

CPRR No. 60

"Jupiter"

Operating Manual



Developed by Smokebox for Dovetail Game's *Train Simulator 2017*™



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Introduction

The model has been built, as far as possible, using the engineering drawings that were produced by the Californian firm O'Connor Engineering Laboratories of Costa Mesa, California, in the 1970s to build a working, life-size replica of the Central Pacific Railroad's 19th century steam locomotive no. 60 "Jupiter" for the Golden Spike National Historic Site, located in West Promontory, Utah, U.S.A., as part of the government-funded Promontory Locomotive Project. Those drawings were developed largely from micrometer measurements taken from 1869 photographs of the locomotive along with a locomotive design engineer's handbook from 1870.

In order to comply with modern safety requirements, the replica has some features that were not found on the original "Jupiter", such as air brakes, safety pop valves, water sight glasses, injectors, etc. This model for Train Simulator 2017™ instead represents "Jupiter" as of May 10th 1869 when she pulled Central Pacific's president, Leland Stanford's, special train to Promontory Summit, Utah Territory, for the Golden Spike Ceremony - it has no air brakes, no sight glasses (only the three try cocks), the safety valve is a spring-balance type with the spring valve located in the cab, behind the steam gauge, and there are no water injectors - the boiler is replenished by water pumps driven off the piston crossheads. This makes it possible to simulate the way that the locomotive would have been operated as built originally in 1868.

Locomotive Technical Specifications

Build date:	September 1868
Builder:	Schenectady Locomotive Works of New York, U.S.A.
First run:	March 20, 1869
Type:	"American"
Wheel configuration:	4-4-0 ("Eight-wheeler")
Operating company:	Central Pacific Rail Road Company of California (CPRR)
CPRR number and name:	60 "Jupiter"
Sister locomotives:	61 "Storm", 62 "Whirlwind", 63 "Leviathan"
Cylinders:	2 each of 16" cylinder bore and 24" piston stroke
Driving wheel diameter:	56.937" without tires, 61.937" with 2.5" thick tires

Boiler pressure:	120 psi ¹
Grate area:	14.5 sq.ft. - estimated
Weight on drivers:	18 U.S. tons (16.1 UK tons) - estimated
Heating surface:	800 sq.ft. - estimated
Weight of tender:	20 tons (17.9 UK tons) - estimated
Tender fuel:	2,000 gals of water, 2 cords of wood ²
Starting tractive effort:	9,523 lbf - estimated
Boiler horsepower:	290 bhp - estimated
Steaming rate:	10,000 lbs/hr - estimated
Maximum cut-off:	+/- 75% (12 forward notches; neutral notch; 6 reverse notches)

Positions of the Controls and Gauges in the Cab

The diagrams below show the positions of the cab controls (operated by dragging or clicking with the mouse) and gauges (or gages, if you prefer).

¹ The boiler on the Jupiter replica at the Golden Spike National Park Site operates at 160psi but the original operated at 120psi.

² Jupiter was converted to coal in 1893. The GSNPS replica was built originally as an oil-burner but has since been converted to burn wood.



- | | |
|--------------------------------|---------------------------------------|
| 1. Quilled Toot | 10. Sander |
| 2. Long Whistle | 11. Cylinder Cocks |
| 3. Short Toot | 12. Feedwater Pump Try Cock |
| 4. Safety Valve Spring Balance | 13. Reverser |
| 5. Steam Gauge | 14. Window |
| 6. Blower Steam Throttle | 15. Water Valve |
| 7. Feedwater Heater | 16. Rear Damper |
| 8. Feedwater Heater | 17. "Stoking Log" (Desired Fire Mass) |
| 9. Throttle | 18. Front Damper |



19. Bell

20. Window

21. Door

22. Window

23. Window

24. Door

25. Water Gauge Try Cock

26. Water Gauge Try Cock

27. Water Gauge Try Cock

28. Blowdown

29. Firebox Door

30. Blower

31. Feedwater Pump Try Cock

32. Handbrake

33. Water Valve

Key Assignments

Item	Key	Action	Remarks
Engineer's Controls			
Throttle	A	Increase	The throttle controls the rate at which the steam chest (not the cylinders directly) is filled with steam.
	D	Decrease	
Reverser	W	Forwards	The reverser controls the length of the valve cut-off, i.e. for how long steam is admitted to the cylinders on each piston stroke, as well as the direction of travel (although it is possible, in the right circumstances, to be travelling forwards with the reverser in reverse, and vice-versa).
	S	Reverse ("Hook up")	
Sander	X	Open	Use the sander to avoid wheelslip in wet or icy conditions.
	Shift X	Close	
Whistle	Spacebar	Blow	Tap quickly to produce a short toot.
	Spacebar Return	Quill	Tap for slightly longer to produce a longer toot. Hold for approximately one second to initiate a long whistle.
Bell	B	Toggle On/Off	The standard way to operate the bell from the keyboard.
Cylinder Cocks	C	Toggle Open/Close	Steam will be expelled from the cylinder cocks only when they are open and the regulator is not fully closed. There will be a catastrophic failure if the cylinder cocks are not used after the loco has been stationary for some time, as a result of steam condensing in the cylinders.
Blowdown	Shift F8	Open	The blowdown uses steam to clear the sludge that can build up in the boiler. In the model, it is merely a visual effect, i.e. a cosmetic feature.

Item	Key	Action	Remarks
Fireman's Controls			
Blower	N	Open	Increasing the blower helps to create more draft, especially when there is not much exhaust pressure. That helps to generate steam more quickly and to prevent the smoke and flames in the firebox from blowing back into the cab.
	Shift N	Close	

Item	Key	Action	Remarks
Blower Steam Throttle	E	Open	The blower is fed with steam from the boiler. That steam is shut off by closing the blower steam throttle. At the start of every scenario, the blower steam throttle is already closed.
	Shift E	Close	
Firebox Door	F	Open	While the door is fully open, the engine script will throw wood on the fire in an attempt to keep the "fire mass" at the level indicated by the position of the moveable log in the firebox.
	Shift F	Close	
Desired Fire Level	R	Increase	Sets the desired level of the fire mass, as indicated by the position of the log in the firebox.
	Shift R	Decrease	
Tender Water Valve (right-hand)	L	Open	Open the tender right-hand water valve to allow water to reach the right-hand feedwater pump, so that it is able to replenish the boiler.
	Shift L	Close	
Tender Water Valve (left-hand)	K	Open	Open the tender left-hand water valve to allow water to reach the left-hand feedwater pump, so that it is able to replenish the boiler.
	Shift K	Close	
Auto-stoking	J	Toggle On/Off	<p>Auto-stoking means that the engine script will automatically open and close the firebox door as and when it needs to put wood into the firebox.</p> <p>Toggling it off will stop the door from opening again after it has closed. This is useful when approaching a tunnel, avoiding a "blowback" error caused by leaving the door open just as the locomotive enters a tunnel at speed.</p> <p>It is enabled by default.</p>

Item	Key	Action	Remarks
Other controls			
Pulling Bar	Ctrl P	Toggle Up/Down	The pulling bar should be raised before coupling with the drawhead of the car in front of the locomotive.

Item	Key	Action	Remarks
Doors and windows			
Cab Window (inner left)	comma	Open	
	Shift comma	Close	
Cab Window (inner right)	period	Open	
	Shift period	Close	
Cab Door (left)	Home	Open	
	Shift Home	Close	
Cab Door (right)	End	Open	
	Shift End	Close	

Item	Key	Action	Remarks
Lights			
Headlight	H	Illuminate	
	Shift H	Extinguish	
Shadow-Casting	Ctrl Shift S	Toggle On/Off	By default, shadows are off.

Item	Key	Action	Remarks
Tender			
Tender Manhole Lid	Y	Toggle Open/Close	
Handbrake	/	Toggle On/Off	

Item	Key	Action	Remarks
Miscellaneous simulation control commands			
Crew	V	Toggle Visible/Invisible	
Performance Report	Ctrl Shift R	Toggle On/Off	Enables a pop-up message giving summary information on various aspects of operating the locomotive.
Track Condition (Friction)	Shift 3	Increase	The track condition is selectable . It starts off as "dry" (less prone to wheelslip) but the slipperiness can be increased progressively through "rain", "snow" and "wet leaves" (very easy to slip). Ctrl 3 progressively decreases the slipperiness. <i>The track condition is initialized automatically in accordance with the weather and season at the start of each scenario.</i>
	Ctrl 3	Decrease	
Base Smoke Density	Shift 4	Decrease	Allows the base density of the stack smoke to be selected between "Dense", "Normal", "Light" and "Sparse". The default is "Normal".
	Ctrl 4	Increase	
Easy Controls	Ctrl D	Toggle On/Off	When toggled on, the throttle response lag is eliminated and the reverser can be moved at any time without it lunging forwards/backwards when there is pressure on the valves. It is toggled off by default.

Animations

This model of "Jupiter" has a huge number of animated parts.

- The entire **valve gear and running gear** is animated, with separate animation sequences for various positions of the reverser. This means that when you move the reverser lever (the "Johnson bar"), you can watch everything that is connected to it and see how the cut-off is adjusted - the amount of travel of the valve pistons will change, the lifting links will raise or lower the links to the Stephenson gear, and so on. This happens even when the wheels are in motion, not just when the locomotive is stationary.
- The **brake rigging** of the tender's rear truck is animated, along with the handbrake wheel and its ratchet.
- The cab **doors** and **side windows** can be opened.
- On the tender, the **water tank manhole lid** on the top deck can be opened.
- The **wood fuel** in the tender is animated such that it gradually disappears as it is used up.
- The **bell**, its **clapper** and the **bell rope** are fully animated with a simulation of the bell's momentum and inertia.
- All of the **cab controls** are animated in both the cab view and the external model so that when looking into the cab from outside, the controls move just as they do in the internal cab view.

Lights

The headlight beam can be toggled between casting shadows or not.

By default, the shadows are OFF. Switching shadows ON will probably decrease the framerate (the impact will depend on your particular system), but on a reasonably powerful system, the effect of the shadows cast by the headlight at night is (in my opinion) well worth the cost.

In order for the headlight to shine brightly, "Headlight Flares" must be enabled in the advanced graphics settings, as shown below:



Sanding

The model has been scripted to simulate a limited amount of sand in the sandbox (sand dome), enough for about two hours of continuous operation.

Particle Effects

The action of the **cylinder cock** steam emitters is scripted to take account of there being two cylinder cocks per cylinder, one for the forward stroke and another for the backward stroke. The script controls the steam emission, alternating between the forward and rear cylinder cocks, synchronized precisely with the piston strokes.

The colour of the **stack smoke** changes depending on the exhaust pressure and the amount of steam and smoke entering the stack. When the steam pressure in the cylinders rises, the exhaust will turn whiter because the ratio of steam to smoke increases.

Smoke and flames can be seen inside the **firebox**. When the locomotive is traveling at speed, the flames will extend out into the cab when the firebox door is open, unless there is enough draft from the exhaust and/or blower to draw the fire away from the cab.

The **blowdown** valve gives off a plume of steam when blowing off.

There is a **spring-balance safety valve** on the steam dome. When the boiler pressure rises past 118.5psi, the safety valve will start to emit some faint wisps of steam. These will increase in density as the pressure continues to rise, reaching full density at 120psi.

The **whistle**, when blown, gives off steam.

Sparks fly from the wheel tyres when enough wheelslip (wheelspin) occurs.

The **sanders** show particles of sand coming out of the nozzles near the driver tyres.

Steam will be seen bleeding from the **packing glands** at the rear of the cylinders when there is steam in the rear half of the cylinder - the amount of bleeding will increase if the cylinders are damaged (through excessive wheelslip or reverse pressure braking).

The **water pump try cocks** squirt water when opened, on each stroke of the pumps, as long as the corresponding water valves in the tender are open.

The **boiler water gauge try cocks** in the cab, when opened, emit steam when the water is at or below the level of the try cock (otherwise the sound of trickling water will be heard).

In winter scenarios, smoke is seen coming from the **stovepipes** of the passenger cars.

Other Special Effects

In cab view, **raindrops** appear on the window panes when it's raining.

When used as an AI, Jupiter will **automatically blow the correct whistle codes** for releasing and setting the brakes when, respectively, starting and stopping a train.

The **oil lamps** inside passenger cars in a consist **illuminate automatically** whenever the locomotive's headlight is illuminated.

Expert mode, Simple mode and Automatic Fireman

Jupiter combines all of its advanced features with the ability to use the F4 HUD if so desired. Unlike previous locomotive models by Smokebox, there is no separation into Advanced and HUD-enabled versions. Instead, the one version of Jupiter does everything.

Furthermore, this unique version of Jupiter can be operated in either Simple Controls or Expert Controls mode, with or without the normal TS automatic fireman enabled.

Genuine Wheelslip

The model features extremely realistic wheelslip physics using a method pioneered by Smokebox.

The motion of the four driving wheels and all of the connected rods, cranks, links and valve gear are governed by LUA scripting (the forwards and backwards motion of the locomotive, as well as the rotation of the pilot truck and tender truck wheels, is still controlled through the core code). This allows the model to exhibit true wheelslip behavior in different track conditions that can be selected (via key presses) by the player. When the locomotive loses traction, the driving wheels slip visibly.

The LUA scripting contains some complex calculations for wheel inertia, momentum and adhesion, taking account of the locomotive's instantaneous tractive effort, the weight on the driving wheels (allowing for the current mass of water in the boiler), sanding and the coefficient of friction between the driver tires and the rails.

The friction can be changed "on the fly" through a keystroke combination, even to the extremely slippery condition of "leaves on the track" (leaves produce a resinous black goo that hardens into a substance so slippery that not even sanding will help).

It's possible to induce wheelslip even when running "light engine" (in fact, the weight of the consist pulled by the locomotive is not a direct factor in determining wheelslip - it only affects how much power is needed to overcome the inertia of the consist and get it rolling). Furthermore, the reverser can be used (carefully!) to slow down the engine and then when traction is lost, the wheels will spin in the opposite sense to the direction of travel of the locomotive.

Once wheelslip occurs, if it's not corrected promptly, the wheels will continue to spin faster and faster until "something bad happens" to your locomotive.

Example: If you close the throttle and put the reverser into the opposite direction, then open the throttle again, the driving wheels will slow down (losing their rotational momentum as the pistons act like brakes) and eventually rotate in the opposite direction (back-peddalling).

Real Steam Chest with Individual Valve Events

The throttle is not connected directly to the cylinders but instead there is a complex, scripted simulation of the way that the throttle actually fills up the steam chest (everything between the regulator ports, through which high-pressure steam enters from the boiler, and the valve admission

ports). It can be thought of as a reservoir of steam that is emptied when the valve gear opens the admission ports to let steam into the cylinders to move the pistons and turn the wheels. The simulation fills this reservoir when the throttle is opened and empties it each time the admission ports are opened (and by an amount that depends on the cut-off and the speed of the pistons). It accounts for losses in pressure caused by condensation in the steam chest, the effect of "wire-drawing" when the valve pistons are moving fast, and the loss of pressure through the cylinder drain cocks when they are open.

There is neither a steam chest pressure gauge nor a back-pressure gauge (for the exhaust pressure) in Jupiter. To control the locomotive properly at very low speed, you need to listen carefully to the sounds it makes.

Throttle and Reverser Behaviour

Notched Quadrants

The throttle and reverser lever quadrants are both notched (the levers have spring-loaded latches that drop into notches cut into their quadrants).

The throttle has 16 evenly-spaced notches. Therefore, the throttle can be changed in increments of 6.25%.

The reverser has 19 unevenly-spaced notches. There are 12 forward notches, a centre (neutral) notch and 6 reverse notches. The reverser determines the amount of valve cut-off and has a range of +75% to -75%. Note that the F4 HUD displays the reverser value in that range but the F5 HUD displays it in the range +100% to -100%, i.e. the F5 value is the cut-off expressed as a percentage of the maximum available cut-off.

Therefore, the available notches for the reverser are as follows:

Reverser Notch	Valve Cut-off	Reverser value shown by F5 HUD
1	75%	100%
2	69%	92%
3	63%	84%
4	57%	76%
5	51%	68%
6	45%	60%
7	40%	53%
8	34%	45%
9	28%	37%
10	22%	29%

11	16%	21%
12	10%	13%
13	0%	0%
14	-17%	-23%
15	-28%	-37%
16	-40%	-53%
17	-52%	-69%
18	-64%	-85%
19	-75%	-100%

Lever Latches

There is no separate key for releasing the latches on the levers. That's because the levers are moved by squeezing the latch handle to lift the latch out of the notch it's currently sitting in, then moving the lever while still squeezing the latch handle, and releasing the latch handle when the latch is over the notch it needs to be in (if it's not exactly over the notch, the lever will move a bit until it drops into the notch). In real life, all of that - squeeze handle, pull/push the lever, release handle - is done in one smooth movement. It would be unnatural to have to press one key to simulate squeezing and releasing the latch handle and a different key to move the lever. The animation is done in such a way that the latch handle can be seen squeezing shut and lifting the latch out of the notch just as the lever starts to move, then springing open and dropping the latch into the notch after the lever stops moving, simulating how it looks and feels in real life.

Reverser Forces

The reverser lever is connected through mechanical linkages to the valve mechanisms. When the admission valves close, to cut off live steam to the cylinders, they have to contend with the pressure of the steam that tries to force the valves open. If the throttle is open enough for the live steam pressure to be greater than about 40psi, when the reverser lever is unlatched, there can be enough force working against it to wrench it from the engineer's hands, causing the lever to lunge forwards (if the locomotive is traveling forwards) or backwards (if the locomotive is backing up). It is possible to adjust the cut-off with the throttle cracked open, as long as the steam chest pressure doesn't rise above about 40psi, but the usual way is to close the throttle and wait until the sound of the exhaust chuffs subsides before trying to move the reverser lever.

Throttle Lag

The throttle valve is located in the steam dome near the cab, some distance from the front-end. Therefore, you must take account of the short pause between adjusting the throttle lever in the cab and seeing a corresponding change in steam pressure at the pistons. Adjust the throttle lever one or two notches at a time and wait to see how the locomotive reacts (also listen carefully to the exhaust).

Note: If you want to eliminate the throttle response lag and to be able to move the reverser without any hindrance, use Ctrl D to toggle the controls to "Easy" (they default to "Difficult").

Brakes

One of the interesting aspects of Jupiter is that the original was built before locomotives were fitted with brakes. The tender has a handbrake that acts on the tender's rear truck but it is intended to be used as a parking brake, not for slowing down the train.

Instead, the engineer must rely on the following methods of braking:

- Signaling to the brakemen to set or release the brakes on each of the cars in the consist
- Live steam pressure acting in reverse against the pistons

Whistling to the Brakemen

The whistle is used to tell the brakemen what to do. This is simulated in the model:

- To **release** the brakes, blow **two long notes** on the whistle, close together
- To **set** the brakes, blow **one short "toot"**

Pressing the spacebar for more or less time will produce different whistle sounds:

- Press quickly for a very short toot
- Press for slightly longer to get another short toot with a bit of "quilling"
- Press for longer to start a long whistle (release the spacebar when the whistle starts to blow).

Alternatively, you can mouse-click on the red handle of the whistle lever:

- The tip of the handle initiates the long whistle
- The middle of the handle plays a quilled short toot
- The base of the handle plays a very short toot

The locomotive script "listens" to the kind of whistle note being played, as well as the time intervals between them, and is able to recognize whistle codes. This means that you can also play any other whistle code - for example, three short toots to indicate that the locomotive is about to back up - without affecting the train brakes.

When taking a train downhill, the brakes should be set (by using the whistle to signal to the brakemen) before reaching the start of the incline. Then the throttle should be used to apply power to pull the train down the incline and to control the speed. Cutting the throttle should be enough to allow the brakes on the train cars to slow the train down even while going downhill. However, if the train still doesn't slow down quickly enough (or at all!), which can happen on very steep inclines, it's possible to supplement the braking by using reverse pressure in the cylinders (see below).

Braking with Reverse Pressure in the Cylinders

In more modern steam locomotives that have train and engine brakes, this method is definitely frowned upon. However, in the days before brakes, trains typically traveled at slow speeds - 10mph for freight trains, 20mph for passenger trains, even if they were physically capable of higher speeds.

One reason for the slow speeds was to control costs by reducing wear and tear (maintenance and replacement costs) and fuel consumption.

Another reason was to allow trains to be stopped within the distance it took to stop a train by the means the crew had at their disposal. This was particularly important given the absence of signaling on single-track roads. The train had to be going slow enough to be able to bring the train to a stop in the time between sighting an obstruction ahead (another train, a fallen tree, a damsel in distress tied to the tracks ...) and reaching the obstruction.

What this means is that while it's possible for Jupiter with a six- or seven-car consist to reach speeds well in excess of 30mph, it's sometimes inadvisable, simply because it increases the risk of not braking in time.

That said, here's what you need to know in order to be able to brake properly using the reverser:

Basically, the technique consists of admitting steam into the cylinders at the end towards which the piston is traveling. That is achieved by putting the reverser into the opposite direction to the way the locomotive is traveling and then cracking open the throttle a little bit (one notch) at a time.

It's important to make sure that the steam chest is more or less empty before putting the reverser into the opposite direction. The sound of the exhaust chuffs gives an audible clue.

After reversing the reverser, open the throttle just a little and wait a few seconds, listening to the exhaust chuffs. If the volume of the sound rises, it means steam is entering the cylinders, so close the throttle to cut off the steam. Don't let it continue to rise quickly. On the other hand, if the sound doesn't get louder, open the throttle a bit more and repeat.

It takes a lot of practice to "stop on a dime" (switching maneuvers are especially challenging!) and it's easy to find that there is still enough pressure in the steam chest to cause the locomotive to start going in the opposite direction after slowing to a stop. One technique to prevent that from

happening is to open the cylinder drain cocks immediately after cutting the throttle and apply the handbrake as soon as the locomotive does roll to a stop.

If too much steam pressure is put against the oncoming piston heads, there is a risk of damage to the pistons (as well as the rods and cylinders). If damage occurs, a warning message will pop up, indicating the damage as a percentage of the maximum amount that the mechanisms can tolerate, in increments of 10%. That allows you to see when you are overdoing the reverse braking, before it gets too serious.

Firebox

Managing the Fire with the Auto Fireman Disabled

Inside the firebox, there is a log of wood that can be moved up and down either by dragging it with the mouse or using the standard stoking commands ("R" to increase, "Shift R" to decrease).

The position of the log determines how much fire mass the engine script will attempt to maintain:

- When the log is at its highest position, the script will try to keep the fire mass at the level that gives the hottest fire temperature (for maximum rate of steam generation) - 480lbs, which is 60% of the maximum;
- When the log is at its lowest position, the script will let the fire die down to a minimum, without it actually going out, to cool the firebox (for a lower rate of steam generation);
- When the log is at any intermediate position, the script adjusts the target fire mass level accordingly.

When the firebox door is open, the script will add fuel to the fire continuously for as long as necessary to get the fire mass to the desired level.

If you close the firebox door, the script will open it automatically at regular intervals to add more fuel to the fire and close it after the fuel has been added. Therefore, after closing the door, you will see it open and close by itself as the script carries on managing the fire for you.

NOTE: The script does this only when the F4 HUD is hidden. If the F4 HUD is on-screen, you have to open and close the firebox door using the HUD button. As soon as you hide the F4 HUD, the script will return to opening and closing the firebox door automatically.

Fire Color

The hotter the fire, the whiter and brighter it gets, so you can easily judge how hot it is just by looking at it when the firebox door is open.

Dampers

The dampers determine how much air reaches the fire. The fire will get hotter when it is fed with more air. There are two dampers, one at the front and one at the back of the firebox (below the level of the grate).

The left-hand damper handle opens and closes the front damper. The right-hand damper handle opens and closes the rear damper.

To feed more air to the fire while the locomotive is traveling forwards, open the front damper and close the rear damper. Conversely, when backing up, close the front damper and open the rear damper. At the start of a scenario, both dampers are closed.

Blowback

Blowback can occur with the firebox door open and a strong fire in the firebox, if the draft from the smokebox isn't strong enough to draw the heat of the fire through the boiler flues and prevent the flames from blowing back into the cab. It is even more likely to occur upon entering a tunnel because of the sudden increase in pressure at the opening of the smoke stack suppressing the draft.

If the blowback does occur at a tunnel entrance, the game will end the scenario with a "fatal blowback" message. At other times, the flames will visibly blow back into the cab!

To prevent blowback, the draft must be sufficient to keep the flames at bay. That can be achieved by increasing the steam chest pressure (opening the throttle more) and/or opening the blower more (the blower steam throttle must also be fully open).

In particular, before closing the throttle, make sure that the blower is on, as that will compensate for the reduction in draft resulting from the lower steam chest pressure.

Managing the Fire with the Auto Fireman Enabled

When the game's auto fireman is enabled, it takes complete control of the management of the fire. You are not able to open the firebox doors yourself, nor can you do anything with the water foot valves in the tender, and although you are still able to move the blower valves in the cab, they have no effect - the auto fireman controls the internal state of the blowers.

Although the auto fireman doesn't maintain the fire mass at the ideal level, it does manage to keep the fire relatively hot.

One indication that the auto fireman is enabled is that when the firebox doors open and close, they do so very quickly!

Water

Crosshead Pumps

"Jupiter" doesn't have water injectors. Instead, there are two mechanical pumps driven directly off the piston crossheads. Water is pumped into the boiler on each stroke of the pistons as long as the corresponding "foot" water valve in the tender is open. The valves can be opened by mouse-clicking on them - the handles will spiral upwards along a screw thread, opening the valves in the foot of the tender to allow water to reach the crosshead pumps.

To check that the pumps are delivering water to the boiler, mouse-click on the handles located near the bottom of the doors in the cab and watch for spurts of water from the open try cocks.

Obviously, when the pistons aren't moving, no water is pumped into the boiler. This means that the boiler cannot be replenished when the locomotive is at a standstill.

In real life, when the locomotive was stopped but the boiler needed to be topped up, there were two ways of doing it:

- Run the locomotive up and down a short length of track to keep the pistons moving, or
- Apply grease to the rails ahead of the driving wheels and then deliberately cause wheelslip so that the pistons would operate the pumps without the locomotive actually going anywhere!

Both of these methods can be used with this model. The first is straightforward. The second requires that you change the track friction "on-the-fly" to the most slippery - that will allow you to induce wheelslip. You just need to be careful with the throttle so that the wheelslip doesn't get out of hand and damage the running gear.

Water Gauge Try Cocks

There are three water gauge try cocks in the cab. Mouse-click on a try cock to toggle it opened/closed.

When a try cock is open, what happens next depends on the level of the water in the boiler versus the height of the try cock:

- Boiler water level is significantly higher than the try cock: the sound of trickling water will be heard;

- Boiler water level is close to the level of the try cock: the sound of trickling water will be heard and a small amount of steam will emanate from the try cock;
- Boiler water level is significantly below the level of the try cock: no sound of trickling water and a lot of steam will gush from the try cock.

The height of the try cocks, crown sheet and the top and bottom of the boiler, in inches and in terms of the water level shown by the F5 HUD, are as follows:

Item	Height in inches	F5 HUD Level ³
Top of the Boiler	53"	1.46
Highest Try Cock	45"	1.0
Middle Try Cock	42"	0.73
Lowest Try Cock	39"	0.43
Crown Sheet	35"	0.0
Bottom of the boiler	0"	n/a

Check the water level in the boiler frequently by opening each try cock for a moment (it's more immersive than relying only on the F5 HUD).

- If no steam comes out when the topmost try cock is open, there is a risk of overfilling the boiler and priming the cylinders, so turn off the water to one or both of the crosshead pumps;
- If steam gushes out of the lowest try cock, there is a risk of uncovering the crown sheet, causing a boiler explosion (which translates into an immediate "Game Over Error"), so turn on one or both of the water foot valves to replenish the boiler.

Auto Fireman Enabled

When the game's auto fireman is enabled, it takes control of the water foot valves - you cannot move them yourself - and does a good job of keeping the boiler water level well above the top of the crown sheet.

³ The reason for the apparent disparity in the increments between the F5 HUD levels versus the height in inches is because of the fact that the boiler is a cylinder.

Speedometer

In 1869, locomotives didn't have speedometers.

Instead, using the F3, F4 or F5 HUD while you practice, you'll soon learn how to recognize your speed from the sound of the chuffs.

Headlight

To light or extinguish the headlight, the locomotive must be at a standstill.

Impaired Operation

The model simulates several ways in which things can go wrong:

- Damage to the cylinders when they aren't properly drained of condensation - use the cylinder drain cocks when moving off after the locomotive has been stationary for some time, especially in winter scenarios;
- Damage resulting from the mechanical stresses of over-speeding (including wheelslip at high revolutions);
- Damage resulting from the mechanical stresses of using the reverser in reverse to slow down the locomotive;
- Problems caused by overfilling the boiler.

All of these are in addition to the "standard" failures such as running out of water, dousing the fire, derailments ...

Cylinder Damage

When the locomotive is left standing for some time with the cylinder cocks closed, condensation builds up in the cylinders. Water, unlike steam, cannot be compressed, so if the water is left in the cylinders when the pistons start to move, it can reach a point where the pistons are pushing up against the water. If they keep on pushing, something has to give, and it's usually the cylinder caps, or sometimes it can be worse and result in damage to the pistons and rods. To prevent that from happening, the cylinder cocks should be opened before the locomotive starts to move, so that on

each piston stroke, water will be expelled from the drain cocks beneath the cylinders. After a few revolutions, the cylinder cocks can be closed - doing so means that steam pressure isn't lost through the drain cocks and it also helps to preserve the lubrication in the cylinders.

Overspeeding

When the rotational speed of the driving wheels exceeds the equivalent of 50 MPH (note that this can happen during extreme wheelslip, even if the actual speed of the locomotive is very low), damage starts to accrue in the motion and valve gear. Eventually, there will be a catastrophic failure (which will end the scenario).

Overfilling the boiler

Care has to be taken to avoid overfilling the boiler - use the water gauge try cocks frequently.

When the topmost try cock is opened, if the sound of trickling water can be heard and there is no more than a hint of steam, it's a sign that the boiler is overfilling.

When the boiler is too full, two things happen. First, when the level is at around 1.15 (the value shown on the F5 HUD), the throttle gets stuck. The throttle will not move again until the water level drops below 1.00. If the water level continues to rise and reaches 1.2, water from the boiler enters the cylinders - game over!

Adjustable Controls Difficulty

In the *Expert* train controls gameplay setting, there are two levels of control difficulty - *Difficult* and *Easy*. Use Ctrl D to toggle between the two levels. The default is *Difficult*.

Difficult

Difficult level enables all of the advanced, realistic control simulation in the engine script and is intended for experienced players looking for a challenge.

Easy

Easy level disables some of the advanced features. It is intended for casual players who want something a little bit more difficult than the *Simple Controls* gameplay setting but without the challenge of the very realistically scripted controls. The control modifications in *Easy* level are as follows:

- Throttle response is immediate (no lag)

- The amount of steam going to the admission valves is directly proportional to the position of the throttle lever (no simulation of the steam chest filling and emptying, nor of condensation in the steam chest, and the wire-drawing effect at the valve apertures is ignored)
- Overfilling the boiler will not cause the throttle lever to jam
- The reverser can be moved without any hindrance (even when there is a lot of pressure in the steam chest)
- The pistons will not accrue further damage (any damage that was caused to the pistons while in *Difficult* level will remain)
- Condensation in the cylinders is ignored (there is no need to drain the cylinders before moving the locomotive)
- Fake engine (a.k.a. independent) brakes are included that can be operated with the brake lever in the F4 HUD (remember to switch from train brakes to engine brakes first). This overcomes one of the most difficult aspects of operating this 4-4-0 and allows the locomotive to be stopped without relying on reverse pressure braking. The amount of brake force is directly proportional to the position of the lever. *In Expert train controls gameplay setting, you must still use the "/" key to operate the tender's handbrake and use the whistle to signal to the brakemen to apply and release the handbrakes on the rest of the cars in the consist.*

Simple Controls

The very easiest way to operate this locomotive is to switch the train controls gameplay setting to *Simple Controls*.

Control difficulty is always *Easy*.

Wheelslip is still simulated, so care must be taken to avoid using too much throttle (moving the F4 HUD's combined throttle/brake lever upwards too quickly).

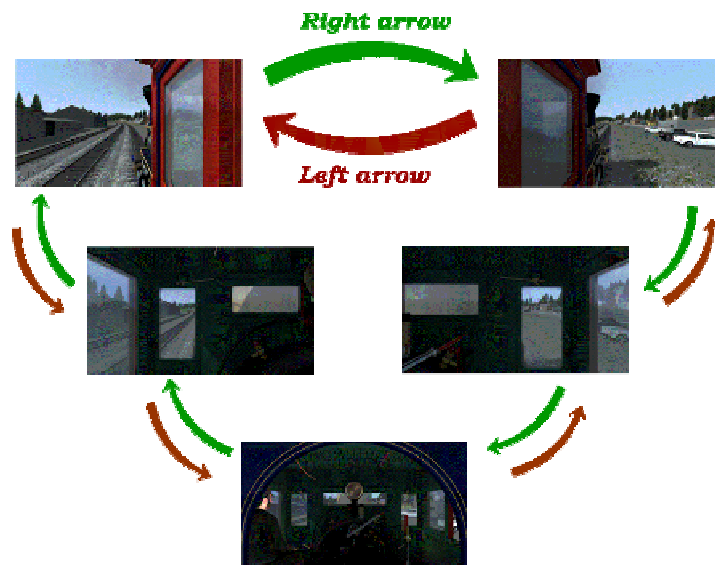
Whistle codes are ignored. Instead, the handbrakes on the tender and the cars in the consist will be applied or released automatically depending on the position of the combined throttle/brake lever:

- lever in range 0% to 49.9%: brakes apply
- lever in range 50% to 100%: brakes release

Cab views and Head-out Views

Cab Views ("1" key)

The cab is entered by pressing the "1" key. There are five cab camera positions. Use the left and right arrow keys to move from one position to another:

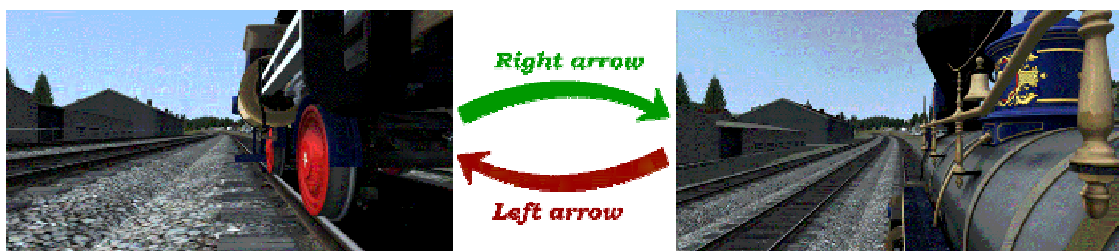


The view that is selected on entering the cab corresponds to leaning out of the right hand window.

Notice that the "1" key cab views already include head-out views from which you can see the track ahead as well as operating the controls with the mouse (if you turn your virtual head a little bit towards the interior of the cab).

Head-out Views ("Shift-2" key combination)

Since the cab head-out views are already covered by the "1" key views, the two camera views that can be selected using the Shift+2 key combination followed by the left and right have been repositioned to give interesting views along the locomotive:



The views also allow you, using the mouse, to turn through 180 degrees to look backwards towards the cab.

Scenarios

Career Scenarios

The package is supplied with three career scenarios set in the 1990's in Donner Pass. The Southern Pacific traces its roots back to the CPRR, which took delivery of "Jupiter" soon after the construction of the route through Donner Pass had been completed (in the spring of 1868).

Donner Pass scenarios:

[Jupiter] 1. Storm's on its Way {Reno to Truckee}

[Jupiter] 2. Storming the Hill {Truckee to Norden}

[Jupiter] 3. Storm's Passing {Norden to Colfax}

Quick Drive

The locomotives are Quick Drive-compatible. A variety of pre-defined consists are available for selection.

A Few More Tips on Operating the Locomotive

- Make sure that the dampers are set correctly for the direction of travel;
- On a 1.1% uphill grade with a 6-car consist, the locomotive will settle down to a steady cruising speed of about 20 miles per hour if the reverser is set at 40% and the throttle at about 53% or more (as indicated on the F3 or F4 HUD) while keeping the fire at its hottest (raise the "stoking log" as high as possible) and the boiler pressure close to 120psi.

If the boiler pressure starts to drop, the locomotive will slow down, but allow it to do so - as the speed drops, less steam will be used and the pressure should start to rise again, which will accelerate the locomotive towards its cruising speed.

If the boiler pressure doesn't appear to be recovering on its own, reduce the throttle to around 40% so that less steam is used. The locomotive will slow down a lot more, but that should be enough for the boiler pressure to start to rise again, and for the locomotive to pick up speed.

- If the locomotive accelerates because the grade has flattened, more steam will be used and the boiler pressure could soon drop - be prepared for this! Close the throttle, wait for the sound of the exhaust chuff to go much quieter, then hook up the reverser (bring it closer to neutral, shortening the cut-off) and open the throttle again. If the cut-off is correct, the speed should continue to rise and so should the boiler pressure.
- On the flat (0% grade), a cutoff of about 22% (as indicated on the F3 or F4 HUD) with the throttle wide open should allow the locomotive to accelerate a 6-car consist to over 35 MPH.
- To raise the boiler pressure, there has to be enough draft coming from the smokebox to draw the heat of the fire through the boiler flues. If the throttle is closed, there will be no draft induced by the flow of the exhaust steam up the smoke stack - in that case, the blower needs to be opened more to provide the necessary draft.
- If the driving wheels slip, back off on the throttle and apply sand.

Asset Selection in the Scenario Editor

The locomotive and rolling stock can be selected by ticking the following in the object filter dialog check boxes:

- **Developer:** "Smokebox"
- **Product:** "Jupiter"

The names of all items in the product package begin with "**CPRR**".

Liveries

Schenectady Locomotive Works delivered Jupiter and her three sister engines in the same livery, but each had a unique name and number.

This package includes all four named locomotives:



No. 60 "Jupiter"



No. 61 "Storm"



No. 62 "Whirlwind"



No. 63 "Leviathan"

Rolling Stock

The Jupiter package is provided with the following additional items of era-appropriate CPRR rolling stock:



30ft Flat Car
- "CPRR Flat Car"



30ft Flat Car with Side Bolsters
- "CPRR Flat Car w/ Side Bolsters"



**30ft Flat Car with Extended Knuckle Coupler (compatible with standard Buckeye Type E)
- "CPRR Flat Car w/ Extended Knuckle"**



**Emigrant Passenger Coach with Clerestory Roof
- "CPRR Clerestory Coach"**



Emigrant Passenger Coach with Rolled Roof and Arched Windows
- "CPRR Coach w/ Arched Windows"



Emigrant Passenger Coach with Rolled Roof and Squared Windows
- "CPRR Coach w/ Squared Windows"



Combined Caboose and Coach
- " CPRR Caboose Coach"



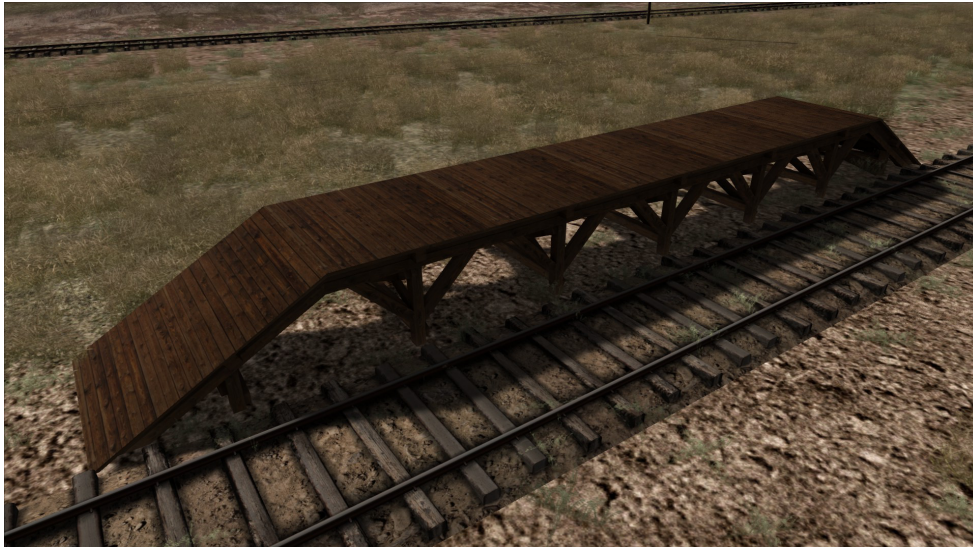
Baggage Car
- " CPRR Baggage Car"

Assets for Route Builders and Scenario Writers

The Jupiter package includes a number of items that can be used by route builders. They can also be placed in scenarios.



"CPRR Fuel Point - Water (Wooden Tower)"
(Category: Track Infrastructure)



"CPRR Fuel Point - Wood"
(Category: Track Infrastructure)



"CPRR Wood Pile"
(Category: Clutter)



"CPRR Telegraph Pole"
(Category: Clutter) - Lofted



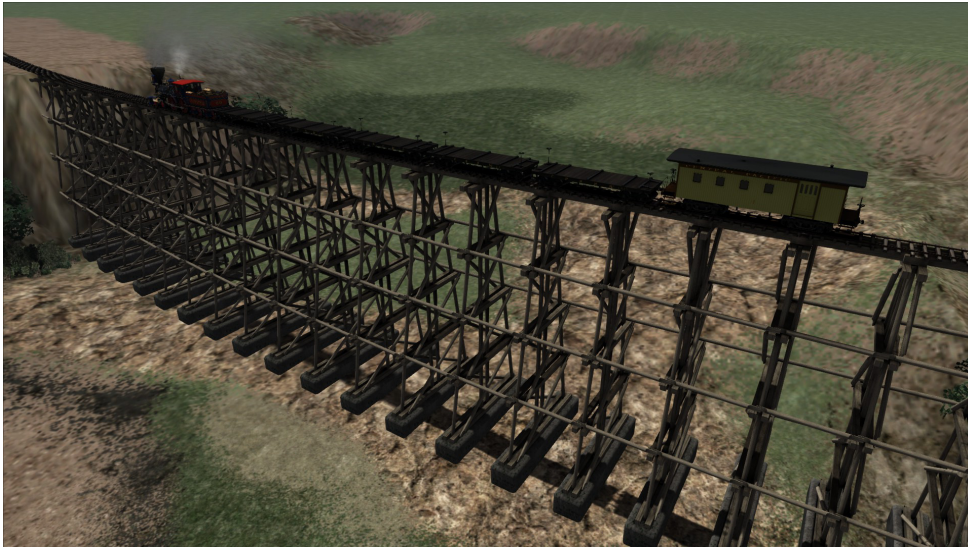
"CPRR Track"
(Category: Track Infrastructure)



"CPRR Track Ties x3"
(Category: Track Infrastructure)



"CPRR Track On Trestle (40ft High)"
(Category: Track Infrastructure)



"CPRR Track On Trestle (80ft High)"
(Category: Track Infrastructure)

The CPRR track rule creates manual junctions with an authentic CPRR harp stand as used in the 1860-1870s. When the lever is pointing directly up, the switch is aligned for the main (straight ahead). The stand should be repositioned if necessary so that it is on the side of track where the track turns, so that when the switch is thrown, the lever tilts to the opposite side. This is illustrated by the following examples:



Example 1: Track diverging to the right - switch set for straight ahead has the lever pointing upwards.



Example 2: Track diverging to the right - thrown switch has the lever pointing left.



Example 3: Track diverging to the left - thrown switch has the lever pointing to the right.

Toolset Used to Build the Model

- **3DCrafter Pro version 9.3** to create the model geometry and animations;
- **Photoshop** to produce the source textures;
- The **Asset Editor** provided with Train Simulator;
- **Power Sound Editor Free** and **Creative Wave Studio 7** to create the sounds*;
- **HxD** (freeware hex editor) to edit the GEOPCDX files, changing the material name of the window textures to enable rain effects. The geometry file is too large to be compiled by the serz.exe application.

* A few sounds, such as switch and button clicks, were made using samples from <http://www.freesound.org>, distributed under a Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0/legalcode>).

Special Thanks

I'd like to extend a special "thank you" to everyone who has helped me with the Jupiter project, in particular:

- **Brian Liesberg**, artist and restorer;
- **Robert Connor**, steam locomotive fireman and engineer ;
- **David Kilton**, Park Ranger Interpretation, and **Gary Willden**, WNPA Park Store Coordinator, Golden Spike National Historic Site;
- **Everett Meehling**, for allowing me to use some of his sound recordings of the exhaust chuff, bell and whistle of York no. 17 (another replica 4-4-0 steam locomotive that has a lot in common with both Jupiter and UP 119);
- **Dovetail Games**.

Mike Rennie

Perth and Kinross, Scotland,
May 2017



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