Low-Comotovation: System Design Document

Contents

0.1 Versioning & Authorship

Version 0.1
Low-Comotovation ©
Software Design Specification: Low-Comotovation
Status: Preliminary Release: Software Design Review

0.2 References

During the development of this document, IEEE 1016 was utilized.

0.3 Purpose

This document will specify the architecture and design of the Low-Comotovation train system. It shall discuss the structural and design and considerations of the train system and the accompanying subsystems of the train system. It shall also detail design considerations in vital subsystems.

0.4 Stakeholders & Concerns

The stakeholders of this document are anticipated to be the following:

- Future Design Teams: Future design teams are anticipated to utilize this document to guide their usage of the track controller system
- Pittsburgh Rail Company: The rail company utilizing the Software Design Specification (SDS) to guide the development of physical systems associated with the software

Future design teams associated with the continued development benefit from increased documentation of the original system by allowing for more efficient software design procedures in future revision by potentially unrelated developers.
The benefits to the Pittsburgh Rail Company from a detailed software design specification are twofold. First, a detailed SDD provides developers of railway hardware the information required to produced a paired system. Second, a documented SDD allows the Pittsburgh Rail Company to evaluate the designs ability to meet specifications for vitality.

1 Introduction

To ensure safe, predictable, and reliable operation of the system, there are three primary considerations:

1. *Vitality:* Vitality of a system within this document refers to a safety-critical system.

2. *Testability:* Any system implemented must be easily tested to ensure reliability

3. *Modularity:* Any system designed must reuse code wherever possible

2 System Design Use Cases

In this section, we detail the use cases of each subsystem. The use case of each subsystem is accompanied by brief descriptions of the use cases.

2.1 Track Model

In this subsection, the use cases of the train model are provided.

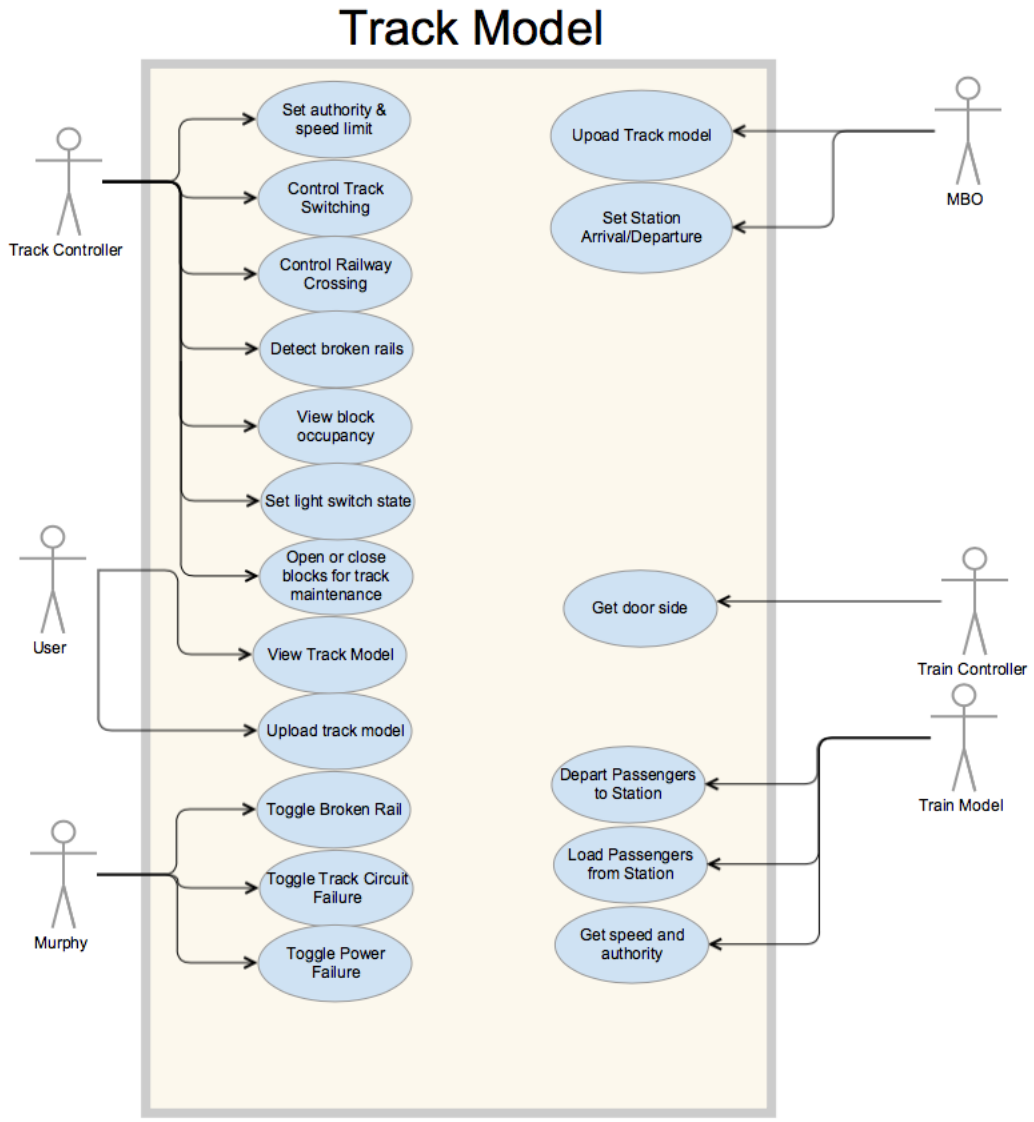

Figure 1: Track model use case diagram

Table 1: Set Speed and Authority

Actors	Track Controller
Description	The track controller shall be capable of setting a speed and authority via the track circuit modeled by the track model
Data	Speed and authority for the trains
Stimulus	None. The speed and authority are set externally
Response	The track model possesses the attributes set.
Comments	The track model only exists as a passthrough for this information

Table 2: Set Switch State

Actors	Track Controller
Description	The track controller shall be capable of setting the switch of a given state
Data	A boolean statement for the state of a switch
Stimulus	The Track Controller signal
Response	Setting the state of the switch
Comments	These are set simultaneously with no delays

Table 3: Control Railway Crossing

Actors	Track Controller
Description	The track controller shall be capable of setting the railway crossing to a given state
Data	A boolean statement for the state of a railway crossing
Stimulus	The Track Controller boolean signal
Response	Setting the state of the railway crossing
Comments	These are set simultaneously with no delays

Table 4: Detect Broken Rails

Actors	Track Controller
Description	The track controller shall be capable of detecting broken rails
Data	A boolean statement for the state of a block
Stimulus	A track controller query
Response	A return of the boolean broken state of the blocks on a track
Comments	The track controller calls the track model in this case

Table 5: View Block Occupancy

Actors	Track Controller
Description	The track controller shall be capable of viewing block occupancy
Data	A boolean statement for the occupancy of the block
Stimulus	A track controller query
Response	A return of the boolean occupied state of the blocks on a trackl
Comments	The track controller calls the track model in this case

Table 6: Set Light Switch State

Actors	Track Controller
Description	The track controller shall be capable of setting the light states
Data	A boolean statement for the next light switch state
Stimulus	A track controller function call
Response	A setting of the light switch state to that set by the track controller
Comments	

Table 7: Set Light Switch State

Actors	Track Controller
Description	The track controller shall be opening or closing a given block for maintenance
Data	A boolean statement for if a given block is open or closed due to maintenance
Stimulus	A track controller function call with a boolean variable
Response	A setting of the blocks open state
Comments	This block will not be considered "open" for planning purposes in new path. This is reflected in the nextBlock functionality

Table 8: Upload Track Model

Actors	User
Description	The user shall be capable of uploading track models to the track model
Data	The track model given in a .csv form. This may be provided by Excel "save as" function or similar.
Stimulus	None
Response	The user loads the files in
Comments	This will require multiple csv files in practice

Table 9: Set Light Switch State

Actors	Track Controller
Description	The track controller shall be capable of setting the light states
Data	A boolean statement for the next light switch state
Stimulus	A track controller function call
Response	A setting of the light switch state to that set by the track controller
Comments	

Table 10: Toggle Broken Rail

Actors	Murphy
Description	A test environment shall be provided to toggle the rail broken state for testing
Data	A boolean statement to set the rail to
Stimulus	External user testing stimulus
Response	Setting a given block to broken or fixed
Comments	This should be considered for test purposes of other modules

Table 11: Toggle Track Circuit Failure

Actors	Murphy
Description	A test environment shall be provided to toggle the circuit failure state for testing
Data	A boolean statement to set the track circuit functionality
Stimulus	External user testing stimulus
Response	Setting the track circuit to broken or functional
Comments	This should be considered for test purposes of other modules

Table 12: Toggle Power Failure

Actors	Murphy
Description	A test environment shall be provided to toggle the power failure state for testing
Data	A boolean statement to set the power failure state of a rail to
Stimulus	External user testing stimulus
Response	Setting a broken or fixed power state to
Comments	This should be considered for test purposes of other modules

Table 13: Upload Track Module

Actors	MBO
Description	Upload a track model to the track module
Data	identical to the user inputs
Stimulus	Initialization of a program
Response	The reading of the excel file
Comments	Functionally equivalent to the read track info for the user

Table 14: Set Station Arrival/Departure

Actors	MBO
Description	Set station arrival and departure time
Data	Receives the expected arrival and departure time from the MBO and displays them at a station
Stimulus	The MBO setting an arrival or departure at a given station
Response	Setting an arrival or departure at a given station
Comments	Set and called by the MBO

Table 15: Get Door Side

Actors	Train Controller
Description	Get the side of the door for arrival at a station given the visible beacon
Data	Returns the side of the door to open for a given train
Stimulus	Query with a station given a beacon
Response	Side of the train to open the door on
Comments	Set and called by the Train Conroller

Table 16: Depart Passengers to Station

Actors	Train Model
Description	Depart passengers from a train to a station
Data	Number of passengers to depart
Stimulus	Train model calling the station of the track model
Response	Add the people to the station loitering group
Comments	Set and called by the Train Model

Table 17: Get speed and authority from a given block

Actors	Train Model
Description	Calls a given block
Data	Number of passengers to depart
Stimulus	Train model calling the station of the track model
Response	Return speed and authority at a given block
Comments	Set and called by the Train Model

Table 18: Load Passengers From Station

Actors	Train Controller
Description	Load passengers to a track model from a station
Data	Maximum number of passengers to load a train to capacity
Stimulus	Train model queryiing the track model
Response	Number of people to add to the train
Comments	Set and called by the Train Controller

2.2 Track Controller

In this subsection, the use cases of the track controller are provided.

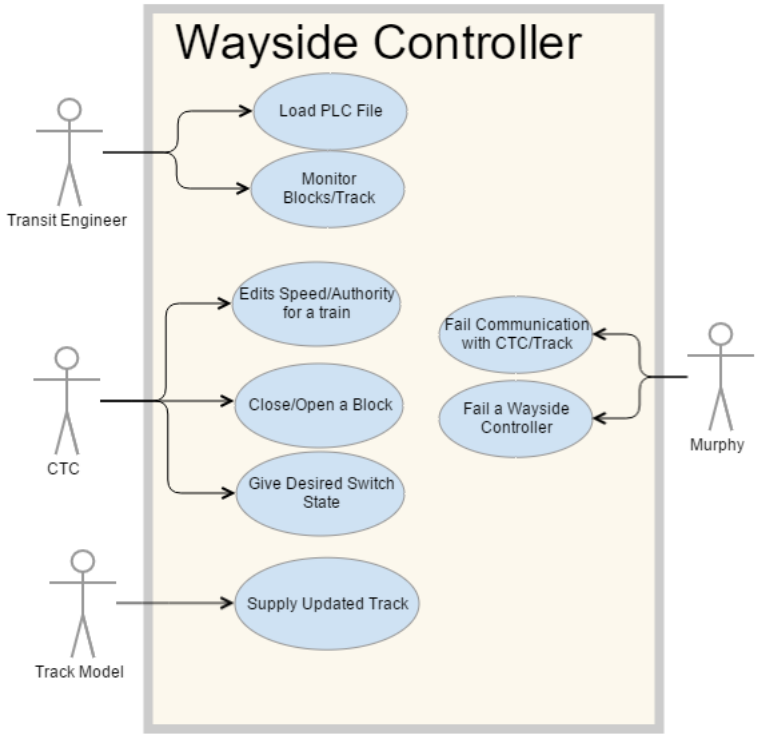

Figure 2: Track controller use case diagram

Table 19: Load PLC File

Actors	Transit Engineer, Wayside Controller
Description	A Transit Engineer will load a PLC file upon startup of the Wayside unit(s), and will do so by either browsing for a file or supplying the file path.
Data	PLC File's name, path
Stimulus	'Load' button pressed
Response	Validity of File checked; Invalid File/Success of Load will be displayed to Transit Engineer
Comments	Proper formatting/convention of PLC file is required

Table 20: Monitor Blocks/Track

Actors	Transit Engineer, Wayside Controller
Description	For a given wayside, a Transit Engineer may select a block (by Line, Section, Block) from dropdowns to view its characteristics i.e. switch state & crossing status (if applicable), occupancy, lights
Data	Track Blocks, Switches, Crossings, Lights
Stimulus	Block selected
Response	Information queried from block and displayed
Comments	Selection of blocks changes based on Wayside Controller selected

Table 21: Dispatch/Edit Train

Actors	CTC, Wayside Controller
Description	A CTC will dispatch a train/update a train with a given speed and authority (passed to wayside controller) which will then be relayed to the track model by the wayside controller.
Data	Speed, Authority, Block
Stimulus	Speed, Authority, and Block passed to Wayside Controller
Response	Wayside sets Speed, Authority of given block on the track model
Comments	

Table 22: Open/Close a Block

Actors	CTC, Wayside Controller
Description	The CTC will prompt the Wayside to close or open a block for maintenance.
Data	Block, Open/Closed Status
Stimulus	CTC prompts Wayside controller to close or open a block.
Response	Wayside sets status of given Block to open/closed.
Comments	

Table 23: Supply Updated Track

Actors	Track Model, Wayside Controller
Description	The Track Model will provide Block Occupancies, Switch statuses, and Crossing statuses to the Wayside Controller
Data	Block, Switch, Crossing
Stimulus	Track sends updated information
Response	Wayside gives updated info to PLC code
Comments	

Table 24: Fail Communication with CTC/Track Model

Actors	Murphy, Wayside Controller
Description	Murphy will eliminate communication between the Wayside Controller and the CTC and Track.
Data	N/A
Stimulus	'Communication Fail' button pressed
Response	All Trains are stopped.
Comments	

Table 25: Fail a Wayside

Actors	Murphy, Wayside Controller
Description	Murphy will break a Wayside Controller causing the unit to be non-responsive
Data	N/A
Stimulus	'Fail Wayside' button pressed
Response	All trains within jurisdiction of Wayside's line are stopped.
Comments	i.e. Red Line can operate if Green Line is shut down.

2.3 Train Model

In this subsection, the use cases of the train model are provided.

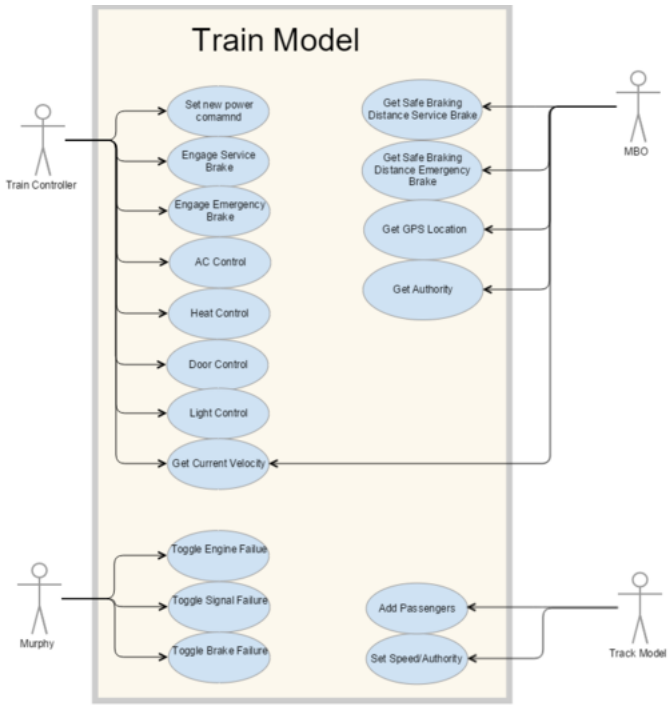

Figure 3: Train model use case diagram

Table 26: Set New Power Command

Actors	Train Controller
Description	Train Controller will set a new power command based on the current velocity of the train and the new setpoint speed set by the driver. This power command will be used to determine the force applied to the train and thus compute the new current velocity.
Data	Power Command issued to the train
Stimulus	When a setpoint speed is provided to the train controller, a Power command is computed using the current velocity and sent to train
Response	New current velocity is returned to actor at the end of the computation.
Comments	

Table 27: Engage Service Brake

Actors	Train Controller
Description	Train controller will engage or disengage the service brake in order to slow down or stop the train for any given reason. Once engaged the power command will be set to zero and the train will begin to decelerate
Data	Service Brake command
Stimulus	Service brake will be engaged under the following conditions: 1) Service brake button is manually pressed by the driver via the train controller 2) Failure occurs in the train that requires the train to stop, this will engage the service brakes unless failure is caused by service brakes 3) Train is set to slow down and service brakes are applied to reduce speed
Response	Service brake status is set to engaged and train begins to decelerate at service brake deceleration rate.
Comments	The service brake can either posses the status of on, off , or failure.

Table 28: Engage Emergency Brake

Actors	Train Controller
Description	Train controller will engage or disengage the emergency brake in order to slow down or stop the train for any emergencies that may occur. Once engaged the power command will be set to zero and the train will begin to decelerate
Data	Emergency Brake command
Stimulus	Emergency brake will be engaged under the following conditions: 1) Emergency brake button is manually pressed by the driver or passenger via the train controller 2) Failure occurs in the service brakes and the emergency brakes are required to stop the train
Response	Emergency brake status is set to engaged and train begins to decelerate at emergency brake deceleration rate.
Comments	The Emergency brake can either posses the status of on or off. For this model we are assuming that the emergency brakes never fail

Table 29: Air Conditioning (AC) Control

Actors	Train Controller
Description	Train controller will activate or deactivate the Air conditioning unit onboard the train to decrease the current temperature of the train.
Data	Air conditioning command
Stimulus	The air conditioning will be turned on or off by the train controller. This will either be performed manually by the driver using a button or automatically by the train controller based on current temperature and thermostat setting.
Response	AC control set to on will result in a gradual decrease of the current train internal temperature.
Comments	The AC can either posses the status of on, off, or failure.

Table 30: Heater Control

Actors	Train Controller
Description	Train controller will activate or deactivate the heating unit onboard the train to increase the current temperature of the train.
Data	Heater command
Stimulus	The heating unit will be turned on or off by the train controller. This will either be performed manually by the driver using a button or automatically by the train controller based on current temperature and thermostat setting.
Response	Heater control set to on will result in a gradual increase of the current train internal temperature.
Comments	The heater can either posses the status of on, off, or failure.

Table 31: Door Control

Actors	Train Controller
Description	Train controller will open and close the doors on the left and right side individually using individual commands for each side.
Data	Left door command, Right door command
Stimulus	The left or right doors will be opened or closed by the train controller. This will either be performed manually by the driver using a button or automatically by the train controller upon arrival and departure at each station.
Response	If the right door command is passed, all doors on the right side are opened. If the left door command is passed, all doors on the left side are opened.
Comments	The Left and Right doors can either posses the status of open, closed, or failure.

Table 32: Light Control

Actors	Train Controller
Description	Train controller will turn the interior lights onboard the train on and off based on time of day and location of train (e.g. within tunnel or not)
Data	Interior Light command
Stimulus	The lights will be toggled on and off by the train controller. This will either be performed manually by the driver using a button or automatically by the train controller based on time of day and upon entering and exiting a tunnel
Response	If the light command is passed, all lights onboard the train are turned on.
Comments	The interior lights can either posses the status of on, off, or failure.

Table 33: Get Current Velocity

Actors	Train Controller, MBO
Description	A call will be made to request the current velocity of the train and this will be passed back to the actor which required it. The train controllor will request the current velocity in order to compute the power command to send to the train model. The MBO will request the current velocity in order to compute the variation between the suggested speed and the actual speed of the train.
Data	Current Velocity value
Stimulus	A request will be sent to the train model to obtain the current velocity of the train at that given moment
Response	The current velocity of the train will be returned to the caller in MPH.
Comments	

Table 34: Toggle Engine Failure

Actors	Murphy
Description	Murphy is able to toggle the engine failure status in order to distrupt the train's engine. Once engaged the train will be required to stop until the issue is resolved.
Data	Engine Failure command
Stimulus	A command will be sent to the train model from the Murphy console to toggle the failure status of the train's engine.
Response	The engine failure status will be toggled as a response to the command. When an engine failure occurs the service brakes are also engaged to bring the train to a stop until issues are resolved.
Comments	The engine failure status will toggle between failure, and non-failure.

Table 35: Toggle Signal Failure

Actors	Murphy
Description	Murphy is able to toggle the signal failure status in order to distrupt the train's signaling and communication abilities. Once engaged the train will be required to stop until the issue is resolved.
Data	Signal Failure command
Stimulus	A command will be sent to the train model from the Murphy console to toggle the failure status of the train's signaling system.
Response	The signal failure status will be toggled as a response to the command. When a signal failure occurs the service brakes are also engaged to bring the train to a stop until issues are resolved.
Comments	The signal failure status will toggle between failure, and non-failure.

Table 36: Toggle Brake Failure

Actors	Murphy
Description	Murphy is able to toggle the brake failure status in order to distrupt the train's service brake. Once engaged the train will be required to stop until the issue is resolved.
Data	Brake Failure command
Stimulus	A command will be sent to the train model from the Murphy console to toggle the failure status of the train's service brake
Response	The brake failure status will be toggled as a response to the command. When a service brake failure occurs the emergency brakes are also engaged to bring the train to a stop until issues are resolved.
Comments	The brake failure status will toggle between failure, and non-failure.

Table 37: Get Safe Braking Distance (Service Brake)

Actors	MBO
Description	In order to better determine the train's footprint the MBO will call to obtain the safe braking distance of the Train. This will be the distance required to bring the train to a complete stop using the service brake deceleration rate. This distance will vary based on the number of passengers on board the train and the current velocity of the train.
Data	Safe Braking Distance for Service Brake
Stimulus	Command will be requested from the MBO to get the current safe braking distance using the service brakes which would be computed based on the current velocity and mass of the train.
Response	The safe braking distance using the service brakes will be returned to the MBO.
Comments	

Table 38: Get Safe Braking Distance (Emergency Brake)

Actors	MBO
Description	In order to better determine the train's footprint the MBO will call to obtain the safe braking distance of the Train. This will be the distance required to bring the train to a complete stop using the emergency brake deceleration rate. This distance will vary based on the number of passengers on board the train and the current velocity of the train.
Data	Safe Braking Distance for Emergency Brake
Stimulus	Command will be requested from the MBO to get the current safe braking distance using the emergency brakes which would be computed based on the current velocity and mass of the train.
Response	The safe braking distance using the emergency brakes will be returned to the MBO.
Comments	

Table 39: Get GPS Location

Actors	MBO
Description	The MBO will elect to receive the current GPS location to determine the train's current location to the nearest meter. This will be determined by calculating the distance traveled by the train and compute the distance into the current block to return to the MBO
Data	Current Block, Distance Into block
Stimulus	Command will be requested from the MBO to get the current GPS location from the train
Response	GPS location will be returned providing the current block the train is in as well as the distance into that current block to the nearest meter.
Comments	

Table 40: Get Authority

Actors	MBO
Description	The MBO will request to receive the current Authority of the given train. This will be used in conjuction with the suggested authority to determine the variation between suggested authority and actual authority for the train.
Data	Current Authority
Stimulus	Command will be requested from the MBO to get the current Authority from the train
Response	Current authority will be returned for that given train
Comments	

Table 41: Add Passengers

Actors	Track Model
Description	The track model will randomly generate a number of passengers to wait at a station then upon arrival to a station a random number of passengers will board based on space avaliable on the train. This number will be sent to the train model to modify passenger count and mass of train based on capacity.
Data	Number of passengers boarding
Stimulus	Command will be requested from the MBO to get the current Authority from the train
Response	Based on space on board, a random number of passengers between 0 and amount of space will be passed to the train model
Comments	

Table 42: Set Speed/ Authority

Actors	Track Model
Description	The track model will pass the speed and authority to the train model. This speed and authority will then be passed to the train controller with no variation.
Data	Speed, Authority
Stimulus	Command will be sent to train model with speed and authority
Response	Speed and authority will be passed to train controller.
Comments	

Table 43: Set Current Block

Actors	Track Model
Description	The track model will pass the current block the train is on as the train enters each new block area. This current block object will provide the train with the block's grade as well as its length, to be used by the train's GPS
Data	Current Block
Stimulus	Command will be sent to train model with current block
Response	Block length will be extracted for train GPS, and Block grade will be extracted for train movement calculations
Comments	

2.4 Train Controller

In this subsection, the use cases of the train controller are provided.

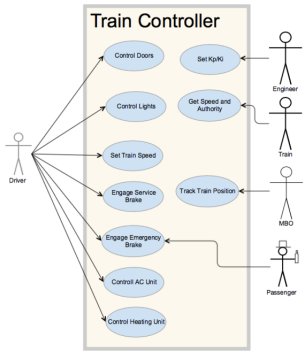

Figure 4: Train controller use case diagram

Table 44: Select Train

Actors	Driver
Description	The user picks a train from the dropdown and switches the train controlled by the Train Controller to the selected train by clicking the 'Switch' button. The Train Controller then passes the selected train to its sub-components.
Data	Train ID corresponding to the item in dropdown box.
Response	The Train Controller now controls the train that was picked from the dropdown.
Comments	

Table 45: Set Speed

Actors	Driver, Train
Description	Begins the process of changing the selected train's speed by using power control law. The power command is passed to the train and the train changes to a new speed. This continues until the train's speed is equal to the speed set by the driver or system.
Data	Set speed, block speed, suggested speed, selected train
Stimulus	Happens when th 'Set Speed' button is clicked or the train enters a block with a different block speed and has to adjust.
Response	Sends a power command to the selected train, signaling to either increases or decreases its speed until the actual speed of the train equals the set speed.
Comments	The set speed must not be over the suggested speed or the block speed. This is made sure by the UI elements in the Speed Controller.

Table 46: Control Utilities

Actors	Driver, Train
Description	The driver will open, close, turn on, or turn off the selected train's utilities such as AC, Heat, Lights, and Left/Right Doors or the utilities will be controlled automatically by the Train Controller. This is done by selecting the corresponding radio button from the Utility Panel.
Data	Selected train
Stimulus	The user changing the states of the radio button or the system detects that a utility must be turn on, off, opened, or closed.
Response	Train updates the states of the corresponding utilities.
Comments	AC and Heat cannot be on at the same time. This is made sure by the UI elements in the Utility Panel.

Table 47: Set K_p and K_i

Actors	Engineer, Train
Description	The Engineer will set K_p and K_i of the selected train by inputting the value as double and clicking the 'Set' button.
Data	The selected train and doubles representing K_p and K_i
Stimulus	The selected train has no K_p and K_i set or the user clicks the 'Set K_p/K_i' button on the Train Controller.
Response	The K_p and K_i of the train will be set.
Comments	If the K_p and the K_i are not chosen for a selected train when the train is first selected, a window will pop up to allow the Engineer to set the K_p and K_i.

Table 48: Engage Service Brake

Actors	Driver, Train
Description	Initiates the service brake on the selected train, decreasing its speed.
Data	Deceleration constant of the selected train's service brake and if the train must slow down.
Stimulus	A negative power command during the power law control or user interaction by pressing the 'Service Brake' button.
Response	The service brake is engaged on the selected train, and its speed decreases by some amount.
Comments	

Table 49: Engage Emergency Brake

Actors	Driver, Train, Passenger
Description	Initiates the emergency brake on the selected train, decreasing its speed.
Data	Deceleration constant of the selected train's emergency brake.
Stimulus	The emergency brake is pressed or the system detects that the train must use the emergency brake.
Response	The emergency brake is engaged on the selected train, and its speed decreases.
Comments	In Manual mode, the user must confirm the use of the emergency brake before it's actually used. This isn't the case in Automatic mode.

Table 50: Get Speed and Authority

Actors	Train
Description	The Train Controller retrieves the suggested speed and authority of the selected train based on which block the train is in. This is used to determine if the train is allowed to continue to the next block, or if it needs to change its speed based on the suggested speed.
Data	The selected train
Stimulus	During every clock tick.
Response	Train Controller updates its sub-components with the suggested speed and authority.
Comments	

2.5 Moving Block Overlay

In this subsection, the use cases of the Moving Block Overlay (MBO) are provided.

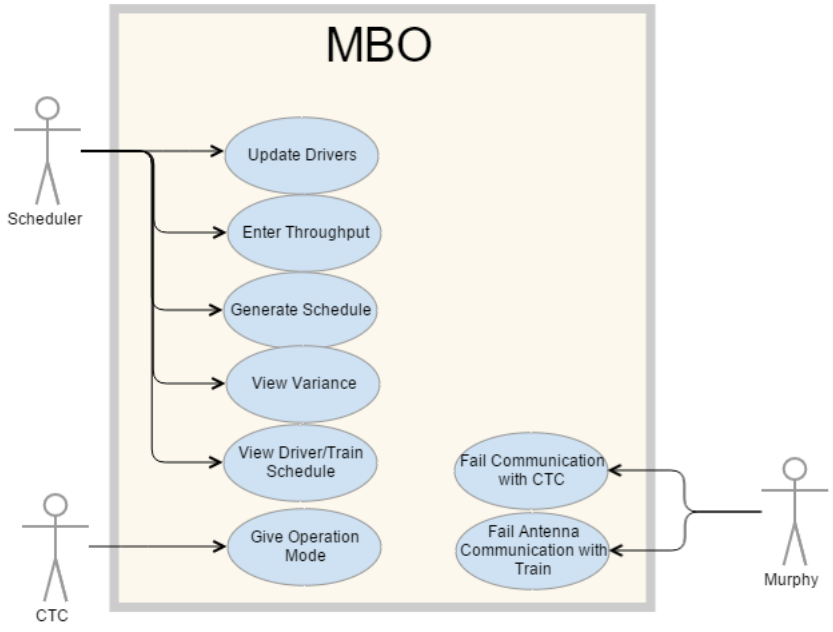

Figure 5: Train controller use case diagram

Table 51: Update

Actors	Scheduler
Description	The Scheduler is able to update the list of drivers. This will change whether or not a driver is able to be scheduled.
Data	filename
Stimulus	Click drivers button
Response	Loops through a CSV file to add all the drivers to the list of drivers. When adding a driver, a driver object will be created with the entered properties. This object will then be added to the Driver Schedule where it can be accessed as part of the list.
Comments	There will be a default file so that it can be saved between sessions.

Table 52: Enter Throughput

Actors	Scheduler
Description	The Scheduler enters the number of trains they would like to be on the track at a certain point in time.
Data	number of trains
Stimulus	Click submit button
Response	The number of trains is entered by the scheduler. This is used to generate both the train and driver schedules for both MBO and FB modes.
Comments	

Table 53: View Train/Driver Schedule

Actors	Scheduler, CTC
Description	Scheduler can see a list of all trains, as well as their station arrival times. Scheduler can see a list of all current drivers, as well as their corresponding break times and current train.
Data	train ID, arrival times, driver name, ID, break times
Stimulus	Updates triggered by clock
Response	Two tables will be displayed, one for the train schedule, and one for the driver schedule. The train schedule will list IDs as the rows and station names as the columns. Each cell will contain the time that train will arrive at that station. The driver schedule will what train they are on at what times. It will also show whenever they start and stop work and when they are on breaks.
Comments	The table that is displayed will automatically update itself when triggered by the clock.

Table 54: View Variance

Actors	Scheduler
Description	Scheduler can see a list of all trains, as well as their corresponding speed and current position. The suggested speed and authority will be displayed as well as the variance between the two.
Data	train ID, speed, suggested/actual position/authority, variance
Stimulus	Updates triggered by clock
Response	In Fixed Block mode the current block will have to be kept track of based on past block occupancy. In MBO mode the position can be gotten through GPS.
Comments	In Fixed Block mode the position is denoted as the current block. In MBO mode the position is denoted as the current block and the distance into that block.

Table 55: Generate Schedules

Actors	Scheduler
Description	When required a schedule will be generated based on the input data. This will then be displayed for the scheduler/CTC. It is used to dispatch trains and calculate a path for a train.
Data	number of trains, track data
Stimulus	On launch, change in number of drivers, clock triggered
Response	A schedule will be generated for trains and drivers. It will have to take into account the mode of operation (MBO or FB), speed limits, track occupancy, drivers break times, and other variables.
Comments	Can only happen in automatic mode - schedule will be either fixed block or MBO depending on dispatcher's selection of mode.

Table 56: Give Operation Mode

Actors	CTC
Description	The CTC sends the mode of operation whenever it is changed.
Data	mode
Stimulus	CTC changes the mode.
Response	The mode is updated in the MovingBlockOverlay class. Any shut-down procedures to switch between modes are performed.
Comments	The default mode will be manual.

Table 57: Fail Communication with CTC

Actors	Murphy
Description	Murphy breaks communication between CTC and MBO.
Data	communication failure
Stimulus	CTC clicks Fail Communication with MBO button.
Response	Since scheduling will be unavailable without communication with the MBO, the CTC will be forced into manual mode and let the dispatcher know with a message.
Comments	

Table 58: Fail Communication with Train

Actors	Murphy
Description	Murphy breaks communication between Train and wayside.
Data	communication failure
Stimulus	Click Fail Communication with Train button.
Response	The MBO can no longer receive the GPS position of individual trains and is therefore unable to safely operate in MBO mode. So a transition must be made to either Fixed Block mode or to manual mode.
Comments	

2.6 Centralized Train Control

In this subsection, the use cases of the Centralized Train Control (CTC) are provided.

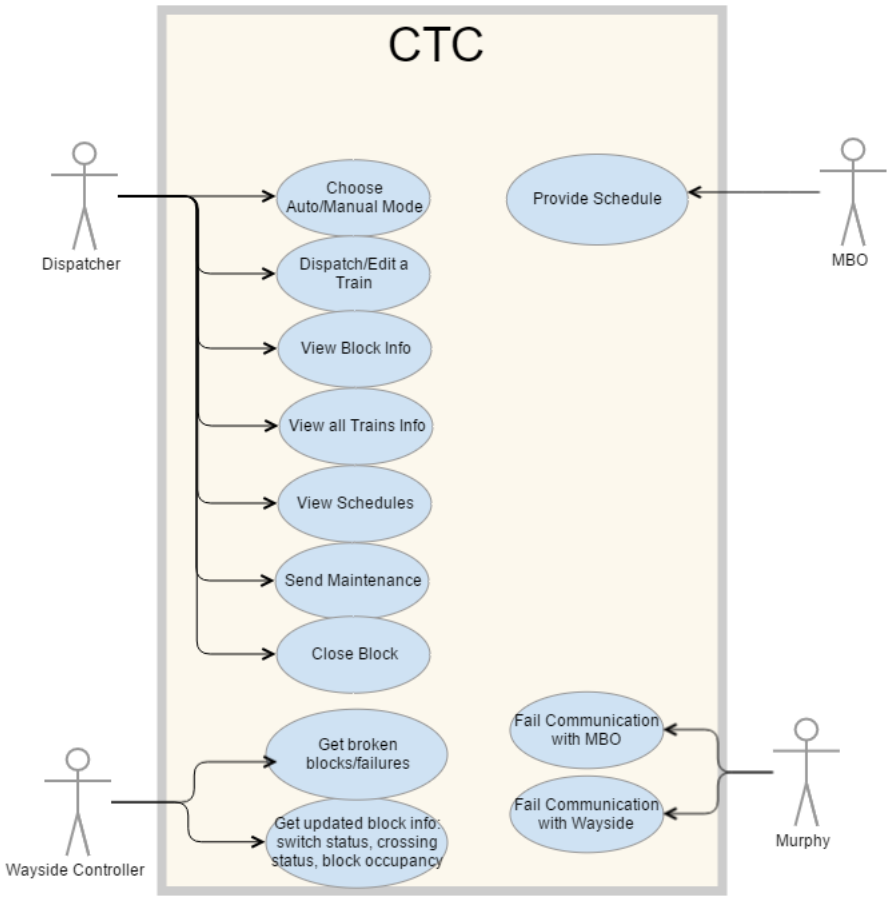

Figure 6: Centralized Train Control use case

3 Class Diagrams

In this section, the class diagrams for each subsystem are provided.

3.1 Track Model

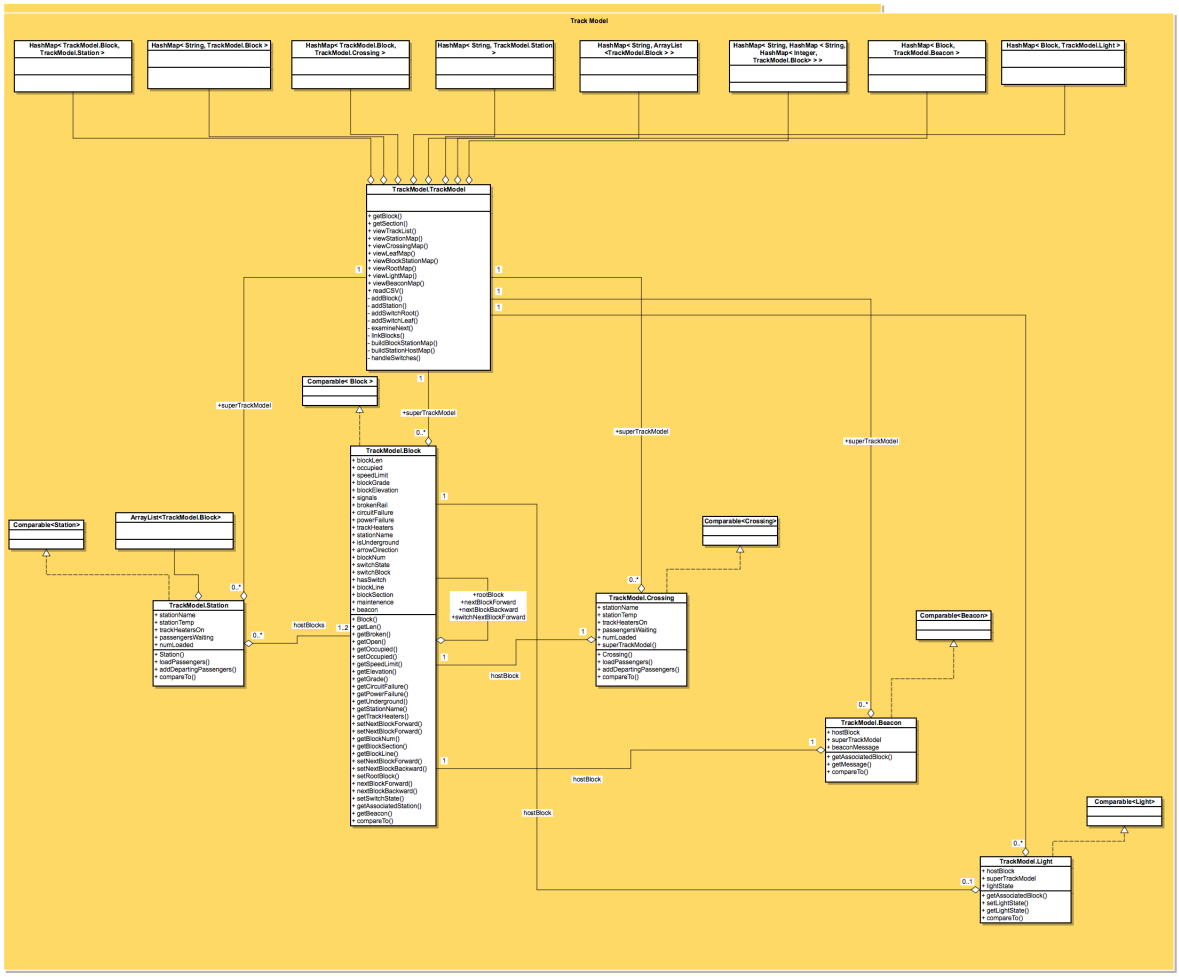

Figure 7: Track Model Class diagram

The track model package consists of a block object to be utilized by all classes,

3.2 Track Controller

3.3 Train Model

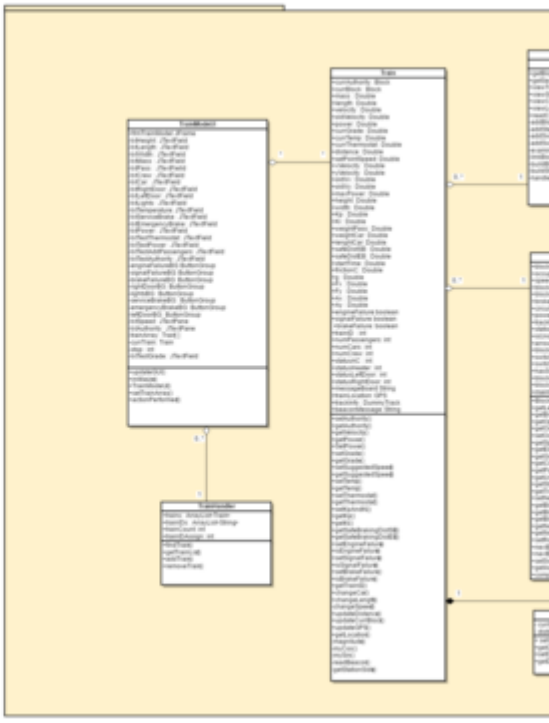

Figure 8: Train Model Class diagram

3.4 Train Controller

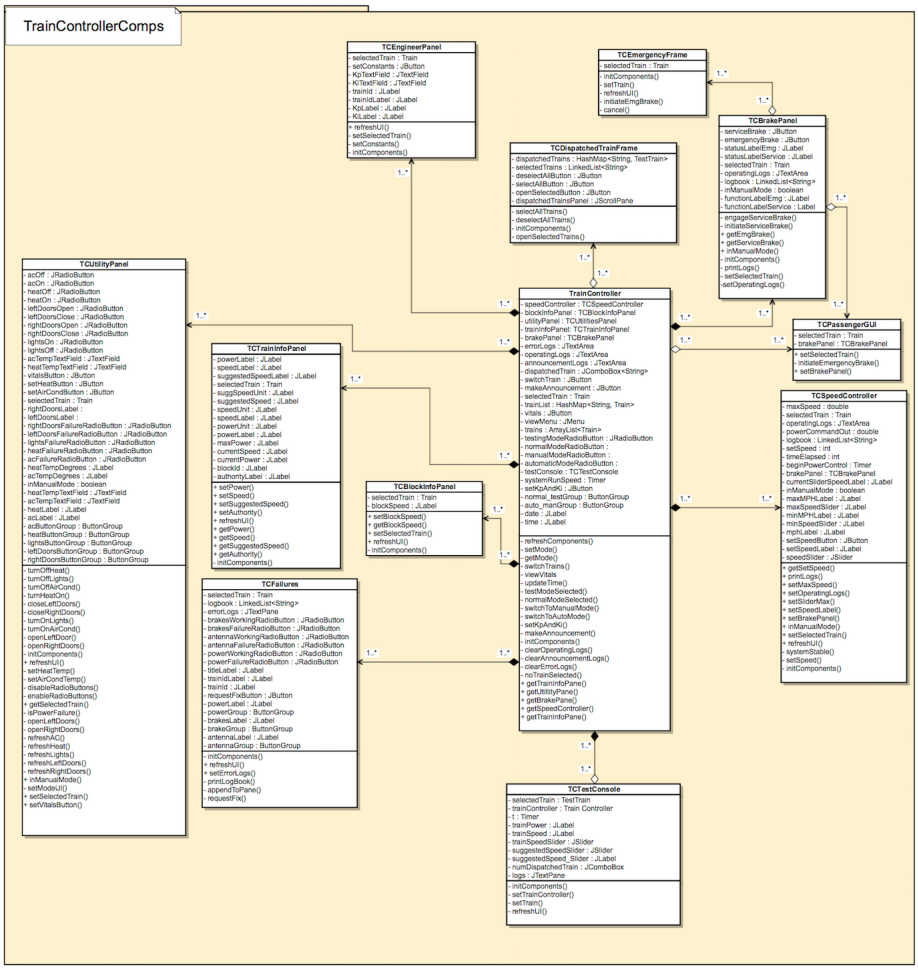

Figure 9: Train Controller Class Diagram

3.5 Moving Block Overlay

3.6 Centralized Train Controller

4 Sequence Diagrams

In this section, we detail the sequence diagrams each subsystem.

4.1 Track Model

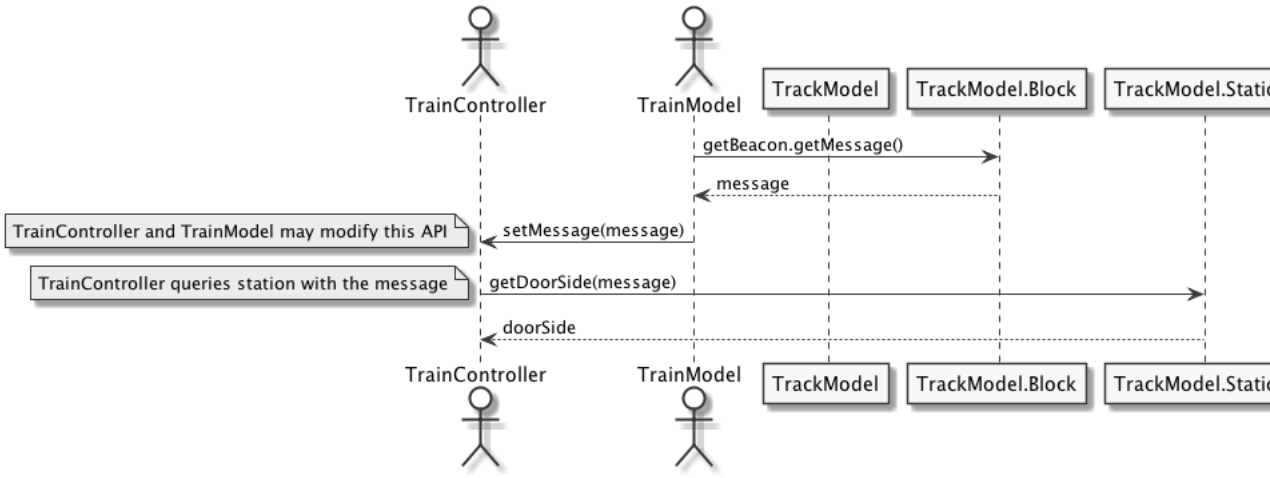

Figure 10: Getting station direction

Table 59: Getting the Door Side to Open on a Train

Actors	TrainModel, TrainController
Description	The train model gets a message, gives it to the train controller, which calls the station with that beacon direction to get a door side
Data	The beacon message
Stimulus	A train reaching a block with a beacon
Response	A message then a door side
Comments	This is a composite action which may not be accurate for actions between the TrainController and TrainModel. While they are assumed to communicate for these purposes, the exact API may not be reflected in this diagram. User should consult pertinent diagrams.

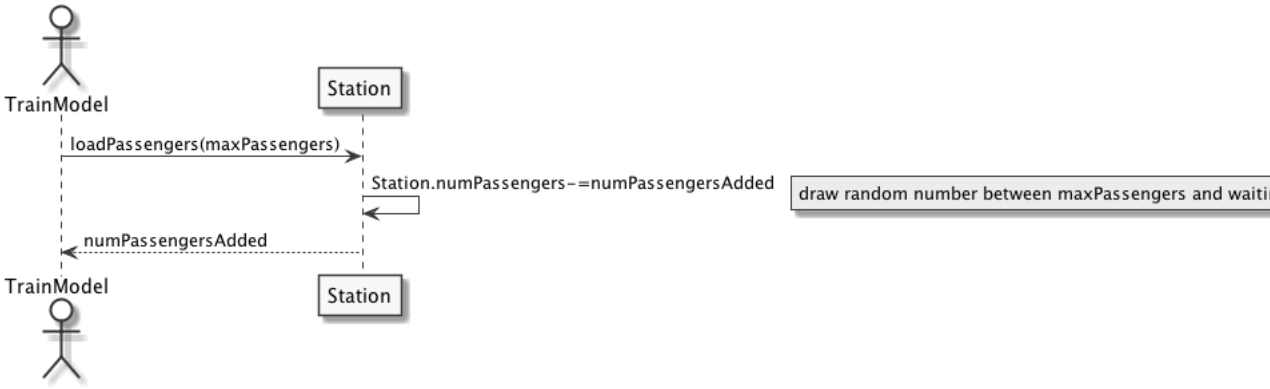

Figure 11: Add Passengers Use Case Diagram

Table 60: Adding passengers

Actors	TrainModel
Description	The train model calls the station to load passengers to a train
Data	maximum number of passengers to add to a train
Stimulus	A train model calling the station
Response	A number of people to add to a given train model
Comments	The passengers added to the trainmodel are removed from the passengers waiting at the station

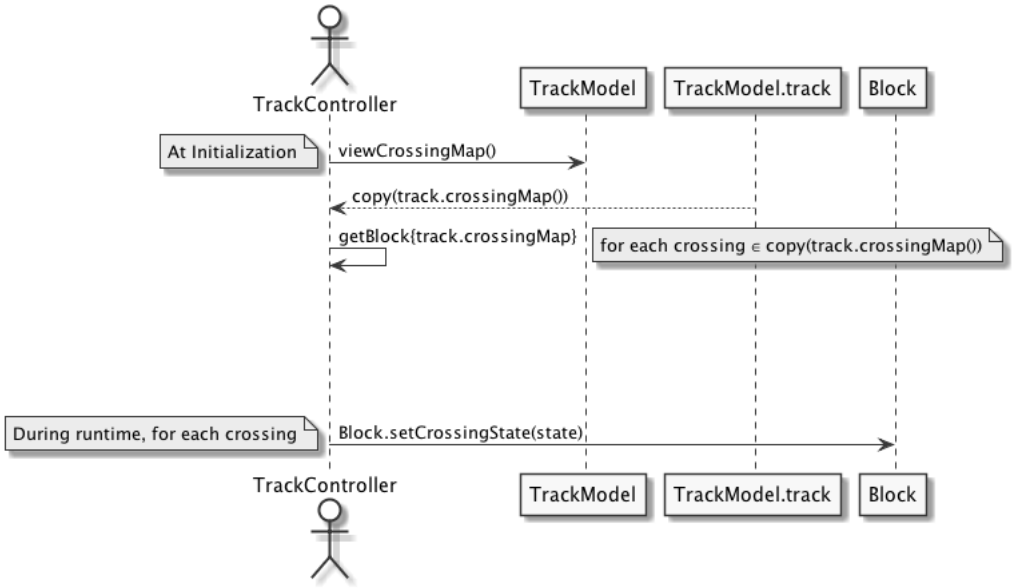

Figure 12: Toggle Crossing State Use Case Diagram

Table 61: Toggle crossing state description

Actors	TrackController
Description	The track controller first indexes all the switches on a given track at initialization. The track controller then calls the toggleCrossing function on each block
Data	A boolean state represented as an Integer
Stimulus	A track controller call
Response	Setting the boolean state of the crossing based on the TrackController
Comments	Blocks without a crossing have a null in lieu of an integer

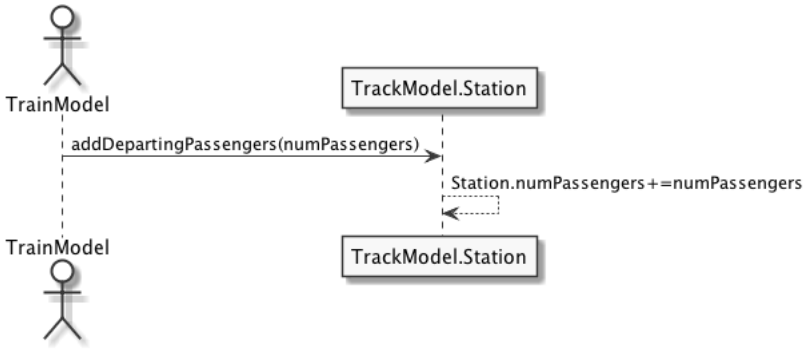

Figure 13: Departing Passengers to Station Use Case Diagram

Table 62: Depart Passengers to a Station

Actors	TrainModel
Description	The train model calls the station to depart passengers from a train
Data	Number of passengers to depart
Stimulus	A train model calling the station
Response	The number of people departing the train are added to the people waiting at a station
Comments	The passengers in the system are assumed to be finite and a closed model in this system

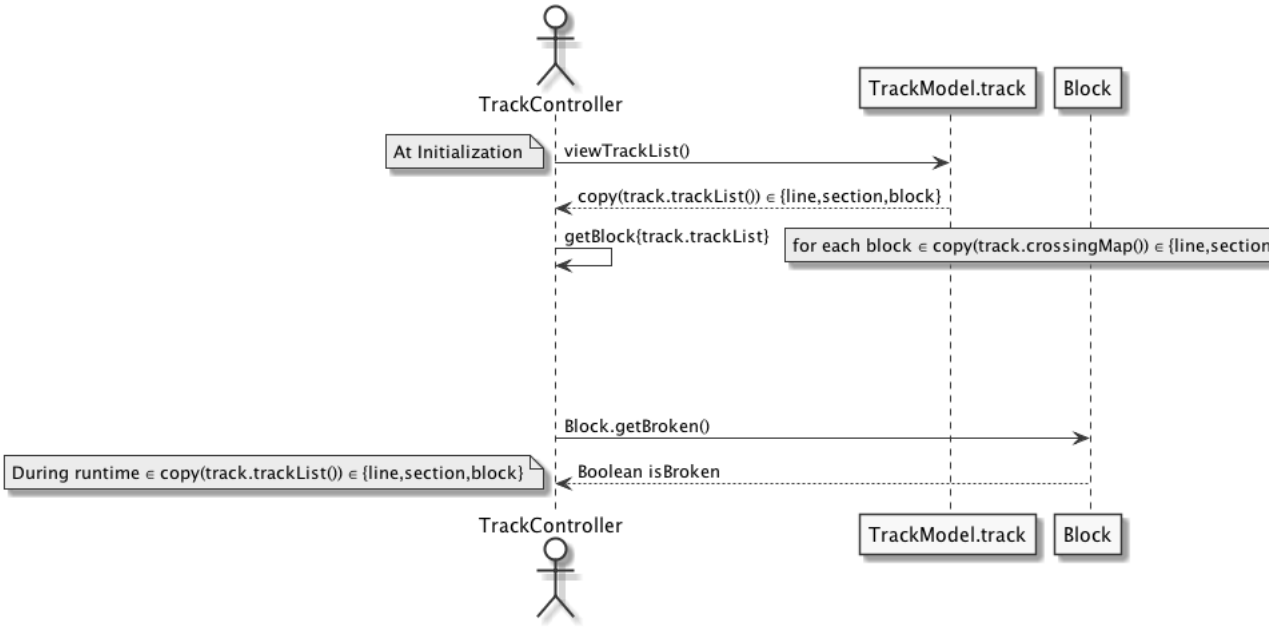

Figure 14: Detect Broken Rail Use Case Diagram

Table 63: Detect broken rail

Actors	TrackController
Description	The track controller iterates over the track to identify any broken rails
Data	None
Stimulus	None
Response	None
Comments	The TrackController is responsible for identifying broken rails

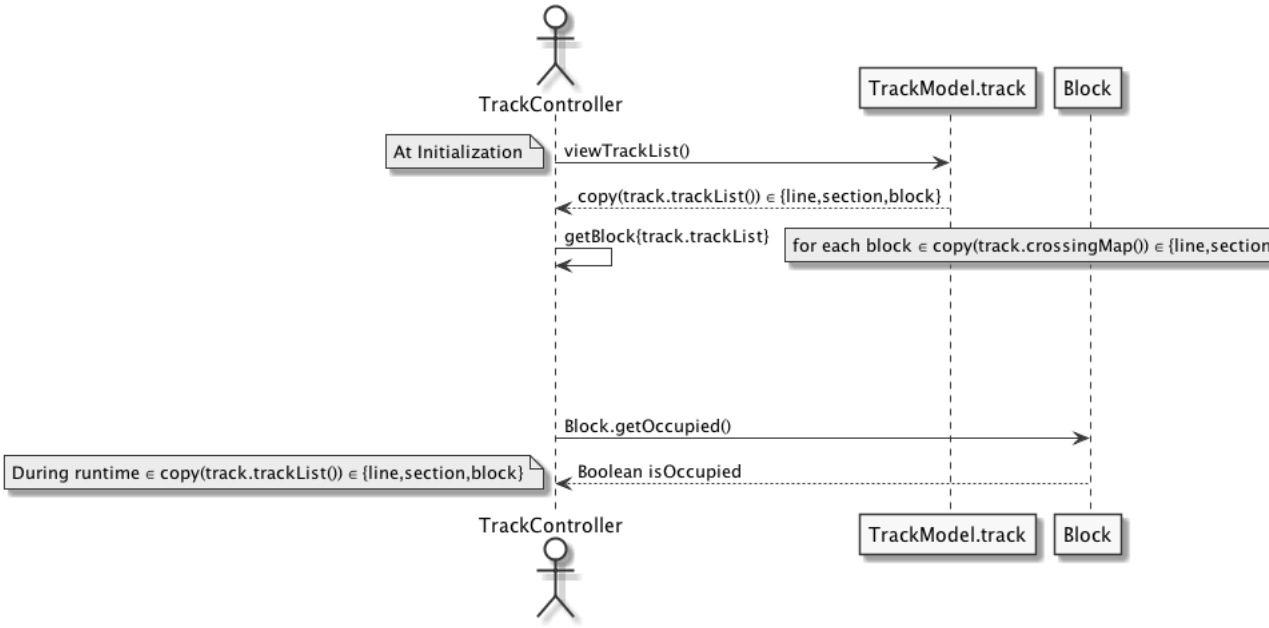

Figure 15: Detect Block Occupancy use Case Diagram

Table 64: Detect block occupancy

Actors	TrackController
Description	The track controller iterates over the track to identify any occupied blocks
Data	None
Stimulus	None
Response	None
Comments	The TrackController is responsible for detecting block occupancy

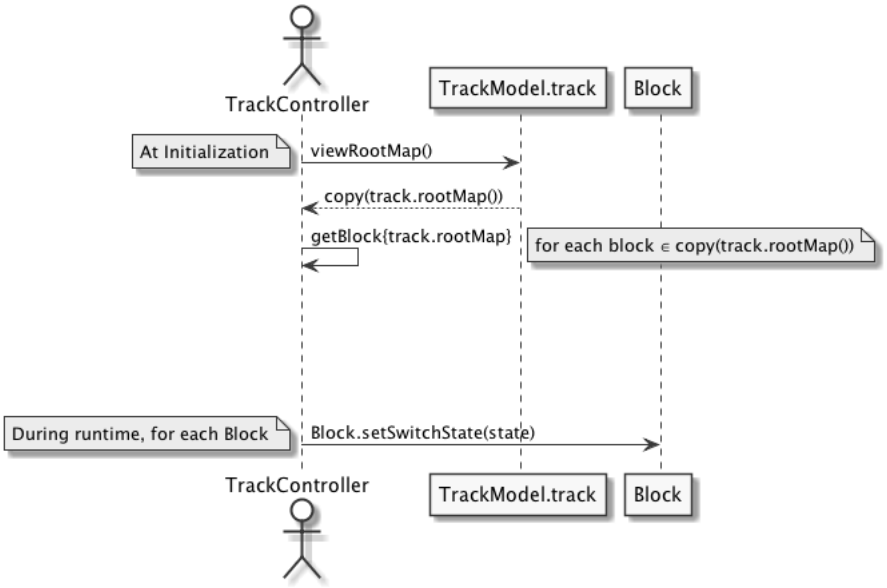

Figure 16: Toggle Switching Use Case Diagram

Table 65: Toggle switching use case description

Actors	TrackController
Description	The track controller switches track switches
Data	Boolean state of the switches of the track
Stimulus	The Track Controller calling the functions
Response	Switching to the desired state
Comments	The TrackController is expected to store the location of the switches at initialization

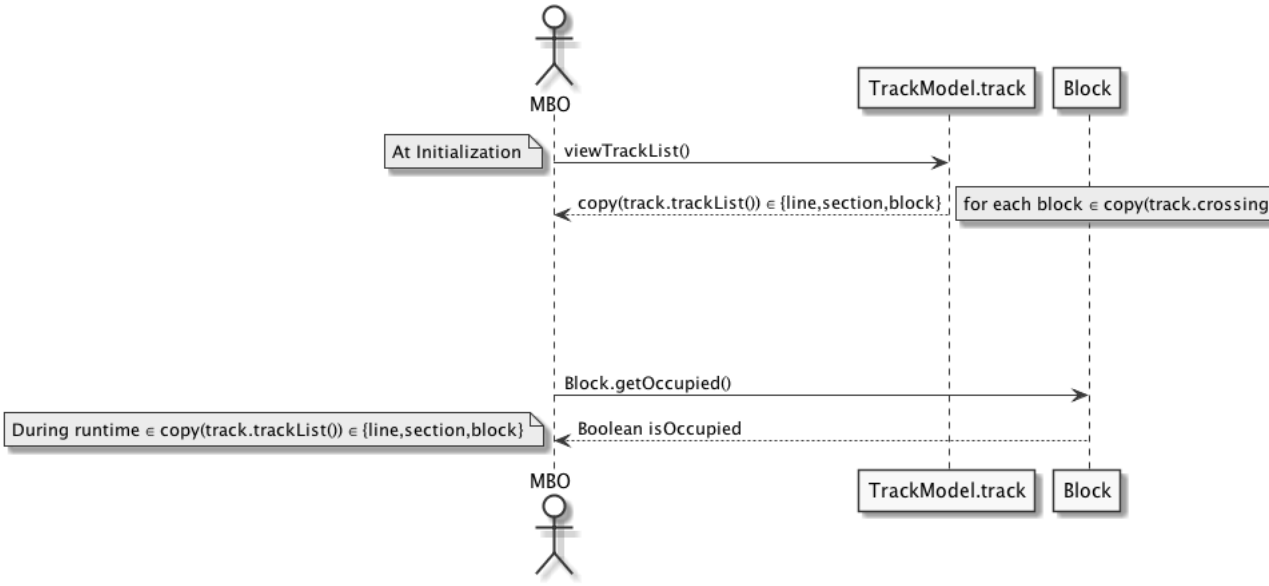

Figure 17: View Block Occupancy Use Case Diagram

Table 66: View Block occupancy

Actors	MBO
Description	The MBO views block occupancy when operating in MBO mode
Data	None
Stimulus	The MBO calling the track model
Response	Return the occupancy state of the blocks in the track
Comments	The MBO is expected to store the listing of blocks at initialization

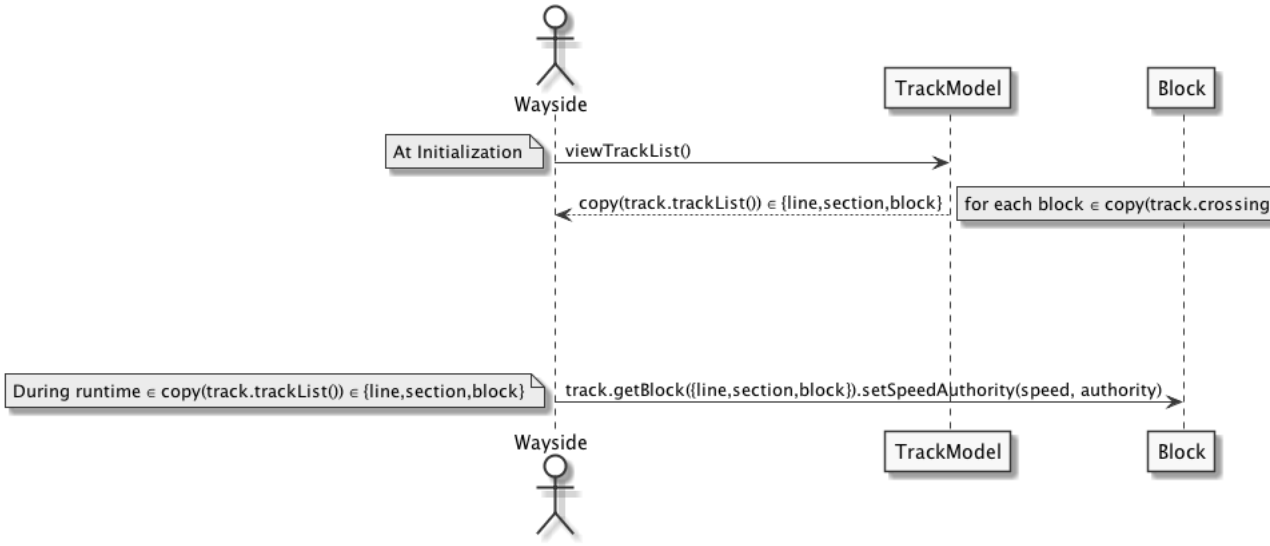

Figure 18: Set Speed and Authority use Case Diagram

Table 67: Set speed and authority description

Actors	TrackController
Description	The TrainController sets a given speed and authority at a block
Data	Double Speed, Block Authority
Stimulus	The TrainController calling the track model
Response	Updating the communicated values of speed and authority sent by a given block
Comments	The TrainController is expected to clear these values after use

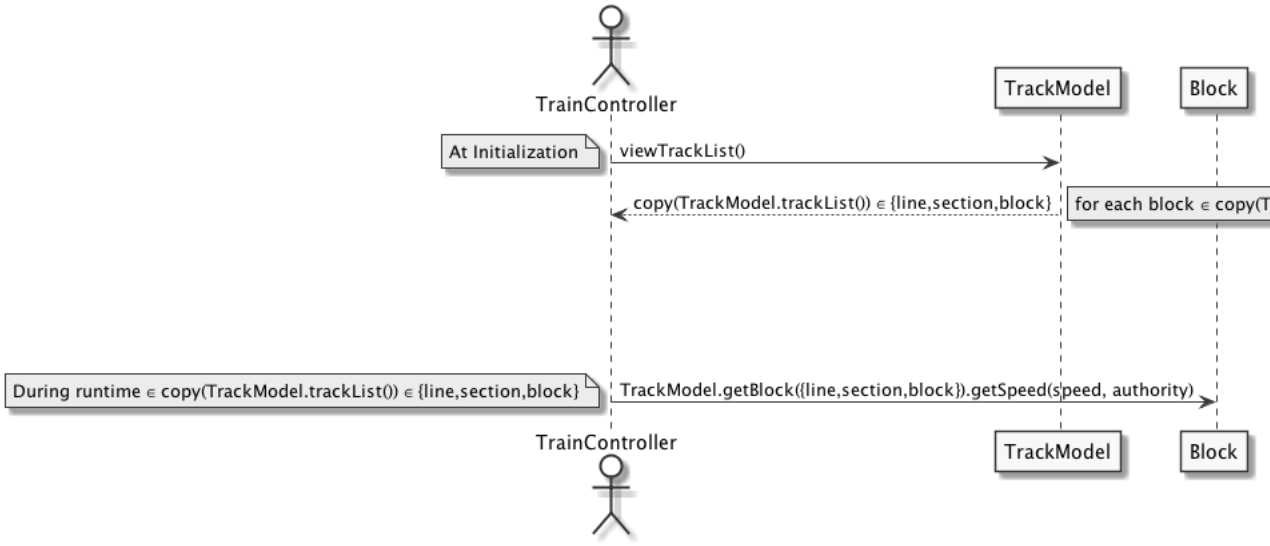

Figure 19: Get Speed Use Case Diagram

Table 68: View speed

Actors	TrainController
Description	The TrainController views block speed message
Data	None
Stimulus	The TrainController calling the track model
Response	Return the speed set at the block on the track
Comments	This value is set by the TrainController

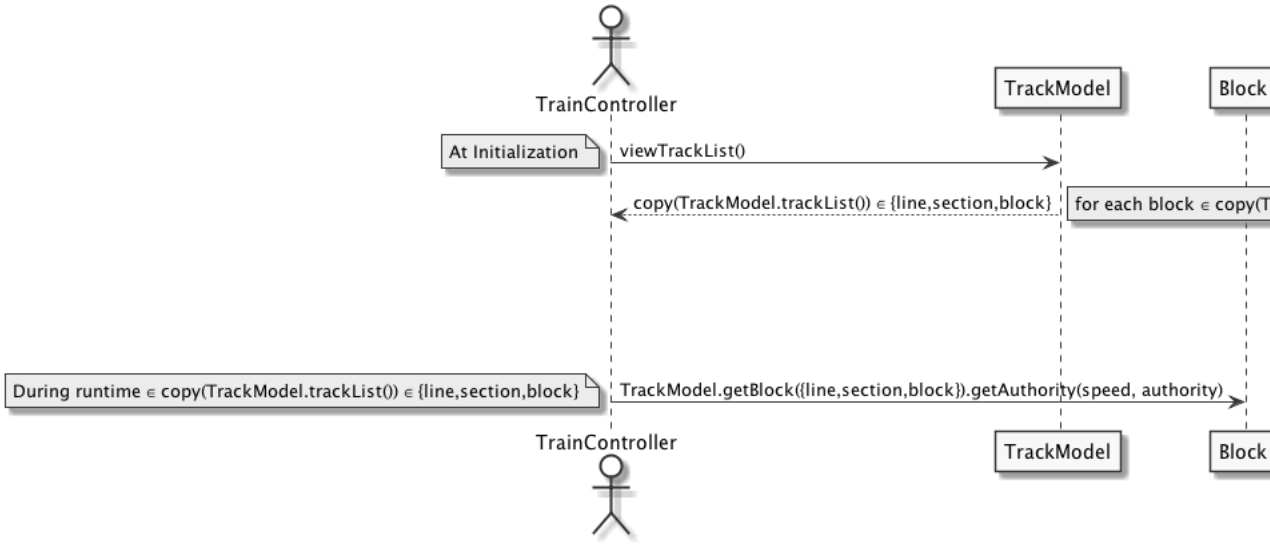

Figure 20: Get Authority Use Case Diagram

Table 69: View authority

Actors	TrainController
Description	The TrainController views block authority message
Data	None
Stimulus	The TrainController calling the track model
Response	Return the authority set at the block on the track
Comments	This value is set by the TrainController

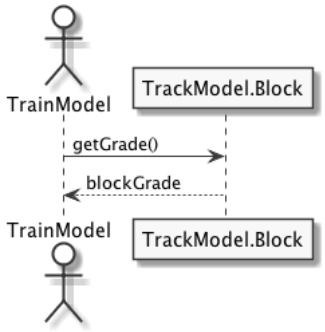

Figure 21: Get Grade Use Case Diagram

Table 70: View block grade

Actors	TrainModel
Description	The TrainModel views block grade attribute
Data	None
Stimulus	The TrainModel calling the track model
Response	Return the grade read in at the block on the track
Comments	This value is set at initialization

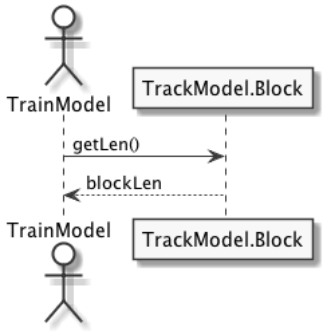

Figure 22: Get Length Use Case Diagram

Table 71: View block length

Actors	TrainModel
Description	The TrainModel views block length attribute
Data	None
Stimulus	The TrainModel calling the track model
Response	Return the length read in at the block on the track
Comments	This value is set at initialization

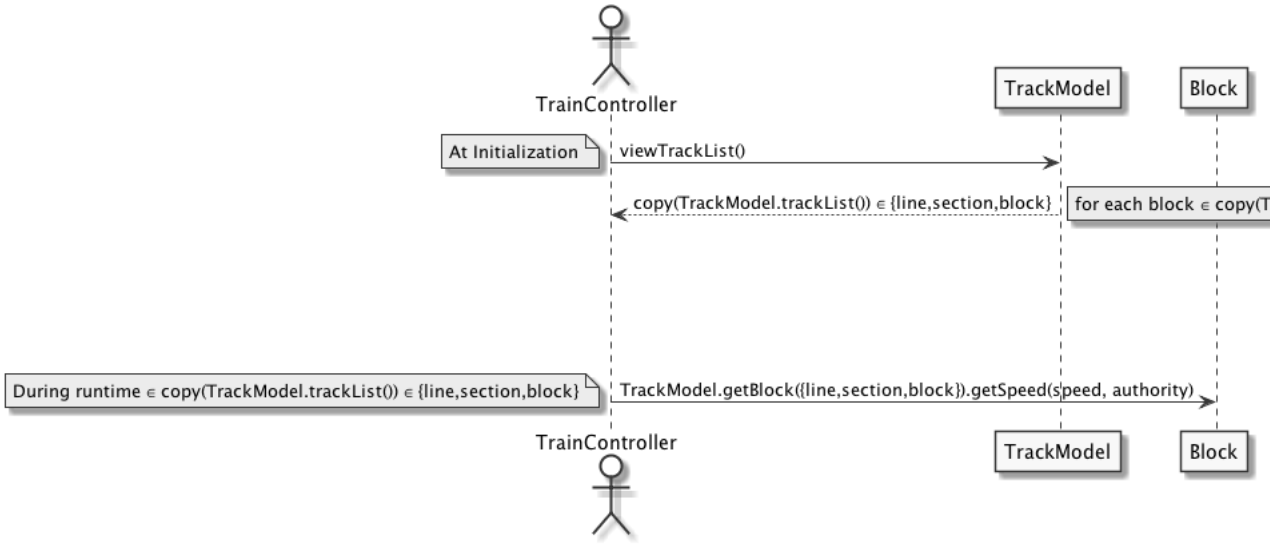

Figure 23: Get Speed Use Case Diagram

Table 72: View block maximum speed

Actors	TrainController
Description	The TrainModel views block speed maximum setting read in at initialization
Data	None
Stimulus	The TrainModel calling the track model
Response	Return the max block speed read in at the block on the track
Comments	This value is set at initialization

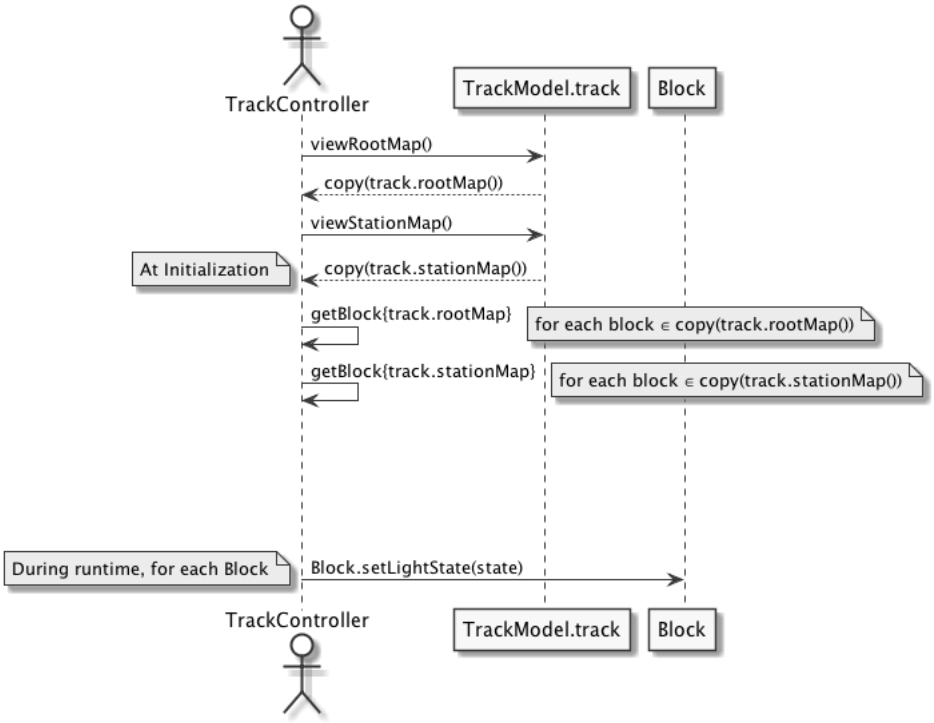

Figure 24: Toggle Lights Use Case Diagram

Table 73: Toggle block lights

Actors	TrackController
Description	The TrackModel toggles lights at any block that has them
Data	None
Stimulus	The TrackController calling the track model
Response	Sets the lights to the boolean state passed by the TrackController (green=1,red=0)
Comments	The TrackModel stores lights at each root of a switch and before and after a station

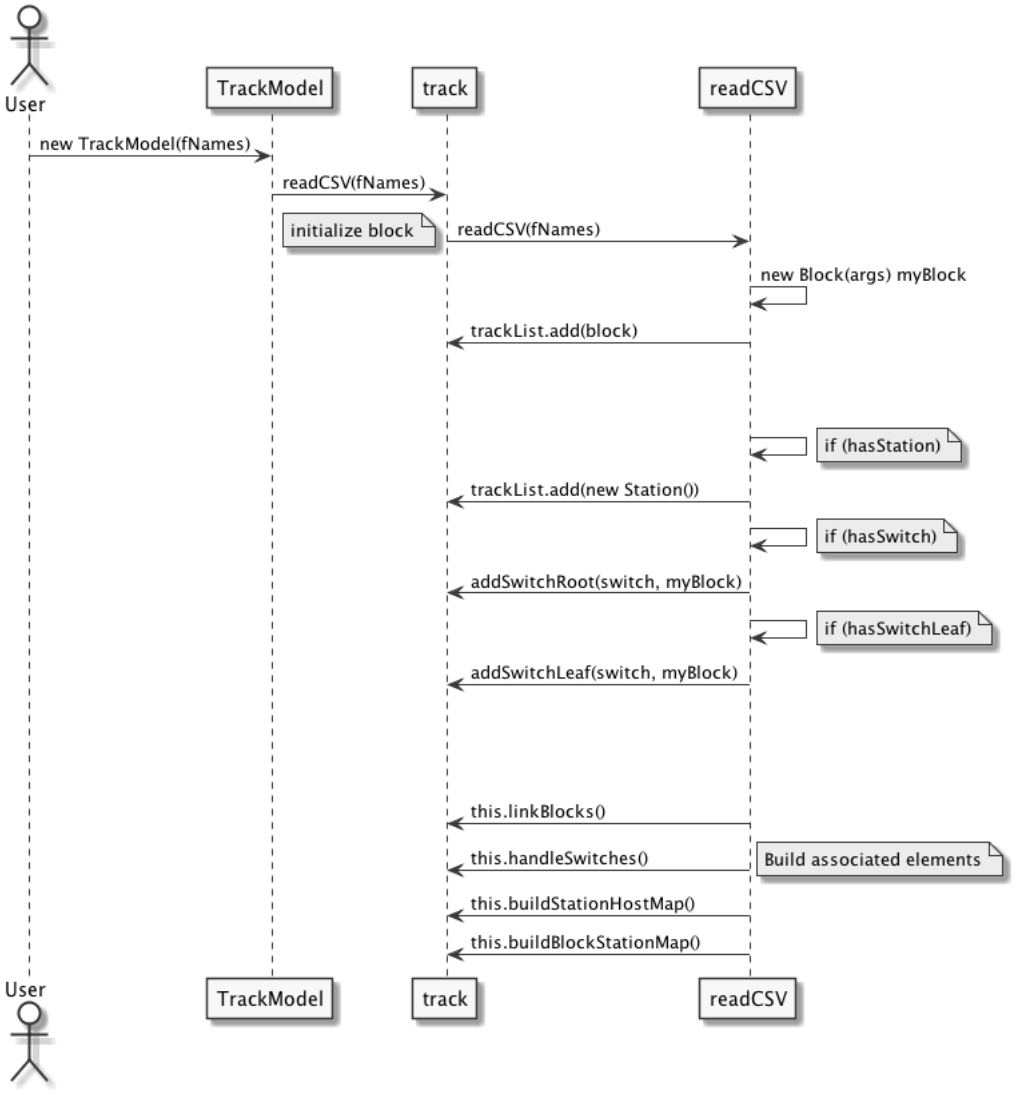

Figure 25: Read File Use Case Diagram

Table 74: Read file

Actors	User (train company)
Description	The TrackModel CSV files to be read in
Data	CSV files for each file to be read in
Stimulus	The user starting the proram
Response	The program will be run on those TrackModel
Comments	The CSV functions are produced by Microsoft Excel :: Save As...::*.csv

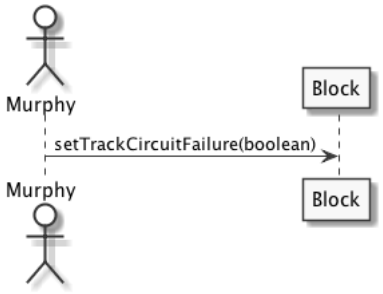

Figure 26: TrackCircuitFailure Test Case

Table 75: Test Track Circuit Failure

Actors	Murphy
Description	The track circuit failure will no longer transmit after setting a failure state
Data	A boolean representing the failure states
Stimulus	A user seeking to test a track circuit failure
Response	A track circuit failure
Comments	This is concisdered a part of the testing and i snot a part of normal functionality

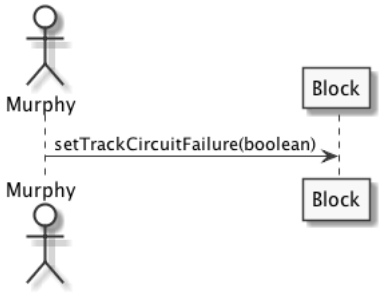

Figure 27: TrackCircuitFailure Test Case

Table 76: Test Track Broken Failure

Actors	Murphy
Description	The track block object broken state will be set for testing by this function
Data	A boolean representing the failure states
Stimulus	A user seeking to test a track block broken failure case
Response	A track circuit broken setting
Comments	This is concisdered a part of the testing and i snot a part of normal functionality

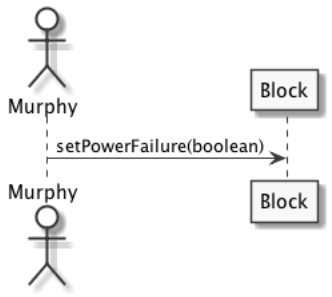

Figure 28: Track Power Failure Test Case

Table 77: Test Track Power Failure

Actors	Murphy
Description	The track block object power failure state will be set for testing by this function
Data	A boolean representing the failure states
Stimulus	A user seeking to test a track block power failure case
Response	A track power failure setting
Comments	This is concisdered a part of the testing and i snot a part of normal functionality

4.2 Track Controller

4.3 Train Model

In this seciton, we provide the sequence diagrams of the train model.

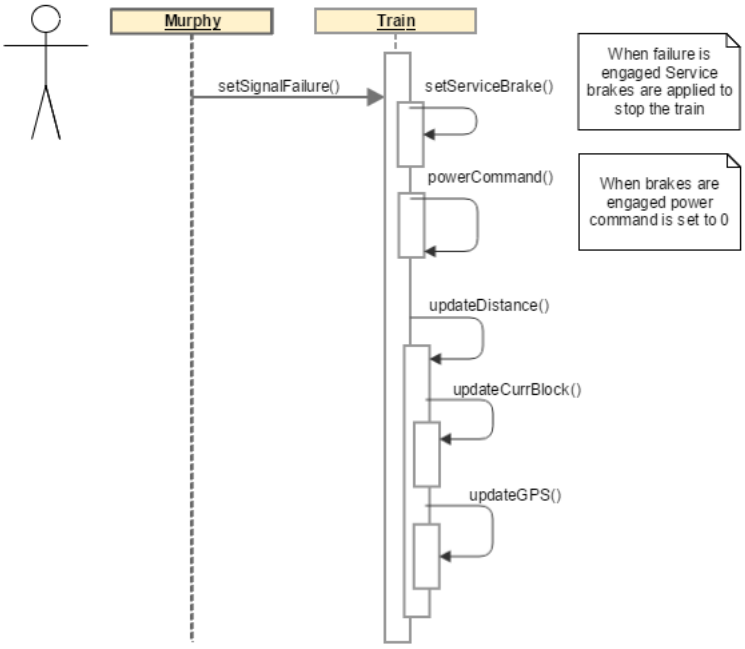

Figure 29: Toggle Signal Failure Use Case Diagram

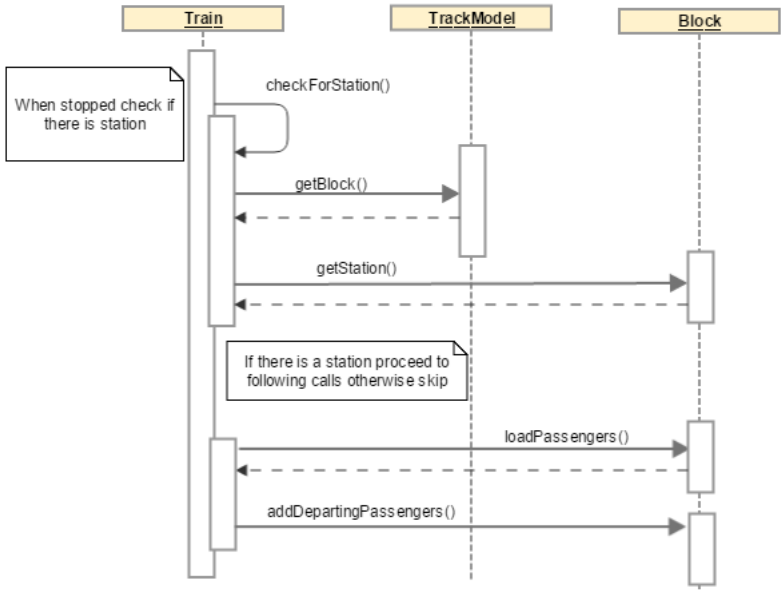

Figure 30: Add Passengers Use Case Diagram

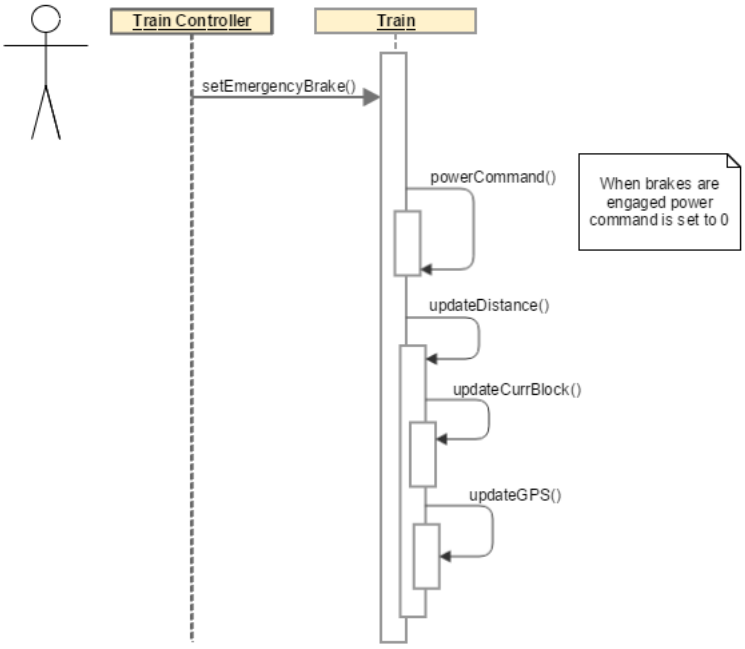

Figure 31: Engage Emergency Brake Use Case Diagram

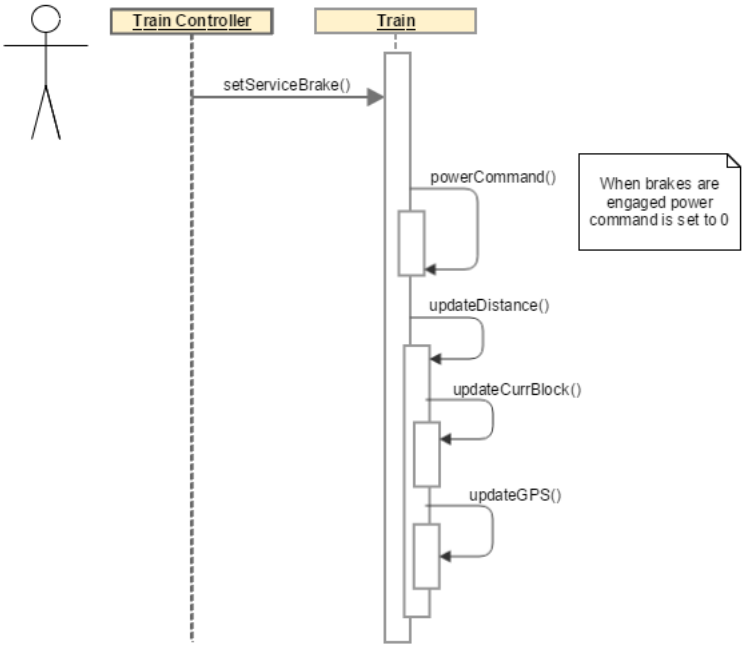

Figure 32: Engage Service Brake Use Case Diagram

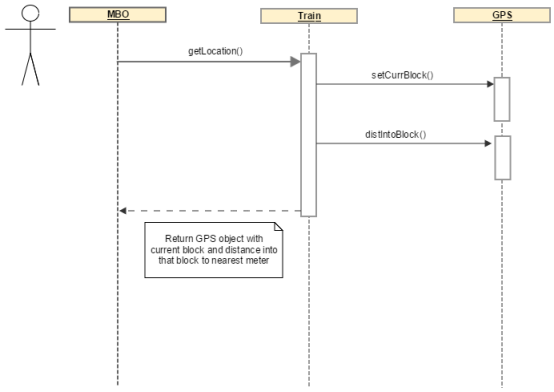

Figure 33: Get Location Use Case Diagram

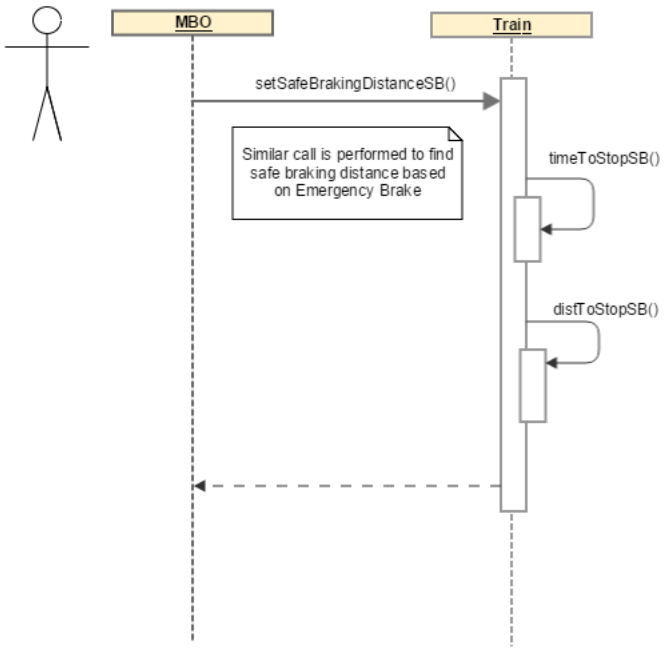

Figure 34: Calculate Safe Braking Distance Use Case Diagram

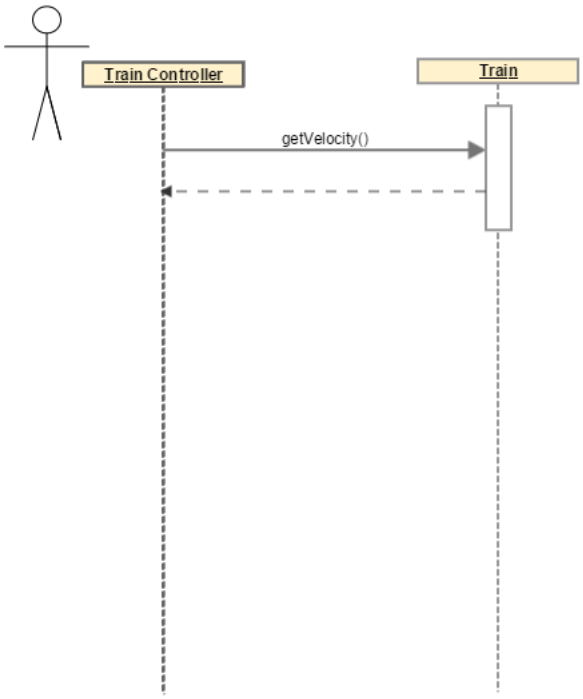

Figure 35: Get Velocity Use Case Diagram

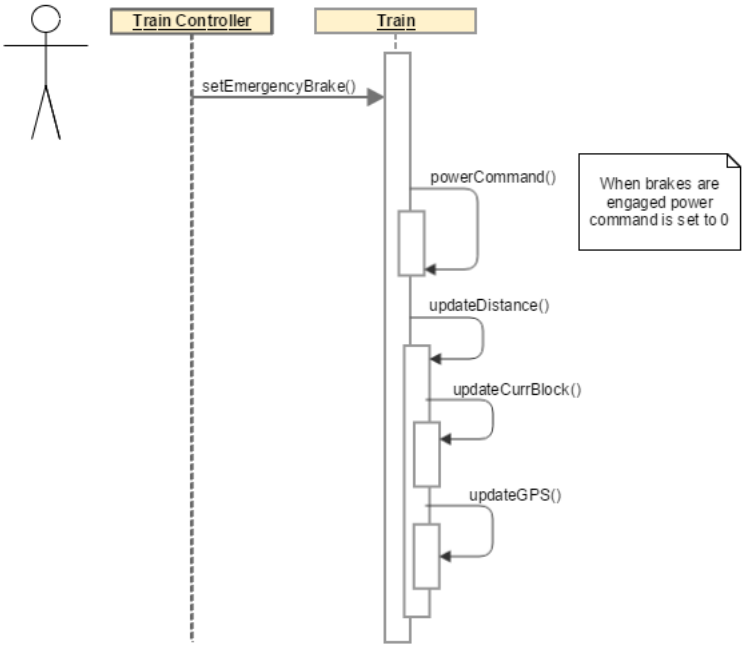

Figure 36: Increase Temperature Use Case Diagram

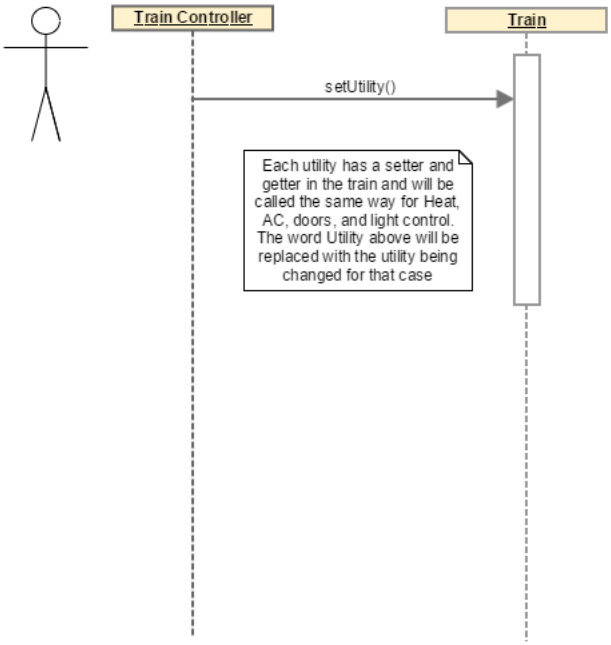

Figure 37: Modify Utilities Use Case Diagram

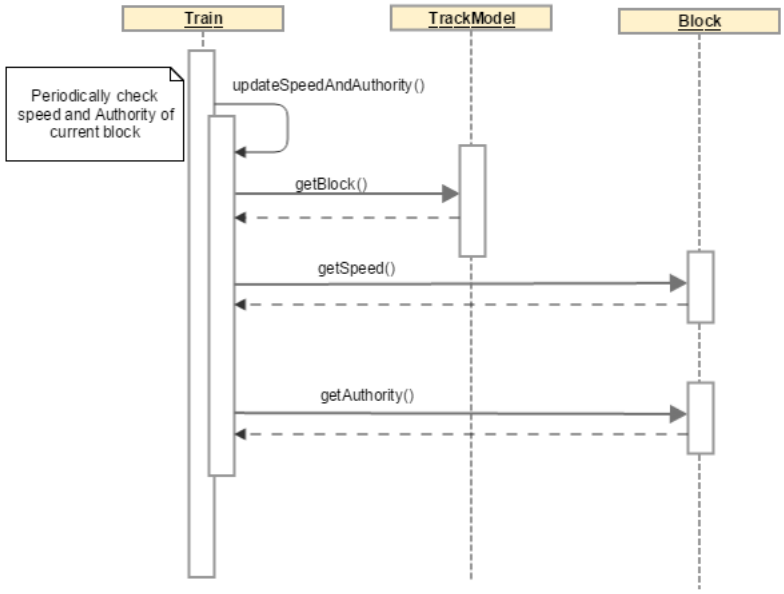

Figure 38: Set Speed and Authority Use Case Diagram

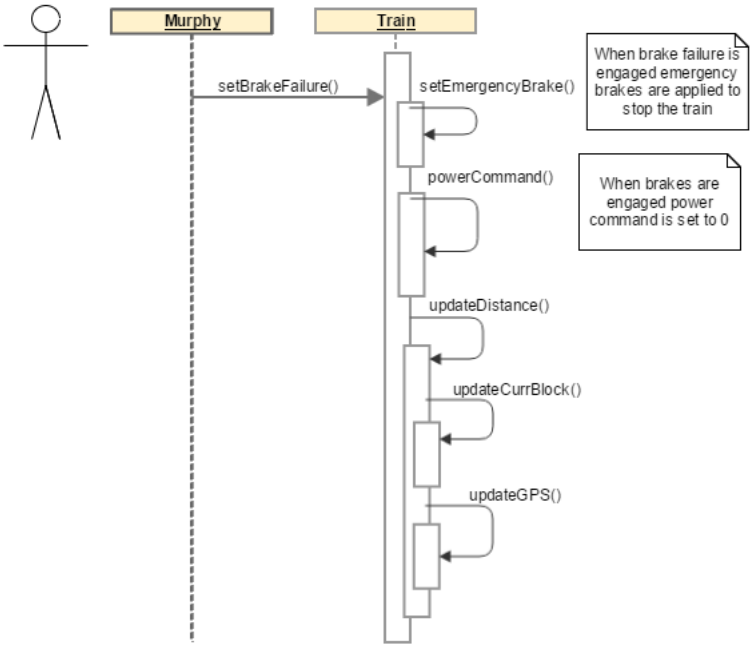

Figure 39: Toggle Brake Failure Use Case Diagram

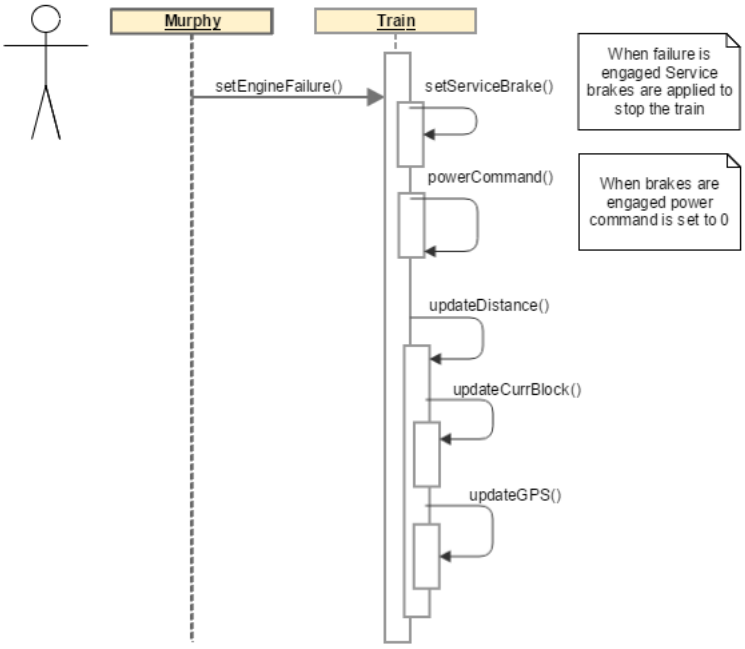

Figure 40: Toggle Engine Failure Use Case Diagram

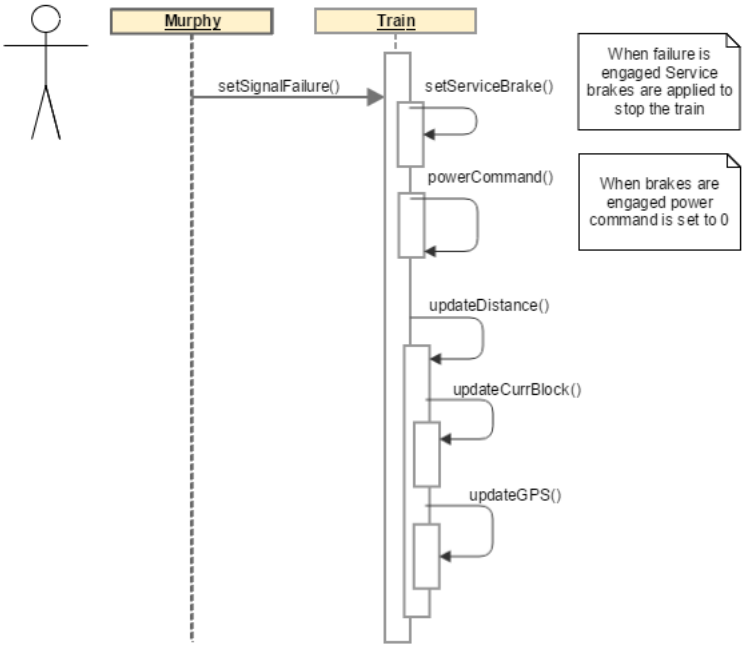

Figure 41: Toggle Signal Failure Use Case Diagram

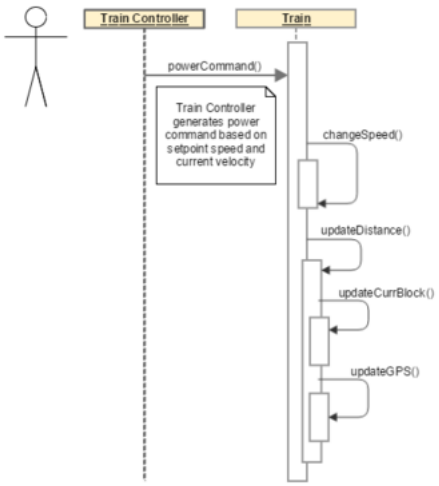

Figure 42: Toggle Signal Failure Use Case Diagram

4.4 Train Controller

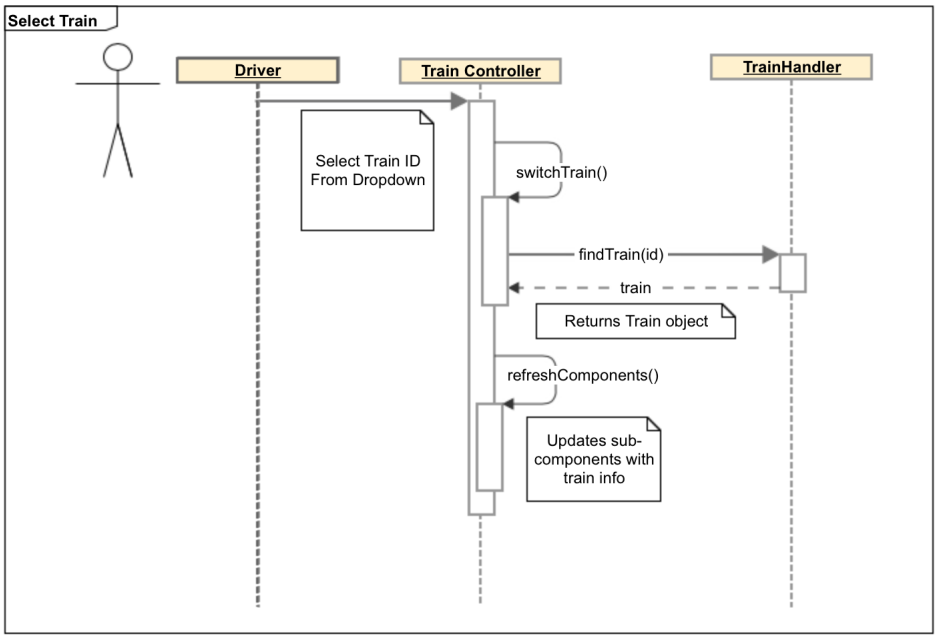

Figure 43: Select Train Use Case

Table 78: Select Train

Actors	Driver, TrainHandler
Description	The user picks a train from the list of dispatched trains to via the Train Controller. The user clicks the 'Switch'. The ID in the dropdown is sent to the TrainHandler and returns the train with the corresponding ID. The Train Controller then refreshes its components.
Data	Train ID
Stimulus	A train was selected from the drop down and the 'Switch' button was pressed by the user.
Response	Switches the train that the Train Controller is controlling and updates the sub-components of with the train information.
Comments	

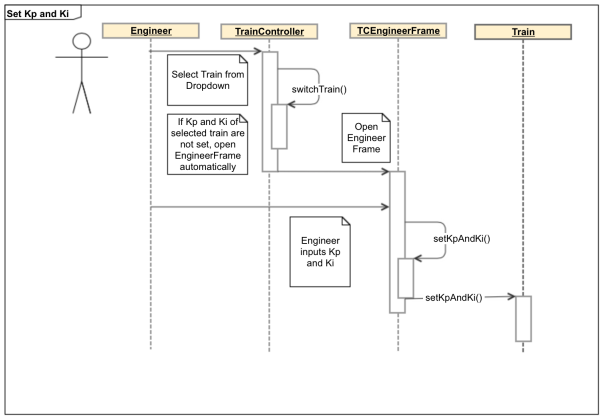

Figure 44: Set K_p and K_i Use Case

Table 79: Set K_p and K_i

Actors	Engineer, Train, TCEngineerFrame
Description	The user selects a for the Train Controller to control and switches to that train. If the selected train has no K_p and K_i set, the Engineer Frame opens. The Engineer can then set the K_p and K_i. The user can also change the Kp and Ki by clicking the 'Set Kp/Ki' button. The train then has its K_p and K_i set.
Data	The selected train
Stimulus	Happens when the user clicks the 'Set K_p/K_i' button or the user selects a train that has no K_p and K_i set.
Response	Sets the K_p and K_i of the selected train.
Comments	

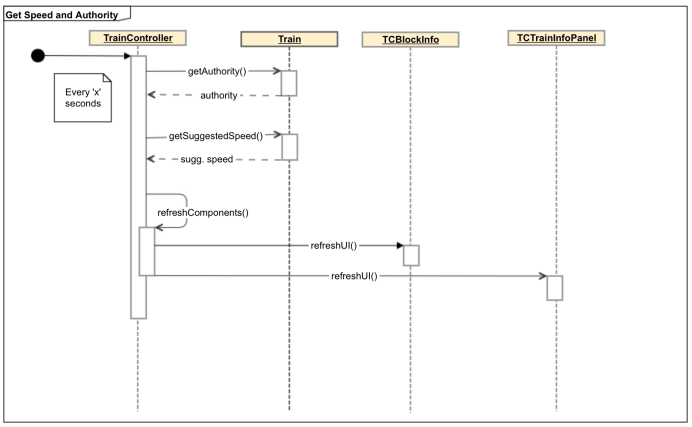

Figure 45: Get Suggested Speed and Authority Use Case

Table 80: Get Suggested Speed and Authority

Actors	Train, TCBlockInfo, TCTrainInfoPanel
Description	The Train Controller gets the suggested speed and authority from the selected train during every clock tick. The Train Controller then refreshes its components.
Data	The selected train
Stimulus	This happens every clock tick.
Response	The suggested speed and authority of the selected train is obtained and used to update the Train Info Pane and the Block Info Pane.
Comments	

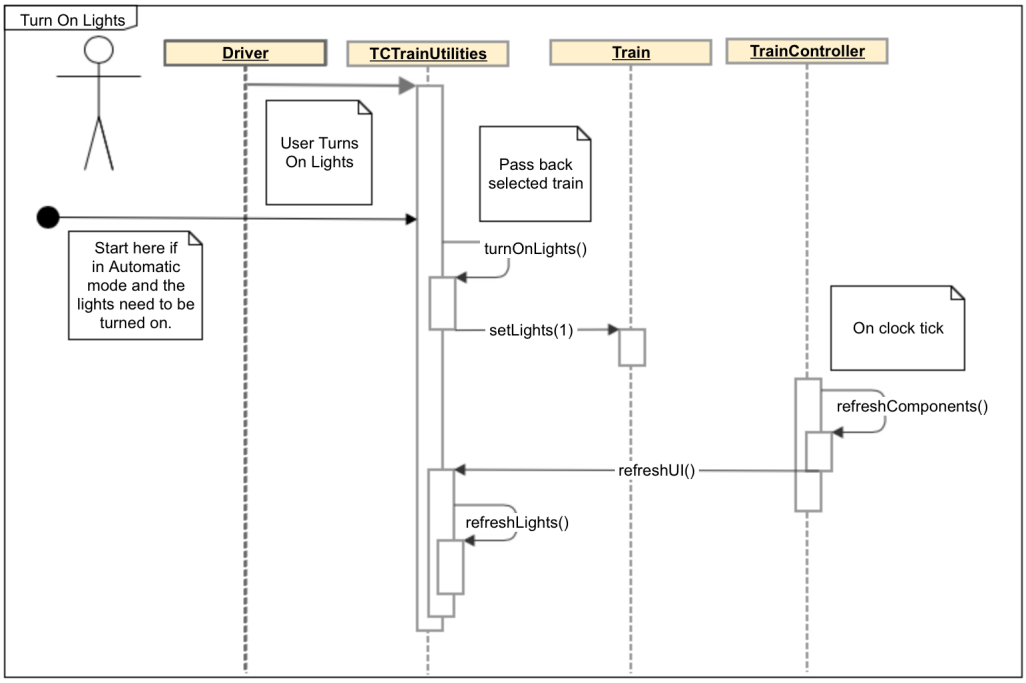

Figure 46: Turn On Lights Use Case

Table 81: Turn on Lights

Actors	Driver, Train, TCUtilities, TrainController
Description	The user turns on the lights by choosing the 'ON' radio button from the Utilities Panel or the system detects that the lights need to be turned on. This will tell the selected train to turn on its lights. On the next clock tick, the UI elements of the Utility Panel will be updated.
Data	The selected train
Stimulus	The user chooses the 'ON' radio button or the system detects that the lights must be turned on.
Response	The selected train turns on its lights.
Comments	

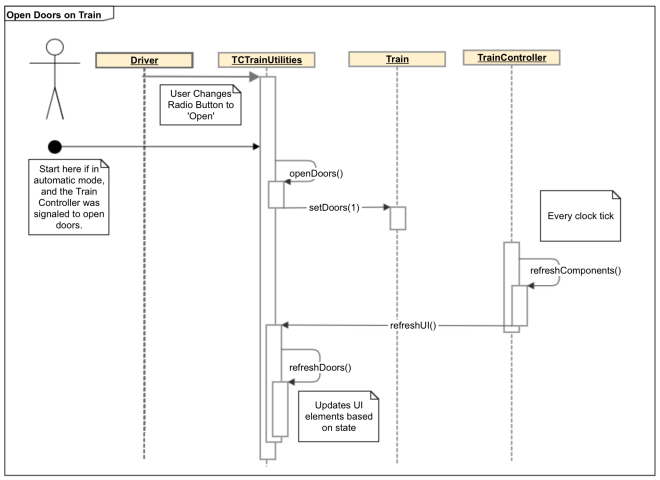

Figure 47: Open Doors Use Case

Table 82: Open Doors

Actors	Driver, Train, TCUtilities, TrainController
Description	The user changes the radio button of the specified doors by selecting the 'Open' radio button. This tells the selected train to open its doors. On the next clock tick, the UI is updated to reflect the state of the doors. If the system is in Automatic mode, and detects that the train must open its door (stopped at a station, etc..), this process is repeated without the user interaction.
Data	The selected train
Stimulus	This happens when the user chooses the 'Open' radio button or the system needs to open the doors to let passengers in and out.
Response	The doors on the train are opened.
Comments	The doors can only be opened when the train is stopped. Assume that the train is stopped for the call diagram.

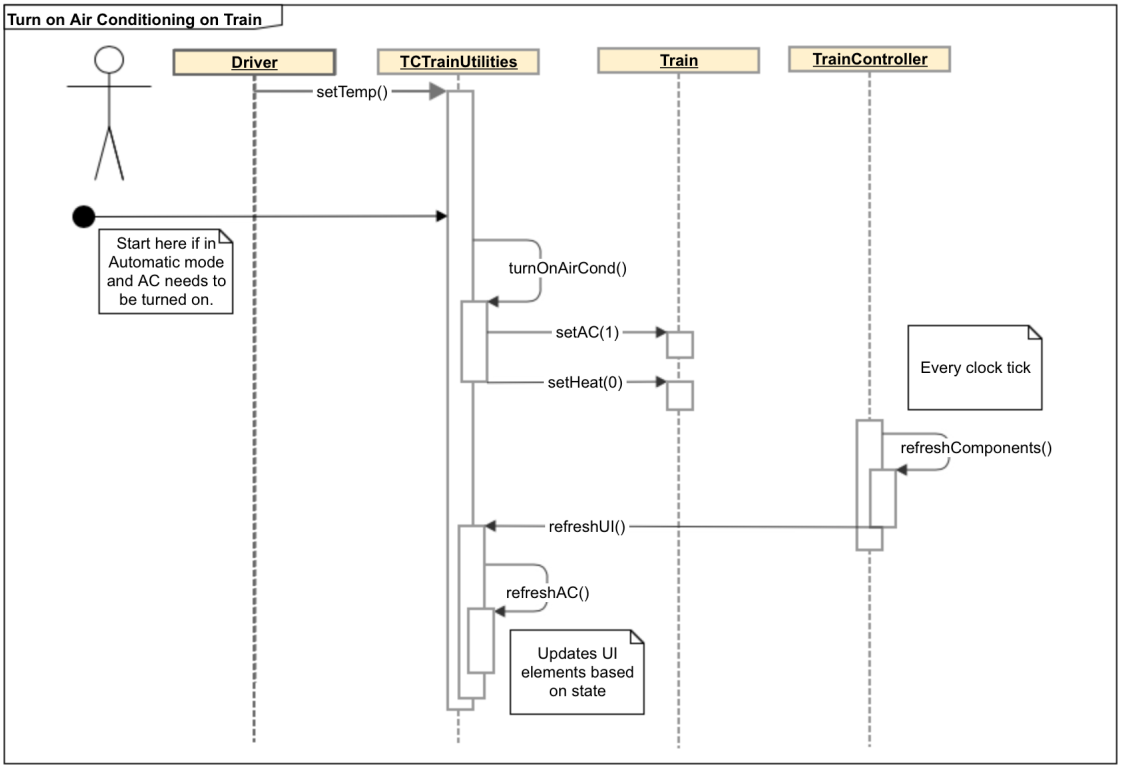

Figure 48: Turn On Air Conditioning Use Case

Table 83: Turn on Air Conditioning

Actors	Driver, Train, TCUtilities, TrainController
Description	The user changes the radio button of the AC to 'On'. This tells the train to turn on its AC unit, and to turn off the heat. On the next clock tick, the UI elements are updated to reflect the state of the AC. If the system in in Automatic mode, and detects that the temperature is too high, this process is repeated without the user interaction.
Data	The selected train
Stimulus	The user chooses the 'ON' radio button or the system detects that the temperature on the train is too high.
Response	Turns on the AC and tells the train to set its temperature to the desired temperature.
Comments	

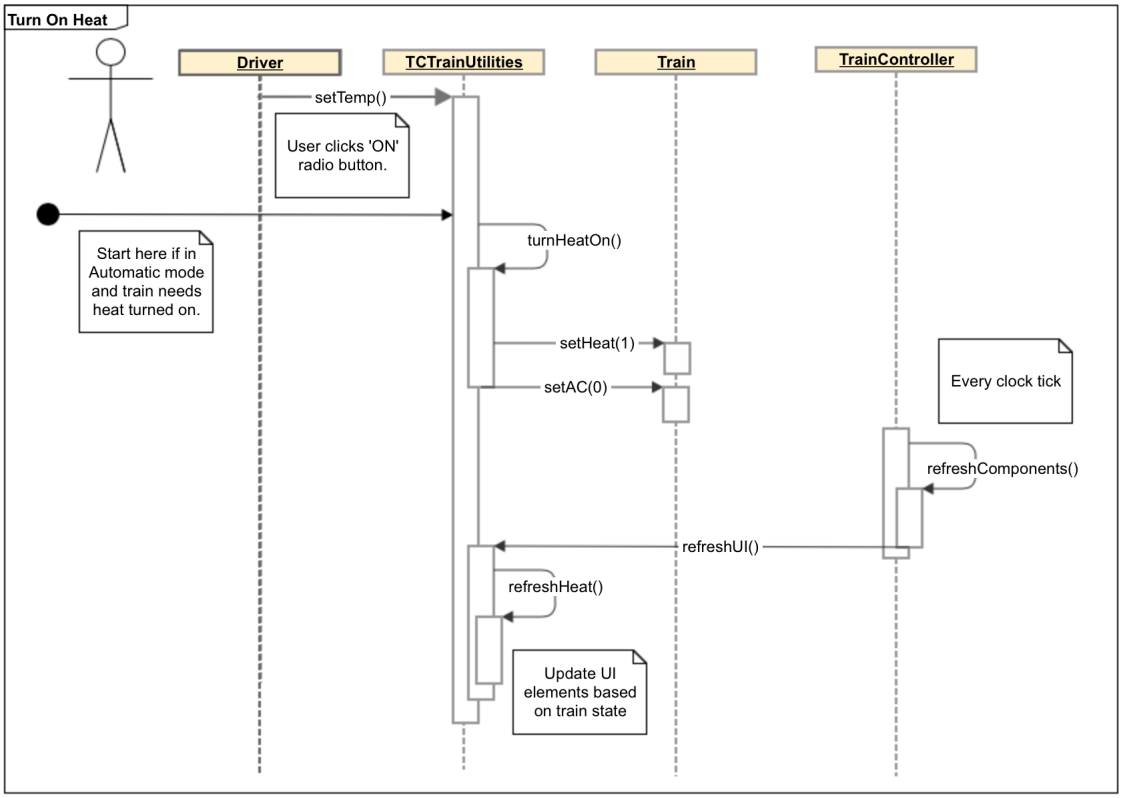

Figure 49: Turn On Heat Use Case

Table 84: Turn on Heat

Actors	Driver, Train, TCUtilities, TrainController
Description	The user changes the radio button of the heat to 'On'. This tells the train to turn on its heating unit, and to turn off the AC. On the next clock tick, the UI elements are updated to reflect the state of the heating unit. If the system in in Automatic mode, and detects that the temperature is too low, this process is repeated without the user interaction.
Data	The selected train
Stimulus	The user chooses the 'ON' radio button or the system detects that the temperature on the train is too low.
Response	Turns on the heat and tells the train to set its temperature to the desired temperature.
Comments	

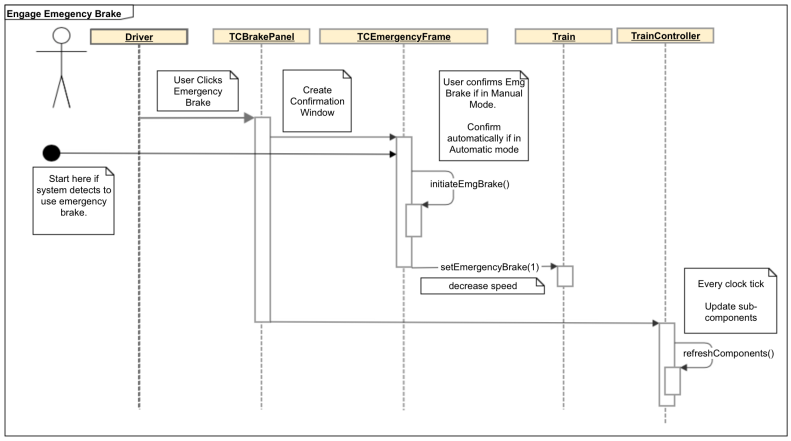

Figure 50: Engage Emergency Brake Use Case

Table 85: Engage Emergency Brake

Actors	Driver, Train, TCBrakePanel, TCEmergencyFrame, TrainController
Description	The user clicks the 'Emergency Brake' button in the Brake Panel. This opens a confirmation window. The user then must click 'Confirm' in order to use the emergency brake. This will tell the train to engage its emergency brake and slow down the train. During the next clock tick, the Train Controller will refresh its components to show the new speed. If the system is in automatic mode, and detects that the emergency brake must be engaged, the process is repeated without the user interaction.
Data	The selected train
Stimulus	The user presses the 'Emergency Brake' button.
Response	Slows down the train by the emergency brake's deceleration constant.
Comments	If in manual mode, the user must confirm using the Emergency brake. This is not the case when in Automatic mode.

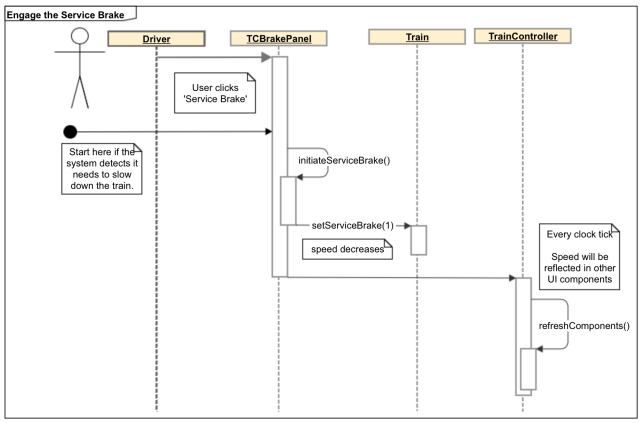

Figure 51: Engage Service Brake Use case

Table 86: Engage Service Brake

Actors	Driver, Train, TCBrakePanel, TrainController
Description	The user clicks the 'Service Brake' button in the Brake Panel. This will tell the selected train to engage its service brake, and slow down the train. On the next clock tick, the Train Controller will refresh its components and update them with the new speed. If the system detects that the train must slow down (during set speed), the process if repeated without user interaction.
Data	The selected train
Stimulus	The user presses the 'Service Brake' button or the system detects that it must slow down the train.
Response	Slows down the train by the service brake's deceleration constant.
Comments	

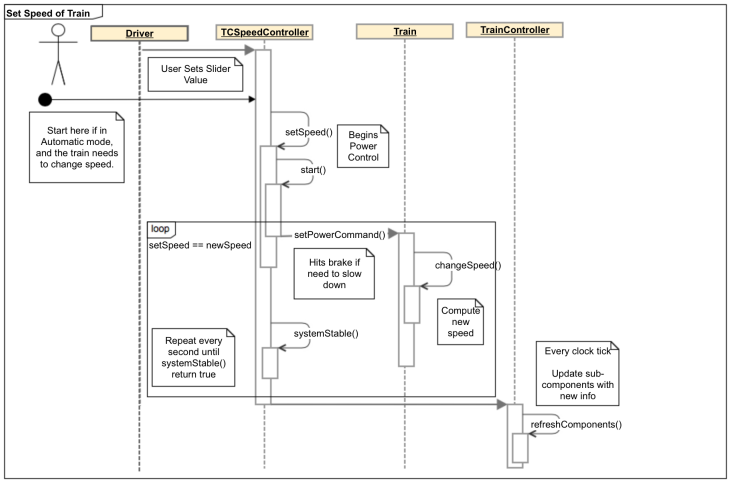

Figure 52: Toggle Signal Failure Use Case Diagram

Table 87: Set Speed

Actors	Driver, Train, TCSpeedController, TrainController
Description	The user sets the desired speed using the slider in the Speed Controller. This starts the power law timer. The Speed Controller sends the train a power command, and the train calculates a new speed. This process is repeated until the speed of the train is equal to the desired speed. During every clock tick, the Train Controller refreshes its components updates its sub-components with the new speed. If the system is in Automatic mode, and detects that the train's speed needs to be changed, the process is repeated without the user interaction.
Data	The selected train, set speed(desired speed)
Stimulus	The user presses the 'Set Speed' button or the Train Controller detects that the train needs to speed up or slow down.
Response	The selected train changes its speed to the set speed.
Comments	The desired speed cannot be set higher than the allowed speed. This is safeguarded by the Speed Controller.

4.5 Moving Block Overlay

4.6 Centralized Train Controller