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Team 519: Composite Airframe Life Extension

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Functional Decomposition

The functional decomposition (FD) breaks down the actions that the part performs into the smallest possible components (McConomy, 2018). These functions describe either the actions the part takes, or the outcomes of the part. The functions were generated by analyzing the customer needs to break down the actions the part must do into the simplest possible components.

This section introduces the functions in graphical form through Figures 1 and 2, afterwards, the functions are explained in detail. This section concludes by discussing how the functions relate to each other and to the project at large.

Hierarchy Chart.

The hierarchy chart focuses on the distribution of functions and how the relate to the main systems. There are two main systems which reflect the two categories of customer needs: withstanding loading and enduring environment. Withstanding loading refers to the mechanical stresses that are induced in the part. Enduring environment refers to the conditions that the part will be exposed to. The part must withstand each loading condition in each environmental condition. This first hierarchy chart shows all the functions and how they relate to the two systems.

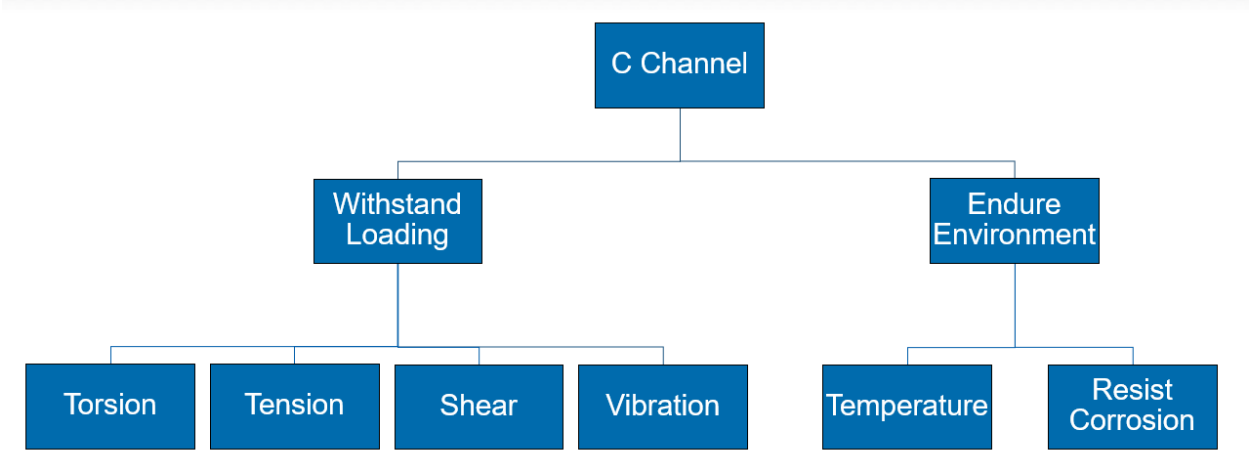

Figure 1. Functional hierarchy graphic depicting functions and branches.

Cross Reference Figure.

As discussed in the customer needs section, some of the customer requirements are not as important as the others. A cross reference figure will compare each function with each other function to down select out of functions that are not very important. This chart is part of the key goal “down select MIL-STD".

The importance of a function is decided by how much it impacts the operation of the aircraft. For example, while a fungal buildup could become problematic, but a layer of fungus on the part will probably not cause the aircraft to crash immediately. On the other hand, if the part cannot withstand the operational temperature and it fractures in flight, this could have severe consequences, thus temperature resistance is more important than fungal resistance. Additionally, some environments are more likely to be encountered than others. For example, the part will probably never be involved in a crash, and even if the aircraft does crash it will only happen once, thus shock is not as important as something like vibration, which the part will be exposed to during every flight.

The functions in the columns are compared against the functions in the rows. If a function in a column is deemed more important than the function in a row, then that cell is filled with a 1, if not it is filled with a 0. The bottom row lists the sum of all cells in that column. The higher the number, the more important that function is to fulfill the customer’s needs.

	Provides Support to Airframe	**Shear**	**Tension**	**Torsion**	**Resist Acoustic Vibration**	**Resist Electrical Current**	**Absorb EM Radiation**	**Control Heat Transfer**	**Resist Corrosion**
Provides Support to Airframe		1	1	1	1	0	0	1	1

Shear	0		1	0	0	0	0	0	0
Tension	0	0		0	0	0	0	0	0
Torsion	0	1	1		1	0	0	1	1
Resist Acoustic Vibration	0	1	1	0		0	0	1	1
Resist Electrical Current	1	1	1	1	1		1	1	1
Absorb EM Radiation	1	1	1	1	1	0		1	1
Control Heat Transfer	0	1	1	0	0	0	0		0
Resist Corrosion	0	1	1	0	0	0	0	1	
Total	**2**	**7**	**8**	**3**	**4**	**0**	**1**	**6**	**5**

Figure 2. Function cross reference table depicting the relationship between customer needs and shelf functions.

The customer needs and functions can be divided into three categories: Critical functions, secondary functions, and tertiary functions. Critical functions scored the highest, indicating they are the most important functions and should be the highest priority to test and validate. Tertiary functions scored the lowest, indicating they are the least important functions and will not be tested. Further testing of these functions is recommended but is outside the scope of this project.

Secondary functions are those that could impact the performance of the part over the long term, or the tension and torsion loading cases which the part may experience occasionally, but withstanding those loads is not the primary purpose of this part. Secondary functions will be validated as budget and time allows.

The critical functions are the most important to validate because the failure of a critical function would mean the immediate failure of the part, which would endanger the aircraft. The critical loading conditions are the way the part is designed to be loaded.

Revised Hierarchy Chart.

Now that the relative importance of the functions has been established, a revised hierarchy chart drops the tertiary functions. This chart contains the functions that will be evaluated in detail.

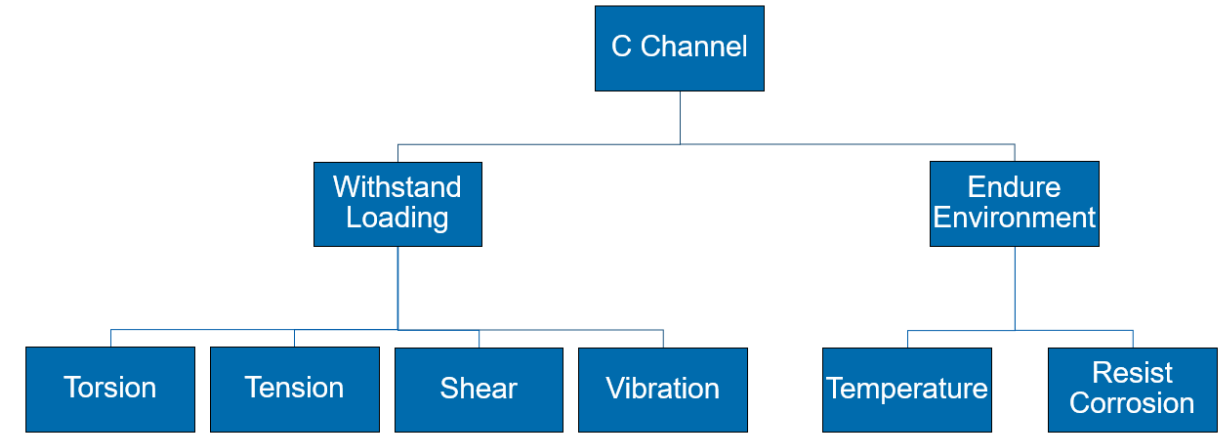

Figure 1. Functional hierarchy graphic depicting functions and branches.

Function List

This is a list of all the important functions in order of importance as determined by the cross-reference table.

Bending y.

The primary purpose of a C channel is to hold a load along the y direction; therefore, this is the most important function. The part holds a load along the y direction.

Bending x.

The part holds a load along the x direction.

Temperature.

The part will be exposed to both high and low temperature extremes and it must provide full strength thorough that range and it must not degrade from extended exposure to those extremes. This is a primary concern because polymers can lose strength before they melt; the part provides adequate strength at the temperature extremes. Also, the part does not degrade after prolonged exposure to the temperature extremes.

Tension.

The part holds a load when loaded in tension.

Vibration.

The part will be exposed to a range of vibration whenever the engines are activated. The part maintains the required strength throughout the vibration profile.

Humidity.

The part will certainly be exposed to a humid environment, which is of concern because some polymers are susceptible to degradation when exposed to water. The part does not degrade at the maximum temperatures and 100% humidity.

Torsion.

There will be some nominal torsion load on the part. It is not the primary loading condition, but the part does need to be somewhat stiff. The part withstands a torsion load.

Thermal Shock.

Some composites can be susceptible to thermal shock, depending on the loading conditions. The part withstands the greatest anticipated thermal shock.

Salt Atmosphere.

The aircraft will continually be exposed to a corrosive environment onboard a carrier. The part resists corrosion caused by salt air.

Sand and Dust.

The part might be exposed to a desert environment with airborne particles. The part is not damaged by exposure to sand.

Function Relationships.

The two systems on the revised hierarchy chart can be understood as loading conditions within the environments. The part must withstand each loading condition while it is exposed to each environmental condition. It is not enough that the part withstands tension in general, it must withstand tension while at high temperature and at low temperature and when wet, etc.

Innovation Opportunity.

The aluminum C channel performs all the functions in each condition; a composite material innovates by performing the same functions at a lower weight and competitive price. The team innovates by leveraging the superior mechanical and secondary properties of composites, like humidity and corrosion resistance. Composites offer more flexibility in the design stage, allowing the engineer to create a part with the exact strength required.

The weight saved by incorporating composites can be allocated to installing more powerful sensing and communication equipment, increasing fuel capacity, or adding additional functionality to the C channel part. A new function could be cable management or airflow channeling to cool the computer systems.

Function Outcome.

The primary function of the part is to provide the same support to the airframe that an aluminum c channel would provide. This means it must have equivalent mechanical strength when loaded in the same manner. The secondary function of the part is to survive the environment. This means it must endure the conditions the aircraft will be in and it must continue to provide support to the airframe throughout those conditions.inue to provide