Part 1: Scenarios

1: Laying a single track consisting of straight and curved sections from Point A to Point B.

     A track beginning with straight segment starting from Point A that is connected to a curvy section that ends at Point B.

2: Moving a stationary engine from Point A to Point B (as defined above), coming to a stop at B.

     The stationary engine at Point A starts moves due to fuel. It moves along the path described by Point A and Point B. Fuel is reduced and removed before reaching Point B. It stops at Point B.

3: Directing a moving engine from Track A onto sidetrack B, coming to a stop at B.

     The train is moving staring from Track A. A track switch toggles to switch the direction from track A to track B. Train is directed from Track A to sidetrack B. Train reduces and removes fuel before reaching Point B. It stops at Point B.

4: Signaling a stationary engine the possible paths to take (A,B,C) with Positive Train Control

     The train is notified on it's use dashboard that three paths (A,B,C) are available for the train to move in as they are labeled green. Train conductor then chooses a path.

5: Flipping a train with Roundhouse

Part 2: User Stories

1.1: Extending existing track, along a canyon.

As a railroad track planner, I want to extend a train track along a canyon with curvy profile.

2.1: Start and end a trains planned journey

As a train operator, I want to get the train to start moving from Point A and stop at Point B.

3.1: Stopping the train on a sidetrack

As a train operator, I want to move the train onto a sidetrack and come to a stop.

4.1: Signaling a train where to drive

As a PTC operator, I want to convey information to a train regarding the routes its' allowed to take.

5.1: Rotating a train for it to move in the opposite direction

As a roundhouse operator, I want to flip a train from it's head to it's tail for it to travel in the opposite direction.

Part 3: Questions

1.1.1: Where does the curve start?

Beginning of curve will influence the rest of the track.

1.1.2: How flat is the straight section?

Incline of track will influence speed, and will influence speed at curvy section

2.1.1: How is the train stopped?

Important to deal with the heat caused by braking

2.1.2: How does the operator know when to stop?

Important to time it right to not waste time or cause excessive wear

3.1.1: What causes the train to switch tracks?

Main requirement to facilitate switching of tracks

3.1.2: What triggers the switching?

Important to know what causes the switching

4.1.1: How does the PTC operator know what tracks are free?

Important to get right to prevent crashes

4.1.2: What is the default behavior if no signal is present?
Make sure no unwanted behavior is present when signal is lost.

5.1.1: How does the train know where to stop?
Prevent train from possibly falling off the end of track
5.1.2: How does the roundhouse know when the train is flipped heads to tail?
Prevent excessive spinning

Part 4: Requirements
1.1.1.1: No track discontinuity between Point A and Point B
Impossible to transition from straight section to curved section otherwise
1.1.1.2: Point A and B are not the same points
Could create a "circular" track.
1.1.2.1: Straight section ends at start of canyon
Traversing the canyon is most efficient with curves around
1.1.2.2: Curvy section is not too tight
Due to physical size restriction of the train

2.1.1.1: Braking system is present on the train
This is the system that facilities braking on the train.
2.1.1.2: Position of Point B is known
To know when/where the train needs to be stationary.
2.1.2.1: Train operator is when braking point is approached
To make sure the train is slowed down in time
2.1.2.2: Warning system
Alert the train operator and track system in dangerous situation

3.1.1.1: Switch is implemented on the track
Device that facilitates switching of tracks
3.1.1.2: Switch responds to user input without bias
It should respond the same every time
3.1.2.1: User control implemented
Manual user control of switch
3.1.2.2: Cutoff implemented
Prevent switching while train is on switch

4.1.1.1: Real time track information is present
Most up-to-date information about the track is required to make the best decision
4.1.1.2: Data missing alert
Obvious indication if track or train stops reporting data.
4.1.2.1: Reliable and consistent fall back behavior is implemented
Catch all edge cases that could pose an issue to the system
4.1.2.2: Warning system
Alert track and train operator that communication is missing

5.1.1.1: Train signaling system implemented
Signal train to tell them to start moving or stop
5.1.1.2: Braking system implemented

Stop rotating assembly from continuing to rotate, or slow the rotation.
5.1.2.1: Queuing system implemented
To facilitate queue system to allow trains to wait for roundhouse
5.1.2.2: Maximum spin per train
Prevent extra rotations for each train that is gets on the platform

Part 5: Specification
1.1.1.1.1: Track shall be combined with gradual increase in curve-ness
This allows for the physical train to curve.
1.1.1.1.2: Track shall be joined on the same plane in all axis
Forces alignment between tracks.
1.1.1.2.1: Point A and Point B do not share the same coordinate
Creates a circular track with no real start or end.
1.1.1.2.2: There does not exist a current shorter path from Point A to Point B
Prevents duplication
1.1.2.1.1: Start curvy section at beginning of canyon
Most efficient way around a canyon.
1.1.2.1.2: Track is not above highest plane of canyon
If track is built higher than canyon, this is redundant
1.1.2.2.1: Curveness is not too high
Due to physical build of train, a curve that is too tight can be physically impossible
1.1.2.2.2: Curve follows curve of canyon
Makes the most sense

2.1.1.1.1: Braking system shall respond to user input
Allow user to manipulate braking sytem
2.1.1.1.2: Braking system shall not react independently
Prevent potential unwanted inputs
2.1.1.2.1: Position B shall be relayed to train operator ahead of time
Allow adequate time for proper response by train operator
2.1.1.2.2: Position B may change, but train operator will be notified.
Train may be required to change it's destination at a moments notice, but the train operator has to be aware of this.
2.1.2.1.1: Braking point should be static for all tracks
Tracks have set speed, so time to brake to correct spot should be fairly consistent.
2.1.2.1.2: Braking point shall be notified even without connectivity
In absence of connectivity between train and track, train should still be notified of braking point.
2.1.2.2.1: Train operator shall be notified if braking point is missed
Train operator should be notified to take corrective action when braking point is missed to prevent crashes.
2.1.2.2.2: Track operator shall be notified if any train misses a braking point
Track operators should be notified to take action if any train misses its' breaking point and enters a zone too quickly

3.1.1.1.1: Switch shall be connected to at-least 3
Minimum requirement for switch to work logically
3.1.1.1.2: Switch tracks join parallel with tracks
Required for smooth transition and movement of the train

3.1.1.2.1: Switch will operate for any logical input
Does not discriminate against input, as long as it makes sense to the switch
3.1.1.2.2: Switch shall not influence output
It does what it does without modification
Whatever the input is given by the user, should be the outcome
3.1.2.1.1: Switch shall respond to input, even if it behavior is undesired
Switch shall respond logically to a logical input, even if the behavior is deemed undesired by the operator
3.1.2.1.2: User interface shall have clear labels and graphics that correspond to physical behavior
User interface should be intuitive and not require too much additional training (*very relative)
3.1.2.2.1: Switching shall be blocked when train is on the switch
Prevent switching that might cause train and/or track damage while train is physically on the switch.
3.1.2.2.2: User shall be notified if output is blocked
In situation where switch is unable to respond or cannot accept input (switching while train is on switch), user should be notified.

4.1.1.1.1: Information about the track and train shall be sent without any modifications
The track operator should receive information that is not tampered.
4.1.1.1.2: Information about the track shall be processed and displayed without any bias
The behavior of the system should be consistent and will not change randomly.
4.1.1.2.1: Track operator shall be notified when train stops communicating
The track operator should be notified in order to begin taking corrective actions.
4.1.1.2.2: Train shall continue operating without communication with track
Train should be still be able to continue operating with only the train operator's input.
4.1.2.1.1: Important values shall be "nil-ed" when communication is disconnected
This prevents train operator from making decisions based on old values that are unrepresentative of the current situation.
4.1.2.1.2: Important messages from the track will continuously broadcast until received by train
This enforces that the train receives any important message that might be missed when disconnected
4.1.2.2.1: Warning system shall notify but not take over controls
While it might be tempting to force a slowdown of the train when warning system is deployed, we predict that this is the best option everytime. Train operator should still have full control.
4.1.2.2.2: Warning system shall be triggered and disabled automatically
The train and track should trigger the system without any additional user input.

5.1.1.1.1: Default behavior shall be stop
This is the absolute safest choice. If all fails, stop all trains.
5.1.1.1.2: Only one train shall get the green light at one time
Prevent other trains from misinterpreting any signals or possible accidents.
5.1.1.2.1: Braking system shall start and continue operating when told, and stop when told
The braking system should respond to user input without any bias or filtering, even if output is considered undesired by user.
5.1.1.2.2: Braking system shall notify user of any faulty
To prevent any possible damages, sensors should be placed on any friction parts to make sure they are always in spec.
5.1.2.1.1: Queue system shall not be modified by train operators
Train operators should not have the authority to modify the queue of the roundhouse.
5.1.2.1.2: Queue system shall allow modifications by the roundhouse operator

Roundhouse operators might run into situations where they need to move a certain train before another. They should be allowed to do so.

5.1.2.2.1: Rotating platform should only rotate at most 180 degrees for each train
Since a roundhouse is only there to facilitate the "flipping" of a train, 180degrees is all it ever needs for any train.

5.1.2.2.2: Rotating platform should only have one train per rotation
Prevent excessive load and engineering required for the platform

Part 6: Verification
1.1.1.1.A.1: Is there a sharp edge where the tracks meet?
1.1.1.2.A.1: Are Point A and Point B at the same coordinates?
1.1.2.1.A.1: Does the start of the canyon correspond to the beginning of our curvy section?
1.1.2.2.A.1: Is the radius of the curve larger than the length of an individual cabin?

2.1.1.1.A.1: Are all the parts necessary to facilitate braking present on the train?
2.1.1.2.A.1: Do we have Position B?
2.1.2.1.A.1: Does the braking point indicator provide audible and visual signals work when triggered?
2.1.2.2.A.1: Does the alarm system provide audible and visual signals when triggered?

3.1.1.1.A.1: Is the switch connected to at least 3 "portions" of tracks?
3.1.1.2.A.1: Does the switch respond physically and consistently when input is given?
3.1.2.1.A.1: Does the user controls send logical and consistent outputs, for a particular input?
3.1.2.2.A.1: Can the switch be toggled when a train is physically on it?

4.1.1.1.A.1: Does the system show the most up to date information?
4.1.1.2.A.1: Does the alarm system provide audible and visual signals when data is missing?
4.1.2.1.A.1: Is there a consistent behavior when connection is disconnected?
4.1.2.2.A.1: Does the alarm system provide audible and visual signals when connection between track and train is missing?

5.1.1.1.A.1: Is there a system that notifies train drivers to start or stop moving?
5.1.1.2.A.1: Can the rotating assembly stop rotating when told to by user input?
5.1.2.1.A.1: Can multiple trains wait for the roundhouse and get flipped according to sequence?
5.1.2.2.A.1: Does the rotating assembly stop rotating after a certain point?

Part 7: Specification Verification
1.1.1.1.1.1: Is the beginning of the track curvier than the end?
1.1.1.1.2.1: Is the point where the track is being joined on the same x-y-z axis?
1.1.1.2.1.1: Do Point A and Point B share the same coordinates?
1.1.1.2.2.1: Can we get to Point A from Point B faster than we can with this new track on existing tracks?
1.1.2.1.1.1: Do the beginning of a canyon and the transition from straight to curvy track share the same coordinates?
1.1.2.1.2.1: Is the track higher than the higher point of the canyon?
1.1.2.2.1.1: Is the radius of the curve larger than the length of an individual cab on the train?
1.1.2.2.2.1: Does the curve of the track closely mimic the curves of the canyon?

2.1.1.1.1.1: Does the braking system respond logically and consistently when a particular input is given?

2.1.1.1.2.1: Does the braking system react on its own when no input is given?

2.1.1.2.1.1: Is Position B relayed to the train operator?

2.1.1.2.2.1: Does the system allow for a change in Position B's position? Is the driver notified of the changes?

2.1.2.1.1.1: Does the braking point change when it is not specifically changed by the track operator?

2.1.2.1.2.1: Is the breaking point shown when no connectivity is provided to the train?

2.1.2.2.1.1: Does the alarm system provide audible and visual signals to the train operator when a braking point is missed?

2.1.2.2.2.1: Does the alarm system provide audible and visual signals to the track operator when a braking point is missed?

3.1.1.1.1.1: Is the switch connected to at least 3 "segments" of tracks?

3.1.1.1.2.1: Are the tracks that are being joined parallel?

3.1.1.2.1.1: Does the switch discriminate against logical inputs?

3.1.1.2.2.1: Does the switch respond logically and predictably to specific user inputs?

3.1.2.1.1.1: If the user provides a valid (but undesired) input, does the switch respond in a valid (but undesired) way?

3.1.2.1.2.1: Does the user interface have graphical and language labels for each input?

3.1.2.2.1.1: Can the switch be operated with a train on it?

3.1.2.2.2.1: Is the user notified when the input cannot be sent to switch?

4.1.1.1.1.1: Is the information received the same information provided by the track and train?

4.1.1.1.2.1: Is the information shown the same as the information received?

4.1.1.2.1.1: Does the alarm system provide audible and visual signals when communication to train is lost?

4.1.1.2.2.1: Does the train continue functioning when communication to track is lost?

4.1.2.1.1.1: Are important values "nil-ed" when communication with track is lost?

4.1.2.1.2.1: Are messaged sent by the track while train is not communicating received when the train reconnects?

4.1.2.2.1.1: Can user still provide input when alarm system is active?

4.1.2.2.2.1: Does the alarm system get triggered and turned off automatically?

5.1.1.1.1.1: When on input is given, is the default behavior stop?

5.1.1.1.2.1: Are more than 1 trains allowed to get the green light at one time?

5.1.1.2.1.1: Does the braking system respond to user input logically and predictably?

5.1.1.2.2.1: Does the system notify the operator when a part has malfunctioned or is not up to spec?

5.1.2.1.1.1: Can train operators modify the train queue?

5.1.2.1.2.1: Can the roundhouse operator modify the train queue?

5.1.2.2.1.1: Can the rotating assembly rotate more than 180degrees per train?

5.1.2.2.2.1: Can more than one train enter the rotating assembly?