SwigSmart
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CS294-84: Interactive Device Design
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Mission statement (1-3 sentences):
SwigSmart offers dialysis patients a way to track their fluid intake while continuing their favorite activities of everyday life. Behind the scenes, physicians receive up-to-date information about a patient’s hydration status to intervene only when needed.

Price (at retailers):
We will initially charge $129.99 per device, in 2013, either to patient or provider (whomever decides to foot the bill) and $100/year to each provider for the back-end service. Price will drop in the following years, to eventually reach $69.99 in 2016. If there is widespread adoption, we may seek FDA approval for a specific indication, at which point insurance could cover some/all of the costs.

Cost (per unit- in years 1 and 5):
SwigSmart will initially cost $52.78 to manufacture, but the cost will drop to $31.08 in 2016. The average manufacturing cost per unit will be $32.57.
How SwigSmart Works:
Our device is unique in that it has two users: physician and patient. The chief design goal of SwigSmart was to make the patient not know it is there. All patient-facing aspects of the device are as similar as possible to a standard water bottle sleeve, such as the CamelBak model we chose to modify for our prototype. This design goal was chosen because of our patients: often very ill men and women who are not all familiar with newer technologies and have other things to worry about. Clinicians, on the other hand, are accustomed to technology and we have provided a state-of-the art web interface that is tailored to provide them clinically meaningful parameters without excess information.

Behind the scenes, we achieve passive, continuous water consumption measurements by the fusion of data from two sensors: a precision load cell and a low power accelerometer. When the accelerometer deems the bottle to be stationary, it signals to the microcontroller to read the incline of the bottle (again from the accelerometer) and the weight (from the load cell). This series of weight and incline measurements, time-stamped by the microcontroller, are transmitted to a cloud server via a Bluetooth-enabled cellphone or computer.

Our microcontroller is a single Bluetooth 4.0 system on chip, which includes the microcontroller core (Intel 8051 based) as well as the wireless communication circuitry. While this complicates the design, it allows for a smaller, significantly more power efficient circuit board, which helps achieve our primary design goal of invisibility. The overall system is outlined below in Figure 1.

![Figure 1 - Lack of bottle motion is sensed by accelerometer, which signals Bluetooth 4.0 System-On-Chip Microcontroller to take an incline and weight measurement. This data is fed to a cloud server where it is processed to infer actual fluid intake. It is then displayed via web and mobile apps.](image-url)

Intended Market
Our intended market is dialysis patients and their physicians. Most dialysis patients suffer from end stage renal disease (ESRD), and tracking water consumption is critical for correctly adjusting their dialysis. Shown in figure 2, nearly 1 in 575 Americans suffers from ESRD. This is a huge economic burden on the United States, with Medicare footing almost the entire bill as its most expensive spending item. Note that if our patient scope was broadened to all chronic kidney disease patients, not just those requiring dialysis w/ ESRD, we could reach potentially 1 in 10 Americans who remarkably suffer from some form, however minor, of chronic kidney disease according to the CDC.

Our device will first be marketed as a technology to help track water intake, without any specific mention of specific improvements in kidney function or adherence to therapy. With such a broad applicability, we can not only have “side-markets” in the health enthusiast “FitBit” crowd, but also avoid (we believe) FDA regulation until we decide a more specific indication is needed. For example, to make a statement such as “using this device is proven to improve life expectancy while on a kidney transplant list” we would need FDA approval, but not for something like “this device helps you keep track of how much water you are drinking.”
In 2009, nearly 600,000 patients suffered from end stage renal disease (ESRD). Many are on dialysis, waiting for a kidney transplant. During this crucial time, it is important to remain healthy and adjust dialysis by strict rules on water consumption.

**Potential Scenario**

John Coffee is a seventy year old man on dialysis to treat his chronic kidney failure. He has regularly visited the dialysis clinic, three times a week, for the past two years while he waits for a kidney to become available for transplant. Recently, Mr. Coffee has been gaining fluid weight, which can be seen by additional bulk in his legs and arms that is translucent when a light is placed near it. When asked how much fluid he has been drinking, Mr. Coffee replies that he religiously uses the same water bottle and fills it up exactly four times a day, making sure to drink it all the way each time.

While Mr. Coffee’s doctor believes him, he wants to be sure of his consumption, so he instructs Mr. Coffee to buy a SwigSmart sleeve to help both the doctor and Mr. Coffee keep better track of his water consumption. Mr. Coffee’s daughter purchases the device from Best Buy and puts it on his water bottle. Data is passively collected until a few weeks later when Mr. Coffee visits his nephrologist again.

Mr. Coffee’s doctor notices that the water bottle has in fact been drank to empty five to six times daily, instead of the stated four. When asked about this, Mr. Coffee says he distinctly remembers filling it only four times. This prompts further questioning by the doctor of Mr. Coffee and his daughter, and it is determined that in the evenings, when the majority of the extra drinking occurs, Mr. Coffee often seems confused and it could be that he is drinking more than he realizes.

He is diagnosed with minor dementia due to increasingly failing kidney function, and his dialysis visits are thus increased in frequency. His symptoms improve and he resumes drinking exactly four bottles a day. He receives his
kidney transplant and is removed from dialysis. He then donates his SwigSmart device to his girlfriend, Jane Tea, whom he met at dialysis clinic a few years after the passing of his wife.

**Manufacturing Product Costs**

Manufacturing costs will be calculated using the formula:

\[
\text{Product Cost} = \frac{(D + T)}{N} + M + L + P + O
\]

- **D** = Design and development costs
- **T** = Tooling costs
- **N** = Number of devices sold over the life of the product
- **M** = Material Costs per product
- **L** = Labor costs per product for operating machines, assembly and packaging
- **P** = Production costs per product
- **O** = Overhead costs (rental space, computers, telephone, electricity)

In the case of SwigSmart, the average five year cost would be per unit would be:

\[
(\$145,450 + $165,000)/1,605,000 + $31.41 + $0.88 + $0.00 + $0.09 = $32.57
\]

**Design and Development Costs (D)**

The cost to produce the first few prototypes has been relatively minimal. The majority of the cost stems from labor which includes all mechanical, electrical, and software design time, along with all fabrication/assembly time. Specifically, to date, the cost is:

\[
$5,450 = $300 \text{ (electronic components)} + $150 \text{ (mechanical components)} + 125 \text{ hours} \times $40/\text{hour}
\]

We expect this expenditure to increase moving forwards into 2013 and beyond, as it is likely that a several hundred more hours of labor and many prototypes will be required before we produce a viable commercial design and product. Updating the numbers with this information makes the total design and development cost per year:

\[
$35,000 = $5,000 \text{ (electrical)} + $10,000 \text{ (mechanical)} + 500 \text{ hours} \times $40/\text{hour}
\]

Together, this brings the total to:

\[
D = $145,450 = $5,450 + $35,000 \times 4
\]

**Tooling Costs (T)**

The next generation of the SmartSwig device is designed to fit into the existing mass manufacturing framework and not require extensive custom tooling. Specifically, the one sided circuit board will be made using a standard automated lithographic process and the radially uniform metal enclosure will be manufactured using a standard Swiss type CNC lathe. It is common practice for manufacturing shops to incorporate these tooling costs (which derives from programming the computer controlling the machine and buying the correct tool bits, which are also relatively cheap) directly into the total price of the part run. For a simple PCB and enclosure such as in the case of SwigSmart the “tooling” cost shouldn’t run more than a thousand dollars at most, but will not be listed as a separate “setup” cost as in injection molding. However, PCB assemblers do usually charge a setup fee, which is a few hundred dollars per run normally.

SwigSmart’s tooling cost is due to tools needed to expedite the final assembly and verification of the device, which is done in-house. Specifically, the rough estimates for the tooling are as follows:
First year (2013):
\[
\text{= } 5,000 \text{ (assem. tools) } + 1,000 \text{ (automatic code flashing) } + 2,500 \text{ (automated test) } + 500 \text{ (PCB setup)}
\]
\[
\text{= } 9,000
\]

The following years (2014-2016) will see expansion of the tooling required:
\[
\text{= } 15,000 \text{ (assem. tools) } + 5,000 \text{ (automatic code flashing) } + 30,000 \text{ (automated test) } + 2,000 \text{ (PCB setup)}
\]
\[
\text{= } 52,000
\]

This brings the total tooling cost to:
\[
T = \$165,000 = 0 + 9,000 + 52,000*3
\]

**Materials Costs (M)**

The cost of these materials listed will vary over the five year model being discussed for two main reasons. Electronic components are getting cheaper over time and the larger the volume being ordered or manufactured the lower the cost due to increased leveraging ability. A list of the materials used in the SwigSmart device can be found on the attached Profit Model Spreadsheet. The average material cost per unit was determined to be:

\[
M = \$31.41 \text{ per unit}
\]

It should be noted prices taken for the metal enclosure are based on rough estimates of the machining costs from custompart.net

**Labor Costs (L)**

The SmartSwig device is specifically designed to minimize the amount of labor required for assembly. The design itself, one sided circuit boards and radially uniform metal enclosures, as mentioned before, are simple and quick to fabricate, done mostly by automated machines. Again, this cost is built into the total price of the job provided by the manufacturers.

Assembly of the PCBs can be considered labor, but as volume goes up, labor costs per unit go down. We estimate that starting in 2013 the “labor” per board assembly will be about $1.00 each and by 2016 it should fall closer to $0.50. The average labor cost per board comes out to be \(\sim\$0.55\).

Labor cost comes exclusively from final assembly in-house, which should be minimized through the use of specialized labor reducing equipment mentioned before. We estimate that it should only take about 3 minutes to completely assemble and test the device. With a labor rate of $20/hr, means that the labor cost to assemble each unit is \$0.33. The total labor cost is:

\[
L = \$0.88 = \$0.33 \text{ (assembly labor cost) } + 0.55 \text{ (PCB assembly per unit cost)}
\]

**Production Costs (P)**

All production will be outsourced; therefore the total production cost is \$0.00.

**Overhead (O)**

The overhead is from renting a small office with workspace that can be used as an assembly area ($2,500 a month) and utilities required for operation ($400 a month). Thus, the total overhead is:
\[
= 163,200 = 2,900 \times 12 \text{ months } \times 4 \text{ years}
\]

Making the overhead per unit cost:

\[
O = \$0.09
\]
Operational Costs
Marketing costs were taken to be 13% of net sales. These will cover web and traditional advertising, medical device convention costs, and all other marketing expenses. Other promotional and running costs were taken to be 8% of net sales. See the profit model spreadsheet for a year by year breakdown.

Company Structure
Biomedical Solutions Incorporated, creator of the SwigSmart device, will operate as a small, agile corporation with key tasks performed in house and majority of manufacturing outsourced overseas. Assembly will be performed in-house, with scale-up if volume increases due to increased demand or penetration into other markets such as health enthusiasts. Our key business strategies will be twofold, first, to develop a robust intellectual property portfolio concerning ways of making water and other fluid consumption measurement as “invisible yet accurate” as possible. Second, we will differentiate our solution by making a seamless design that persists between the device & documentation, phone app, and web app.

Our corporation will be led by the CEO, who will handle business development and set overall corporate strategy. Accounting and HR will be outsourced. The CMO will handle sales and marketing, leading a small team of 1-2 product managers. The COO will handle procurement from overseas vendors, leading 1-2 assemblers and a procurement manager. They will also handle ordering and stocking for the R&D lab, which will be led by the Chief Medical Officer. The Chief Medical Officer will lead a small team of one mechanical and one electrical engineer to develop new versions of the device and hone the web interface, and hopefully in the future, expand to other products and markets.

Competitive Landscape
There are two main groups that SwigSmart will be competing with: hardware-based and software-only competitors. Hardware-based competitors such as the Camelbak Flow Meter and Hydracoach Intelligent Water bottle rely on turbine-based flow sensors placed in-line with the fluid path to measure consumption. They receive abhorrent customer reviews largely due to false positive readings (presumably due to the turbine spinning during exercise or other motion) and difficulty cleaning. These solutions, unlike SwigSmart, are not cloud-based—all data and analytics are accessed via a small LCD screen on each device, making them not suitable for the patient market. Health enthusiasts as well are becoming more accustomed to having their information available on their smartphone, and thus are not likely to purchase competitive products in the hardware-only space.

The software-only space are mobile, desktop, and web apps that ask the user to manually input their fluid intake. MyFitnessPal is an example, though there are roughly a dozen such solutions. This presents the greatest competition to our product, as if users input their information into the app, it is readily available with “shared” users, i.e. a physician, parent, etc. Our strength against these software-only competitors is that our solution will work with users who do not have a regiment that involves inputting data into the app: perhaps because they are very ill or because they simply are not comfortable with technology. Many of the aforementioned apps actually offer APIs to enter fluid consumption in from other platforms—we could perhaps explore partnering with one of these other companies to have our “passive, always on” fluid system input reliable fluid readings directly into their software.
### Profit Model Spreadsheet: Five Year "Most Likely" Scenario

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Sales Price Medical</strong></td>
<td>N/A</td>
<td>$129.99</td>
<td>$99.99</td>
<td>$74.99</td>
<td>$69.99</td>
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<tr>
<td><strong># Units Sold (Medical)</strong></td>
<td>0</td>
<td>5,000</td>
<td>25,000</td>
<td>75,000</td>
<td>200,000</td>
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<td><strong># Units Sold (Health)</strong></td>
<td>0</td>
<td>0</td>
<td>50,000</td>
<td>250,000</td>
<td>1,000,000</td>
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<tr>
<td><strong>Total Units Sold</strong></td>
<td>0</td>
<td>5,000</td>
<td>75,000</td>
<td>325,000</td>
<td>1,200,000</td>
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<tr>
<td><strong>Cumulative units sold</strong></td>
<td>0</td>
<td>5,000</td>
<td>80,000</td>
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<td><strong>Medical Service Fee ($100 per clinic)</strong></td>
<td>$-</td>
<td>$25,000.00</td>
<td>$100,000.00</td>
<td>$500,000.00</td>
<td>$2,000,000.00</td>
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<tr>
<td><strong>Net Sales</strong></td>
<td>$-</td>
<td>$674,950.00</td>
<td>$7,599,250.00</td>
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<td>$85,988,000.00</td>
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<td><strong>Cumulative Net Sales</strong></td>
<td>$-</td>
<td>$674,950.00</td>
<td>$8,274,200.00</td>
<td>$33,145,950.00</td>
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<td><strong>Material Costs (by component):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Weight Sensor</td>
<td>$-</td>
<td>$10.00</td>
<td>$9.00</td>
<td>$8.00</td>
<td>$8.00</td>
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<tr>
<td>Accelerometer</td>
<td>$-</td>
<td>$4.00</td>
<td>$3.00</td>
<td>$2.00</td>
<td>$1.00</td>
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<tr>
<td>One Sided PCB</td>
<td>$-</td>
<td>$0.30</td>
<td>$0.25</td>
<td>$0.20</td>
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<td>Bluetooth Module</td>
<td>$-</td>
<td>$12.00</td>
<td>$9.00</td>
<td>$7.50</td>
<td>$6.00</td>
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<tr>
<td>Battery</td>
<td>$-</td>
<td>$1.00</td>
<td>$0.50</td>
<td>$0.50</td>
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<td>PCB Components</td>
<td>$-</td>
<td>$0.15</td>
<td>$0.08</td>
<td>$0.05</td>
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<td>Metal Enclosure</td>
<td>$-</td>
<td>$20.00</td>
<td>$15.00</td>
<td>$14.00</td>
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<td>Mechanical Components</td>
<td>$-</td>
<td>$1.00</td>
<td>$0.60</td>
<td>$0.50</td>
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<td>Packaging</td>
<td>$-</td>
<td>$3.00</td>
<td>$1.00</td>
<td>$1.00</td>
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<tr>
<td><strong>Total Unit Material Costs (per unit)</strong></td>
<td>$-</td>
<td>$51.45</td>
<td>$38.43</td>
<td>$33.75</td>
<td>$30.25</td>
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<td><strong>Labor (per unit)</strong></td>
<td>$-</td>
<td>$1.33</td>
<td>$1.13</td>
<td>$0.98</td>
<td>$0.83</td>
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<td><strong>Total Unit Costs</strong></td>
<td>$-</td>
<td>$52.78</td>
<td>$39.56</td>
<td>$34.73</td>
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<td><strong>Cost of Products Sold</strong></td>
<td>$-</td>
<td>$263,900.00</td>
<td>$2,967,000.00</td>
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<td><strong>Gross Margin</strong></td>
<td>$-</td>
<td>$411,050.00</td>
<td>$4,632,250.00</td>
<td>$13,584,500.00</td>
<td>$48,692,000.00</td>
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<tr>
<td><strong>% Gross Margin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>61%</td>
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<tr>
<td><strong>Development Costs (prototyping)</strong></td>
<td>$5,450.00</td>
<td>$35,000.00</td>
<td>$35,000.00</td>
<td>$35,000.00</td>
<td>$35,000.00</td>
</tr>
<tr>
<td><strong>Tooling Costs</strong></td>
<td>$-</td>
<td>$9,000.00</td>
<td>$52,000.00</td>
<td>$52,000.00</td>
<td>$52,000.00</td>
</tr>
<tr>
<td><strong>Overhead Costs</strong></td>
<td>$-</td>
<td>$34,800.00</td>
<td>$34,800.00</td>
<td>$34,800.00</td>
<td>$34,800.00</td>
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<tr>
<td><strong>Marketing (13% net sales)</strong></td>
<td>$-</td>
<td>$80,994.00</td>
<td>$992,904.00</td>
<td>$3,977,514.00</td>
<td>$14,296,074.00</td>
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<tr>
<td><strong>Other (8% net sales)</strong></td>
<td>$-</td>
<td>$53,996.00</td>
<td>$661,936.00</td>
<td>$2,651,676.00</td>
<td>$9,530,716.00</td>
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<tr>
<td><strong>Total Operating Expenses</strong></td>
<td>$5,450.00</td>
<td>$213,790.00</td>
<td>$1,776,640.00</td>
<td>$6,750,990.00</td>
<td>$23,948,590.00</td>
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<tr>
<td><strong>Pre-Tax Profit</strong></td>
<td>$(5,450.00)</td>
<td>$197,260.00</td>
<td>$2,855,610.00</td>
<td>$6,833,510.00</td>
<td>$24,743,410.00</td>
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<tr>
<td><strong>% Profit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29%</td>
</tr>
<tr>
<td><strong>Cumulative Profit</strong></td>
<td>$(5,450.00)</td>
<td>$191,810.00</td>
<td>$3,047,420.00</td>
<td>$9,880,930.00</td>
<td>$34,624,340.00</td>
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