Design of an Advanced On-street Parking Meter

by

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Approvals

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To my parents
Acknowledgements

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Chapter 1
Introduction

Background

On-street parking meters have been around for more than 60 years to increase city parking turnover and collect money for city revenue. They have been serving well in many cities around the world. They also represent a symbol of industrialization of a city. However, there are still problems in the parking meter system. Some cities regard them as efficient tools in controlling downtown short-term parking while others prefer free, short-term parking instead. With no doubt, the parking meter system is one of the most effective ways of controlling on-street parking in cities. This thesis explores the feasibility for designing a hi-tech parking meter system that will take the advantage of technologies available and will improve and resolve the existing problems.
Issues

Albany, New York

For a variety of reasons, the City of Albany, New York decided to remove parking meters from its streets in 1980. A system of free parking was implemented, but long-term parkers reduced the availability of short-term on-street parking spaces. Downtown retailers suffered because customers could not find on-street parking to access the businesses. Finally, after eighteen years, they pressured authorities to return the meters, and 900 electronic units were installed in 1998. The result has been a marked increase in parking turnover and in the availability of convenient, short-term on-street parking spaces.¹

Washington D.C.

In Washington D.C., 15,500 electronic parking meters are being installed.

According to The Parking Professional, “The meters already are equipped to take parking account cards, or ‘smart cards,’ instead of coins.... Customers put money on their cards and insert them at meters instead of using change.”²

“The parking enforcement officers (meter maids) in Washington D.C. needed to reach their daily ‘quota of fines,’ which is ninety tickets in six hours.” This means that they need to issue one ticket every four minutes. It causes many arguments and complaints because the officers often take a more aggressive attitude or approach in issuing tickets.

**St. Petersburg, Florida**

In St. Petersburg, Florida, however, recently installed hi-tech parking meters have thoroughly confused the customers. People were unable to figure out how the system operated, and couldn’t understand the instruction for paying their parking fee.

**Newark, Delaware**

In the city of Newark, Delaware, *The Downtown Parking Committee Report to the Newark City Council* suggests that the rate for on-street parking should be raised higher than off-street parking. “The meter rates of $0.25 per hour should be increased to at least

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$0.50 per hour immediately. On-street parking is the most convenient parking in downtown. Ideally, the on-street rates should be higher than off-street rates, but off-street rates are so high that a change from $0.25 per hour to $1.00 per hour would be too much of an increase. Eventually, parking rates should be adjusted so that on-street rates are higher than off-street rates. The high on-street parking rate will increase chances for people who really need to have short-term parking. It will also increase downtown parking turnover and city revenue, which are two major reasons that major cities still keep parking meters.

These issues offer a broad perspective over current meter programs in different parts of the country. The problems behind these issues differ from city to city. I divided these problems into three categories: money, enforcement and user friendliness. These categories are separated in current meter programs. One has nothing to do with the other. I intend to propose a new meter design that is going to improve the problems in the three categories above by incorporating proper technologies. This hi-tech meter will no longer be coin activated, no multiple standard in enforcement and more user-friendly.

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5 Downtown Parking Committee (Newark, Del), Downtown Parking Committee Report to the Newark City Council 1997: 34
Proposal

Parking meters are the most popular means of control we have for on-street parking. I propose a more user-friendly and efficient on-street parking meter system by applying new technologies in my design. It will also improve the interface between vehicle drivers and on-street parking control.

The parking meter we use today is a coin-collector with a parking-control indicator. It needs to be monitored by officers to be efficient in controlling short-term parking. In some cities like Washington DC, the officers were expected to reach a quota of fines everyday which was 90 tickets in 6 hours. Reports show that the meters are easily vandalized and there are problems with the coin-collection system.

The operation of parking meters hasn’t been changed for decades, while new technologies have made many of the interfaces between people and machines more user friendly. I hope to create an advanced user friendly meter system to control on-street parking. The design of the proposed product will be described by models, computer renderings and an animation of the user interface.
Chapter 2
Research

Parking Meters

Meter Head

Parking meters serve as time indicators and coin collectors in the on-street parking system. A meter head includes two units: a “flag” unit and a coin collection unit. The “flag” unit is a mechanical instrument that shows the remaining parking time and parking violations. It is normally a white “flag” with time scale on it (see Fig. 1). The scale indicates to a certain time when a coin is inserted into the meter (depending on the local parking program), and the timer starts. A red flag marked “EXPIRED” rises when the parking time is over.

Latest parking meters use a liquid crystal display (LCD) panel to replace the mechanical “flag” (see Fig. 2). They also include card readers that accept pre-paid debit cards. The red flag with “EXPIRED” on it is replaced by a red rectangular LCD spot. The small size of the LCD panel makes it hard to read. The user has to stand close to a meter
to read the remaining time. One can hardly see the red rectangular spot that indicates time expiration because of the transparency of the LCD panel.

The coin collection unit accepts and stores money from the parkers. It usually accepts quarters, dimes and nickels. When a coin is inserted, the white “flag” will rise to show the time one can stay. The user can add coins until the maximum time limit of the meter is reached.

**Installation**

A metal post to the ground on curbside supports a meter head. The joint between the post and the head is the key to keep meters from being knocked off. The “Bar-Pin Security Post Mounting Device,” (See Fig. 3) which is designed and patented by three New York City traffic device maintainers, is a device that has been tested and proven. It is a stainless steel threaded piece of bar stock that replaces the traditional parking meter
wedge system. It’s easy to install in a pre-drilled post, and easy to remove and reuse. The Bar-Pin is installed inside the post sleeve to keep the post from being cut with a pipe cutter (See Fig. 4).

Most of the meter posts are set into the ground with concrete so that they will stand solidly. However, when a new post is to replace a damaged one, it is expensive to dig out the concrete. This might cause inconvenience to the pedestrian, too. A new way of construction is called the “Wedge-Lock Post Mounting System.”\(^1\) It works in four steps which are explained in Fig. 5.

\(^1\) [http://www.pom.com](http://www.pom.com)
**Step 1:**
Install locator socket in 8”x18” hole with coarse gravel in bottom. Fill with concrete to flush with ground.

**Step 2:**
Install post/wedge assembly and turn to seat on locator bar. Insert installation tool to flatten wedge.

**Step 3:**
View of properly installed post with flattened wedge extending into slots inside of post and into groove inside locator socket.

**Step 4:**
To remove post, insert pointed removal tool and drive downward to bend wedge. Remove post and install new one. No need to destroy surrounding concrete!

---

**Fig. 5. Wedge-Lock Post Mounting System**

**Maintenance**

In order to repair traditional meters, technicians need to remove them from the street and take them back to the shop. It usually takes days to repair and return them to service. Thus the maintenance of an electronic meter is much easier. The service people can replace the damaged one with a new one on-site, thanks to the modularity of the
electronic meters. In this way, the meters are able to go back into service immediately after the service people complete the repair on-site.

**Enforcement**

*Parking enforcement officers*

The meter system includes parking enforcement officers, used to be called "meter maids," although some are males. The responsibilities of these parking enforcement officers are to monitor meters in a certain region and issue tickets to violators. In fact, it's impossible for them to issue tickets to every meter violation. "An empirical study of meter enforcement level in Ann Arbor, MI indicates a low level of enforcement, measured in terms of tickets issued versus violations that took place." Overall, the survey recorded only 33 of 396 violations were ticketed (8.3%). This data shows that the parking meter enforcement is not efficient enough in this specific study of this specific site.

A further study also shows that the low enforcement level is not unique to Ann Arbor.

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The productivity of enforcement personnel was similar in several Michigan cities (See Table 1). There is no reason to suspect that Ann Arbor has a higher violation rate. This leads to the conclusion that this low enforcement rate probably prevails throughout the United States.³

This study indicates that the parking enforcement is not uniform for those people who were ticketed, because over 90% of the violators were not ticketed. However, this doesn’t mean that parking enforcement officers didn’t do their job well. It is actually difficult for them to ticket every violator, because they monitor an “area” not a “spot.”

<table>
<thead>
<tr>
<th>City</th>
<th>Population (x 1,000)</th>
<th>Enforcement Personnel</th>
<th>Spaces Enforced</th>
<th>Citations/Employee/Day</th>
<th>Citations/Enforced pace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ann Arbor</td>
<td>104</td>
<td>12</td>
<td>18,285</td>
<td>66</td>
<td>0.043</td>
</tr>
<tr>
<td>Grand Rapids</td>
<td>183</td>
<td>5</td>
<td>8,299</td>
<td>64</td>
<td>0.039</td>
</tr>
<tr>
<td>Lansing</td>
<td>128</td>
<td>6</td>
<td>7,200</td>
<td>63</td>
<td>0.052</td>
</tr>
<tr>
<td>Kalamazoo</td>
<td>80</td>
<td>7</td>
<td>5,100</td>
<td>61</td>
<td>0.083</td>
</tr>
</tbody>
</table>


The meter enforcement today usually gives the parkers impression that they may not be caught if they are late for a couple minutes. Most of them are right because of the low enforcement level that shows in Table 1. In order to achieve more efficiency and fairness in enforcement, a self-enforced or computer-enforced meter system should be the choice in the future.

³ Transportation Quarterly, Vol. 41, No3, July 1987, 301
Coin Collecting

There are certain people in a city authority who are responsible for collecting coins from the parking meters. In some cities, the local police departments take this responsibility. The money they collect should be turned into city revenue. However, a report from The Parking Professional states that in the city of Albany, NY, four police officers pilfered the coins inside meters in the '80s.4 This was one of the reasons that forced the city authorities to remove the parking meters from streets 18 years ago.

The manufacturers redesigned the meters and provided a special device for collecting coins in a secure way. With this new design, the coins fall into a sealed coin box inside the meter (See Fig. 6). The collectors have to remove this sealed box and put it into a heavy-duty collection cart (See Fig. 7). With a turn of a handle, the coins are deposited into the cart and the coin box is automatically resealed for immediate reuse (See Fig. 8). The city authority of Albany, NY, where the police officers once pilfered money from parking meters, now uses these collecting carts and sealed coin boxes to ensure that the money goes into city revenue.

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Violations

There are two types of violations regarding the parking meter system: "insufficient payment" and "exceeding time limit." Both Violations are considered "folk crimes."\(^5\) Insufficient payment means that a driver parks for a legal duration that doesn't exceed the time limit, but pays only part of the fee for that duration, or none at all. Exceeding the time limit means that a driver parks at the same metered-space for duration longer than the legal time limit. One violates the meter regulations even if one pays for the extended stay, which is known as "meter feeding."\(^6\) The punishment usually amounts charging the violators fines. These fines will be part of city revenue eventually. According to a report in *The Rochester, NY Democrat and Chronicle*, October 4 1998, the collected fines in

Washington D.C. in 1997 amounted to 49 million dollars, which was more than three times the regular meter revenue. The research didn't show if this is common across the country. However, it is important to take it as a fact that people in Washington D.C. paid so much fines in a year.

**Vandalism**

Vandalism is a huge threat to meters in every city. Almost every city with parking meters installed spends thousands of dollars replacing vandalized meters. There are a variety of reasons that cause parking meters to be vandalized. The most important one is that there are coins inside. Moreover, the low visibility of the meters to police patrol is a key factor that leads to meter vandalism. Anyone who intends to knock off a meter can easily do it without witnesses. While one may get 20 or 30 dollars by knocking off a meter, the city has to spend 400 dollars or more to fix or replace one.

A meter without coins inside would be less likely to be vandalized, because there is no money to steal. However, it's not going to stop vandalism. Someone will still knock

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off a meter head for no reason. However, a study of crime in commuter parking lots by
the Regional Planning Agency (RPA) for the Connecticut Department of Transportation
concluded that there are three conditions that contribute to theft and vandalism: isolation
from public view, poor lighting, and low level of police activity. Recommendations by
RPA and the state and local police departments are made to keep crime from commuter
parking lots. Some of the same recommendations can be used for installation of parking
meters because there are meters installed in parking lots as well as roadside locations.
They are:

1. *Telephones.* Easy access to a telephone was considered to be important for quicker
   reporting and for persons who may need help for any reason.

2. *Video camera surveillance.* This method of protecting facilities from criminal
   activities was felt by some to be the next best thing to the physical presence of
   guards.

3. *Signage to indicate emergency and/or police number.* The existence of signs
   indicating the appropriate numbers to call for help was felt to be important in
   reporting a crime as soon as possible.

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8 Alan N. Mancini, Rejendra Jain, "Commuter Parking Lots—Vandalism and Deterrence, Transportation
Quarterly, Vol. 41, No 4, October 1987 (546-49)
Financial Issues

Knowing the operational cost and profit of a meter system helps in managing a meter system. It also helps in understanding what industrial designers can do to improve the parking meter system. There are difficulties in the research of financial issues about a parking meter system. The authorities all consider the information as confidential material. However, a study by Katherine Kuzemka gives an overall picture of the financial issues of parking meter programs in the United States.9 This study is based on a survey of 37 cities nationwide. The results of the study include the following findings:

1. The average annual revenue is $708 per meter.

2. A great majority of meter programs charge 50 cents an hour.

3. The meter programs today collect more revenue than any of the previous 10 years.

4. In average, the meter programs spend nearly half of their operating budget on personnel costs.

5. The meter programs today operate at a cost-benefit ratio of $1 spent for every $3 earned.

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The conclusion of the study states that “Meter programs will still not be as cost effective as they could be, but they will continue to be profitable. Trends indicate that, while inventories are shrinking, revenues will continue to rise as a result of higher hourly fees and diligent enforcement.”

The data in Table 2 shows the general performance per meter per year in cities nationwide with different scales of programs. Comparing the cost of a mechanical meter, which is $400 to $500, and the cost of an electronic meter, which is above $600, shows that parking meter programs in big cities are pretty profitable. In consideration of the possible high cost of this proposed hi-tech meter, it would be more suitable for installation in cities with high meter revenue. Seattle and Pasadena, for example, would be potential cities for this hi-tech meter system.

<table>
<thead>
<tr>
<th></th>
<th>Large Programs (more than 10,000 meters)</th>
<th>Medium Programs (5,000 to 9,999)</th>
<th>Small Programs (less than 5,000)</th>
</tr>
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<tr>
<td><strong>Average Hour Rate</strong></td>
<td>$0.58</td>
<td>$0.71</td>
<td>$0.71</td>
</tr>
<tr>
<td><strong>$/Per Meter/Year</strong></td>
<td><strong>Highest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>New York $965</td>
<td>Seattle $1,042</td>
<td>Pasadena $1,464</td>
</tr>
<tr>
<td></td>
<td><strong>Lowest</strong></td>
<td>Miami $285</td>
<td>Atlanta $195</td>
</tr>
<tr>
<td></td>
<td><strong>Average</strong></td>
<td>$853</td>
<td>$609</td>
</tr>
</tbody>
</table>

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Moreover, on average, over half of the budget in parking meter division was spent on personnel expenses (See Fig. 9). One of the features of the proposed hi-tech meter system is "self-enforcement," which means that the meters will perform the enforcement themselves. It will be a "meter maid free" system. It will help in reducing the personnel expenses and will affect an increase of revenue from parking meters. In other words, an automatic or a self-enforced meter system will be more cost effective than the current system.

Fig. 9. Budget Distribution
Technology

Parking Information

People who first arrive at a city and look for parking meters usually don’t know where to start. They may have maps for a city, but usually don’t know where to find a parking meter. The only means to guide drivers to parking facilities is the signage system typically found on the roadside (See Fig. 10-12). However, it only indicates where the parking facilities are. It can’t tell the drivers where parking spaces are available. The drivers still have to drive around hoping for luck. It's very inconvenient and dangerous, especially for people who have urgency. Some of them might park illegally or resort to aggressive driving in order to get a parking space. The result could be dangerous to innocent people.

Fig. 10. Signage I  
Fig. 11. Signage II  
Fig. 12. Signage III
With the advances of technology, the GPS map system is now installed in some cars now. It helps with guiding drivers to their destination just like traditional maps. It would be a great benefit for drivers if there were a networked parking information system, which offered real time parking information that could be accessed when drivers were looking for parking spots.

*The Microwave Detecting Technology*

Electronic tollbooth at the entry points to the city of Trondheim, Norway allow vehicles to pass through at up to 50 km/hr (31.6 mph). The throughput is tripled over traditional booth to about 1500 vehicles per lane per hour, and cost of ownership of the tolling system is reduced by up to 90%. Moreover, the best systems allow vehicles go through without slowing down.

Fig. 13 shows a basic non-stop tolling system. The system includes three key elements: a device (tag) which is mounted inside the window of a vehicle, an interrogator on the roadside of toll station and a control center. The tag inside the window is a device that records the account information of a user. This device (See Fig. 14-15) only modifies and returns a microwave signal sent to it from interrogator but can't generate a signal of its own. It is extremely reliable and unobtrusive. About 90% of those in use today for
tolling are of this type. The interrogator constantly sends out microwaves and receives the response from every passing vehicle. It transfers the data response from the passing cars
to the control center immediately. The computers in the control center sum up the information and bill monthly.

**The Roadcheck™ System**

The Roadcheck™ System, which is developed by Mark IV Industries Ltd. has been proven successful on the E-Z Pass of New York State Thruway System for more than six years. It includes the readers (interrogators), the vehicle mounted transponders (tags), and a central computer system (See Fig. 16).

The system used in Trondheim, Norway charges users right after they pass the interrogator. The E-Z Pass system needs to keep tracking the entrance and exit of each vehicle. The data from each E-Z Pass tollbooth is sent to a central computer system to calculate the charge for each vehicle everyday. It takes a large computer system to track and calculate the balance of all of the accounts (about 300,000 accounts now and increasing) because several transactions are posted against each account each day. It is also why a major portion of the money is spent on Account Management Services (AMS). The AMS provider, which is responsible for maintaining customer accounts,

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11 The Roadcheck™ System is the operation system of E-Z Pass in New York State Thruways.
bills the users monthly. It also maintains an 800 number service center that requires many full time operators accessing an on-line system to answer customers’ questions.

Fig. 16. The Roadcheck ™ System

The E-Z Pass also includes the Violation Enforcement System (VES), which is a camera-based system to identify toll violators. The camera takes pictures of the violators’ plates when vehicles pass through the toll lane without tags being detected. These images are then collected and forwarded to the AMS provider. Operators in the AMS provider forward the plate numbers from the images to the Department of Motor Vehicles to obtain the names and addresses of the vehicle owners. The operators then mail violation notices to the vehicle owners. Approximately 99% of violators are captured and 70% of the images can be read clearly.
E-Z Pass in New York State Thruway system has been very successful. The users have increased from 70,000 people in 1993 to 300,000 people in the beginning of 1999 and are still increasing. The system processes more than three times the vehicles per hour than the cash toll booth system. The performance of E-Z Pass has been so convenient that the New York State Department of Motor Vehicles (DMV) intends to standardize an identification device that will be installed on every new car in the future. This device will facilitate the E-Z Pass system for tracking automobiles on the Thruway network for tolls just like the car tag now. In this way the new vehicles in the future will have identification devices on board that can be identified by a proper device.

**Radio Frequency Identification (RFID) Technology**

Speedpass of the Mobil gas station offers the fastest way for customers to purchase gasoline without using a credit card. It uses an electronic system located in the pump to communicate with miniature transponder devices — key tags or car tags — that are attached to customers’ key rings and/or the rear window of vehicles. Customers enrolled in this program will simply park or wave a key tag in front of a designated pump.

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12 Barry Soloman, “NYS Thruway supports ITS with the E-Z Pass Electronic Toll Collection System.” NYS Thruway Authority, 200 Southern Blvd., Albany, NY 12209
and will be able to immediately fuel and drive away.

![Fig. 17. A Speedpass Key Tag](image1.png)  ![Fig.18. A Speedpass Car Tag](image2.png)

The essence of Speedpass technology is the Radio Frequency Identification (RFID) control, which was developed for Mobil in cooperation with Texas Instruments Registration and Identification System (TIRIS) and the Wayne Division of Dresser Industries. Fig. 19 shows how the Speedpass works. It is similar to the one in Trondheim, Norway. However, there are unique features as follows:

- **Flexibility in account selection.** The Speedpass accepts most of the major credit cards and debit cards available (e.g. VISA/Master cards, American Express...). In comparison with the E-Z pass system, in which the AMS provider has to bill customers, the Speedpass directly charges to the credit/debit account to which one has been assigned. There is no extra bill at all.

- **Account Security.** The data transmission between a key/car tag and the interrogator inside a gas pump is through a unique code in identifying a customer's account. The customer's credit card account number remains outside
of the transmission. There is no way for a third party to be able to access the customer's credit card account number in the process of activating Speedpass.

Fig. 19. Speedpass

Networking

Networking is one of the advantages in using computers for managing and monitoring. A basic network includes two machines, one called "Server" the other called "Client." A server is capable of managing several clients, depending on the server itself and the software that is used. The connection between a server and a client is usually a specific cable. However, the advances in cell phone technologies make wireless networking easier and cheaper, especially when networking parking meters on the street.
Networking also provides monitoring functions for a parking meter system. The study of the expenses in meter systems shows that an average of about 50% of the budget is used on personnel expenses (Fig. 9). With networking, there is no need to have enforcement officers on the street. There will only be people monitoring at a control center.
Chapter 3
Scenario

Hypothesis

I want to propose a picture of a future parking meter system based on a study of the existing meter system and the technologies:

The automobiles in the future will be equipped with an identification device that will facilitate the automatic tolling system tracking and charging tolls on highways and bridges. The hi-tech parking meter system in the future will take advantage of this. On every parking meter, there will be a sensor interrogator installed which can detect a car that parks in front of it. The parking meters will accept credit cards or debit cards, which will be available at most grocery stores nearby, instead of coins.

The meters will perform a self-enforcement function, which means that they will be able to charge fines to a user’s account if any violation occurs. Consequently, no parking enforcement officers will be required in the future. It also means that every violation will be recorded and fined. The networking capability offers a remote-monitoring function, which means there will be people from the city parking meter division monitoring the
meters in a control center and reporting to the service department or local police department if necessary. The networking can also offer real time parking information for drivers to access through the GPS system onboard. It would bring convenience to drivers who are looking for on-street parking spots.
The Current Meter System

Enforcement officers are keys to the current meter system.

Officer, I am only 2 mins late. Could you give me a chance?

Okey, no problem. I have met my quota today.

The Proposed Meter System

The proposed meter system is fully automatic.

You are 10 mins late. $5 has been charged to your account.

Fig. 20. Scenario I Officer Enforced V.S. Self-Enforcement
Fig. 22. Scenario III The Remaining Time from the Previous Vehicle
Fig. 23. Scenario IV: Vandalism

The Current Meter System

The proposed meter system accepts credit cards only.

The Current meters contain the coins that are collected.

The proposed meters are easily vandalized.

It helps to reduce meter vandalism.

open new meters no coins inside.
The Current Meter System

It's usually hard to find an on-street parking spot when you really need it.

I've been circling around this area for 16 mins, I still can't find a parking spot.

The Proposed Meter System

The proposed meter system will be capable of networking. Real-time parking information will be available through the navigation system onboard vehicles.

The red dots represent possible parking spots available.

It's easier to find a parking spot with this hi-tech meter system.

The blue dot represents the location of your vehicle.

Fig. 24. Scenario V Real-Time Parking Information
Chapter 4
Design Development

The Goals

The overall goal of this proposed hi-tech parking meter design is to improve the existing parking meter system by applying new technologies and to improve the user interface of the current meter system. It should offer solutions:

- To reduce the possibility of meter vandalism.
- To provide better enforcement performance.
- To provide better control in short-term parking and create more opportunities for short-term parkers.
- To reduce the use of human labor in the parking meter system.
- To provide the capability of being networked.
- To help drivers to find on-street parking spaces easier.
- To provide flexible ways in paying charges.
- To provide more visible clues for people who are looking for parking meters.
- That considers aesthetics to serve in a variety of environments as street furniture.
• That allows people recognize it as a parking meter without confusion.

• That considers the capability of installation with an existing system.

• That considers the source of electricity for the new design.

Design Criteria

Feature Functions

This hi-tech meter should provide the following functions:

• There should be two sensors to provide radar/microwave detection. One to detect a car pulling in and out, the other sensor to start the timer.

• There should be a credit/debit card reader for people who don’t have a tag to start the timer.

• This new meter should not accept coins to avoid possible vandalism.

• It should provide a better solution for the users than the 2-D flags and the LCD panels on the existing meters.

• There should be a LCD panel for instant assistance and information.

• This hi-tech meter should include a compact computer, a modem and a cell phone for being remotely networked.
• The new design should be able to perform a self-enforcement function to reduce the use of labor and increase the efficiency.

• This new design should be capable of being installed into the existing meter system. The requirement to reconstruct the curbside should be avoided.

• There should be solar panels and a rechargeable battery to take advantage of the solar energy and also to be a self-contained power supply.

Ergonomics

In order to meet the requirement of The Americans with Disabilities Act to accommodate the heights of the fifth percentile women. Some physical limitations are stated as follows:

• The height for LCD panel is about 4'-7"

• The height for function keys/key sensor is between 4' and 4'-5"

• The height of this meter should be over 4'-5" to make it obvious to drivers.

Material Application

In order to meet the requirement of exposure to outdoor environment, the materials of this hi-tech meter should be able to stand on the street for years without degrading.
These materials should also be able to survive possible impact caused by people, small stones and such. Transparent materials are required, too, in some functional parts such as the housing for meter flags and LCD panels. Polycarbonate is one of the materials that fits the criteria. It is strong and durable under exposure to sunshine (UV Rays). It could also be made in different colors. Moreover, it could be either opaque and/or transparent. These qualities make it the ideal material for the housing of this design.
Initial Sketches

The goal of this project was to design a hi-tech meter system that would improve the problems of the current one by applying advanced technologies. These problems include vandalism, standard of enforcement... etc. Fig. 25 shows a wide exploration of different possibilities. Fig. 26 shows further developments utilizing the existing “pole” structure of the current meters. The “pole” infrastructure has existed ever since the first parking meter was invented. Almost all parking meters use it now. It would be a good idea to incorporate these poles into the design of the new meter system instead of building a brand new infrastructure. Fig. 27 shows different approaches.
A Study of connecting two meter heads to one pole.

It could be a piece of contemporary sculpture.

Some ideas around "Timer"

Fig. 25. Initial Sketches
Fig. 26. Initial Sketches
Fig. 27. Initial Sketches
Refined Sketches

Figs. 28-30 show development on the current infrastructure. The sketches imply a human figure standing on curb. It was the intention to reflect the self-enforcement capability of the technology I’m proposing. Fig. 28 implies a figure that looks like an armed officer while Fig. 29 and Fig. 30 imply a figure that is more friendly looking. Fig. 31 and Fig. 32 represent a sculptural approach. Fig. 31 reflects a bold, tough image while Fig. 32 shows a more refined piece of sculpture.
Fig. 28. Armed Officer Image
Fig. 29. Friendly Image
Fig. 30. Alternative Friendly Image
Fig. 31. Sculptural Approach
Fig. 32. Alternative Sculptural Approach
Selected Design

Fig. 33 shows the final sketch that was selected for this project. It was chosen for two reasons. First, it’s good to be able to utilize the current infrastructure since it’s more cost-effective and easier in terms of its construction and installation. Second, people have been familiar with the look of current parking meters for decades. It would be better to approach this design with an evolutionary appearance instead of a revolutionary one.
Fig. 33. Selected Design
Chapter 5
Design Result

Final Delivery

The final result of this project was presented with a 3D virtual model constructed in Alias modeling software. There was also an animation to demonstrate the operation process. The animation was recorded on a compact disk (CD-ROM) format (see appendix).

Introduce the E-meter

The E-Meter is proposed for solving the existing problems of on-street parking meter systems, which are vandalism, ambiguity in enforcement, scandal, etc. It is also proposed to improve the user interface by integrating both existing and prospective technologies into the product’s design. The overall design of this E-meter keeps the same, basic configuration as the existing meters, that is, a meter head mounted on a pole to the ground. It is better for the new design to share the same general appearance as the existing meters for easy recognition. It is also good to be able to utilize the existing pole infrastructure instead of constructing brand new ones on the curb.
Fig. 34. The E-meter
Features

The styling of the meter implies a human figure. It reflects the self-enforcement function of the design. It looks like a parking enforcement officer standing on the curb and monitoring on-street parking. The other features are:

The 3-D Flag design with its dome housing providing 360 degree visibility for users so that they will have good visual contact with the meter from distance,

LCD Instruction Panel with Functional Buttons offering real-time interactive instruction for operation.

Keypass Sensor with Instruction Panel an activation device.

Credit/Debit Card Reader providing flexibility and protection from vandalism in paying for parking.

Car Sensor offering real time parking monitoring and information through networking.

Operation Indicator showing the operation status.

Solar Panels offering self-contained power supply.

Poly Carbonate Housing providing strong, durable material for direct UV exposure every day.
1. Stand By

2. When a car approaches, the car sensor detects the transponder on the vehicle. The E-meter is activated.

3. The "EXPIRED" flag rotates into the meter-head indicating that it is ready for operation.

4. The user activates his/her account with a keypass. The yellow indicator to the right of the sensor lights to confirm the operation.

5. The Green flag raises to a default time of 30 mins.

6. The E-meter prompts an instruction on the LCD screen asking for time adjustment.

Fig. 36. Steps of Operation 1
7. The user presses the "+" to increase his staying time.

8. The user sets his staying time at 50 mins.

9. The user presses the "ENTER" button to confirm his selection.

10. The E-meter informs the user the amount of money that is charged to his/her account.

11. The user is all set to leave.

Fig. 37. Steps of Operation II
Fig. 38. Color Scheme
**Fig. 39. A Comparison of Current Meters with E-Meter**

<table>
<thead>
<tr>
<th>E-Meter</th>
<th>Current Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Enforcement -- Less Labor, More Efficiency</td>
<td>Officer Enforced -- A Waste of Officers’ Labor</td>
</tr>
<tr>
<td>Keypass, Credit/Debit Card Accessible -- Less Vandalized</td>
<td>Coins Collecting System -- Often Vandalized</td>
</tr>
<tr>
<td>3D Flag Design -- All Around Visibility</td>
<td>2D Flag Design -- Limited Visibility</td>
</tr>
<tr>
<td>Security -- On-site Monitoring</td>
<td>No Security Function</td>
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<tr>
<td>On-line Instruction -- User Friendly</td>
<td>Instruction on Stickers Hard to Read</td>
</tr>
<tr>
<td>Solar Energized with Rechargeable Battery</td>
<td>Mechanical or Battery Powered</td>
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Chapter 6
Conclusion

This project provides an example of how technology can enhance an urban utility that has been known for problems and issues for years, but nothing major has been done to it and the way it works yet. As an Industrial Designer, I tried to look into this project from both the views of the users and the city authorities during the research and development stage. I wanted to bring the users a meter system with credit/debit card accessibility and a more user-friendly design. For the benefit of the city authorities, I wanted to design a meter system with self-enforcement, network capability and less concern for vandalism.

According to my research, all the proposed technologies, such as: the radio frequency identification (RFID) technology, The Roadcheck™ system and the microwave detecting technology can all be implemented immediately. The technology for networking and monitoring is also available. In other words, what I am proposing here is a concept that integrates the technologies available into a product to make it more powerful, functional and friendly to the end users.
Parking meters are important for controlling and encouraging city parking turnover. They can play a key role in promoting the business and vitality of a city because of the convenience that they offer. This project provides an example of making a parking meter better by integrating technology to resolve some known issues. It shows a more viable solution than is currently available on the market. I am looking forward to seeing these ideas on the curb in the near future.
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