

**Redesigning The Portable Toilet**  
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## Introduction

Imagine this familiar situation. You are at an outdoor concert and suddenly you have an urge to go the bathroom. You frantically look around, hoping to find a nearby building with indoor plumbing, but alas, you find none. Instead, you see a row of brightly colored “porta-potties” designated for concert guests. If you are like most people, your stomach churns in disgust, and you reassess how bad you actually have to “go”.

Why are outdoor portable toilets, commonly referred to as “Porta-Potties” or “Porta-Jons”, so unpleasant to use? How does the design of these buildings lead to the common consensus that portable toilets are dirty, unsanitary, and uncomfortable to use? In this report, I will be addressing these questions, and exploring some design solutions that would make portable toilets more cleanly and comfortable to use.

## Research and Evaluation

Previous research in the area of public restrooms has revealed that public toilets are very unsanitary. Greed (2006) reports that it has been demonstrated that in public toilet settings, the chances of pathogen transmission are very high even in toilets that may appear to look clean, because complete strangers mix and use the same facilities causing a high risk of bodily fluid exchange, contamination and organism transmission. Dirty toilets also attract disease-carrying varmints such as flies, lice, mice, and ticks (Greed, 2006). Many people perceive this fact, and change their behavior in public toilet settings. For example, it has been shown that around 80% of women “hover” over the seat to urinate in public settings in order to “avoid catch germs” (Greed, 2006). This type of behavior only magnifies the chances of fluid transmission, because many women do not put the seat up and thus leave urination residue on the seat top. It has also been shown that 55% of males like to use their feet to kick up toilet seats if they must use a standard toilet bowl to urinate (Siu, 2006). This can have the effect of getting dirt on the seat. Even worse, Siu (2006) reports that 35% of males will not take up the seat when urinating, causing fluid to easily spray on to the seat. Siu (2006) has also conducted studies that show that about 70% of people are extremely dissatisfied with public toilet ventilation systems, and this feeds these behavior changes.

Since a portable toilet is different from a public toilet in that it does not have plumbing and is usually in an outdoor setting, I wanted to see if Siu and Greed’s results could be translated to how people view and interact with portable toilets. So, I administered a survey (Fig. 1) to eleven individuals, five males and six females, that captured their opinions and actions when using a portable toilet.

The first four questions were about how people used portable toilets. I asked participants to rate on a 7-point Likert scale (seven (7) means very likely and one (1) means very unlikely) how likely would you be to use a portable toilet if you had to go to the bathroom (a) bad, (b) somewhat bad, or (c) only a little. I also asked how likely would you be to sit on the seat. The average of the answers were six, four, and two for the first three questions, (a), (b), and (c), respectively. The average for the last question was 1, which meant that most people would definitely not sit on the seat of a portable toilet.

I also asked participants how they felt about the size of portable toilets. Eight participants said they were too small and three said they were just right. Of the eight participants that said portable toilets were too small, four made special note that they were usually too small between the seat and the door, but the height was always acceptable.

Finally, I asked participants what they thought to be the pros and cons of portable toilets. The most popular “pro” was convenience (5), followed by privacy (2), and any available ventilation (2),

two other pros had only one respondent. There were many perceived downsides of portable toilets: bad smell (9), seeing waste in the pot (4), filth (3), and germs (2), seven other cons having only one respondent (see fig. 2 & 3 for full results). When asked what features participants would add to portable toilets, popular additions included hand sanitizers, more ventilation, and seat liners.

I believe the results from my survey echo, if not magnify, the results of Greed and Siu. Portable toilets have serious problems with air ventilation, cleanliness, and space. Design solutions must be made to address these problems.

### **Brainstorming A Design Solution**

Before making design recommendations, we first have to examine the current design trends of portable toilets, and review exactly how people interact with public toilets.

#### *Reviewing Current Design Trends*

The type of portable toilet that I am redesigning is the type that you often see at outdoor concerts and construction sites (fig. 5a & 5b ). They are often used by men and women who have normal ability to move and go to the bathroom with out assistance. Barton (2007) notes that there are many other types of portable toilets on the market today, including wheelchair accessible portable restrooms and restroom trailers that have running water. My redesign will not be geared toward these new types of portable toilets because I have little information on these buildings or the audience that uses them. However, I think that alternative types of restrooms should be offered for disabled individuals alongside standard types of portable toilets whenever possible.

I reviewed eleven different portable toilets on the market for size, floor space (if available), and tank size (fig. 6). I found that on average, portable toilets are 44 inches wide, 45.6 inches deep, and 88.1 inches high. Only three models I reviewed gave specifics on floor space, but two had a floor area of 861 sq. inches, and one had a floor area of 915 sq. inches. All of the models I reviewed had a shelf seat (fig. ). Five models commented on tank storage: one had a 60 gallon tank, two had a 70 gallon tank, and two had a 80 gallon tank. Wikipedia (2007) reports that these tanks can hold, on average, enough sewage for 10 people during the course of a 40 hour work week, or about 120 uses.

We have to think about how the current design of portable toilets should constrain any new redesign. We can all imagine the ultimate outdoor toilet solution that is made from fine porcelain and gold, but it is not reasonable for how these toilets are used, produced, or transported. A new redesign should consider cost and portability. It should also consider the process of how people use portable toilets.

#### *Reviewing Interaction Series*

Siu (2006) recorded a common series of interaction that people had with public restrooms. The four main actions were:

- (a) Enter a toilet by opening the main door to the toilet.
- (b) Open and lock the door of a toilet compartment.
- (c) Use the toilet (a seat-type toilet tub):
- (d) Open the main door of the toilet and leave. If the door handle is very dirty, a user may wrap his/her hand in tissue paper before opening the door.

Siu also recorded in-depth the actions an average user would take during the “use the toilet” phase (Fig. 4). Common interactions include inspecting the seat, moving the seat up and down, and squatting or sitting on the seat. These interactions shed light on design deficiencies of public toilet seats. Most of the interactions described involve touching the seat. This causes the spread

of germs and disease. I think that this should be taken into serious thought when redesigning portable toilets.

### **Design Recommendations**

I propose a design solution that addresses three aspects of portable toilet design: the toilet seat, the physical building design, and portable toilet accessories.

#### *Toilet Seat Design*

The current shelf toilet seat design is very poor. If anything is sitting on the seat, such as toilet paper, they can be contaminated with body fluids. Greed (2006) recommends from her studies that a minimum of 250 mm be maintained around the toilet seat so walls, doors, and toilet paper do not touch it. The current design does not accommodate this minimum requirement. It also leaves no space on either side of the bowl for footing. This is extremely detrimental to those who want to hover or squat over the toilet seat. Since every woman and man in my study said they hover over portable toilet seats, I think we should design seats so that it is easy to squat or hover over them.

When I was in Asia, I discovered a female urinal, and I believe that a modified version of the female urinal would be ideal for portable toilets in the United States. Female urinals are mostly unheard of here, so I should take a few minutes to explain the concept, and how I would make them easy to use.

Female urinals come in a few varieties. Some are on the floor (fig. 8), some are freestanding and modeled after men's urinals (fig.9), others are face-forward urinals. I think that these urinals work well, but they are so foreign to American women that they may be even more off putting than the portable toilet itself. I propose a modified design of the female urinal that is currently in use Dubai.

You may view a picture of this design in figure 10. It is essentially a toilet seat that only has the back part of the seat, and dips down like a urinal in the front. This type of seat in a portable toilet would allow men and women to stand or squat if they wanted, but would also allow for those who wanted to sit on the back part of the seat. It would minimize how much fluid spray got on the sitting part of the seat, and eliminate the need to touch the seat to lift it up.

It would be very important to get the measurements for this seat so that it would be comfortable to use standing in front of it, squatting over it, and sitting on it.

The back part of the seat is the part you would sit on. This part has to be able to comfortably sit an individual with their legs slightly apart on each side. The back most portion should be large enough to accommodate the hip breadth, which for an average individual is 14.1 inches. However, individuals ranges between 12.1 (5<sup>th</sup> percentile for males) and 17.2 inches (95<sup>th</sup> percentile for women) should still be able to sit on the seat with some degree of comfort (Sanders & McCormick, 1993). This width should continue out for a bit on both sides of the whole because sitting on the back part of the seat alone would not allow the person to take a bow movement. The seat should support most of the thigh both length and width. Unfortunately, I was not able to find data for thigh anthropometric data, however both top panels of the seat should support a range between the 5<sup>th</sup> and 95<sup>th</sup> percentile of thigh widths and heights. This would be at a minimum of 17.7 inches (class notes) and likely much more to accommodate for the center hole.

The whole in the center should extend forward past the seat top. This would be the urinal part of the seat. Women and men could squat over or stand in front of this part to urinate if they did not want to sit. The sides would be thin and the hole would be bigger than the sitting hole. When thinking about the urinal aspect of the design, it is important to consider height. The back seat would be slightly higher than the urinal part to accommodate knee space. I would recommend

that the seat height accommodate people with ranges of popliteal height between 14 inches and 19 inches when sitting down, with the maximum comfort for those at the average of about 16.5 inches (Sanders & McCormick, 1993). The urinal part should be a little bit lower so shorter women can adequately squat over it if needed.

Finally, it would be important to explain how to use this new type of toilet. I suggest three graphic symbols in a horizontal line on the inside of the door on the unit that show the three methods of using the toilet: standing, squatting, and sitting. All three graphic symbols would be enclosed in contrast squares, be easily interpreted, and would follow the principles of good graphic symbol design as outlined in "Human Factors in Engineering and Design" on page 126 and others (McCormick & Sanders, 1993). It is important to locate the symbols on the back of the door because this is where people will be staring while they relieve themselves. Other places, such as the back wall, would be harder to see and thus possibly ignored.

### *Building Design*

The building materials of the unit itself would be relatively similar to current designs. I would use the same type of plastic and general structure to erect the building. However, I would make a design change in the shape of the building.

If you look on page 431 of Sanders and McCormick's "Human Factors in Engineering and Design" we will see a set of diagrams relating clearances for various body positions. Look at the crouching position of the diagram on the top row and on the right. This diagram shows us why many portable toilet users do not feel as if there is enough space between the seat and the door. This position is most similar to how someone would crouch over a toilet seat to urinate. The recommended clearance is 40-44 inches. This is almost the same depth as an average portable toilet (45.6 inches). However, let's make some of the necessary changes to the diagram to account for how people actually squat over toilets.

Let's position the man so he is standing up straighter but in a similar crouch position. This would cause his head to come up and forward. Further, let's reposition his feet so that they are not touching the back of the space. In a portable toilet room, your feet will be several inches at least from the back of the room because of the toilet fixture – especially with the shelf seats that are common in today's models. This will move the man's body forward several inches. When you take these factors in to consideration, it is easy to see why many people think there is not enough space between the seat and the door. For sitting or standing, the space may be adequate, but for squatting, your head will probably be right up against the door.

This has inspired me to redesign the portable toilet building itself so that it juts out in front a little to give the user a little more space (fig. 11). Most of today's portable toilets are rectangle, but this design would give the room a slightly angled front. This would give a few extra inches to the user. I would recommend adding a minimum of 4-8 inches to the depth of the room.

A common complaint I saw in the survey results was that users did not like seeing the waste in the toilet pot. I believe that the new style of seat will help this a little because there will be a slight angle down to the pot from the front of the seat. However, a change that this new type of seat will necessitate is a slight movement of the waste department.

In current models, waste can accumulate in the bottom of the portable toilet and then into the shelf seat. This can cause overflow and unsightly waste in the pot. In my design, the elimination of the shelf will require us to heighten the floor a little so the waste can be stored underneath the base of the toilet. The floor needs to be heightened enough so that the total volume of the waste container is still 60-80 gallons.

By raising the height of the floor we run into another issue: the total height of the unit. These units still need to fit in trucks to be moved, so their total height should not go much higher than the average of 88 inches to 89 inches. So, I propose that the top of the portable toilet unit have collapsible netting (fig. 11).

The collapsible netting will be easy to set up by four retractable polls on each side of the roof of the unit. This type of netting gives us a big benefit in the amount of ventilation in the unit. In fact, the amount of netting could be added or subtracted depending on how much ventilation is actually needed in the unit. This netting, along with common deodorization liquid in the tank, could significantly increase the quality of the smell in portable toilets. The top of the unit will still be hard plastic that can snap on to the other walls when the netting is retracted. The average person could collapse the top easily at night or in the rain via a small metal latch in the stake polls at the top.

#### *Portable Toilet Accessories Design*

From my research, I have come to the conclusion that there are two necessary accessories for every portable toilet. The first is toilet paper. I believe that in the portable toilet, the toilet paper roll is ineffective. You can only have one per unit with out the risk of the extra ones sitting on the floor or on the seat collecting germs. So, I propose a toilet paper dispenser that is common to a vertical napkin dispenser (fig. 11). People could pull out sheets from the bottom of the dispenser, as they needed them. This would eliminate the possibility of them touching other people's toilet paper or of them having to replace the toilet paper roll (and probably not doing it adequately). A few of my survey participants responded that portable toilets are always running out of toilet paper. We know from research that a portable toilet can be used 120 times, so we should stock enough paper to accommodate a little over that to make sure they don't run out.

The second is hand sanitizer. I believe hand sanitizer should be a requirement in every portable toilet. However, I think we should invent a mechanism for it to be dispensed through a foot pump. Siu (2006) noted in his paper that foot pumps were especially effective for flushing mechanisms on toilets because they allowed for minimal transfer of germs. I believe this system could also be effective with hand sanitizer dispensers. The user could use his foot to pump out a small bit of sanitizer to his hands and then quickly leave the unit. I think the effectiveness of this type of design depends on our ability to make a foot pump that is not easily jammed or clogged. It also depends on the consumer realizing the foot pump exists and how to use it. To remedy this problem, I recommend putting clear graphic symbols and concise directions on how to operate the sanitizer-dispensing device.

Both the toilet paper and the hand sanitizer should be at accessible locations. I recommend positioning them on each side of the slanted just out in the front of the unit. This way they are visible and reachable. The toilet paper should be at a height somewhere around elbow rest height, which is, on average 9.4 inches above the sitting plane (the seat) (Sanders & McCormick, 1993). However, we have to take into consideration that not all users will be sitting, some will be squatting and others standing. So, I recommend placing it a bit higher to make up for the height differences. The soap dispenser should be placed between elbow and shoulder height. This is between 41 inches and 53 inches off the ground, on average (Sanders, McCormick, 1993).

#### **Conclusion & Implications**

I realize that some of the changes I suggested for portable toilet redesign may look good on paper, but are unproven in an American market place. Manufacturers may have fears that women will be turned off by the female urinal design. While I myself have tried female urinals and like them, only testing on the general public will help us know whether these types of design are optimal for public portable toilets. In fact, I agree with Siu (2006) that more public participation in

the design process of public toilets would be beneficial to the design process. I believe that once women learn how to use such devices they will adapt to them quickly and find them more sanitary than standard toilets in public spaces.

I strongly believe that redesigning the outdoor portable toilet would be extremely beneficial for the public's health, safety, and ease of mind. The design recommendations I made here should be prototyped and tested immediately. If these design recommendations were received well after several user tests, I would consider them a success. I think a huge spot in the market place would open up for a portable toilet company to differentiate itself from its competitors by making an affordable, safer, more comfortable outdoor portable toilet.

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McCormick, E., & Sanders, M. (1993). Human Factors in Engineering and Design. New York: McGraw-Hill, Inc.

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Portable toilet. (2007). In Wikipedia, The Free Encyclopedia. Retrieved 00:49, November 28, 2007, from [http://en.wikipedia.org/w/index.php?title=Portable\\_toilet&oldid=169603382](http://en.wikipedia.org/w/index.php?title=Portable_toilet&oldid=169603382)

## Other Background Reading

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Levinson, Orde (1999). The Female Urinal. The British Toilet Association. Retrieved November 27,2007 from <http://www.femaleurinal.com/>

女の人も立っておしっこ? (2004). ["Can Women Urinate Standing Up?", Original Japanese Text, Self-Translated] Toto Toilets for Kids. Retrieved November 27,2007 from <http://www.toto.co.jp/kids/alacarte/04.htm>  
(Nice diagrams and animations, even if you don't speak Japanese.)

Figure 1: Pre-Design Survey.

*Please rate from 1= not very likely to 7 = very likely*

• **Imagine you are at an event like slope day or an outdoor concert. You suddenly have to use the restroom. You see the event has porta-toilets provided. How likely are you to use the porta-toilets if....**

- o You have to go to the bathroom really bad:
- o You have to go to the bathroom somewhat bad:
- o You have to go to the bathroom only a little:

*Please rate from 1= not very likely to 7 = very likely*

• **When you use a porta-toilet, how likely are you to sit on the seat (vs. hovering over it, squatting, etc. ):**

• **Do you think porta-toilet rooms are usually: (circle one and if too big or too small, please explain in what dimension/area.)**

- o Too big
- o Just right
- o Too small

• **What features of porta-toilets do you like?**

• **What features of porta-toilets do you not like?**

• **If you could add or take away any features of a standard porta-toilet, what would it be?**

Figure 2: Survey Results

sex	go bad	go mid	go little	sit on seat	size	pros	cons	new features	other comments
female	6	6	6	1	too small	ventilation fans	odor	hand sanitizer	
female	6	6	3	1	too small	convenience	bad smell, too dark at night, crap easy to see, no place to wash hands, out of tpaper, too small	more light and airy	too small of space between the seat and door
female	6	3	1	1	too small	convenience	germs, filth, bad smell, lack of privacy, small	urinal for men	too small of floor space between door and seat, height is okay.
female	7	4	2	2	too small	convenience, privacy	smell, small	ventilation fan	
female	7	4	1	1	just right	convenience, when they have a ventilation top	the smell, seeing other ppls crap	seat liners, flush, air freshener	
female	6	4	1	7	too small	hand sanitizers	smell, bright colors of the wall	fan, air circulatory system	
male	7	5	2	1	too small	privacy	too small, smelly, camped, gross	hand sanitizer	too small between the door and the seat
male	7	5	3	1	too small	nice when they are vented and not filled to the brim	Smell, bugs coming out of the pot, huge mounds of stuff in the pot, limited space	well vented, good locks, make them more stable, less gerry	they seem like they could be easily tipped over with you inside. not stable enough. bad experience with this as a kid. too small of space between the door and the seat.
male	5	5	3	2	just right	urinal attachment	bad smell, seeing the crap	antibacterial hand wash	
male	7	5	2	1	just right	none	std worry	make cleaner	
male	7	3	1	2	too small	convenience for taking a pee	too small filthy	way to wash your hands	too small depth wise, has trouble closing the door
Average	6.454545455	4	2	1					

Figure 3: Survey Ideas

<b>Trait</b>	<b>Pro or Con</b>	<b>Number of People</b>
bad smell	bad	9
convenience	good	5
seeing waste in the pot	bad	4
filth	bad	3
any available ventilation	good	2
private	good	2
germs/std worry	bad	2
available hand sanitizers	good	1
available urinals	good	1
no hand washing facility	bad	1
too dark	bad	1
out of toilet paper	bad	1
bugs	bad	1
privacy concern	bad	1
brightly colored walls	bad	1
building seems unstable	bad	1

Figure 4 – Sequence of Interactions.

Source:

Siu, M. (2006). Design Quality of Public Toilet Facilities. International Journal of Reliability, Quality & Safety Engineering, Aug2006, Vol. 13 Issue 4, p341-354, 14p, 1 diagram, 1c Retrieved November 27, 2007, from Business Source Premier database.

We observed the general sequence of a user using a toilet from entering a toilet to leaving it. The sequence is as follows:

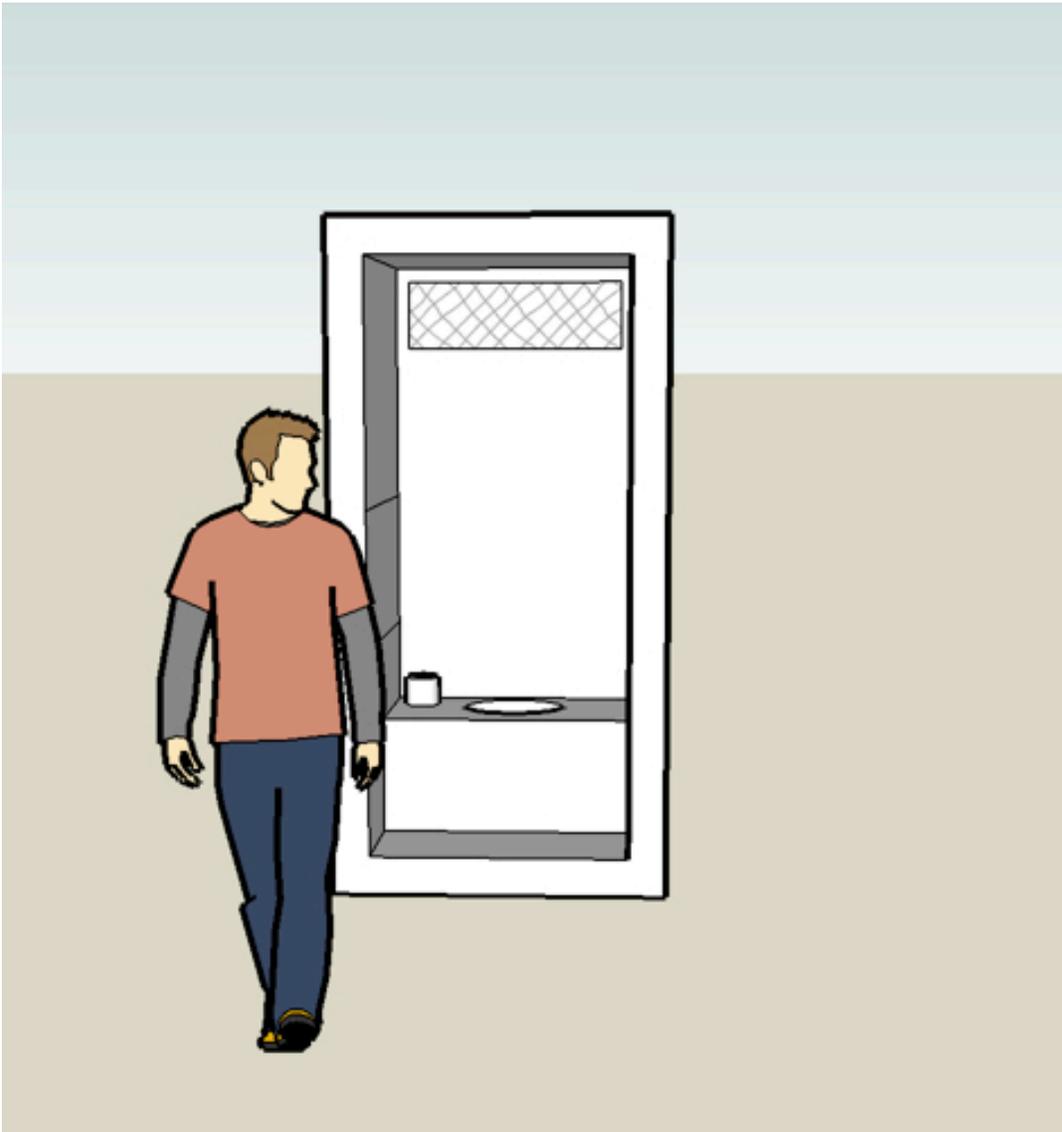
- (a) Enter a toilet by opening the main door to the toilet.
- (b) Open and lock the door of a toilet compartment.
- (c) Use the toilet (a seat-type toilet tub):
  - Inspect the seat.
  - Put down the seat.
  - Clean the surface of the seat or cover it with provided seat-cover or tissue paper.
  - If the seat is very dirty and difficult to clean, a user will prefer not to use it, or will squat on the seat or not touch it.
  - Use the toilet and clean oneself after use.
  - Use hand or foot (shoe) to push the seat-cover or tissue paper into the toilet tub.
  - Take (or kick) up the seat.
  - Inspect the flushing handle.
  - Flush the toilet. If the handle is very dirty, a user may not flush the toilet, or will wrap his/her fingers in tissue paper before flushing the toilet.
  - Open the door of the compartment.
  - Inspect the water tap.
  - Open the water tap (if the water tap is not operated by an auto-sensor) and wash hands. If the tap is very dirty, a user may not wash hands.
  - Close the water tap (if the water tap is not operated by an auto-sensor).
  - Dry hands with tissue paper or a hand-drying device (if the button of the non-automatic hand-drying device is very dirty, a user may not dry their hands).
- (d) Open the main door of the toilet and leave. If the door handle is very dirty, a user may wrap his/her hand in tissue paper before opening the door.

Figure 5a. A Row of Standard Portable Toilets.



Source:  
Portable toilet. (2007). In Wikipedia, The Free Encyclopedia. Retrieved 00:49, November 28, 2007, from [http://en.wikipedia.org/w/index.php?title=Portable\\_toilet&oldid=169603382](http://en.wikipedia.org/w/index.php?title=Portable_toilet&oldid=169603382)

Figure 5b. A Model of a Portable Toilet (In Scale) (Door Removed).



*Please Note: This mockups was drawn by Jenna Holloway (me) in Google SketchUp. I learned SketchUp solely for this project, so it is very amateur. It is meant to represent a rough draft sketch only.*

Figure 6: A Survey of Current Existing Models: Portable Toilet Comparison

Name	Capacity	Seat Type	Wide	Deep	High	Floor Space	Tank	Other Features
Hale Puka	Single	Shelf	45	45	88		60 Gallon	Urinal
Rental Site Single	Single	Shelf	45	45	88		-	Urinal
High Tech	Single	Shelf	44	48	90		80 Gallon	Urinal
Taurus	Single	Shelf	44	48	90		80 Gallon	Urinal
Deluxe Single	Single	Shelf	44	44	90		-	Urinal
Tufway	Single	Shelf	44	48	88	41" x 21" (1041mm x 533mm)	70 Gallon	Urinal
Maxim 3000	Single	Shelf	44	48	90	Floor area: 915 sq in. (5901 sq cm)	70 Gallon	None
Mr John	Single	Shelf	45	45	88	41" x 21"	-	Urinal
Porta-John	Single	Shelf	41	41	80		-	None
SaniJon	Single	Shelf	44	44	89		-	None
Avg			44	45.6	88.1			

Figure 7: Inside of a portable toilet showing a shelf seat.



As you can see, it is very easy for fluid to accumulate on the shelf.

Figure 8: Female Urinal (Floor Version).



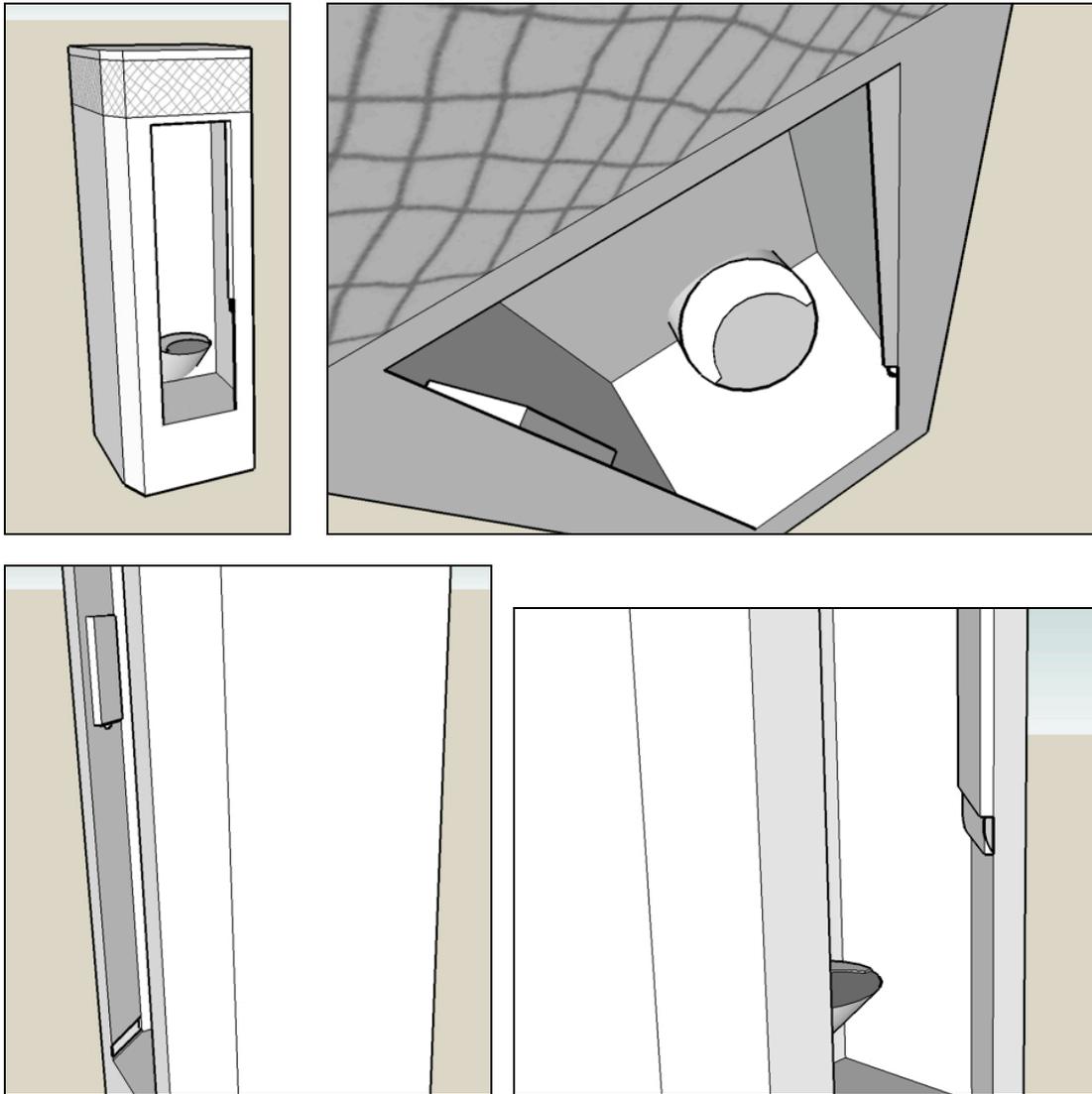
Figure 9: Wall-Mounted or Freestanding Female Urinal.



Figure 10: Modified Female Urinal in Use in Dubai.



Figure 11: Mockup Model of Redesign (Door Removed).



Top Left: Outside picture of the redesign.

Top Right: Overhead view of the inside of the toilet.

Bottom Left: View of the soap dispenser and foot pump on the floor.

Bottom Right: Paper Dispenser.

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