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Sky Harbor Rental Car Facility Layout and Throughput Analysis Challenges Met by Dynamic Modeling

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Sky Harbor Rental Car Facility Layout and Throughput Analysis Offers Unique Challenges Best Met by Dynamic Modeling

By Amy Brown (Nashville), Jeff Jarvis (Phoenix), and Randy Gibson (San Diego)

The Phoenix Sky Harbor International Airport is one of the busiest airports in the United States and services over 40 million passengers annually. In January of 2006, a consolidated rental car center opened to simplify the car rental process. Upon leaving the airport, passengers board a rental car bus, which takes them to a facility containing all major rental car companies. This reduces confusion in locating a rental car location and provides efficiency improvements by requiring the rental car companies to share shuttle resources.

Challenge: Determine the Layout that Would Most Increase Throughput

For planning purposes, the airport wanted to know how to increase the capacity of the bus system if that became necessary. TranSystems developed several layout alternatives, and together with the airport and rental car companies, reduced the number of potential layouts to three.

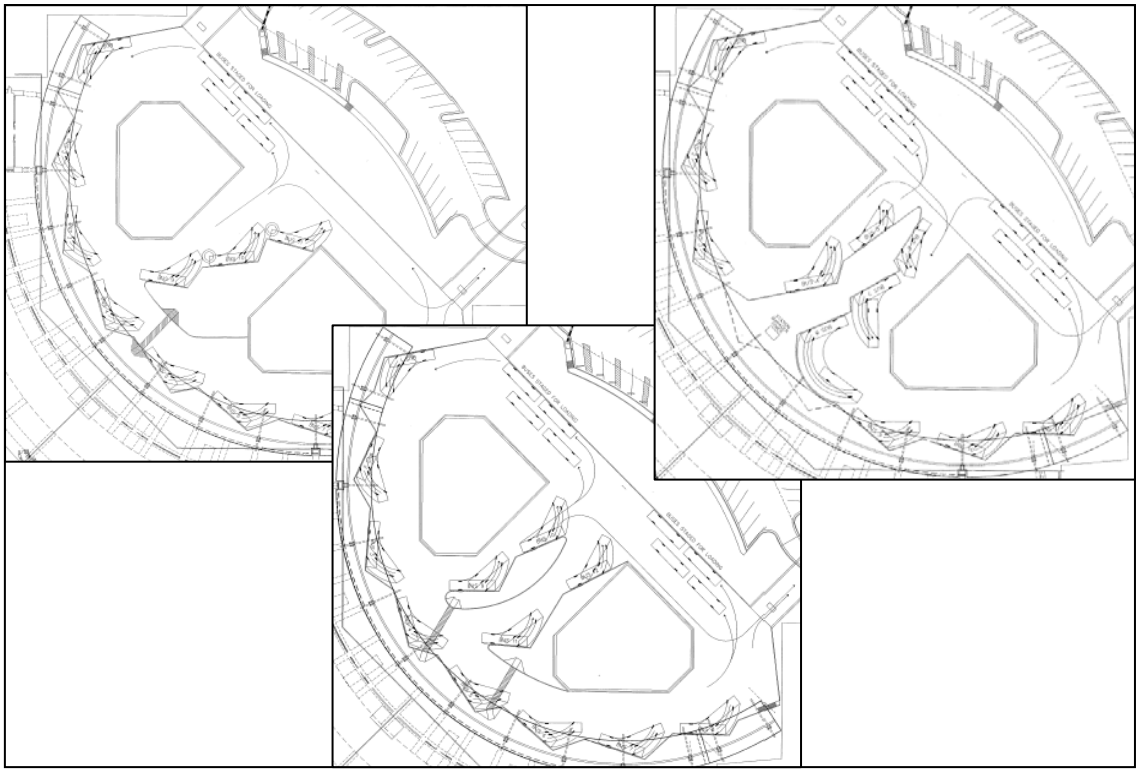

Figure 1 - Bus Loop Layout Alternatives

Because of the dynamic nature of the system, it was difficult for the team to determine which layout would increase throughput the most. While one layout had an extra bay, it also may have additional bus congestion, potentially slowing down the overall system. Two of the layouts also required crosswalks, which created concern the system would be slowed down by buses waiting for pedestrians and pedestrians waiting on buses to cross.

The primary objective of this project was to determine which layout alternative provides the RCC with the highest passenger throughput capability. As demand increases, the RCC must be sure it has the capacity to process passengers in a timely manner. An increased passenger throughput rate results in a higher number of passengers that can be processed, without incurring excessive wait times.

Solution: A Dynamic Model of All Three Layout Alternatives

An initial model was developed of the current system. The model was developed with an Excel user interface that allowed the user to input bus arrival at the RCC, number of passengers per bus, returning passenger arrivals at the RCC, time required to load and unload buses, passenger walk times, and how buses are assigned to bays. Figure 2 illustrates how these input forms were displayed in Excel.

BUS SCHEDULES				
Period Start	Period End	Number of Buses In System		
		Terminal 2	Terminal 3	Terminal 4
0:00	1:00	1	2	2
1:00	2:00	1	2	2
2:00	3:00	1	2	2
3:00	4:00	1	2	2
4:00	5:00	5	8	6
5:00	6:00	8	10	13

Figure 2 - Example Inputs Form

The example shown in Figure 2 is just one example of the input tables used for this project. Specifically, the table shown in Figure 2 allows the user to define the number of buses being used by time of day, and how these buses were distributed to the various terminals. In the actual user interface, this table extended to cover an entire 24 hour period.

The model used the input parameters from Excel and launched the dynamic model, which could be run with or without animation. Figure 3 shows the animation screens. The screen on the left side of Figure 3 displays dashboard metrics of the systems performance. The screen on the right side of Figure 3 displays the layout, with buses and passengers moving through the system. The user can move between these two animation screens by using the button at the bottom left of the animation window.

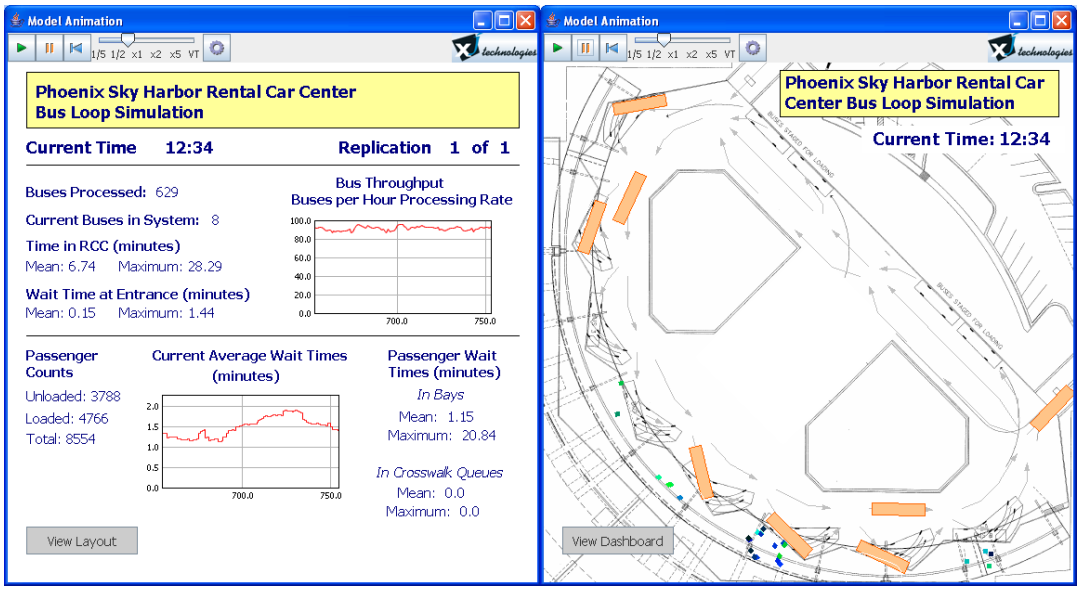

Figure 3 - Animation Screens

Once the model has run, outputs are loaded into the Excel user interface, and provide the user with summary tables and graphs. Figure 4 shows the buses processed per hour by the rental car center and the total number of buses in the system over the course of a 24 hour period. Being able to examine system behavior over the course of time is an advantage of using dynamic modeling for a design problem like the Phoenix Sky Harbor RCC bus loop.

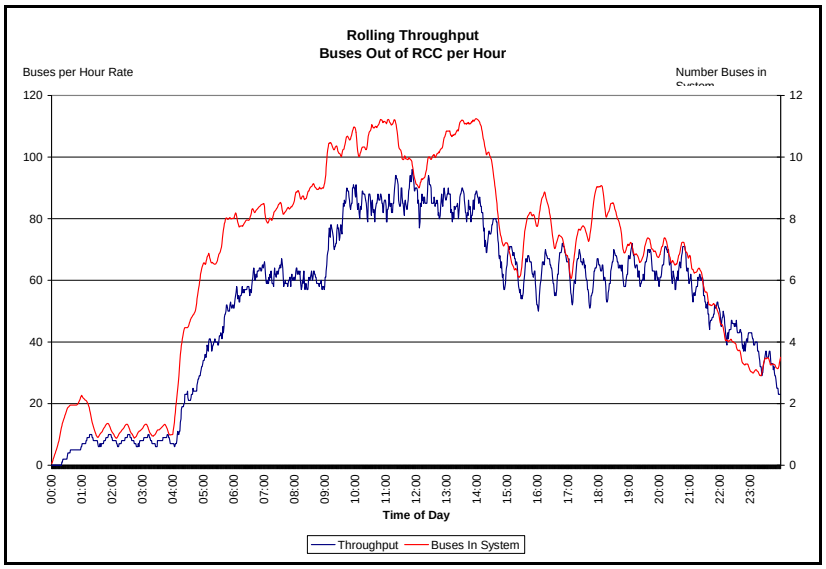

Figure 4 - Example of Dynamic Model Output Graph

After the baseline model was developed, a validation effort was conducted to ensure the model adequately represented reality. Bus time in system was defined as time from entering the RCC bus loop to leaving the loop, and time stamps for an entire days worth of buses were available from the real system. The passenger volumes and bus schedules from that day were entered as inputs into the model, and then the bus time in system from the real day were compared to the output results of the model. After some model changes resulting from the validation effort, the model predicted actual system performance with the required accuracy.

After validating the baseline model, the additional three layout alternatives were added to the model, and the user could evaluate their performance by selecting which layout to use via the Excel user interface. Based on the baseline validation, the team was confident the model accurately modeled bus and passenger behavior. The only factor that would now be varied was the layout.

Results & Conclusions: Unexpected Findings Help the Rental Car Center Improve Passenger Throughput Capacity

The rental car center simulation analysis showed none of the alternative layouts perform better than the current layout. Figure 5 displays the passenger throughput of each layout alternative over the course of a day, with the current number of active buses. This figure shows the performance of each layout is similar.

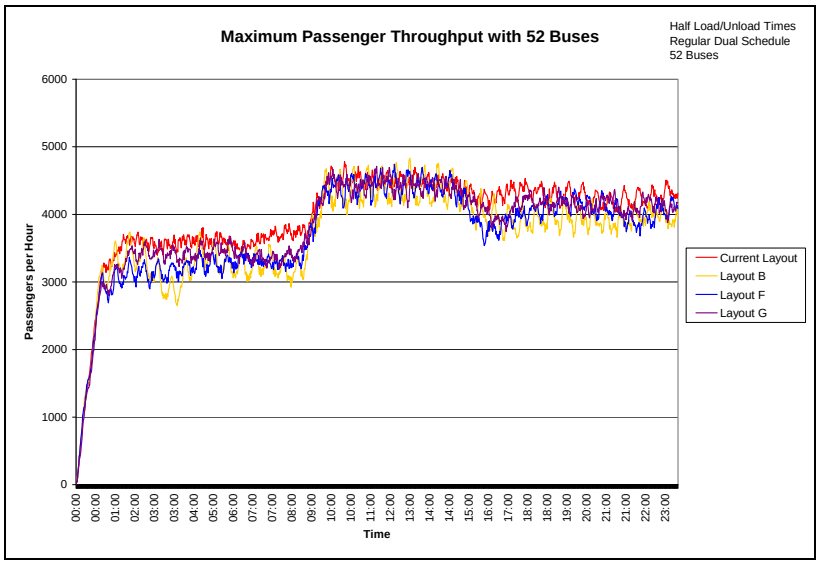

Figure 5 - Maximum Passenger Throughput with 52 Buses

It may seem counter-intuitive, and even a bit shocking to the team, that additional bays do not improve system performance. The results illustrated in Figure 5 are for the current number of buses in the system. This analysis found that with an unlimited number of buses in the system, some layouts do perform better than others. While increasing the number of bays can increase the throughput of the RCC, this increase in throughput is only achieved if additional buses are added to the system. The number of buses in the system is placing the largest constraint on system throughput, not the number of bays at the rental car center.

Figure 6 illustrates passenger throughput with varying number of buses in the system for the current layout. The increased throughput seen during the middle of the day reflects when the bus to bay assignment is managed differently. This finding is being used by the RCC to better manage the system during peak times.

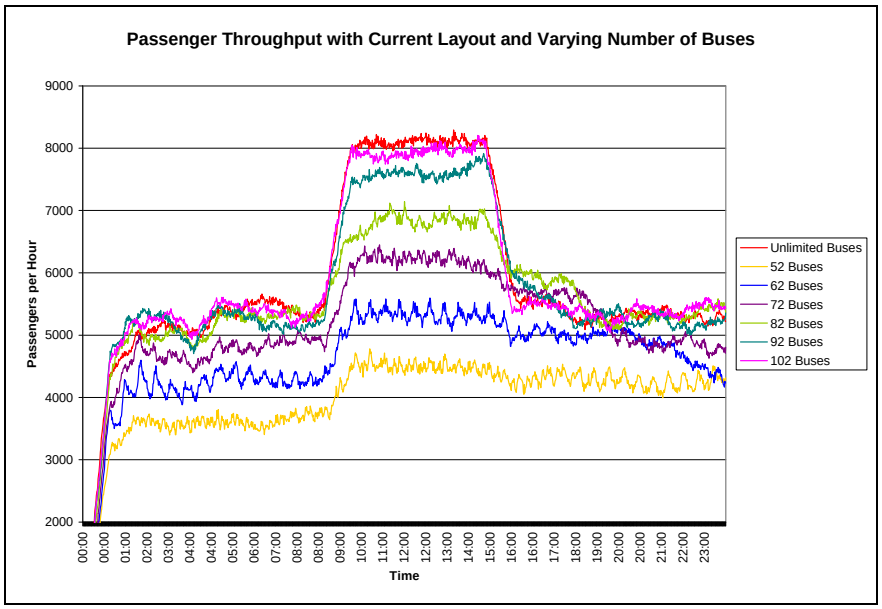

Figure 6 - Passenger Throughput with Current Layout and Varying Number of Buses

By increasing the number of active buses in the system, increased throughput can be achieved with the current layout. Based on historical data, the busiest hour of 2006 processed approximately 4,600 passengers. According to the model analysis, the maximum passenger throughput with 52 buses would be approximately 4,780 passengers. The current system has already performed at close to capacity, but adding additional buses will increase the system capacity.

The Phoenix Rental Car Center is continuing to explore ways to improve service. The results of this analysis prevented the RCC from constructing a new layout that would have not improved system performance. The results of this analysis also helped the RCC understand a better way to manage the assignment of buses to bays.