Functional Decomposition

Introduction

The functional decomposition process was employed to transform the project scope details into more precise, specific requirements that are essential for the project's success. By establishing basic level functions for the F1TENTH scale car chassis, the group will be able to identify the system's targets and metrics. In completing the functional decomposition, the group ensures that each functional component contributes to the overall quality and functionality of the chassis.

Data Generation

The functions listed below in Figure 1 were determined by analyzing questions such as what is crucial for the F1TENTH project, what functions affect one another, and what functions are not needed for research and development. Some of the questions that helped determine what the functions are for the project are “What kind of different iterations would we like to see?” and “How modular would we like the car to be?” Knowing what each function can do and what is correlated increases efficiency with good organization with the understanding of the F1TENTH project. By looking at the key goals, customer needs, project scope, and interpreted answers, the answers for the functions are listed as a flow chart below:

Flow Chart Reasoning

The functional decomposition hierarchy chart, seen in Figure 1, is broken down into four major systems: *movement, structure, utilization, and protection*. The *movement* system encompasses all functions pertaining to the movement of the car. The *structure* system covers the stability and positioning of the components within the chassis, as well as the material of the design. The *utilization* system covers the accessibility of the components as well as the intended use of the components. The *protection* system covers crash durability and user handling of the car.

The F1/10th vehicle chassis was broken down in the four systems based on the primary objective with aligning key goals and interpreted need from customer evaluation. Interpreted from evaluation was a need of a chassis with definite mechanical metrics that is easily reproducible. As designed for competitive use, the limiting factors from F1/10th competition will remain in consideration to metrics.

Movement is divided into two subsystems: Suspension and steering. Under suspension, the functional interaction of the chassis to the limitation of body roll and other stabilizations of the entire vehicle can be seen such as dampening vibrations and ground clearance. When steering the vehicle there is also the functional requirement for clearance of the chassis during max turn radius.

The chassis structure system is divided into five subsystems: Compact, aerodynamic material, vibration, and fixed. With consideration of compactness and constraints, there is an ability to utilize and optimize the consumption of available space by the chassis keeping in mind necessary components. Competitive use of vehicles entails the use of aerodynamic design benefits in downforce generation and drag force limitation. The structural integrity of chassis material ensures the weight capacity to support components and withstand collisions. Aside from suspension dampening occurring in collaboration with chassis, the dampening of vibrations can be future induced by the selected materials and structure. A fixed structure will ensure components to be fixed to their mounting points and enable rotations in all axes.

Utilization is composed of subsystems access and components. User interaction with the components is prioritized when testing or making adjustments that will require the chassis to enable components to be easily accessible and ports to not be obscured.

In conjunction with other systems, protection system divides into the subsystems: crash and user handling. Upon collisions or roll overs, there is assurance that components will be protected, and chassis will remain intact. Fabrication considers the safety of the user from any sharpy extrusion or electrical grounding with exposure to high voltages.

Connection to Systems

The objective of the functional decomposition hierarchy was to create as many functions as possible that satisfy the customer's needs. As you descend the hierarchy, the specificity of the system increases. The first tier of the hierarchy which includes movement, structure, utilization, and protection are unique yet relative functions that are general enough to capture necessary functions. Each tier 1 system can’t exist without the other when discussing functions of a vehicle chassis. The next tier are more specific subsystems such as aerodynamics, steering, components, and more. These subsystems were implemented to create a more organized and translatable set of functions. Shown below in Table 1, the functional decomposition cross reference chart is a chart comparison of various functions as they relate to the overall system. The tally is useful in determining which function will take priority in the design process. The “X” indicates the given function that is correlated to. Some functions may relate to multiple systems as shown in Table 1:

Table 1: Functional Decomposition Cross Reference Chart

System Functional Decomposition				
Function	*Movement*	*Structure*	*Utilization*	*Protection*
Limits Body-Roll	X			
Dampens Vibrations	X	X		

Clears Ground	X	X		
Clears Maximum Turn Radius	X			
Contains Cables		X		
Utilizes Free Space		X	X	
Limits Length, Width, and Height		X		
Influences Fluid About Body		X		
Generates Downforce		X		
Supports Weight of Components		X		
Withstands Forces from Crashes		X		X
Dampen Component Vibrations		X		
Fixes Components to Chassis		X	X	
Allows for Rotation About All Axes		X		
Allows for Easily Accessible Input/Output Ports			X	
Allows for Components to be Used as Intended			X	
Protect Against Collisions				X
Protects Against Roll-Over				X
Protects User from Sharp Extrusions or High Voltages				X

Integration

The first functions split into multiple sub-systems which are movement, structure, utilization and protection. The movement and structure will work together as it will utilize power for movement, as well as physical forces of the structure affecting the movement. Protection and support also relate with one another as the structural integrity of the chassis will determine how durable the car is with unexpected damage. Utilization and support correlate with accessibility to components and the structure design to access them. The four functions all relate to one another, but it is crucial that they are split into smaller sub-systems to help organize the workload while also knowing what component affects the other.

Action and Outcome

The main action for the design to perform is to provide a stable and accessible platform for the components in the F1TENTH car. This platform should not inhibit the motion of the

F1TENTH car and should be able to survive extreme loading cases such as high-speeds, cornering, acceleration and deceleration, crashes, and transport.

The customer needs the design to allow free movement of the F1TENTH car. The wheels need to be able to steer the car without colliding with the frame. The steering arc and suspension travel of each wheel should be free to move through their entire travel without colliding with the chassis. The weight of the car cannot cause it to bottom out during normal maneuvers. If the chassis design weighs too much, the suspension on the F1TENTH car will not behave correctly. The suspension system of the subframe is designed to perform best with a specific load which will limit the system's mass. Overloading the system with too much mass will cause the springs to compress undesirably and the system will become underdamped and oscillate undesirably. The chassis design should arrange the components so that the F1TENTH car has favorable handling characteristics. The steering geometry is pre-determined on the F1TENTH subframe, so the center of mass should be kept as low as possible to limit the rolling moment acting on the car during acceleration, braking, and cornering. The outcome of a lower center of mass will be a decrease in the weight shift from front to back or side to side during acceleration/braking and cornering, respectively.

The customer also needs a design which can be easily transported and handled so the vehicle is not easily damaged. The design should act to protect the components of the car and present obvious points where the chassis can be lifted from. This will provide the customer with assurance that the design is sufficient in its structural integrity.

The customer has requested that the components of the F1TENTH car be easily utilized. The design should allow easy access to all components of the car, with special attention paid to the components that need to be most easily accessible, which the customer identified as the battery and the onboard computer. The design will give access to all the F1TENTH car's components by utilizing organization techniques to arrange the components within the chassis, so they are not blocked by less important components.

The protection of the components within the chassis as well as of the chassis itself during operation of the F1TENTH car was also emphasized by the customer. The structure of the chassis will allow a system to be attached to the extremities of the chassis which can reduce the stress of an impact in a crash. Combined with the emphasis on a robust structure, this impact reduction system's outcome will be to protect the components and the chassis of the F1TENTH car.

Figure 1. Functional Decomposition Hierarchy

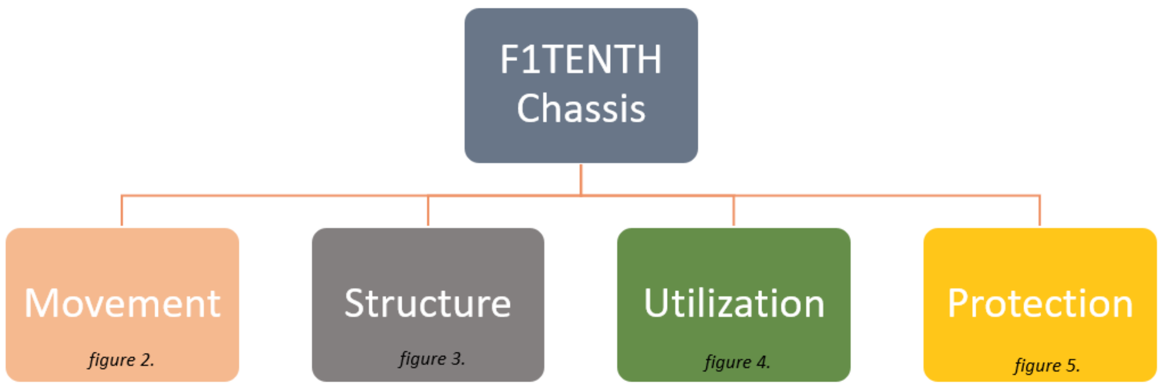

Figure 2. Movement Subsystem, Functional Decomposition Hierarchy

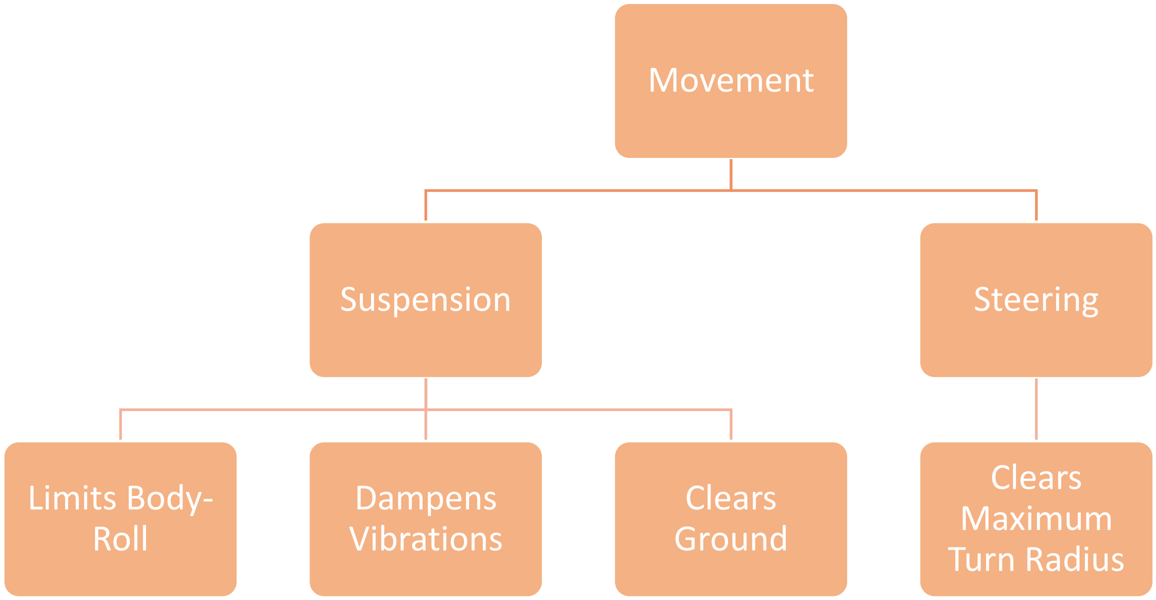

Figure 3. Structure Subsystem, Functional Decomposition Hierarchy

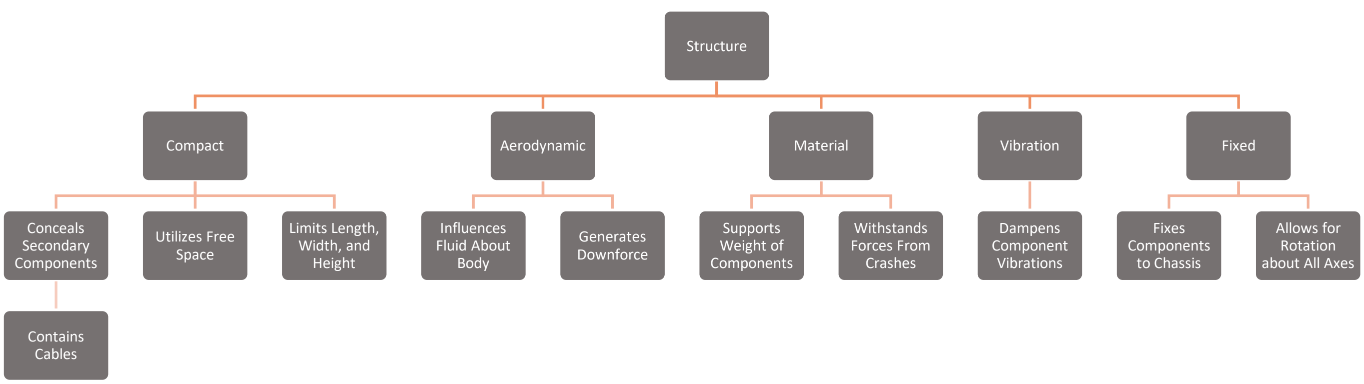

Figure 4. Utilization Subsystem, Functional Decomposition Hierarchy

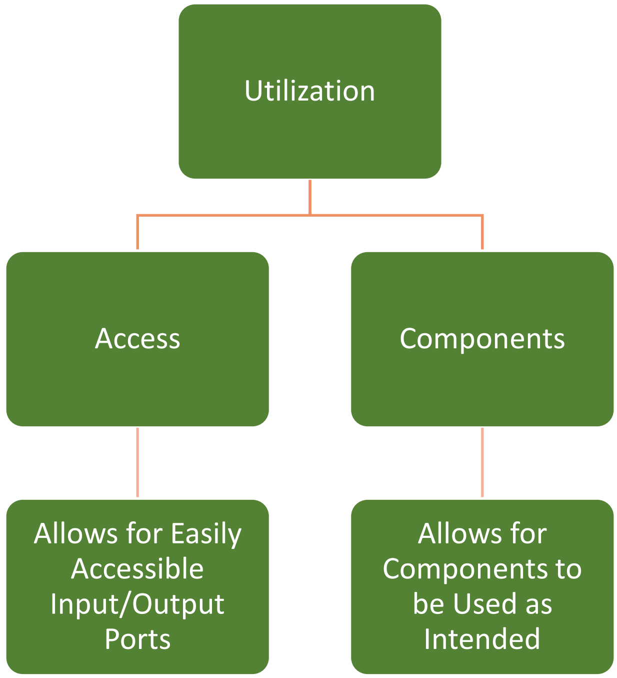

Figure 5. Protection Subsystem, Functional Decomposition Hierarchy