

January 27, 2002

Fil Salustri, Brian Burns, Arlene Gould  
Advanced Design and Manufacturing Institute  
2655 North Sheridan Way  
Mississauga, Ontario L6K 2P8

We are pleased to provide you with a household appliance preliminary design as requested on November 24, 2001.

Should you have any questions or wish to discuss any aspect of this work, please feel free to contact any of the team members.

Sincerely,

V. Baquiran  
N. Husain  
L. Scott  
D. Sellors  
D. Wood

# *InDesign*

Innovation for Better Living

---

## *Vacu-Drone:*

### A Household Appliance Design Project

*Prepared for:* Fil Salustri, Brian Burns, Arlene Gould,  
DM-1016 Design Methodologies  
Advanced Design and Manufacturing Institute  
2655 North Sheridan Way  
Mississauga, Ontario  
L5K 2P8

*Prepared by:* V. Baquiran  
N. Husain  
L. Scott  
D. Sellors  
D. Wood

January 27, 2002

## **EXECUTIVE SUMMARY**

InDesign was tasked to develop a new household appliance design utilizing established design methodologies. Initial brainstorming lead to the decision to develop a product to autonomously clean a variety of flooring surfaces with minimal user interaction.

Competitive analysis was performed, looking primarily at the large market of conventional consumer vacuum cleaners. Canister, upright, built-in, and 'hybrid' (crossover designs that don't easily fall into one specific category) vacuum cleaner products were studied.

A Canadian demographic analysis was performed, and it was determined that benefits offered by an autonomous floor cleaner would be realized by a variety of demographic groups ranging from people in their twenties who don't want to clean, to people in their thirties and forties for whom a clean environment is important but there never seems to be enough time to get everything done, to seniors who may have difficulty lifting and using conventional vacuum cleaners, or may suffer from some sort of limiting condition such as arthritis.

A series of floor cleaning task specific Functional Requirements, Product Characteristics, Constrains, and Performance Metrics were identified for this product design.

Initial concepts were generated and the results were reviewed and a final design concept was developed. The resulting 'Vacu-Drone' design addressed all Functional Requirements and Product Characteristics, while adhering to the defined constraints. Identified Performance Metrics will be reviewed during prototype testing, but all targets should be met.

The 'Vacu-Drone' design is a rechargeable, fully autonomous vacuum cleaner with automatic collision and fault detection. The device will autonomously manoeuvre through an environment cleaning the floors. A simple to use interface panel will provide necessary user feedback. Standard 'off-the-shelf' dirt collection bags are used. The target retail-selling price for this product is \$200.

## TABLE OF CONTENTS

<i>Executive Summary</i> .....	<i>i</i>
<i>List of Figures</i> .....	<i>iii</i>
<i>List of Tables</i> .....	<i>iii</i>
<i>1.0 Introduction</i> .....	<i>1</i>
<i>2.0 Business Strategy – Unique Selling Proposal</i> .....	<i>2</i>
<i>2.1 Market Research and Consumer Segmentation</i> .....	<i>2</i>
<i>2.2 Features and Benefits</i> .....	<i>3</i>
<i>2.3 Corporate and Brand Positioning</i> .....	<i>3</i>
<i>3.0 Discussion</i> .....	<i>5</i>
<i>3.1 Product Design Specification (PDS)</i> .....	<i>6</i>
<i>3.2 Conceptual Design and Evaluation</i> .....	<i>8</i>
<i>3.3 Product Architecture Schematic</i> .....	<i>11</i>
<i>3.4 Final Concept Rendering</i> .....	<i>13</i>
<i>4.0 Project Management Summary</i> .....	<i>18</i>
<i>5.0 Conclusions</i> .....	<i>19</i>
<i>6.0 Bibliography / References</i> .....	<i>21</i>
<i>7.0 Appendices</i> .....	<i>22</i>
<i>Appendix A – Brainstorming / Appliance Selection / Problem Definition</i> .....	<i>22</i>
<i>Appendix B – Canadian Demographic Data</i> .....	<i>24</i>
<i>Appendix C – Internet Repository Service</i> .....	<i>25</i>
<i>Appendix D – PC’s, FR’s, Constraints, PM’s, and DP’s</i> .....	<i>26</i>
<i>Appendix E – Initial Conceptual Design Sketches</i> .....	<i>29</i>

## **LIST OF FIGURES**

Figure 1 - Baseline Project Timing .....	5
Figure 2 - Quality Function Deployment (QDF) Chart.....	9
Figure 3 - Product Architecture Schematic (PAS).....	11
Figure 4 - Final Concept Top View .....	16
Figure 5 - Final Concept Front and Rear Views .....	16
Figure 6 - Final Concept Bottom View.....	17
Figure 7 - Final Concept - Side View .....	17

## **LIST OF TABLES**

Table 1 - Product Design Specification (PDS).....	6
Table 2 - Selected Preliminary Patent Search Results .....	10
Table 3 - Project Management Summary.....	18
Table 4 - Team Signoff .....	18

*These Lists do not include Figures or Tables contained in the Appendices.*

## **1.0 INTRODUCTION**

This report details the process undertaken during the preliminary design of a household appliance. Criteria for this project included the option of basing the design on an existing product category, or the development of an entirely new product category. The resulting product design must be useable in an average home, and must be suitable for use by any adult.

This design project consists of a number of elements, including the Business strategy taken for the development of this product design, a Product Design Specification (PDS), Conceptual Design and Evaluation, Product Architecture Schematic (PAS), Final Concept Rendering, and Conclusions.

Selection of the household appliance design subject began with a brainstorming session. Summarized results of the initial task brainstorming session are contained in Appendix A. A number of common themes emerged during the task brainstorming, including cleaning/hygiene, convenience, and timesaving. The group decided on the household task of floor cleaning as the basis of the design study. The vacuum cleaner was selected as a benchmark class of product for comparison purposes, but great care was taken to not immediately generate a vacuum cleaner design, but rather develop a product design based on task requirements. As one team member rightly commented, “People don’t want vacuum cleaners, they want clean floors”.

## **2.0 BUSINESS STRATEGY – UNIQUE SELLING PROPOSAL**

### **2.1 MARKET RESEARCH AND CONSUMER SEGMENTATION**

Based on Consumer Reports magazines and buying guides from 1998 to 2000, Hoover and Kenmore have been the most consistently recommended brands of upright and canister vacuums. Other preferred vacuum brands were Samsung, Electrolux, Sharp, and Eureka.

Of the higher-ranking vacuum models, the more notable features that customers highly praised were good deep-cleaning, clean exhaust, convenience, easy tool changes, good cleaning along edges, and excellent cleaning of bare floors. Features that were often missed by the majority of vacuums were adequate under-furniture clearance, suction control, stability on stairs, variable motor speeds, easy manoeuvrability, noise, easy bag changing and clean dirt disposal, easy maintenance of belt and rotating brush, and lack of tolerance to any wetness, especially after freshly shampooing a rug.

According to Consumer Reports, the needs of many consumers cannot be met with one machine, rather, they need more than one product to complete all household vacuuming. Also, price is generally not proportional to a vacuum's ability to clean. Some \$800 to \$1500 vacuums, like Miele, Electrolux, and Kirby, performed at similar levels of ability as some \$200 and \$300 models.

The market is saturated with different makes and models of conventional vacuum cleaners. Kenmore currently accounts for 30% of all canister vacuums sold in the U.S. Hoover sells about 100 different models, for up to \$400. Eureka, sells 50 different low-priced models. Dirt Devil is a low-priced brand best known for its stick brooms and hand vacuums. Other popular name brands are Oreck, whose products are sold through direct marketing, Fantom, Kirby, Rainbow, a brand only sold door-to-door, Bissell, Sanyo, Panasonic, and Nilfisk. Of these hundreds of models, the variety is mostly in the marketing and packaging, and not in different features.

Before the introduction of multipurpose cleaners, compact canister, hand, and stick vacuums, consumer choice was essentially limited to two types of vacuum cleaners – traditional uprights

and canisters. But, definitions are blurring and uprights are taking on characteristics of canister styles by being more manoeuvrable on stairs and adding permanent stretchable hoses.

## **2.2 FEATURES AND BENEFITS**

In order to compete in the saturated market of traditional canister, upright, and hybrid vacuum cleaners, a new floor-cleaning appliance must offer benefits above and beyond what conventional vacuum cleaner products can offer. This product will meet a strict set of functional requirements, and will have a set of product characteristics that will appeal to consumers. Most notably, this new floor-cleaning product will be fully autonomous, requiring no user interaction other than to place it on the floor and turn it on. The fully rechargeable device will be self-navigating, with built-in logic processing to monitor its progress and shutdown if any problems arise. Weighing in at less than 10kg (design target), this device will be able to effectively navigate over and clean a variety of flooring types. Complete details of the defined functional requirements, product characteristics, design constraints, and performance metrics can be found later in this document.

## **2.3 CORPORATE AND BRAND POSITIONING**

*InDesign* Inc. is committed to providing consumers with the highest level of quality and convenience in everyday products. We strive to exceed customer expectations by defining requirements and characteristics up-front, and then developing designs to meet the specified needs. We don't simply re-design existing products, but design new products to meet a specific set of task goals.

*InDesign* Inc. is proud to present a detailed design study of the first product in our soon to be released line of revolutionary household appliances. Vacu-Drone is a fully autonomous floor cleaning device that will simplify the task of maintaining a clean household environment by eliminating the time-consuming task of regular vacuuming and sweeping. Vacu-Drone will not eliminate the need for occasional 'deep-cleanings' with more traditional products, but will

provide a simple means of maintaining a satisfactory level of floor cleanliness with virtually no user involvement, and a minimum of inconvenience.

Vacu-Drone will be positioned in the mid-price range of traditional vacuum cleaners, with a suggested retail price target of \$200. This will provide excellent value to consumers, and will help customers with busy lifestyles regain valuable personal time. Customers with limited physical capabilities will also benefit by being able to maintain a satisfactory level of household cleanliness without aggravating physical conditions or limitations.

*InDesign Inc.* strives to successfully apply universal design concepts in product design. Instead of targeting small ‘niche’ markets that can quickly become saturated with high-priced, low-volume products, *InDesign Inc.* endeavours to ‘appeal to the masses’ by offering well designed, practical product solutions. The application of demographic data analysis as an integral part of product design helps ensure the widest possible cross-section of potential customers. Vacu-Drone will be well positioned to be adopted by a variety of very diverse demographic groups. Twenty-something? Turn on Vacu-Drone and head out to enjoy your active lifestyle. Return home after a busy day to clean floors. Thirty-something to Fifty-something? Not enough time to get all the chores done? Turn on Vacu-Drone and let it take care of the floors while you take care of the more important things. Over Fifty? Tired of lugging around that heavy and awkward canister or upright vacuum all over the house? Suffering from arthritis or some other limiting factor? Turn on Vacu-Drone, and eliminate the pain and strain of traditional floor cleaning. Vacu-Drone provides a lifestyle solution to a wide demographic group - virtually everyone who lives in their own home, regardless of their age. Nearly twenty million Canadians currently fall within Vacu-Drone’s target demographic groups, and these numbers will continue to grow through 2011<sup>1</sup>. *InDesign Inc.* – Innovative Design for Better Living.

---

<sup>1</sup> Source – Statistics Canada. See Appendix B for Canadian demographic data.

### 3.0 DISCUSSION

This product development project was initiated on November 24, 2001, with a completion deadline of January 30, 2002. This required all aspects of the project objective to be completed in less than ten weeks. A baseline target completion date of January 17, 2002 was set in order to allow for team review at the start of the second class module, and to provide a comfortable project buffer in case of any unforeseen circumstances or issues that could arise. This accelerated target date required all aspects of the project objective to be completed in less than eight weeks. In order to achieve this target date, a base timing chart was prepared to define the necessary critical path, and was utilized throughout the project to gauge progress.

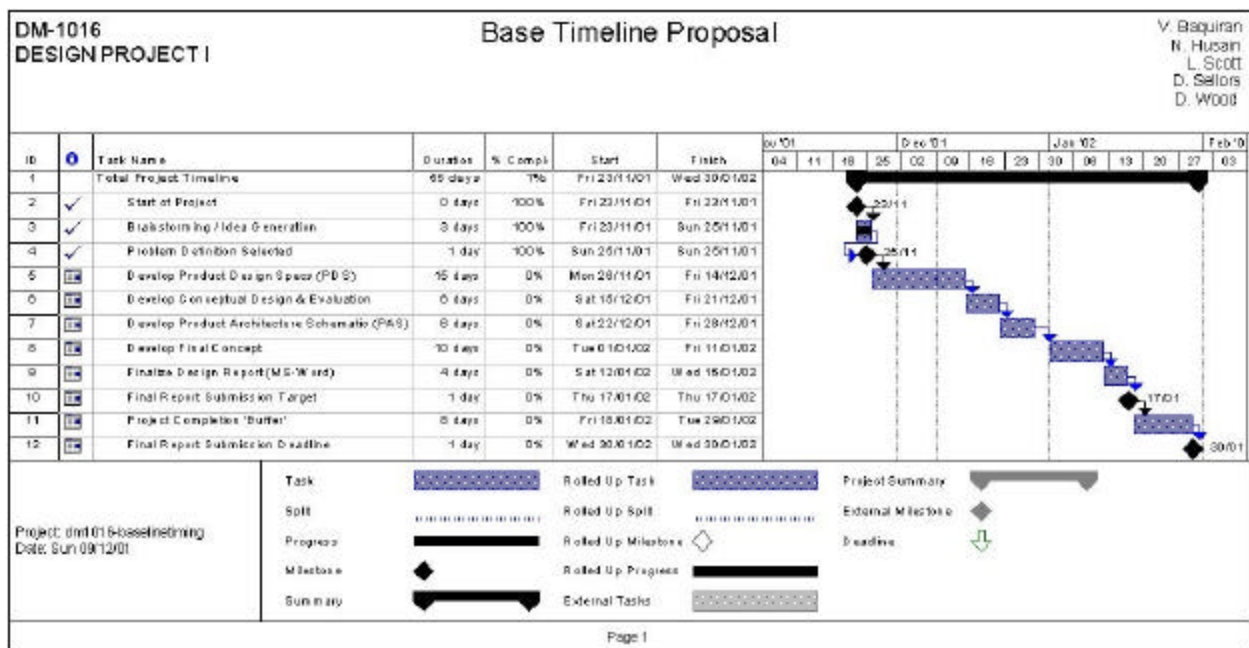


Figure 1 - Baseline Project Timing

To minimize the negative impact of geographic location of the five team members, a central internet-based repository in conjunction with e-mail was utilized for communication, file sharing, and document review activities. Appendix C contains detail of the internet-based service used. Two in-person group meetings were also arranged during the course of the project to ensure group direction was maintained. Overall, the team makeup was very complimentary, and even with the challenges of distance the team was successful in achieving targets set out at the onset of the project.

### 3.1 PRODUCT DESIGN SPECIFICATION (PDS)

During the initial brainstorming session, a series of Product Characteristics (PC's), Functional Requirements (FR's), Constraints, Performance Metrics (PM's), and associated Design Parameters (DP's) were generated. A complete list of these items is contained in Appendix D for reference.

**Table 1 - Product Design Specification (PDS)**

Product Characteristics (PC)	Functional Requirements (FR)	Constraints
Safe	Clean different household flooring surfaces	Weigh less than 10kg
Durable	Hold 'dirt'	Use standard or no vacuum bags
Quiet	Navigate intelligently through the home	Use 12V DC input source for charging
Easily Moved	Recharge its power source	Meet CSA/UL safety requirements
Easily Stored	Stop automatically on fault	Run at least 1 hour on full charge
User Friendly		Fully charge in less than 4 hours
Autonomous		Clean at least 500 ft <sup>2</sup> per hour

Based on the Product Characteristics, Functional Requirements, and Constraints selected, a series of Performance Metrics (PM) were developed to provide a means of evaluating the finished design. The chosen Performance Metrics were:

1. Weight: 10kg – Actual Weight.
2. Run Time: Actual run time on full charge – 1 hour.
3. Charging Time: 4 hours – Actual time to fully charge.
4. Cleaning time: 1 hour – Actual time to clean 500 ft<sup>2</sup>.

A Performance Metric result of zero means the goal was exactly met, a positive (+) result means the design goal was exceeded (i.e. good thing), and a negative (-) result means the design goal was missed. Actual performance metric results will be calculated and evaluated during product prototyping.

Specific Design Parameters (DP's) were created to address each of the identified FR's. The selected DP's for this product are listed below, where the number references the associated FR.

1. Must clean different household flooring surfaces - Suction (airflow) and sweeping action (single motor drive for air pump and sweeper).
2. Must hold 'dirt' - Use standard 'off-the-shelf' vacuum bag.
3. Must navigate intelligently through the home - Independent left and right drive (1 motor each) for movement. Collision sensors (detect collision with object, stairs, etc.). Central logic processor (input from sensors, movement routine, etc.).
4. Recharge its power source – Battery (power storage) system – 12V NiCd. Charger system.
5. Must stop automatically on a fault - Use central logic processor. Collision sensor positive input for 5-minutes, shut-off. Temperature sensor on motors – shutoff on overheat condition.

### **3.2 CONCEPTUAL DESIGN AND EVALUATION**

With a well defined business strategy and a detailed Product Design Specification, a Quality Function Deployment (QFD) Chart was developed to provide a summary of more detailed comparative information pertaining to functional performance, human interface factors, and product characteristics. The QFD chart also provides insight into likely product interactions and interrelations, provides an opportunity to compare PDS items with competitive product classes, and allowed for key product design targets to be identified based on relative importance and competitive advantage.

The competitive products used for the purpose of the QFD analysis were typical product classes, as opposed to specific products. The classes chosen were a typical canister household vacuum cleaner, a typical upright household vacuum cleaner, and a typical built-in household vacuum cleaner. These three product groups represent the most common existing products used by consumers for floor cleaning activities, and encompass the majority of competitive products with very varied product performance characteristics.

The Quality Function Deployment (QFD) Chart is shown in Figure 2.

Using the data generated from the Business Strategy, Product Design Specification (PDS), and the design targets identified from the Quality Function Deployment (QFD) Chart, a number of rough design concepts were created individually by team members. These initial Conceptual Designs are contained in Appendix D for reference.

The resulting initial design concepts were then reviewed as a group, and the key design benefits and features of each concept were compiled. A resulting list of key product benefits and features was then compiled as the input for the final design concept.

Product Description: Autonomous Vacuum Cleaner Date: 17-Jan-02

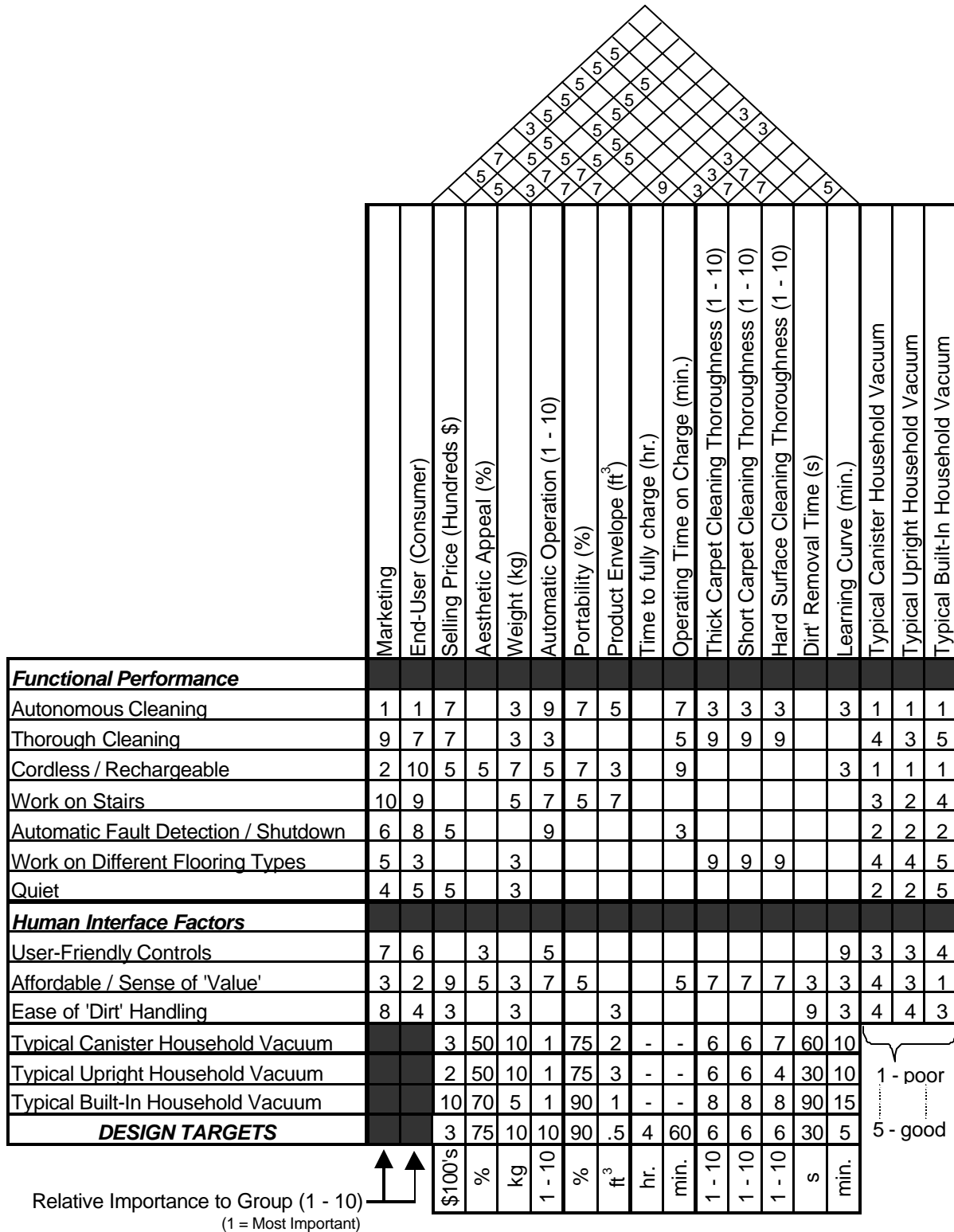


Figure 2 - Quality Function Deployment (QDF) Chart

At this point, a preliminary United States patent search was performed to determine if the development of this product would infringe on any existing intellectual property. A number of search terms and phrases were used including ‘autonomous vacuum’, ‘automatic vacuum’, and ‘robotic vacuum’. Some potentially relevant entries were identified, which will warrant more detailed review and analysis if the development of this product is to continue further.

Patents issued prior to 1995 were subject to 17-year protection, while patents issued since 1995 are subject to 20-year protection. A selection of the most directly relevant patents identified during the search is shown below.

**Table 2 - Selected Preliminary Patent Search Results**

Patent # 5,095,577	Mar. 17, 1992	Automatic vacuum cleaner.	
Patent # 5,012,886	May 7, 1991	Self-guided mobile unit and cleaning apparatus such as vacuum cleaner comprising such a unit.	
Patent # 4,831,813	May 23, 1989	System for automatic performance of agricultural tasks such as lawn mowing.	
Patent # 3,739,421	Jun. 19, 1971	Automatic suction cleaner.	(EXPIRED)
Patent # 3,570,227	Mar. 16, 1971	Self-propelled random motion lawnmower.	(EXPIRED)

Most patents dealing with automatic cleaning devices make reference to following a pre-described path or pattern, either by means of path programming, or incorporating guides into the environment. No recent patents could be found which made reference to a random motion device with collision detection.

The patent search was left until this point in the project to avoid the tendency to overanalyze existing designs, or to borrow concepts from other existing sources. A primary goal of this design project was to develop a design concept using a logical progressive procedure of identifying and quantifying functional requirements and product characteristics based on what the product is to accomplish, as opposed to how it will accomplish the task.

### 3.3 PRODUCT ARCHITECTURE SCHEMATIC

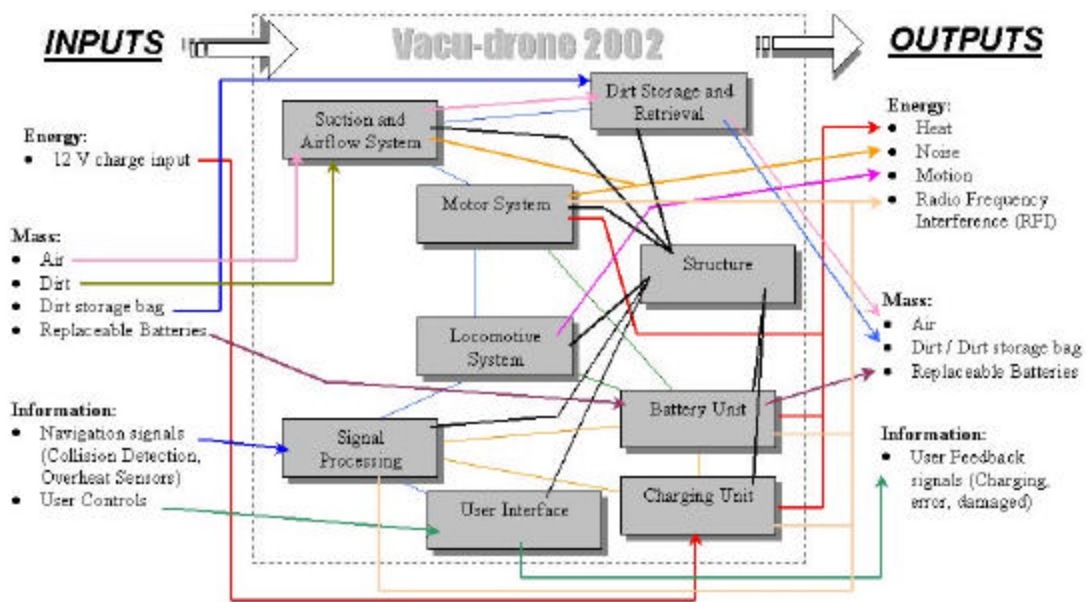


Figure 3 - Product Architecture Schematic (PAS)

Through the development of the Product Design Specification (PDS), required product functions and associated required subsystems to meet the defined requirements were identified. To be autonomous, the device must have a locomotive system, a motor system to drive the locomotive and cleaning systems and battery system to store the energy required for the device to function. This motor system connection to the cleaning (suction and airflow system) will be separate and distinct from the locomotion motors. The user interface will provide status feedback, including charge level status, and estimated remaining run time.

The battery system was selected over traditional direct plug-in to eliminate cords from the machine that would create navigation hazards for the device, as well as safety issues for product users and property. The battery system, locomotion and suction systems interact with other subsystems such as signal processing and user interface such that the locomotive system knows where to go and what to do. Such subsystems are needed to instruct the machine to perform its function and to avoid obstacles such as furniture and staircases. Locomotive control is based on a random motion algorithm, coupled with collision avoidance input sensors. The suction and

airflow system works with the motor system as well to achieve temporary dirt storage within the machine, and ultimate disposal outside of the machine. This combined set of features is of significant importance, as without them, the primary function of this device will not be met.

The charging unit works with signal processing and the battery unit to determine when the battery charge is low, as well as receiving the 12V DC input to be converted into stored energy. This interaction with signal processing is vital in ensuring that the device can accurately report current charge status to the user by means of the user interface, to provide adequate warning of power drain. The charging unit is merely a receptacle for the input plug at the recharging station, in order to reduce the operating mass of the entire device. The signal processor can detect if the charging plug has been inserted as well as the current battery charge level.

Since this product is designed to be fully autonomous, it is critical that the device be able to monitor its own state, detect faults, and shut itself down if faults are detected. This will prevent the device from potentially doing damage to its surroundings through collisions, or due to excessive overheating that could lead to fire. The auto shutdown logic will also reduce the risk of internal damage to the unit in case of some sort of failure. The signal processing system receives input from a series of infrared object detectors placed on the front of the device, which 'look' for obstacles and stairs. If input from any collision sensor, or sensors, is continually maintained for a period of five minutes (i.e. device is 'stuck' or cannot manoeuvre out of collision position) the unit will enter auto shutdown mode. Heat (temperature) sensors on motor are also fed into the signal processor as inputs. This temperature monitoring will react to any potential overheating condition by invoking the auto shutdown mode. The input from the collision and temperature sensors is fed into the signal processing system, which is then tied into the locomotive system for directional control, as well as the user interface for information output.

The structure of the system must allow for easy interface with the recharging station and the charging unit. The structure must also support the changing centre of mass that will occur through the bag storage range of empty to full. The motor, locomotive, battery and air suction system must also be arranged within the structure to prevent overheating, and the user interface must be easily accessible and visible to the user.

---

### **3.4 FINAL CONCEPT RENDERING**

The final concept rendering sketches are contained on pages 15 and 16.

The final design concept successfully addresses all identified functional requirements, product characteristics, and is expected to achieve all defined constraints and performance metrics.

The device, named 'Vacu-Drone', is essentially a self-powered vacuum cleaner with a beater/sweeper bar. The front of the Vacu-Drone contains 4 infrared sensors used to detect obstacles. When any sensor sends a positive (potential collision) signal to the processing unit a change in direction is initiated. The four sensors are located on each front side (left and right), one in the center facing slightly down to maintain detection of the floor, and one in the center facing slightly up to detect under-furniture clearance. If either left or right or center-up (furniture clearance) sensors detect an object, a random move command is initiated. The floor detection sensor works on the opposite basis, whereby the sensor must provide a continuous detection signal in order for the Vacu-Drone to continue. If no signal exists, that suggests that the Vacu-Drone is at the top of a set of stairs, and must change direction before falling down the stairs.

Should a positive collision signal be received for a period of five consecutive minutes (i.e. Vacu-Drone cannot find a way 'out' of a collision situation), the device will shutdown and go into a collision error mode. This prevents the device from staying on the same piece of floor for an extended period of time, and also minimizes the risk of overheating the drive motors from constant move adjustments.

Vacu-Drone will have three drive motors, one for each drive wheel, and another to drive the air suction and the rotation of the beater/sweeper bar. Each motor will be installed with a temperature sensor connected to the signal processing sub-system. If any thermocouple sensor detects an overheating condition, the device will shutdown and go into an overheat error mode. A full dirt bag will also trigger this error, as the airflow through a full dirt bag will be greatly reduced and will lead to additional strain on the drive motor. These overheating safeguards will prevent damage to the device or surrounding items if some sort of overload should occur.

The Vacu-Drone will operate on a random motion algorithm. At random intervals, the Vacu-Drone will stop moving forward, make some sort of rotational direction change, and continue moving forward. This random pattern should statistically allow for the majority of any given flooring surface being covered at some point during Vacu-Drone's operation.

On the top/back surface is the power switch and user interface panel. The user interface panel consists of a series of LED's to provide status feedback, as well as a 2-digit numerical display for detailed charging information. There is adequate room on the user interface panel for a combination of up to six standard LED's or push-buttons, so a variety of functions can be communicated via this panel. Potential interface panel configuration would be as follows:

1. Power LED - On when unit is turned on.
2. Charging LED - On when unit is connected to charger and is charging.
3. Low Charge LED - On when unit is turned on and low on charge.
4. Overheat Fault LED - On when unit is turned on and an overheating condition has been identified in one or more motors.
5. Collision Fault LED - On when unit is turned on and an unavoidable collision condition has been identified.
6. Charge Status Button - Press to display % charged on 2-Digit Display.
7. 2-Digit Display - Estimated remaining run time when in operation (minutes), estimated time to full recharge when charging (minutes). If the remaining run or charge time is more than 99 minutes, the display will blink to identify more than 99 minutes. The minute countdowns then start at 99 minutes (1 hour, 39 minutes) and will countdown to zero minutes.

A single power button exists on the top/back of the device, just below the user interface panel. This is a 2-position "see-saw" type toggle switch. To the right of the power switch is the 12V DC input plug for recharging.

On the underside of the Vacu-Drone is a beater/sweeper bar, two drive wheels, and a battery/service access panel. The beater/sweeper bar is at the very front of the device, with the air (suction) inlet directly behind the beater/sweeper bar. Near the back are two rubber drive wheels. An access panel covers most of the bottom of the Vacu-Drone, and this is to access the replaceable 12V NiCd (Nickel-Cadmium) batteries, and also for service access should repairs be required.

The front half of the Vacu-Drone body is hinged on top at approximately the mid-way point. The front half of the Vacu-Drone pivots about this point to provide access to the inside of the unit where the dirt collection bag is installed, and also provides access to the internal workings of the Vacu-Drone should service be required. Access panels will cover critical components from being fully exposed with the top open, but will be removable for service access if and when required. Just behind the pivot point on the top/back of the Vacu-Drone is a large air exhaust port.

Ideal product locomotion speed, and therefore exact motor and battery specifications, will be determined during prototype testing. Initial overall target dimensions for Vacu-Drone is 16" wide x 18" long x 6" high, with a target working weight of 9kg with an empty bag.

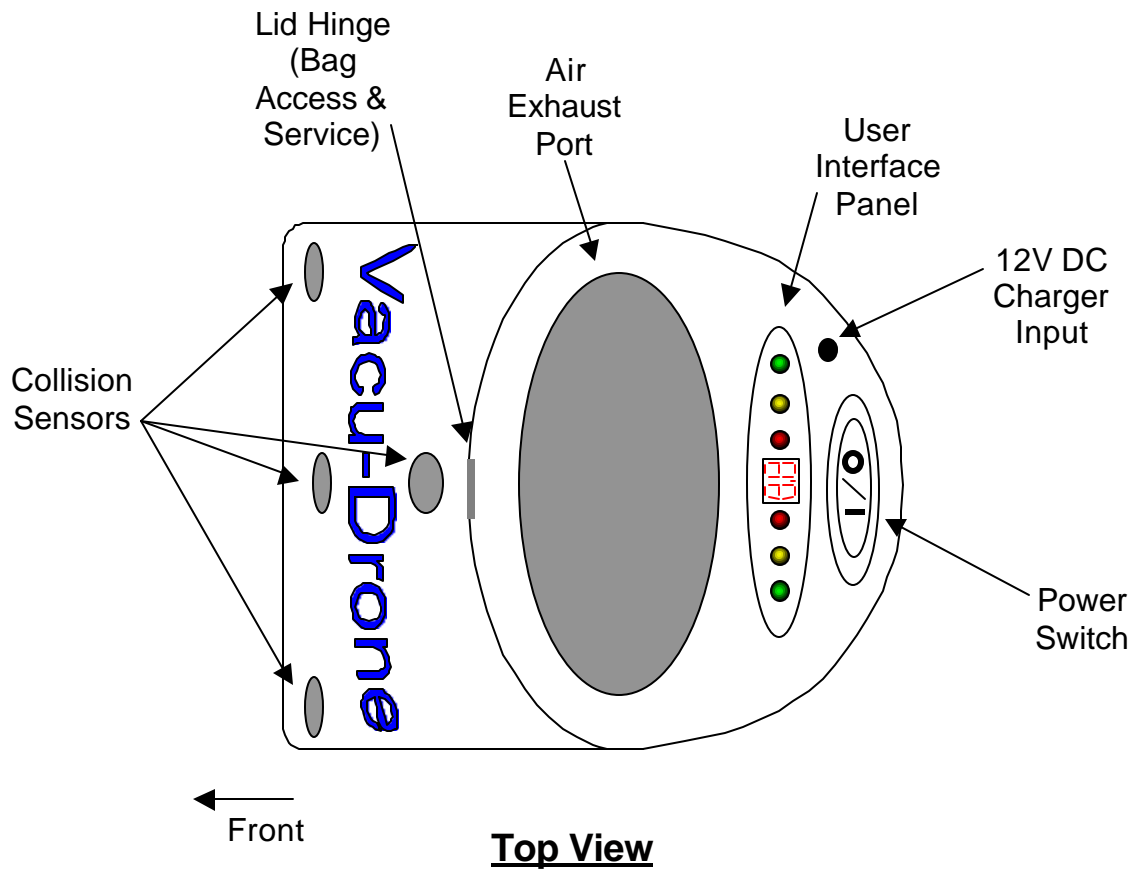


Figure 4 - Final Concept Top View

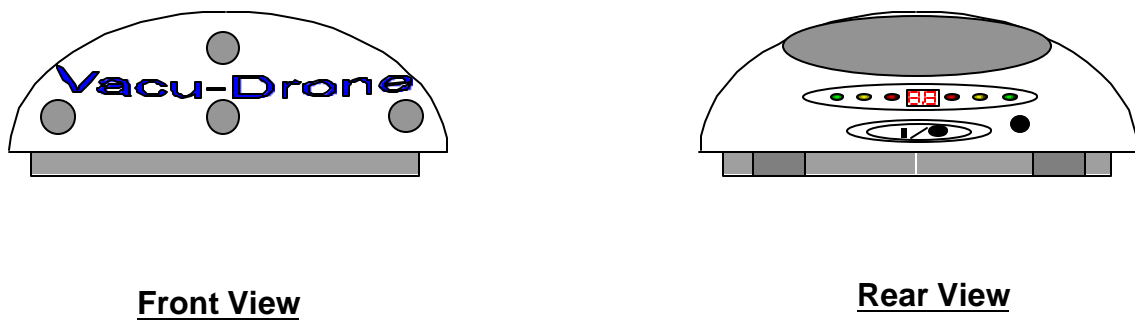
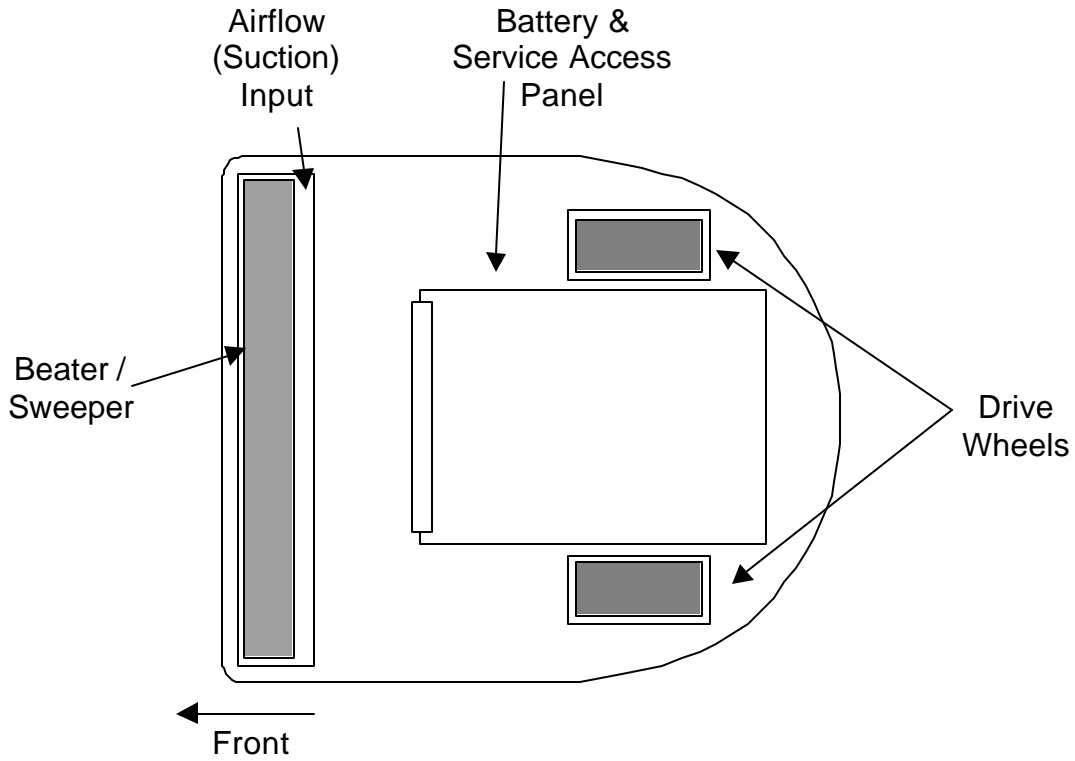
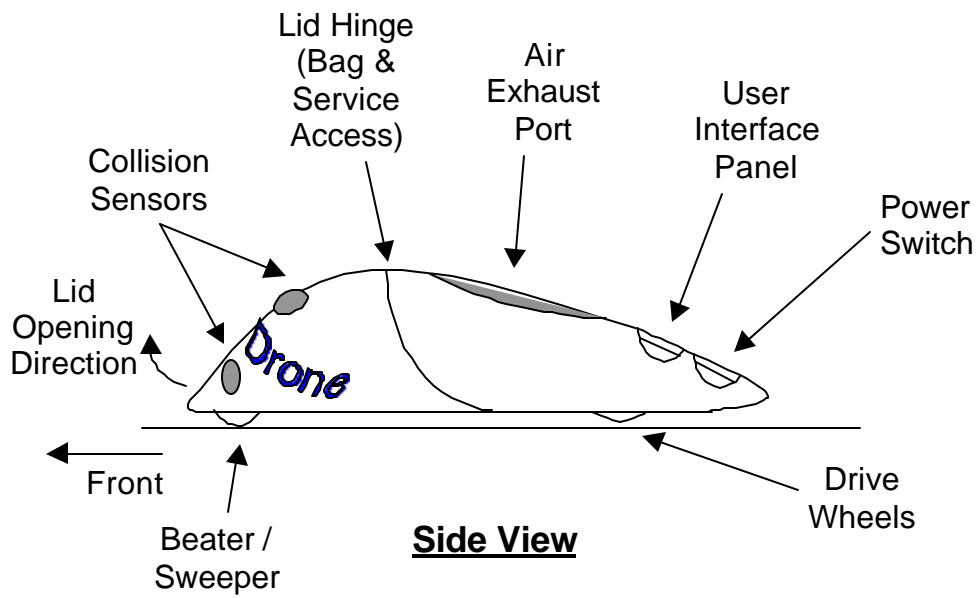


Figure 5 - Final Concept Front and Rear Views



**Bottom View**

Figure 6 - Final Concept Bottom View



**Side View**

Figure 7 - Final Concept - Side View

**4.0 PROJECT MANAGEMENT SUMMARY**

**Table 3 - Project Management Summary**

<b>Criteria</b>	<b>Team Members</b>				
	<b>Vivien Baquiran</b>	<b>Naseem Husain</b>	<b>Liz Scott</b>	<b>David Sellors</b>	<b>David Wood</b>
Document Preparation (editing, typing, etc.)	4	3	3	3	4
Background Research	4	4	4	4	3
Business Strategy	4	3	4	3	3
Product Design Specification	3	4	4	4	4
Concept Design and Evaluation	3	4	4	4	4
Systems Identification and Design (PAS)	3	4	3	3	3
Product Rendering	4	3	3	4	4

*Rating Scale:*

0 – Little or no work

1 – Marginal or unacceptable work

2 – Work was adequate

3 – Contributed significantly

4 – Exceptional contribution

**Table 4 - Team Signoff**

<b>Team Member</b>	<b>Signature</b>
Vivien Baquiran	V i v i e n B a q u i r a n
Naseem Husain	N a s e e m H u s a i n
Liz Scott	L i z S c o t t
David Sellors	D a v i d S e l l o r s
David Wood	D a v i d W o o d

## **5.0 CONCLUSIONS**

The design group is confident that the primary objectives of this design project were achieved. Design thinking, design capabilities and design resources were successfully applied to achieve a product design concept that successfully addresses all of the functional requirements and product characteristics identified at the start of the project, and also conforms to the defined constraints. Performance metrics should all prove to be positive once final design and testing can be performed.

During the development of Vacu-Drone, additional concepts were identified that could have been included in the product design. In the interest of maintaining project focus, these new ideas were off-loaded into a ‘parking lot’ for future reference during possible product re-design and evolution in the future. Some of the ideas, while providing excellent functionality to the end product, would at this point in time prove too technically complicated or expensive to implement in a low-cost consumer product. As technology continues to improve and become less expensive, some of these ideas may become more feasible in the near future. Some such concepts included:

- Complete ‘awareness’ of surroundings and location, including recharging station, so that Vacu-Drone could automatically return for recharging when power reserve was getting low
- Addition of solar panel to top of device to provide some level of automatic recharging while Vacu-Drone is working
- Flooring sensors to determine flooring type and adjust cleaning pattern accordingly
- Optional wireless remote control (similar to RC car) to allow specific path programming, or manual use of Vacu-Drone by remote control
- Built-in cleanliness sensors to determine level of floor cleanliness and adjust cleaning pattern accordingly

The geographic diversity of the design group provided an immediate challenge that was successfully overcome by making use of available technologies to bridge the geographic gap between team members. E-mail was used extensively to communicate between members and to

transfer files. The use of a specially created *Yahoo! Groups* web site specifically for this team provided a central repository for all messages and files, and also served as an excellent time-charted history of the activity of the group throughout the project. The group site also allowed access by team members from any world-wide-web enabled computer, so communication between team members was possible even when people were away from home or the office.

The diverse background of the team members provided an excellent cross-section of talent and ability for this project. The differing views and opinions stemming from our varied backgrounds provided an abundance of useful thoughts and concepts, especially during brainstorming and development activities. Fortunately, the varied experience, expertise, and backgrounds of the team members did not result in any ambiguity or in fighting amongst team members. Instead, the team managed to successfully draw and expand from differing ideas and concepts to the final proposal contained in this report.

Although this was a short exercise in applying the concepts of design methodologies, the team believes they have been successful in developing a useful Final Design Concept. The success of the project through the application of design methodologies became clear during the preliminary patent search that was performed as part of our conceptual design and evaluation. No obvious registered intellectual property that identified and addressed the Functional Requirements and Product Characteristics we identified was found. This suggests that the process the team used to develop the Product Design Specification and subsequent Design Concepts successfully bridged the gap between a specific task goal (clean floors) and a product design concept, instead of simply adapting or trying to improve an existing product.

## **6.0 BIBLIOGRAPHY / REFERENCES**

1. ADMI DM-1016 Class Notes
2. Auto Fundamentals, Stockel, Stockel, Johanson, Goodheart Wilcox, Tinley Part, IL, 1996
3. David K. Foot, *Boom Bust & Echo 2000*, Macfarlane Walter & Ross, Toronto, ON
4. Consumer Buying Guide, 2001 edition, Publications International, Ltd., Lincolnwoods, IL, 2001
5. Consumer Reports January 2000, Volume 65, No. 1, Consumers Union of United States, Inc., Yonkers, NY, 2000
6. Consumer Reports January 1999, Volume 64, No. 1, Consumers Union of United States, Inc., Yonkers, NY, 2000
7. Consumer Reports July 1999, Volume 64, No. 7, Consumers Union of United States, Inc., Yonkers, NY, 2000
8. Consumer Reports March 1998, Volume 63, No. 3, Consumers Union of United States, Inc., Yonkers, NY, 2000
9. Consumer Reports Buying Guide 2000, Consumers Union of United States, Inc., Yonkers, NY, 2000
10. How Stuff Works, <http://www.howstuffworks.com>
11. Market Research Handbook, 2001 edition, The authority of the Minister responsible for Statistics Canada, Minister of Industry, October 2001
12. Miele Catalogue, 2001
13. United States Patent Search, <http://www.delphion.com/cgi-bin/patsearch>

## **7.0 APPENDICES**

### **APPENDIX A – BRAINSTORMING / APPLIANCE SELECTION / PROBLEM DEFINITION**

#### **Appliance Brainstorming – Existing & New Ideas**

- Acrylic “See-through” Sink
- Automatic Window Cleaner
- Blender
- Blow Dryer
- Can Opener
- In-Garage Carwash
- General Cleaning
- Clock-Radio-TV
- Computer Systems
- Curling Iron
- Floor Cleaner
- Electric Toothbrush
- Sushi Grill / Ironing Surface
- Stove that Detects Food Burning
- Flip-Down Off-the-Wall Appliances
- Kitchen Lighting
- Light-up Grime in Sink
- Modelled After a Cat
- Personalizable Appliances
- Razor
- Shaver
- Shower
- Stove
- Fast Toasting
- Fire Alarms
- Sweeping
- Toaster-Radio
- Toaster-TV
- TV-Kitchen
- Vacuum
- Dishwasher

#### **Common Themes:**

Cleaning-hygiene, food preparation, entertainment, speed/time issues, space-size, hidden, convenience, low-maintenance, user-friendly

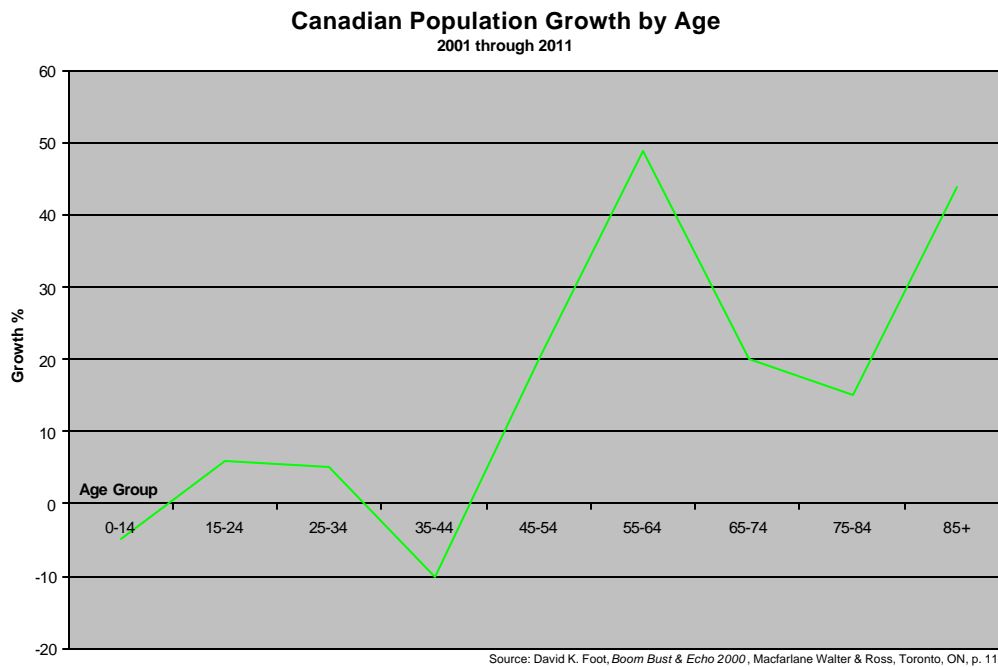
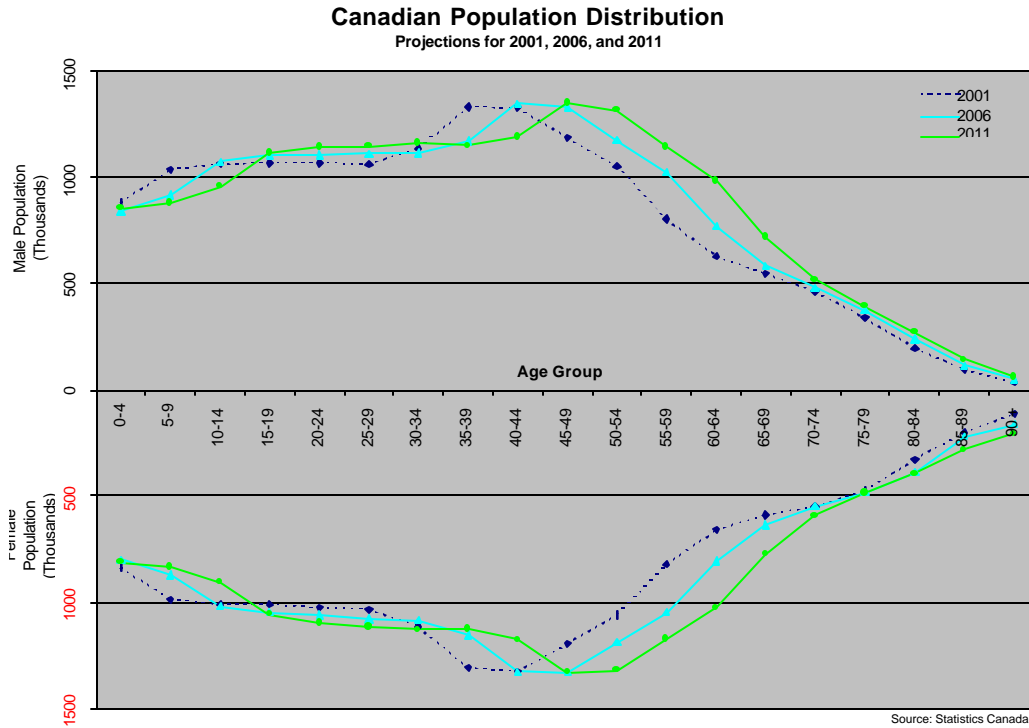
Function to be addressed in project: **Floor Cleaning**

Benchmark current appliance: **The Vacuum Cleaner**

**Problem Definition: Floor cleaning is awkward because:**

- The process is time consuming
- Current machines are: noisy, heavy, ugly, bulky, unergonomic, limited in life
- Cost of equipment and consumable items is expensive
- The noise scare animals and interrupt others
- Filter/bag cleaning can be messy and awkward and unhygienic
- Corded machines present trip hazard
- Different flooring types require different equipment or equipment changes

## APPENDIX B – CANADIAN DEMOGRAPHIC DATA



APPENDIX C – INTERNET REPOSITORY SERVICE

Yahoo groups <http://groups.yahoo.com>

Group Name: ADMI\_DM1016\_DDLNV

**Yahoo! Groups : ADMI\_DM1016\_DDLNV - Netscape**

File Edit View Go Communicator Help

Bookmarks Location: [http://groups.yahoo.com/group/ADMI\\_DM1016\\_DDLNV/](http://groups.yahoo.com/group/ADMI_DM1016_DDLNV/) What's Related

**YAHOO! Groups** [Groups Home](#) - [Yahoo!](#) - [Account Info](#) - [Help](#)

Welcome, **davewood71** (davewood71 · davewood71@yahoo.ca) [Start a Group](#) - [My Groups](#) - [Sign Out](#)

**ADMI\_DM1016\_DDLNV** · ADMI DM1016 DDLNV [Group Owner](#) [ [Edit My Membership](#) ]

**Welcome eGroups Members!**  
[Learn More](#)

**Home**

- [Messages](#)
- [Pending](#)
- [Post](#)
- [Chat](#)
- [Files](#)
- [Photos](#)
- [Bookmarks](#)
- [Database](#)
- [Polls](#)
- [Members](#)
- [Pending](#)
- [Calendar](#)

---

[Promote](#)

[Invite](#)

---

[Group Settings](#)

[Group Activity](#)

---

★ = Owner

☆ = Moderator

😊 = Online

**Description** **Category:** [Other](#)

Collaboration site for:  
 ADMI DM1016 Design Methodologies  
 Group #5:  
 Vivien Baquiran, Naseem Husain, Liz Scott,  
 David Sellors, David Wood

Created: 25-Nov-01

**Most Recent Messages**

Jan 1 [New PAS = great PAS! - Naseem Husain](#)  
 It looks good David, nice work! Welcome to 2 - double o - 2 everyone! Nasee

Jan 1 [Happy 2002!!! - davewood71](#)  
 Hey gang, Happy 2002!!!! Hope it was a safe and happy holiday season for every

Jan 1 [New file uploaded to ADMI\\_DM1016\\_DDLNV - ADMI\\_DM1016\\_DDLNV@yahoogroups.com](#)  
 Hello, This email message is a notification to let you know that a file has bee

Dec 25 [Re: Bimimetric Project - Final Draft - Naseem Husain](#)  
 Take a look at this weblink, and see if you find anything you like! If you see

Dec 24 [Re: Bimimetric Project - Final Draft - Iscott191](#)  
 Attached is the final draft of the bimimetrics project - let me know if you wou

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	<a href="#">3</a>											
2001										<a href="#">4</a>	<a href="#">36</a>	

**Group Email Addresses**

Post message: [ADMI\\_DM1016\\_DDLNV@yahoogroups.com](mailto:ADMI_DM1016_DDLNV@yahoogroups.com)  
 Subscribe: [ADMI\\_DM1016\\_DDLNV-subscribe@yahoogroups.com](mailto:ADMI_DM1016_DDLNV-subscribe@yahoogroups.com)  
 Unsubscribe: [ADMI\\_DM1016\\_DDLNV-unsubscribe@yahoogroups.com](mailto:ADMI_DM1016_DDLNV-unsubscribe@yahoogroups.com)  
 List owner: [ADMI\\_DM1016\\_DDLNV-owner@yahoogroups.com](mailto:ADMI_DM1016_DDLNV-owner@yahoogroups.com)

**Membership**

You are a moderator of this group

[ [Edit My Membership](#) ]

**Pending**

0 Members  
 0 Messages

**Group Info**

Members: **10**  
 Founded: **Nov 25, 2001**  
 Language: **English**

**Group Settings**

- Not listed in directory
- Restricted membership
- Unmoderated
- All members may post
- Archives for members only
- Email attachments are permitted

Copyright © 2001 Yahoo! Inc. All rights reserved.  
[Privacy Policy](#) - [Terms of Service](#) - [Guidelines](#) - [Help](#)

Document: Done

## **APPENDIX D – PC’S, FR’S, CONSTRAINTS, PM’S, AND DP’S**

### **Product Characteristics (PC)**

Safe

Durable

Quiet

Easily assembled

Easily moved

Easily stored

User friendly

Easily cleaned

Affordable

Easily maintained

Autonomous

### **Functional Requirements (FR)**

1. Must clean different household flooring surfaces
2. Must hold ‘dirt’
3. Must navigate intelligently through the home
4. Must recharge its power source
5. Must stop automatically on a fault

## **Constraints**

Weight < 10kg

Use standard or no bags

Must use 12V DC input for charging

Must meet CSA / UL safety requirements

Must run at least 1 hr on full charge

Must fully charge in less than 4 hours

Must clean at least 500 ft<sup>2</sup> per hour

Must clean dry spills only (no liquids)

## **Performance Metrics (PM)**

(0 = met goal, +ve result exceeds goals = good thing, -ve result missed goal)

Weight: 10kg – Actual Weight

Run Time: Actual run time on full charge – 1 hour

Charging Time: 4 hours – Actual time to fully charge

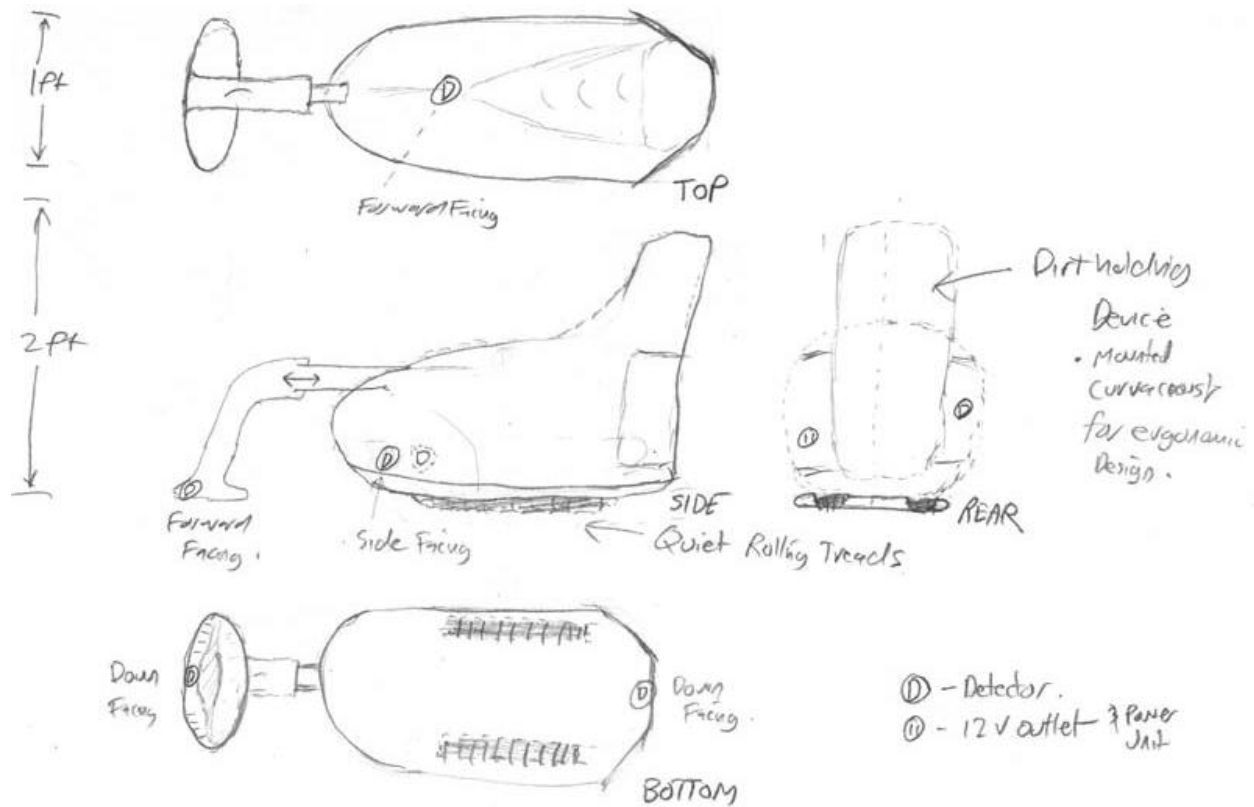
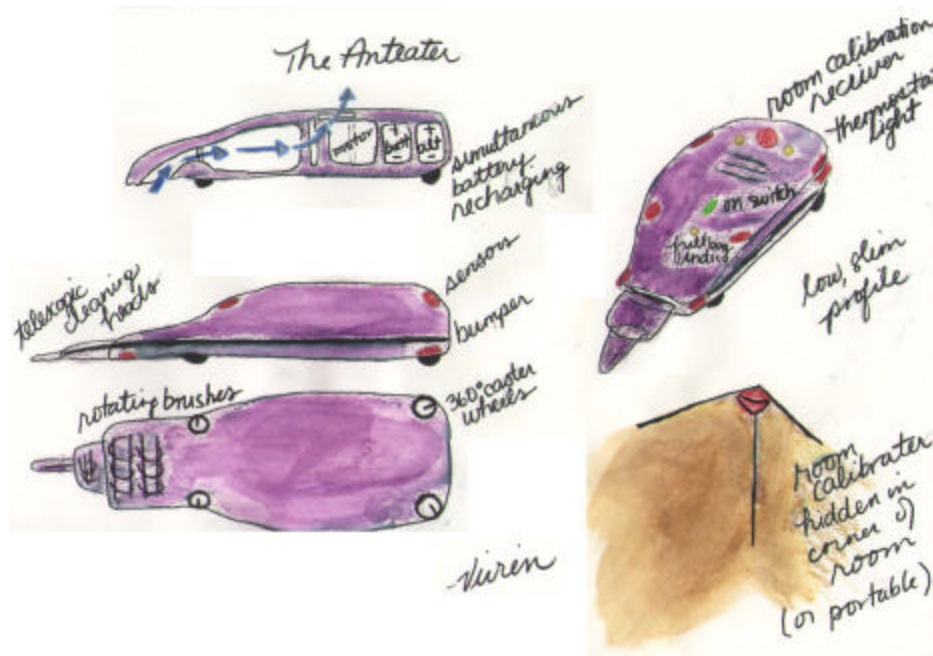
Cleaning time: 1 hour – Actual time to clean 500 ft<sup>2</sup>

## **Design Parameters (DP)**

Numbers reference Functional Requirements (FR)

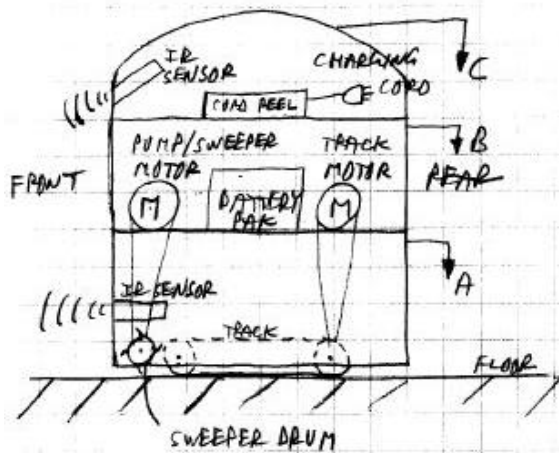
1. Must clean different household flooring surfaces -
  - Suction (airflow) and sweeping action (single motor drive for air pump and sweeper).
  
2. Must hold 'dirt' -
  - Use standard 'off-the-shelf' vacuum bag.
  
3. Must navigate intelligently through the home -
  - Independent left and right track drive (1 motor each) for movement.
  - Collision sensors (detect collision with object, stairs, etc.).
  - Central logic processor (input from sensors, movement routine, etc.).
  
4. Must recharge its power source –
  - Battery (power storage) system – 12V NiCd.
  - Charger system.
  
5. Must stop automatically on a fault
  - Use central logic processor.
  - Collision sensor positive input for 5-minutes, shut-off.
  - Temperature sensor on motors – shutoff on overheat condition.

APPENDIX E – INITIAL CONCEPTUAL DESIGN SKETCHES

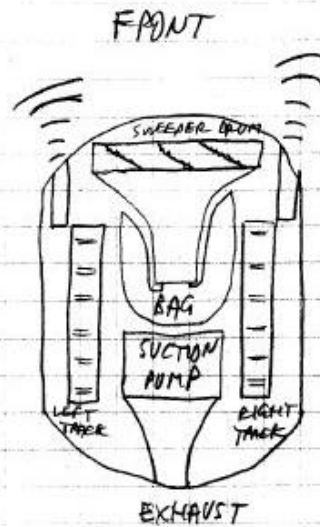


D. SELLOWS

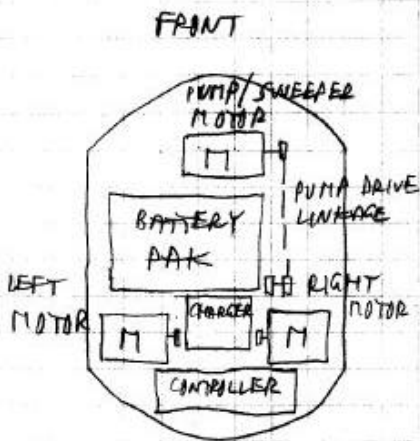
# VACU-DRONE CONCEPT



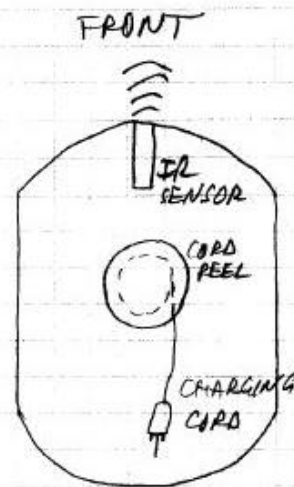
SIDE VIEW



SECTION A

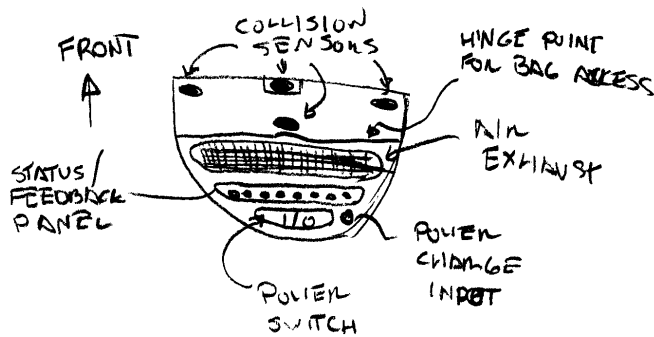


SECTION B

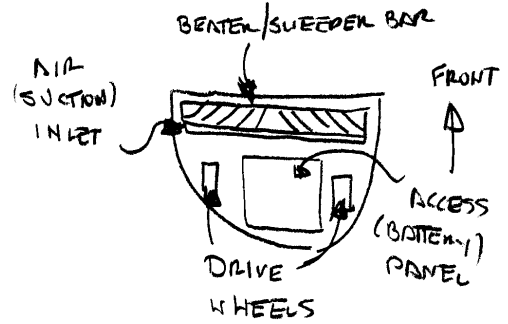


SECTION C

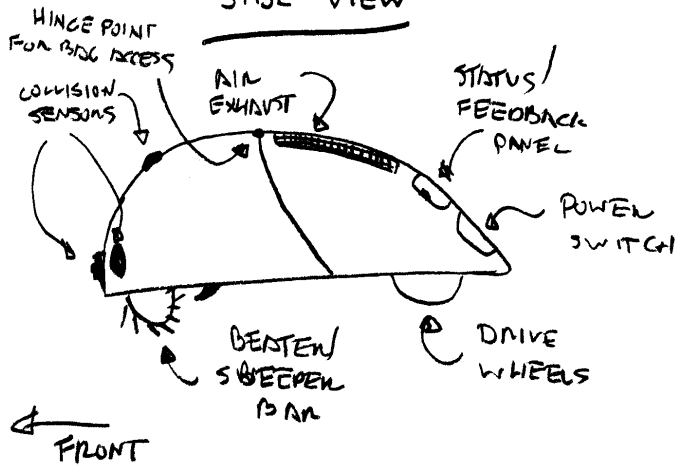
TOP VIEW



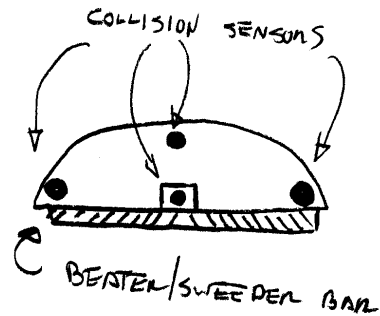
BOTTOM VIEW



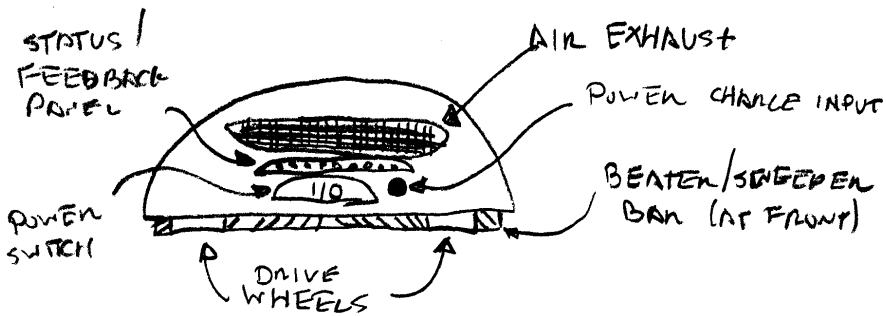
SIDE VIEW



FRONT VIEW



REAR VIEW



*Handwritten signature* 28 Dec 01

FINAL PAGE OF REPORT  
INTENTIONALLY LEFT BLANK

*Copyright © 2002,  
V. Baquiran  
N. Husain  
L. Scott  
D. Sellors  
D. Wood  
All Rights Reserved*