# Architectural requirements

## Actuators

There are four actuators in total, two on each elevator.

* Left Inner
* Right Inner
* Left Outer
* Right Outer

## Actuator modes

Each actuator with have five modes.

### Passive mode

The actuator is waiting and does not generate actuator control signals. An actuator in passive mode can take control of the elevator control system.

### Standby mode

The actuator's control law is active, but no force is applied to the actuator. It is ready to take control of the system and will introduce minimal transients when it does.

### Active mode

The actuator is active and controls the elevator.

### Isolated mode

The actuator is turned off indefinitely. An actuator must be able to be isolated from any mode.

### Off mode

The actuator is turned off temporarily because of a failure and will come back online only if all failures for that actuator are fixed.

## Actuator mode logic

The mode logic subsystem manages the fault isolation and recovery aspects of the design. Once a fault is detected, the actuator model logic subsystem must isolate the fault and then take an appropriate recovery action.

# Functional Requirements

## Fault Recovery

### Default start-up condition

If there have been no failures detected, the outer actuators have priority over the inner actuators. Therefore the elevator actuators should default to the following modes: The left outer and right outer actuators should transition from the Passive mode to the Active mode. The left inner and right inner actuators should transition from the Passive mode to the Standby mode.

### Left inner actuator in Passive mode

* If the left inner actuator is in the Passive mode, and the left outer actuator is in the Active mode
  + Transition the left inner actuator to the Standby mode.
  + Otherwise, transition the left inner actuator to the Active mode.

### Left inner actuator in Standby mode

* If the left inner actuator is in the Standby mode, and the left outer actuator is not in the Active mode or the right inner actuator is in the Active mode
  + Transition the left inner actuator to the Active mode.
  + Otherwise, keep the left inner actuator in the Standby mode.

### Left inner actuator in Active mode

* If the left inner actuator is in the Active mode, and the right outer actuator is in the Active mode and the left outer actuator is in the Active mode
  + Transition the left inner actuator to the Standby mode.
  + Otherwise, keep the left inner actuator in the Active mode.

### Right inner actuator in Passive mode

* If the right inner actuator is in the Passive mode, and the right outer actuator is in the Active mode
  + Transition the right inner actuator to the Standby mode.
  + Otherwise, transition the right inner actuator to the Active mode.

### Right inner actuator in Standby mode

* If the right inner actuator is in the Standby mode, and the right outer actuator is not in the Active mode or the left inner actuator is in the Active mode
  + Transition the right inner actuator to the Active mode.
  + Otherwise, keep the Right Inner actuator in the Standby mode.

### Right inner actuator in Active mode

* If the right inner actuator is in the Active mode, and the left outer actuator is in the Active mode and the right outer actuator is in the Active mode
  + Transition the right inner actuator to the Standby mode.
  + Otherwise, keep the right inner actuator in the Active mode.

### Left outer actuator in Passive mode

* If the left outer actuator is in the Passive mode, and the left inner actuator is in the Active mode
  + Transition the left outer actuator to the Standby mode.
  + Otherwise, transition the left outer actuator to the Active mode.

### Left outer actuator in Standby mode

* If the left outer actuator is in the Standby mode, and the left inner actuator is not in the Active mode or the right outer actuator is in the Active mode
  + Transition the left outer actuator to the Active mode.
  + Otherwise, keep the left outer actuator in the Standby mode.

### Left outer actuator in Active mode

* If the left outer actuator is in the Active mode, and the right outer actuator is not in the Active mode and the left inner actuator is in the Active mode
  + Transition the left outer actuator to the Standby mode.
  + Otherwise, keep the left outer actuator in the Active mode.

### Right outer actuator in Passive mode

* If the right outer actuator is in the Passive mode, and the right inner actuator is in the Active mode
  + Transition the right outer actuator to the Standby mode.
  + Otherwise, transition the right outer actuator to the Active mode.

### Right outer actuator in Standby mode

* If the right outer actuator is in the Standby mode, and the right inner actuator is not in the Active mode or the right outer actuator is in the Active mode
  + Transition the right outer actuator to the Active mode.
  + Otherwise, keep the right outer actuator in the Standby mode.

### Right outer actuator in Active mode

* If the right outer actuator is in the Active mode, and the left outer actuator is not in the Active mode and the right inner actuator is in the Active mode
  + Transition the right outer actuator to the Standby mode.
  + Otherwise, keep the right outer actuator in the Active mode.

### Outer actuator in Isolated mode

* If an outer actuator is in the Isolated mode
  + The other outer actuator, if in the Active mode, should be transitioned into the Standby mode; otherwise it should not change modes.
  + The inner actuators should be transitioned to the Active mode.

### Inner actuator in Isolated mode

* If an inner actuator is in the Isolated mode
  + The other inner actuator, if in the Active mode, should be transitioned into the Standby mode; otherwise it should not change modes.
  + The outer actuators should be transitioned to the Active mode.

### Outer actuator in Off mode

* If an outer actuator is in the Off mode
  + The other outer actuator, if in the Active mode, should be transitioned into the Standby mode; otherwise it should not change modes.
  + The inner actuators should be transitioned to the Active mode.

### Inner actuator in Off mode

* If an inner actuator is in the Off mode
  + The other inner actuator, if in the Active mode, should be transitioned into the Standby mode; otherwise it should not change modes.
  + The outer actuators should be transitioned to the Active mode.

## Fault Isolation

Fault isolation is used to identify the unit that caused the faulty behavior based on all the measurements available.

### Hydraulic pressure 1 failure

If a failure is detected in the hydraulic pressure 1 system, while there are no other failures, turn off the left outer actuator.

### Hydraulic pressure 1 fails and then recovers

If a failure is detected in the hydraulic pressure 1 system and the system is recovered, switch the left outer actuator to the Standby mode.

### Hydraulic pressure 2 failure

If a failure is detected in the hydraulic pressure 2 system, while there are no other failures, turn off both the left inner actuator and the right inner actuator.

### Hydraulic pressure 2 fails and then recovers

If a failure is detected in the hydraulic pressure 2 system and the system is recovered, switch the left Inner actuator and the right inner actuator to the Standby mode.

### Hydraulic pressure 3 failure

If a failure is detected in the hydraulic pressure 3 system, while there are no other failures, turn off the right outer actuator.

### Hydraulic pressure 3 fails and then recovers

If a failure is detected in the hydraulic pressure 3 system and the system is recovered, switch the right outer actuator to the Standby mode.

### Actuator position failure

If a failure is detected in an actuator, while there are no other failures, isolate that actuator.

### Hydraulic pressure 1 and left outer actuator failures

If a failure is detected in both the hydraulic pressure 1 system and the left outer actuator, while there are no other failures, turn off the left outer actuator.

### Hydraulic pressure 2 and left inner actuator failures

If a failure is detected in both the hydraulic pressure 2 system and the left inner actuator, while there are no other failures, turn off the left inner actuator.

### Hydraulic pressure 2 and right inner actuator failures

If a failure is detected in both the hydraulic pressure 2 system and the right inner actuator, while there are no other failures, turn off the right inner actuator.

### Hydraulic pressure 3 and right outer actuator failures

If a failure is detected in both the hydraulic pressure 3 system and the right outer actuator, while there are no other failures, turn off the right outer actuator.

### Multiple failures on left hydraulics and actuators

If multiple failures are detected in either the hydraulic pressure 1 or 2 systems and either the left outer actuator or the left inner actuator, isolate the left outer actuator and the left inner actuator.

### Multiple failures on right hydraulics and actuators

If multiple failures are detected in either the hydraulic pressure 2 or 3 systems and either the right outer actuator or the right inner actuator, isolate the right outer actuator and the right inner actuator.

### Actuator intermittent failures

If an actuator has been switched on and off 5 times during operation, isolate that actuator.

### Hydraulic pressure intermittent failures

### Hydraulic pressure 1 fails and recovers. Then Right Inner Actuator fails

If a failure is detected in the hydraulic pressure 1 system, this failure recovers, and then the Right Inner Actuator fails, then isolate the fault by switching the Right Inner actuator to the isolated mode.

### Hydraulic pressure 1 fails and recovers. Then Left Inner Actuator fails

If a failure is detected in the hydraulic pressure 1 system, this failure recovers, and then the Right Inner Actuator fails, then isolate the fault by switching the Left Inner actuator to the isolated mode.

### Hydraulic pressure 1 fails. Then Hydraulic pressure 2 fails.

If a failure is detected in the hydraulic pressure 1 system, followed by a failure detected in the hydraulic pressure 2 system, then isolate the fault by switching the Left Inner actuator and Left Outer actuator to the isolated mode.

### Hydraulic pressure 2 fails. Then Hydraulic pressure 1 fails.

If a failure is detected in the hydraulic pressure 2 system, followed by a failure detected in the hydraulic pressure 1 system, then isolate the fault by switching the Left Inner actuator and Left Outer actuator to the isolated mode.

### Hydraulic pressure 2 fails. Then Hydraulic pressure 3 fails.

If a failure is detected in the hydraulic pressure 2 system, followed by a failure detected in the hydraulic pressure 3 system, then isolate the fault by switching the Right Inner actuator and Right Outer actuator to the isolated mode.

### Hydraulic pressure 3 fails. Then Hydraulic pressure 2 fails.

If a failure is detected in the hydraulic pressure 3 system, followed by a failure detected in the hydraulic pressure 2 system, then isolate the fault by switching the Right Inner actuator and Right Outer actuator to the isolated mode.

## Safety constraints

There is additional logic required for the system to function safely.

### One active actuator / elevator

The system can have 1 and only 1 actuator per elevator active at any one time. It is better to have no actuator driving an elevator, for a short period of time, than to have both actuators active, which should never happen as it can lead to permanent damage.

### Actuator priority

The outer actuator (running the full control law) has priority over the inner actuator (running a reduced control law) if they are in the same mode.

### Symmetric requirement between left and right elevators

If possible, keep symmetry between the two elevators. For example, if the left outer actuator is active, then the right outer actuator, if possible, should be active as well.

### Minimize mode switching

• Keep the number of mode changes to a minimum; only respond to failures. Do not switch from the inner actuators back to the outer actuators if the outer actuators come back online, without a failure occurring in one of the inner actuators first.

### No failures, inner actuators in Active modes

If there are no active failures and the left inner and right inner actuators are in the Active mode, then all actuators shall stay in their current modes.

### No failures, outer actuators in Active modes

If there are no active failures and the left outer and right outer actuators are in the Active mode, then all actuators shall stay in their current modes.