Using the BusMeister Public Transport Game in the Classrooom

Vienna, Austria

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August 22, 2011

WORKING DRAFT *– Please send comments to: andy@andynash.com*

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1. Introduction

Urban transportation is a critical element in making our cities more livable and sustainable. Transportation currently generates over xx% of greenhouse gas emissions – and this share is growing. Automobiles and trucks, while necessary parts of our transportation system, make our cities less friendly and reduce possibilities for interaction and innovation.

There are many forms of transport that are more appropriate for cities than cars. In cities distances are short enough to walk, bike or use public transport. Delivery services can bring large items right to your door – even better than using your car!

One of the biggest problems with cars is their size. There simply is not enough room for everyone in a city to drive without destroying the purpose of a city: bringing people together. Consider the Saturday afternoon crowds on the Mariahilfestrasse: what if everyone drove their car? There would be no room for the stores and cafes!

Public transport is one of the most environmentally friendly ways of travel. A well used public transport network like the WienerLinien moves people efficiently and quickly throughout the city. Vienna could not function without good public transport.

But public transport is not simple to understand or operate. There are many technologies that can make public transport more effective and attractive, but they are not obvious and often require great creativity. Furthermore, sometimes improving public transport means making automobile transport worse for example when a parking lane is taken to provide a bus lane. This is often controversial.

BusMeister is designed to teach people about public transport and how to improve it. The on-line game takes players through a series of levels each illustrating a different aspect of public transport operations. In the final levels players design their own public transport route using all the tools and strategies.

The game requires players to balance the happiness of public transport passengers with the cost of operating public transport and the happiness of automobile drivers (we can't forget about automobiles because sometimes they really are necessary). In each game level players are given targets for these goals and are challenged to optimize them using a specific set of public transport tools and operating strategies.

This guide describes how to get started playing BusMeister and the educational objectives of each game level. More information is available on the GreenCityStreets website (www.greencitystreets.com).

Link List

GreenCityStreets Home Page.....www.greencitystreets.com

BusMeister Game .....www.greencitystreets.com/busmeister

BusMeister Game Instructions .....http://wiki.greencitystreets.com/play-busmeister/

BusMeister Best Practices wiki .....http://www.busmeister.wikispaces.com

Acknowledgements

The BusMeister game was developed by Andrew Nash and Platogo. The Bus Meister project has been assisted by funds provided by the City of Vienna through ZIT: The Technology Agency of the City of Vienna.

2. Getting Started

This chapter describes how to play BusMeister. The first five sections present basic instructions, sections 2.6 – 2.8 present more details.

2.1 **Starting BusMeister** - starting screen and login.

2.2 **Level 1** - street screenshot and how to play.

2.3 **BusMeister step-by-step** instructions for a typical game.

2.4 **Running BusMeister** - what you see as the game runs.

2.5 **Results Panel** - have you met the level targets?

2.6 **Public Transport Improvements** - Stations, traffic signals, bus lanes, congestion reduction measures;

2.7 **Transport Operations Settings** - Vehicle type, frequency, fare collection

2.8 **Statistics Panel** - BusMeister statistics panel.

(This section on-line: http://wiki.greencitystreets.com/play-busmeister/playing-busmeister/)

2.1 Starting Bus Meister

Start the game by clicking on the link: www.greencitystreets.com/busmeister. After the game loads you will see the screenshot presented in Figure 1.

Figure 1 - Starting BusMeister - screenshot.

Now you can:

- **Login** - click here if you have already signed-up with our system;
- **Sign-up** - click here if you want to sign-up using our system to store your scores and level information in our system (this means your scores and level information will be saved so you can continue playing later);
- **Login with Facebook** - to play with your friends and use the social networking tools (your scores and level information will be saved); or
- **Play without Login** - your scores will not be saved and you will need to start from Level 1 next time you want to play.

Next simply click on the ***"1"*** box at the left side of the screen to go to the first level.

2.2 BusMeister: Level 1

After clicking the ***"1"*** box, BusMeister displays the level information screen (Figure 2). This screen tells you the level objective.

Figure 2 - BusMeister Level Information Screen

In levels 1 and 2 BusMeister provides guided help to walk you though the game providing information about game features and information displays. It's a little long, so if you want to skip it (you can always read the instructions here) simply click on ***"Guided Help"***.

Click ***"Start"*** to begin BusMeister. You will be taken to the BusMeister Street screen for your level. Figure 3 illustrates the main features of the BusMeister street for Level 1.

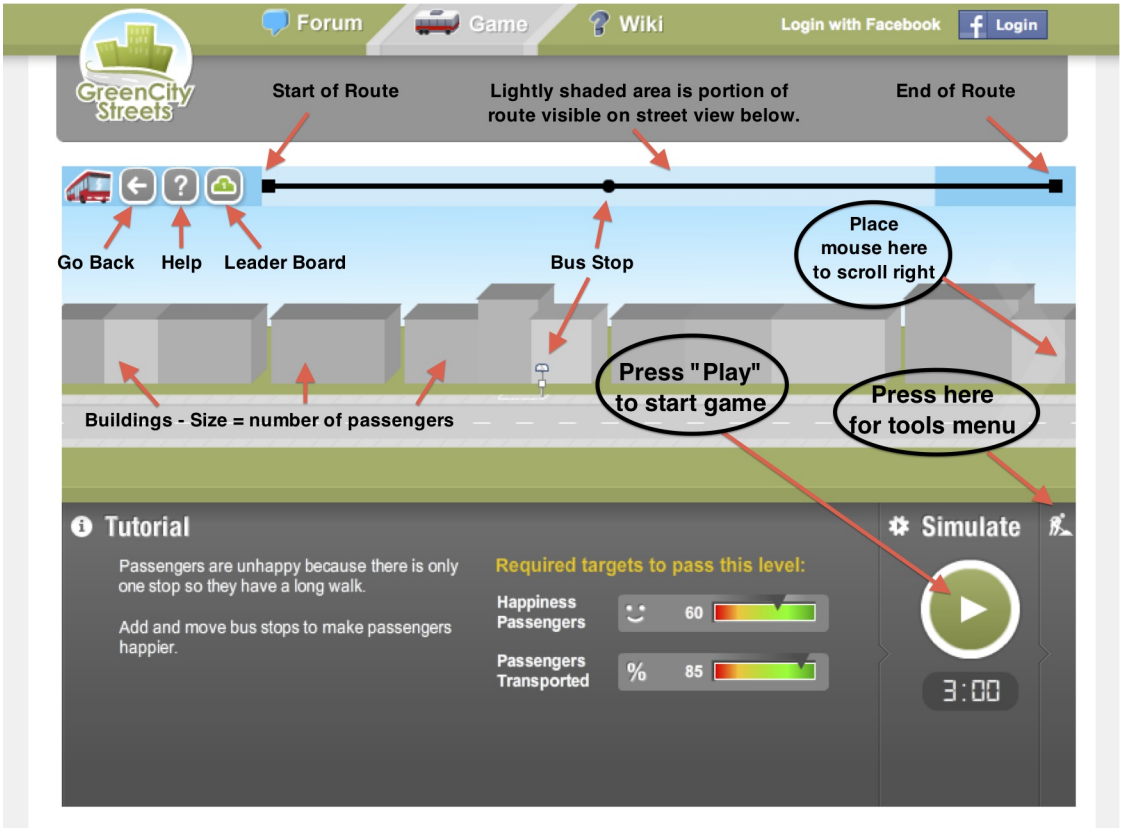

Figure 3 - BusMeister Game: Annotated screenshot.

You will see the following things on the street shot:

- **Top: Route stick map** (buses will be displayed on this map).
- **Buildings:** Buildings indicate how many potential passengers are available: bigger buildings = more passengers.
- **Street:** The street where buses and private vehicles operate.
- **Level Info** (in this case: Tutorial) - Presents information on the problem to be solved in this game level and the required targets.
- **Simulate Panel** (the gear icon) - Click on the "Play" button to start the game. The simulate panel opens presenting players with a simulation speed control and real time results for a variety of performance measures (see below).
- **Tools Menu** - Click here to open the tab that presents the improvements (e.g. bus stops) that players can add/delete/move on the route (see below).

NOTE: ***The whole street is not displayed on the screen!*** Scroll right/left by placing the mouse button on the right/left side of the street to move in that direction or use the mouse to move the light blue shaded area in the Route Stick Map at the top of the page.

2.3 Playing Bus Meister: Step-by-Step

The general process for playing BusMeister is:

1. Read about the level and goal;
2. Press ***"Play"*** to run the simulation to see the initial conditions;
3. Scroll to see the entire street by moving the mouse to the left and right sides of the screen at street level;
4. Speed up the simulation using the slide bar;
5. Stop the simulation and add improvements using the tools or settings panels. For information on improvements and settings please see Section 2.6 (Public Transport Improvements - Tools Panel) or Section 2.7 (Transport Operations Settings - Settings Panel) below;
6. Press ***"Play"*** to re-run the simulation with the new measures and compare results with your previous runs.
7. Continue adjusting the measures until you reach the level goal and maximize your bonus points.
8. Move on to the next level.

In Level 1 the goal is relatively easy: making the customers more satisfied. Level 1 starts with only one bus stop and people are unhappy since they need to walk a long distance. Use the Tools Panel to add bus stops. It's possible to gain extra points by carefully adjusting the bus stops to reduce costs while keeping the customers happy. Higher levels are more difficult.

2.4 Running BusMeister

After pressing the ***"Play"*** button BusMeister runs a simulation of the improvements you have placed on the street. The number of buses and cars changes with each level (in higher levels you can control the number of buses operating). The cars and buses interact so there is some variability in the game. As the game is running BusMeister displays real time statistics as shown in Figure 4 below.

Figure 4 shows what you will see as BusMeister runs through the simulation. Some hints:

- You can control the speed of the simulation using the slide tool to the right of the "Play" button;
- You can select which statistics and happy faces are displayed (see Statistics section 2.8 below);
- In this view the player has played the level once, then made changes to the improvements and this is the second attempt. This is shown by the two yellow lines in the real time happiness graph: the light line is the first attempt and the dark line is the second attempt. This information is important so you can see if the changes you made improve the situation or make it worse.

See BusMeister Statistics (Section 2.8 below) for more information on the statistics and how to choose which to display.

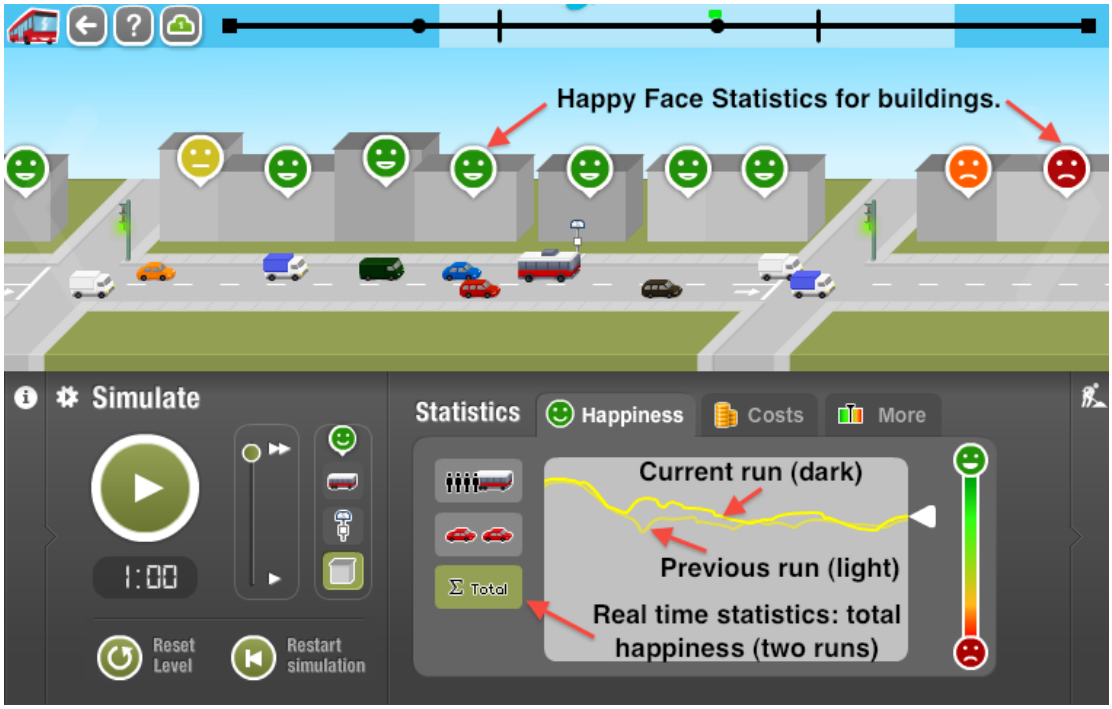

Figure 4 - BusMeister: Real time statistics displayed as game runs.

2.5 BusMeister Results

When the simulation is completed BusMeister displays the results panel telling you how well you did in terms of the required goals and the bonus point targets. The Results Panel is illustrated in Figure 5.

Figure 5 - BusMeister: Results panel.

The Results Panel tells you how well you did and gives you several options on what to do next. Here are some of the main points in Figure 5:

- At the top is information on this level's required goal. The target is shown on the left of the slider control and my score is shown on the right. The green "check mark" shows I met the required goal.
- If I click on the ***"Continue"*** button I will go on to the next level - but I may want to try to increase my score on the current level, if so I just click the brown ***"X"*** in the upper right hand corner of the results panel.
- The bottom shows the bonus goals for this level. Again the target is shown on the left side of the slider control and my score is shown on the right. Green "check marks" show which goals I have met and red "Xs" show which bonus goals I have not reached. In this case I met 3 of the 4 bonus goals.
- My total score for the level is shown at the bottom of the results panel.
- You can click on the ***"Leader Board"*** button to see how well you have done on this level compared to other players.

At this point you decide whether to replay the level to increase your score or go onto the next level. Click on:

- ***"Continue"*** to go to the next level;
- ***"X"*** to close the results panel and replay the current level.

The next sections provide more details on how to add improvements to the street, how to change the public transport vehicle settings and how to understand the BusMeister statistics.

2.6 Public Transport Improvements (Tools Panel)

The Tools Panel enables players to add, remove or move improvement measures to the street. The number of improvement measures increases with the game level. Figure 6 illustrates the Tools Panel for Level 2: players can add stations and traffic signals.

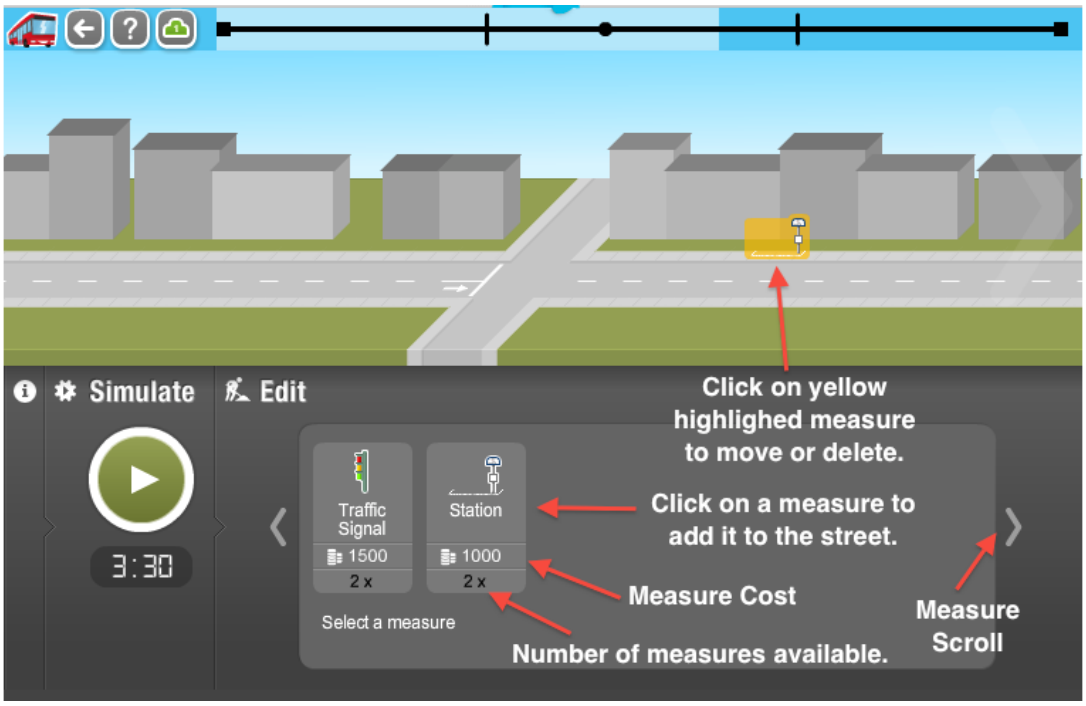

Figure 6 - BusMeister Tools Panel: Level 2.

Some key features of the Tools Panel are annotated in Figure 6 including:

- Use the arrows on the right and left sides to scroll through the available improvement measures (in Level 2 only two measures are available but in higher levels you need to scroll to see all the available measures);
- Each block illustrates the measure, displays the cost and the remaining number of times you can add the measure to the street;
- On the street, clicking on a measure highlights it and allows you to move or delete it from the street (if you delete it you receive a credit for it in the Tools Panel);
- All streets must have at least one station so you cannot delete the last station!

There are three main types of improvements available: stations, traffic signals and congestion reduction/bus lanes. These improvements are described in Chapter 3 (and on-line at: http://wiki.greencitystreets.com/play-busmeister/busmeister-public-transport-improvements/). The following text describes how to add, delete or move improvements (measures).

Moving and Removing Improvements

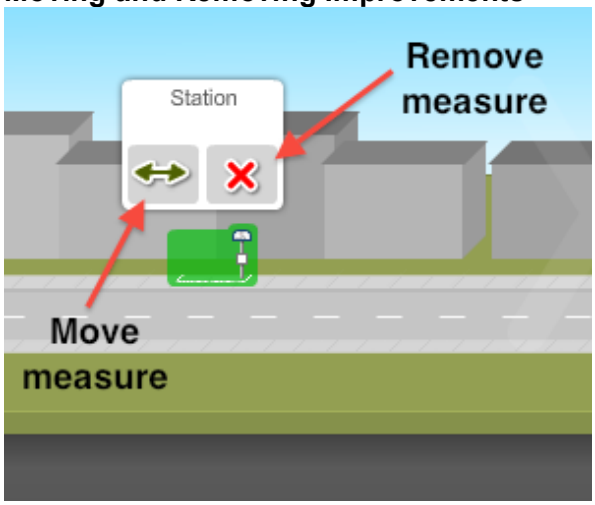

Figure 7 - BusMeister: Moving and removing improvements.

Here's how to move or remove an improvement from the street:

1. Click on the measure you want to move/remove: it is highlighted in green and the move/remove panel is displayed (as shown in Figure 7).
2. Choose the "arrow" to move the measure and the "X" to remove the measure.
3. If you are moving the measure simply drag it where you want it on the street. Releasing the mouse button places it.
4. If you are removing the measure it automatically re-appears in your Tools Panel for use later.

A Note on Moving Stations

It's often especially helpful to move stations. A small change in location can significantly improve customer happiness and/or can enable you to reduce the number of stations on your route: thus reducing cost and increasing happiness. (This is also true in the real world!)

Adding an Improvement

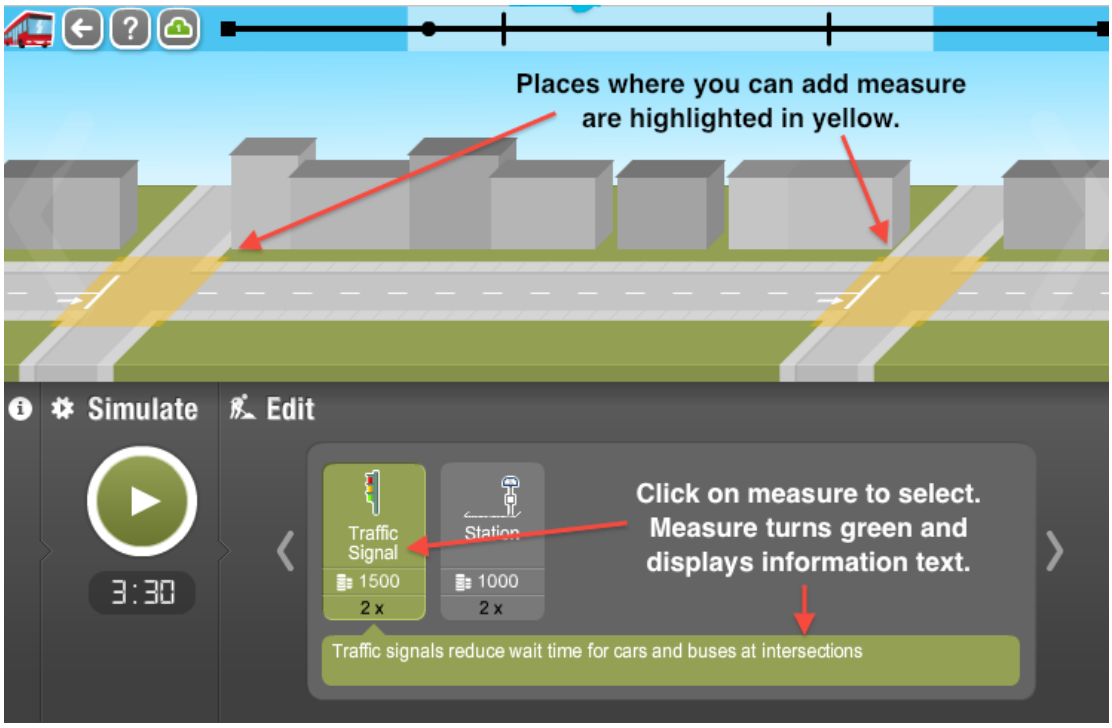

Figure 8 - BusMeister: Adding an improvement to the street.

Add an improvement to the street:

1. Click on the measure you want to add to the street in the Tools Panel as shown in Figure 8.
2. Measure is highlighted in green and information about the measure is displayed.
3. Locations where you can add the selected improvement are highlighted in yellow on the street.
4. Click on the yellow highlighted area where you want to add the improvement ... improvement is added.
5. Repeat process for all improvements you want to add.

2.7 Public Transport Operations Settings (Settings Tool)

In advanced levels of the game, the Settings Tool enables players to define the type of vehicles used, the vehicle frequency (headway) and the type of fare collection system. The Settings Tool is displayed in Figure 9.

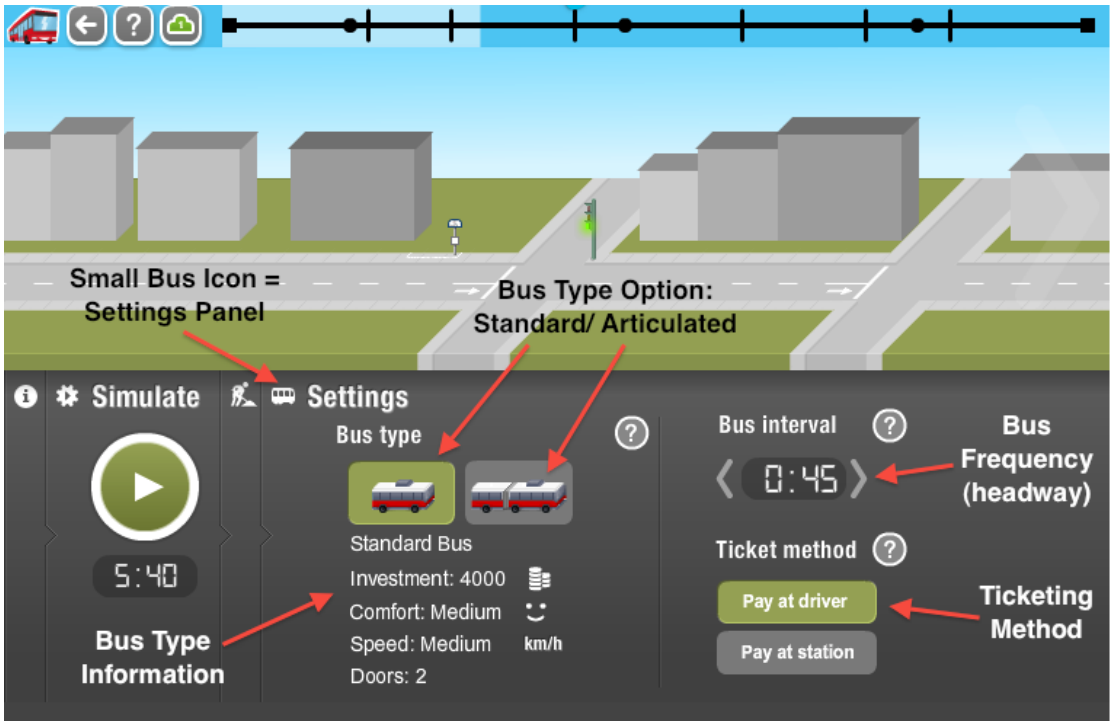

Figure 9 - BusMeister: Vehicle settings panel.

Some key features of the Settings Panel are annotated in Figure 9 including:

- You can choose which type of vehicle to use: standard buses or articulated buses. Information about the selected vehicle type is presented below the figure.
- You can increase or decrease the vehicle headway by clicking on the arrows. (All times in BusMeister are compressed to make playing more interesting.)
- You can choose whether to have passengers pay on board the vehicle or before boarding.

For more information about any BusMeister feature please contact us.

2.8 BusMeister Statistics

BusMeister automatically calculates a wide variety of performance statistics during the simulation. These statistics are used to determine whether or not you have met the Level Targets and bonus point objectives.

You can choose which statistics to view in real time so that you can better understand the effects of the improvements you have added to the street. In the higher levels you will probably test several different improvement scenarios as you attempt to meet the level targets and increase your bonus points.

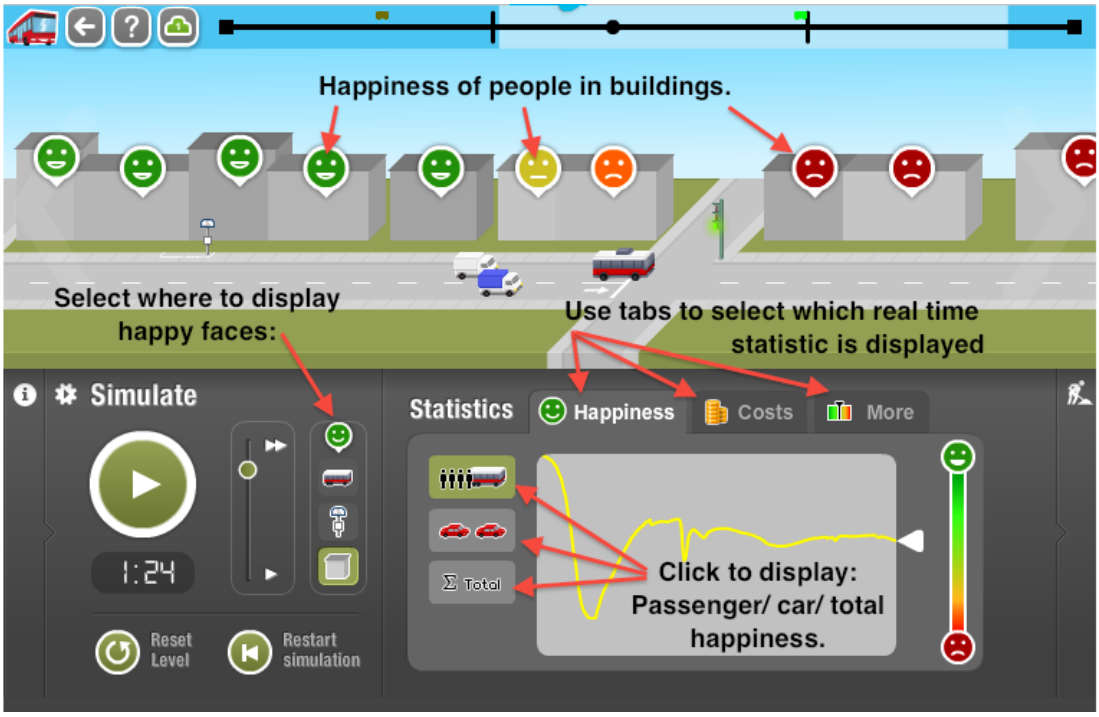

Figure 10 - BusMeister: Statistics display options.

Some key features of the Statistics Panel are annotated in Figure 10 including:

- You can choose which Happy Faces are displayed: for the buses, for the stations and for the buildings. In the figure only building happy faces are shown (the building icon is highlighed in green). Click on an icon to display as many or as few happy faces as you want.
- The real time Statistics Graph displays happiness, costs or other statistics. You can choose which happiness (passenger, car or total) and which cost (variable or fixed) to display by clicking on the appropriate icon. In the illustration the public transport passenger happiness is shown.
- On the statistics graph previous levels are also shown in a lighter shade. (Not shown in this illustration.)

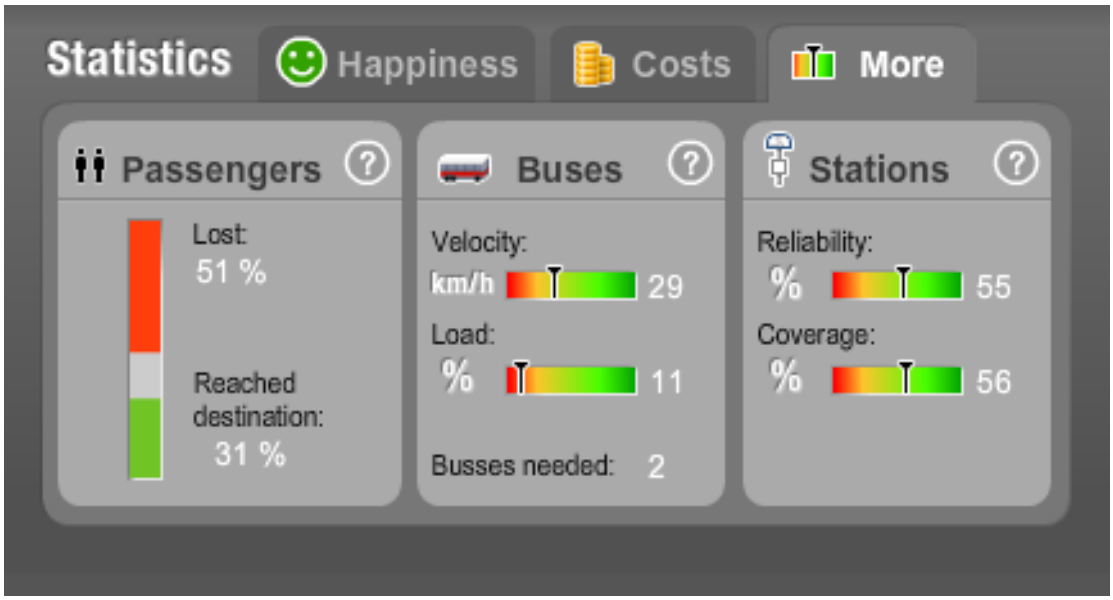

Figure 11 - BusMeister: More statistics display.

- The "More" statistics panel (shown in Figure 11) presents information about the number of passengers lost because of unhappiness, bus statistics (speed, load) and station information.

BusMeister uses a relatively simple system to estimate happiness (although this can be revised to make the game more accurate for a specific situation). Public transport passenger happiness is calculated based on wait time, travel time, and how crowded the public transport vehicle is.

Automobile happiness is calculated based on the level of congestion on the street (the amount of congestion changes depending on the street improvements). The combined happiness is calculated based on the number of PT or automobile passengers multiplied by the appropriate happiness level.

For more information on how the BusMeister statistics are calculated please see Chapter 4: BusMeister Evaluation Measure Descriptions.

3. BusMeister Levels: Educational Objectives

The general goal of the BusMeister game is to teach players how to improve street-based public transport. In the game players move, add and remove measures designed to make public transport more attractive and efficient. The goal is to reach pre-set attractiveness and efficiency goals within the given budget.

In playing the game players learn the benefits of particular public transport improvement measures (e.g. exclusive bus lanes), factors influencing the cost and attractiveness of public transport, and how to balance costs and benefits to achieve the best results.

A good example is Level 1 of the BusMeister game. In Level 1 players are confronted with a street that has one bus station. Residents are unhappy because many of them need to walk a long distance to the station. Players are allowed to add two more bus stations to the street, this makes all the residents happy. However, a bus system with three stops costs more than a system with one stop (since it takes longer for the buses to make a full trip). Therefore, the optimal solution is to have two stations located at the right points on the street to satisfy the residents while keeping costs as low as possible.

This example illustrates one of the most common questions people ask real public transport companies: Why isn't there a bus stop in front of my house? Level 1 of the game is designed to show clearly the tradeoffs between bus operating costs and customer satisfaction that form the basis for answering this question.

This chapter begins with an introduction to some of the main strategies for improving public transport attractiveness and efficiency. Following this introduction the specific educational goals for each level are outlined with references for further information.

3.1 Improving Public Transport Attractiveness and Efficiency

The main factor in making public transport attractive and efficient is speed. When public transport is fast it is:

- more attractive to customers, and
- less expensive to operate.

Furthermore, more customers mean higher fare revenues, so not only does it cost less to operate fast public transport services, but you collect more money.

Speed defines the attractiveness of public transport service because, when people decide how to make a trip they compare the time and cost of one type of transport to the other possible types of transport available. In most cases the most important variable is time. So, when you decide how to travel to school you might compare the time it takes by bus to the time it takes to ride your bike. If it will take an hour to ride your bike and 15-minutes to take the bus, you will probably choose taking the bus.

Speed also helps determine the cost of operating public transport. Imagine a public transport line 10-kilometres long. If a bus can travel at 20 Kilometres per hour (kph) then it can make the trip twice, but if the bus can only travel at 10-kph, it can only make the trip once. This means that twice as many buses are needed to serve the line, doubling the cost of service.

Of course there are more factors that determine the attractiveness and efficiency of a public transport service including ticket cost, safety and cleanliness. These factors must be considered in planning a public transport system, but they can be ignored in

the operational planning process because they are policy issues that are determined for the entire public transport system rather than for particular public transport routes (although we hope to deal with them in future games!).

Given the importance of speed in determining public transport attractiveness and efficiency, most of the BusMeister game's features are based on speed. For example, the impact of improvement measures is defined in terms of the increase in speed that they provide. Similarly, the passenger happiness is based, in part, on how fast the trip is (although BusMeister also considers comfort based on how full the bus is).

There is one final aspect of speed to mention. When people decide which type of transport to use they consider the total trip time, not the time spent in the vehicle. In other words, for a bus, they also consider the time spent: walking to the bus station, waiting for the bus and walking from the bus station to their destination. For a car this means the time spent walking to the car, the time spent looking for parking and the time spent walking from the parking place to the final destination.

As described below, in the BusMeister game passenger satisfaction is based partly on the amount of time it takes to walk to the bus station and the amount of time spent waiting for a bus.

The rest of this chapter describes the specific educational objectives of each BusMeister game level.

3.2 BusMeister Level 1: Station Placement

Deciding where to put public transport stations is a complex question involving:

- Physical space – is it physically possible to place a station in the desired location?
- How close is the station to nearby stations? Stations need to be close enough so people can walk to them easily, but far enough apart so the bus or tram is not stopping too frequently (since this increases operating costs).
- Transfer possibilities – is a station needed in a specific location to allow people to transfer to another public transport line?
- Major destination – is a station needed to serve a specific destination such as a hospital or university?

The BusMeister game focuses on the second question: how close together are the public transport stations. (The other questions will be considered in future games.)

Level 1 of the BusMeister game begins with one bus station on the street. Figure 12 shows how the screen will look after about 2-minutes of simulation time.

Figure 12 - BusMeister Level 1 - Annotated screenshot.

As shown in Figure 12, potential passengers located far away from the single bus station are unhappy and passengers close to the bus station are happy.

The solution is to add bus stations to make the passengers happier. This is done by clicking on the tools panel icon (person at work symbol on far right hand side of the screen, just under the street).

After clicking on the tools panel icon you will see the screen displayed in Figure 13.

As shown in Figure 13, you can now either add a station to the street by clicking on the station in the tools panel or move the existing station by clicking on the yellow highlighted area around the existing station. (See Section 2.6 above for directions on how to add or move stations.)

Figure 13 - BusMeister Level 1 - Tools panel screenshot.

To make the passengers happier we decide to place two more stops on the street so passengers will not have to walk so far to the bus station. This is shown on Figure 14.

Figure 14 - BusMeister Level 1 - Three bus stations on street.

All the potential passengers are happy and this solution is satisfactory as shown in the results screen that is displayed once the simulation is finished (Figure 15).

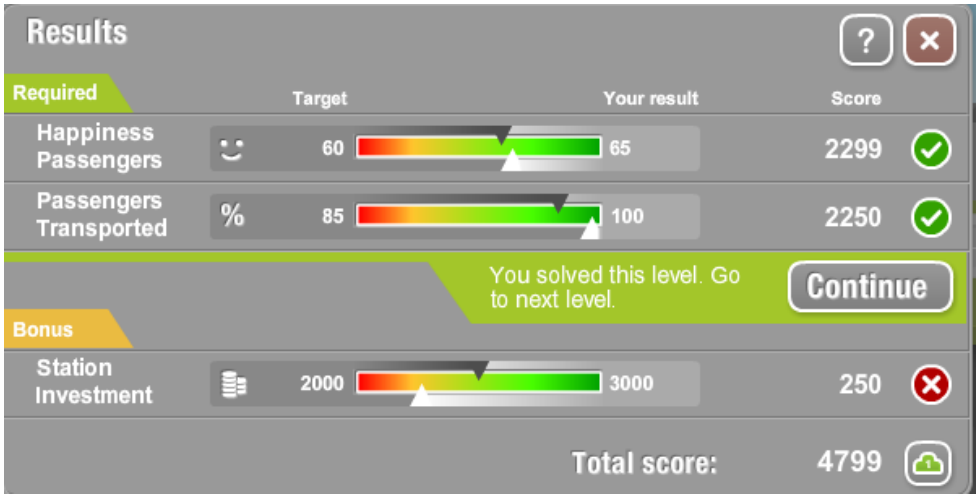

Figure 15 - BusMeister Level 1 - Results for three bus station solution.

However, notice that the three stop solution does not achieve the bonus goal for station investment. Is it possible to make all the passengers happy with only two bus stations? Let's see. Figure 16 shows the street with two bus stations carefully placed to be at the ¼ and ¾ points on the street. This means that the people walking farthest would be walking the same distance to both stations.

Figure 16 - BusMeister Level 1 - Screenshot: two bus stations on street.

As shown in Figure 16 most of the potential passengers are happy with their walk distances although some in the middle are slightly unhappy. Figure 17 presents the results screen for this solution and as you can see this solution achieves the bonus goal for station investment.

But, there's something else interesting when you compare Figure 17 (two station solution) to Figure 15 (three station solution), namely, the passenger happiness is larger for the two station solution (74) than for the three station solution (65). Why is that?

Remember, passenger happiness is based on total travel time, not just walk time to the bus station or time spent on the vehicle. Reducing the number of bus stations on the line makes the buses faster and therefore passengers are happier.

Finally, while operating cost is not one of the variables considered in the results for Level 1 (it is considered in higher levels), BusMeister's statistics panel (Figure 18) shows that the two bus station solution also has lower operating costs than the three bus station solution, although higher costs than the one bus station solution.

You can click on the various statistics to learn more about how well each solution performs based on different measures. See Section 2.8 for more information on BusMeister statistics.

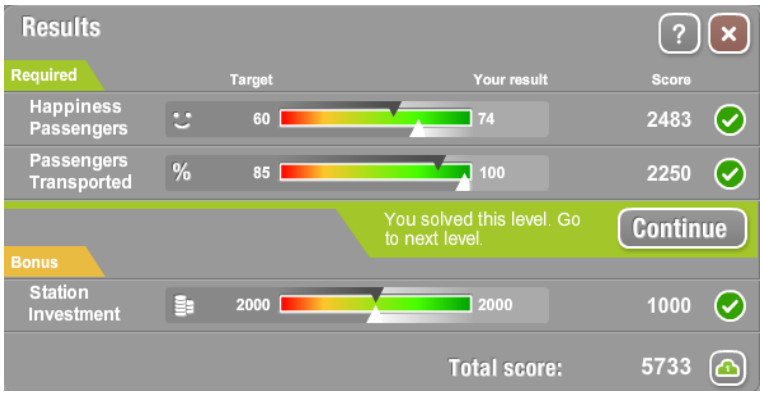

Figure 17 - BusMeister Level 1 - Results for two bus station solution.

Figure 18 - BusMeister Level 1 - Statistics panel for two bus station solution.

3.3 BusMeister Level 2: Intersections

In Level 2 we introduce intersections into the game. At an intersection traffic must take turns depending on who has the right to proceed (right of way). In BusMeister the right to proceed is determined by stop signs or traffic signals. In the real world there are other possibilities including uncontrolled intersections (no signs or traffic signals) and Yield signs as well.

As we have learned the objective for public transport is to increase speed. Stopping at an intersection delays the vehicle and reduces speed, therefore it increases operating costs and decreases passenger happiness.

In Level 2 of BusMeister players have the option of adding traffic signals to the street. Traffic signals are better than stop signs because at a stop sign all vehicles must stop, at a traffic signal, if the signal is green vehicles do not need to stop. This helps increase the overall speed of vehicles (including public transport).

Figure 19 illustrates BusMeister Level 2 without any improvements. As shown the first intersection is controlled with a stop sign which means all the traffic on the street needs to stop before proceeding across the intersection. While no vehicles are shown on the cross street in the game screen (for simplicity sake), the game engine assumes vehicles are using the cross street and the amount of time that vehicles spend stopped on the main street depends on the amount of this cross traffic.

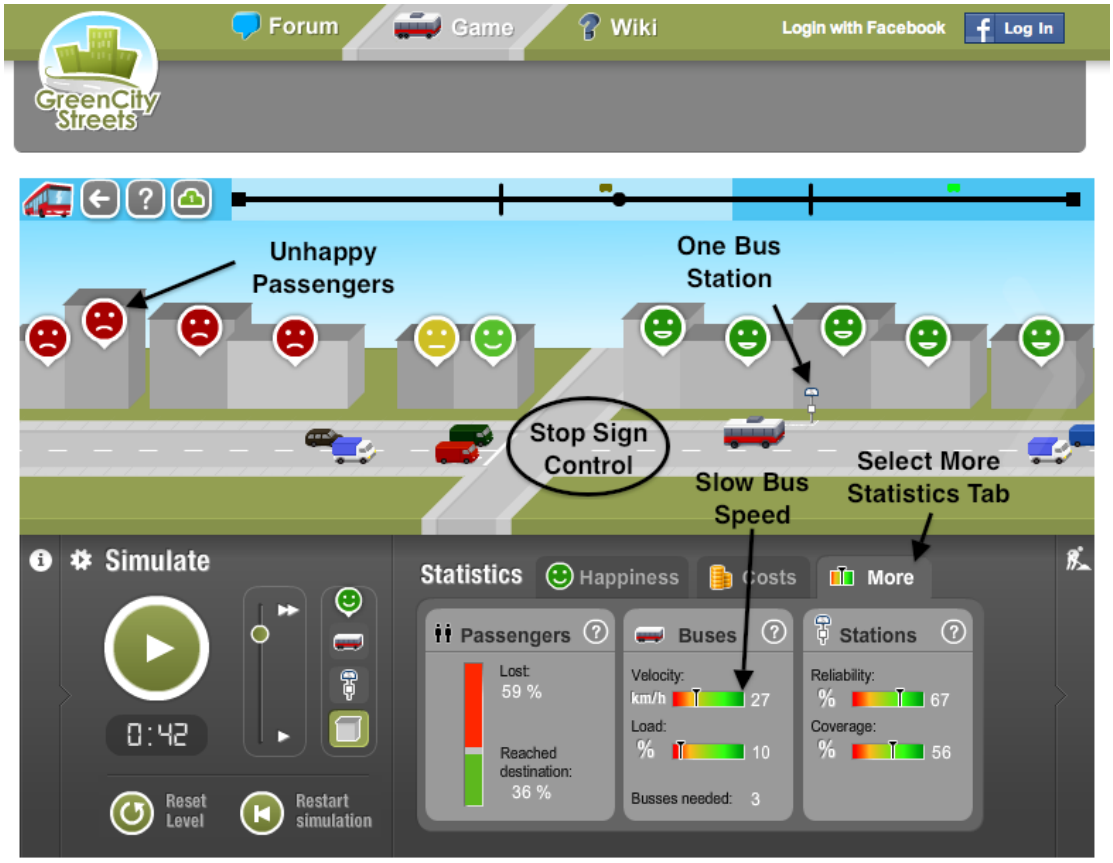

Figure 19 - BusMeister Level 2 - Initial conditions screenshot.

Notice that the passengers who have to walk a long distance to the one bus station are unhappy. While Level 2 introduces intersections players still need to consider the station placement lessons they learned in Level 1.

Figure 19 shows the “More” statistics. In this case we are especially interested in the speed (velocity) of the buses. As shown the bus speed is a relatively slow 27 km/h.

In order to solve Level 2 players need to add traffic signals – which will reduce the time that buses spend stopped at the two intersections (the second intersection is not visible in this screenshot, you need to scroll right to see it – or use the stick map at the top of the screen). Also, players will need to adjust the stations to increase passenger happiness. Figure 20 illustrates one potential solution.

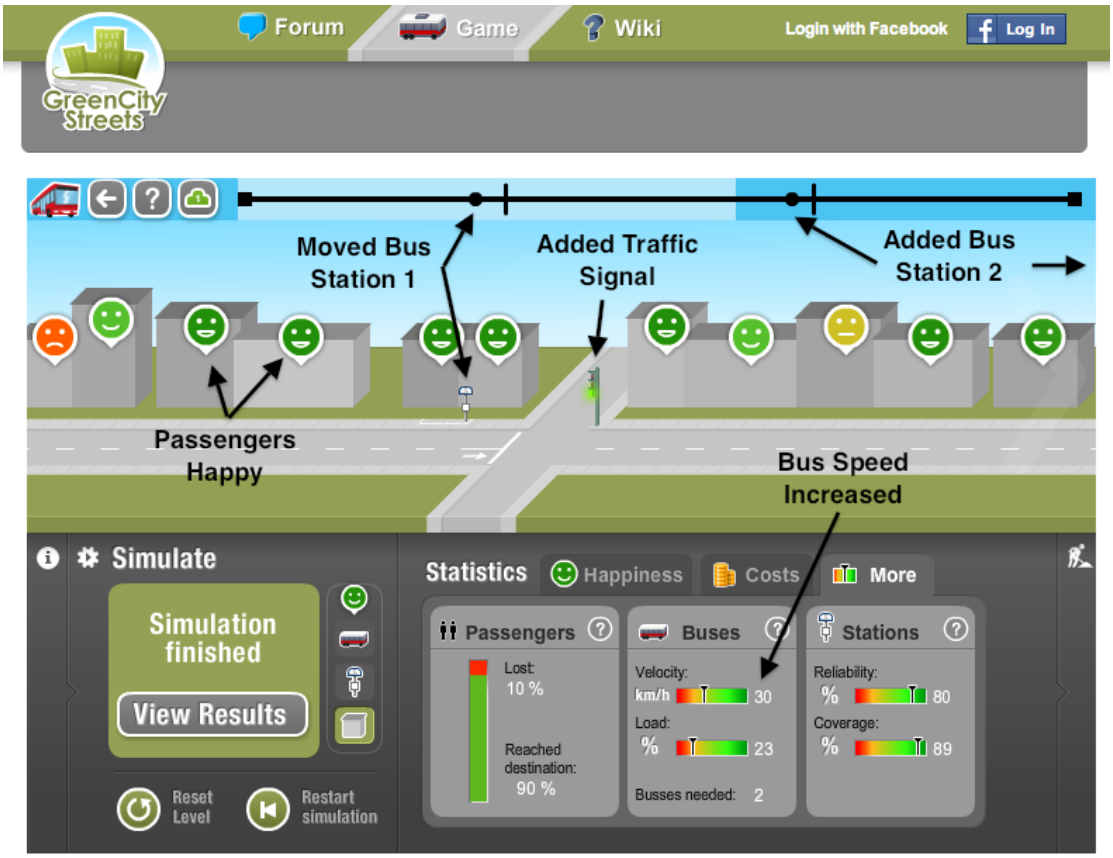

Figure 20 - BusMeister Level 2 - Screenshot potential solution.

As shown in Figure 20, a traffic signal was added to the first intersection (also to the second intersection, but that is not visible on this screenshot), the original bus station was moved to the first block, and a second bus station was added to the second block (it’s not visible on the screenshot, but is shown on the stick map at the top of the screen).

Under the “More” statistics you can see that the bus speed has increased from 27 km/h to 30 km/h. This may not seem like much but it is about a 10% increase (and represents a 10% decrease in costs!). It’s also important to remember that adding the second bus station caused a decrease in speed (since the buses need to stop) so the 3 km/h speed increase is significant.

Figure 21 presents the results screen for this solution. As shown, the solution meets all the required and bonus objectives, although it would be possible to improve the

scores by further adjusting station locations and possibly using only a single traffic signal.

Finally, it is important to mention that the question of whether to place a bus station before an intersection with a traffic signal or after the intersection is very important. If many people are waiting at the station it's possible that a bus could be delayed by passengers boarding and alighting, and miss the green light, thus being forced to wait for another traffic signal cycle; if the bus stop were on the other side of the intersection, the bus would proceed through the intersection, then passengers would board and alight, and the bus could proceed when everyone was on board. BusMeister models this behaviour although it is not extremely precise.

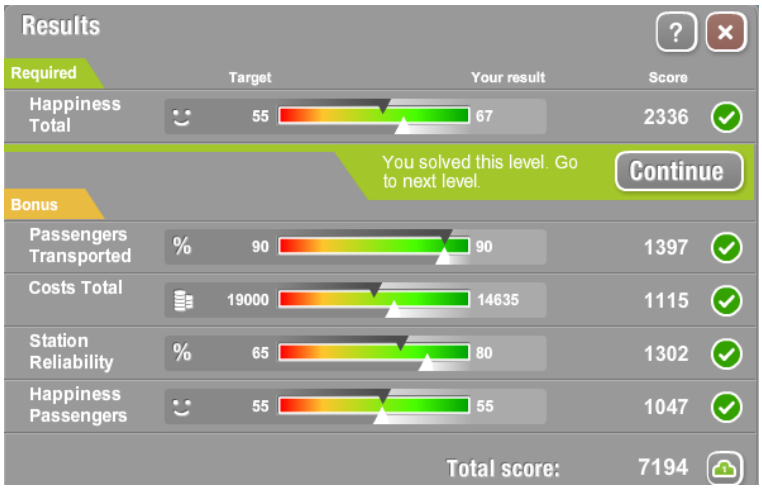

Figure 21 - BusMeister Level 2 - Results screen for one potential solution.

3.4 BusMeister Level 3 – Station Types

Passenger comfort is one factor that influences whether people will use public transport or not. One aspect of passenger comfort is the quality of public transport stations: higher quality stations will attract more passengers.

BusMeister has three types of stations:

- Simple stations – just have a sign;
- Shelter stations – have a shelter to protect waiting passengers from the weather; and
- Information stations – have a shelter and real time information telling passengers when the next bus will arrive.

Information stations are the best because they have protection from the weather and, since they have information displays, they reassure passengers that the bus is coming and let them know how long their wait will be.

An interesting element of human nature is that when asked how long they have been waiting for a bus most people will respond with a value 2-3 times higher then the actual time. This is one reason real time displays help increase passenger satisfaction.

BusMeister uses these station types to determine how happy waiting passengers are. For example, a person waiting 3 minutes at a simple station is less happy then a person waiting at an information station. Of course a simple station costs the least and an information station costs the most.

The best strategy is to place the more expensive information stations in locations where more people will use them. The number of potential passengers is shown based on the size of the buildings: larger buildings generate more passengers.

Level 3 starts with two simple stations on a four block long street. Players have the option of adding one shelter station and one information station to the street, as well as the option of moving and/or removing the existing stations. The required targets are “Station Coverage” which means the percentage of potential passengers attracted to public transport and “Bus Load” which means the percentage of bus capacity. The station coverage target is 100%, since the level focuses on stations, and the bus capacity is set at 20% minimum.

Figure 22 illustrates the Tools Panel view of Level 3. It shows the two types of stations that can be added to the street. Note that only about half the street is shown on the street portion of the screen; the whole street is shown in the stick map at the top of the screen. Since the “Info Station” icon has been selected it has been highlighted in green and yellow areas appear on the street where the station can be placed.

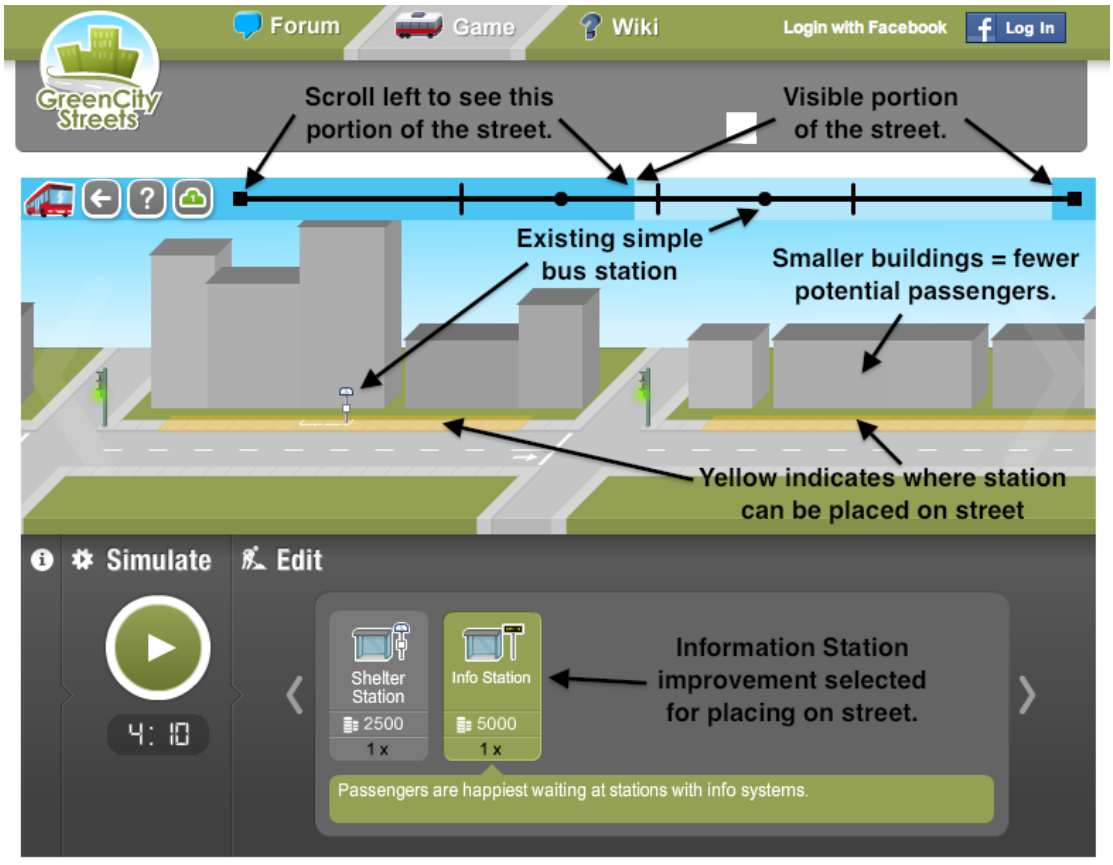

Figure 22 - BusMeister Level 3 - Tools Panel.

Level 3 is relatively easy to solve (although it’s hard to optimize) so a more detailed description is not provided here.

3.5 BusMeister Level 4 – Traffic Reduction

Streets have only a limited amount of space and so more traffic means more congestion, more congestion means slower speeds. When congestion reaches a relatively high level traffic flow breaks down and speeds drop significantly.

BusMeister simulates the impact of traffic on travel speed. The more traffic on the street the slower the traffic moves. As we have learned, speed is critical for public transport attractiveness and efficiency, so more traffic means worse public transport.

There are a variety of measures that cities can take to reduce the amount of traffic on their streets. These include;

- **Traffic calming** – these measures are designed to reduce traffic speed and volumes in neighbourhoods, they include improvements such as chicanes, raised cross walks, partial closures and traffic regulations. One guiding concept is to "move" traffic to designated streets and out of neighborhood-serving or public transport streets. More information including photos of traffic calming is available on the Best Practices wiki at: http://busmeister.wikispaces.com/intro_complimentary#livable.
- **Regulations** – cities can regulate traffic with signs and enforcement (e.g. traffic police and cameras) to reduce traffic. For example, a sign can be used to allow only public transport vehicles and bikes to use a certain portion of the street.
- **Congestion Charges or Limited Access Zones** – cities can reduce traffic by requiring that people pay a charge to drive in a specified area and/or requiring special permission to drive (e.g. residents only). These programs have been introduced successfully in many cities throughout the world. More information is available on the Best Practices wiki at: http://busmeister.wikispaces.com/intro_complimentary#charging.

BusMeister allows players to reduce traffic by three different levels: 30%, 60% and 90% which correspond to different levels of implementation of real world improvements. The higher levels of reduction cost more than the lower levels.

When these measures are applied to streets they cause the traffic in the lane used by the buses to be reduced by the given amount. These measures only work for the block where they are added, the traffic attempts to move back into the lane used by buses in the next block (unless another reduction measure is added to that block).

In Level 4 the target variable is "Traffic Happiness". This may sound odd for a public transport oriented game, but it's important to remember that the goal is not to make driving a car difficult just because, but rather to improve conditions for public transport (or some other worthy goal). This means that planners need to consider the needs of all types of transport when they make improvements.

Level 4 is a bit more complicated than previous levels because it has more traffic and it introduces a changing street width. As shown in Figure 23 the street width goes from 3 lanes to 2 lanes at the first intersection and from 2 lanes to 3 lanes at the second intersection.

Note that Figure 23 displays "Happy Face" indicators on the buildings, buses and bus stations. To do this simply click on the indicator icons to the right of the simulation speed control (they are highlighted in green when selected). Also note that the buses in the stick map at the top of the screen are green, this is another way of showing that the passengers are satisfied.

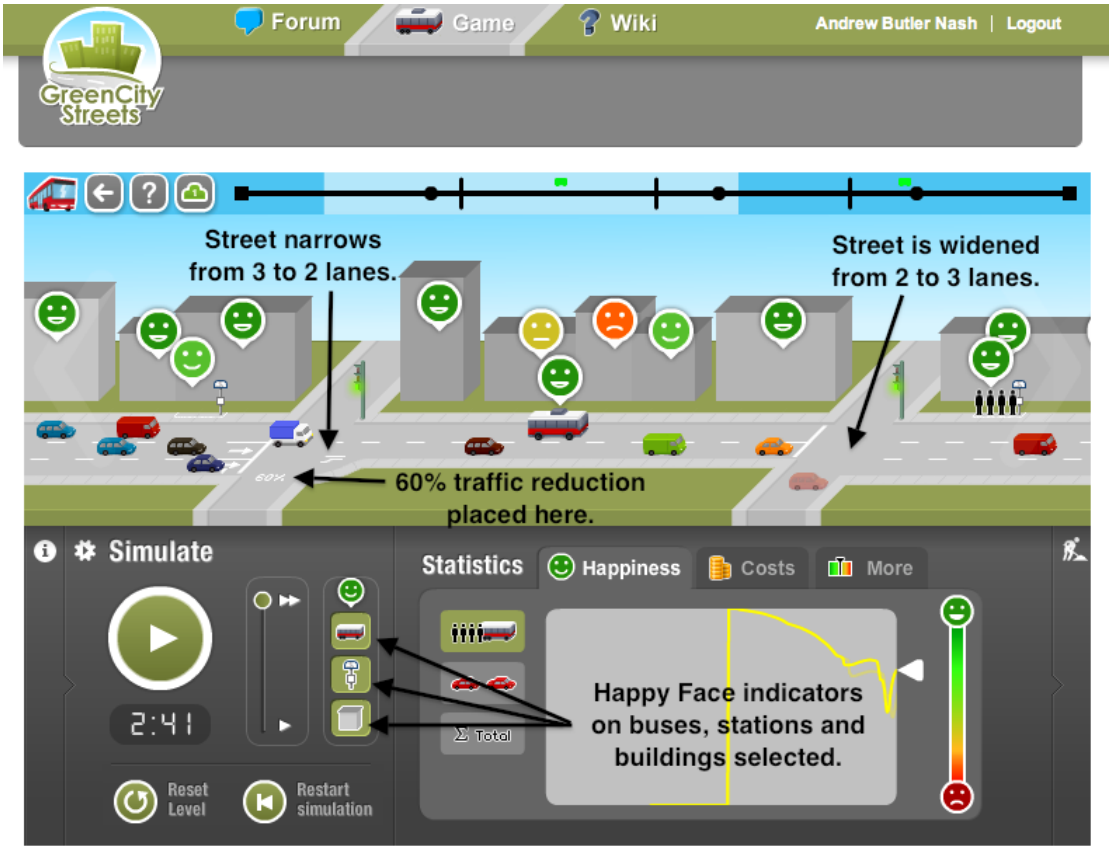

Figure 23 - BusMeister Level 4 - Screenshot.

In Figure 23 the 60% traffic reduction measure has been placed at intersection 1 because it is important to reduce the amount of traffic when the street is narrowed. If all the traffic from the three lanes of street from the first block were to proceed to the second block (with only two lanes) there would be a significant increase in congestion, which would reduce the happiness of bus passengers and traffic, as well as increasing public transport operating costs. This is shown in Figure 24, where Level 4 has been run with no improvement measures added to the street.

Solving Level 4 is a bit more complicated than previous levels and will likely take several trials. The traffic reduction measure is a bit complex because the traffic in BusMeister is not always the same. As in the real world the vehicle movement is based on how the vehicles around it are moving and the amount of traffic varies slightly from one trial to the next. This keeps the game interesting and is more similar to real life.

Figure 24 - BusMeister Level 4 - Street with traffic congestion.

3.6 BusMeister Level 5 – Transit Signal Priority

Level 5 introduces a new public transport improvement measure: transit signal priority (TSP). Transit signal priority means that traffic signals recognize when a bus or tram is approach and turn green so that the bus or tram can pass through the intersection without stopping.

There are a variety of ways which transit signal priority can be implemented in the real world including:

- **Simple Priority** – When a bus or tram approaches the intersection the traffic signal turns green.
- **Extended Green/Shortened Red** – The amount of time that the traffic signal is green can be extended if a bus or tram is within a specified distance of the intersection (extended green), or the amount of time that the traffic signal is red is reduced if a bus or tram is waiting in the queue (shortened red).
- **Schedule-based Priority** – The extended green/shortened red is only done if the bus or tram is running behind schedule (in other words if it is late).
- **Advanced Priority** – The traffic signal phases are adjusted based on a real time estimate of when the bus or tram will arrive at the intersection so that the bus or tram receives a green light when it needs it.

There are many specific techniques for implementing these types of priority systems. See Best Practices wiki (http://busmeister.wikispaces.com/intro_TSP) for more information.

The important point is that providing buses and trams with priority at traffic signals increases their speed, thus making public transport more attractive and efficient.

In the real world transit signal priority is not used as much as it could be since simple priority systems can create negative publicity. If automobile drivers see the traffic signal turn green for a bus, but then the bus slowly arrives and crosses the intersection, the car drivers complain that they have to wait unnecessarily. The more advanced techniques have been developed to address this problem but they are more complicated to design so they have not been implemented as much as they could be.

In BusMeister the transit signal priority improvement measure increases the amount of time that the traffic signal displays green for the street with public transport service. This is a simple way to model the extended green/shortened red approach to TSP.

Figure 25 illustrates the starting screen for Level 5 with the game just started. Notice that the street is fairly long (5 intersections), complex (it includes lane reductions) and that there are stations on each block. If you scroll to view the whole street you will see that only 2 of the intersections have traffic signals. The tools panel allows you to place 3 transit signal priority (TSP) traffic signals on the street. It's also possible to move/remove the existing traffic signals and bus stations.

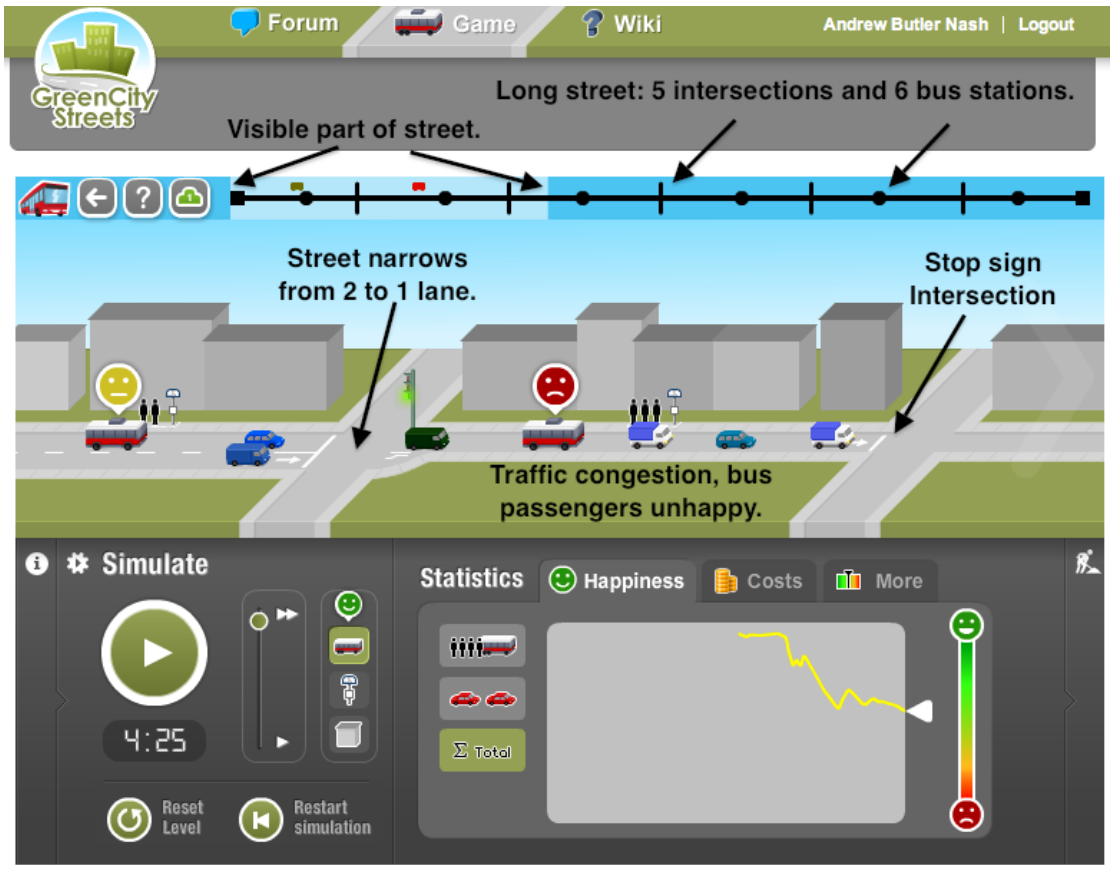

Figure 25 - BusMeister Level 5 - Initial conditions screenshot.

The best solution to Level 5 can be achieved by optimizing the locations of the bus stations and traffic signals (including deciding where the best places for TSP traffic signals).

3.7 BusMeister Level 6 – Bus Only Lanes and Bus Bulbs

Level 6 introduces two public transport improvement measures designed to help speed-up buses and trams: bus only lanes and bus bulbs.

Bus Only Lanes

Bus only lanes are lanes that can only be used by buses or trams. Since cars and trucks are not allowed to use these lanes buses and trams can travel quickly, free from traffic congestion. Many cities have created bus lanes on congested streets used by buses and trams. In some cases taxis and bikes can also use these lanes. Figure 26 illustrates a bus only lane on Neustiftgasse in Vienna.

Figure 26 - Bus only lane on Neustiftgasse Vienna.

(Need a better photo, one with a bus!)

Bus only lanes are often difficult to implement because they are politically controversial. A bus only lane means that the city must remove parking from the curb lane or designate a lane that has been used by cars, trucks and buses for use only by buses. This upsets the people who were formally parking or driving in the lane.

One of the biggest problems in implementing a bus only lane is that the people upset by losing parking or car drivers are much more active opposing the bus only lane than the many bus riders who would benefit from the lane, so decision-makers are unwilling to implement the bus only lane. A key BusMeister goal is teaching public

transport users how important improvements like bus only lanes are so that they become more active advocates for better public transport.

See Best Practices wiki (http://busmeister.wikispaces.com/intro_BSD) for more information.

Bus Bulbs

Bus bulbs are extensions of the sidewalk into the street at bus and tram stops. The objective of a bus bulb is to allow the bus to pick-up and drop-off passengers without pulling over to the curb. This speeds up the bus since it does not need to pull-in to the curb and especially since it does not need to wait for a break in traffic to pull-out from the bus stop back into traffic. Figure 27 illustrates a bus bulb.

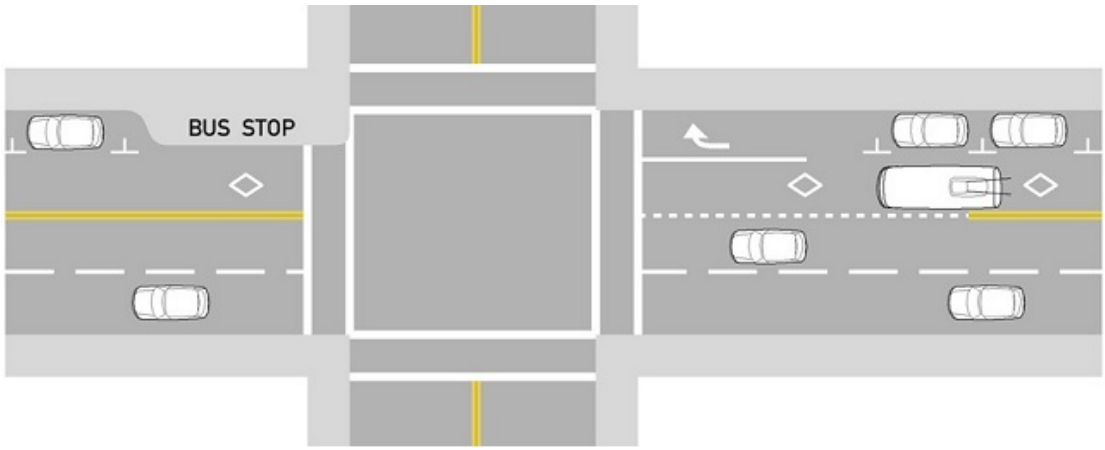

Figure 27 – Bus Bulb shown as: “Bus Stop” in figure. (Source: Michael Kiesling & Matthew Ridgway, Effective Bus-Only Lanes, 2006, http://www.arch21.org/BusLanes/BusOnlyPaper.html).

Bus bulbs also make it easier for passengers to board the bus since they are at the sidewalk level (several centimetres above the street level), otherwise passengers face a high step from the street level to the floor of the bus or tram. The reduction in height that a passenger needs to step up to also speeds up buses because passengers can board the bus more quickly.

Another way of speeding up passenger boarding is to use low floor buses and trams. These are not only more convenient and comfortable for passengers but also more efficient for public transport companies since they speed up service. Vienna’s Ultra Low Floor (ULF) tram illustrated in Figure 28 is an excellent example of a low floor tram.

Figure 28 - Vienna Ultra Low Floor (ULF) Tram

Bus Only Lanes and Bus Bulbs in BusMeister

In BusMeister, bus only lanes work similar to the traffic reduction improvements described in Section 3.5, except that they remove 100% of the traffic from the lane until the next intersection.

Adding a bus bulb to a bus station in BusMeister reduces the time it takes for passengers to board and alight the vehicle, and therefore reduces the amount of time the bus spends stopped at the bus station.

Figure 29 illustrates the game with no improvements. As shown the street is fairly complex (lanes are removed and added at intersections) and the traffic volume is high. This leads to congestion, which makes bus passengers unhappy and causes buses to bunch-up (see left side of street).

Bus bunching is one of the most common complaints about street based public transport: Why do I wait for 15-minutes and then 3 buses come at once? The answer is that when congestion delays the first bus, the second bus has fewer passengers to pick-up and so it goes faster, but the first bus goes slower, so eventually they catch each other.

See the Best Practices wiki for more information on Bus Bunching: http://busmeister.wikispaces.com/intro_OPS#busbunching.

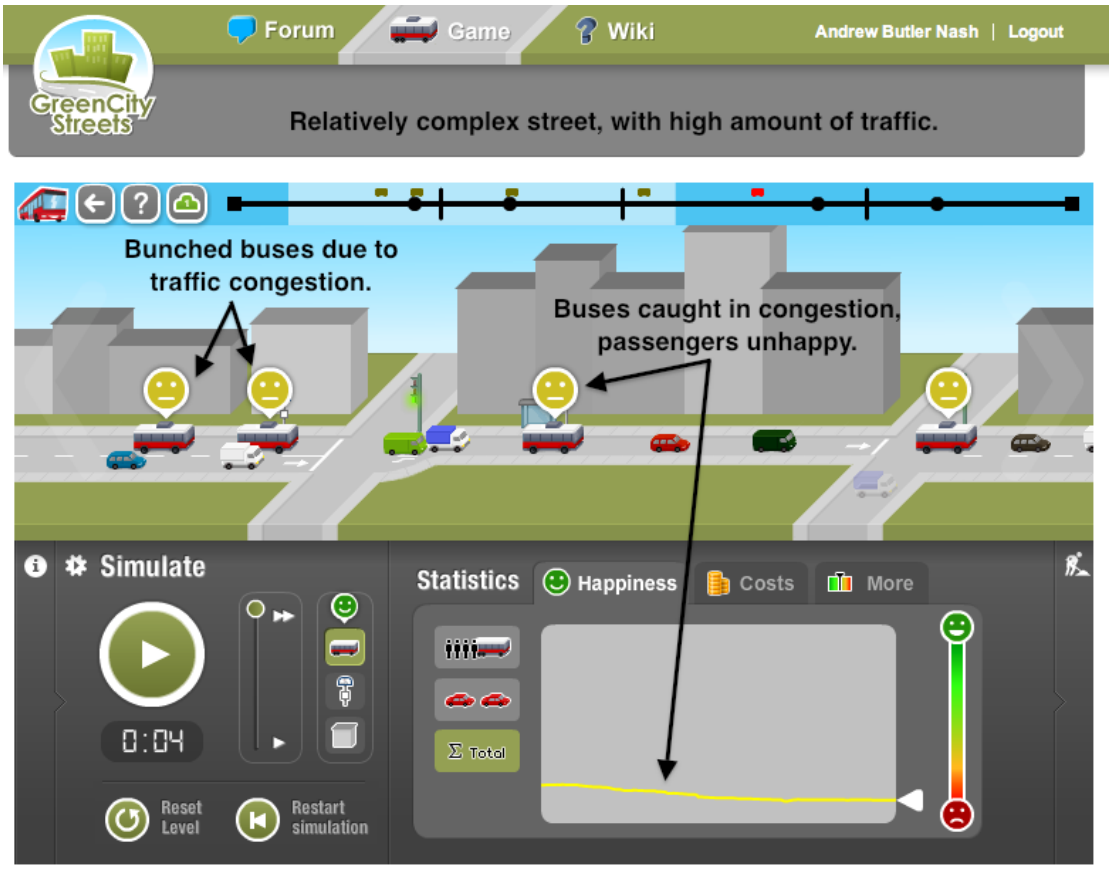

Figure 29 - BusMeister Level 6 - Initial conditions screenshot.

In order to solve this level players can add the bus only lane and bus bulb as well as moving/removing stations or changing the type of station. This level, as with all the more advanced levels, has many different solutions. Players can fairly easily achieve the required targets, but meeting the bonus targets is more difficult. This illustrates the real concept that there are many tradeoffs in planning public transport.

The biggest tradeoff in Level 6 is with cost. It is relatively easy to achieve the required target by using all the improvement measures, but this means players cannot meet the bonus target for cost. Again, this simulates real life, it's easy to solve problems with lots of money, solving problems efficiently is hard.

3.8 BusMeister Level 7 – Vehicle Settings

In Level 7 players have the opportunity to change the type of vehicle and how the vehicle operates. This is done with another tool panel, the Vehicle Settings Panel, which can be opened by clicking on the small white bus icon to the right of the improvement measures panel icon. (The Vehicle Settings Panel is only available in BusMeister levels 7 and higher.)

Figure 30 illustrates the vehicle settings panel (it's repeated from Section 2.7 above).

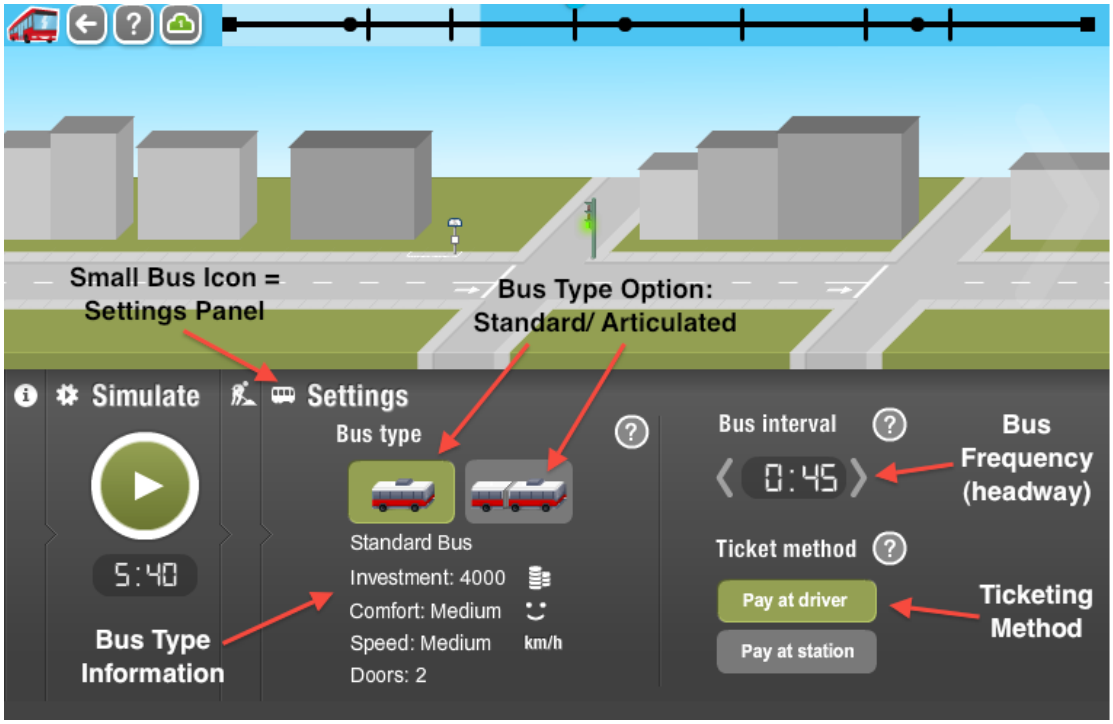

Figure 30 - BusMeister Vehicle Settings Panel

As shown in Figure 30 there are three vehicle settings that players can control:

- **Bus Type** – BusMeister currently provides two types of bus: standard and articulated (larger);
- **Bus Interval** – How often the buses come; and
- **Ticketing Method** – Where passengers pay their fares.

These three settings influence the bus speed and passenger comfort as outlined below.

Bus Type

The type of public transport vehicle used on a route is based on the number of passengers. More passengers generally means a bigger vehicle. From smallest to largest there are mini-buses, standard buses, articulated buses (long buses with an extra section at the end connected to the front of the bus with an “articulated” section), trams (streetcars) and metro vehicles (underground or heavy rail systems). BusMeister allows players to choose between standard and articulated buses (we hope to add more vehicle types in the future).

Each type of vehicle has specific characteristics. The main characteristics used by BusMeister are shown in the bus type information presented below the selected vehicle type. In Figure 30, the information shows that the standard bus costs 4000, it provides medium passenger comfort, medium speed and has two doors. These characteristics impact the way BusMeister calculates speed and passenger comfort.

The bus speed is influenced by speed (naturally) but also the number of doors: more doors mean that more people can board or exit the bus at the same time, thus reducing the amount of time a vehicle spends stopped at a station. In many cities, like Vienna, even standard buses have three doors to speed-up service.

The passenger comfort is influenced by the passenger comfort value (in BusMeister this is intended to account for things like seat comfort, ability to move around in the vehicle and cleanliness) and bus capacity (the capacity is not shown in the characteristics displayed, but is used by BusMeister to estimate passenger happiness). Capacity is important because when vehicles are crowded they are less comfortable for passengers. Furthermore, when vehicles are full of people they are also slower because it takes more time for people to board and exit the vehicle.

Bus Interval

The bus interval is the frequency of bus departures from the starting point. This is also called the route "***headway***". The bus interval helps determine passenger happiness and public transport operating cost.

In terms of passenger happiness, the bus interval helps determine how long passengers must wait for the bus at a station. Recall that when choosing which type of transport to use passengers consider the total travel time, so people riding the bus consider how long they need to wait for the bus. Longer waits make passengers less happy.

The general rule for estimating how long people wait for a bus is that they wait half the bus interval when the bus interval is less then 10-minutes or about 5-minutes if the bus interval is over 10-minutes.

The thinking behind this rule is that if the bus interval is less then 10-minutes, passengers do not worry about the schedule, they just arrive at the station and wait – so, on average they wait half the bus interval. In contrast, when the interval is over 10-minutes, passengers check the schedule and plan to arrive at the station based on when the vehicle should arrive. Notice that if buses are delayed, passengers will likely wait longer.

In terms of cost, the bus interval determines how many buses are operated on the route. A shorter bus interval means more buses are operated; this increases both the equipment (bus) and operating costs.

At this point it is important to mention that BusMeister uses a very compressed time period to make the game more enjoyable. This means that the bus interval ranges from about 30-seconds to about 2-minutes. In the real world very few bus systems operate with less than a 3-minute bus interval and an interval of between 5- and 10-minutes is considered to be excellent service. BusMeister calculates costs and passenger happiness correctly, the numbers are just smaller because of the compressed time frame.

BusMeister shows the bus interval in seconds. Click on the arrow on either side of the Bus Interval value shown in Figure 30 to increase or decrease the bus frequency.

Ticketing Method

The final vehicle setting is ticketing method. The way in which passengers buy tickets for public transport plays a major role in the vehicle speed. If all the passengers have to board the vehicle through the front door to buy a ticket from the driver (or show their ticket) it takes much longer than if passengers buy their ticket before boarding the bus and can board through any door.

Many public transport systems in the United States require that all passengers board through the front door to show their tickets to the driver. In contrast, many European systems require people to buy tickets in advance and allow them to board through any door (this is called "***proof of payment***" because fare inspectors randomly board

buses and ask to see the tickets for all passengers). For more information on ticketing please see the Best Practices wiki: http://busmeister.wikispaces.com/intro_vehicles#fcsystems

As shown in Figure 30, BusMeister provides two options: pay at driver requires everyone boarding the bus to enter through the front door and pay at station allows passengers to board through any door. This impacts the amount of time the bus spends stopped at the station and therefore the speed of the bus. The speed, in turn, impacts the operating costs (slower is more expensive) and the passenger happiness (slower means less happy passengers).

Using Bus Settings in BusMeister

In BusMeister players can select the different vehicle settings. Generally there is a tradeoff between vehicle size and bus interval: bigger vehicles allow you to operate service less frequently, this reduces operating costs, but can make passengers less happy since they may need to wait longer.

Figure 31 illustrates a screenshot from a game played with the initial vehicle settings and improvements. These settings did not meet the required targets. Figure 32 shows the initial vehicle settings.

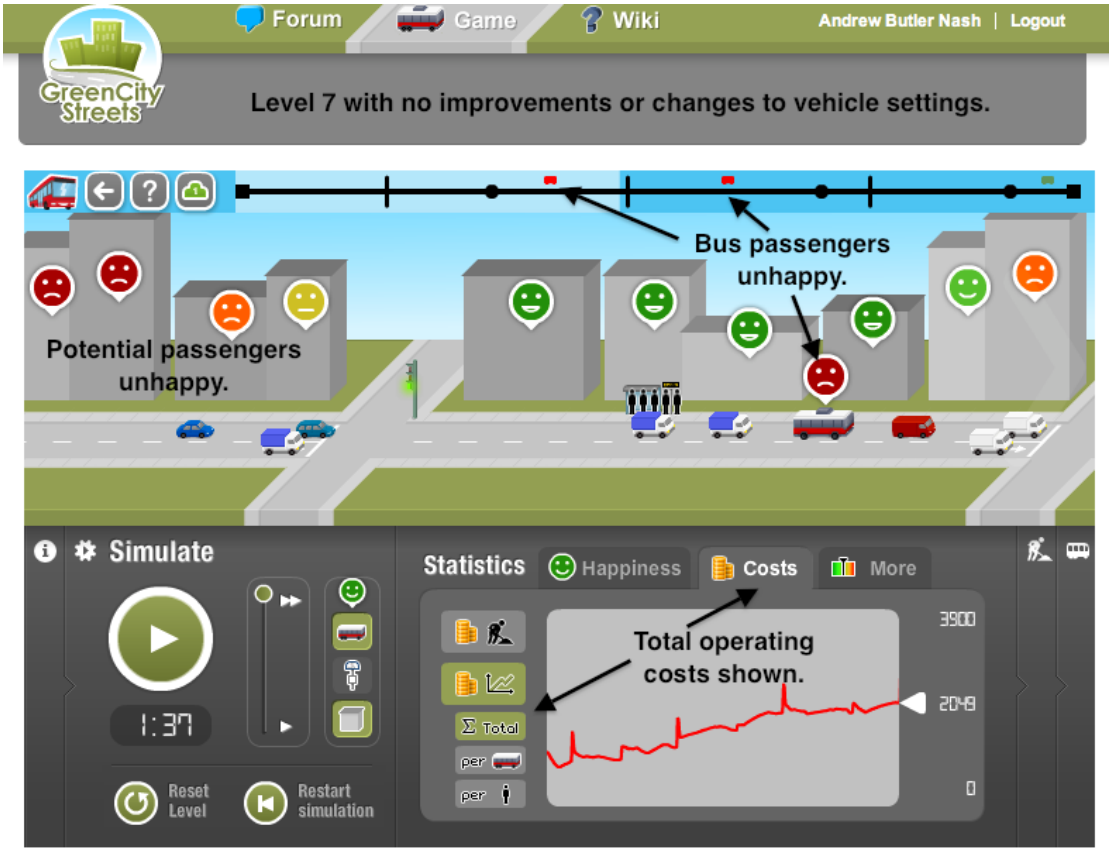

Figure 31 - BusMeister Level 7 - Initial conditions screenshot.

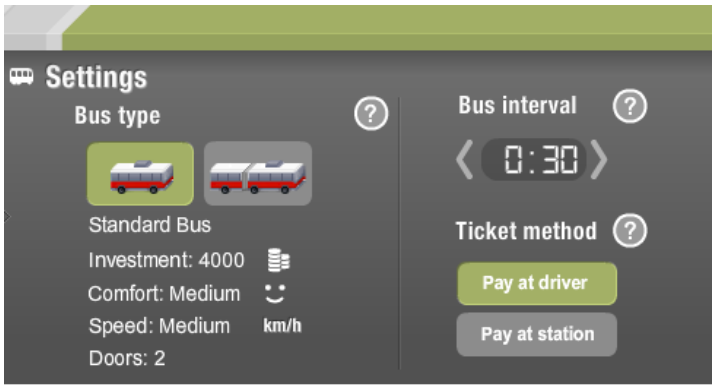

Figure 32 - BusMeister Level 7 - Initial vehicle settings.

The “Happy Face” information on Figure 31 and results from running the full game (not shown) provide ideas for what should be changed to achieve the Level 7 targets.

One problem is that the costs were high. To address this the bus interval could be increased and the ticket method could be changed from “pay at driver” to “pay at station”. Another problem is that potential passengers are unhappy, this suggested that stations should be moved to provide better service. Figure 33 presents results of a (quite good) solution that included these changes.

Of course there are many different combinations of bus type, bus interval and precise bus station locations that all meet the required targets, but they all will have different levels for each of the measured values, the objective is to try and get the highest score by identifying the best trade-off between the different improvements and settings.

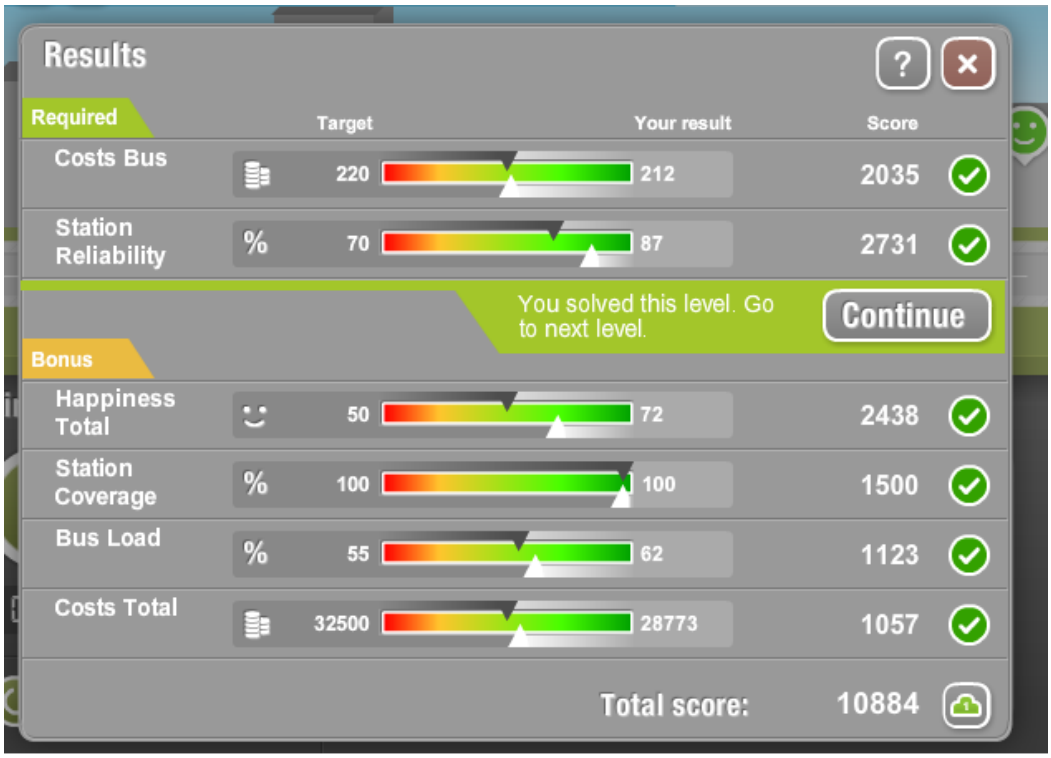

Figure 33 - BusMeister Level 7 - Results from one possible solution.

3.9 BusMeister Level 8 – Suburban Neighborhood

Level 8 is the first level where players start with a relatively undeveloped public transport line and they can add improvements and change vehicle settings to develop the basic service.

Level 8 is designed to illustrate the difficulty of serving suburban neighbourhoods with public transport. The problem, in a nutshell, is that there are not enough people living in suburban neighbourhoods to support high quality public transport service. Providing frequent service is simply not possible without spending a great deal of money. Another problem illustrated in Level 8 is that suburban neighbourhoods often suffer from traffic congestion because people need to drive their cars more than in the city.

In Level 8, players must focus on providing good public transport service at a relatively low cost. It is especially important to reduce the impacts of congestion on bus service.

Beginning a Higher Level BusMeister Game

Step 1 – The first step in playing more complex level BusMeister games is to survey the initial conditions and what improvements are available.

- Look at the stick map at the top of the screen: how many bus stations are there? Are the stations well distributed? How long is the street? How many intersections are there?
- Scroll to the right and left on the street: how large are the buildings? Where will passenger demand be highest? Are there changes in the number of lanes that could cause traffic congestion? What types of traffic control are placed at intersections (stop sign, traffic signals or TSP traffic signals)?
- Click on the Tools Panel icon: what improvements can you add to the street? Be sure to use the arrow button to scroll through to see all the improvements available.
- Click on the Vehicle Settings icon: what are the initial vehicle settings? How might they be improved to solve the particular problem posed in this level?

Step 2 – The second step is to start the game without adding any improvements and changes:

- Scroll along the street to see where problems develop. Use the Happy Face indicators to help identify problems (they are especially helpful for identifying where stations are too far from potential passengers).
- How much traffic is there on the street? Are there places where you see congestion? How happy are bus passengers (check color of buses in stick map)?
- Click on the various real time statistics tabs to see how the overall system is working. You should pay particular attention to the statistics related to the required goals.

Step 3 – Think about the general goal for this level and the problems you saw when you played the game without improvements:

- Begin making improvements and changes to the vehicle settings.
- You may want to make simple sketches of the street (similar to the stick map at the top of the screen). Indicate on these sketches where you place improvements and what vehicle settings you use. This will be helpful when you try to optimize the route operations. (See Figure 34 for an example sketch).

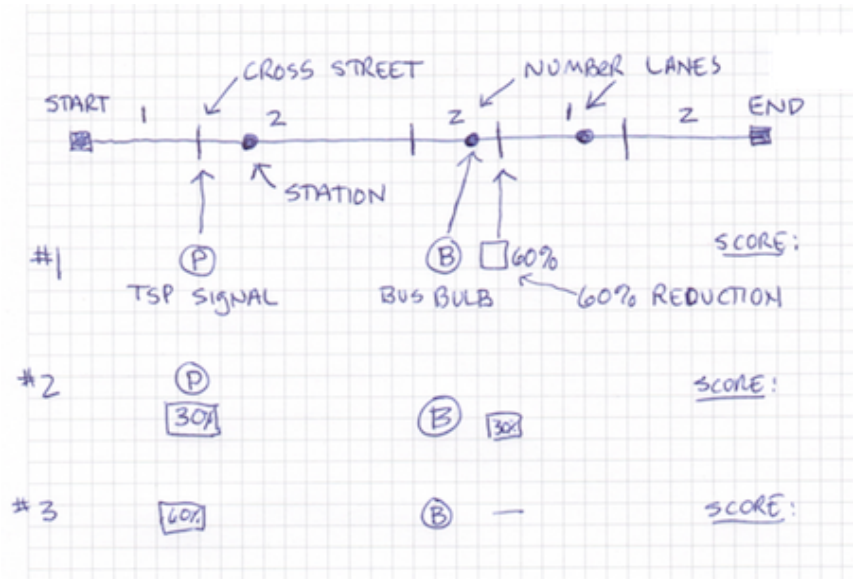

Figure 34 - BusMeister Level 8 - Sketch solutions.

- Play the game with your improvements. Scroll along the street to see how they are working: are you serving most of the potential passengers? Is there noticeable congestion? How do the real time statistics look?
- View your results. Did you meet the required goals? What about the bonus goals?
- Try to improve your score. The goal in BusMeister, as in real world planning, is to optimize public transport service. Try to achieve all the bonus goals and increase your score.
- In some BusMeister levels it is fairly easy to meet the required goals by adding all the possible improvements – but the best scores come from meeting the goals with the minimum possible number of improvements since this reduces costs. This is where your sketches will come in handy, keep track of what changes you make so you can identify the best solutions.
- Have fun.

Playing BusMeister Level 8

Figure 35 illustrates the initial conditions for BusMeister Level 8. The annotations present assessments based on the questions described in Step 1 above.

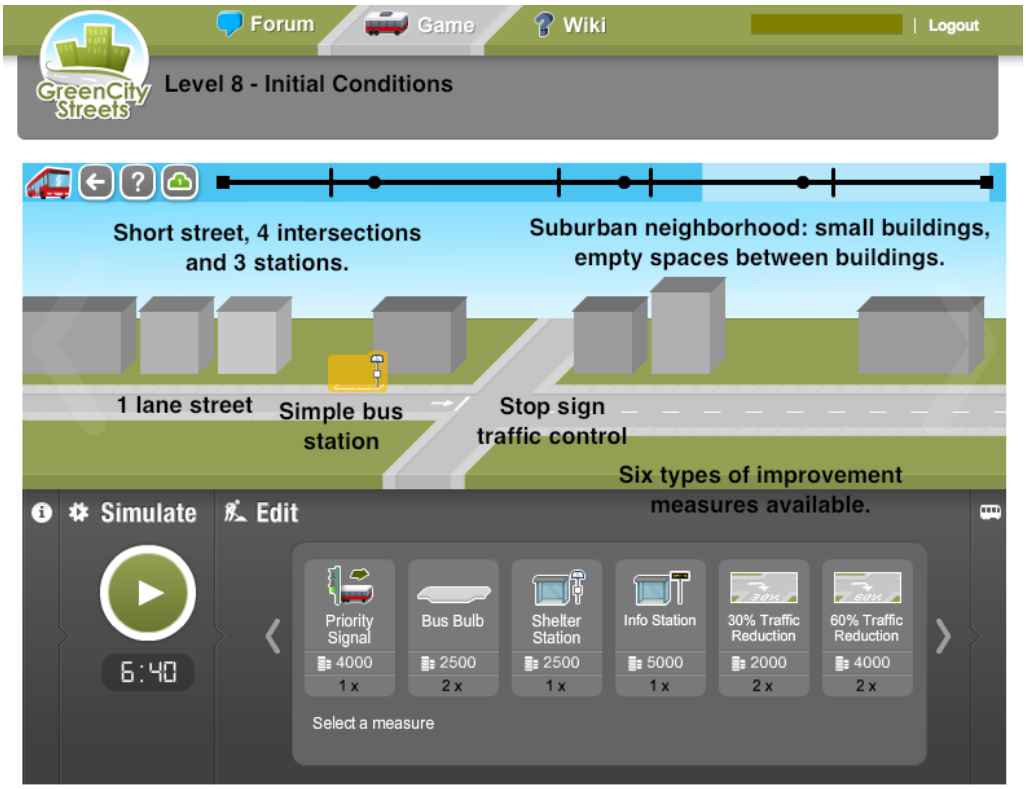

Figure 35 - BusMeister Level 8 - Initial conditions screenshot.

As shown in Figure 35, the buildings are small and spread apart indicating relatively low potential patronage. The intersection is controlled by a stop sign, which is fine when there is little traffic. The bus station is simple, this makes sense in areas with low demand in order to reduce costs. Six different types of improvement measures are available, several can be used twice.

Running the game without improvements shows significant congestion. Intersections where the street narrows and with stop signs have especially long traffic back-ups. This illustrates another common problem in suburban areas; people need to drive their cars everywhere, thus increasing congestion.

The results of running the game show that the bus passenger happiness is very low. This is due to the very low bus speed (when you watch the game you can see that the buses are red in the stick map). Therefore, the first objective should be to improve the speed.

There are several improvements available in this level to improve speed: the traffic signal, bus bulb and traffic reduction improvements. Experiment with adding these to the street and check the results. Once you have a successful solution, try to achieve the bonus goals – especially the total costs goal. Figure 34 (above) illustrates my worksheet sketches for some of the solutions I tried in Level 8.

Figure 36 illustrates the results panel for my final solution, it's pretty good if I do say so myself. I really focused on trying to understand the problem and then minimized the number of improvements that I used to solve this problem. There are better solutions possible, so try to beat this one!

Figure 36 - BusMeister Level 8 - Results for one potential solution.

3.9 BusMeister Level 9 – Small City

Level 9 consists of optimizing a bus line in a small city. Again players have a wide variety of improvement measures to choose from and can adjust all the bus settings.

In Level 9 the street is two lanes wide along its entire length. It has a variety of traffic controls and three bus stations. Buildings are moderately sized and relatively close together.

Providing public transport in small cities can also be a challenge because many people will choose to drive since often parking is easy to find and there is not as much congestion as in large cities.

Figure 37 illustrates BusMeister Level 9 with the initial settings. Several obvious problems are identified in the annotations including the insufficient number of bus stations, the congestion that builds up due to stop sign controls and the low satisfaction of bus passengers due to the slow speed.

Again there are many ways to achieve the target goals and to further improve the situation so that you can achieve the bonus goals as well.

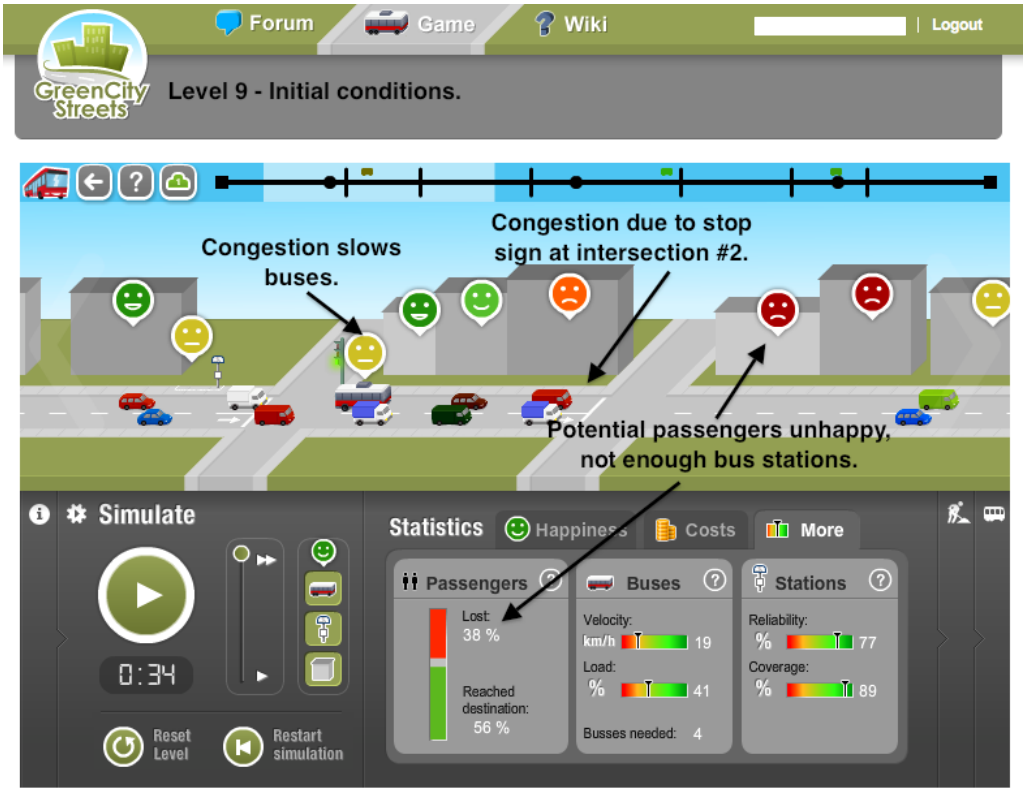

Figure 37 - BusMeister Level 9 - Initial conditions screenshot.

One strategy for solving these advanced levels is to place more improvements on the street then necessary and use the vehicle settings to provide a high level of service, then, once you have achieved the required goals you can gradually reduce the number of improvements until you optimize your score. Figure 38 presents the results from one potential solution.

Figure 38 - BusMeister Level 9 - Results for one potential solution.

3.11 BusMeister Level 10 – Choke Point

BusMeister Level 10 is designed to illustrate a choke point. This is an area where the street becomes very narrow. These choke points often occur in downtown areas.

As you can see from scrolling along the street the Level 10 street starts with 3 lanes, narrows to 2 lanes in the second block, narrows to only 1 lane in the third block, then widens to 2 lanes in the fourth block and to 3 lanes in the fifth block. The building size is largest in the third block – where the street is the narrowest! This is similar to real cities where downtown areas often have the most people but the least street space.

The initial street setting only has one bus station. All the intersections are controlled by traffic signals. The full set of improvements can be placed on the street.

It should be clear that more bus stations will be needed and that the lane narrowings will cause traffic congestion. Running the game with no improvements shows that this is correct. Figure 39 illustrates a portion of the street showing six buses bunched together due to the congestion generated at the first street narrowing and that all the buildings on this section of the street are filled with unhappy potential passengers.

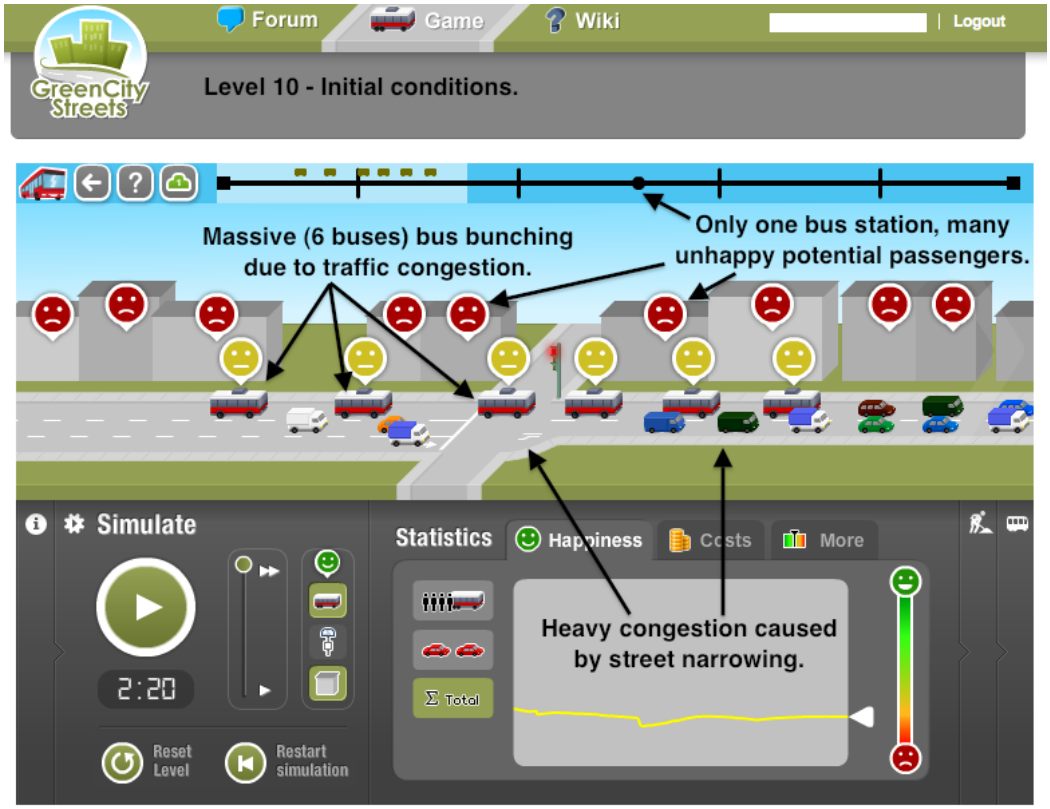

Figure 39 - BusMeister Level 10 - Initial conditions screenshot.

While it is fairly easy to understand the problems in Level 10, it is a complex situation – again similar to real cities – and it may take several trials before you meet the required goals and several of the bonus goals. If you meet all the goals send us a mail – it's really hard!

3.12 BusMeister Level 11 – Two Cities

Level 11 presents the situation of two cities connected by a wide roadway. There are lots of buildings in the cities but few in the connecting section. The streets are two lanes wide in the two cities and three lanes wide in the connecting section. In the initial conditions there are only two bus stations so it is clear that players will need to add several bus stations.

While the title of this level is “Two Cities” it also demonstrates a common situation inside cities where there are several locations with lots of buildings and activity. Bus routes often connect these locations so people can go from one to the other. One strategy to improve service on these types of routes is to have fewer stations in the less developed areas to increase vehicle speed.

Figure 40 is a screenshot from running the game with no improvements or changes to vehicle settings. As expected the total happiness is low, many passengers are unhappy and there are several locations with heavy congestion.

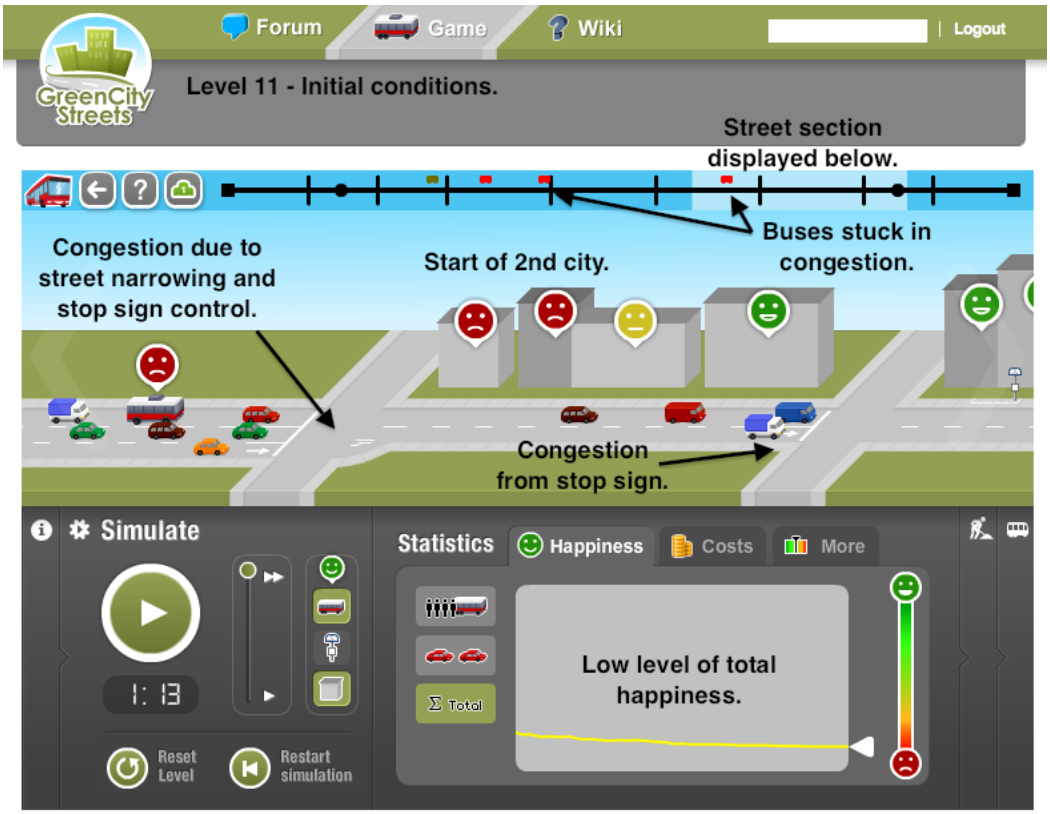

Figure 40 - BusMeister Level 11 - Initial conditions screenshot.

Level 11 requires players to add many improvements to the street. Remember to scroll through all the possible improvements when you open the “Tools Panel” by clicking on the arrows at the right and left side of the improvements box.

The best process for solving this level is to begin by adding improvements and setting the service characteristics to a high level until you achieve the required goals. Then make changes to try to maximize your score and achieve all the bonus goals. Often it’s a good idea to change only one thing and see how that impacts the score. Again, sketching your solution and keeping track of the score for each solution on a piece of paper is a handy way of working.

3.13 BusMeister Level 12 – Big City

Level 12 starts with only one bus stop and a long street. Players can add all the different improvement measures and adjust all the vehicle settings to develop the best possible public transport service.

The street has seven intersections, two narrowings, one widening and different sized buildings on the blocks. This gives players a chance to see how different improvement measures and vehicle settings can be used to improve service.

The difficult aspect of this level is achieving the required goals and optimizing your score while keeping within the cost goal.

Figure 41 illustrates the start screen when you have completed all the levels. You can go back now and replay the levels where you have not met all the bonus goals or any level where you want to improve your score. Levels where all the bonus goals have been met are indicated by green circles, levels where all the bonus goals have not been met have circles that are partially red.

Good luck and let us know what you think of the game!

Figure 41 - BusMeister Start Screen - After completing all levels.

4. BusMeister Evaluation Measure Definitions

This chapter describes the evaluation measures used in BusMeister as “Required Goals” and “Bonus Goals”.

4.1 Costs

In BusMeister, as in the real world, there are two general types of cost:

- ***Capital Costs*** are the costs of building improvements (for example installing a traffic signal) and buying vehicles.
- ***Operating Costs*** are the costs of providing the public transport service.

Capital Costs

BusMeister calculates capital costs by adding the cost of improvements players place on the street to the cost of public transport vehicles (buses) needed to operate the service. To calculate the cost of public transport vehicles, BusMeister multiplies the cost of one bus by the number of buses used (the cost of buses is shown in the vehicle settings panel as shown in Figure 30).

The number of buses needed to operate service depends on the bus interval (headway) and the speed of the buses. As in the real world, if the buses are fast fewer buses are needed to operate the service, but if bus speed is slow more buses are needed. The number of buses needed to operate service is shown in the “More” statistics tab as shown in Figure 11.

To view capital costs for an alternative click on the “***Costs***” statistics tab and select the capital cost icon (“Man at Work” icon) as shown in Figure 14.

Operating Costs

In BusMeister the operating cost consists of the public transport ***vehicle operating cost*** minus the fare revenue. In the real world other items could also be included in the operating costs such as the cost of maintaining the bus stations or the cost of enforcing the bus only lanes. But considering only vehicle operating cost is sufficient since this represents the overwhelming majority of operating costs.

In the real world vehicle operating cost is calculated on the basis of time; in other words the number of hours that the vehicles take to operate the service. This time is determined by the speed of the vehicles: faster speeds = less time and therefore lower cost. The same method is used to calculate operating cost in BusMeister, the amount of time it takes to complete the trip is multiplied by a cost per minute for operating the vehicle (as shown on the vehicle settings panel, different vehicles have different operating costs). The cost of all trips is summed to calculate the total vehicle operating cost.

This illustrates the key public transport trade-off: it’s possible to make capital improvements to the street that increase the public transport vehicle speed. Increasing the speed reduces the number of buses needed to operate the service (reduces capital costs) and reduces the vehicle operating cost. The trade-off is how much should be invested in capital improvements to achieve a given decrease in operating costs?

(Could have an example here.)

To calculate operating cost BusMeister subtracts passenger ticket revenue from vehicle operating cost. The ticket revenue is calculated by multiplying an average ticket price by the number of passengers. The ticket revenue is subtracted from the vehicle operating cost to calculate the net operating cost.

Here again it is possible to see the benefit of speeding-up public transport service: faster service attracts more passengers = more fare revenue. In BusMeister the number of public transport passengers attracted increases when speed increases (click on the "***More***" statistics tab to see the passengers carried/lost statistic).

In summary, speeding-up public transport service provides benefits both in terms of lower vehicle operating costs, a reduced need for vehicles and increased passenger revenues.

BusMeister Cost Variables

BusMeister uses the following costs in the required and bonus goals:

- **Costs Total** – This is the total of operating and capital costs.
- **Costs Bus** – This is the net operating costs (i.e. vehicle operating cost minus fare revenues).
- **Costs Passenger** – This is the fare revenue.

4.2 BusMeister Happiness Variables

Happiness is a measure designed to show how satisfied people are with the transport system. It is important to emphasize that BusMeister considers both public transport passenger and driver happiness in the game.

Happiness Passenger

The most complex part of BusMeister's happiness calculation is passenger happiness. This is similar to the real world because there are many factors that influence the happiness of passengers. In BusMeister the following data are used to calculate passenger happiness:

- **Distance to Bus Station** – the closer the station the more happy the passenger; beyond a certain distance passengers will not walk to the station (these are reflected as lost passengers);
- **Waiting Time at Bus Station** – the less time spent waiting for a bus the more happy the passenger. The quality of the station also impacts happiness: in BusMeister there are three types of stations: simple (lowest quality), shelter and information (highest quality). For each of these station types BusMeister calculates a different happiness value based on the amount of time each passenger spends waiting (the station Happy Face indicator shows how happy passengers are at any time). If the waiting time is over a specified amount (different for each station type), the passenger is lost.
- **Travel Time** – the faster the public transport trip the happier the passenger;
- **Bus Capacity** – crowded vehicles mean less happy passengers; it a bus is at capacity it will leave potential passengers behind at bus stations;
- **Vehicle Comfort** – different public transport vehicles have different comfort levels.

This description of passenger happiness elements illustrates some of the tradeoffs involved in real world public transport planning including:

- More bus stations means passengers have to walk shorter distances, but this slows down service, increasing waiting time, travel time and operating costs;
- More frequent public transport service reduces wait time, leads to less crowded vehicles and increases comfort, but increases operating costs;
- Larger, more comfortable vehicles increase happiness but also costs.

The BusMeister game is designed to help illustrate these tradeoffs and help people think about how best to balance the competing goals in a complex public policy environment.

Players can view the passenger happiness in real time by clicking the "**Happiness**" tab on the statistics panel, then selecting the bus and person icon at the top, as shown in Figure 10.

Happiness Traffic

The happiness traffic value is designed to estimate the happiness on automobile drivers on the street.

The main factor used to determine traffic happiness is the speed. This is consistent with real life as people want to get to their destination as quickly as possible.

BusMeister creates a simple simulation of vehicle movement. Vehicles have a maximum speed and road sections have a maximum speed set in the game. The actual speed depends on the amount of traffic: more traffic = slower speed. This is the same as real life and also more complex transport simulation models.

Vehicles can change lanes when there is space available and when they are moving slower than the maximum speed (although this happens rarely).

The public transport vehicles move the same way but their maximum speed is lower and they always stay in the curb lane.

The second factor used to determine traffic happiness is the ability to drive on the BusMeister street. This means that adding traffic reduction or bus only lane improvements to the street reduces traffic happiness. This is similar to real life since when drivers are forced to make detours it takes longer to reach their destination. On the other hand it's important to remember that there are many people on the bus who benefit and only a few drivers who are delayed.

Players can view the traffic happiness in real time by clicking the "***Happiness***" tab on the statistics panel, then selecting the automobile icon in the middle, as shown in Figure 10.

Happiness Total

The total happiness is the weighted average of the passenger happiness and the traffic happiness.

The goal of any transport system is to provide the most benefits possible. A simple way of looking at this is that vehicles that carry more people should be given more priority. This is what the total happiness value describes.

For example, if ten cars carrying two persons each are delayed by the same amount as one bus carrying 25 persons is sped-up, there is a net increase in efficiency (and therefore happiness).

Players can view the total happiness in real time by clicking the "***Happiness***" tab on the statistics panel, then selecting the summation icon at the bottom, as shown in Figure 10.

4.3 Additional BusMeister Variables

In addition to cost and happiness BusMeister calculates several variables that help determine the quality of public transport service in more detail. These variables are important for planning public transport service and can help BusMeister players determine how to optimize improvements and vehicle settings (especially in the more complex levels).

Players can view all these variables in real time by clicking the "More" tab on the statistics panel. The statistics are displayed as shown in Figure 42.

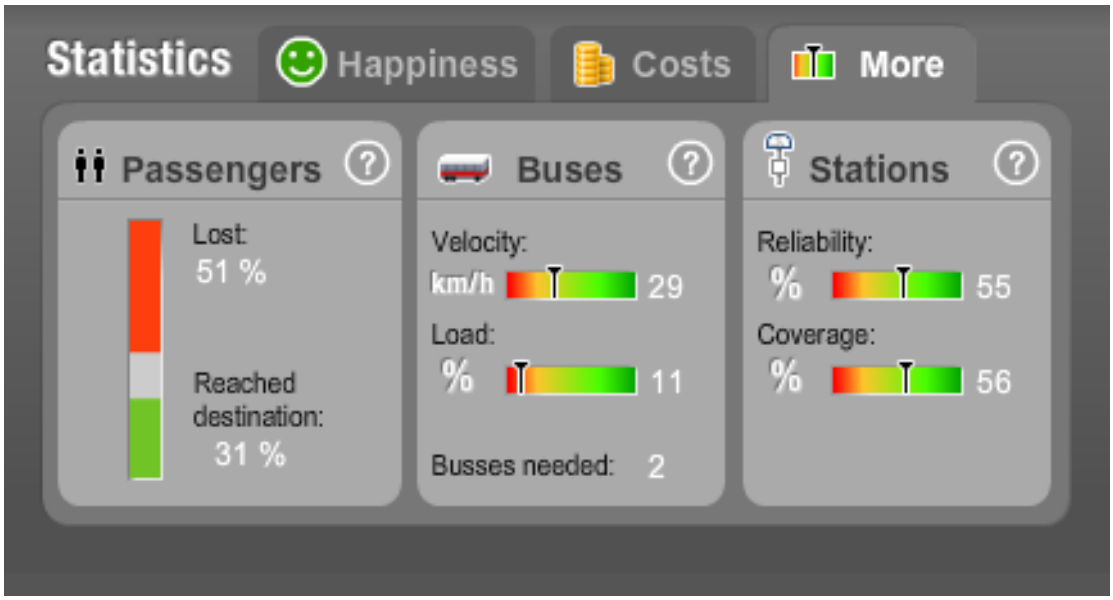

Figure 42 - BusMeister more statistics display.

Passengers Transported

The passengers transported variable shows what percentage of potential passengers are attracted to the public transport service.

You lose passengers if they need to walk too far to reach the station, if the passengers need to wait too long at the station, or if the vehicles travel too slowly.

It's important to realize that you don't have to attract all the passengers. It may be too expensive or slow-down service too much to achieve this goal.

Buses

The buses variables consist of the following:

- **Bus Speed** – simply the average speed for the bus, the higher the better.
- **Bus Load** – the percentage of seats occupied on the bus; this is complicated because a higher load means lower costs, but less passenger comfort, it's important to find the right balance.

- **Buses needed** – this is not used as a required or bonus goal, but is quite useful in helping optimize service during the game.

Stations

There are two stations variables:

- **Station Reliability** – station reliability compares the bus interval at stations to the bus interval at the route start. For example, if the bus interval at the route start is 45-seconds but the buses are delayed in congestion so that they only arrive at the stations every 60-seconds, this is unreliable service. The percentage is calculated based on all the arrivals at all the stations.
- **Station Coverage** – station coverage is the percentage of potential passengers within walking distance of a station. As in real life passengers living relatively far from a station may be able to walk to the station, but because walking takes a long time, they may be unwilling to wait for the bus or to ride the bus because the total travel time would be too long – these passengers are then lost. This means that it's possible to have 100% station coverage but still lose passengers.

5. How well does your public transport system work?

Now that you have learned the basics of public transport system planning, why not take a look at how public transport works in your city? This section provides some ideas on how you can do that.

5.1 Field Work

Unfortunately, city streets can be dangerous places. Many people drive too fast and many drivers are distracted by telephones, conversations and activities occurring on the sidewalk or in the street.

Therefore, the first rule for doing any activity near a street or road is to ***BE SAFE***. This means staying on the sidewalk, even keeping your distance from the curb and not getting involved in pushing and shoving your friends.

When you are doing field work, where you may be making a sketch of a street, copying information into a notebook or taking a photo:

- Always pick a safe place on the sidewalk out of the way of cars and pedestrians.
- Stand in that safe place and fully complete the activity.
- Put down the sketch pad, notebook or camera.
- Look around to re-orient yourself to your surroundings before moving (if you start moving before really looking-up, you place yourself at risk).

It's unfortunate, but if you spend a little time observing traffic on city streets you will probably be amazed by how many people are driving their cars or trucks, but not really paying attention to the street. Cars and trucks are massive pieces of equipment compared to the human body, they cause real damage. That's why you need to be extremely careful around streets.

5.2 Observing a Public Transport Route

The best way to understand a public transport route is to walk along the route observing the physical conditions and the bus or tram operations. Stop frequently and make a simple sketch of what you see (following the common sense guidelines above).

One good idea is to make a simple stick diagram sketch of the route (or part of the route) and then fill in details on your walk. You can use computer mapping devices like Google Maps to create your stick map. Figure xx presents a stick map for a portion of the Bus 48 route in Vienna.

Figure xx – Stick map developed using Google Maps for WienerLinien 48A Bus.

When you are making your observations consider all the improvements you learned about playing the BusMeister game:

- How wide is the street (how many lanes)?
- Is there a bus only lane?
- Are there improvements that reduce the amount of traffic on the street?
- Where are the bus stations? What type of bus stations are on the route?
- Do the stations have bus bulbs? Does the bus need to wait to pull out into traffic after picking up passengers?
- What type of traffic control is provided at each intersection: stop sign, traffic signal, public transport priority traffic signal, stop sign for one direction only?
- Are there traffic signals or stop signs at intersections?

Figure xx illustrates a sketch completed for Bus 48 route in Vienna. Of course you can also take photos of interesting things you see on your walk.

Figure xx – Stick map with route information for WienerLinien 48A Bus.

After walking the whole route it's time to watch how the public transport works. Try to determine the information shown in the BusMeister vehicle settings panel:

- What type of vehicles are used?
- What is the bus interval (frequency, headway)? You can find out by looking at a schedule posted at a station or via the internet.
- What type of ticketing is used (pay driver or buy ticket in advance)?

Once you have this information you may want to just watch how the vehicles operate. Do you notice any problems? Check a few locations and take photos if you have a camera.

Finally you should ride the bus to get a better idea of how it operates. It's especially useful to ride when the bus is full (in the morning or afternoon peak hour) because this is when the most problems occur. Keep track of what problems you see and where you notice them. Figure xx illustrates notebook entries for several trips on the 48A Bus in Vienna.

Figure xx – Problems noted on 48A Bus in Vienna.

5.3 Developing an Improvement Plan

Once you know what the street looks like and have observed the public transport route in operation it's time to think about how the route might be improved.

First, make a list of the problems you observed. You might want to make a notation of these problems on your stick map. You could also create a computer map based on Google Maps or some other geographic or drawing program.

Second, consider these problems, did you notice similar problems when playing BusMeister? For example, did you notice any locations with lots of traffic congestion that slowed down the bus? Did you notice locations without traffic signals that slowed down the bus? Did people have difficulty boarding or exiting the bus?

Third, could any of the BusMeister ideas be applied to the route to help improve service? What about a transit signal priority traffic signal? A traffic reduction improvement? A bus only lane? Write down potential solutions on your stick map. Figure xx illustrates some ideas for improving the 48A Bus in Vienna/

Figure xx – Ideas for improving Bus 48A in Vienna.

Finally, once you have identified all the possible solutions, try to identify the priorities. What improvements could make the most difference in improving service? Also, are there any tradeoffs that would need to be considered if you wanted to implement this improvement?

These are not easy questions and the best way to approach them is to discuss them in groups. One method is for one person to play the role of the bus company, another person to play the role of a bus passenger, another plays a shopkeeper on the street and a fourth is a car driver. What are the pros and cons of different improvements.

Another activity would be to invite a transport planner from your city or bus company to speak to the class and present the planner with your ideas. The planner can then give you more information about how easy it would be to implement your recommended improvements. Maybe you will find a good idea the city has not thought of!

6. Resources and References