Northrop Grumman Umbilical

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Abstract

Northrop Grumman Space Systems launch vehicles are used in a variety of missions which include delivering satellites to orbit and suborbital missions to protect our nation. On the launch pad these vehicles are supplied with electrical power, communications, pressurized gasses and other various resources through a variety of cables and hoses. These cables and hoses that connect the vehicle to the Ground Support Equipment (GSE) are referred to as umbilical cables. To ensure the performance of these vehicles during lift off, it is important to retract the umbilical lines away from the vehicle to avoid interference. The objective of this project is to design an umbilical retraction system. The retraction system needs to be easily installed and removable. It cannot exert excessive force on the umbilical cables prior to separation with the launch vehicle. In addition, it needs to be reliable for mission success and durable to withstand launch environments. Our design features a motor-driven reel that is actuated via a switch that is triggered upon vehicle takeoff. Through our design and manufacturing efforts, we were able to construct a device that tailors to all the given customer requirements.

Background

To retract umbilical cables on both their small and large launch vehicles, Northrop Grumman currently utilizes an elastic chord that is loaded under tension prior to launch. Upon launch, the umbilical detaches from the vehicle and is pulled away via the pre-tensioned chord. Inevitably, this tension causes interference to the vehicle upon launch as it exerts a side force . Northrop Grumman tasked us with designing a device that limits this side force and is reliable.

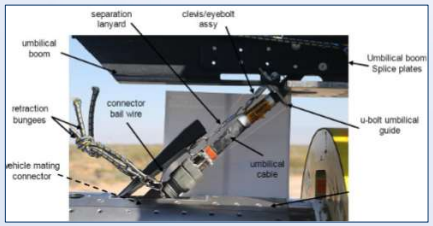


Figure 1: Current Umbilical Diagram

Problem Breakdown

Table 1: Customer Requirements

Customer Requirements
CR1 - High Manufacturability
CR2 - High Reliability
CR3 - Easily Removable/Installed
CR4 - High Durability
CR5 – ESD Safe

Table 2: Engineering Requirements

Engineering Requirements	Target
ER1 - Cost	<5000 ($)
ER2 - Side Force	<10 (lbs)
ER3 - Retraction Speed	6ft/s
ER4 - Temperature	-30 to 160 (F)
ER5 - Weight	1lb/1ft
ER6 - Adjustible	2 - 6 (ft)
ER7 - Success Rate	100 (%)

Final Device

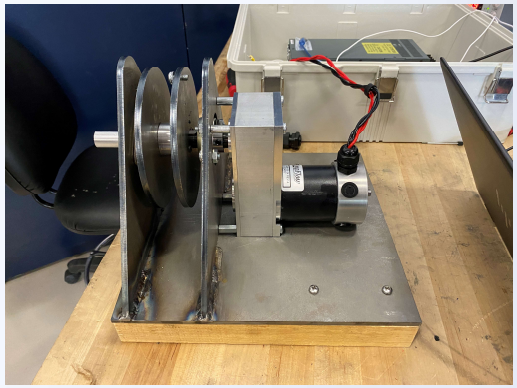
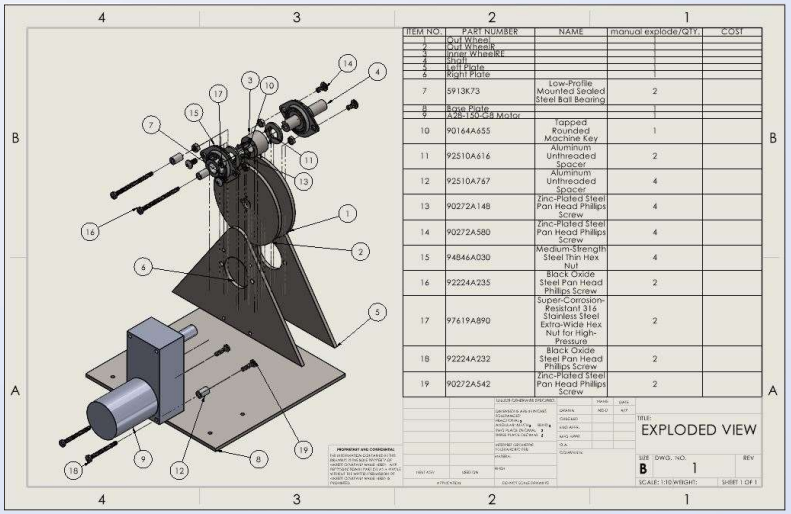


Figure 2: Final Build of Design

Figure 3: Enclosure Containing MCP (Right), Power Supply (Left) and Fuses/Miscellaneous Wiring

CAD



ITEM NO.	PART NUMBER	NAME	manual explode/QTY.	COST
1	Out Wheel		1	
2	Out Wheel		1	
3	Inner Wheel8E		1	
4	Shaft		1	
5	Left Plate		1	
6	Right Plate		1	
7	5913K73	Low-Profile Mounted Sealed Steel Ball Bearing	2	
8	Base Plate		1	
9	A2B-150-G6 Motor		1	
10	90164A655	Tapped Rounded Machine Key	1	
11	92510A616	Aluminum Unthreaded Spacer	2	
12	92510A767	Aluminum Unthreaded Spacer	4	
13	90272A148	Zinc-Plated Steel Pan Head Phillips Screw	4	
14	90272A580	Zinc-Plated Steel Pan Head Phillips Screw	4	
15	94846A030	Medium-Strength Steel Thin Hex Nut	4	
16	92224A235	Black Oxide Steel Pan Head Phillips Screw	2	
17	97619A890	Super-Corrosion-Resistant 316 Stainless Steel Extra-Wide Hex Nut for High-Pressure	2	
18	92224A232	Black Oxide Steel Pan Head Phillips Screw	2	
19	90272A542	Zinc-Plated Steel Pan Head Phillips Screw	2	

Figure 4: Final CAD Drawing of Design

Sponsor

"Northrop Grumman solves the toughest problems in space, aeronautics, defense and cyberspace to meet the ever-evolving needs of our customers worldwide. Our 90,000 employees are Defining Possible every day using science, technology and engineering to create and deliver advanced systems, products and services."

Testing

Table 3: Testing Outline

Test	Relevant Requirement	Procedure Summary	What was Learned
Motor Startup	CR2	Motor, MCP and power supply all connected and ran. Emergency stop intiated at different speeds.	All components working correctly. Gearbox was capable of handling braking load.
Cable Test	CR2, CR4, ER4, ER6	Flame applied to cable. Different weight were hung from cable.	Chosen cable could withstand loads and conditions that our device would experience.
Rotation Speed	ER2, ER3, ER5, ER6, ER7	Device was ran at different duty cycles and speed was measured with a tachometer.	Were able to obtain speeds for different duty cycles which were used for calibrating our motor controller.
Retraction Speed	ER2, ER3, ER5, ER6, ER7	Device tested with different loads that mocked pulling an umbilical cable.	Helped determine if our device would meet our customer requirements for retraction speed.
Side Force	ER2	Our cable was attached to a force gauge and the initial force from the weight of the chord and carabiner were recorded.	Showed that we were well under the customer requirement for initial side force.
Environmental Testing	CR2, CR4, ER2, ER3, ER4, ER5, ER6, ER7	Device tested at extreme temperatures to simulate launch conditions.	Showed that our device could withstand launch conditions.

Results

Table 4: Specification Sheet (CRs)

Customer Requirement	CR Met? (Yes or No)
CR1 - High Manufacturability	Yes
CR2 - High Reliability	Yes
CR3 - Easily Removable/Installed	Yes
CR4 - High Durability	Yes
CR5 - ESD Safe	Yes

Table 5: Specification Sheet (ERs)

Engineering Requirement	Target	Tolerance	Measure/Calculated Value	ER Met? (Yes or No)
ER1 - Cost	<5000 ($)	Maximum	1860 ($)	Yes
ER2 - Side Force	<10 (lbs)	Maximum	<1 lb	Yes
ER3 - Retraction Speed	6ft/s	Minimum	4.98 ft/s	No
ER4 - Temperature	-30 to 160 (F)	Within Range	N/A	Yes
ER5 - Weight	1lb/ft	Minimum	10 lbs	Yes
ER6 - Adjustible	2 - 6 (ft)	Within Range	N/A	Yes
ER7 - Success Rate	100 (%)	100%	100%	Yes

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