Part 1: Use Cases

Use Case 1: Elevator Foundation Technician

EFT means Elevator Foundation Technician

- Primary Actor: EFT
- Stakeholders and Interests:
    - Building owner
    - Regulatory agency and inspector
    - Safety/fire department in case of fire/emergency actor
- Pre-condition:
    - The architect completes the structural diagram for the elevator.
- Success Guarantee (Post-condition)
    - The EFT completed the installation of the elevator foundations successfully and the hydraulics are ready to be installed.
- Main Success Scenario:
    1. The EFT installs the spot brackets at the topmost of the shaft.
    2. A Plumb line with a 12-point weight to the elevator pit is dropped to line the lower brackets with the spots up top accurately by the EFT.
    3. The EFT installs rail brackets that are straightened to a tolerance of 1/64th of an inch for each floor on each side.
    4. Guide rails are attached with a one-tone chain hoist attached.
    5. Car sling installation is done along with platform styles, and crossheads
    6. A rugged steel construction is made as a foundation of the cabin.
    7. Precise measurements are taken to install the struts that guide the hold door installation at each landing.
    8. Brackets are then installed to hold the structure securely in place.
    9. The hoistway sill is placed at the entrance of each level.
    10. Marks are made to prepare for the installation of the door box.
    11. Headers are placed along the top of the entrance at each landing to complete the frame of the door for installation.
    12. After securing the top and bottom to strict and exact specifications, the landing door is raised on the landing header and installed.
    13. Gibbs are used to guide the track and assembly of the cab begins.
    14. The side and rear interior walls are joined.
    15. The dome and sealing units are unpacked and the top of the elevator is sealed off.
- Extensions:

    12a. The landing door does not open/shut properly

    12a1. Make adjustments and raise the landing door again after verifying that it opens/shuts smoothly.

Use Case 2: Hydraulic Installers

HI means hydraulic Installer technician

- Primary Actor: HI
- Stakeholders and Interests:
    - Building owner
    - Regulatory agency and inspector

    - Safety/fire department in case of fire/emergency actor
- Pre-condition:
    - The elevator foundation, rails, and brackets are installed.
- Success Guarantee (Post-condition)
    - The HI successfully installed the hydraulics and the computerized motion control system and the cabin installation is ready.
- Main Success Scenario:
    1. HI installs hydraulic pistons.
    2. Sensor monitors for the pistons are installed.
    3. The selector is installed to monitor floor position.
    4. The computerized motion control system is installed.
- Extensions:
        1a. The installed hydraulic piston speed is too fast
            1a1. HI makes adjustments to the valve control to decrease the pressure and the valve control to adjust the cab speed.
        1b. The installed hydraulic piston speed is too slow
            1b1. HI makes adjustments to the valve control to increase the pressure and adjust the cab speed.

Use Case 3: Cabin Installation Mechanic

CIM means Electric & Computer Engineers

- Primary Actor: CIM
- Stakeholders and Interests:
    - Building owner
    - Regulatory agency and inspector
    - Safety/fire department in case of fire/emergency actor
- Pre-condition:
    - The foundations for the elevator are in place and working.
    - The hydraulics and computerized motion control system are installed.
- Success Guarantee (Post-condition)
    - The elevator cabin and front panel are successfully installed and are ready for wiring and sensor installation.
- Main Success Scenario:
    1. The car sling platform is installed as well as a rugged steel foundation for the cabin.
    2. Structures that guide the door are installed at each landing as well as brackets to hold the structure in place.
    3. The hoistway sill is placed at each entrance as well as the header for the door frame installation.
    4. The cab is assembled by joining the side and rear interior walls as they sit on top of the platform
    5. The strike column and return column are installed.
    6. A front panel that houses a computer interface is installed.
    7. Dome and sealing units are attached to the cab.
- Extensions:
        4a. Cab does not open properly at each entrance.
            4a1. Re-adjust hoistway sill and check precise measurements for each floor for the landing door and frame positions.

4a2. Verify that cab works using the temporary override control on top of the cab.

Use Case 4: Electric & Computer Engineers

ECE means Electric & Computer Engineers

- Primary Actor: ECE
- Stakeholders and Interests:
  - Building owner
  - Regulatory agency and inspector
  - Safety/fire department in case of fire/emergency actor
- Pre-condition:
  - The foundations for the elevator are in place and working.
  - The hydraulics and computerized motion control system are installed.
  - The cab is installed and the top is sealed off.
  - The front panel that houses the computer interface is installed.
- Success Guarantee (Post-condition)
  - All wiring (low/high voltage) is successfully completed, computer system is programmed, sensors are working, and cab is set to fully automatic control.
- Main Success Scenario:
  1. A mechanism to lock & unlock the door is installed.
  2. Sensors to reopen doors when obstructed are installed.
  3. Electrical wiring on top of the elevator for lights and ventilation fan is completed.
  4. Wiring for both electric systems (high voltage) and signal wiring (slow voltage) are completed.
  5. Computer and control system wiring is completed.
  6. The temporary override jumper is removed and the remaining car control systems are wired.
  7. The remaining wiring for buttons and switches is completed.
  8. The computer is programmed with commands and protocols for proper operation and is turned into full automatic control.
- Extensions:

  2a. The sensors are not working properly

  2a1. ECE makes adjustments to sensors and reprograms them.

Use Case 5: Verification Tester

VT means Verification Tester

- Primary Actor: VT
- Stakeholders and Interests:
  - Building owner
  - Regulatory agency and inspector
  - Safety/fire department in case of fire/emergency actor
- Pre-condition:
  - The foundations for the elevator are in place and working.
  - The hydraulics and computerized motion control system are installed.
  - The cab is installed and the top is sealed off.
  - Electrical wiring is done and a temporary run box is installed.

- Success Guarantee (Post-condition)
    - The elevator is fully built, functioning, and properly tested by the VT for all emergency scenarios, sensors, and full-weight tests.
- Main Success Scenario:
    1. Schedule inspection with a certified inspector.
    2. VT tests every button, switch, and system.
    3. VT checks door safety sensors.
    4. Fire safety systems are checked by VT to make sure the elevator recalls to the proper floor in case of emergency.
    5. VT performs a full load weight test on the elevator.
    6. Plumbing is checked to ensure a leak-free high-pressure hydraulic system.
- Extensions:
    4a. Elevator does not recall to proper floor in case of emergency.
        4a1. Front panel and programming for proper emergency button are re-done and tested again.
    3a. Door attempts to close even with door-obstruction.
        3a1. Sensors are re-programmed and tested again

Use Case: Elevator Control System

- Primary Actor(s): User/passenger
- Stakeholders & Interests:
    - Building owner
    - Safety inspector and regulatory agency
    - Fire department/emergency services
- Pre-condition(s): The elevator is fully built, functioning, and has been tested by an elevator safety inspector. Additionally, all emergency buttons, control system, and backup battery are working and have been tested.
- Success Guarantees (Post-conditions)
    - The user is successfully able to enter and exit the elevator at their desired floors and in case of emergency, the emergency protocols are properly executed by the elevator.
- Main Success Scenario:
    1. The user presses the elevator up/down button.
    2. The elevator arrives at the user's floor and the elevator door opens.
    3. The user enters the elevator and the elevator door closes.
    4. The user presses their destination button.
    5. The elevator moves to the destination floor.
    6. The elevator doors open and the user exits to the destination floor.
- Extensions:
    4a. The control system receives a ‘Help’ alarm signal from the elevator.
        4a1. The user is connected to the building safety service through a voice connection
        4a2. If there is no response from either side within 5 seconds, a 911 emergency call is placed.
    3a. The light sensor is interrupted due to an obstacle in the door.
        3a1. The control system will stop the door from closing and immediately open it fully.

3a2. If this keeps occurring over a short period of time, a warning is found over the audio system and a text message is also displayed.

4b. The control system received a ‘Fire’ alarm signal from the building.

4b1. The elevator receives a command to move to a safe floor (usually the ground floor). An audio and text message is presented to the user.

4b2. The user exists once the safe floor is reached.

3b. The control system received an ‘Overload’ alarm signal from the elevator.

3b1. Sensors detect that passenger or cargo load has exceeded carrying capacity.

3b2. The elevator will not move and an audio and text message is presented to users asking to reduce the load.

3b3. The elevator attempts to move again by checking if the load has been reduced.

5c. The control system received a ‘Power Out’ alarm signal while elevator is moving to the destination floor.

5c1. Elevator stops temporarily

5c2. The battery backup power is turned on and the elevator is powered again.

5c3. An audio and text message is presented to users to inform them of the power outage.

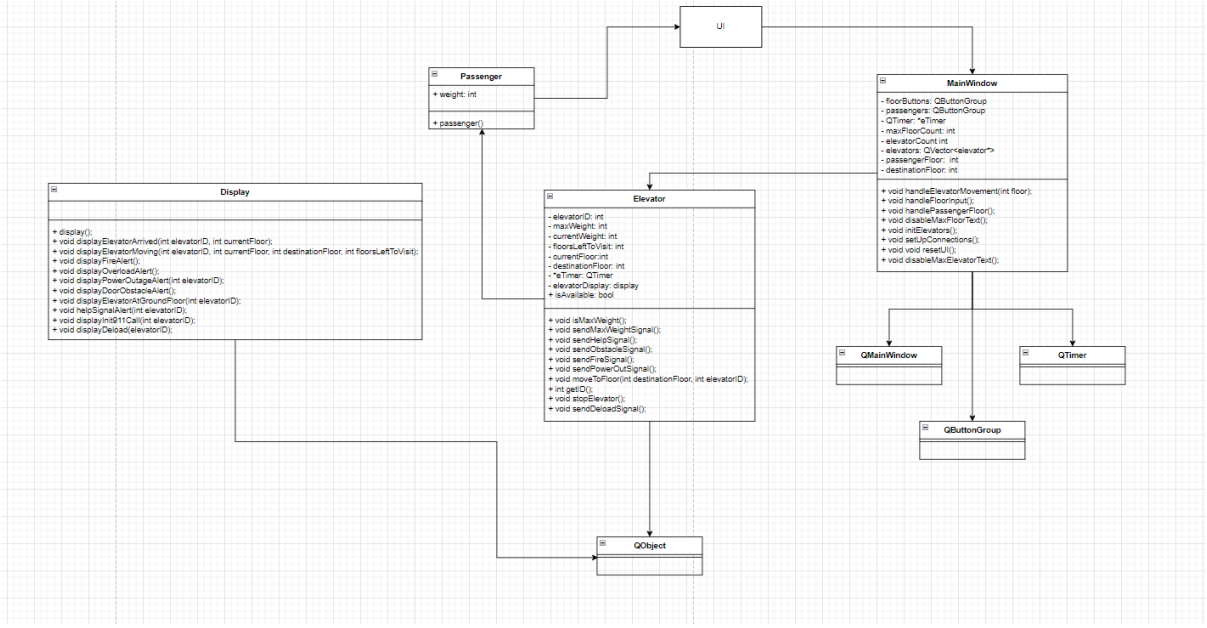
5c4. The elevator moves to a safe floor.

5c5. Elevator sends an audio and text message informing user to leave.

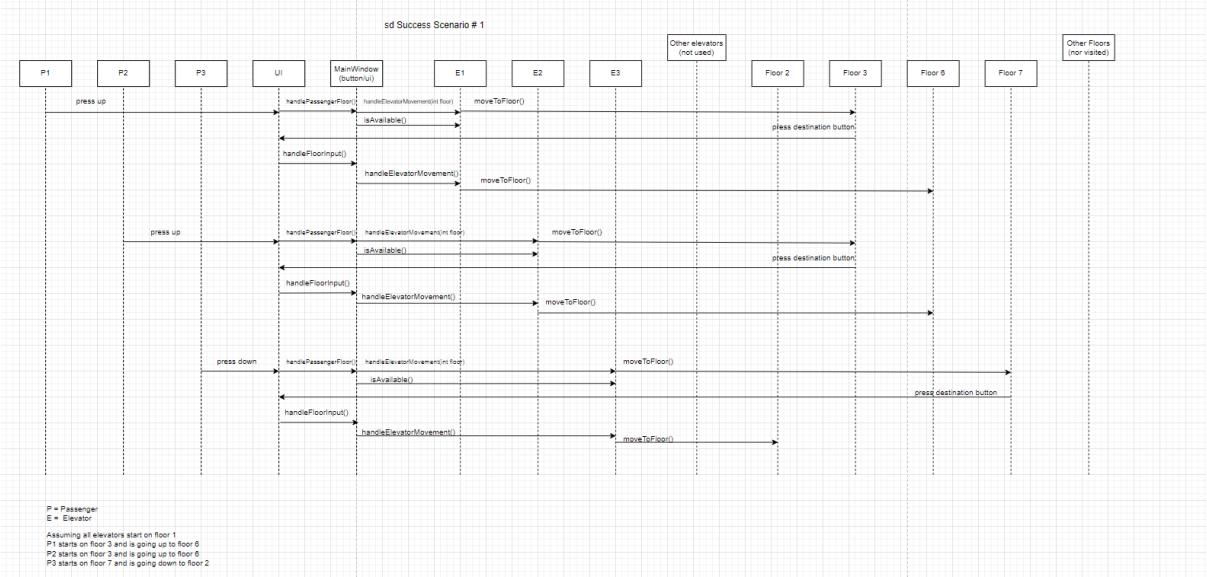
5c6. Users exit the elevator.

Part 2: Design Documentation

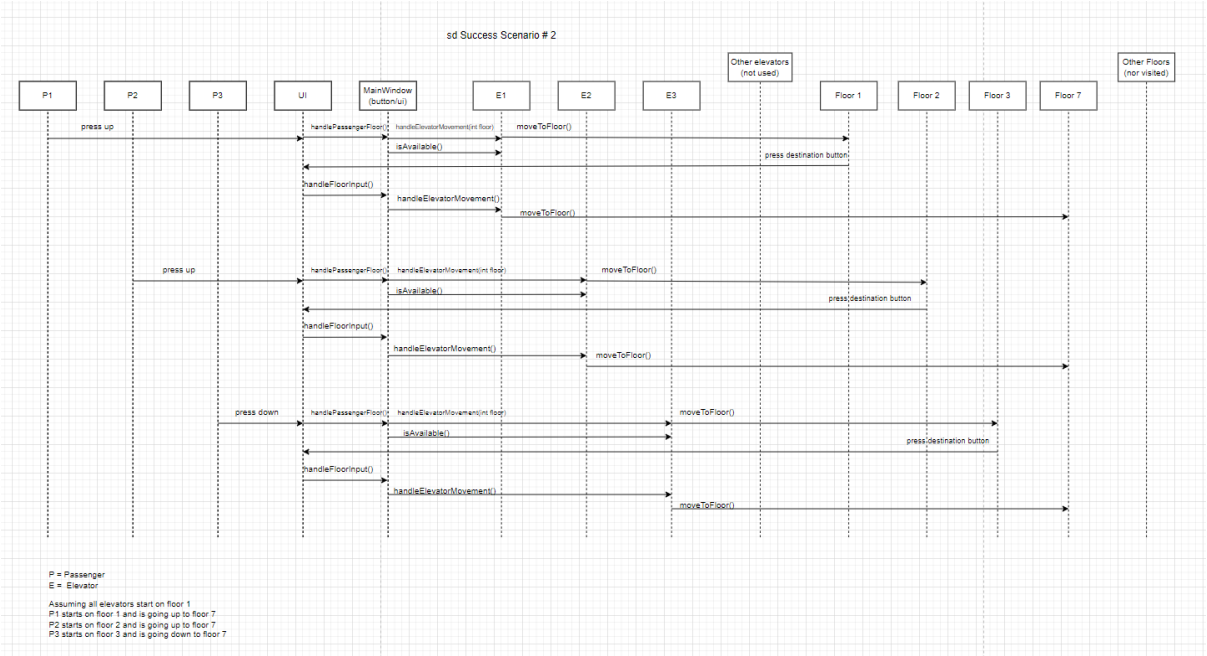
UML Class Diagrams:



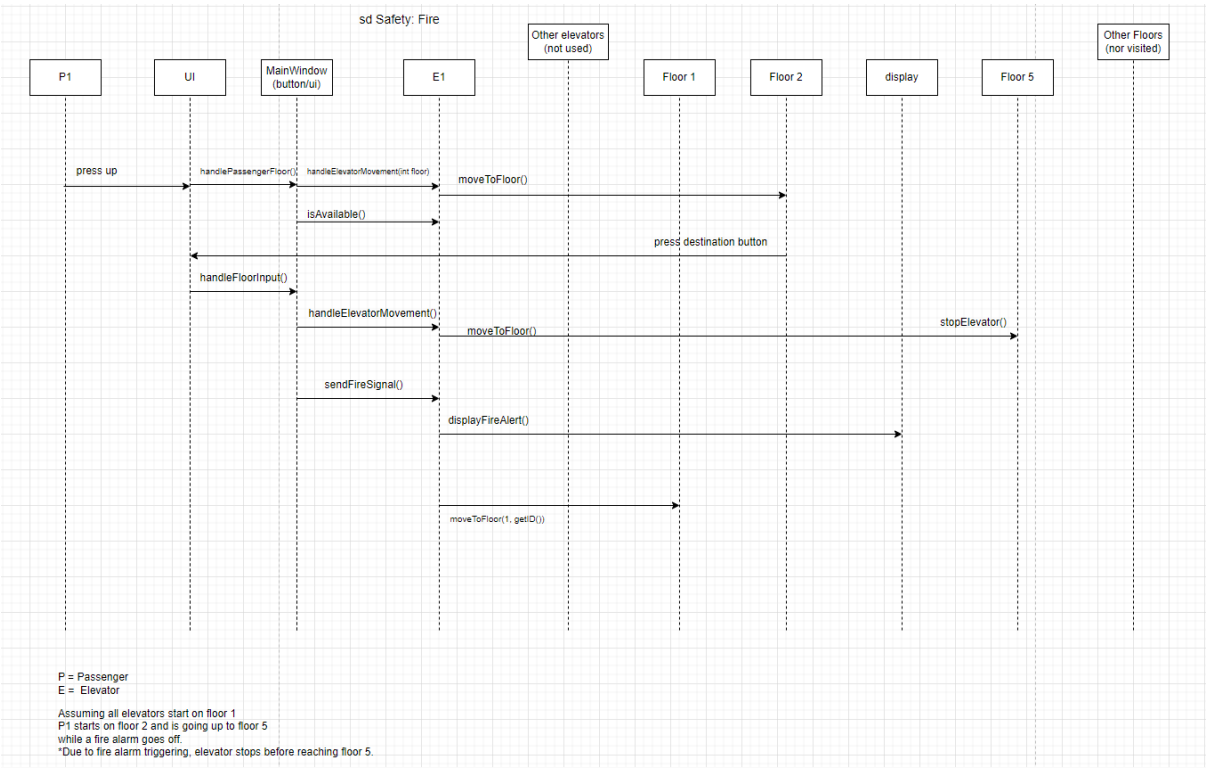
Sequence Diagrams:
Success Scenario #1:



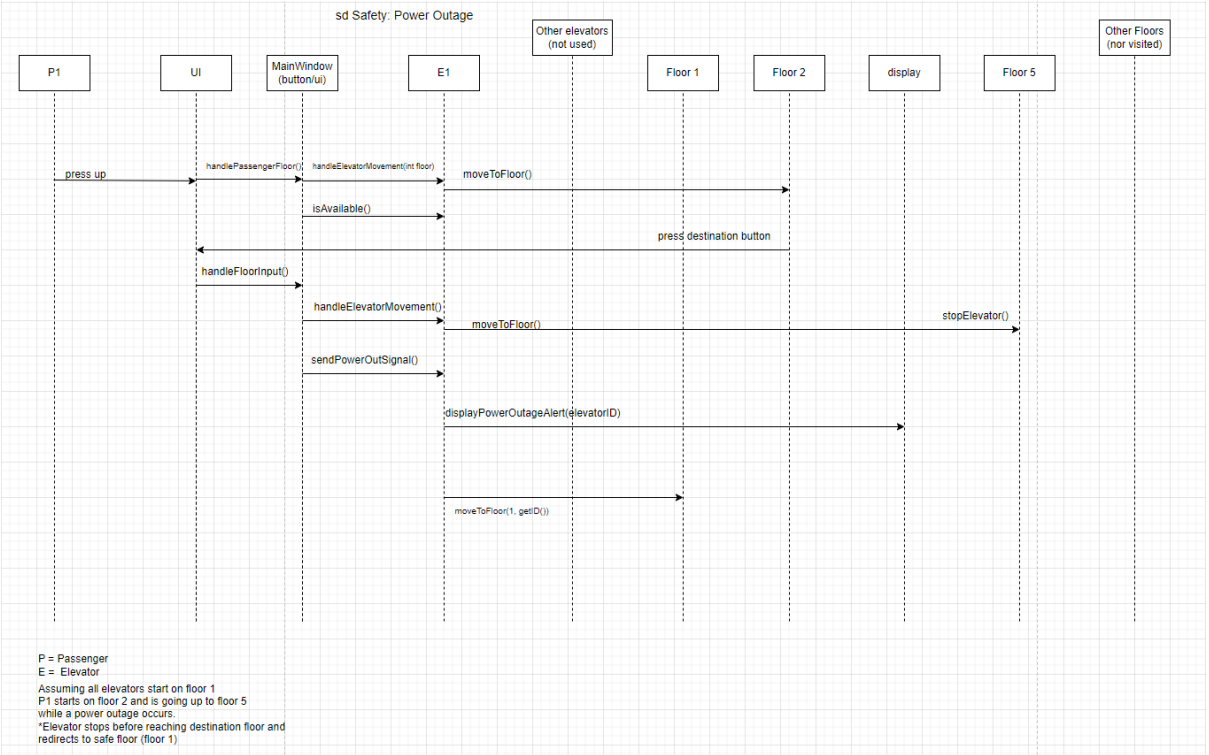
Success Scenario #2:



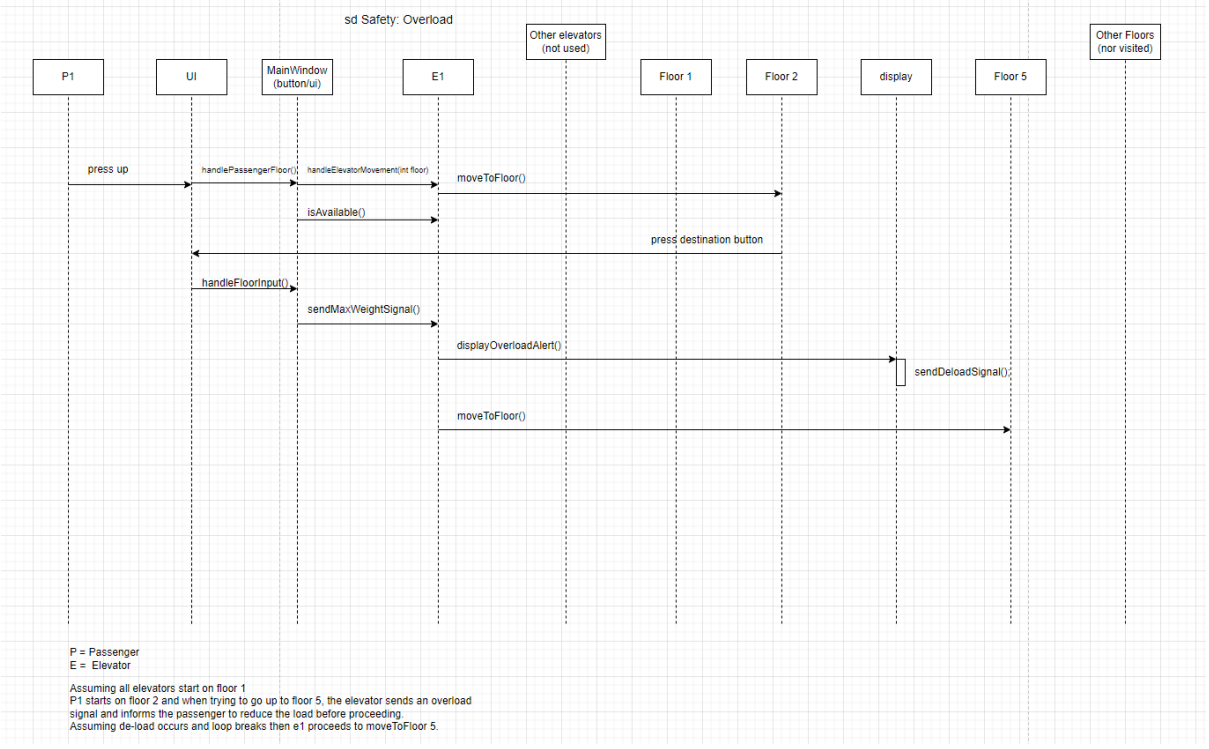
Safety: Fire:



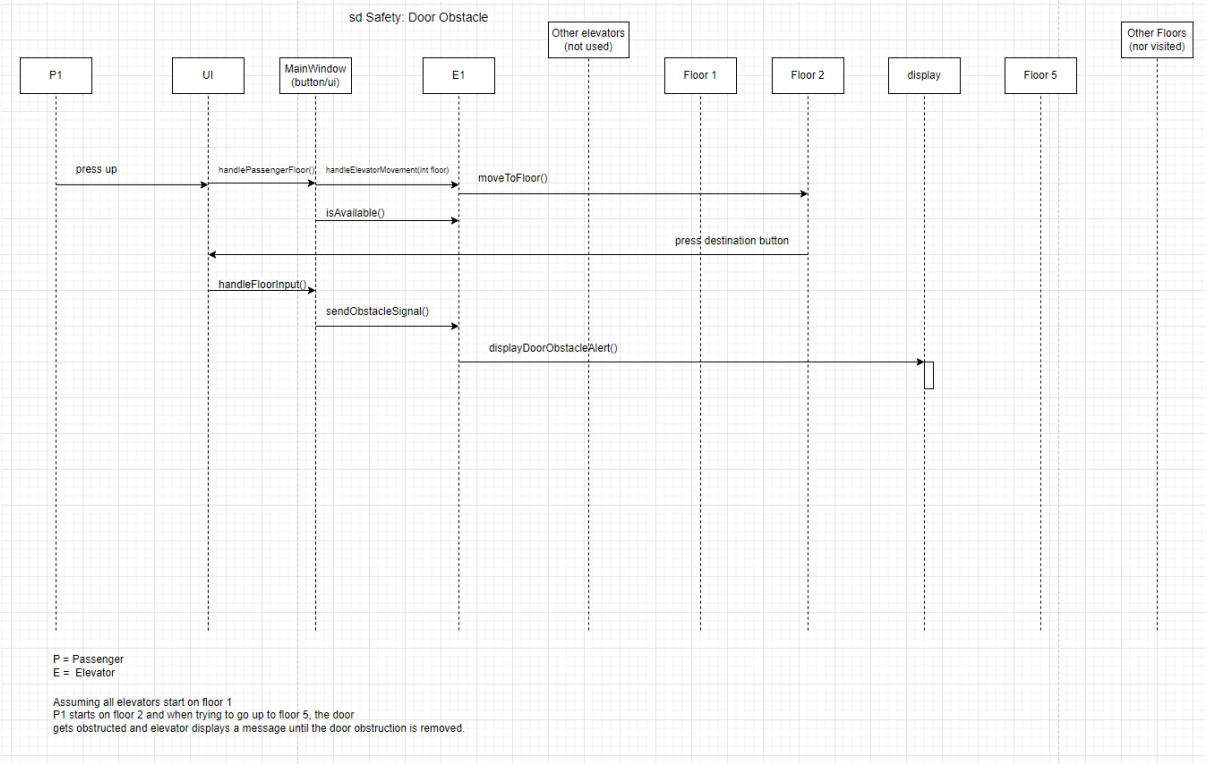
Safety: Power Outage:



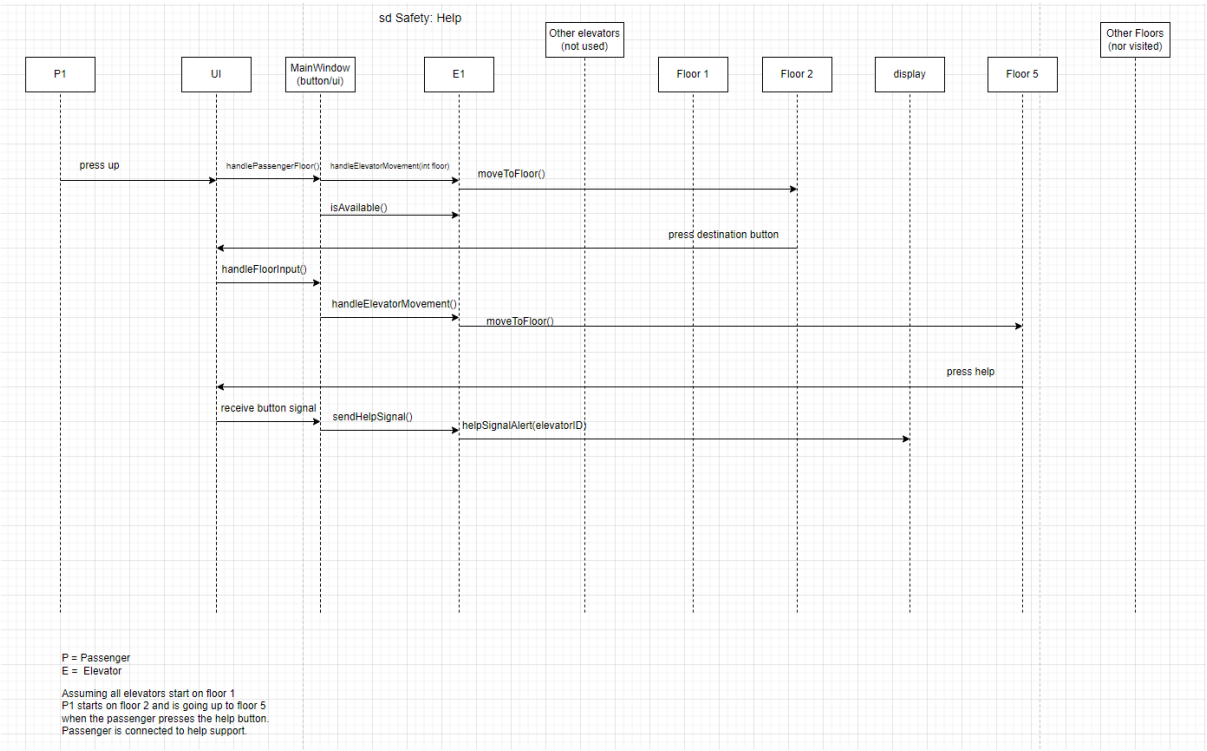
Safety: Overload:



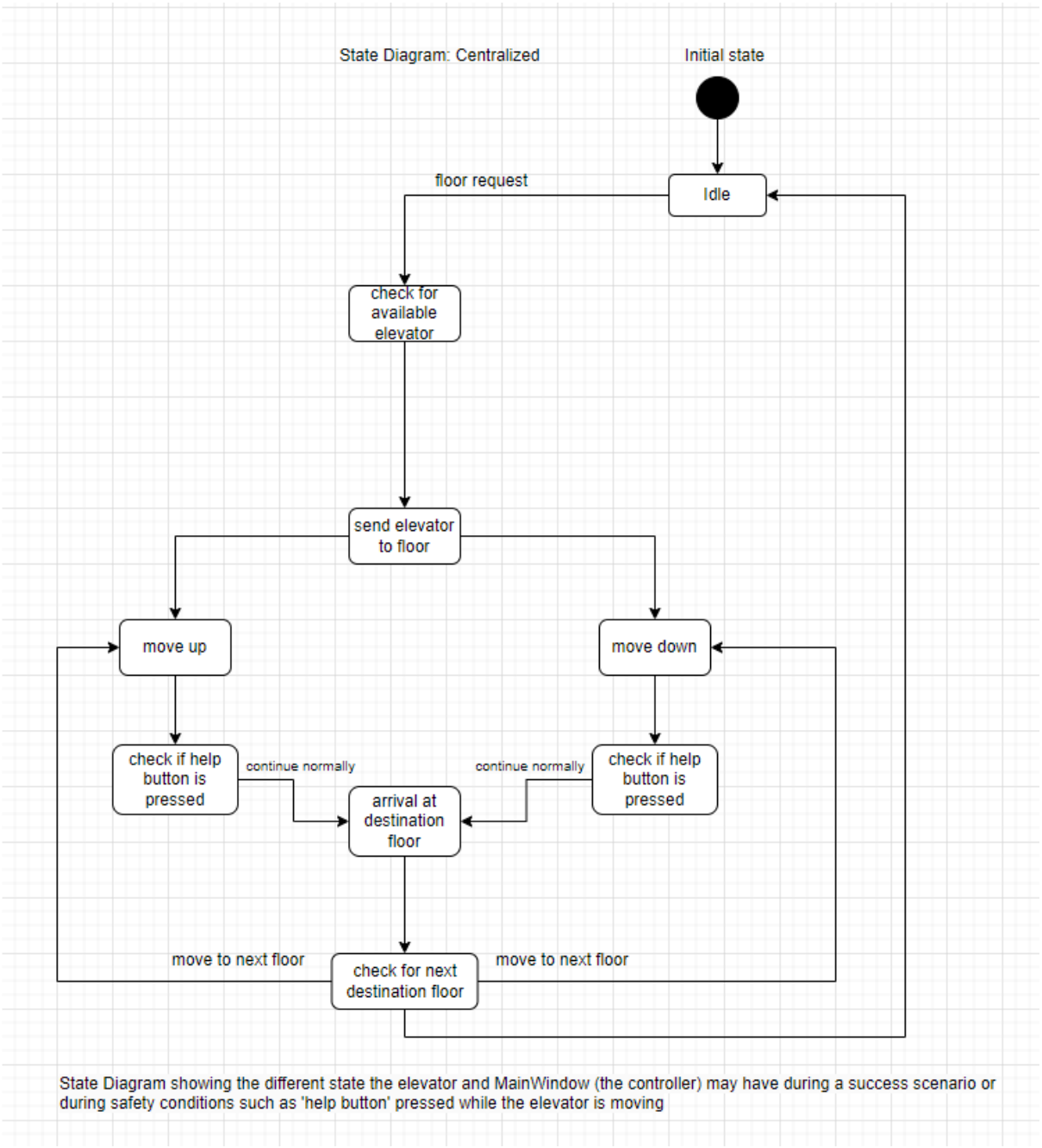
Safety: Door Obstacle:



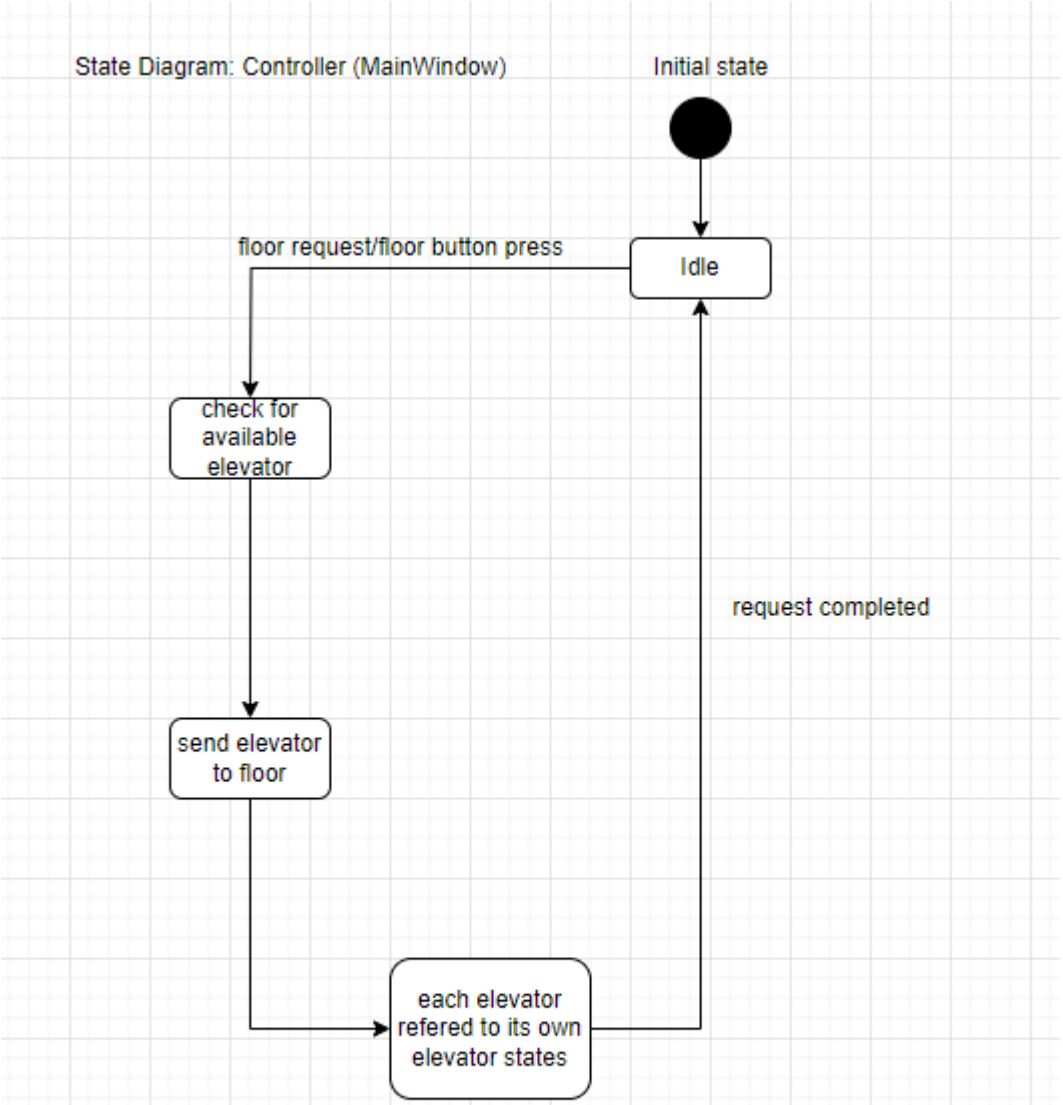
Safety: Help:



State Diagrams:



State Diagram showing the different state the elevator and MainWindow (the controller) may have during a success scenario or during safety conditions such as 'help button' pressed while the elevator is moving



State diagram showing the different states the ECS will have and how it interacts with elevators.

Design Explanation: I chose to use the centralized design as it contains an elevator control system. In my design, the ECS is the main window as this class handles the logic for managing elevators, etc. It checks to see which elevators are free, creates the elevator vectors, and sends elevators to their destinations as well as handles slots/signals that come from UI button presses.

Part 3: Requirements Traceability Matrix

ID	Requirement	Related Use Case	Fulfilled By	Test	Description
1	N floors & M elevators	N/A	MainWindow, UI	Run simulation in QT and enter desired N/M numbers in UI text box then run the simulation to test it.	Simulation supports any number of floors & elevators and is not restricted to the normal 7 floors and 3 elevators.
2	Button press	UC 1	Passenger, UI, MainWindow	Run simulation and test by pressing buttons.	All button presses are done through the UI and trigger different scenarios.
3	Ring elevator bell	UC 4	Passenger, Display, elevator	Run simulation and test by sending an elevator to a floor and view the logs for “Ring Ring”.	This is seen in the logs and is fulfilled by the display class. It indicates an elevator door is opening/closing.
4	Close elevator door	ECS	Passenger, UI, MainWindow, Elevator	Run the simulation and test by pressing the door close button.	The elevator doors can be closed in the simulation using the close door button. The related use case involves running the simulation and testing it by pressing door close.
5	Open elevator door	ECS	Passenger, UI, MainWindow, Elevator	Run the simulation and test by pressing the door open button.	The elevator doors can be opened in the simulation using the open door button. The related use case involves running the simulation and testing it by pressing the door open.
6	Elevator help button	UC 4	Passenger, elevator, Mainwindow, UI	Run the simulation and test by pressing the help button while an elevator is moving/idle.	The elevator help button sends a signal that connects the passenger to the safety department.
7	Elevator sensor notifies when it arrives at a floor	UC 4	elevator, display	View terminal logs when elevator arrives at a floor or passes one when simulation is running.	The application provides notifications through logs when it passes and arrives at a floor.
8	Each elevator has a display and an audio system	UC 4	Elevator, display	Test the outputs of the logs and “ring ring” for audio system each time a door opens.	The application provides text/audio in the form of console logs when it passes and arrives at a floor and open/close door.

9	The display shows the current floor number and warning messages that are synced with audio warnings.	UC 4	Elevator, display	View logs during different safety cases after the buttons are pressed in the simulation.	The display (console log) shows the floors visited and floors left to visit as well as displays any other signals received from the mainwindow.
10	The control system receives a “Help” alarm signal from an elevator	UC 4	Passenger, UI, MainWindow, elevator	Press the help button when simulation is running.	The elevator help button sends a signal that connects the passenger to the safety department.
11	Passenger is connected to building safety service	Use Case: Elevator Control System	Elevator, display	Press help button and view terminal to see elevator being connected to safety services.	This happens after help button is pressed.
12	If there is no response from either sides for 5 seconds after pressing ‘Help’, 911 emergency call is placed	UC 4	N/A	Press help button and wait 5 seconds, the log will show 911 call initiated for that elevator.	The elevator help button sends a signal that connects the passenger to the safety department and waits 5 seconds before sending 911 call.
13	Door obstacles	Use Case: Elevator Control System	Elevator, display, MainWindow	Press the open door button to send an obstacle signal and wait a few seconds for the elevator to attempt to close the door.	Door obstacles trigger door obstacle signal which makes the elevator keep its doors open and attempt to close again in 5 seconds.
14	If this occurs repeatedly over a short period of time, a warning is sounded over the audio system and a text message is displayed	UC 4	Display, elevator, UI, MainWindow	Press the door open button multiple times in a row, elevator wont move and logs will be shown.	Door obstacles trigger door obstacle signal which makes the elevator keep its doors opened and attempt to close again in 5 seconds.
15	The control system receives a	UC 4	Elevator, display, UI, MainWindow, Passenger	While the simulation is running in QT, move the elevator	Each elevator will receive the signal and move to the ground floor.

	“Fire” alarm signal from the building and commands all elevators to move to a safe floor			and press ‘Fire’ button.	
16	Similarly, a “Fire” alarm signal from the elevator itself will cause that elevator to go to a safe floor	UC 4	Elevator, display, UI, MainWindow, Passenger	While the simulation is running in QT, move the elevator and press ‘Fire’ button.	Each elevator will receive the signal and move to the ground floor. Any elevators that are idle will also receive the signal and act accordingly (will tell passenger to exit if elevator is already at ground floor (safe floor)).
17	An audio and text message are presented to passengers informing them of an emergency and asking them to disembark once the safe floor is reached	Use Case: Elevator Control System	Elevator, display	Press the ‘Fire’ button during the simulation and view the logs.	After a fire alarm is received, elevators will move to safe floor (usually ground floor/1) and passengers are asked to exit.
18	The control system receives an “Overload” alarm signal from an elevator	UC 4	MainWindow, UI, Passenger, elevator	Run simulation in QT and press overload button when passenger enters and door is closing.	If elevator receives overload, request to deload the elevator before moving on.
19	The elevator does not move and an audio and a text messages are presented to passengers asking for the load to be reduced before attempting to move again.	Use Case: Elevator Control System	Display, elevator	In QT, press overload button and then press deload button to reduce weight.	If elevator receives overload, request to deload the elevator before moving on.
20	The control	UC 4	Elevator,	Run simulation in QT	If the control system receives

	system receives a “Power Out” alarm signal		MainWindow, UI, Passenger	and press the power out button when elevators are moving or idle.	power out, it sends a signal to each elevator, they are turned to battery power mode and are brought to ground floor.
21	Elevator class	UC 3	MainWindow, Display	N/A	The elevator class is responsible for moving to floors to pick up passengers and receiving/sending signals and acting according during different scenarios.
22	Mainwindow class	Elevator Control System	Elevator, UI	N/A	The mainwindow class interacts with the UI and contains slots/signals. It is responsible for reading the use input and informing elevators to go to floors as well as checking for elevator availability.
23	Display class	UC 4	elevator	N/A	The display class is responsible for printing the outputs and logs every time a button is pressed or a floor is passed and any safety scenarios.
24	Passenger class	UC 5, elevator control system	UI, elevator	N/A	The passenger class has a weight/floor and elevators come to their location to pick them up.
25	The application does not contain any memory leaks	N/A	N/A	Run valgrind to check for leaks	All dynamically allocated memory is deallocated in the deconstructor class (eg. elevator and mainwindow deconstructors).

Link to Youtube Simulation: https://www.youtube.com/watch?v=j-rtXne6Q1c