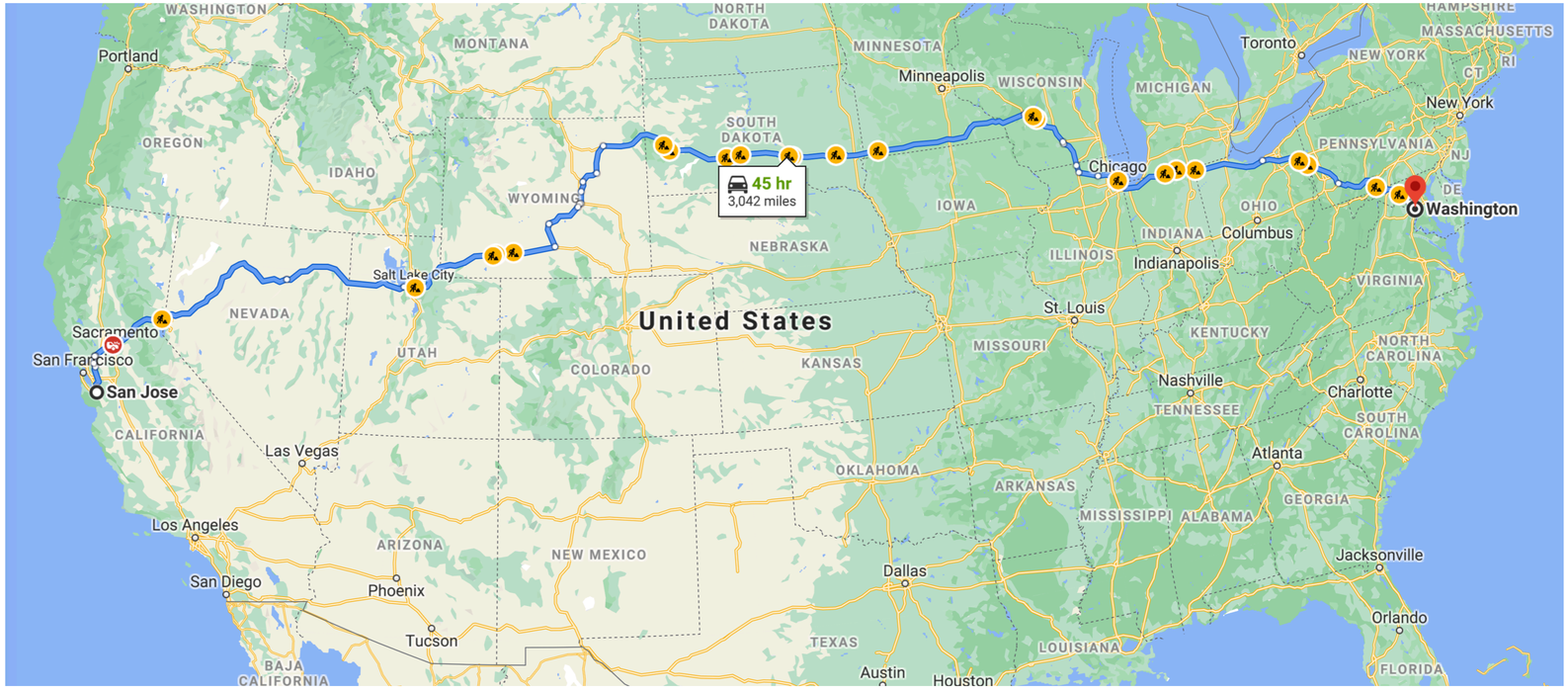
no real-time sensing

Closed loop (feedback) control

is an “output-table”

requires real-time sensing

Feedback is necessary to handle uncertainties: **a motivating example**



Control ≠ Controller

Control

is a signal

is along an arrow (in the block diagram)

is also called “input” /“action”

Controller

is an algorithm

is a box (in the block diagram)

is also called “policy” /“rule”

Control (signal) is the output of the controller block

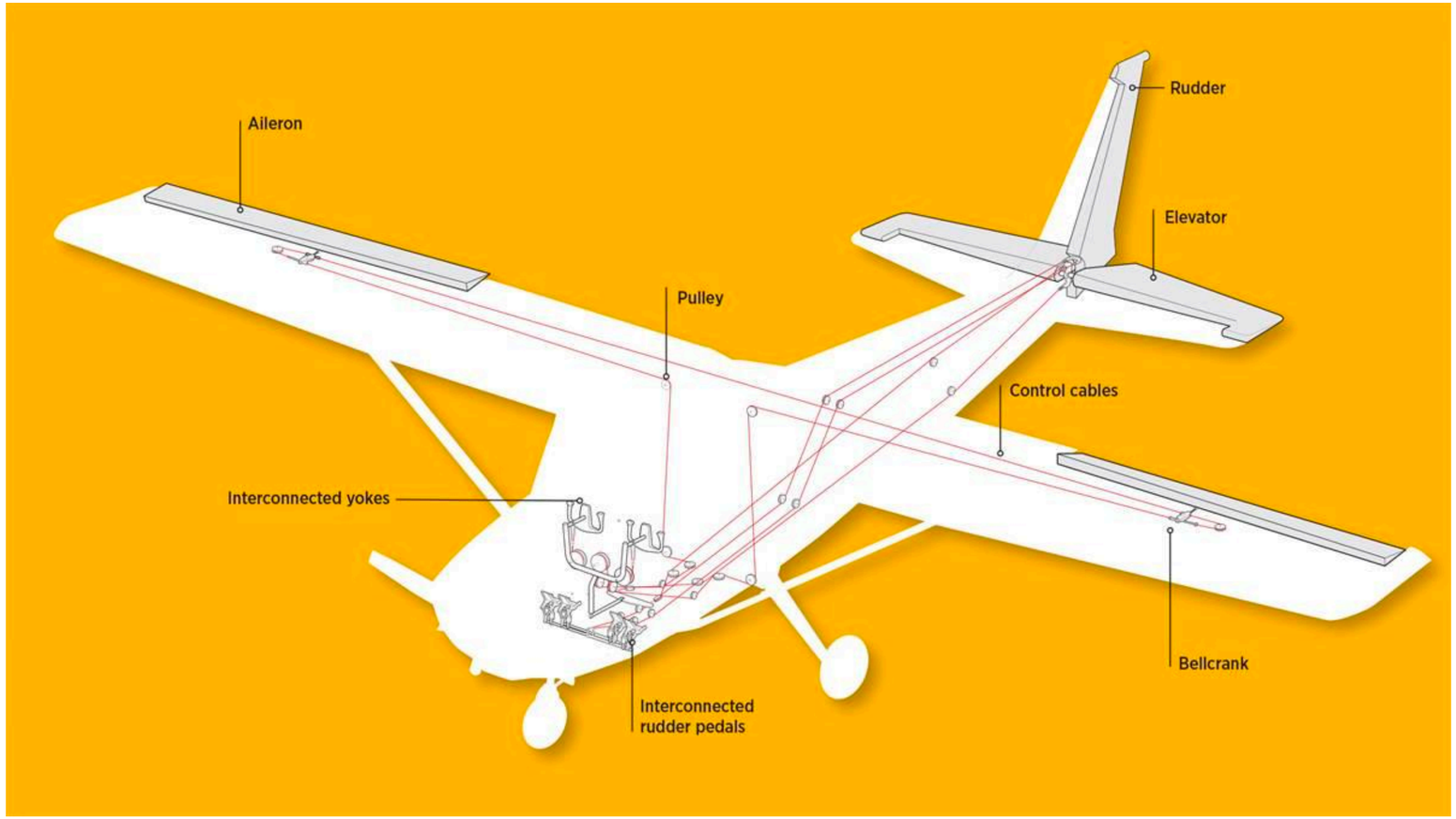
What do the arrows really mean?

"Channel" to transfer the signal. **Different types:**

- **Mechanical:** rod, gear, rope, chain, pulley
- **Hydraulic:** pump, pipe, valve, reservoir, filter
- **Digital:** electrical cable, fiber-optic cable, wireless network

In reality, these channels are not perfect: **they are "lossy"**

Example: hydro-mechanical actuation channels in flight control



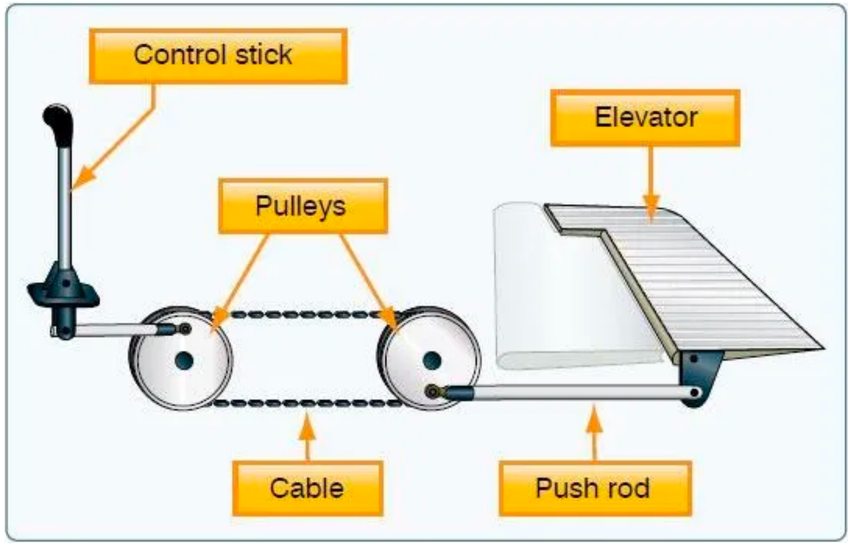


Image credit: Steve Karp

Example: “fly-by-wire” actuation channels in flight control

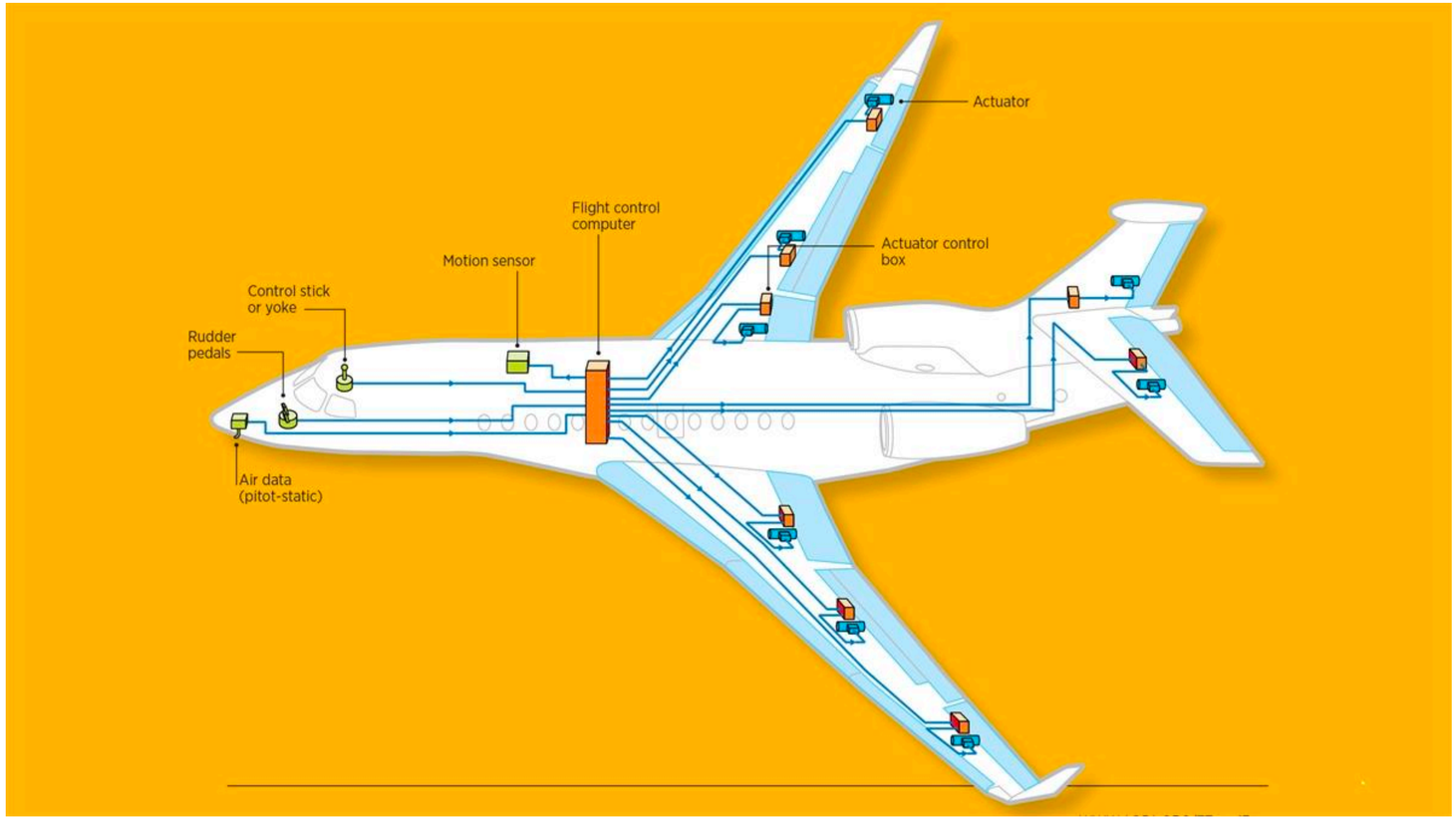
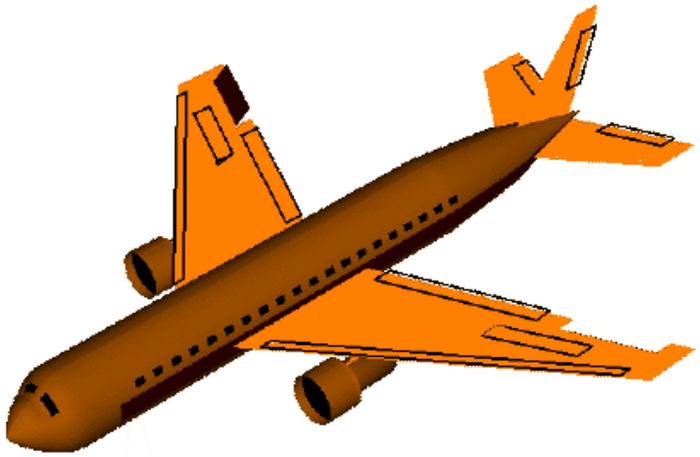
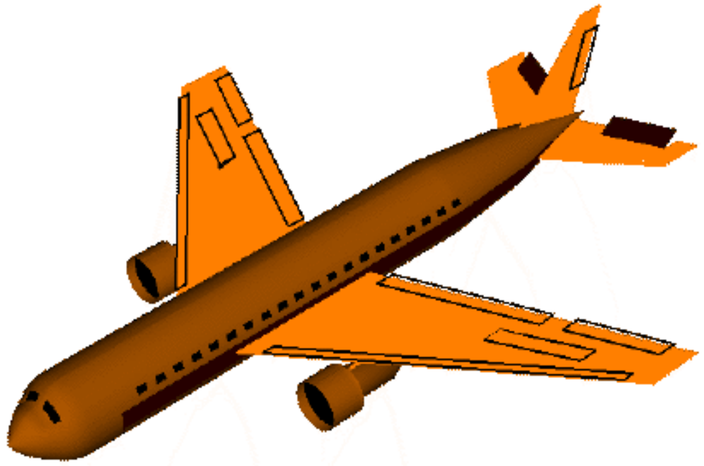


Image credit: Steve Karp

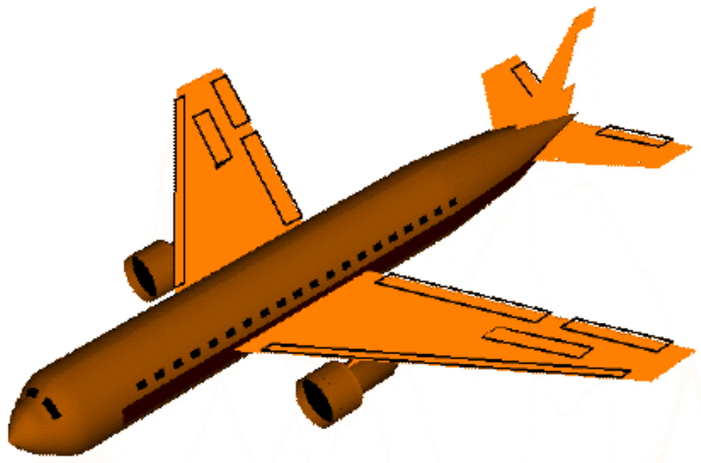
Example: actuation in flight control



Aileron (actuator) ⇝ Roll motion



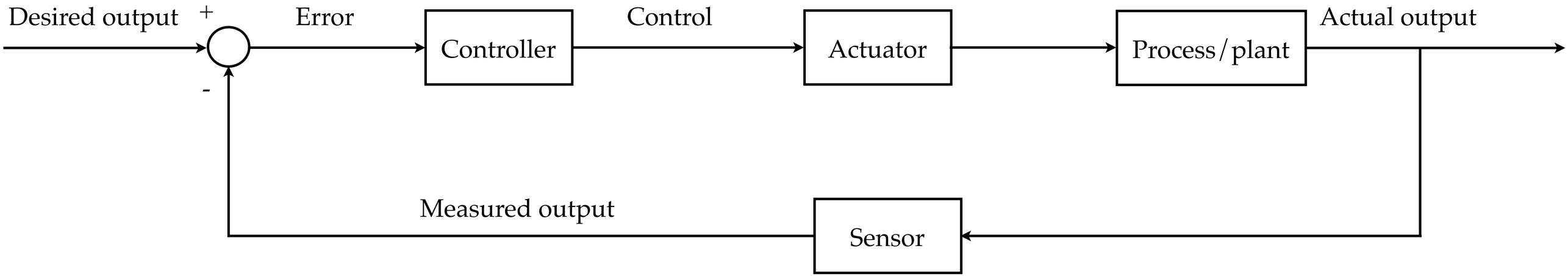
Elevator (actuator) ⇝ Pitch motion



Rudder (actuator) ⇝ Yaw motion

Image credit: NASA

Exercise 1: identify components of block diagrams



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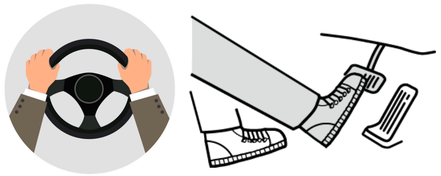

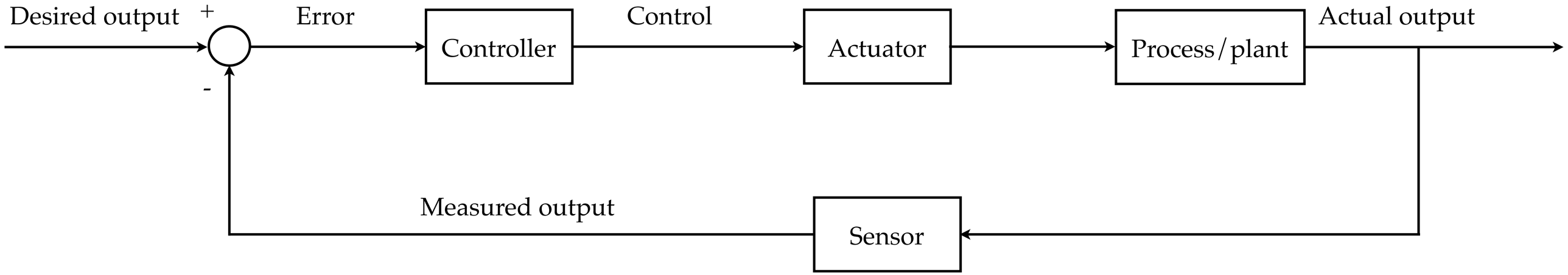

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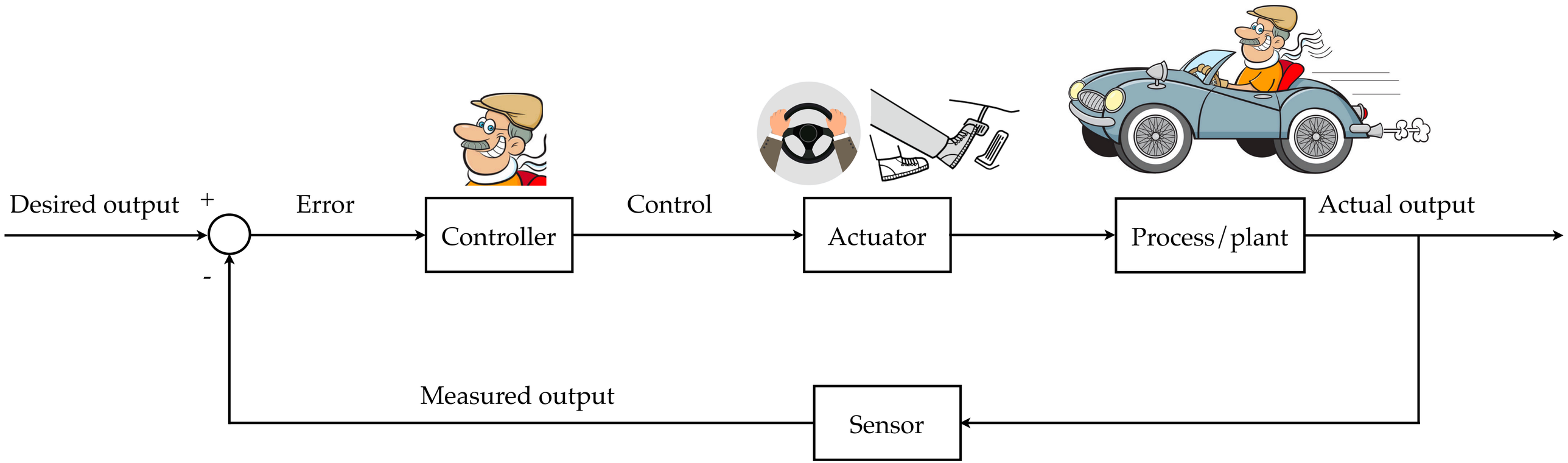

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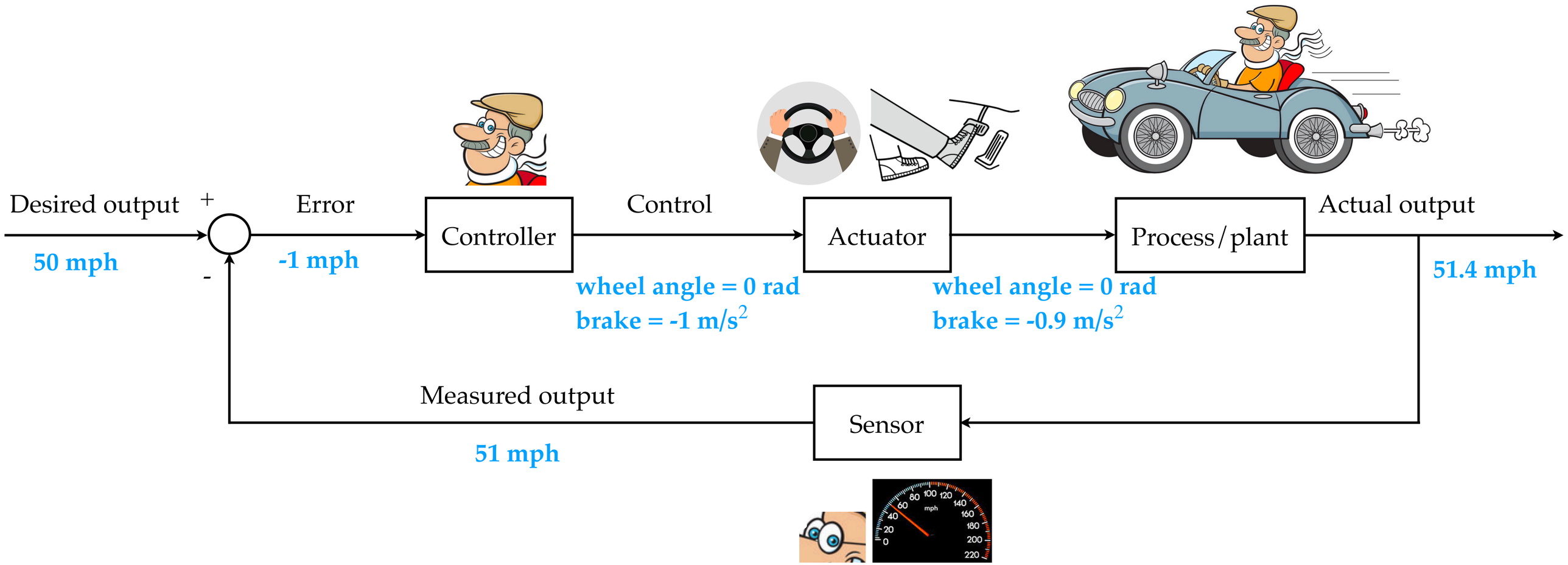

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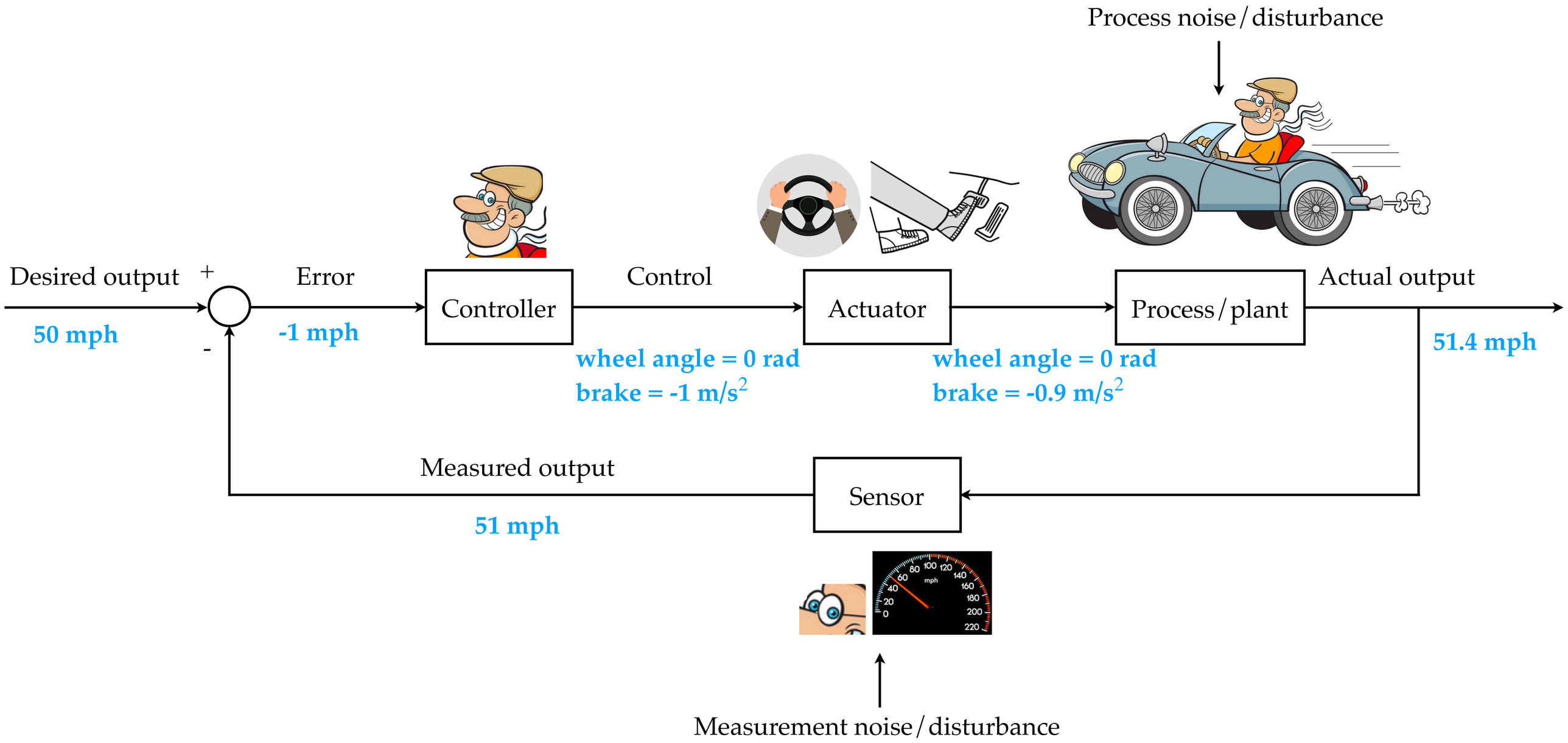
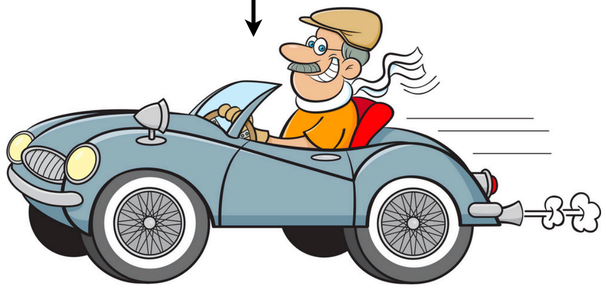
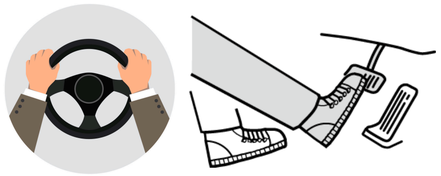


Exercise 1: identify components of block diagrams

Process noise / disturbance





Desired output

50 mph

+

-

Error

-1 mph

Controller

Control

wheel angle = 0 rad

brake = -1 m/s^2

Actuator

wheel angle = 0 rad

brake = -0.9 m/s^2

Process / plant

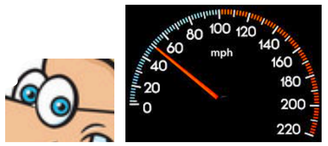
Actual output

51.4 mph

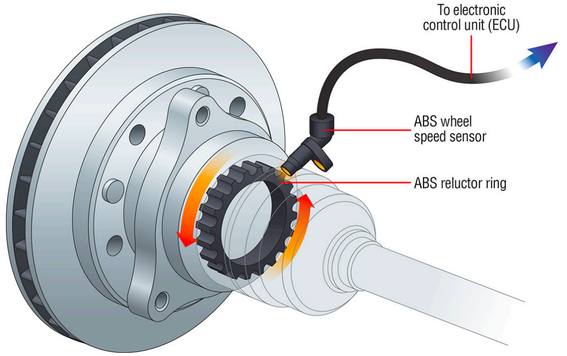
Measured output

51 mph

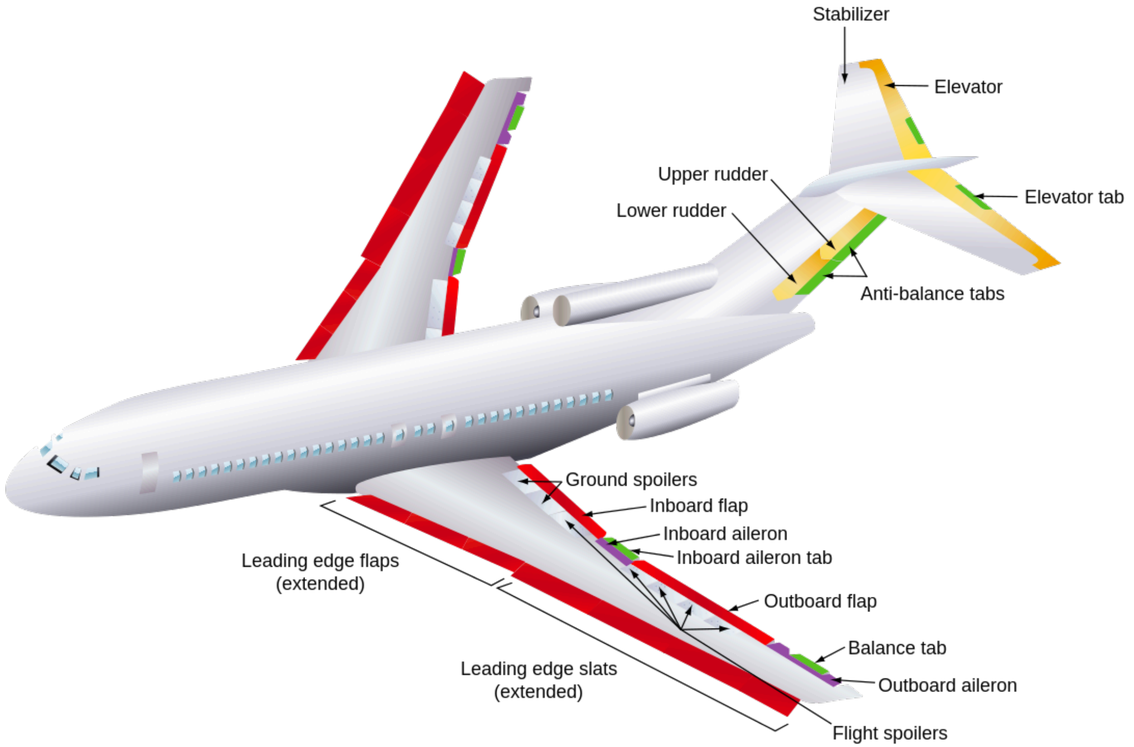
Sensor



Measurement noise / disturbance



Exercise 2: identify components of block diagrams



Boeing 727
Image credit: FAA