James Madison Undergraduate Research Journal

Volume 1 | Issue 1

2013-2014

Where to Park? The East Campus Dilemma

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Where to Park?
The East Campus Dilemma

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James Madison University's East Campus expansion has created parking problems. Students struggle to find a decent parking spot, sacrificing time to park and then perhaps more time to walk to class. This research project seeks answers to the parking problems on the east side of campus, specifically the Festival and Convocation lots. Should students spend the time navigating the Festival lot looking and waiting for a spot or should they go directly to the Convocation lot? The data and research explain why the latter solution is much more efficient.

Parking around the James Madison University campus has become very tight in recent years as the school has expanded rapidly. Students struggle to find a decent spot and hope to avoid parking tickets. This research project focuses on parking problems on the east side of campus, specifically the Festival and Convocation lots.

The habit for students is to drive to the Festival lot hoping to find an open spot. The walk from the Festival lot to classrooms in the ISAT building and the Physics and Chemistry building is not very long and is relatively flat. Commuters arriving in the Festival lot before 9:00 a.m. can usually find a parking space with relative ease. However, when students attempt to find a spot in Festival after approximately 9:05 a.m., it is a different story. All 586 spots in Festival's main lot are filled by that time, and students are stuck driving around, searching fruitlessly for an open spot. They not only hope to have somebody leave, but also battle other commuters hoping the exact same thing.

Plenty of stories circulate around JMU about students missing class or being late for tests because they spent an absurd amount of time looking for parking. Some students make only a couple of loops around the Festival lot and then give up, while others circle endlessly without appreciating just how unlikely it is that they will find a spot.

Students are plagued with this problem every day of the academic week, wasting time and gas while circling the lot. This research project seeks answers to the problem: should students spend the time navigating the Festival lot looking and waiting for a spot or should they go directly to the Convocation lot? The following data and analysis explain why the latter solution is much more efficient and will save those precious minutes before class begins.

Data

Part I: Data Acquisition

Research began with a study of how the parking lots around East Campus fill up. Since the Convocation lot never fills to capacity, it was assumed that there are enough spaces for students to park there during the day. The Convocation lot will be considered our "reservoir" for JMU commuters. To begin the process, the filling trends of the lot next to the Physics and Chemistry building and Festival lot had to be determined. After three days of basic observation, it was concluded that the Physics and Chemistry lot fills well before the Festival lot is near capacity. Because of this observation, further studies were performed on only the Festival lot since the most spaces open up in that area. Next, the Festival lot was studied using Google Maps. The lot has 586 spaces, not including handicap or motorcycle spots.

The initial observation phase to determine how the Festival lot fills up required five days. To get a good view, the lot was observed from a window on the fourth floor of Rose Library where all the spots were visible and the cars entering and leaving could be counted. The testing started each day after 7:00 a.m. and ended at roughly 9:30 a.m.

It took several trials to find out how to count the total cars in the lot, but an effective process was determined. When observation began each day at 7:45 a.m., each car in the lot was counted. The initial number was usually very low, around 50 to 60 cars. Following this process, each car that parked in the lot was added to the total number of cars, and each car that left the lot was subtracted from the total. For example, if 200 cars were in the lot at 8:30 a.m. and 50 more entered the lot over the next 5 minutes, then 250 was the recorded number of cars in the lot at 8:35 a.m. As cars began to pull in and out of the lot frequently, it became somewhat difficult to count all of the cars, which led to an estimated uncertainty of as much as ±5 cars. This uncertainty does not ruin any data for the rest of the research because the question being answered here is related to the time required to find a spot when the lot fills to capacity. This part of the observation was conducted only to determine the approximate time the lot fills up and the manner in which it fills.

Table 1 shows the number of cars that entered the Festival lot at between 7:45 and 9:15 a.m. on Wednesday, February 13, 2013. See Appendix A for data from all 5 observation days. Figure 1 shows a trend in of the lot filling, sloping up rapidly around 8:30 a.m. and leveling out close to 9:00 a.m., which corresponds with the number of students arriving on East Campus for their 9:05 a.m. M/W/F classes.

The next step in data acquisition was to determine the time at which the lot completely filled. Full lot capacity was determined not when 586 cars were counted in the lot, but when there were no spots left. Table 2 shows the approximate times at which the lot was filled to capacity on each observation day.

Time	Cars in Lot
7:45 a.m.	49
7:50 a.m.	90
7:55 a.m.	114
8:00 a.m.	132
8:05 a.m.	153
8:10 a.m.	170
8:15 a.m.	198
8:20 a.m.	213
8:25 a.m.	236
8:30 a.m.	270
8:35 a.m.	315
8:40 a.m.	348
8:45 a.m.	405
8:50 a.m.	468
8:55 a.m.	518
9:00 a.m.	530
9:05 a.m.	551
9:10 a.m.	568
9:15 a.m.	586 (FULL)

Table 1: Festival lot data from Wednesday, February 13, 2013

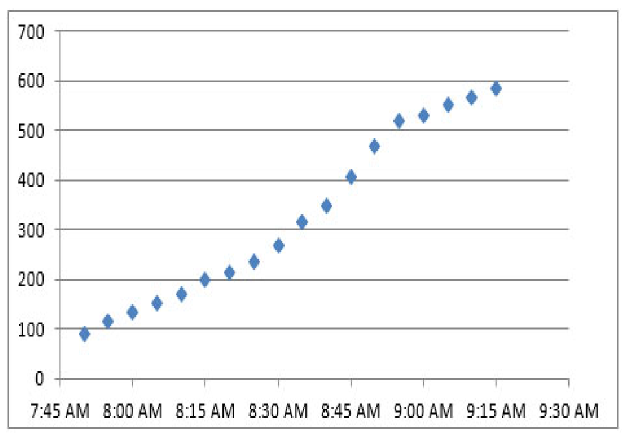

Fig. 1: Scatter graph to show trend of the lot filling up

Observation Date	Time Filled
2-11-13 (Mon)	9:05 a.m.
2-13-13 (Wed)	9:15 a.m.
2-26-13 (Tues)	9:05 a.m.
3-13-13 (Wed)	9:10 a.m.
3-21-13 (Thurs)	9:05 a.m.
Average Time Lot Filled	9:08 a.m.

Table 2: Times at which the lot filled.

Part II: Excel Models

The next step was to model the new data in Excel using the Excel macro tool. Visual Basic for Applications code (VBA) was used in these macros, with buttons inserted for simplified use. In this case, the macros were used to model the pattern in which the Festival parking lot fills up. Filling follows a predictable trend since students look for a spot closest to the building where their classes are located. Figure 2 shows how the lot fills. Commuters consistently fill up the spots to the left of Evelyn Byrd Avenue and closest to Festival. They continue to fill the open spots closest to these areas.

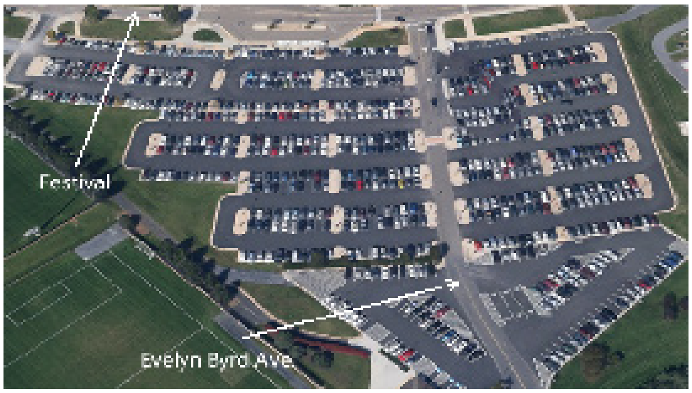

Fig. 2: Google Earth view of the Festival parking lot

Since each car does not fill the same spot every day, modeling for several macros had to be incorporated. First, the parking lot was modeled in Excel by inserting borders around individual cells and different formats to model the Festival lot, Evelyn Byrd Avenue, and the time of day. Figure 3 displays the final look of the "Excel parking lot."

The data from each day of observation was then used to determine how these spots filled, what trends the filling followed and at what time the parking lot became completely full. Each outlined cell represents a parking spot; when a dark blue color fills a cell, it represents that the spot has been parked in.

To model the randomization of the spots filling, VBA coding in each macro was used. In each of the six macros created to model a certain time, a number of spots were picked to be permanently filled while others incorporated a degree of randomness as to whether they were filled or not. This was done by inserting the equation "=RANDBETWEEN(1,2)" into the cells that were chosen to be random. The Excel function picked either the number 1 or 2 and entered it into that chosen cell. Using VBA coding, Excel was then told to fill that cell with the dark blue color if the number was 1. If the number was 2, Excel was told to leave the cell unfilled, indicating that it was an open spot and available for a driver to take. This technique was done for about 20 spots per macro. Table 3 shows the times used to model the parking respective to the macro's name. Figure 4 displays an example of what the Excel sheet would look like at 8:30 a.m. Notice that in each of

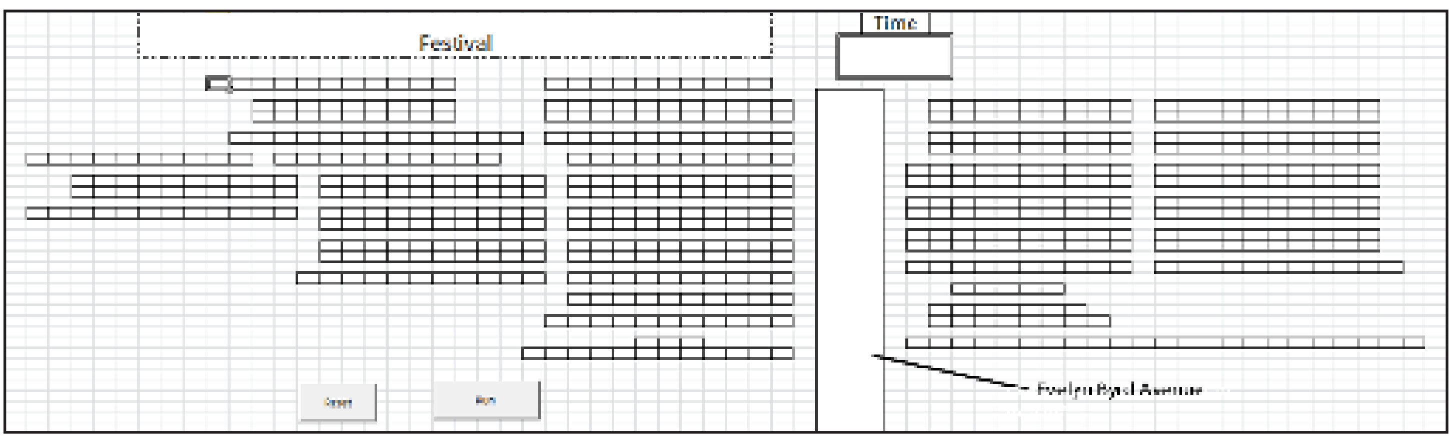

Fig. 3: Excel model of Festival parking lot

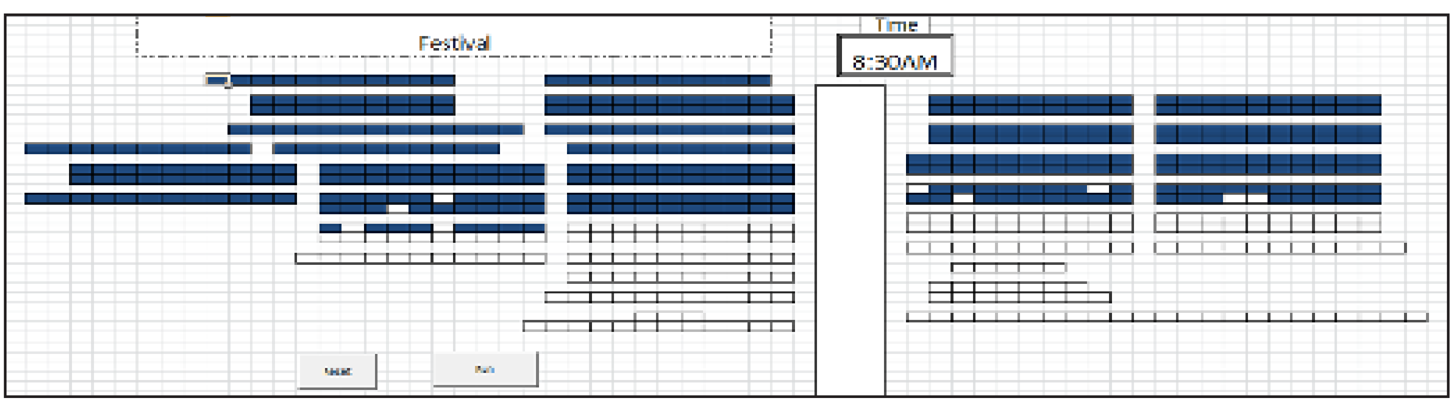

Fig. 4: Excel model of the Festival parking lot at 8:30 a.m. Notice the open spots incorporated within the filled ones. These cells used "=RANDBETWEEN" to randomize the filling of spots.

Macro Description	Macro Name
7:45 a.m.	S_45
8:00 a.m.	E_00
8:15 a.m.	E_15
8:30 a.m.	E_30
8:45 a.m.	E_45
9:00 a.m.	N_00
Reset	Reset
Run All	Whole_Macro

Table 3: Times modeled by macros and corresponding macro names

the cells there are no values visible. This does not mean that there is nothing written in the cells but rather that the content was made invisible to better mimic a parking lot. The spreadsheet view became quite "busy" when the numbers were visible.

Six macros were created to model different times of the day, but two more were needed to simplify the model. A "reset" macro cleared the spots and reset the time to blank so that the simulation could be run again. Also, a "whole" macro ran all six of the macros together. A button labeled "Reset" was assigned to the reset macro and a button labeled "Run" was assigned to the whole macro. The "whole" macro incorporated a wait function in the VBA coding so that when the simulation was run, it waited 3 seconds between each individual macro run. The delay allowed the viewer to take time to see what was happening. The following coding is an example of how the "whole" macro used VBA in this waiting process:

```
Call S_45

Application.ScreenUpdating = True

Application.Wait Now + TimeValue("00:00:03")
```

The first line of code above calls the 7:45 a.m. macro and tells Excel to run it. The next line freezes the screen until the simulations are complete, then unfreezes it to show which spots are filled. The freezing allows a smooth transition between the calling of each macro and the actual display of the simulation; otherwise, the viewer would see Excel rapidly going through each cell and filling it. This would all happen very fast, but it looks much smoother when the screen is frozen and then unfrozen. The third line of tells Excel to wait a time value of 3 seconds before it calls the next macro at 8:00 a.m.

Part III: Time Variance

For the next process of this procedure, the time variances had to be factored in. These variances include the time a person takes driving around the Festival lot, the time it takes to walk to class from the Convocation lot, and the time saved or lost by choosing either option.

Fig. 5: Two walking paths from the Convocation lot to the ISAT building. The average distance is 2,395 feet.

The average walking speed of a person was determined by how long it took participants to cover a 20-foot distance. The time it took each participant was recorded in seconds using a stopwatch and then converted to miles per hour (see Appendix B). The data yielded the result that an average person walks roughly 3.5 mph.

This approximation was used to determine how long it would take a person to walk from the Convocation parking lot to the ISAT building. Google Earth was used for this calculation because it can show and measure the lengths of different paths. Figure 5 shows two possible paths from the Convocation lot to the ISAT building. The distances of these paths and average walking speed of a person were then used to determine how long it would take to make the trip.

With an average distance of approximately 2,400 feet to the front of the ISAT building and an average walking speed of 3.5 mph, the trip takes 7.79 minutes—rounded up to 8 minutes for the sake of clarity. This is the time it takes for a person to walk to the front of the ISAT building and does not include the extra time it will take to then walk to a classroom. It might be assumed that the student will walk to the front of the ISAT building and not to one of the side doors because the path length to one of the side doors is greater than the length to the front door. Due to the way the paths are configured, walking to the front of the ISAT building and continuing to class averages roughly 100 feet shorter than if the side doors of the building are used. Depending on where one is going, it can take another minute to get from the front of the ISAT building to a classroom in the front of the building or up to 3 minutes to walk from the front doors to a classroom in the Physics and Chemistry building. In total, it is a 9–11 minute walk from the Convocation lot to a classroom. This time will later be compared to the time it takes a person who is looking for a spot in the Festival lot to get to a classroom.

Besides the average time the Festival lot fills up being determined during the 5 days of observation, a few other factors were determined as well. These factors include how many cars are driving around looking for a spot at a given time, how long the average car drives around before leaving or finding a spot, how often a spot opens, and how long it stays open. The average times for each of these factors are shown below in Table 4 (see Appendices C, D, and E for complete data).

Factor	Result
Average Number of Cars Looking for a Spot	7 cars
Average Time a Car Drives Around Lot	90 seconds
Average Time for a Spot to Open Up	4 minutes
Average Time a Spot Stays Open	11.25 seconds

Table 4: Other factors determining additional time

The averages in Table 4 were useful for observation purposes, but a macro was again necessary to approximate how long it takes a person to find a spot in the Festival lot. In this instance, the macro simulated how many "tries" it would take a driver to find an open spot in the Festival lot. These tries were then converted to units of time in minutes using the above data that determines how often a spot opens up.

To set up the simulation, the number of spots available per car had to be determined. Assuming an average of 7 cars driving around the lot at a given time and 586 total spots, there are approximately 84 spots available for each car. This assumption simplified the simulation and yielded an approximate time it would take for a car to find a spot in the lot.

In addition to the first 5 days of observation, an extra day was used to find the percentage of cars that actually find a spot when arriving at the Festival lot. This observation began when the lot was completely full at 9:30 a.m. on Monday, April 1, 2013. Cars were picked at random as they entered the lot and observed to see if they found a spot or if they drove in the lot for a few minutes and then left. Of the 278 randomly picked cars, 14 found a spot. The rest drove around the lot before leaving. Some drove around for more than 5 minutes while others parked in aisles, waiting for spots to open up. Dividing 14 by 278 and multiplying by 100 yielded the percentage of cars that found a spot: a rounded total of 5.04 percent. This percentage was incorporated into the simulation macro described below.

To create the simulation, a VBA code was written that would select a random number and then highlight that cell if the number was within a certain range representing the percentage of cars finding a spot. The "=RANDBETWEEN" equation was used again, this time with numbers between 1 and 1000. To incorporate the 5.04 percent into the equation, Excel was told to highlight the cell if the number was less than 50, as 50 is 5 percent of 1000. Relative Reference[1] was used while the macro was first recorded for the sake of simplicity, so that a "For… Next" loop[2] could be made in the VBA coding. Figure 6 shows the coding for this particular macro.

```
1.  For n = 1 To 84
2.  ActiveCell.FormulaR1C1="=RANDBETWEEN(1,1000)"
3.  If ActiveCell < 50 Then
4.  With Selection.Interior
    .Pattern = xlSolid
    .PatternColorIndex = xlAutomatic
    .ThemeColor = xlThemeColorLight2
    .TintAndShade = 0
    .PatternTintAndShade = 0
5.  End With
6.  End If
7.  ActiveCell.Rows("1:1").EntireRow.Select
8.  Selection.Insert Shift:=xlDown,
    CopyOrigin:=xlFormatFromLeftOrAbove
9.  Next n
10. End Sub
```

Fig. 6: VBA coding for the simulation macro.

Line 1 of Figure 6 displays the specified number of times this coding is going to be repeated. This number is referred to in the "n=1 to 84" portion since, as stated before, each car is allotted 84 spots each. Line 2 tells Excel to place a number between 1 and 1,000 in the given cell and to highlight the cell a dark blue color if the number is less than 50. Line 7 tells Excel to insert a new row above the most recent cell used to make room so that another cell can find a number between 1 and 1,000. Without this instruction, Excel would run the coding, but the whole list of 1 to 84 would not be seen. Excel would instead continue changing the same cell, so when the macro was completed there would be only 1 value visible, instead of 84. Line 9 of the coding tells Excel to run the macro again for the next value of n. Since n began at 1 and ended at 84, Excel ran the loop 84 times.

This simulation was run until at least one cell was highlighted because a highlighted cell meant a car found a spot. If no cells were highlighted in a given run, then the simulation ran until a cell became highlighted. In other words, the simulation was run as many times at it took for a car to find a spot. This simulation was split up into runs and trials, with a "run" representing a running of the macro and a "trial" representing a car finding a spot.

One hundred trials were performed using this simulation; each required from 1–10 runs for a total of 297 runs, giving an average of 2.97 runs per trial (rounded up to 3 runs per trial). As seen in Table 4, 1 spot opens up every 4 minutes. This means that 1 run in a trial is equivalent to a time period of 4 minutes. Since each trial averaged 3 runs and since each run was 4 minutes, a person would have to drive around the Festival lot for 12 minutes to get a spot.

1 Relative Reference is used to repeat or extend formulas in an Excel macro. This is done by performing basic cell references that can adjust and change when copied or when AutoFill is used.

2 A "For…Next" loop is a specific VBA coding that allows certain equations or codes to be repeated a specified number of times within a macro.

To park in the Festival lot, commuters must account for the time it takes to find a spot *and* for the time it takes to walk to class. The two shortest paths from the Festival lot to the Physics and Chemistry building are shown in Figure 7. Google Earth offers an average distance of approximately 1,680 feet, which means that a person walking 3.5 mph can cover the distance in roughly 5.45 minutes—rounded up to 5.5 minutes for the sake of clarity. As noted earlier, it can take 1–3 minutes to walk to a classroom from the entrance of the Physics and Chemistry building. The total walking time is then 6.5–9 minutes.

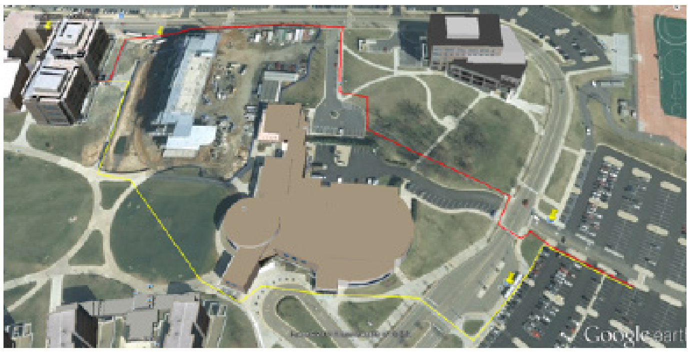

Fig. 7: Shortest walking paths from the Festival parking lot to the Physics and Chemistry Building

With an average of 12 minutes to find a spot in the Festival lot and an additional 6.5–9 minutes to walk to a classroom, the total trip time involved in finding a spot in the Festival lot can range from 18.5–21 minutes. This can be compared to the total trip of parking in the Convocation lot—about 9–11 minutes.

Discussion

When the data are analyzed, it is clear that drivers should travel straight to the Convocation lot if they arrive on East Campus after 9:05 a.m. The odds of finding an open spot in the Festival lot after 9:05 a.m. are simply too low. Drivers willing to wait for a spot to open in the Festival lot should plan on arriving in their classrooms in approximately 18–21 minutes. In contrast, drivers who proceed directly to the Convocation lot can plan on arriving in their classrooms in approximately 9–11 minutes. They will spend more time walking, but will save the time they will probably have to invest waiting for a Festival lot spot.

For commuters driving from Port Republic Road to University Boulevard, it makes even more sense to park in the Convocation lot after 9:05 a.m. because they are passing the lot to begin with.

Another benefit of parking in the Convocation lot is that commuters can better plan their travel time. If commuters were to plan to park in the Festival lot, they may have to leave their home earlier because of the uncertainty of time that comes with searching for a spot. In contrast, if they were to go straight to the Convocation lot, they could possibly leave for campus later because they remove the time it takes to drive around Festival lot—about 1.5 minutes per loop—from the equation. If commuters find they cannot leave later, traveling directly to Convocation will still incorporate a more concrete transit time.

One variable to consider is if a student is late to class. In this case, traveling to the Festival lot may be a good idea because of the 5 percent possibility of a spot being open. It could be argued that spending a small amount of time looking for a spot may prove useful if one were to be open. The opposite could also be argued: If a student is late to class, the amount of time spent just circling the lot could have been spent taking the extra time walking from the Convocation lot.

An additional variable is the fact that some of the walk from the Convocation lot is uphill. Figure 8 shows three different paths. The red path begins in the Convocation lot and ends at the steps that lead up to the front of the ISAT building with an elevation change of 51 feet downhill. The bright green path has an elevation change of 56 feet downhill, but the third, yellow path is the opposite. This path goes from an elevation of 1,347 feet to 1,416 feet, a difference of 69 feet uphill. An uphill climb might deter students from parking in the Convocation lot. Also, just because students travel downhill to go to class does not mean they bypass this climb when they leave campus. After a long day of classes and work, many students may not wish to climb this hill to the Convocation lot.

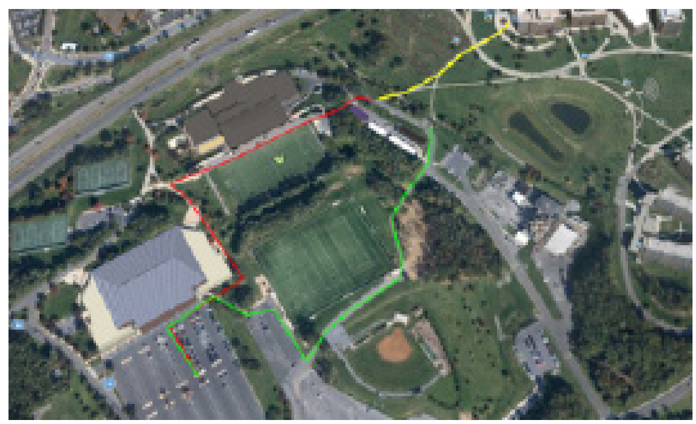

Fig. 8: Three paths with three different elevation changes.

One alternative to traveling these two paths is to park farther down in the Convocation lot and walk a different route. Figure 9 shows this route as a red line at a length of 2,196 feet, cutting through trees on a path worn by students. No pavement for an actual pathway or steps is laid and should not be considered for this data set. The alternative is to take the red path and walk down University Boulevard, the yellow path. The yellow route totals 2,775 feet with a maximum elevation change of 30 feet uphill over a distance of 265 feet, resulting in an 11.32% grade.[3] This grade is much less than the maximum grade of 16.38% found in the yellow path in Fig. 8, and will make for an easier walk. Given an average walking pace of 3.5 mph, this results in a time of 9 minutes to arrive at the ISAT building's side door. In this case, the side door was chosen because it was the nearest entrance to the path.

One source of uncertainty encountered in this data is a student's walking speed. The average speed was calculated to be 5.13 feet per second or 3.5 mph. To find a range of values

3 Grade is calculated by taking the overall change in height of a path and dividing it by the horizontal distance of the path. To get the percent grade, the grade is multiplied by 100.

Fig. 9: Walking path from the lower portion of Convocation lot.

Fig. 10: Diagram of the R1 and C3 lot with respect to ISAT

for this data, the standard deviation of the data set was taken, which comes to be 0.11 mph, resulting in the average speed of a person walking at 3.5±0.11 mph. Students may opt to travel faster than 3.5 mph.

One last detail is that some may suggest parking in the R1 and C3 lots seen in Figure 10. These two lots produce a travel distance of only 1,960 and 1,564 feet respectively, but they also add another variable: the driving paths to these lots. Depending on what housing development a student is traveling from, traffic patterns may make these lots unfeasible. With the addition of the campus gates, students traveling from Port Republic Road may spend more time traveling along the outer perimeters of JMU's campus to reach the R1 and C3 lots. Further studies could determine if these lots would be a good choice for specific students looking to commute to East Campus.

Overall, it is likely that students do not consider parking in the Convocation lot because they think it is much further to walk from there than from the Festival lot. In reality this is not true. The walk from Convocation to the front of ISAT is roughly 2,400 feet. Compared to the 1,680 foot trip from the Festival lot, there is only a difference of 720 feet which equates to a little less than 2.5 football fields. Students who state that JMU's campus needs more parking should realize that there is plenty of parking available on the east side of campus, even though it may not be in the desired location.

Conclusion

If students are driving to East Campus around 9:00 a.m., they have a small chance of finding a spot in the Festival lot. If it is much later than 9:05 a.m., their best choice is to drive directly to the Convocation lot. Finding a spot in the Festival lot after this time is unlikely, and waiting for a spot to open or driving around looking for one will take a significant amount of time. Even though parking in the Convocation lot may produce a longer walk up some steeper hills, it is still worth the time saved and gas used.

Citations

1. "Harrisonburg." 38°25'52.66" and 78°52'04.45" W. *Google Earth.* October 4, 2012. March 11, 2013.
2. Reinke, Helmut; Unverhau, Sara; Pfeifer, Eckehard and Fienitz, Bodo, 2011, *Microsoft Excel 2010 Formulas and Functions Inside Out, Microsoft Publication,* 1,088 p.

Appendices

Appendix A: *Number of cars parked in the Festival lot during the 5 observation days*

Time (a.m.)	Cars in Lot: Mon, 2/11/13	Wed, 2/13/13	Tues, 2/26/13	Wed, 3/13/13	Thurs, 3/21/13
7:45	33	49	34	61	43
7:50	81	90	95	78	76
7:55	126	114	120	11	101
8:00	135	132	143	122	130
8:05	149	153	157	150	167
8:10	181	170	174	179	189
8:15	194	198	199	203	221
8:20	222	213	211	210	249
8:25	231	236	234	248	269
8:30	289	270	287	268	290
8:35	323	315	314	303	309
8:40	347	348	353	349	368
8:45	399	405	410	400	410
8:50	455	468	488	459	470
8:55	509	518	524	520	532
9:00	553	530	561	533	571
9:05	586 (FULL)	551	586 (FULL)	549	586 (FULL)
9:10	-	568	-	570	-
9:15	-	586 (FULL)	-	586 (FULL)	-

Appendix C: *Cars looking for a spot at given time.*

Time (a.m.)	Cars Looking for a Spot: Mon, 2/11/13	Wed, 2/13/13	Tues, 2/26/13	Wed, 3/13/13	Thurs, 3/21/13
9:20	6	5	8	9	8
9:25	4	7	8	10	4
9:30	7	6	6	9	7
9:35	9	6	7	7	7
9:40	5	8	10	8	8
9:45	5	5	5	8	7
9:50	6	10	8	5	5
Total Avg.	6.94				

Appendix B: Time trial of participants walking 20 feet

Participant	Time (seconds)
1	3.76
2	3.99
3	3.80
4	4.01
5	3.61
6	3.90
7	3.93
8	3.83
9	3.92
10	4.19
Average	3.89

Appendix D: Amount of time randomly selected cars drove around the Festival lot before leaving

Car Observed	Time Car Drove Around (mm:ss)
1	1:23
2	0:50
3	0:45
4	1:45
5	1:15
6	0:55
7	3:00
8	1:45
9	1:04
10	1:55
Average	1:28

Appendix E: Time a spot opens and how long until another car fills that spot (data from Wednesday, March 13, 2013)

Time Spot Opened (a.m.)	Time Spot was Open (sec)
9:13	8
9:14	6
9:18	7
9:23	12
9:25	3
9:26	1
9:27	50
9:29	5
9:37	6
9:49	12
9:58	8