Functional Decomposition T303

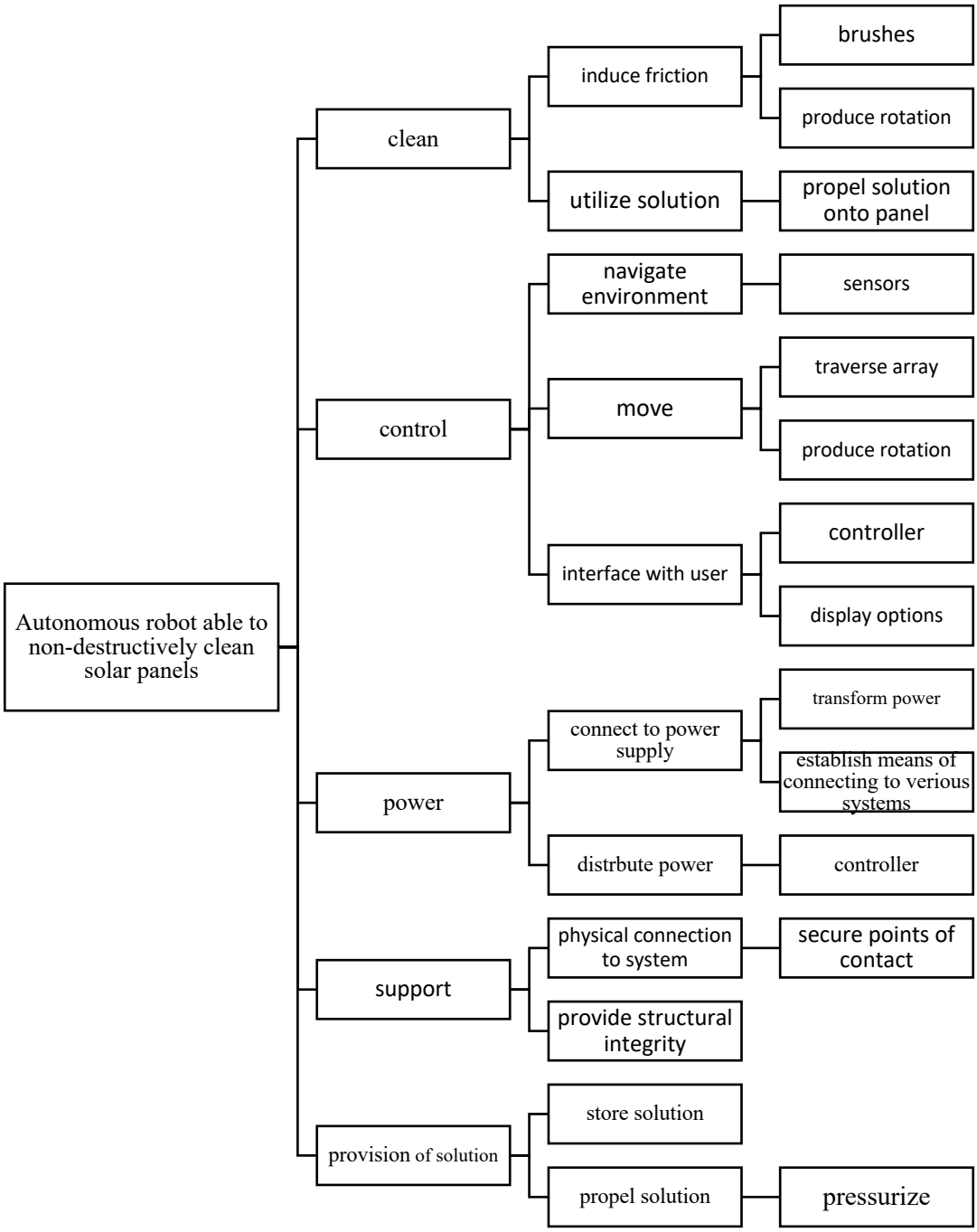
Introduction

For our senior design project, our goal is to design a system that can autonomously clean solar panels in a non-destructive way. Our vision is to have that system be an automatic robot that has the ability to move up and down the solar panel with a cleaning system attached to the bottom of the robot. The robot will have the ability to switch to different modes, such as a deeper clean mode or a regular maintenance mode. The robot will also need to be light weight so an average person would be able to install it on a roof housing solar panels without much trouble. The ability for the robot to be lightweight will also help keep the solar panels from being harmed.

For the functional decomposition of the system, we start with the big picture idea which is the creation of a cleaning robot. From that system, we will go deeper into the process of assessing what components are necessary for the robot to be able to do its job efficiently and effectively. This system is being created for the use of residential solar arrays and would be beneficial for companies who service the residential systems. The system will be able to have the durability to clean neglected panels while also having the ability to maintain the solar arrays for regular maintenance. The functions created for the robot have some overlapping elements, such that the cleaning brushes will need to use the provision of solution to effectively clean the panel.

Using the data gathered from the customer needs, the function tree and decomposition levels were created and thus broken down to be understood. Our team came up with functions the system must have which are, ability to clean, control the system, power the system, support for the system and provision of solution for the panels.

Function Tree



Cross Reference Table

Cross Reference Table	**Major Functions**	Customer Needs	Clean	Control	Power	Support	Provision of Solution	**Ranking**
Minor Functions								
Induce Friction		1, 6	**X**			**X**		7
Utilize Solution		1, 5, 6, 7	**X**				**X**	10
Navigate Environment		2, 3, 4		**X**	**X**			5
Move		1, 2, 3, 4	**X**		**X**	**X**		2
Interface with User		2, 4		**X**	**X**			11
Connect to power supply		3, 4, 7			**X**			1
Distribute Power		4, 7			**X**			3
Physical Connection to System		3, 5, 6		**X**		**X**		6
Structural Integrity		3, 5		**X**		**X**		4
Store Solution		1, 5	**X**					8
Propel Solution		1, 2, 5				**X**	**X**	9
Ranking			3	4	1	2	5	

Needs Key:

1. Clean Panels
2. Autonomous
3. Lightweight
4. Power Requirement
5. Solution Tank
6. Interchangeable Brushes
7. NEMA Rated

Decomposition Levels

Level 0

Module	Autonomous robot able to non-destructively clean solar panels
Inputs	Power: 120 V AC rms, 60 Hz
Outputs	Type of motor that will spin the cleaning brushes to reach the solar panel and clean the array
Functionality	Effectively and efficiently clean the solar panels automatically without damaging the structure or integrity of the panels.

Level 1

Module	Power
Inputs	120 V AC rms, 60 Hz
Outputs	Certain number of ? V DC
Functionality	Able to take the power coming from the grid and transform it to a lower voltage so that voltage can be used by the controllers, motors, etc.

Module	Cleaning
Inputs	5 V DC
Outputs	Motor that spins at ? RPM
Functionality	Able to move the brushes so solution of the panel can work off the dirt or grime on the solar panel and thus be removed

Module	Control
Inputs	Certain type of controller
Outputs	Applied to motors, signals to sensors, movement of robot
Functionality	Controls the movement of the robot, such as, where it is going and how fast it will be moving. Also controls the speed of the motors that will be moving the cleaning brushes that will interact with the solar panel.

Module	Support
Inputs	Clamps, rails, and cross beam support
Outputs	Keep the robot in sturdy on the panel
Functionality	Able to hold the robot on the solar panel without damaging the structure and quality of the panel and the

Module	Provision of Solution
Inputs	Solution and way to get the solution where it needs to go
Outputs	Propel a mixture of water and solution to a needed area located on the array

Functionality	To help clean the array

Level 2

Module	Induce Friction
Inputs	Power and interchangeable brushes
Outputs	Produces a force that moves the brushes
Functionality	To remove the dirt and/ or grime on the surface of the solar panel

Module	Utilize Solution
Inputs	Solution
Outputs	Distribution of solution onto solar panel
Functionality	Use the solution to clean the panel

Module	Navigate Environment
Inputs	Initial user input or device, designed algorithm within microcontroller
Outputs	Proper motion in all direction
Functionality	The functionality will consist of a set of code that will provide the robot with an effective solution to provide proper navigation around the array.

Module	Move
Inputs	Initial input from user or device Certain DC voltage to supply power
Outputs	Movement from motors and drivers (controllers) in horizonal and vertical direction
Functionality	Movement allows the robot to navigate the array to cover all areas and provide a proper cleaning route

Module	Interface with User
Inputs	Size, dimension, array width and height (Hard coding will be applied initially)
Outputs	LCD screen, keyboard, ect. (not determined)
Functionality	This will allow the user to communicate with the robot and input the size of the array the robot is being tasked with. Display error messages(future)

Module	Connect to Power Supply
Inputs	Power from the grid, a battery, or a generator (power source TBD)
Outputs	Power generated at a voltage and/or current level compatible with our cleaning system's electrical components
Functionality	Take power from the grid so if can power the robot so it is able to perform all the functions necessary.

Module	Distribute Power
Inputs	A nominal voltage supplied to a BUS
Outputs	Distributed to each component that needs a certain amount of power

Functionality	One or multiple distribution BUS's will be designed to supply required voltages to various components throughout the system. When choosing powered components, voltage comparisons will be taken into consideration.

Module	Physical Connection to System
Inputs	Cleaning device, solar array, clamps, possibly pulleys
Outputs	Security for cleaning device and untouched structural integrity of array
Functionality	Cleaning device can securely traverse array without possibility of damage

Module	Structural Integrity
Inputs	Cleaning device, solar array, various joint types, wheels (support)
Outputs	Dynamic mechanical device
Functionality	Strong structural integrity ensures an adequate freestanding structure that can support its own weight and allows for system cleaning

Module	Store Solution
Inputs	Water, concentrate solution of certain mixture
Outputs	Mixture or ratio of solution and water
Functionality	This device will hold a concentrated solution that then can be further diluted to the needed mixture (mixture determined by customer)

Module	Propel Solution
Inputs	Voltage that the chosen motor requires (not determined)
Outputs	Valve or fitting that can attach to a distribution device that will distribute the water at a certain force
Functionality	Distribute the solution onto the solar panel so it can be utilized by the interchangeable brushes and clean the panel

Summary

Our function decomposition makes use of the top-down approach. We began with the level 0 function of *Autonomous robot able to non-destructively clean solar panels.* The five minor functions are *clean, control, power, support, and provision.*

The “clean” minor function is focused on the physical removal of dirt, pollen, debris, etc. from the solar panels. It is broken down to the level two functions “induce friction” which describes how the robot will traverse the solar panel plane and how the brushes will apply force to remove the debris, and “utilize solution” addresses the application of the cleaning solution. This is accomplished by propelling the solution from the tank onto the solar panel and is then rinsed when the robot goes back over the respective section.

The “control” minor function is regarding the movement functionality of the robot, the autonomous navigation, and the user interface. It is broken down to the level 2 functions “navigate environment” which addresses the robots autonomous decision making for its cleaning route, “move” which addresses the robots following of the cleaning route, and its physical movement functionality, and “interface with user” which allows the robot to communicate its functionality, progress, errors, and needs to the user.

The “power” minor function relates to the supplying of energy to the various components of the robot, including the physical movement components, solution propelling method, the creation of water pressure, and user interface. It is broken down to the level 2 functions “connect to power supply”, which describes the physical connection between the robot and our power supply, and “distribute power” which expresses our circuit analysis approach of power distribution from our source.

The “support” minor function describes the physical support system of our robot. It is broken down to the level 2 functions “physical connection to system”, which describes the manner in which our robot will be attached to the solar panel and how it will move along the solar array in an efficient manner, and “provide structural integrity” which addresses our methodology of ensuring the structural integrity of the system, and furthermore avoid damaging the solar panels.

The “provision of solution” minor function is in reference to the containment and application of the cleaning solution that will be applied to the solar panels. It is broken down to the level 2 functions “store solution”, which describes the methodology in which the solution will be contained for application, and “propel solution” which describes the way the robot applies the cleaning solution to the solar panels.

Based on the function decomposition that was worked on and revised, there is a sufficient understanding of what is required for the robot to clean the solar panels autonomously and efficiently.