

Requirements Specification for an Elevator Controller
Assignment 3
CS846 - Requirements Engineering

Rolando Blanco
School of Computer Science
University of Waterloo

November 9th, 2005

Contents

1	Introduction	4
1.1	Purpose	4
1.2	Scope	4
1.3	Acronym's, Abbreviations, Definitions, Notational Conventions	4
1.4	References	4
2	General Description	5
2.1	Product Perspective	5
2.1.1	Hardware Interfaces	6
2.1.2	Communication Interfaces	8
2.2	Product Functions	8
2.2.1	Operation Modes	9
2.3	User Characteristics	9
2.4	Constraints	9
2.5	Assumptions	9
3	Use Cases	10
3.1	Use Case Diagram	10
3.2	Use Case Descriptions	11
4	State and Conceptual Diagrams	22
4.1	System State Diagrams	22
4.2	Conceptual Diagram	24
4.3	State Diagrams for Selected Concepts	26
4.3.1	Car Selector	26
4.3.2	Request Tracker	27
4.3.3	Travel Planner	27
4.3.4	Request Server	28
4.3.5	Movement Controller	30
4.3.6	Operation Mode Setter	30
4.3.7	Recall Controller	31
4.3.8	Fire Alarm Coordinator and Emergency Announcement Controller	32
4.3.9	Door Controller	33
4.3.10	Alarm Bell Controller	34
5	Collaboration Diagrams	35
5.1	Unified Collaboration Diagram	35
5.2	Collaboration Diagrams for Selected Use Cases	36
5.2.1	Travel To Floor	36
5.2.2	Elevator Car Recall	37
5.2.3	Ring Alarm Bell	37
6	Reference Tables and Descriptions	40
6.1	Functional Requirements Table and Traceability Document	40
6.2	Non Functional Requirements Table and Traceability Document	49

List of Figures

1	Context Diagram for Elevator System	7
2	Floor Doors and Hall Buttons	7
3	Control Panel (inside each elevator car)	8
4	Direction Indicators	8
5	Floor Indicators	8
6	Use Case Diagram	10
7	Sequence Diagram for UC1 - Travel to Floor	13
8	Sequence Diagram for UC2 - Service Floor	14
9	Sequence Diagram for UC3 - Open Door	15
10	Sequence Diagram for UC4 - Close Door	16
11	Sequence Diagram for UC5 - Announce Emergency	17
12	Sequence Diagram for UC6 - Ring Alarm Bell	18
13	Sequence Diagram for UC7 - Set Operation Mode	19
14	Sequence Diagram for UC8 - Recall Due to Fire Alarm	20
15	Sequence Diagram for UC9 - Recall to Floor	21
16	System Statechart Model	23
17	System Statechart Model (Recalling to Floor)	24
18	Elevator Controller Conceptual Diagram	25
19	State Diagram for Car Selector	26
20	State Diagram for Request Tracker	27
21	State Diagram for Travel Planner	28
22	State Diagram for Request Server	29
23	State Diagram for Movement Controller	30
24	State Diagram for Operation Mode Setter	31
25	State Diagram for Recall Controller	32
26	State Diagram for Fire Alarm Coordinator	32
27	State Diagram for Emergency Announcement Controller	33
28	State Diagram for Door Controller	33
29	State Diagram for Alarm Bell Controller	34
30	Unified Collaboration Diagram	35
31	Collaboration Diagram For “Travel to Floor” Use Case (UC1)	36
32	Collaboration Diagram For “Elevator Car Recall” - Related Use Cases (UC5, UC7, UC8, UC9)	38
33	Collaboration Diagram For “Ring Alarm Bell” (UC6)	39

1 Introduction

1.1 Purpose

This document describes the requirements specification of an Elevator Controller for a two car elevator system servicing a low rise building. The intended audience of this document are individuals that may be interested in the the portion of the functionality of an Elevator Controller that is visible to elevator passengers.

1.2 Scope

The product described in this document specification is an Elevator Controller which main function is to command the operation of a two speed, two car elevator system in a building with no more than ten floors. The functionality of the Elevator Controller here described matches the functionality of existing elevator controllers with regards to:

- Operation of the elevator system by passengers using the interfaces visible to passengers during normal operation
- Interaction between the elevator system and the fire alarm system in the building where the elevator system will operate.
- Interaction between the elevator system and a building security monitoring system.

This document does not describe the requirements nor specification of the Elevator Controller as it relates to devices on top of the elevator cars used during repair and maintenance of the elevator system, even though these devices interact with the Elevator Controller.

This document does not describe the physical interface, sampling rates, wire protocol, and other low level requirements needed by a Elevator Controller to command the operation of the components of the elevator system. Only passenger-visible functionality is specified in this document.

1.3 Acronym's, Abbreviations, Definitions, Notational Conventions

DFD	Dataflow Diagram
EC	Elevator Controller. The System to be produced

1.4 References

- [cod04] *CSA B44-04 Canadian Safety Code for Elevators and Escalators*. CSA International, 2004. (Bi-National standard – USA, with ASME A17.1), CSA International. 2004. Current elevator standards.
- [cod05] *CSA B355-00 Lifts for Persons with Physical Disabilities*. CSA International, 2005. National Standard for Canada; Revision 2005.

2 General Description

The main function of the EC is to coordinate and control the operation of the components in the elevator system. Through sensors and interfaces the EC controls the location and movement of the cars in the system with the purpose of transporting passengers between floors in the building where the elevator system is installed. The EC is also in charge of providing feedback to the passengers to allow them to use/operate the elevators.

2.1 Product Perspective

The elevator system controlled by the EC has two cars servicing n floors in a low rise building. For illustration purposes, we will assume $n = 6$. The context diagram in Figure 1 (in DFD format) illustrates the components that are controlled by the EC. Figures 2 to 5 show some of the user interfaces assuming a six floor building. Besides the EC itself, the components of interest in the elevator system are:

- Two cars. Each car has a door (*car door*) that the EC opens when passengers are to enter/exit the car.
- Two *close-door timers*, one per car door, are used to determine the amount of time to wait before closing a car door.
- Two *door sensors*, one per elevator car door. The door sensors avoid closing the car doors when there is an object blocking the way of the door.
- Two doors (*floor doors*), one per car on each floor (Figure 2) . Each door allows access to one of the cars when the car is parked at that floor and the car door is open. A mechanism in the floor door opens/closes the floor door at the same time the car door is open/closed, without direct intervention of the EC.
- Up and down push buttons (*hall buttons*) between the two doors on intermediate floors (2 to 5 in a six storey building), Up button only on floor 1, and Down button only on the last floor (6th floor); see Figure 2. Buttons are pressed by waiting passengers to request (call) a car and to specify the direction they wish to travel. The hall buttons stay illuminated until the car that will service the passenger arrives. Hall buttons also serve to indicate to waiting passengers whether a car has already been called for a given direction.
- A control panel on each car (Figure 3). Located by the car door, the control panel allows passengers to control the operation of the car. Components in the control panel are:
 - *Floor buttons* allow passengers to select the floor they wish to go to. In a six storey building there are 6 floor buttons numbered 1 to 6.
 - An *open door button* opens the door if the button is pushed and the car is parked on a floor. Once the door is open, the door timer is set and the door closed again once the timer completes.
 - A *keyed operation switch* allows to set the operation mode of the car to *auto*, *hold* (reserved operation) or *service* mode. During *auto* operation, the car is assigned to serve call requests of passengers waiting for elevators. During *hold*, the car is not considered by the EC when servicing call requests by passengers. Moreover, the EC

only responds to the devices inside the elevator (floor buttons, open door button, etc), and the car door is kept open while parked at a floor. When set to *service* mode, the elevator car is recalled to a predetermined floor (typically the ground floor), and kept in that floor with the door open until the operation mode is set back to *auto* or *hold*. Section 2.2.1 discusses the operation modes in more detail.

- An *emergency button* rings an emergency bell while being pushed, and recalls the elevator car to a predetermined floor (typically the ground floor). While on the recall floor, the elevator car door is kept open. The elevator car is only put back on service until the operation mode switch is reset to either *hold* or *auto*.
 - A *bell button* rings an alarm while being pushed by a passenger. In contrast with the emergency button operation, the elevator car continues its operation while the bell button is pushed.
- Light indicators (*direction indicators*) inside the car indicate the direction the car is/will travel when the car arrives to a floor (Figure 4). The direction indicators are visible to waiting passengers outside the car when the car door opens.
 - *Floor indicators* inside the car on top of the car door. Floor indicators are labelled 1 to 6 in a six storey building, and indicate to passengers in the car the current location (floor number) of the car (Figure 5).
 - An electric *motor* for each car. When directed by the EC, the motor lifts, lowers, slows down, or stops the car.
 - A *location sensor* for each elevator car. The location sensors allow the EC to determine if an elevator car is arriving, or at a floor. The EC uses the information provided by the location sensors to accurately stop an elevator car at a specific floor.

Although the interface so far described assumes that *visual* indicators are used by the EC to aid passengers in using the elevator system, *sound* indicators are commonly used as well to aide passengers that are visually impaired. For example, a short beep can be sound in an elevator car as the elevator passes each floor, and a long beep can be sound to announce passengers of the arrival to a requested floor. For this reason, we will abstract the actual passenger notification mechanism from the specification. For actual notification requirements, please refer to [cod04, cod05].

Besides the components in the elevator system already mentioned, the EC also interfaces with the building's fire emergency system, and security monitoring system. In case of a fire alarm, the fire emergency system informs the EC of the event. The EC then recalls the two cars to a floor determined by the fire alarm system. To put the elevator cars in operation again, the operation switch needs to be reset to *hold* or *auto* (see Section 2.2.1).

The interface with the building security monitoring system is used by the EC to inform the security monitoring system when a passenger uses the emergency button in any of the two elevator cars.

2.1.1 Hardware Interfaces

Communication of events between the components of the elevator system and the EC is done via I/O interfaces to be determined (*Note: description or reference to the actual wire protocol should follow; sampling rates; etc*).

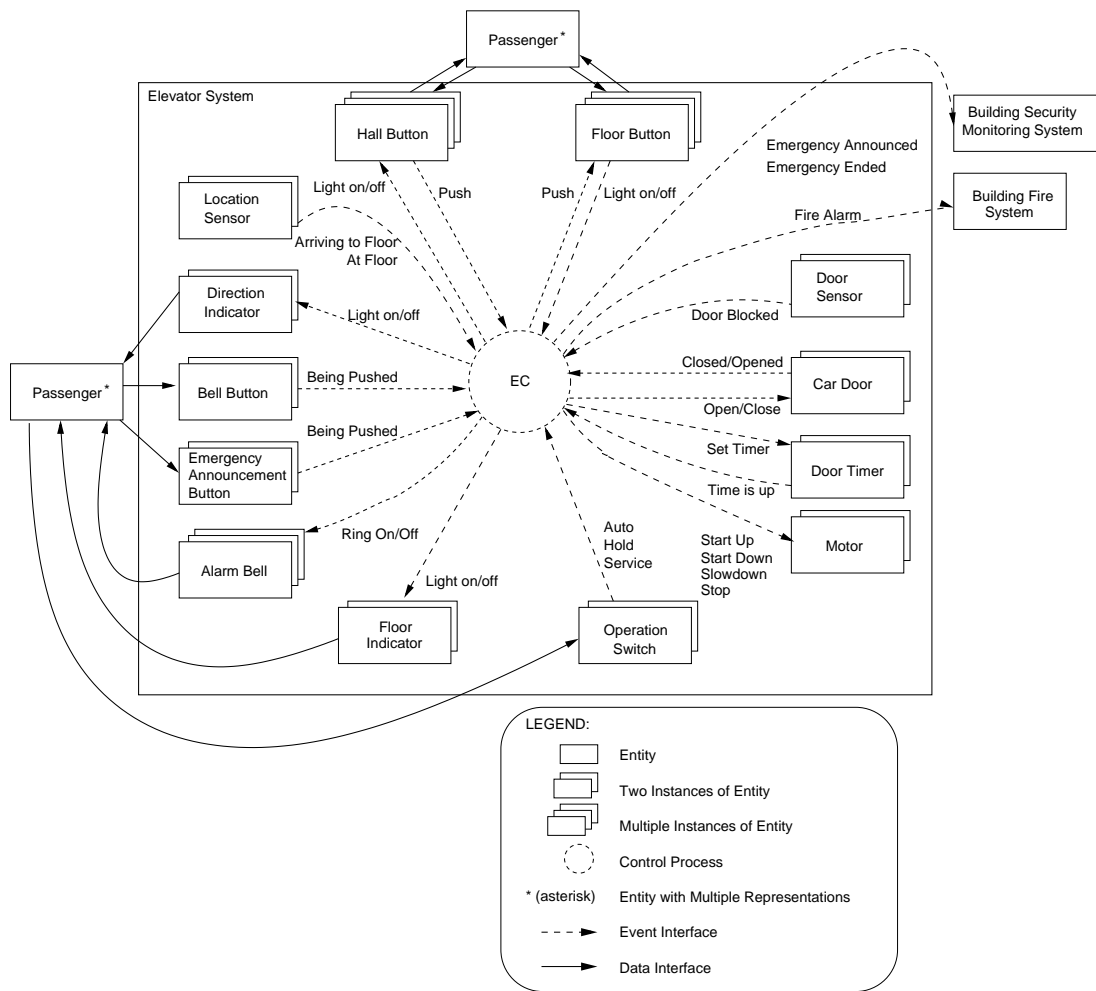


Figure 1: Context Diagram for Elevator System

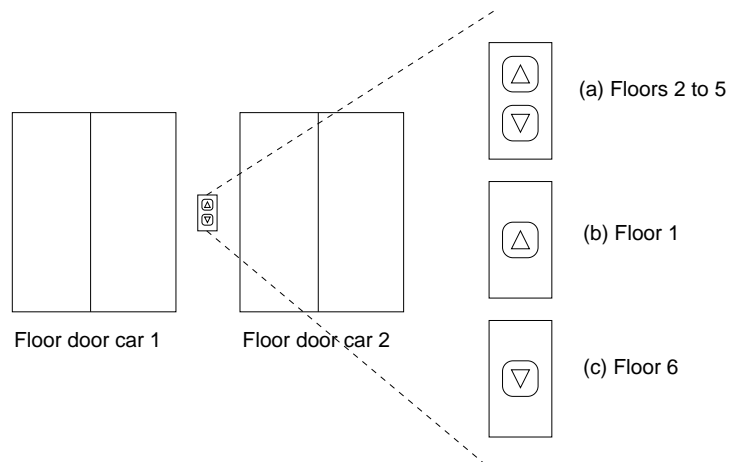


Figure 2: Floor Doors and Hall Buttons

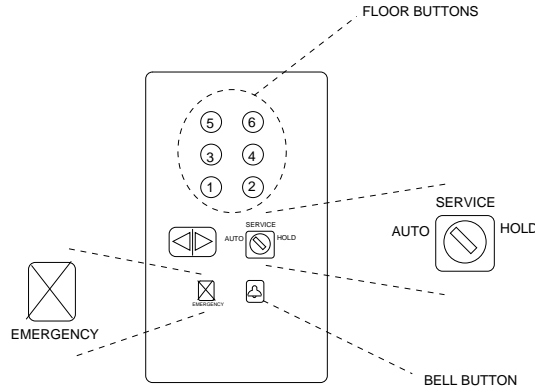


Figure 3: Control Panel (inside each elevator car)

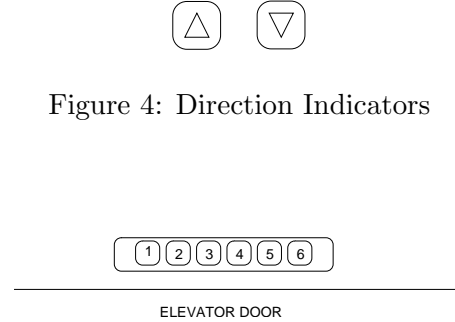


Figure 4: Direction Indicators

Figure 5: Floor Indicators

2.1.2 Communication Interfaces

The EC shall support a TCP/IP network interface for communicating with the building's security monitoring system. *Note: The actual application protocol for the communication between the EC and monitoring system is to be determined.*

2.2 Product Functions

The main function of the EC is to coordinate the operation of components in the elevator system to allow passengers to use the elevator cars for their transportation from one floor to another. More specifically the EC must be able to:

- Interact with the buttons passengers use to operate the elevator cars. The EC must be able to recognise that a button has been pressed, and it must be able to notify passengers that a request for a car or to travel to a floor has been accepted by the elevator controller. The EC must also be able to notify passengers when a request has been served.
- Interface with the indicators that inform the passengers of the states of the elevator system of interest to them (e.g. floor and direction indicators, alarm bell).
- Select and deliver an elevator car to service passengers waiting on a given floor, and allow the passengers to access the elevator car.
- Transport the elevator car where a passenger is in to the floor indicated by the passenger, and allow the passenger to exit the car.
- Modify the behaviour of the elevator system based on the mode of operation selected by the passenger (*hold/auto/service*), or as triggered by a fire alarm or emergency announcement.
- Recall the elevator cars and suspend operation of the elevator system in case of a fire alarm, operation in service mode, or emergency announcement.

2.2.1 Operation Modes

An elevator car is said to be operating in **normal mode**, if it is operating in either *auto* or *hold* mode. In *auto* mode the elevator car is considered by the EC to serve call requests made by passengers (via the hall buttons on each floor). In *hold* mode, the elevator car is no longer considered to serve call requests and only responds to requests made by passengers via the control panel inside the elevator car. Elevator cars are typically put in *hold* mode when goods or passengers will be constantly moved between two floors (for example when a new tenant moves to a residential building, or when several trips with goods need to be done in a commercial building). By putting the elevator car in *hold* mode, the car is essentially being reserved for specific use.

An elevator car is said to be in **recall mode** if the operation switch is set to *service* mode, or if there is a fire alarm, or if a passenger announces an emergency. While in recall mode, the elevator car is taken to a floor determined by the type of event that took the elevator car into recall mode. Once on the recall floor, the elevator car door is kept open and the car is not considered for call nor destination requests. The elevator car is taken back to normal operation (*hold* or *auto* mode), by resetting the operation switch inside the elevator car to the *auto* or *hold* position.

The use cases UC7 *Set Operation Mode*, UC8 *Recall Due to Fire Alarm*, and UC9 *Recall to Floor* illustrate the behaviour just described. These use cases are presented in Section 3.

2.3 User Characteristics

A *passenger* is anyone that uses the elevator system with the purpose of going from one floor to another.

2.4 Constraints

Any physical specifications (e.g. dimensions), power consumption, and operation environmental should be listed here or a reference to standards document (e.g. [cod04]).

2.5 Assumptions

- It is assumed that emergency mechanisms that stop the cars in case of a malfunction of the elevator system operate autonomously without the involvement of the EC. These emergency mechanisms include locking features in case of power outages.

3 Use Cases

3.1 Use Case Diagram

Figure 6 shows the use cases that relate to the EC. Most use cases are initiated by the interaction of passengers with the elevator system, while a few cases are initiated by the direct interaction between the building fire alarm system and the EC.

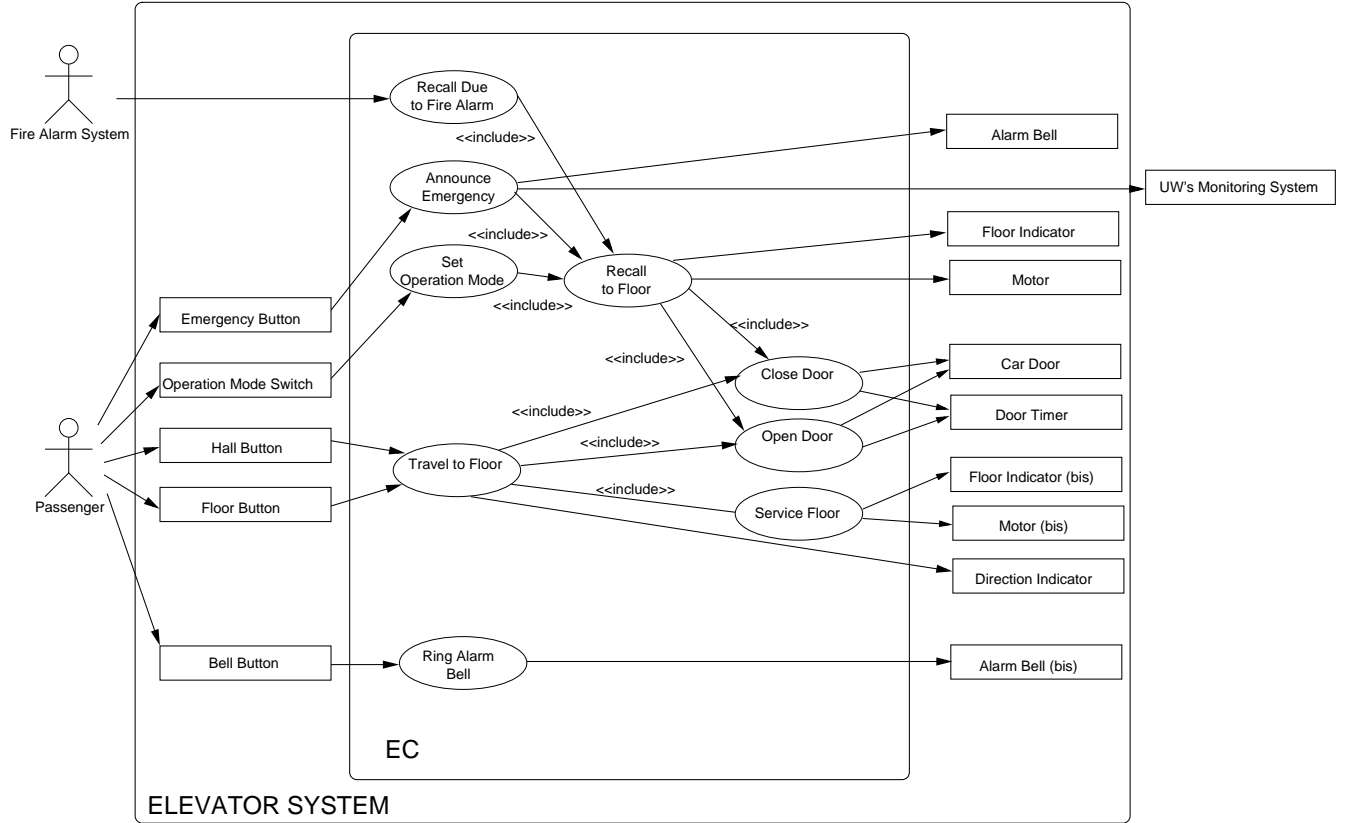


Figure 6: Use Case Diagram

The principal use cases are:

- The *Travel to Floor* use case illustrates the process a passenger goes through in order to call an elevator car, and once the elevator car arrives, travel to a specific floor.
- *Set Operation Mode* illustrates how the operation mode of an elevator car is changed via the operation mode switch.
- *Ring Alarm Bell* shows how a passenger can ring the alarm bell in an elevator car.
- The *Announce Emergency* use case shows how a passenger inside an elevator car announces an emergency in the car. When a passenger announces an emergency the elevator car is taken to an emergency recall floor.

- The use case *Recall Due To Fire Alarm* is initiated by the fire alarm system in the building where the elevator system is installed, and causes both elevator cars to be recalled to a floor specified by the fire alarm system.

Use cases included by the principal use cases are:

- *Recall To Floor* illustrates the actual process of recalling an elevator car to a floor (independently of the reason for the recall).
- *Open Door* and *Close Door* show how elevator doors are open/closed.
- *Service Floor* shows how an elevator car travels from one floor to another.

Section 3.2 contains the detailed description of these use cases.

3.2 Use Case Descriptions

Use cases included by other use cases that are not triggered directly by actors are tagged as *Incomplete Use Cases*.

UC1: Travel to Floor

Overview:	System delivers an elevator car to a passenger, and transports the passenger to a destination floor.
Event:	A Passenger on a given floor, requests an elevator car to travel on an intended direction (up/down). Inputs are the floor where the passenger is at and the direction the passenger intends to travel towards.
Precondition:	There is no fire alarm
Postcondition:	Passenger is transported to the passenger's intended destination floor
System:	EC - Elevator Controller
Actors:	Passenger (initiator), hall button, floor button, motor, car door, direction indicators, floor indicators.
References:	F1 - Control Car Movement; F2 - Location Tracking; F3 - Control Doors; F4 - Service Call Requests; F5 - Service Destination Requests; F6 - Status Feedback; F7 - Request Tracking; F8 - Request Processing
Related Use Cases:	Includes: UC2 - Service Floor; UC3 - Close Elevator Car Door; UC4 - Open Elevator Car Door;
Typical Process Description:	<ol style="list-style-type: none"> 1. Passenger requests an elevator car at a given floor to travel on an intended direction (up/down) 2. System selects which elevator car will serve request 3. System assigns request to selected elevator car 4. System notifies passenger that the request has been assigned to an elevator car 5. System sends elevator car to the passenger's floor (see UC2 <i>Service Floor</i>) 6. System notifies passenger, that the elevator car has arrived 7. System opens elevator door (see UC3 <i>Open Door</i>) 8. System notifies passenger of direction the elevator car will travel

9. Passenger enters elevator car
10. Passenger selects destination floor passenger wants to travel to
 11. System records request
 12. System notifies passenger that request has been recorded
 13. System closes car door if open (see UC4 *Close Door*)
 14. System sends elevator car to requested floor (see UC2 *Service Floor*)
 15. System notifies passenger that request to travel to floor has been served
 16. System opens elevator door (see UC3 *Open Door*)
17. Passenger exits the elevator car

Variation 1:

10. Destination floor requested by passenger not in direction elevator car will travel
 - 11 to 13. *Same as main flow*
 14. System serves request to travel to floor selected by passenger after all other pending requests for the elevator car have been served
 - 15 ... *Same as main flow*

Variation 2:

10. Destination floor requested by passenger is the same floor where the passenger is
 11. System discards the request

Exception 1:

2. If there are no cars available (all in *hold* mode, see UC7 *Set Operation Mode*; or due to a fire alarm, see UC8 *Recall Due to Fire Alarm*), the request is discarded.

Exception 2:

9. Passenger decides not to enter the elevator car
 10. If the elevator car is operating in *auto* mode (see UC7 *Set Operation Mode*), System closes elevator car door (see UC4 *Close Door*) and continues serving any other requests assigned to the elevator car; If operating in *hold* mode, door is kept open.

Exception 3:

- 11-16: If a fire alarm occurs while travelling to destination floor selected by the passenger, the car is sent by the System to a predetermined fire recall floor (see UC8 *Recall Due to Fire Alarm*).

Exception 4:

11-16: If the elevator car is put in service mode while travelling to destination floor selected by the passenger, the car is sent by the System to a predetermined service recall floor (see UC7 *Set Operation Mode*).

Exception 5:

11-16: If the passenger announces an emergency while travelling to destination floor selected by the passenger, the car is sent by the System to a predetermined emergency recall floor (see UC5 *Announce Emergency*).

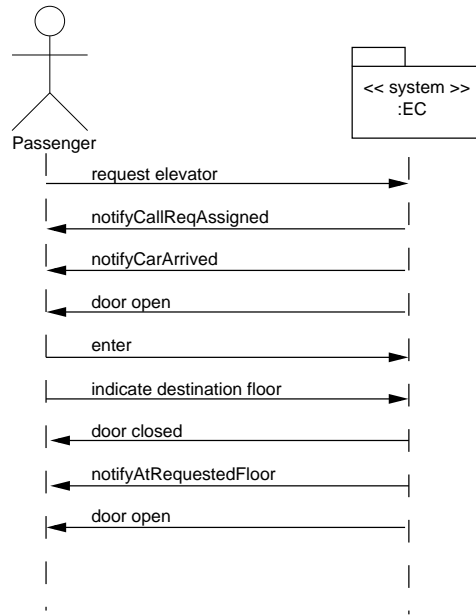


Figure 7: Sequence Diagram for UC1 - Travel to Floor

UC2: Service Floor

(*Incomplete Use Case*)

Overview:

System takes elevator car from a current floor F_o to a destination floor F_d

Event:

None

Precondition:

Elevator is parked at a floor and is operating in *auto* or *hold* mode; there is no fire alarm.

Postcondition:

Elevator car is stopped at destination floor F_d

System:

EC - Elevator Controller

Actors:

motor, car door, direction indicator, floor indicators

References:

F1 - Control Car Movement; F2 - Location Tracking; F3 - Control Doors; F4 - Service requests for Elevator; F5 - Service Requests to Travel to Floors; F6 - Status Feedback; F8 - Request Processing.

Related Use Cases: Included by: UC1 - Travel to Floor

Typical Process Description:

1. Elevator car is at floor F_o , the next requested floor is F_d
2. If the elevator car is open, system notifies passenger in current floor (F_o) of direction the elevator car will take (up/down), and the system closes the elevator car door (see UC4 *Close Door*)
3. System moves elevator car in direction to floor F_d
4. System notifies passengers inside elevator car of each floor passed
5. System stops car when at destination floor F_d

Variation 1:

A floor F_n between F_o and F_d is requested while in direction to F_d

REPEAT:

- 3a. System stops car at floor F_n
- 3b. System notifies passenger that request to floor F_n has been served.
- 3c. System opens elevator door (see UC3 *Open Door*)
- 3d. System notifies passenger of direction the elevator car will travel
- 3e. System closes elevator door (see UC4 *Close Door*)
- 3f. System moves elevator car in direction to floor F_d
4. System notifies passengers inside elevator car of each floor passed

UNTIL: there are no more requested floors F_n between F_o and F_d

5. System stops car when at destination floor F_d

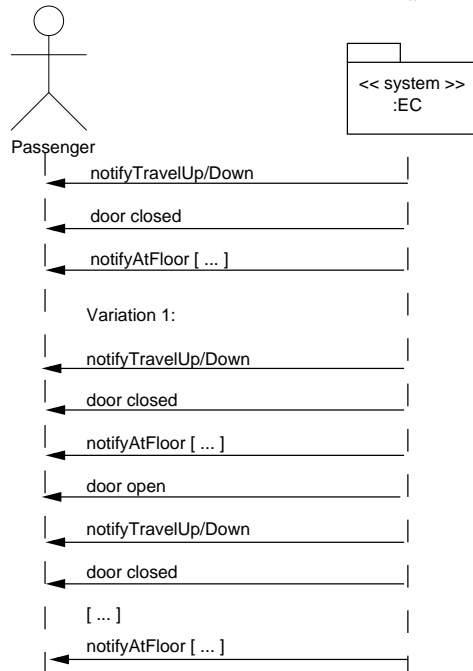


Figure 8: Sequence Diagram for UC2 - Service Floor

UC3: Open Door	<i>(Incomplete Use Case)</i>
Overview:	System opens elevator car door
Event:	None
Precondition:	Elevator car is stopped at a floor and the car door is closed or being closed; there is no fire alarm
Postcondition:	Elevator car door is open
System:	EC - Elevator Controller
Actors:	car door, door timer
References:	F3 - Control Doors; F9 - Operation Mode Setting; F10 - Elevator Recall
Related Use Cases:	Included by: UC1 - Travel to Floor; UC2 - Service Floor; UC9 - Recall to Floor

Typical Process Description:

1. System opens the elevator car door
2. System sets door timer if elevator car operating in *auto* mode (see UC7 *Set Operation Mode*)

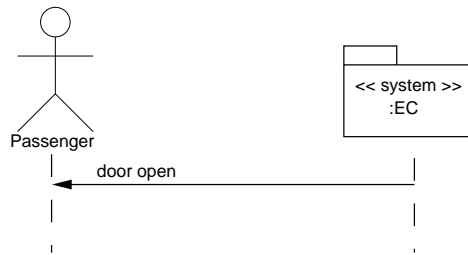


Figure 9: Sequence Diagram for UC3 - Open Door

UC4: Close Door	<i>(Incomplete Use Case)</i>
Overview:	System closes elevator car door
Event:	None
Precondition:	Elevator car is stopped at a floor and the car door is open; there is no fire alarm
Postcondition:	Elevator car door is closed
System:	EC - Elevator Controller
Actors:	car door, door timer
References:	F3 - Control Doors
Related Use Cases:	Included by: UC1 - Travel to Floor; UC2 - Service Floor
Typical Process Description:	

1. System waits for door timer if timer set
2. System closes elevator car door

Variation 1:

Car door is blocked while door is being closed by system

- 2a. System opens car door (see UC3 *Open Door*)
- 2b. System attempts to close operator door again (back to step 1)

Variation 2:

Passenger requests the door to open (pushes *open door button*) while door is being closed by system

2a, 2b as in Variation 1

Exception 1:

Elevator car is parked at fire recall floor because of fire alarm (see UC8 *Recall Due to Fire Alarm*)

System discards request to close door

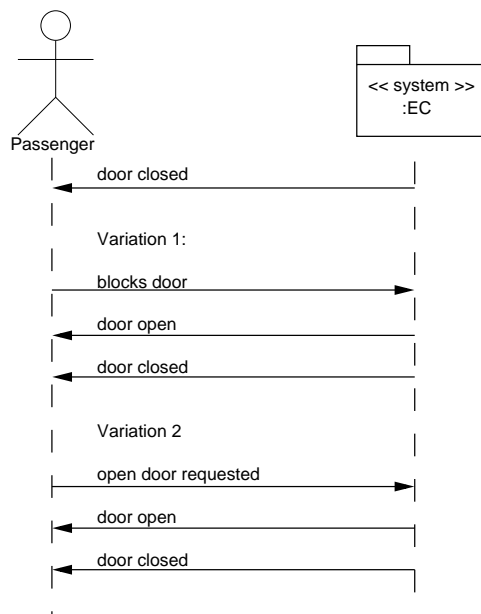


Figure 10: Sequence Diagram for UC4 - Close Door

UC5: Announce Emergency**Overview:**

The elevator car is recalled to a predetermined emergency recall floor. While the passenger is announcing an emergency (emergency button inside the elevator car is being pushed), the alarm bell is ringing

Event:

Passenger announces an emergency in the elevator car

Precondition:

The elevator car is not already recalled

Postcondition:

The elevator car is recalled at the emergency recall floor

System:

EC - Elevator Controller

Actors:

Passenger (initiator), emergency button, alarm bell, motor, building security monitoring system

References: F1 - Control Car Movement; F2 - Location Tracking; F3 - Control Doors; F6 - Status Feedback; F10 - Elevator Recall; F12 - Emergency Announcement

Related Use Cases: UC7 - Set Operation Mode; UC9 - Recall to Floor

Typical Process Description:

1. Passenger announces an emergency in the elevator car the passenger is in
2. System sounds the alarm bell
3. System recalls elevator car to emergency recall floor (see UC9 *Recall to Floor*)
4. System inform building security monitoring system of emergency
5. System stops operation of elevator car until operation mode reset to *auto* or *hold* via the operation mode switch (see UC7 *Set Operation Mode*)
6. Passenger ends the emergency announcement
7. System turns the alarm bell off

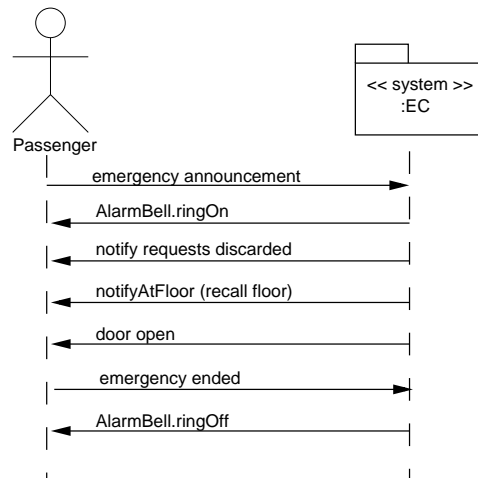


Figure 11: Sequence Diagram for UC5 - Announce Emergency

UC6: Ring Alarm Bell

Overview: Alarm bell rings while bell button is being pressed by the passenger.

Event: Passenger rings alarm bell

Precondition: None

Postcondition: Alarm bell is not ringing

System: EC - Elevator Controller

Actors: Passenger (initiator), bell button, alarm bell

References: F13 - Alarm Bell Operation

Related Use Cases: None

Typical Process Description:

1. Passenger requests the alarm bell to ring
2. System rings alarm bell
3. Passenger ends alarm bell request
4. System stops ringing alarm bell

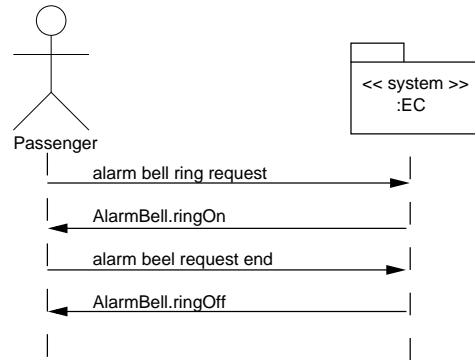


Figure 12: Sequence Diagram for UC6 - Ring Alarm Bell

UC7: Set Operation Mode

Overview:

System modifies behaviour of elevator system depending on new operation mode. In *hold* mode elevator car accepts inputs from control panel inside elevator car only. In *auto* mode, input is accepted from hall buttons and elevator car control panel. In *service* mode the elevator car is recalled to a predetermined service recall floor.

Event:

Passenger with the operation mode switch key changes the operation mode of the elevator car

Precondition:

None

Postcondition:

Elevator car mode changed to *hold* or *auto* depending on switch position

System:

EC - Elevator Controller

Actors:

Passenger (initiator), operation mode switch, motors, car doors

References:

F3 - Control Doors; F4 - Service Requests for Elevator; F6 - Status Feedback; F10 - Elevator Recall

Related Use Cases:

UC7 typically occurs after the following use cases: UC8 - Recall Due to Fire Alarm, UC5 - Announce Emergency; UC7 includes: UC9 - Recall to Floor

Typical Process Description:

1. Passenger changes elevator car operation mode to *hold*
2. System discards any pending requests for elevator car taken to *hold* mode
3. Passengers are notified pending requests have been discarded
4. System no longer considers car taken to *hold* operating mode when servicing call requests
5. When car is parked at a floor car door is kept open

Variation 1:

1. Passenger changes elevator car operation mode to *auto*
2. System considers elevator car for servicing call requests

Variation 2:

1. Passenger changes elevator car operation mode to *service*
2. System recalls elevator car to service recall floor (see UC9 *Recall to Floor*)
3. System keeps doors open
4. System stops operation of elevator car until operation mode is reset back to *hold* or *auto*

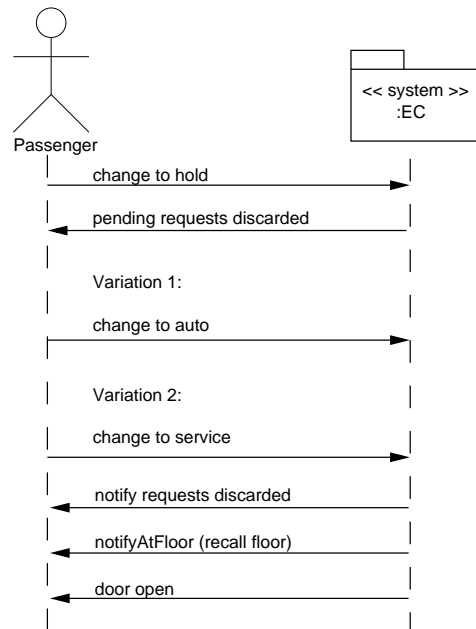


Figure 13: Sequence Diagram for UC7 - Set Operation Mode

UC8: Recall Due to Fire Alarm

Overview:	Elevator cars are recalled to a floor, determined by the fire alarm system in the building, when the fire alarm is activated
Event:	Fire alarm is activated, input is the floor to which the elevator cars are to be recalled
Precondition:	None
Postcondition:	Elevator cars are at the recall floor specified by alarm system with doors open
System:	EC - Elevator Controller
Actors:	Fire alarm system (initiator), motors, car doors
References:	F1 - Control Car Movement; F2 - Location Tracking; F3 - Control Doors; F6 - Status Feedback; F10 - Elevator Recall; F11 - Response to Fire Alarms
Related Use Cases:	UC9 - Set Operation Mode, occurs after UC8 when putting elevator cars back in normal operation; UC3 - Open Door, and UC9 - Recall to Floor, are included by UC8

Typical Process Description:

1. Fire alarm system informs System fire alarm has been activated

FOR EACH ELEVATOR CAR:

2. System recalls elevator car to fire recall floor (see UC9 *Recall to Floor*)
7. System keeps doors open
8. System stops operation of elevator car until operation mode reset to *auto* or *hold* via the operation mode switch (see UC7 *Set Operation Mode*)

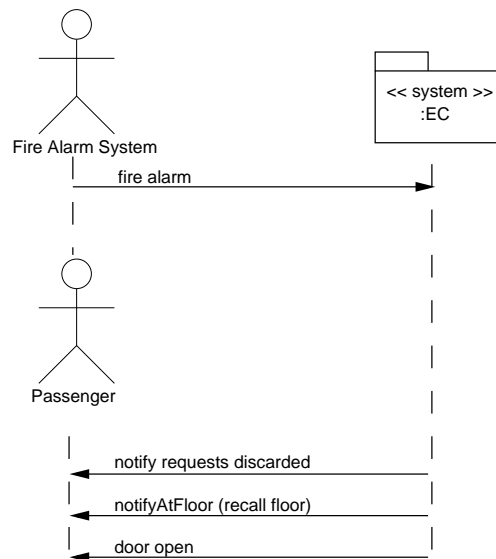


Figure 14: Sequence Diagram for UC8 - Recall Due to Fire Alarm

UC9: Recall to Floor*(Incomplete Use Case)*

Overview: Elevator car is recalled to a floor; once on the recall floor the elevator door is open

Event: Recall floor is passed as parameter

Precondition:

Postcondition: Elevator car is at given recall floor with door open

System: EC - Elevator Controller

Actors: motors, car doors

References: F1 - Control Car Movement; F2 - Location Tracking; F3 - Control Doors; F6 - Status Feedback; F9 - Operation Mode Setting; F10 - Elevator Recall; F11 - Response to Fire Alarms ; F12 - Emmergency Announcement

Related Use Cases: Included by: UC5 - Announce Emergency; UC6 - Set Operation Mode; UC8 - Recall Due to Fire Alarm. Typically followed by: UC7 - Set Operation Mode (when elevator taken from recall mode).

Typical Process Description:

1. System discards all pending requests assigned to elevator car
2. System notifies passengers that requests have been discarded
3. System stops elevator car if moving in direction contrary to recall floor
4. System sends elevator car to fire recall floor if elevator car is not at the recall floor (see *Section Travelling to Recall Floor*)
5. System opens elevator car door if closed (see UC4 *Close Door*)

Section: Travelling to Recall Floor

1. If elevator car is parked with the door open, the system closes the elevator car door
2. If the elevator is not travelling towards the recall floor, system moves elevator car in direction to recall floor
3. System notifies passengers inside elevator car of each floor passed in direction to recall floor
4. System stops car when at recall floor

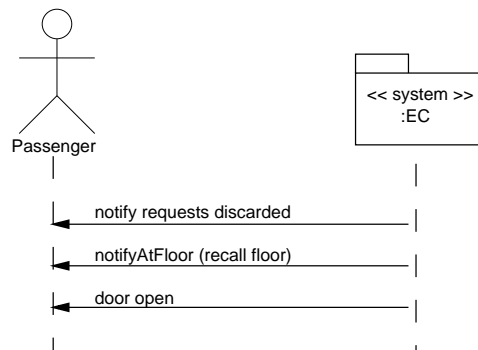


Figure 15: Sequence Diagram for UC9 - Recall to Floor

4 State and Conceptual Diagrams

4.1 System State Diagrams

As shown in Figure 16, the EC operates the cars in “normal” (non-recall) mode until there is a fire alarm, or a passenger announces an emergency, or the operation switch is put in the “service” position. In the case of a fire alarm, both elevator cars are recalled to a floor (the floor is determined by the fire alarm system, and passed as parameter in the fire alarm event). In the case of the operation switch being set to “service”, or a passenger announcing an emergency, only the elevator car where the passenger is located is recalled to a predetermined floor (typically the ground floor). Figure 17 shows the statechart for the actual recalling composite state.

For the “normal” operation, several states run concurrently (Figure 16):

- The *assigning call requests* composite state, waits for call requests and assigns them to a specific elevator car. Note that a call request is added to the requests an elevator car will serve only if: (1) the car is not already at the requested floor with the doors open or, (2) if the car is at the floor the passenger has recalled an elevator car, and the elevator car’s intended travel direction is not the travel direction requested by the passenger. There is only one instance of the *assigning call requests* state in the system.
- The *recording destination requests* composite state waits for destination floor requests and adds them to the requests to serve by the elevator car only if the elevator car is not already at the requested floor. There are two instances of this composite state in the system (one instance per elevator car).
- Switching to *hold* and *auto* modes is handled by the *switch operation mode*. There is one instance of this composite state per elevator car.
- Requests from passenger to sound the alarm bell are handled by the *controlling alarm bell* composite state. There is one instance of this composite state per elevator car.
- The actual processing of destination and call requests by an elevator car is made by the *servicing requests* composite state. This state represents a service loop where the next direction to travel is selected and the elevator car is sent towards that direction. As the elevator passes each floor, the system decides whether or not to stop at that floor based on the requests to serve by the elevator car. If the decision to stop is made, passengers are notified of the requests that have been served by the stop (a call request, a destination request, or both).

As mentioned before, the composite state at the bottom of the figure (*recalling car to floor*) is presented in Figure 17. When recalling one (or both) elevator cars, any pending requests are discarded. If the elevator car is travelling in a direction contrary to the recall floor the elevator motor is stopped and the car is sent in direction to the recall floor. Once on the recall floor, the doors are open and the system waits for the end of the recall. The end of the recall is indicated by moving the operation mode switch to the *hold* or *auto* position. The composite state *operating in normal non-recall mode* in Figure 17, corresponds to Figure 16 and has already been discussed.

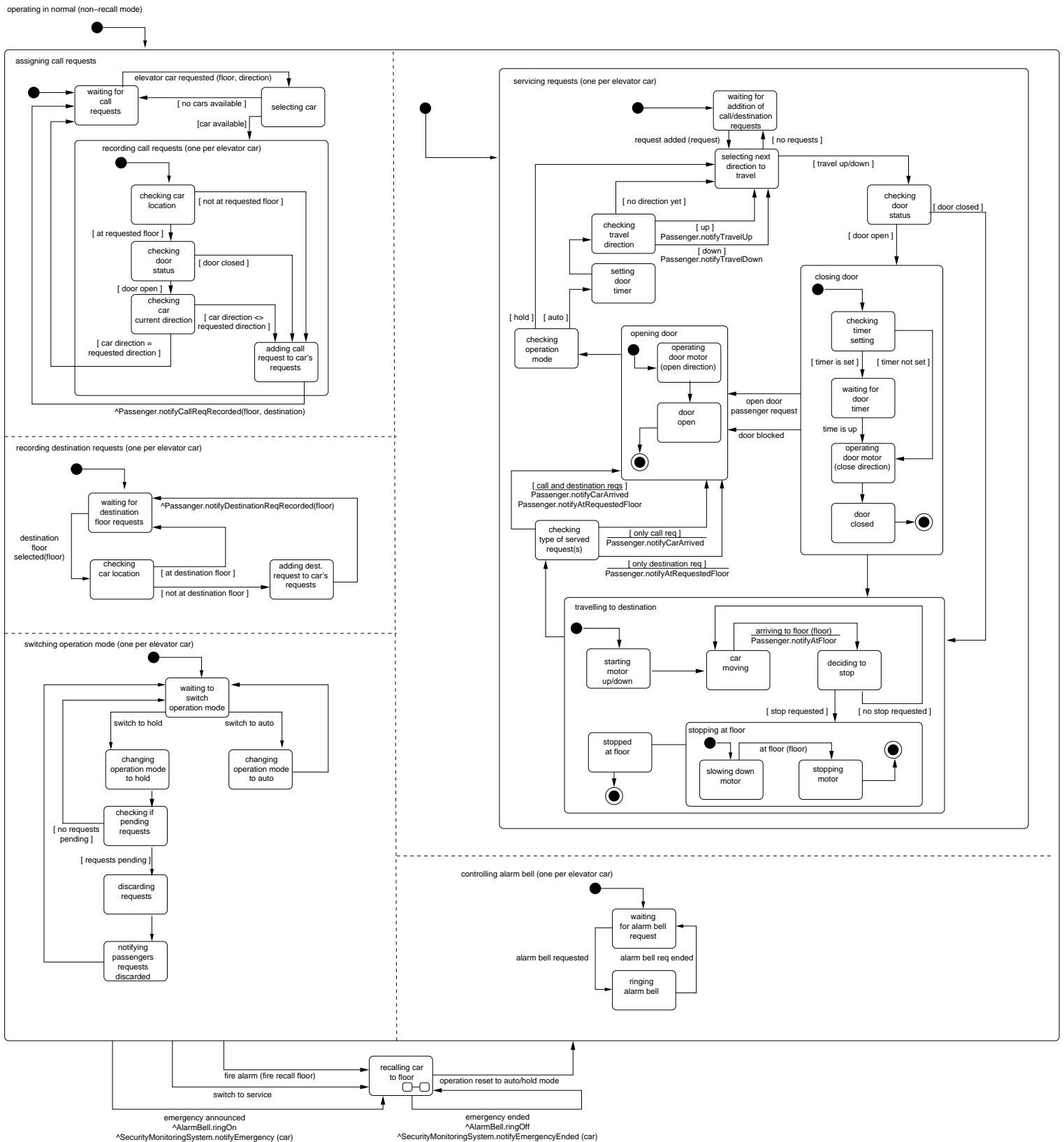


Figure 16: System Statechart Model

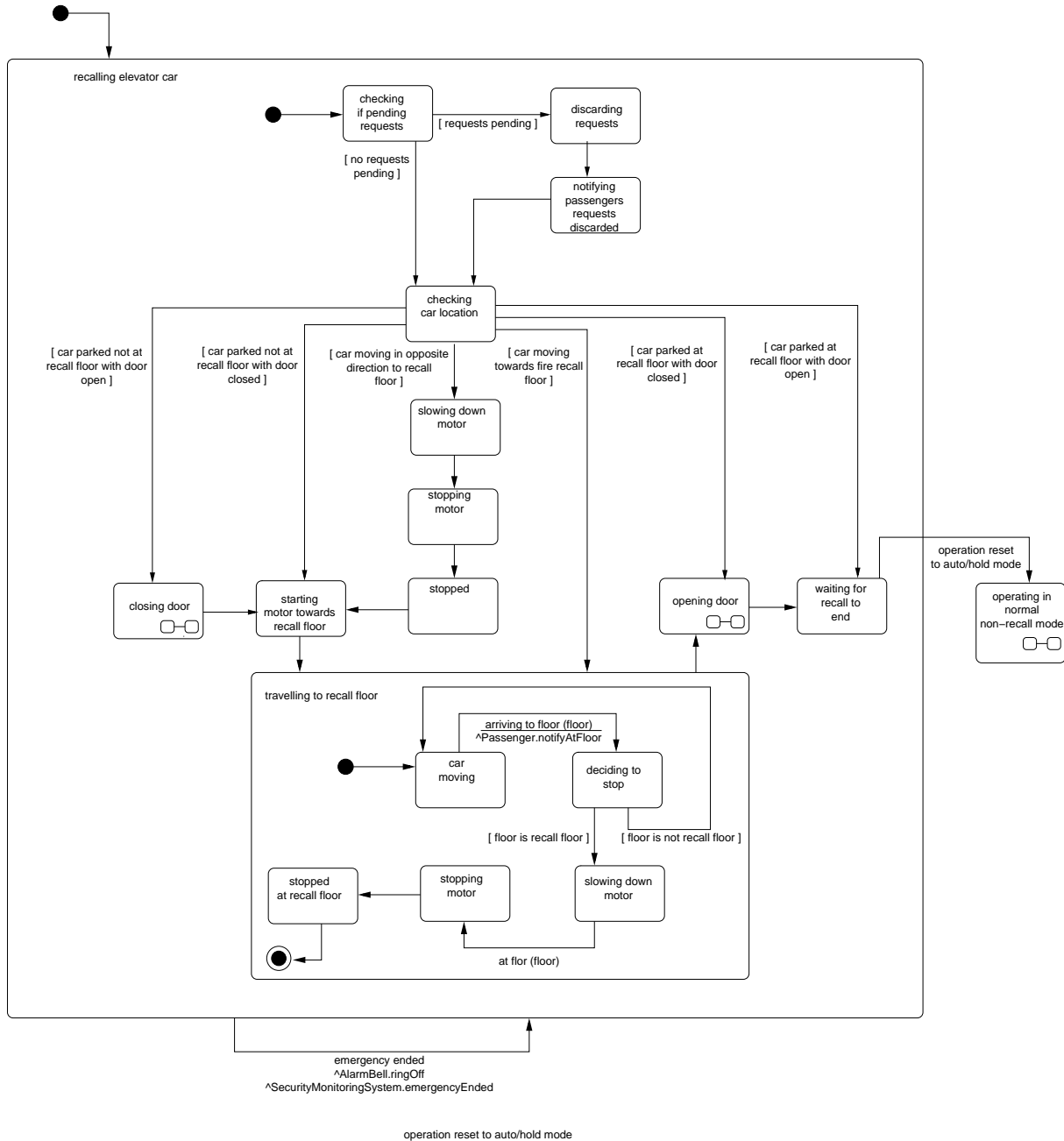


Figure 17: System Statechart Model (Recalling to Floor)

4.2 Conceptual Diagram

Figure 18 shows the conceptual diagram for the EC. To simplify the diagram (and abusing the notation) the relationships between entity and non-entity classes are shown at the bottom of the figure. The non-entity classes that relate to the entity classes are shown in a list at the right of each one of the entity classes.

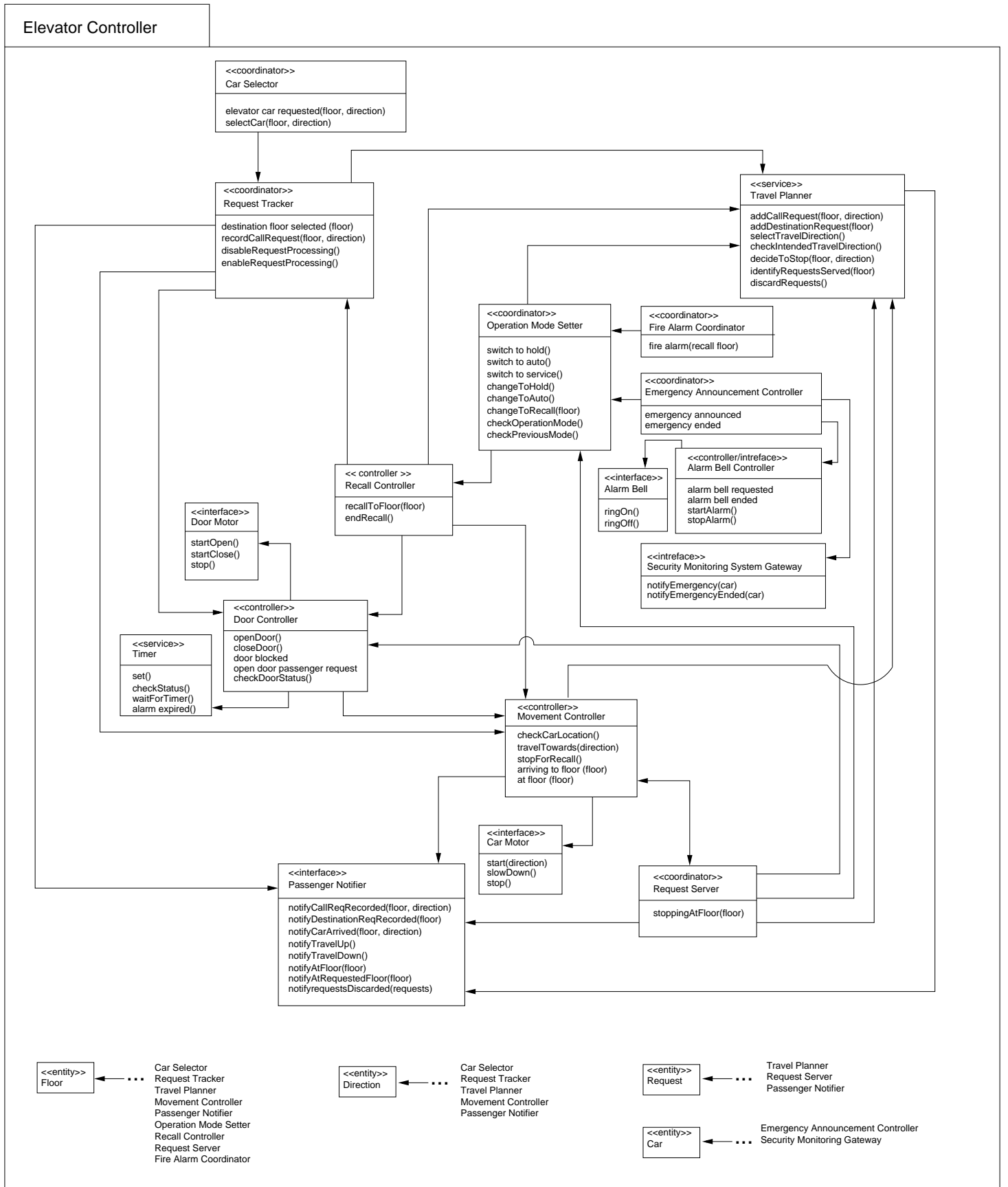


Figure 18: Elevator Controller Conceptual Diagram

In the concept diagram, the *Request Tracker* receives the call requests assigned by the *Car Selector* to a specific car. The *Request Tracker* also receives the destination floor requests submitted by passengers. Once the *Request Tracker* decides that the request is not trivial (a trivial request is for example a floor destination request when the elevator car is already at that floor), the *Request Tracker* informs the *Travel Planner* of the new requests. The *Travel Planner* is in charge of scheduling the trips for the elevator car. Based on the planned schedule, the *Request Server* sends the elevator car in the direction of the next request to serve. The actual movement of the elevator car motor is controlled by the *Movement Controller*. As the car travels in a given direction, the *Movement Controller* is informed as the elevator car passes by each floor. The *Travel Planner* indicates the *Movement Controller* if the elevator car should stop at the floor the elevator car is approaching. When the elevator car is stopped by the *Movement Controller*, the *Request Server* queries the *Travel Planner* for information about which requests have been served by the stop, and notifies the Passenger via the Passenger Notifier. The elevator car door is open/closed as required by the *Door Controller*.

The *Operation Mode Setter* alters the operation mode of the elevator car based on input from the operation mode switch, the *Fire Alarm Coordinator*, and the *Emergency Announcement Controller*. The *Recall Controller* is in charge of sending the elevator car(s) to a recall floor, and wait for the recall to end before putting the car(s) back into normal operation.

Given that there are two elevator cars in the system, there will be one instance of the *Car Selector*; one instance of the *Fire Alarm Coordinator*, and two instances of all other classes in the diagram.

The state diagrams for each one of these classes are presented in section 4.3.

4.3 State Diagrams for Selected Concepts

4.3.1 Car Selector

Figure 19 shows the state diagram for the *Car Selector*. The main purpose of the *Car Selector* is to decide which car will serve a call request. Once the elevator car has been selected, the request is given to the *Request Tracker* instance for the selected car.

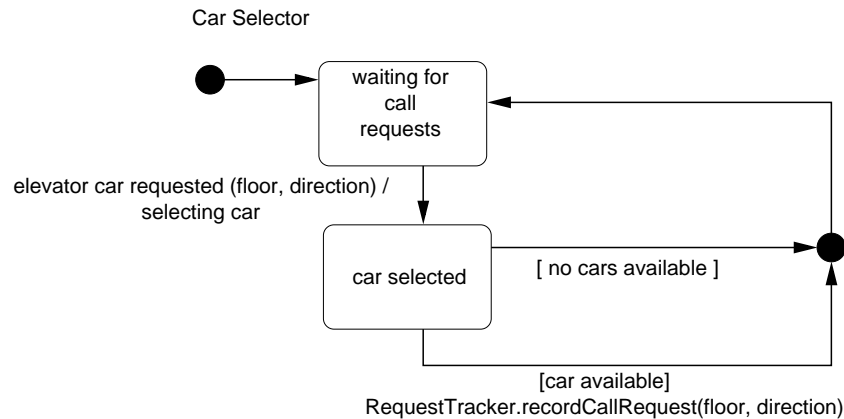


Figure 19: State Diagram for Car Selector

4.3.2 Request Tracker

Figure 20 shows the state diagram for the *Request Tracker*. When the *Request Tracker* receives call requests from the *Car Selector*, it checks if the request needs to be passed to the *Travel Planner* or if it can be discarded because the elevator car is already at the requested floor with the doors open, and will travel towards the intended destination. The *Request Tracker* also receives destination floor requests from passengers inside the elevator. If the elevator car is already at the requested floor, the *Travel Planner* is not informed of the request.

An important task of the *Request Tracker* is to disable processing of requests when an elevator car is recalled. When request processing is disabled, the *Request Tracker* does not respond to destination nor call requests, until it is informed (by the *Recall Controller*) that processing of requests should be enabled once again.

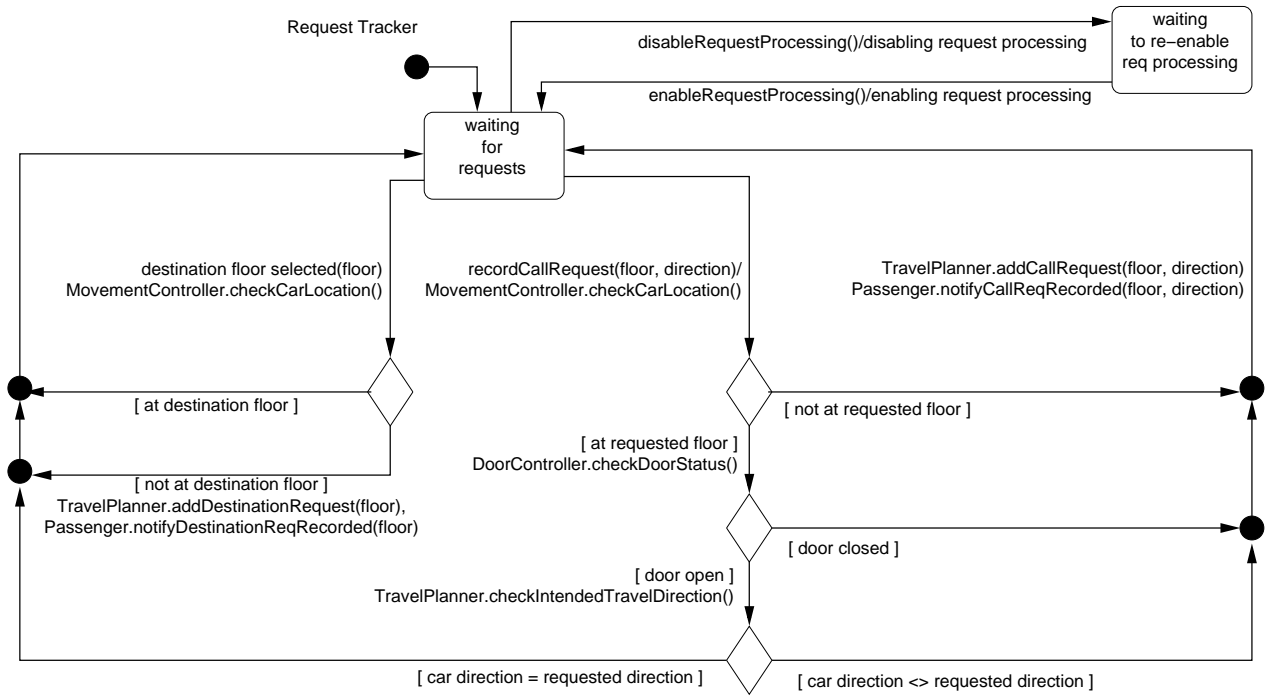


Figure 20: State Diagram for Request Tracker

4.3.3 Travel Planner

Figure 21 shows the state diagram for the *Travel Planner*. The *Travel Planner* is in charge of providing scheduling services for an elevator car based on the requests that have been assigned to that car. As the elevator car travels on a direction, the *Travel Planner* decides if the car should stop on the floor the car is approaching. When the elevator car is on a floor, the *Travel Planner* decides on what direction it should travel next.

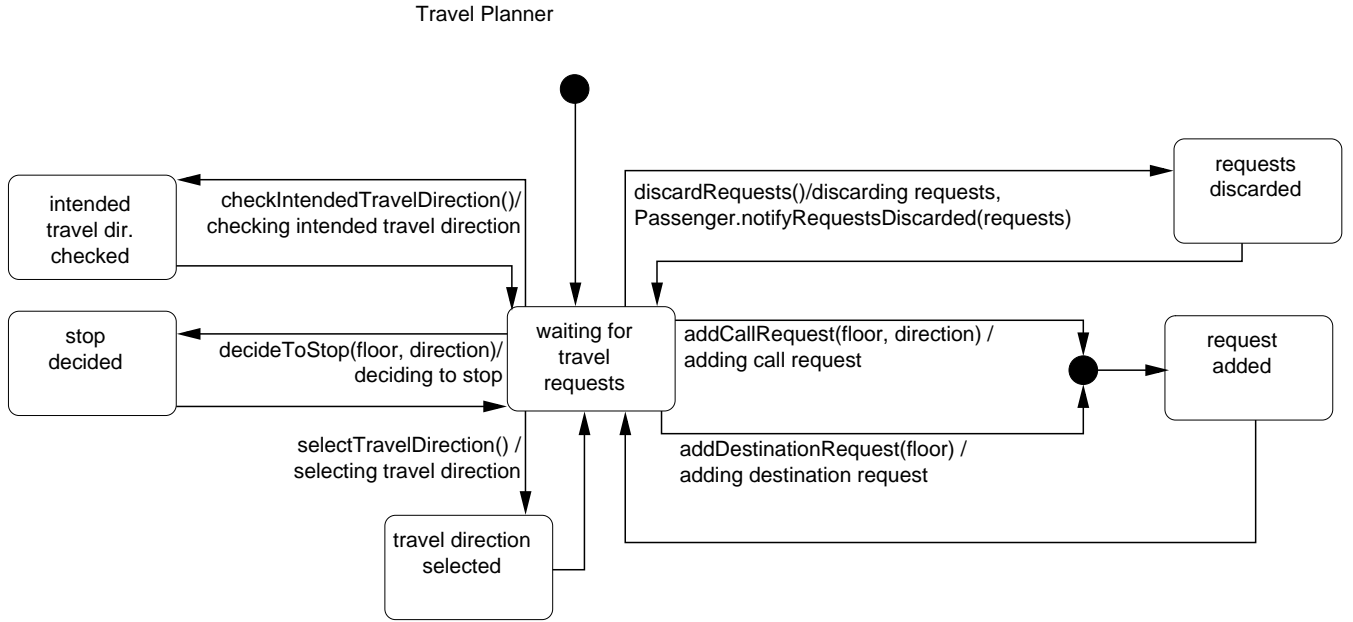


Figure 21: State Diagram for Travel Planner

When the elevator car is recalled, the *Travel Planner* is informed that it must discard all pending requests for the elevator car.

4.3.4 Request Server

Figure 22 shows the state diagram for the *Request Server*. The *Request Server* implements a service loop. It queries the *Travel Planner* for the direction the elevator car should travel towards. Once the direction has been selected, the *Request Server* sends the elevator car on that direction, closing the car door first if necessary.

When the elevator car stops at a floor, the *Request Server* asks the *Travel Planner* for information about the requests that have been served by the stop, and informs passengers that the requests have been served. Finally, the *Request Server* opens the elevator car door, communicates passengers of the intended travel direction and queries the *Travel Planner* for the next direction to travel.

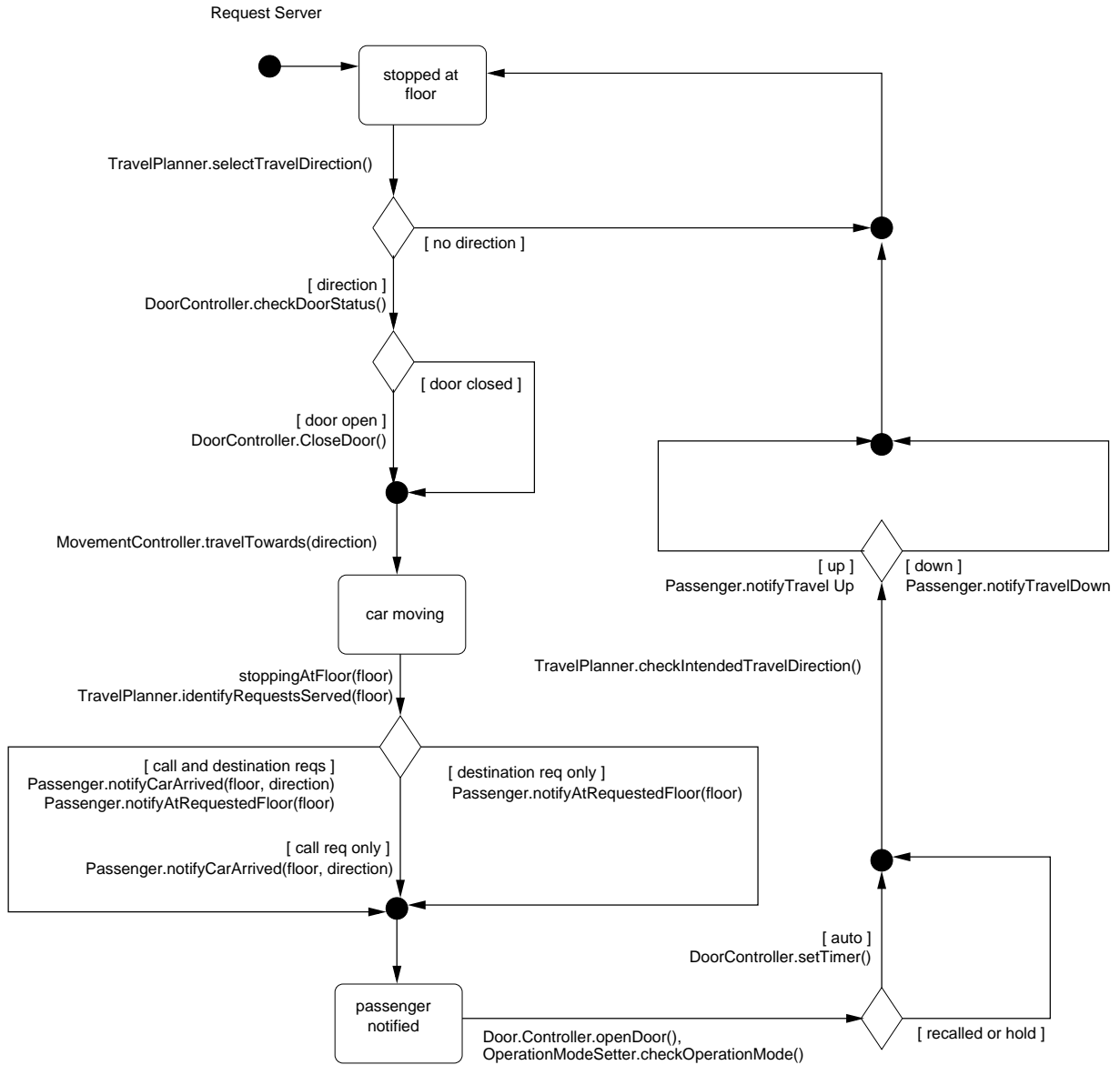


Figure 22: State Diagram for Request Server

4.3.5 Movement Controller

Figure 23 shows the state diagram for the *Movement Controller*. The *Movement Controller* is in charge of moving the car towards a direction and stopping the car when decided by the *Travel Planner*. As will be discussed when the unified collaboration diagram for the system is presented (Section 5.1), a location sensor informs the *Movement Controller* when a car is “arriving” to a floor, or “at” a floor. Assuming that the elevator car should stop at a floor, the speed of the elevator car motor is reduced when arriving to the intended destination. Once at the floor the motor is stopped.

On recall situations, the *Movement Controller* stops the car even if not at a particular floor, so that the car can be later sent towards the recall floor (see the state diagram for the *Recall Controller*). The *Movement Controller* also responds to requests for information about the location of the elevator car.

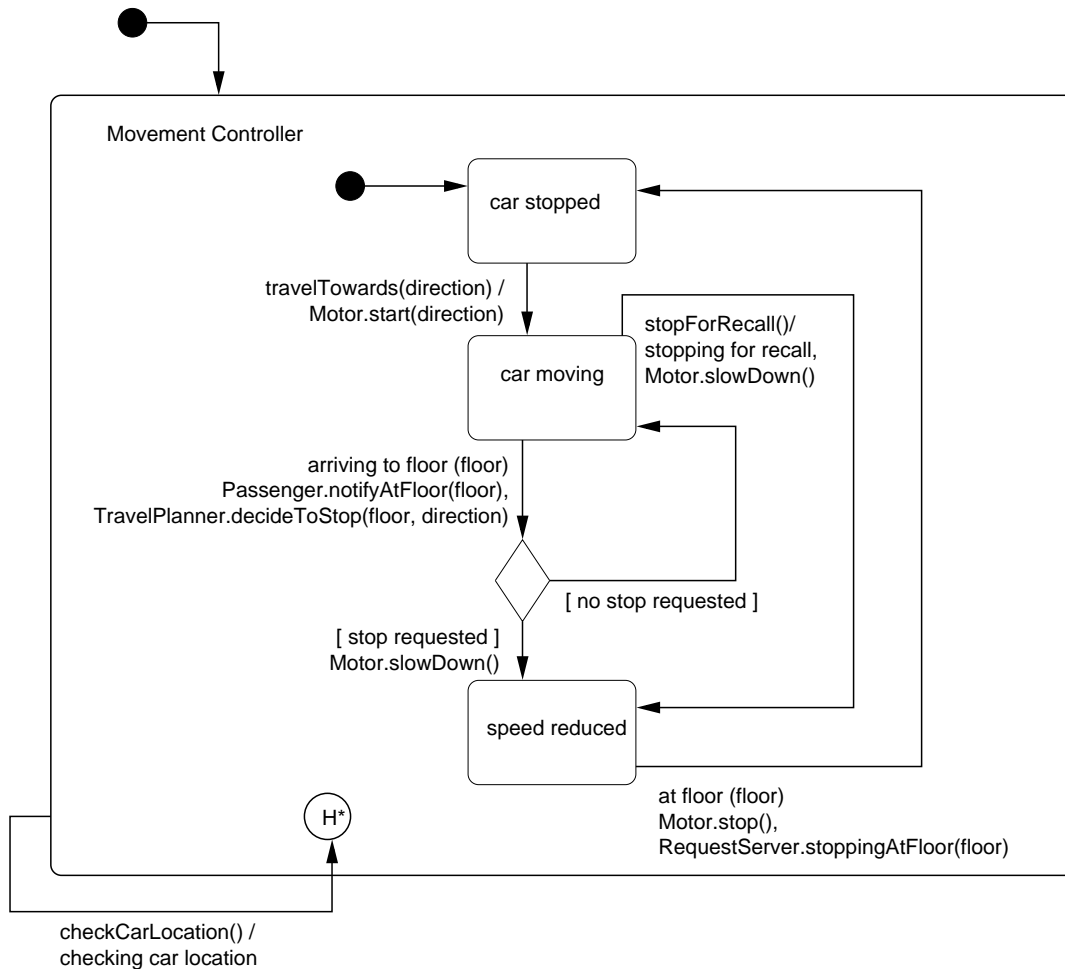


Figure 23: State Diagram for Movement Controller

4.3.6 Operation Mode Setter

As shown in Figure 24, the *Operation Mode Setter* sets the operation mode of the elevator car to *hold* or *auto* based on the position of the operation mode switch; or to *recall* based on the

position of the operation mode switch (setting *service*), a fire alarm situation, or an emergency announcement. When the operation mode is set to *recall*, the *Recall Controller* is informed that the elevator car shall be recalled. Once in *recall* mode, the operation mode switch needs to be reset to *auto* or *hold* to re-establish service of the elevator car.

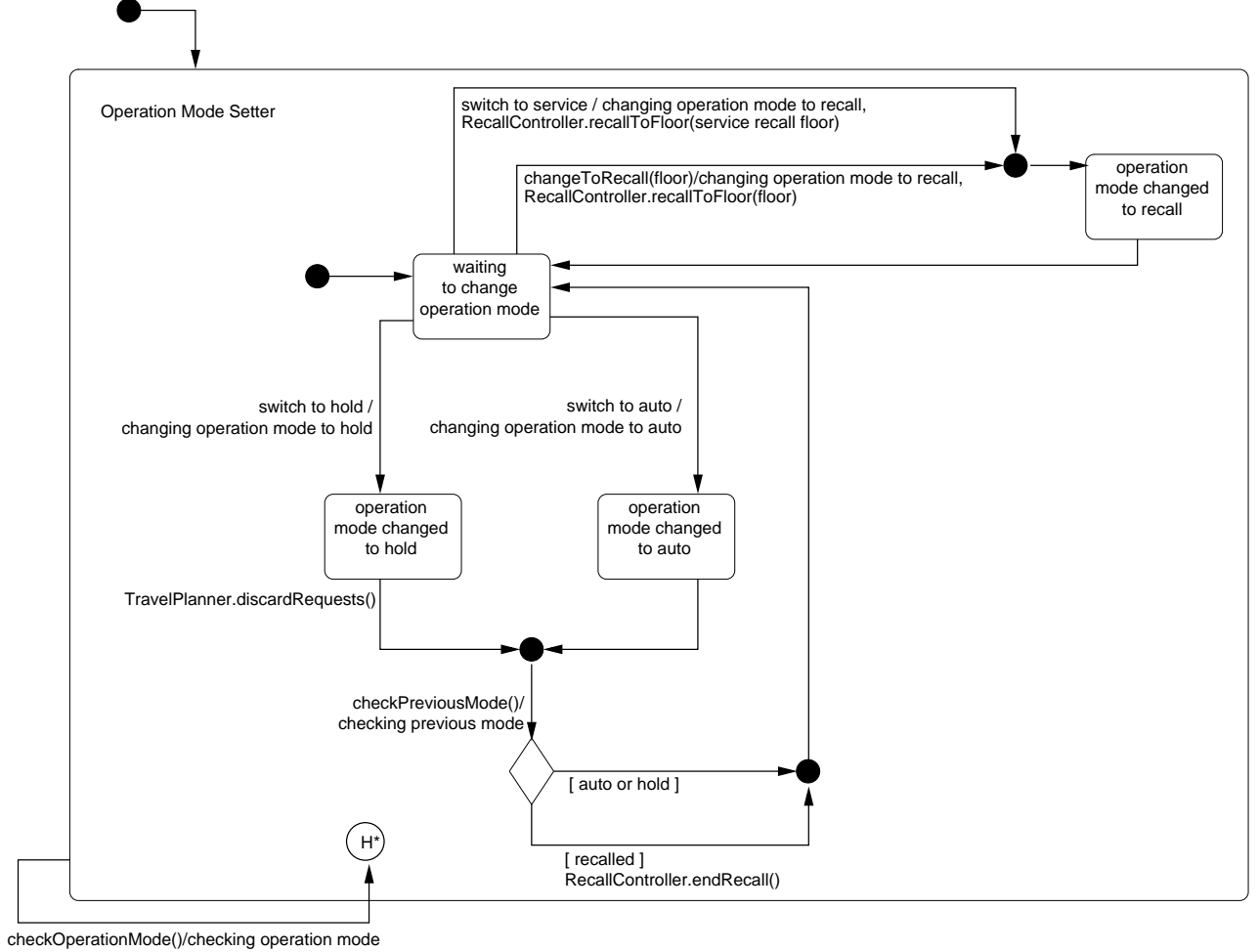


Figure 24: State Diagram for Operation Mode Setter

4.3.7 Recall Controller

The actual recall to a floor is controlled by the *Recall Controller* as shown in Figure 25. On a recall, the *Recall Controller* asks the *Request Tracker* to stop processing requests and the *Travel Planner* to discard any pending requests for the elevator car. Then the *Recall Controller* stops the elevator car if the car is not going in the direction of the recall floor. Once the car has been stopped, it is sent towards the recall floor by adding a destination request for the recall floor to the *Travel Planner*. Since the *Travel Planner* was previously asked to discard all other requests, the destination request for the recall floor will be the only request that will be serviced. Also, since the processing of requests from passengers is disabled, no other request but the destination to recall floor request will be serviced. When the *Operation Mode Setter* informs the *Recall Controller* that the recall has ended, processing of requests is re-enabled.

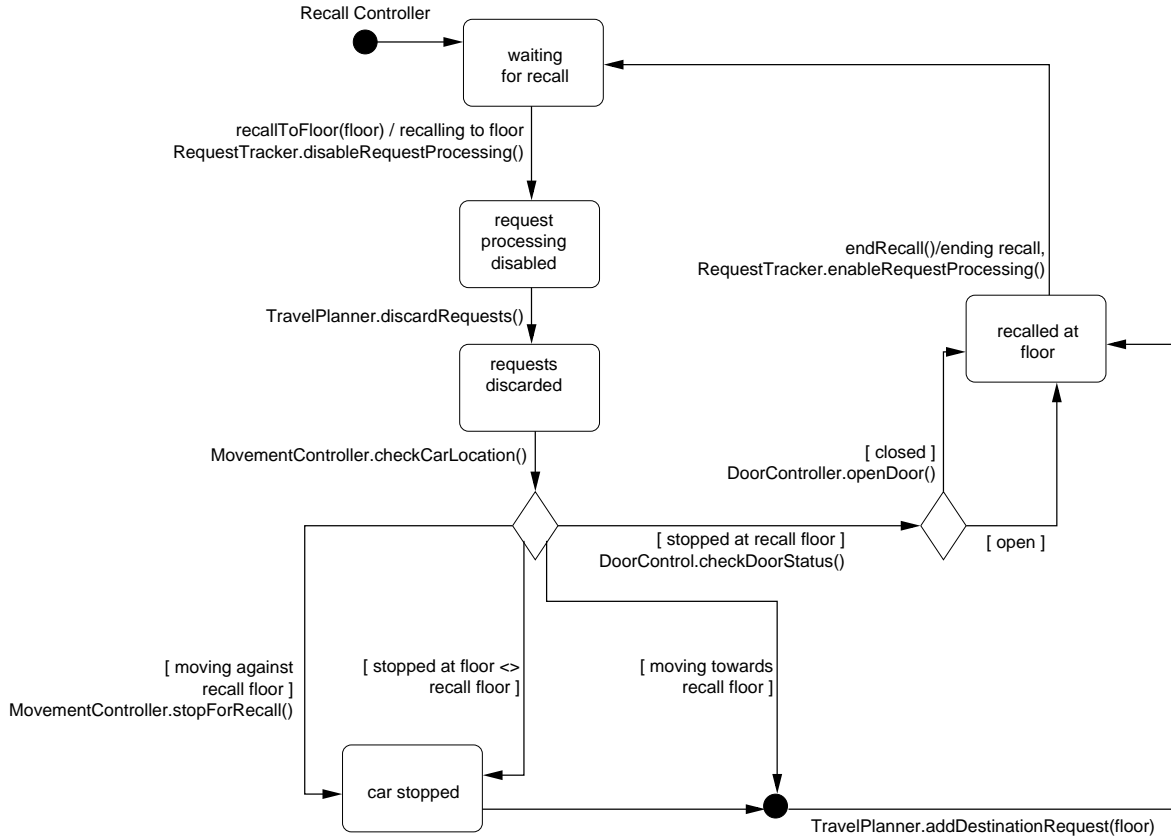


Figure 25: State Diagram for Recall Controller

4.3.8 Fire Alarm Coordinator and Emergency Announcement Controller

Besides the operation switch put in the *service* position, the other ways a recall is produced are due to a fire alarm, and an emergency announcement. Figures 26 and 27 show the relevant state diagrams. In the case of an emergency announcement, the alarm bell is ringing while the emergency button is being pushed.

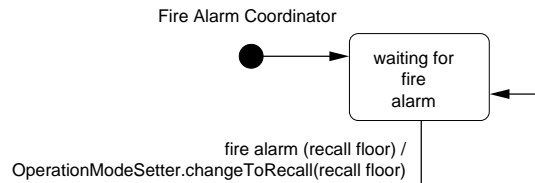


Figure 26: State Diagram for Fire Alarm Coordinator

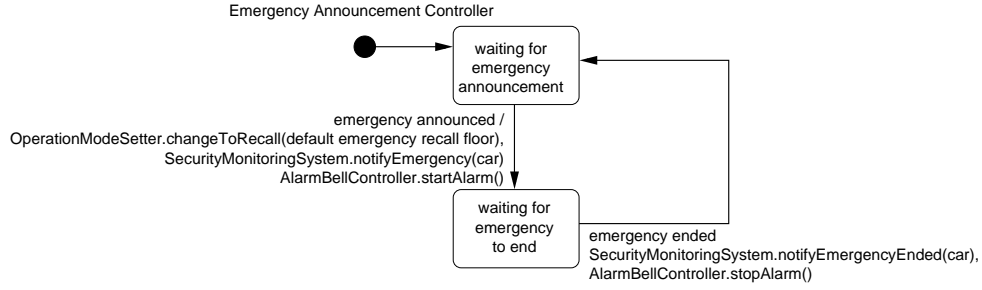


Figure 27: State Diagram for Emergency Announcement Controller

4.3.9 Door Controller

Figure 28 shows the state diagram for the *Door Controller*. An elevator car door is closed until a request to open the door is received. The request can come from the passenger via the elevator door (“open door requested”), or from somewhere else in the system via a method call (`openDoor()`). When it is the passenger requesting the door to be open, care must be taken to guarantee that the car is not moving. Once the door is open it is closed when the door timer expires, or via a method call (`closeDoor()`). While the door is being closed, it can be blocked, or the passenger may request the door to open via the open door button. In these two cases, the movement of the door is reversed and the door is open. Once the door is open, a door timer is set and the *Door Controller* attempts to close the door once again after the timer expires.

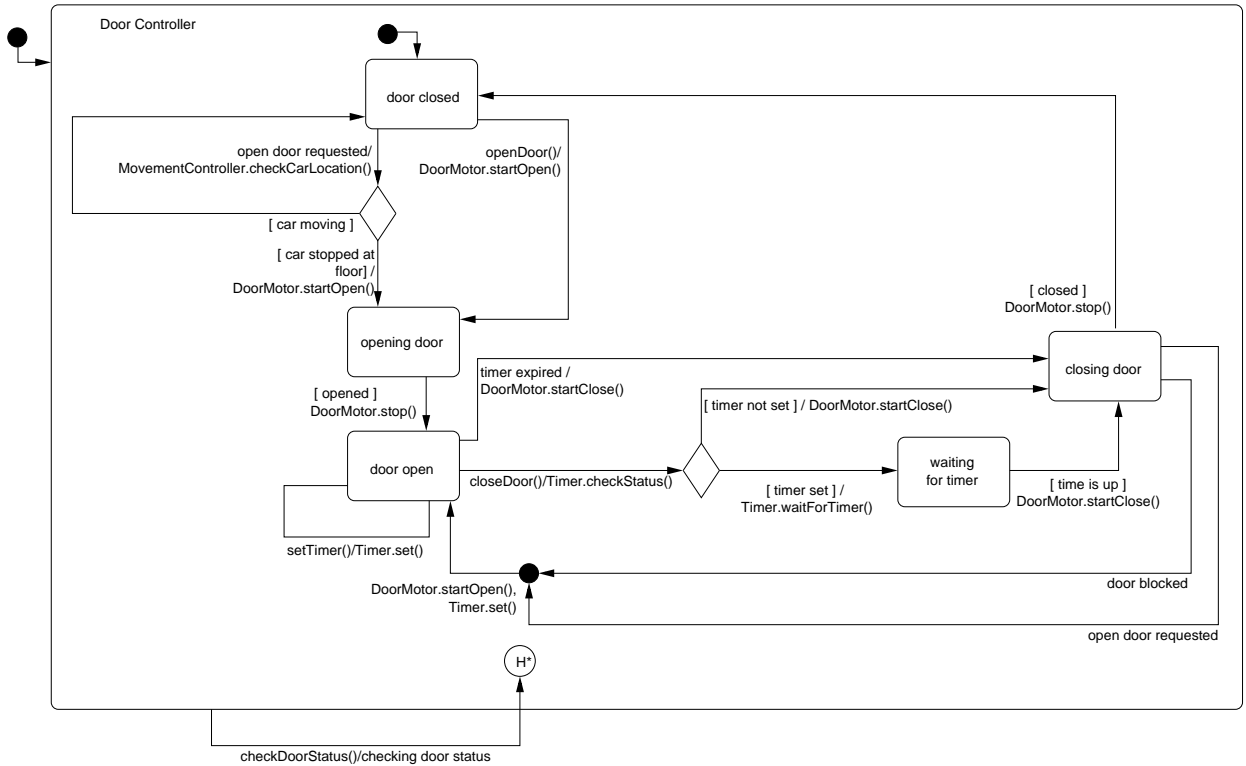


Figure 28: State Diagram for Door Controller

4.3.10 Alarm Bell Controller

Figure 29 shows the state diagram for the *Alarm Bell Controller*. The alarm bell rings either because the passenger pressed the bell button, or because the passenger is announcing an emergency.

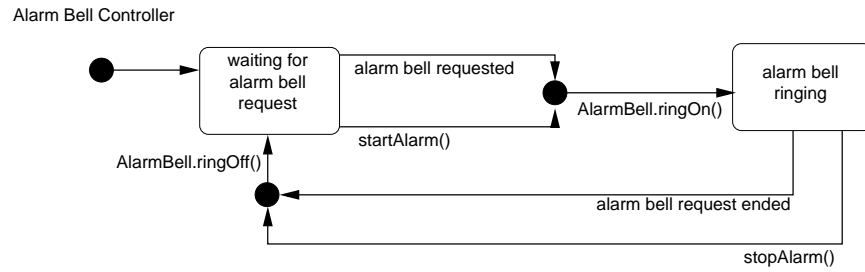


Figure 29: State Diagram for Alarm Bell Controller

5 Collaboration Diagrams

5.1 Unified Collaboration Diagram

Figure 30 shows the unified collaboration diagram for the EC. Interactions are triggered by actions/events generated by hall buttons, floor buttons, operation mode switches, open door buttons, door sensors, fire alarm system, emergency buttons, bell buttons, and the elevator car location sensors.

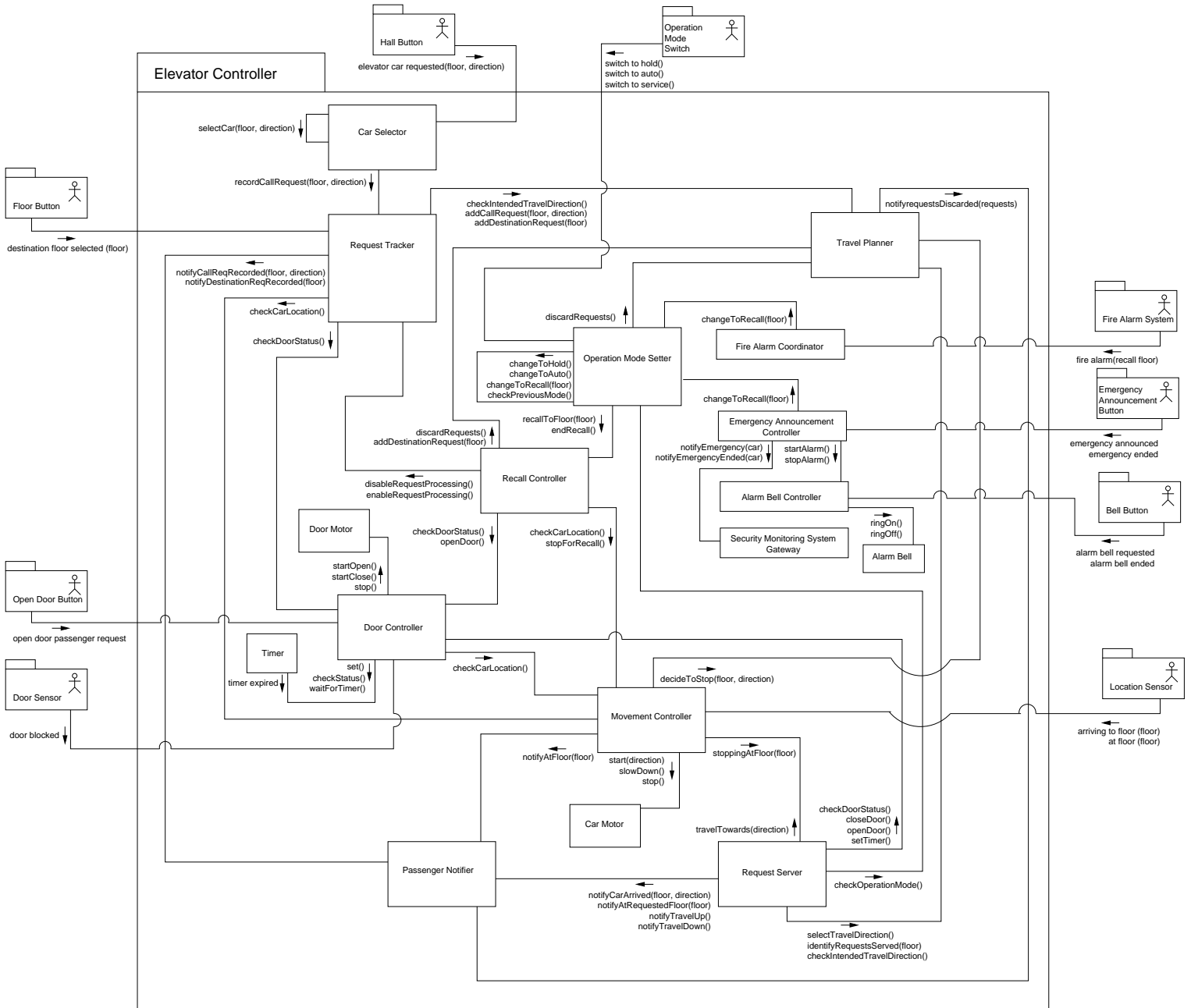


Figure 30: Unified Collaboration Diagram

The passengers inside the elevator car are informed of each floor the car passes (step 13). Assuming that the car is arriving at the floor where the passenger is waiting, the car is stopped (steps 14, 15, and 16), and the *Request Server* is informed of the stop (step 17).

The *Request Server* asks the *Travel Planner* to identify the requests served (step 18) and informs the passengers of the requests served (steps 19.1 and 19.2). The car door is then open (step 20, 20.1, 20.2). The *Request Server* checks the operation mode (step 21), and assuming operating in *auto* mode, sets the door timer (step 22. 22.1). The *Request Server* then asks the *Travel Planner* for the intended travelling direction (step 23) and informs passengers (step 24a or 24b). The passenger then enters the elevator car, and selects the destination floor to travel to (step 25).

The *Request Tracker* decides if the request is not trivially served (i.e. if the requested floor is not the same floor the elevator car is at) (step 26). Assuming that the passenger selects a floor different than the current floor, the destination request is added to the requests to serve (step 27), and the passenger is notified (step 28). The *Request Server* then asks the *Travel Planner* to select the direction to travel towards (step 29), and goes through similar steps as the ones taken to move the elevator car to the floor the car is currently at (steps 30 to 42). The collaboration ends at step 42 when the door is open – once the elevator car has arrived to the destination requested by the passenger in the elevator car.

Due to the inclusion of the use cases UC3 *Open Door* and UC4 *Close Door*, Figure 31 also illustrates the operation of the doors.

5.2.2 Elevator Car Recall

Figure 32 shows the collaboration diagram in the case of recall of an elevator car. The recall can be caused by a change in operation mode of the car via the operation mode switch (step 1a: operation mode switch set to *service*), a fire alarm reported by the fire alarm system (step 1b), or an emergency announced by a passenger in the elevator car (step 1c).

Although several use cases have been specified for each of these situations, we have chosen to only present a collaboration diagram than includes all of them. The reason is the similarity between all these use cases. Specifically, the relevant use cases are: UC5 *Announce Emergency*, UC7 *Set Operation Mode*, UC8 *Recall Due to Fire Alarm*, and UC9 *Recall to Floor*, where UC9 is a use case included by UC5, UC7 and UC8. Also note the UC7 illustrates not only a situation in which a car can be recalled (due to the operation switch set to *service*), but also the steps required to put the elevator car back in operation after it has been recalled – independently of the reason for the recall.

The final step in the Elevator Car Recall collaboration diagram is number 27, when the request processing is re-enabled after the operation switch has been rest to *auto* or *hold*.

5.2.3 Ring Alarm Bell

The final collaboration diagram presented in Figure 33 illustrates the case when a passenger rings the alarm bell by pushing the bell button.

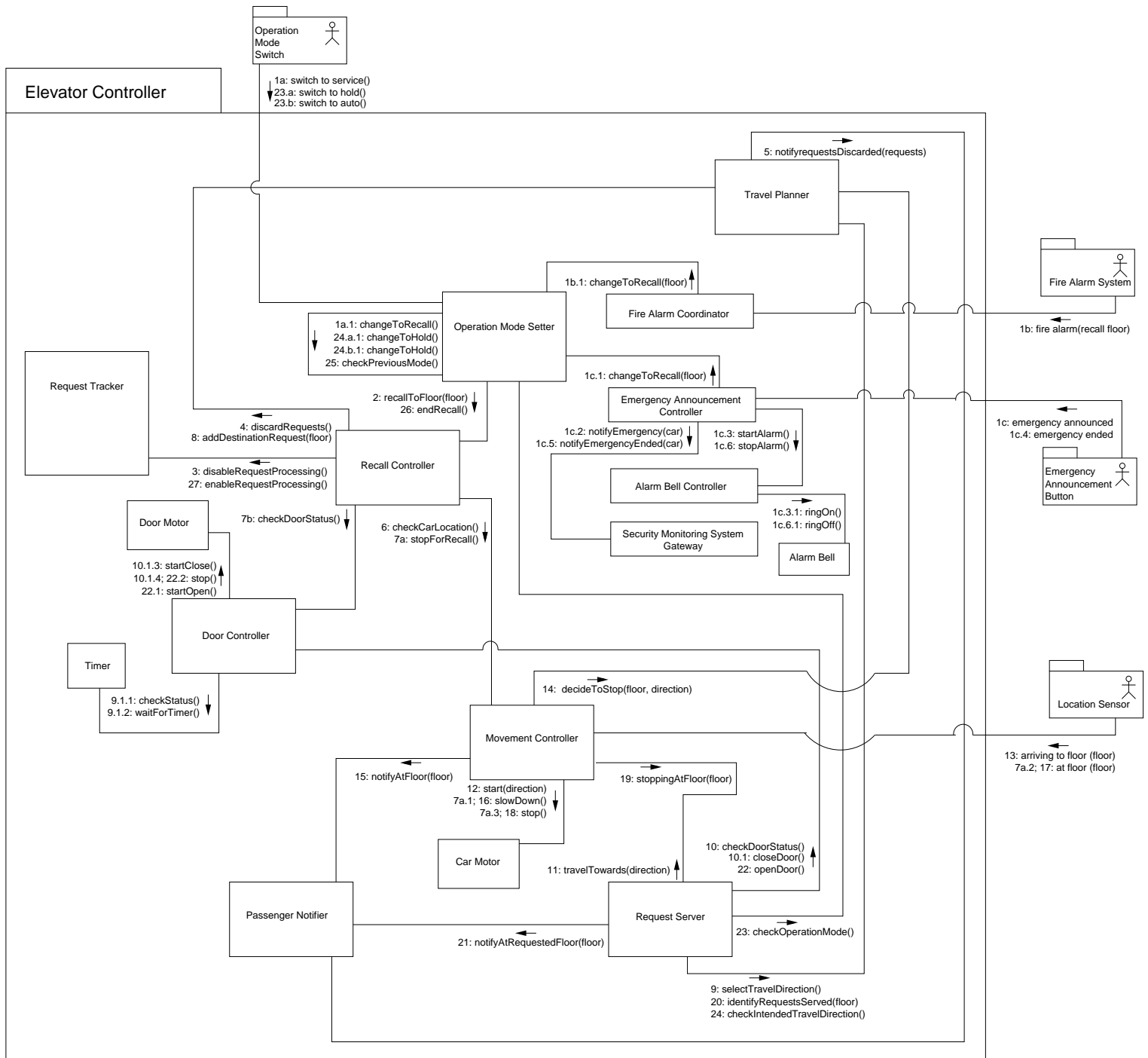


Figure 32: Collaboration Diagram For “Elevator Car Recall” - Related Use Cases (UC5, UC7, UC8, UC9)

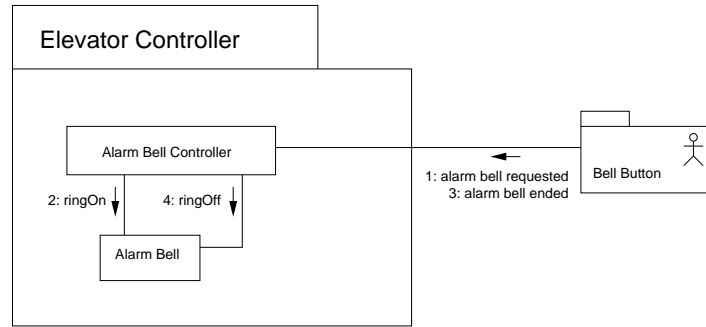


Figure 33: Collaboration Diagram For “Ring Alarm Bell” (UC6)

6 Reference Tables and Descriptions

6.1 Functional Requirements Table and Traceability Document

Main functional requirements are numbered Fi . Functional requirements decomposed from main requirement are numbered $Fi.j$.

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F1	E	Control Car Movement	EC shall control the movement and direction of the elevator cars		F2, F4, F5, F10, N1	UC1, UC2, UC5, UC8, UC9	Figs 22, 23, 30, 31, 32
F1.1	E	Travel Towards Direction	EC shall be able to run the elevator car motor towards a given direction (up/down).		F4.2, F5.1, F10.3	UC1, UC2, UC5, UC8, UC9	see F1
F1.2	E	Slow Down Elevator Car	EC shall be able to slow down the speed of the elevator car when approaching a floor where the car will stop		F2.1, F4.2, F5.1, F10.3	UC1, UC2, UC5, UC8, UC9	see F1
F1.3	E	Stop Elevator Car at Floor	EC shall be able to stop the elevator car when it arrives to a floor.	The car must first be slowed down and then stopped to avoid discomfort for passengers riding in the elevator.	F2.2, F4.2, F5.1, F10.3	UC1, UC2, UC5, UC8, UC9	see F1
F1.4	E	Stop for Recall	EC shall be able to stop the elevator car between floors when the elevator car is being recalled	When car is being recalled and its travelling direction is contrary to recall floor, the car must be able to stop in between floors in order to reverse the travelling direction.	F10.3	UC1, UC2, UC5, UC8, UC9	Figs 23, 25, 32

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F2	I	Location Tracking	EC shall know where the elevator cars are at all times	Elevator cars are near a floor, at a floor, or between floors. EC must be able to accurately land an elevator car at (exactly) a given floor.	F1, N2, N3	UC1, UC2, UC5, UC8, UC9	Figs 23, 30, 31, 32
F2.1	I	Arriving to Floor Tracking	EC shall know when an elevator car is close to arrive to a floor.	Information about when the elevator car is close to arrive to a floor allows the EC to slow down the elevator car in preparation to a stop.	F1.2	UC1, UC2, UC5, UC8, UC9	see F2
F2.2	I	At a Floor Tracking	EC shall know when an elevator car is at a floor	Information about when the elevator car is at a floor allows the EC to stop the elevator car at exactly a given floor	F1.3	UC1, UC2, UC5, UC8, UC9	see F2
F3	E	Control Doors	EC shall be able to open and close elevator car doors	When elevator car arrives at floor, EC shall open car door; EC shall close car door before moving the elevator car	F4, F5, F10	UC1, UC2, UC3, UC4, UC5, UC7, UC8, UC9	Figs 28, 30, 31, 32
F3.1	E	Open Doors	EC shall be able to open the elevator car door	The elevator car door is opened when the elevator car arrives to a destination. The elevator car door should never be opened while the elevator car is moving, or if the elevator is not at a given floor. The elevator door is also opened when the passenger pushes the open door button in an elevator car, and the car is parked at a floor.	F3.1, F4.2, F5.1, F10.3	UC1, UC2, UC3, UC5, UC8, UC9	see F3

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F3.2	E	Close Doors	EC shall be able to close the elevator car door	The elevator car door is always closed before moving the elevator car from one floor to another.	F3.1, F3.3, F3.4, F4.2, F5.1, F10.3	UC1, UC2, UC4, UC5, UC8, UC9	see F3
F3.3	E	Door Blocked Processing	EC shall be able to reverse the closing of a door if the door is blocked while being closed.	When the elevator car is being closed, any object blocking the way of the door should cause the door to stop moving towards the closing position and reverse its movement until the door is open again.	F3.2, F3.4	UC3, UC4	Fig 28
F3.4	E	Open Door Request while Closing	EC shall be able to reverse the closing of a door if the passenger requests the door to open	When the elevator car is being closed, if a passenger in the elevator car pushes the open door button, the door should stop moving towards the closing position and reverse its movement until the door is open again.	F3.2, F3.3	UC3, UC4	Fig 28
F3.5	E	Door Timer Control	EC shall be able to close the elevator door after a short period of time (usually 2 to 3 seconds)	Once the elevator door is opened, and if running in <i>auto</i> mode, the elevator car door should be closed again after a period of time (2-3 secs). Also, if the closing of the elevator car is aborted because a blocking object or because a passenger's open door request, the door timer must be set to attempt to close the door again after the timer expires	F9.2	UC3, UC4, UC7	Fig 28

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F3.6	E	Door Status	EC shall know the status of the elevator car door at all times	EC shall know if the elevator car door is closed, open, being open, or being closed.	F3.1, F3.2	UC1, UC5, UC8, UC9	Fig 28, 22
F4	E	Service Requests for Elevator ("Call Requests")	EC shall send an elevator car to the floor from which an elevator car is being requested.	EC shall select an elevator car to serve a call request. When the car arrives at floor, EC shall let passengers into the elevator car.	F1, F3, F6, F9, N2	UC1, UC2, UC7	Fig 19, 22, 30, 31
F4.1	E	Selection of Elevator Car	EC shall decide which elevator car will serve each call request	When a call request is made, the EC shall select an elevator car running in <i>auto</i> mode to serve the request. Car selection should attempt to minimise the time the passenger waits for the selected elevator car to arrive.	F6.1, F6.5, F9.1, F9.2	UC1, UC7	Fig 19, 31
F4.2	E	Travel Towards Call Request Floor	EC shall send the elevator car where the passenger is waiting	The elevator car shall be sent in direction to the floor where the passenger making the call request is. The elevator car shall stop at the floor when it arrives and it shall let the passenger in by opening the elevator car doors.	F1.2, F1.3, F3.1, F6.3	UC1, UC2	Fig 22, 30, 31
F5	E	Service Requests to Travel to Floors ("Destination Requests")	EC shall transport the elevator car to the floor requested by a passenger in the elevator car	When car arrives at floor, EC shall let passengers out of the elevator car.	F1, F3, F6, N3	UC1, UC2	Fig 22, 30, 31

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F5.1	E	Travel Towards Destination Floor	EC shall move the elevator car in the direction of the floor selected by passenger	If the destination floor selected by the passenger in the elevator car matches the travel direction of the elevator car, the EC shall move the elevator car towards the destination floor. When the elevator car arrives to the destination floor, the EC shall stop the elevator car and open the doors to let the passenger out. If the destination floor selected by the passenger is not towards the elevator's travel direction, the request shall be processed after all other pending requests assigned to the elevator car.	F1.2, F1.3, F3.1, F3.2, F6.2, F6.3, F6.4, F9	UC1, UC2	see F5
F6	E	Status Feedback	EC shall provide feedback to elevator passengers	EC turns on/off hall buttons, floor buttons, direction and floor indicators as a way to provide feedback to passengers of the elevator system. This feedback allows passengers to use the elevator system and notifies them when a request has been completed.	F4, F5, F9, F10, N4	UC1, UC2, UC5, UC7, UC8, UC9	Fig 20, 21, 22, 23, 24, 25, 30, 31, 32
F6.1	E	Call Request Recorded Feedback	EC shall provide feedback to elevator passengers when a call request has been assigned to an elevator car		F4.1	UC1	Fig 20
F6.2	E	Destination Request Recorded Feedback	EC shall provide feedback to elevator passengers when a destination request is added to the requests the elevator car will serve		F5.1	UC1	Fig 20

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F6.3	E	Car Arrived Feedback	EC shall provide feedback to elevator passengers when an elevator car arrives at a floor to serve a call request		F4.2	UC1	Fig 22
F6.3	E	At Request Floor Feedback	EC shall provide feedback to elevator passengers when the elevator car arrives at a destination requested by a passenger		F5.1	UC1	Fig 22
F6.4	E	At Floor Feedback	EC shall provide feedback to passengers about the floor the elevator car is passing	As the elevator car passes each floor when travelling on a given direction, the EC shall provide feedback to elevator passengers about the floor the elevator car is passing	F5.1	UC2	Fig 23
F6.5	E	Travel Up/Down Feedback	EC shall provide feedback to elevator passengers about the intended travel direction of the elevator car	When an elevator car running in <i>auto</i> mode arrives to a floor and opens its doors the EC shall provide feedback to passengers about the direction the elevator car is travelling towards.	F4.1	UC1	Fig 22
F6.6	E	Requests Discarded Feedback	EC shall provide feedback to passengers in the elevator car and passengers waiting for the elevator when the elevator car is recalled	When an elevator car is recalled, the EC shall notify the passengers that made the requests assigned to the elevator car, that the requests have been discarded.	F9.2, F9.3, F10.1	UC5, UC7, UC8, UC9	Fig 25, 24
F7	I	Request Tracking	EC shall keep track of all service requests (call and deliver to floor)	No requests should be skipped/dropped	F4, F5, F10, N2, N3	UC1	Fig 20

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Req</i>	<i>Related UCs</i>	<i>Found In</i>
F8	I	Request Processing	EC shall decide as it is arriving at each floor if stopping at that floor will serve any requests	When the elevator car is close to a floor, the EC shall decide if there are requests that will be served by stopping at that floor. If there are requests, the EC shall stop at the floor, if not, the EC shall bypass the floor.	F1, F2, F4, F5, N2, N3	UC1, UC2	Fig 22
F9	E	Operation Mode Setting	EC shall respond to changes in the operation mode made via the operation mode switch		F3, F4, F5, F10	UC3, UC9	Fig 24, 25, 32
F9.1	E	Switch to Auto	EC shall make the elevator car available for call requests when the operation mode is set to <i>auto</i>		F10.4	UC3, UC9	Fig 24
F9.2	E	Switch to Hold	EC shall make the elevator car unavailable for call requests when the operation mode is set to <i>hold</i>	Requests assigned to the elevator car put in <i>hold</i> mode shall be discarded, and passengers shall be notified that their requests have been discarded. When at a floor, the elevator car shall be kept with the door open until a destination request is made.	F3.5, F4.1, F6.6, F10.4	UC3, UC9	Fig 24
F9.3	E	Switch to Service	EC shall take the elevator car to a predetermined service recall floor when the operation mode is set to <i>service</i>	While the operation mode switch is in the <i>service</i> position the elevator car is kept parked at the service recall floor with the door open. The elevator car does not respond to destination floor requests made by passengers in the elevator car. The elevator car is not considered for servicing call requests (see F10 - Elevator Recall)	F10, F6.6	UC3, UC9	Fig 25, 32

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F10	E	Elevator Recall	EC shall recall elevators to designated floor when there is a fire alarm, the elevator car is put in service, or a passenger announces an emergency		F1, F3, F4, F5, F6, F9, F11, F12	UC2, UC3, UC5, UC7, UC8, UC9	Fig 20, 21, 22, 23, 24, 25, 32
F10.1	E	Discard Requests	EC shall be able to discard requests of an elevator car being recalled	When an elevator car is being recalled, all pending requests assigned to the elevator car shall be discarded.	F6.6, F7	UC5, UC7, UC8, UC9	Fig 25, 32
F10.2	E	Disable Passenger Request Processing	EC shall not accept passenger requests (call nor destination) while an elevator car is being recalled	When an elevator car is being recalled, no requests shall be assigned the elevator car. Requests for destination floors made by passengers in the elevator car being recalled should not be assigned to the elevator car. Once at the recall floor, no passenger requests shall be assigned to the recalled elevator car until the recall ends.	F7	UC5, UC7, UC8, UC9	Fig 20, 25, 32
F10.3	E	Travel to Recall Floor	EC shall be take the elevator car to the recall floor	When an elevator car is recalled, the elevator car must reverse its travelling direction if travelling in a direction contrary to the recall floor. When the elevator car arrives to the recall floor, the elevator car doors shall be opened and maintain opened until the recall ends. No stops should be made when travelling towards the the recall floor.	F1.1, F1.2, F1.3, F1.4, F3.1	UC2, UC3	Fig 22, 23, 25, 32

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F10.4	E	End Of Recall / Re-enable Request Processing	EC shall be able to assign passenger requests to the elevator car after it is no longer in recall mode	Recall mode ends when the operation mode switch is reset to either the <i>hold</i> or <i>auto</i> position. If reset to the <i>hold</i> position, the elevator car is not considered for servicing call requests, but it is considered for servicing passenger destination requests. If reset to the <i>auto</i> position, the elevator car is services both call and destination requests.	F9.1, F9.2	UC8, UC9	Fig 24
F11	E	Response to Fire Alarms	EC shall recall both elevator cars to a recall floor determined by the fire alarm system when there is a fire alarm in the building		F10	UC8, UC9	Fig 25, 26, 32
F12	E	Emergency Announcement	EC shall recall the elevator car where a passenger announces an emergency (via emergency button)	The elevator car is recalled to a predetermined emergency recall floor. The elevator car is maintained in recall mode until the operation mode switch is reset to the <i>auto</i> or <i>hold</i> position.	F10, F13	UC5, UC9	Fig 25, 27, 32, 29, 30
F12.1	E	Emergency Alarm Bell	EC shall ring the alarm bell while the emergency button is being pushed		F13	UC5	Fig 29, 30
F12.2	E	Interaction with Security Monitoring System	EC shall inform the Building Security Monitoring System when an emergency is announced.	The elevator car number, and elevator current location shall be provided to the Security Monitoring System. The Security Monitoring System shall also be informed when the passenger stops pushing the elevator car button.		UC5	Fig 27, 32, 30

continues on next page...

...continues from previous page

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
F13	E	Alarm Bell Operation	EC shall ring alarm bell while passenger pushes bell button		F2.1	UC6	Fig 29, 30

6.2 Non Functional Requirements Table and Traceability Document

<i>ReqId</i>	<i>Category</i>	<i>Name</i>	<i>Description</i>	<i>Details/Constraints</i>	<i>Related Reqs</i>	<i>Related UCs</i>	<i>Found In</i>
N1	M	Comfortable Ride	EC shall move/stop elevator cars in a way that does not cause discomfort to passengers		F1, F2		
N2	W	Efficient Allocation	EC shall efficiently assign requests for service to elevator cars		F4, F5		
N3	M	Efficient Transportation	EC shall efficiently transport the passenger in the elevator	EC shall service destination requests in ascending floor order when moving the elevator car upwards, and in descending floor order when moving the elevator car downwards.	F4, F5		
N4	M	Similarity to other elevators	EC shall make elevator system behave like every other similar elevator system	No new interfaces, elevator modes, ...		F4, F5, F6	