Parking Meters at Carnegie Mellon University

Team F: Kaylee Makel, Nancy Geronian, Victor Wilczynski, Jeff Lee, Jungmoon Jang

A. Why is this topic interesting? Why does this survey need to be done now? Is there a client for whom you might do the survey?

Coin parking meters are becoming a rarity in today's technologically advanced era, so why at Carnegie Mellon has there not been a technological improvement in terms of parking on its campus since CMU is known for being such a big tech hub? In reality, Carnegie Mellon is in working stages of implementing technological improvements in terms of parking on its campus (i.e. Traffic21, ParkPGH). We want to survey on campus parking meters to determine if there is a high frequency in unpaid meters. To add, we would like to see if there are any correlations between other factors, such as owning an expensive car, time of day, etc. This project is very interesting for anyone who uses the parking meters on campus, especially those who have been ticketed for parking violations.

B. What question(s) do you propose to study? Give a brief answer that would have been understandable by a non-statistician.

We wish to look at different aspects of meter parking at Carnegie Mellon University:
a.   How frequent do people not pay meters
b.   Are certain days/times more likely to have unpaid meters
c.   Are different types (color/brand/model) of cars more likely to be at an unpaid meter
d.   Are cars registered as Pennsylvanian or outside states (by checking license plate) more likely to be at an unpaid meter

In our project we would like to survey the parking meters at different times and on different days and record how frequently they are unpaid and which types of cars are parked there. Depending on what we find out, we would like to see if there should be a push to seek alternative methods to coin operated parking meters.

C. What research has already been done on the topic or on the theoretical construct of central importance to your topic? What could be learned from survey results? Each group member should locate and review 1 relevant piece of research (e.g., article, report, book, etc)

1) Nancy Geronian: "Local, national companies contracted for parking meter efficiency: Revenue rises in Tampa with new meter technology" from Tampa Bay Business Journal by Mark Holan, Staff Writer on Friday December 31, 2011. Web.

<http://www.bizjournals.com/tampabay/print-edition/2010/12/31/local-national-companies-contracted.html?page=all>.

Summary: The key point of this article states how advancing meter technology will reduce costs, increase revenue, and improve convenience, so in our project we can show how inefficient regular coin parking meters really are.

2) Kaylee Makel: Goals, IndustriesBy ApplicationsBy. "Integrated Parking Management." *Parking Solutions, Multi-Space Parking Meters | Digital Payment Technologies*. 2011. Web. 28 Jan. 2012. <http://www.digitalpaytech.com/parking-solutions/integrated-parking-management.aspx>.

Summary: As technology advances, consumers are now able to pay their parking meters via phone without bearing weather conditions or leaving an office meeting. Parking meters are now being monitored by space sensors using a Smartphone application which yields immediate payment without ever having to visit the pay station. This sort of technological advancement is beneficial for consumers, especially students and professors on a tight schedule.

3) Jeff Lee: "Environmental Indicators for Carnegie Mellon University: Baseline Assessment." 2004. Web. <http://www.cmu.edu/greenpractices/campus-assessment/environmental-indicators/transportation.pdf> .

Summary: CMU wants to reduce the number of vehicles that travel to campus whereas more and more people find the convenience of driving to campus well worth the cost of permit/metered parking and/or the risk of being fined. There are multiple reasons as to why, including poor public transportation, unreliable shuttle service, and close proximity of metered parking.

4) Jung Moon Jang: M. Grynbaum, "The Last Days of the Old Parking Meter." September 18, 2011. <http://www.nytimes.com/2011/09/19/nyregion/uprooting-the-old-familiar-parking-meter.html?pagewanted=all>.

Summary: New York City has replaced all of the parking meters to a solar-powered meter with Wi-Fi and ability to control eight parking spaces at once and to speak seven languages. The new meter system is very convenient because instead of carrying coins in pocket, people can pay with credit card. Also, because the parking meters no longer define each spot, it is expected that the city will have 10 to 15% more parking spaces.

5) Victor Wilczynski: "Advanced Parking Meters Help Increase Asbury Park's Parking Revenue by More Than 60 Percent." November 1, 2011. <http://www.marketwatch.com/story/advanced-

parking-meters-help-increase-asbury-parks-parking-revenue-by-more-than-60-percent-2011-11-01>.

Summary: The installment of 100 multi-space parking pay stations in New Jersey has increased parking revenue over 60 percent. The parking stations allow many different payment options including cash, coins, credit, and debit, so maybe Carnegie Mellon University should make a switch to more efficient methods.

D. What is the sampling frame? What population or populations do you plan to sample from?
The sampling frame: parking meters on Frew, Tech, and Margaret Morrison Street.

E. What is the target population? To what population(s) do you wish to make inferences?
How does the target population differ from the sampling frame, for your survey?
What possible sampling and non-sampling errors could arise in the survey that you plan to conduct?
Explain each possible error, how it could occur, and how you suggest tackling it.

The target population is all on campus parking meters, since our target population is not that large in size, we can observe all units in the target population. We are not sampling the drivers of these vehicles, since it is impracticable plan to wait around for the driver to hand them a survey or stick a survey into their windsheild. Reason being, people out of their consciousness will not want to admit that they blantantly did not pay their meter. The sampling frame are the meters on three streets on campus mentioned in part D.

We could see a sampling error in variance, although the three streets are located next to each other, they could be more attractive to different drivers considering the buildings they are closest to. We will handle this by analyzing the data for each street as well as combined to see if there is any significant difference. Although we will be able to survey every meter each time we survey, there may not always be a car parked at it. This could be considered a non-response error. I think that by analyzing data for number of cars parked versus illegally parked cars will still be sufficient to provide data. This information is still valuable because if we notice a certain time where there are very few cars then monitoring habits can be adjusted accordingly by the parking authority.

Another error could be a measurement error, since we do not know if a parking meter is broken or not. If it is broken, the driver is not able to pay and if we cannot identify that the driver has not paid because the meter is broken or for some other reasons, that would be a measurement error.

F. What is the mode of data collection? How do you plan to carry out the survey (e.g., by telephone, e-mail) and why?

We would carry out the survey by checking each parking meter at different times and on different days, and recording our observations.

G. What variables do you propose to measure?

Our main focus will be to see if there is an abundance of people parking illegally. However, we will also look at factors such as timing to see if there are certain times of day or certain days of the week that there is a higher frequency of illegal parking. We are going to record what state the car is registered (license plate) to see if there is a difference of out of state versus Pennsylvanian residents. We also are going to make note of variables such as make/model and color to see if there is any connection with these factors and illegal parking.

H. On the basis of feedback to your submission for Parts I and II, choose a final survey topic, and update or revise your answers to (A) through (G) above. Submit the revised proposal.

K. Decide on a sampling scheme (e.g., SRS, Stratified random sample, etc.) and explain why you chose it.

There are total of 224 parking meters on campus.

Margaret Morrison St	5
Tech St	29
Frew St	168
University Center	6
Behind Morewood	16

The sampling scheme is a census on all 224 parking meters. Because we are observing, checking all 224 parking meters on campus is doable and the results from census is more reliable than the one we would get from doing random sample since there is no error.

L. Write a questionnaire with 20–30 questions. Up to approximately 1/3 of these can be background or demographic questions and the rest should be directly related to the research questions you will try to answer with your survey. NOTE: If your survey involves observations instead of asking people questions, then instead you should carefully describe your observation protocol. That is, list 20–30 things you will always look for when observing each unit in your survey.

We will use the same EXCEL spreadsheet (using a small lap-top or pad-like lap-top) to record the findings.

Questions related to the parking meter
1. Is there a vehicle parked at the parking meter?
2. Is the vehicle parked at an expired meter?
3. Is the meter broken?

Questions related to the vehicle
1. What color is the vehicle?
2. Type of vehicle (compact, minivan, truck, etc.)
3. Make of vehicle (Chevy, Ford, BMW, Mazda, Honda, Pontiac, etc.)
4. Model of vehicle (Accord, Focus, Protégé, Sunfire)
5. What state is their license plate from?
6. Does the vehicle have a ticket?
   a. How much is the ticket?
   b. What were they ticketed for?
7. Is the car clean or dirty?
8. Do they have registration? (tag located on license place)
   a. Is the registration expired?
9. Do they have their vehicle inspected? (tag located on windshield)
   a. Is their inspection expired?
10. Does the vehicle have any after market additions? (fancy exhaust system, suspension lift, spoiler, fancy rims)
11. Is the vehicle parked at a handicapped parking spot?
    a. Do they have a handicapped tag/license plate
12. Does the vehicle have any major dents, scrapes, or shattered windows?
13. Is the vehicle driving on a spare tire?
14. Does the vehicle have a parking pass to park on another on-campus location?

Questions not related to either the meter or the vehicle
1. What day of the week is it?
2. What is the time?
3. What street is the vehicle parked on?
4. What is the weather like? (sunny, rainy, cold, hot, etc.)
5. Total percentage of cars parked on each street/region

M. Give some idea of the sample size you will require and how you arrived at this number (talk about the margin of error for inferences you want to make).

Since we are doing a census, our sample size is going to be 224 and the margin of error would be zero. However, if we would sample, we will calculate for n for SRS without replacement. We use 0.5 for p, since we are unsure of this statistic. Also, for margin of error we will use 0.10,

since this is a generic ME commonly used. To add, we want to be 95% confident in this estimation, so we use 1.96 for the z-value. Therefore,

$$n \geq \frac{(Z)^2(SD)^2}{(ME)^2} = \frac{(1.96)^2*(0.5)^2}{(0.10)^2} = 96.04$$

Now apply correction $n^{\geq}$ $\quad \frac{Nn}{N+n} = \frac{(224)(96.04)}{224 + 96.04} = 67.22$

Therefore, we could have a sample of 68 (about a third of the sample) and reach the ME of 0.10. However, we have chosen against random sampling because 224 is not a huge sample number and if we spend about 30 seconds to a maximum of 1 minute per meter, each census will not take more than 3 hours, where we have allotted 3 hours for each data collection. So, in order to not go through all the trouble of arriving at a random sampling method we believe sampling all 224 parking meters is feasible, since it may be the case that many meters will not even have a car present.
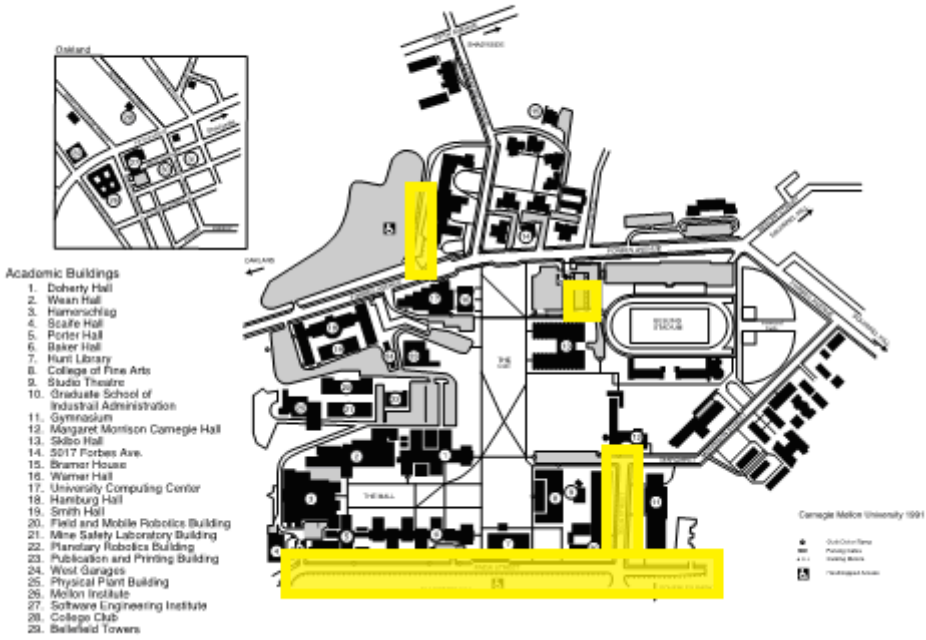
In addition to the questions for II.4:

1) *How many parking meters are there in your target population?*

There are total of 224 parking meters on campus.

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Frew St	168
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Behind Morewood	16

2) *Provide a map (preferable official) of the locations of all of the meters in your target population.*

Carnegie Mellon University Campus Map

Academic Buildings
1. Doherty Hall
2. Wean Hall
3. Hamerschlag
4. Scaife Hall
5. Porter Hall
6. Baker Hall
7. Hunt Library
8. College of Fine Arts
9. Studio Theatre
10. Graduate School of Industrial Administration
11. Gymnasium
12. Margaret Morrison Carnegie Hall
13. Skibo Hall
14. 5017 Forbes Ave.
15. Bramer House
16. Warner Hall
17. University Computing Center
18. Hamburg Hall
19. Smith Hall
20. Field and Mobile Robotics Building
21. Mine Safety Laboratory Building
22. Planetary Robotics Building
23. Publication and Printing Building
24. West Garages
25. Physical Plant Building
26. Mellon Institute
27. Software Engineering Institute
28. College Club
29. Bellefield Towers

3) *Provide a careful description of all the times of day and week you will look at meters, and why these represent all of the variation in usage, not paying for parking, etc., that you hope to see:*

We found that conducting a census of parking meters on campus is feasible therefore our problem dealt dividing up the variable time when conducting our study.

Since parking meter fees apply between 8am and 10pm for the Skibo/Baker parking meters, 8am until 5pm for the meters behind Morewood, and 24 hours at the UC meters, we will create two groups to administer our census. We will conduct a study of morning commuters, from 8am to 12:00pm, and afternoon commuters, from after 12:00pm. Specific times will not be of interest to us as long as the study is done in the morning time slot and an afternoon time slot.

Since we are completing a census we want to have a complete data collection of morning and afternoon of every day of a school week for two weeks. However, if it does rain we will reschedule for another week. For example, if it rains Monday morning we will reschedule for another Monday morning in two weeks. Looking at all of our schedules, we have arrived to the following scheduled census collection:

M W F census collection		
Jungmoon/Nancy (will help after 10:20pm on M W) & Victor (will help F)	Morning	9:00-12:00pm
Victor/Nancy	Afternoon	3:30-6:30pm
T Th census collection		

| Jeff | Morning | 9:30-12:00pm |
| Kaylee/Nancy | Afternoon | 12:00-3:00pm |

We feel that our 4 subgroups cover some key demographics of student, faculty, and visitors for presence on campus. We may be able to find some interesting differences between morning commuters versus afternoon commuters' behavior towards parking meters on campus. In each of the 4 subgroups, we will conduct a full sample of all parking meters on campus (Frew Street, Tech Street, Margaret Morrison Street, University Center, behind Morewood Gardens).

4) *It may be the case that doing a census at all of the times you provide in (3) is too much work. Provide a plan for how to sample locations to read the meters, if you can only afford to sample 1/3 of the meters at each day and time, and explain why this produces a repsentative sample of the target population.*

We have determined that random sampling takes more time than completing a census, so we have decided to do a survey of 224 parking meters.

II.5:

Research Question explained: Coin parking meters are becoming a rarity in today's technologically advanced era, so why at Carnegie Mellon has there not been a technological improvement in terms of parking on its campus since CMU is known for being such a big tech hub? In reality, Carnegie Mellon is in working stages of implementing technological improvements in terms of parking on its campus (i.e. Traffic21, ParkPGH). We want to survey on campus parking meters to determine if there is a high frequency in unpaid meters. To add, we would like to see if there are any correlations between other factors, such as the estimated value of the car, time of day, day of week, color of car, etc.

N. Pretest of a revised version of your questionnaire (or observation protocol) on a group of possible respondents/units.

There are total of 224 parking meters on campus:

Margaret Morrison St	5
Tech St	29
Frew St	168
University Center	6

| **Behind Morewood** | 16 |

The **sampling scheme** for our survey project is a census of all 224 parking meters, so our pretest was held on **Thursday March 8th at noon** where Kaylee Makel and Nancy Geronian were planning to survey all 224 units of our population, yet due to weather conditions (the rain) we were able to sample all the parking meters behind Morewood (16 parking meters). Our main goals were to see if a three hour time slot is enough time to sample all parking meters at Carnegie Mellon and if there are any necessary revisions needed to be made on our survey questions.

We used an EXCEL spreadsheet (we were planning to use Jungmoon's small lap-top) to record our findings; however, due to the rain we had to use a clip-board and a print out of the excel spread sheet:

Also, Victor and Kaylee created a reference sheet for the make of the vehicle, which we carried along while we recorded the data.

OLD questionnaire:

Questions related to the parking meter
4. Is there a vehicle parked at the parking meter?
5. Is the vehicle parked at an expired meter?
6. Is the meter broken?

Questions related to the vehicle
15. What color is the vehicle?
16. Type of vehicle (compact, minivan, truck, etc.)
17. Make of vehicle (Chevy, Ford, BMW, Mazda, Honda, Pontiac, etc.)
18. Model of vehicle (Accord, Focus, Protégé, Sunfire)
19. What state is their license plate from?
20. Does the vehicle have a ticket?
    a. How much is the ticket?
    b. What were they ticketed for?
21. Is the car clean or dirty?
22. Do they have registration? (tag located on license place)
    a. Is the registration expired?
23. Do they have their vehicle inspected? (tag located on windshield)
    a. Is their inspection expired?
24. Does the vehicle have any after market additions? (fancy exhaust system, suspension lift, spoiler, fancy rims)
25. Is the vehicle parked at a handicapped parking spot?
    a. Do they have a handicapped tag/license plate

26. Does the vehicle have any major dents, scrapes, or shattered windows?
27. Is the vehicle driving on a spare tire?
28. Does the vehicle have a parking pass to park on another on-campus location?

Questions not related to either the meter or the vehicle
6. What day of the week is it?
7. What is the time?
8. What street is the vehicle parked on?
9. What is the weather like? (sunny, rainy, cold, hot, etc.)
10. Total percentage of cars parked on each street/region

O. Report on the specification of and results from the pretest, and any redesign of the questionnaire (or observation protocol) that may be required.

Necessary Revisions:

Due to the rain Thursday afternoon, we realized that recording data without using a laptop or an ipad-like computer is not feasible. We instead sampled only the parking meters behind Morewood, so a total of 16 units of our entire target population. However, even with this rather small proportion we were able to see what necessary revisions need to take place. To summarize our findings, only 12 vehicles were present at the 16 parking meters (75%). It took us from 12:00pm until 12:10pm to record all the data for the 16 parking meters (about .833 seconds per car). Since it was a rainy day we believe that more people will want to drive to work and park closer (using the parking meter locations at a higher rate). Therefore, there will be around a 75% "vehicle present" rate if not less on a non-rainy day. We made some calculations and if there will be about 168 vehicles present at 224 parking meters, it will take us about 2 hours and 20 minutes in total to sample all campus parking meters. We will add some buffer time in order to walk from location to location and in case it takes a little longer for every parking meter, so a 3 hour tim slot to complete the census will be alotted.

Specific to our questionarre, we also noticed a couple of things while surveying the 16 parking meters behind Morewood. First, we noticed that most of questions are "yes" or "no" questions, so re-writing that repeatedly is a waste of time. So, we will code "1" for "yes" and "0" and "no." We also noticed how the order of the questions is a bit inconvenient. Therefore, we altered the question order to better the efficiency during the survey. We also realized that our reference sheet should be formatted in a more efficient manner. So, we put the makes of the vehicles in a column format where only a front and a back of a piece of paper is necessary instead of 7 pages. Another way to save time we coded the "type of car" using 1 for a car/sudan, 2 for a truck, 3 for SUV, 4 for VAN, 5 for motorcycle/scooter, 6 for other. Coding will be used for all but four questions in our survey. This coding method will also be on the reference sheet.

Another thing that the rain taught us during the pretest is that it is practically impossible to record data when there is rain. So, we will change the weather category on the EXCEL

spreadsheet to temperature. Therefore, the surveyers must check the temperature before they begin the census. As a result, if it does rain, we will have to reschedule for the same day/time block, but during a later week. Another thing we realized is that some group members may not know how to answer some of the questions, because they may not know what the "model" of the vehicle is or where the inspection sticker or registration sticker is located, and where a parking pass for another on-campus location would be located. We will have a quick group meeting Sunday March 18th informing everyone of the changes, so everyone knows how to properly carry out the survey.

FINAL QUESTIONARRE:

1) Vehicle Present?
2) Color?
3) Type?
    - Car/Sudan/Cross-over
    - Truck
    - SUV
    - Van
    - Motorcycle/Scooter
    - Other
4) Make?
5) Model?
6) State of license plate?
7) Expired meter?
8) Broken meter?
9) Ticket?
10) What for?
11) How much?
12) Clean/Dirty?
13) Registration present?
14) Registration expired?
15) Inspection present?
16) Inspection expired?
17) Handicapped spot?
18) Handicapped plate/tag?
19) Fancy market additions?
    - Tinted windows
    - Rims
    - Wing

- Etc.
20) Major dents or scratches on vehicle?
21) Any cracked or shattered windows?
22) Vehicle driving on spare tire?
23) Vehicle has parking pass for another on-campus location?

GENERAL QUESTIONS in addition to vehicle/parking meter questions:

1. Date
2. Day of week
3. Surveyers
4. Outside temperature
5. Start time
6. End time