ENSC 305W/440W Grading Rubric for Functional Specification

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project.	**/05%**
Content	Document explains the functionality of the proposed product without excessive design content (i.e., outlines the "what" rather than the "how").	**/10%**
Technical Correctness	Ideas presented represent valid functional specifications that must be considered for a marketed product. Specifications are presented using tables, graphs, and figures where possible (rather than over-reliance upon text).	**/15%**
Process Details	Complete analysis of problem. Justification for chosen functionalities. Sources of ideas referenced. Specification distinguishes between functions for present project version and later stages of project (i.e., proof-of-concept, prototype, and production versions). Comprehensively details current constraints.	**/20%**
Engineering Standards	Outlines specific engineering standards that apply to the device or system and lists them in the references.	**/10%**
Sustainability/Safety	Issues related to sustainability issues and safety of the device are carefully analyzed. This analysis must cover the "cradle-to-cradle" cycle for the current version of the device and should outline major considerations for a device at the production stage.	**/10%**
Conclusion/References	Summarizes functionality. Includes references for information from other sources.	**/05%**
Presentation/Organization	Document looks like a professional specification. Ideas follow in a logical manner.	**/05%**
Format Issues	Includes letter of transmittal, title page, executive summary, table of contents, list of figures and tables, glossary, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted.	**/10%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear concise, and coherent. Uses passive voice judiciously.	**/10%**
Comments		

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Simon Fraser University
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October 17, 2013
Mr. Lakshman One
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Functional Specification for the SmartPlant™ design

Dear Mr. Lakshman One,

We are writing with regards to our functional specification for SmartPlant™, which describes our prospective project for Engineering Science 440. The objective of our design is to inspire people to grow their own fruits and vegetables. The SmartPlant™ is a smart flower pot, which has an automated watering system and shading system to protect the plant from dehydration and sun damage. The product also comes with a SmartPlant™ application, which helps users to gain some knowledge about gardening.

The functional specification provides the detail of our product by breaking it down into three sections: watering, shading and SmartPlant™ application. Each section will outline the requirement for proof-of-concept, final product and both phases of development. This document will be used by the project manager and design engineers in order to accomplish their goal.

E-Plant Innovation is composed of four talented and motivated team members whose knowledge and skill set is superlative. These include, David Hsu, Jae Sung Park, Mandan Vahabzadeh and Yang Zhang who are all fourth-year engineering students majoring in electronics and systems engineering.If you have any questions or concerns regarding our functional specification, please do not hesitate to contact me anytime at mvahabza@sfu.ca.

Sincerely,

Mandan Vahabzadeh

Mandan Vahabzadeh
Chief Executive Officer (CEO)
E-Plant Innovation

E - Plant Innovation

Team Members:

David Hsu
Jae Sung Park
Mandan Vahabzadeh
Yang Zhang

Date: October 17, 2013

Executive Summary

Environmentalists have been warning us for years to conserve energy to reduce our impact on the planet. We can help our planet by using energy-efficient home appliances, alternative method to driving such as public transportation, planting, and gardening. Nowadays the entire economy is in decline, so generally people try to reduce consumption. As food prices increase, more people attempt to save money due to the economy. The home gardening has been getting more popular in recent years. According to Burpee Seed Co., "An investment of $50 for seeds and fertilizer can produce $1,250 worth of groceries purchased at a supermarket"[1]. Growing fruits and vegetables seems overwhelming to most of us, but all you need is soil, a little time and a SmartPlant™ device.

At E-Plant Innovation we aim to develop a device that will help and encourage everyone to have their own garden. The SmartPlant™ waters the plant automatically and protects plant from excessive sunlight. By having a SmartPlant™ application, users can grow their own vegetables and fruits with a minimum amount of knowledge about gardening. The Android application will help the user to search for specific plants, which will give instruction and information on how to grow the plant.

The functional requirements for SmartPlant™ have been prioritized. The highest priority requirements are necessary for the function of our product. This includes the ability to water the plant automatically and open/clos the shade. The moisture sensor inside the soil will send data from the sensor to the microcontroller and if the moisture level is low the watering system will be activated. The shading system will be open or closed according to microcontroller which receives data from the photo resistor sensor. Moreover, the android application has the encyclopedia of plant, ideal climate environment and notifies users about the water tank level. The medium priority is making a marketable product which will have proper packaging, a suitable price and attractive appearance. Finally, the low priority requirements are for future development in order to construct the final product.

In conclusion, our goal is to develop an affordable and simple design to motivate everyone to grow their own plants. Therefore, at E-Plant Innovation we will comprehensively test our product to ensure functionally is correct and easy to use.

Table of Contents

List of Figures and Tables

Glossary

CEO	Chief Executive Officer
TM	Trademark
CSA	Canadian Standards Association
IEEE	Institute of Electrical and Electronics Engineers
LED	Light Emitting Diode
PC	Personal Computer
Hz	Hertz
AC	Alternating Current
PCB	Printed Circuit Board
FAQ	Frequently Asked Questions
JUnit	Jave Unit Test
UNO	Universal Network Object

1.0 Introduction

The SmartPlant™ system is a device that helps everyone to have their own garden. Regardless of the amount of sunlight and temperature, this device will automatically water the plant and open the shade in order to protect it from sun damage. The photo resistor and moisture sensors perform as plant protector. Also the android application is used to supplies customer with rich information containing a variety of plants' growth habit. This document lays out the functional requirement for our SmartPlant™ system in order to provide a comprehensive reference for this user friendly product.

1.1 Scope

This document will outline a complete list of functional requirements that must be met by E-Plant Innovation. It will also provide a development test plan that will be used to ensure the SmartPlant™ meets the product requirement. Moreover, these requirements carry out the system overview and product design.

1.2 Intended Audience

The functional specification is written as a guideline for the design and implementation process of SmartPlant™, which will be used by all members of E-Plant Innovation. The CEO, Mandan Vahabzadeh, will use this document as a measure of compliance and progress of our project development. Design engineers of E-Plant Innovation will refer to functional specification to ensure that the current design complies with our goal. Also, engineers should properly take the requirements into consideration when developing the android application and ensure compatibility between technical part and application. Finally, the testing team will use this document as a template to ensure all functions have been working as outlined.

1.3 Classification

This document uses the following convention in order to denote the SmartPlant™ functional specifications:

[Rn-p] A specific functional requirement.
'n' is the number of the functional requirement
'p' represent the priority of the functional requirement

A. These requirements are high priority and apply to the proof-of-concept system only.

B. These requirements are medium priority and applies to both the proof-of-concept system and the final product

C. The requirement applies to the final production system only.

2.0 System Requirements

2.1 System Overview

The Smart Planting System high-level block diagram is shown as in Figure 1.

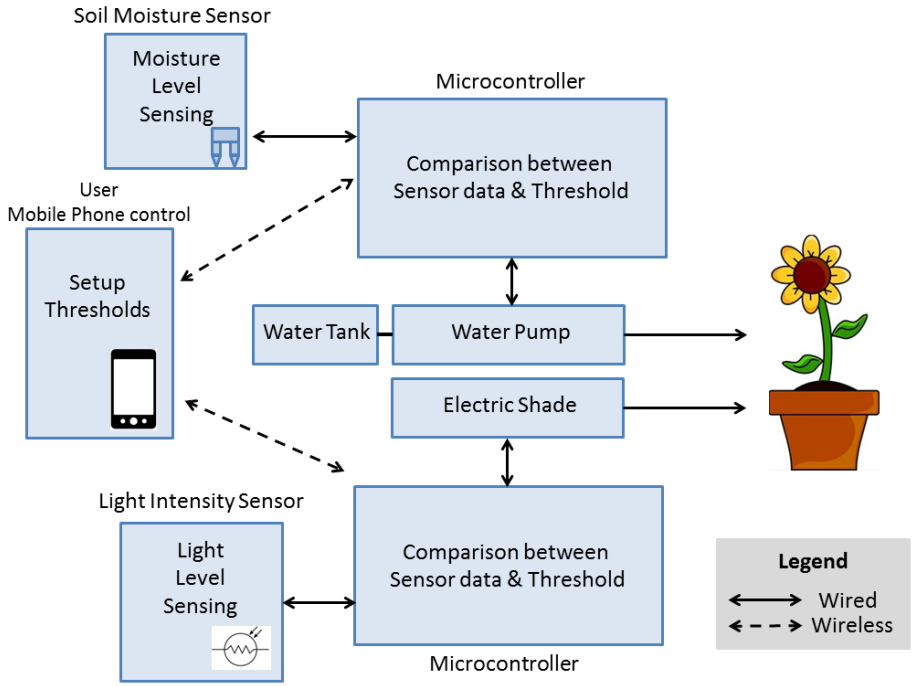

Figure 1: Smart Planting System High-level Block Diagram

The system will contain three subsystems: the cellphone Android user interface, the soil moisture level control and the sunlight protection control. The cellphone user interface will have an Android application supported by wireless Bluetooth connections with microcontrollers. The Android application will provide intuitive display which help user to select a certain plant that user wants to grow. Once the plant decision is made, the cellphone application will send the moisture and light intensity thresholds to the corresponding microcontrollers. Thereby microcontrollers control the water pump and electric shade.

The moisture level of the soil will be measured with the moisture sensor in real time. The moisture sensor has two probes and they are placed into the soil to read the resistance between them. “Soil that contains 10% moisture by weight will as much as five times lower soil resistivity than that which contains 2.5%. Soil at room temperature will be as much as four times lower in resistivity than that at 32 degree.”[2]. The microcontroller will receive the output signal from the sensor and based on the pre-set lower and upper thresholds, it will determine the operation of the water pump.

The sunlight protection control will work in a similar way with the moisture level control. This subsystem will play crucial role when raising plants since majority of plants must avoid strong direct sunlight [3]. To detect the intensity of the sunlight, the photoresistor will be used. The higher light intensity, the higher conductivity it has. Applying this characteristic, a simple circuitry can be built with the photoresistor to output the different level of voltages [4]. These output signals will be sent to analog input of the microcontroller and the microcontroller will compare the input with its pre-defined thresholds. If the input is out of appropriate range, the microcontroller will turn on or off the switch to fold or unfold the electric shade.

2.2 General Requirements

[R1-C] The system shall be used at both indoor and outdoor environment.
[R2-C] The final product price of the Smart Plant System shall be less than CDN $200.
[R3-C] The final product shall be composed of recycled materials.

2.4 Electrical Requirements

[R9-B] The system shall not have exposed wires and all electrical connections must be appropriately insulated.
[R10-B] In indoor environment, the system shall use a typical wall power outlet and the system's power adopter must be compatible with general North American power outlets (60Hz, 110V/120V AC).
[R11-B] BeagleBone Black microcontroller shall not have analog input more than 1.8 volts from the sensor to avoid damage on the board [5].
[R12-B] Arduino Uno microcontroller shall not have analog input more than 5 volts from the sensor to avoid damage on the board [6].
[R13-C] In outdoor environment, the system shall be powered by battery cells.

2.3 Physical Requirements

[R4-B] The flowerpot shall not have planting area larger than 100 x 100 cm^2.
[R5-B] The flowerpot shall have appropriate size that can adopt general houseplants with height less than 1 meter.
[R6-B] The water pipe line must be installed inside and along the sidewall of flowerpot.
[R7-C] All the components (water pump, water tank and flowerpot) shall be designed as uni-body.
[R8-C] The final product shall look modern and high-tech.

2.5 Environmental Requirements

[R14-A] The system shall operate properly in a normal indoor environment (10 ~ 30 °C).
[R15-B] The water pipe line and moisture sensor shall withstand plant fertilizers or chemicals that are required for growing plants.
[R16-C] The water pipe line and moisture sensor must be composed of material that does not harm the plant.
[R17-C] The system shall operate at outdoor properly in winter season without freezes at water pump and water pipe.

2.6 Standards

[R18-B] The Smart Planting System shall conform to IEEE 802.15.1 standards relating to Bluetooth communication [7].
[R19-B] The Smart Planting System shall conform to CSA standards [8].

2.7 Safety Requirements

[R20-B] All the electric parts of the system shall be enclosed in an insulated container.
[R21-B] The system shall not have flammable parts.
[R22-B] The system shall not leak hazardous material.
[R23-B] The system shall not emit excessive heat while operating.
[R24-B] The system shall not melt while operating.
[R25-B] The system shall not have any sharp edges.
[R26-C] The electric shade must stop operating when human places finger on the lead rail.

2.8 Performance Requirements

[R27-B] Within 10 seconds, the microcontrollers receive signal from sensors and operate water pump/electric shade.
[R28-A] The water pump shall have pumping capability up to 30 inches high.
[R29-A] The water pump shall have flow rate of 3-1/2 gallons per hour.
[R30-B] The electric shade shall be fully open and close in 60 seconds.
[R31-B] The Bluetooth module shall maintain its connection with Android cellphone up to 5 meters.
[R32-B] The water tank must alert user for the water refill through LED indicator.
[R33-B] The water tank shall need refill in a period longer than 1 month.

2.9 Usability Requirements

[R34-B] The system must be controlled with Android application.
[R35-B] The system shall easily be lifted and relocated by the user and not be heavier than 3 kilograms.
[R36-B] The water tank shall easily be refilled.

3.0 Android Application

The Android Application will be installed on user's cellphone and will provide broad range of plant selections for the user. Each plant has certain thresholds of soil moisture level and light intensity. Once the user selects the specific plant, the application sends thresholds data to the microcontrollers to operate water pump and electric shade accordingly. Also, the Android application will display recommendations of other kinds of plant that can be raised along with user's primary selection. This will allow the user to raise different kinds of plants at the same time.

3.1 General Requirements

[R37-B] The Android application shall be optimized for Android devices (cellphones and tablet PCs).
[R38-B] The Android application shall come with the system without extra cost.
[R39-B] The Android application shall have Bluetooth connection with the microcontrollers in the system.

3.2 Usability Requirements

[R40-B] The Android application shall have intuitive display.
[R41-B] In the case when the Bluetooth is at off state, the Android application shall alert the user to go to "Settings" on cellphone and turn on the Bluetooth.
[R42-B] Once the user's plant selection is made, the Android application shall provide recommendations for other plants that can be raised together.
[R43-B] The Android application shall alert user once a week to check the water amount at the tank.
[R44-B] The Android application shall have "Recent Search" feature.
[R45-C] The Android application shall be easily updated by user.
[R46-C] The Android application shall have search function when the user wants to find a certain plant.
[R47-C] For the case the system is powered by battery cells, the Android application shall notify the user when the battery of the system is low.

4.0 Sunlight Protection System (Sunroof)

The Sunlight Protection System will be consisted of input light intensity sensor that communicates with the microcontroller via wired connection. This will activate the electric shade to open or fold based on the data the microcontroller receives from the light intensity sensor.

4.1 General Requirements

[R48-A] The Sunlight Protection System shall cost less than CDN $100.
[R49-B] The system should be appealing to the eye.
[R50-C] The system must be able to withstand a vibration test.

4.2 Electrical Requirements

[R51-B] The system must be able to link wirelessly with mobile device.
[R52-B] When sunlight level exceeds an upper threshold level, sunroof shall be activated.
[R53-B] When surrounding light intensity has reached a lower threshold value or certain amount of time has passed, sunroof shall retract into initial resting position.
[R54-B] The motor unit in the system shall be battery powered.
[R55-B] The motor shall the inertia ratio of 5:1.
[R56-B] The sensor input must be able to continuously communicate with microcontroller.

4.3 Physical Requirements

[R57-B] The shade must be lightweight, not exceeding total weight of 5kg, as not to induce high strain on the motor.
[R58-B] The supporting structure shall be able to support weight of sunroof.
[R59-B] When the sunroof is activated, it should always be at an angle to prevent possible accumulation of water on top.
[R60-B] The surface area of sunroof shall be large enough to cover considerable plot of planting area.
[R61-C] The material of the sunroof system shall not be washed off and leak hazardous material.

4.4 Environmental Requirements

[R62-B] The motor for the system must be waterproof.
[R63-B] The system must be made of material that can withstand rust.
[R64-B] The system shall operate normally under typical weather conditions and temperatures.

4.5 Safety Requirements

[R65-B] The system must have a built-in circuit breaker or fuse.
[R66-B] The battery for the motor does shall not leak alkaline into surrounding area.
[R67-C] The system must have Ground Fault Circuit Interrupters to prevent possible electrocution.
[R68-C] The system must be installed with surge protectors to counter electrical storms.

5.0 Watering System

The watering system will be consisted of a water tank, water pipe and a controller package. The controller package includes a battery supply, PCB with a relay, Arduino UNO microcontroller and a small water pump. In order to meet the requirement of a portable smart planting system, the controller packaging must be as compact as possible.

In the watering system, the soil moisture detection will be achieved with the three-terminal soil moisture sensor. The moisture sensor will be compatible with Arduino UNO microcontroller as shown in Figure 2, and for the moisture measurements, its two probes will be inserted into the soil.

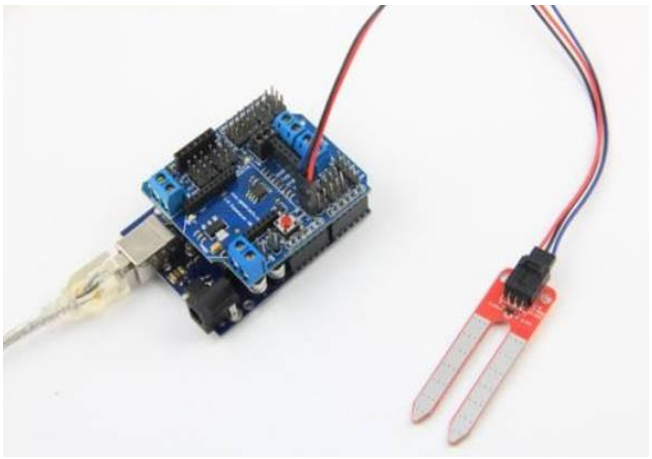

Figure 2: Soil Moisture Sensor Compatible with Microcontroller

5.1 General Requirements

[R69-B] The Watering System must cost less than CDN $100 including necessary microcontroller, pump, pipes and relay.

[R70-B] All the electrical components shall be encapsulated inside a waterproof case.

5.2 Electrical Requirements

[R71-B] The battery voltage for Arduino UNO shall be between 7V and 12V.

[R72-B] When the moisture level is decreased below a lower threshold, microcontroller shall activate the water pump.

[R73-B] When moisture level has reached an upper threshold value or certain amount of time has passed, pump shall stop working.

[R74-B] The microcontroller shall communicate with mobile device via Bluetooth.

5.3 Physical Requirements

[R75-B] The watering system shall weigh less than 3 kg.

5.4 Environmental Requirements

[R76-B] The moisture sensor shall have working humidity from 10% to 90% with no condensation.

[R77-C] The watering system shall work normally under typical weather conditions.

5.5 Safety Requirements

[R78-B] The watering system power requirements must lie within human safety limits.

[R79-C] The controller packaging case must be made by insulation material.

[R80-C] The system shall be installed with urgent stop circuit breaker on PCB.

6.0 User Documentation

The user documentation package will only be included with SmartPlant™ product. It will include a detailed documentation of how the system functions, SmartPlant™ android application, as well as a simple user's guide on how to operate the device.

6.1 General requirement

[R81-C] User documentation shall include picture, text, table, and step by step operation instructions on how to activate the SmartPlant™.

[R82-C] User documentation shall have information about the warranty of our product.

[R83-C] The troubleshooting and FAQs sections shall contain technical problem about the hardware.

6.2 User manual requirement

[R84-C] The user manual shall be written for an audience with minimal technical background.

[R85-C] The user manual shall teach user how to operate the device.

[R86-C] The user manual shall educate user how to take care of the device.

[R87-C] A safety guide shall be provided to explain the potential hazards and warnings.

[R88-C] The user manual shall describe the limitations of the device and summarize its usability.

6.3 Software Requirements

[R89-C] The SmartPlant™ application shall be automatically update itself.

7.0 Engineering Standard

- The E-Plant Innovation will conform to IEEE 802.15 standards relating to wireless communications
- SmartPlant™ device must conform to CSA standard 22.2

8.0 Sustainability and Safety (Cradle to Cradle Design)

Our product employs several key parts, each of which is essential to the overall functionality of our device. These parts include the water pump system, the sunlight protection system, the plant pot, and the wiring that connects each system to its respective microcontroller. For each of these individual portions, we ordered the parts online, with the hopes to make our product as sustainable as possible. We would like to show exactly how our product intends to meet a cradle to cradle design philosophy, and to be able to share our knowledge with other people in our industry.

With regards to managing our three primary pillars (social equity, restorative environmental impact, and profitability), it is very important to not compromise design or any other area. This is because, without profit, there can be no product, and without a product we will be unable to achieve our other goals. Profit should always be the bottom line, but never at the expense of sacrificing our other core pillars. The decision-making process should be one of fairness and neutrality, with regard for not just the profit, but all three of our core pillars. It is by equally supporting each of our core values that we will be able to achieve our goals of developing products that improve our ecosystem and replenish the environment.

Primarily, our plant pot will be designed to be of decomposable material, which will be economically affordable as well as environmentally friendly. One option for this is to make it out of a natural substance such as wood or bamboo. Since the majority body of our product will be the plant pot itself, and this plant pot is mainly used outdoors, it is best that this portion of the product be made as sustainable as possible. Another part that is to be considered is the Sunlight Protection System. The material for the roof should also be made to be as sustainable as possible, without the compromise of material decomposition such as rust. The rest of the product consists of metal devices (i.e. water tank, water pipe) and circuit components (i.e. photo resister), which should ideally be recycled by discarding at a local electronic recycle station.

However, if we now look at the organic part of our product, which includes the soil, the various plants, and any organisms that might live in the soil, we can see that our product is very sustainable. Since the SmartPlant™ System takes in inputs and adjusts the environment accordingly, the condition for the surrounding area will be in an optimal condition for organisms to live in. Looking at the bigger picture, we can say that the SmartPlant™ System is creating an isolated ecosystem for plants to grow and thrive in.

9.0 System Test Plan

Plants change very fast depending on a variety of factors such as temperature, location, season, and weather. Several tests need to be performed to ensure the product is both durable and reliable. To achieve this, we need to do separate testing for individual tasks and at the end combine all of them together.

The first section of testing is the watering system. The purpose of this test is to see if the watering system is responding to a different level of soil moisture. Software testing is an important part of this step, which is required to get data from the sensor and transfer it to Arduino microcontroller. The microcontroller should respond to data by activating or deactivating the water pump. We will also test the sensitivity of the moisture sensor by writing a simple program to make sure that the sensor is working properly. By debugging the programming we can ensure that the code is running correctly without any miscalculation.

The second section is testing the electric shade which will be open when there is excessive sunlight. There are two test plans for shading system: hardware and software. The mechanical part is the testing the motor to accurately open the shade. Also we will need to test our design to make sure opening the shade will not damage the plant. The programming part is to ensure that the photo resistor sensor is operating and sending data to the microcontroller so the motor will be started.

The Android application is another section of the test plan. In this section we have to test the application by searching for the size of flower pots and name of the seeds. Android test use the JUnit test framework to test Java classes that does not call the Android API. The JUnit test is framework for Java programming. We need to have different test cases and test each of cases separately. After that we need to combine all of these cases together in order to the SmatPlant application work properly.

Finally, we have to combine these three sections together to ensure that all of them work simultaneously. The battery life would impact the system effectiveness. Therefore, in this section we have to test the power supply to see how much battery we need to activate watering system and open/close the shade.

9.1 Typical usage scenario

- From SmartPlant™ application user chooses what type of flower pot have; depend on the flower pot size the application suggest to plant specific set of vegetables and fruits.
- Depends on what type of plant user is planting the watering and shading system will adjust automatically.
- The application will notify user weekly to refill the water tank or recharge the battery

10.0 Conclusion

The functional specification detailed in this document clearly and concisely defines the requirements for our SmartPlant™ system. In addition, these requirements are prioritized by a three tier system and dictate the developmental steps for our smart system. With the completion of each step, higher priority requirements are satisfied and the device evolves from a proof of concept, to a marketable product and to a final product. The proof of concept device is well under development and we are excited and confident in the completion of the final product by Dec. 10, 2013

11.0 References

[1] G.Ball. “Families Can Cultivate Financial Savings With Burpee's Money Garden Seed Pack”, Internet: http://www.burpee.com/gardening/pressrelease, Feb 4, 2009, [Oct 12, 2013].

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