SKI HAUS

TOW ROPE

Team Members

Hallie Eha – CAD Engineer, Financial Engineer

Kailey Lewis- Project Manager, Test Engineer

Jesse Wells- Logistics Manager, Manufacturing Engineer

Project Description

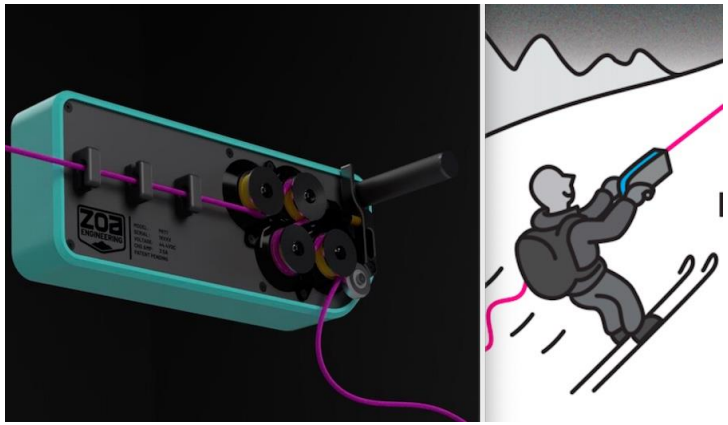
- A Tow Rope is a motorized device that hauls skiers up a slope via a rope.
- Portability provides an easy temporary solution to any slope when needed.
- Sponsor: Ski Haus
- Local Ski Shop that hosts freestyle ski competitions
- A portable tow rope would reduce fatigue from hiking during these competitions

SKI | HAUS
FLAGSTAFF, AZ

Background & Benchmarking

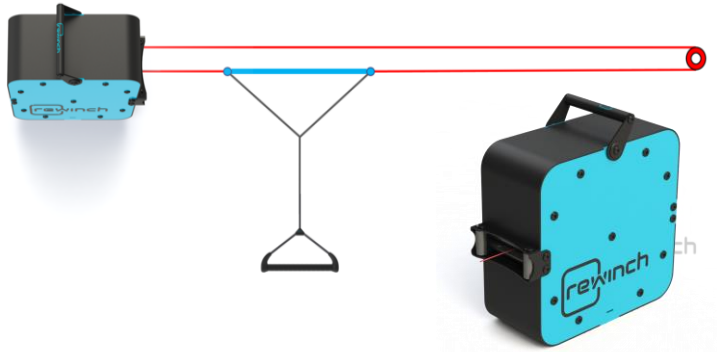
Benchmarking measures: Cost, Weight, Compact, Power, User Capacity, Gas/Electric, Relevance

- ZOA PL1: In development, Cost TBD, 10.5 lbs, compact, power TBD, one user limit, electric.
- TowPro TP15: $30,000, 400 lbs, 45" W x 38" L x 19" H, 10-15 people, 15 hp, electric.
- Rewinch: $3545, 30 lbs, 6" W x 13" L x 13" L, one user limit, 12 kW, electric.



ZOA PL1

TowPro



Rewinch

Literature Review

Cable-Pulley Interaction with Dynamic Wrap Angle Using the Absolute Nodal Coordinate Formulation

- Involves the dynamic variations in a wrap angle and cable tension
- Shows how wrapping cable about several pulleys increases torque
- Interaction of static pulley and a suspended load
- This concept can be applied to the driving system to increase torque on the tow rope

Australian ski lift directory

- Describes uses of a tow rope
- Varying types of tow ropes and the differences between them
- Pros and Cons of every variation of tow rope
- Parts used for differing types of tow ropes
- Weatherproofing aspects of tow rope
- Practicality of tow ropes

Comparison of motor speed control methods

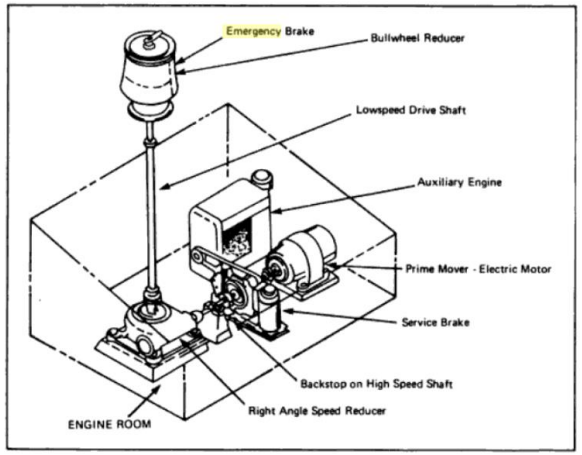
- Techniques of limiting the process output of a motor
- Centrifugally-based processes and their equations that relate torque needed compared to speed
- Adjustable speed drives (ASDs) : adjusts the operating speed of a normally fixed speed motor
- Includes older models and methods for AC motor speed control

Literature Review

Design of a Ski Lift Inspection & Maintenance System

- Components: haul rope, terminals, and safety systems
- parts of a chairlift support assembly
- Tables describing each part, separated by power, mechanical, and safety
- Specifies all conditions that must be met before open to public
- Inspection protocols
- Chart of typical failures of each part and measurable indications

All safety and design is regulated under ANSI B77.1-2017 standards

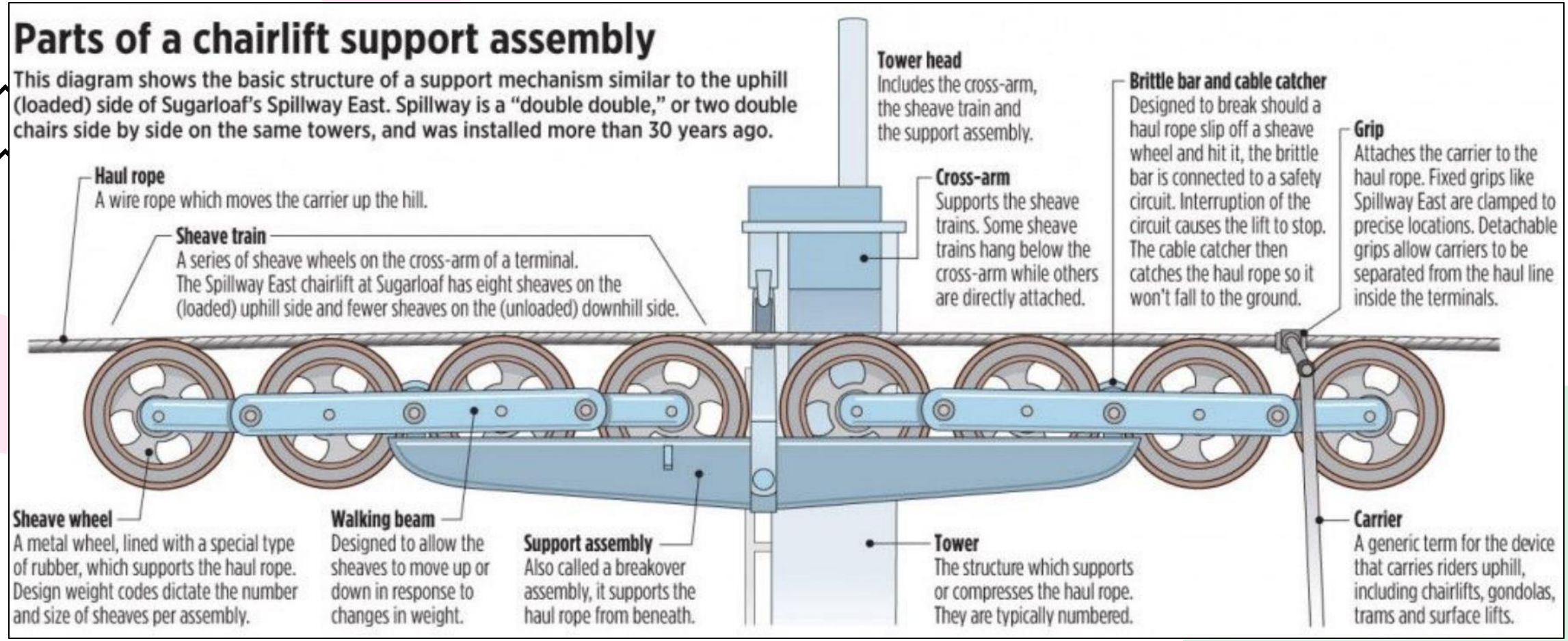


Aerial Tramways, Ski Lifts, and Tows: Description and terminology

- Mechanical Equipment overview and diagrams
- Drive systems and their components (sheaves, bearings, bull wheels, etc.)
- Types of motors and their best uses
- Speed reduction systems
- Brake systems

Shigley's 10th ed. Mechanical Engineering Design

- Fatigue Failure resulting from variable loading
- Temperature effects
- Important design equations
- Clutches and brakes
- Belt drivers
- Power transmission
- Force analysis



Aspects of the sheave wheels, walking beam, haul rope, cable catcher can be implemented into our design

Literature Review

The Kinetic Friction of Snow

- Involves the study of sliders on snow and ice to find friction coefficients
- Experiments with various slider material and velocities
- Studies different temperatures of snow and textures
- Establishes dry, suction, lubricated, and total friction values
- Allows for calculations of resistance from riders loaded on tow rope

The influence of deformation conditions in solid-state aluminum welding processes on the resulting weld strength

- Studies the weld strength of aluminum under various conditions
- Identifies parameters such as normal and shear stress, strain, strain rate, and temperature for weld deformation
- Assists in correct welding technique and maximizing strength of welds on aluminum tow rope frame

Engineering Mechanics Dynamics 14th edition by Russell C. Hibbeler

- Dynamics textbook on kinetic and kinematic motion
- Reference for kinematic calculations of rider motion on inclined plane
- Work done by tow rope engine
- Pully tension and velocity calculations
- Impulse and momentum of rider relative to tow rope

Customer & Engineering Requirements

Customer Requirements

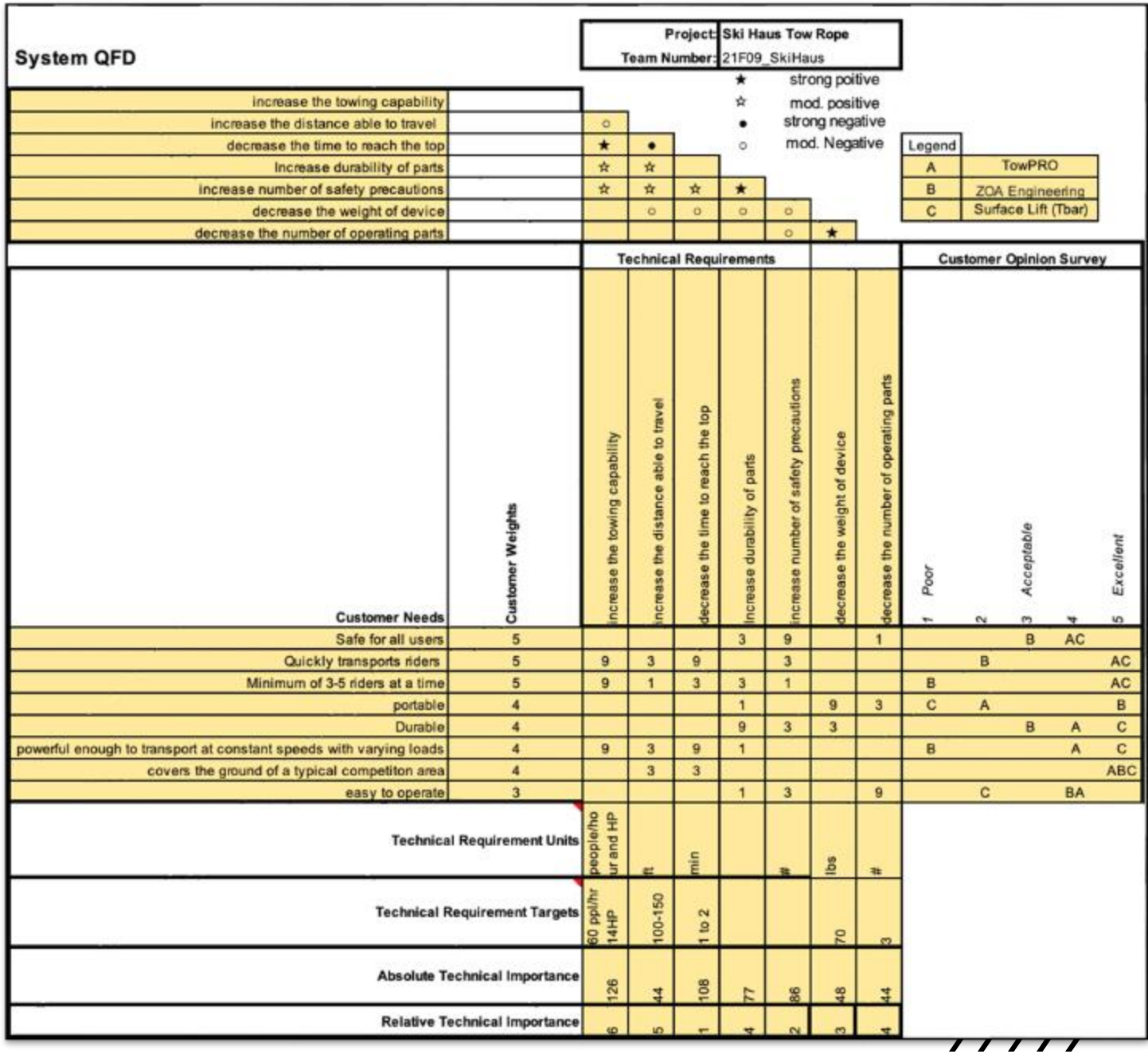
- Quickly Transports riders
- Safe for all riders
- Minimum towability of 5 people
- Portable (easy set up/take down)
- Maintains speed with varying loads of riders
- Easy to operate
- Covers the ground of a typical rail jam competition
- Durable for all weather conditions

Engineering Requirements

- Motor capable of towing 60 people/hour
- Towable distance of 150ft - 200ft
- Safety features: emergency stop button, adjustable speeds, and encased mechanical parts
- Portability: less than 200lbs, wheels and handles
- About a 14 HP motor

House of Quality

Technical Requirement Units	people/hour and HP	ft	min		#	lbs	#
Technical Requirement Targets	60 ppl/hr 14HP	100-150	1 to 2			70	3
Absolute Technical Importance	126	44	108	77	86	48	44
Relative Technical Importance	6	5	1	4	2	3	4



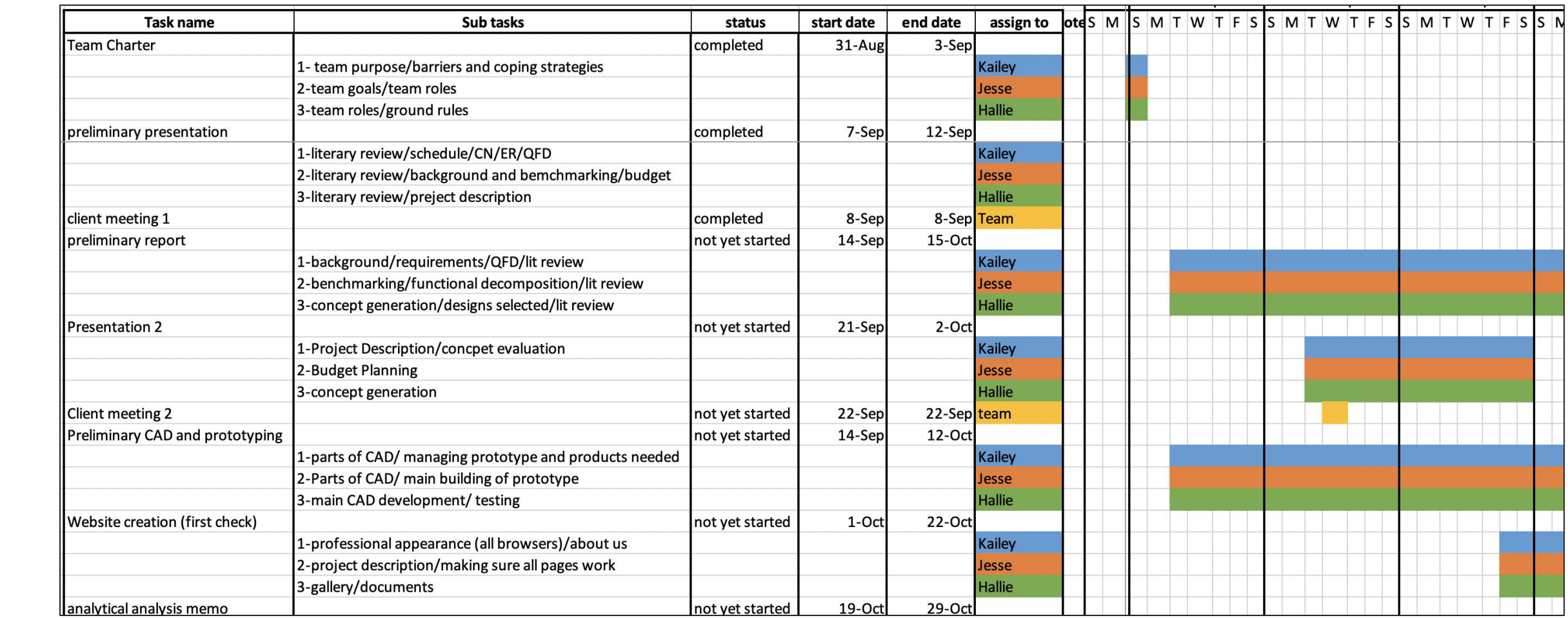
increase the towing capability															
increase the distance able to travel		○													
decrease the time to reach the top		★	●												
Increase durability of parts		☆	☆												
increase number of safety precautions		☆	☆	☆	★										
decrease the weight of device			○	○	○	○									
decrease the number of operating parts						○	★								

★ strong poitive
☆ mod. positive
● strong negative
○ mod. Negative

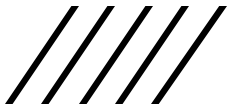
	Customer Weights	increase the towing capability	increase the distance able to travel	decrease the time to reach the top	Increase durability of parts	increase number of safety precautions	decrease the weight of device	decrease the number of operating parts	1 Poor	2	3 Acceptable	4	5 Excellent
Safe for all users	5				3	9		1			B	AC	
Quickly transports riders	5	9	3	9		3				B			AC
Minimum of 3-5 riders at a time	5	9	1	3	3	1			B				AC
portable	4				1		9	3	C	A			B
Durable	4				9	3	3				B	A	C
powerful enough to transport at constant speeds with varying loads	4	9	3	9	1				B			A	C
covers the ground of a typical competiton area	4		3	3									ABC
easy to operate	3				1	3		9		C		BA	

Schedule

Task name	Sub tasks	status	start date	end date	assign to
Team Charter		completed	31-Aug	3-Sep	
	1- team purpose/barriers and coping strategies				Kailey
	2-team goals/team roles				Jesse
	3-team roles/ground rules				Hallie
preliminary presentation		completed	7-Sep	12-Sep	
	1-literary review/schedule/CN/ER/QFD				Kailey
	2-literary review/background and bemchmarking/budget				Jesse
	3-literary review/preject description				Hallie
client meeting 1		completed	8-Sep	8-Sep	Team
preliminary report		not yet started	14-Sep	15-Oct	
	1-background/requirements/QFD/lit review				Kailey
	2-benchmarking/functional decomposition/lit review				Jesse
	3-concept generation/designs selected/lit review				Hallie
Presentation 2		not yet started	21-Sep	2-Oct	
	1-Project Description/concpet evaluation				Kailey
	2-Budget Planning				Jesse
	3-concept generation				Hallie
Client meeting 2		not yet started	22-Sep	22-Sep	team
Preliminary CAD and prototyping		not yet started	14-Sep	12-Oct	
	1-parts of CAD/ managing prototype and products needed				Kailey
	2-Parts of CAD/ main building of prototype				Jesse
	3-main CAD development/ testing				Hallie
Website creation (first check)		not yet started	1-Oct	22-Oct	
	1-professional appearance (all browsers)/about us				Kailey
	2-project description/making sure all pages work				Jesse
	3-gallery/documents				Hallie
analytical analysis memo		not yet started	19-Oct	29-Oct	



Task name	Sub tasks	status	start date	end date	assign to
Team Charter		completed	31-Aug	3-Sep	
	1- team purpose/barriers and coping strategies				Kailey
	2-team goals/team roles				Jesse
	3-team roles/ground rules				Hallie
preliminary presentation		completed	7-Sep	12-Sep	
	1-literary review/schedule/CN/ER/QFD				Kailey
	2-literary review/background and bemchmarking/budget				Jesse
	3-literary review/preject description				Hallie
client meeting 1		completed	8-Sep	8-Sep	Team
preliminary report		not yet started	14-Sep	15-Oct	
	1-background/requirements/QFD/lit review				Kailey
	2-benchmarking/functional decomposition/lit review				Jesse
	3-concept generation/designs selected/lit review				Hallie
Presentation 2		not yet started	21-Sep	2-Oct	
	1-Project Description/concpet evaluation				Kailey
	2-Budget Planning				Jesse
	3-concept generation				Hallie
Client meeting 2		not yet started	22-Sep	22-Sep	team
Preliminary CAD and prototyping		not yet started	14-Sep	12-Oct	
	1-parts of CAD/ managing prototype and products needed				Kailey
	2-Parts of CAD/ main building of prototype				Jesse
	3-main CAD development/ testing				Hallie
Website creation (first check)		not yet started	1-Oct	22-Oct	
	1-professional appearance (all browsers)/about us				Kailey
	2-project description/making sure all pages work				Jesse
	3-gallery/documents				Hallie
analytical analysis memo		not yet started	19-Oct	29-Oct	



Budget

Income

- The Mayor Flagstaff Ski Haus movie premier
- Custom merchandise sales at Ski Haus and ski swap
- Raffle of donated Ski Haus gear at NAU Ski and Snowboard Club events
- Advanced construction fund provided by Ski Haus
- Local Flagstaff business promotion on housing of tow rope for donations

Expenses

Part	Avg. Cost Per Part	Quantity	Total
Engine	$300	1	$302
Rope	$1.72 / ft	300 ft	$515
Rope Coupler	$10	1	$10
Safety Gate	$20	1	$20
Aluminum Frame	$4.80 / ft	50ft	$240
Top Pulley	$13	1	$13
Bull Wheel	$17	1	$17
Come-Along	$30	1	$30
Gearbox	$100	1	$100
Shaft Coupler	$30	1	$30
Ratchet Tie Down	$14	4	$56
Power Button	$10	4	$40
Mounting Hardware	$90	1	$90
Transportation Wheels	$10	2	$20
Gasoline	$3.09 / Gal	5	$15.45
Total			**$1498.45**

QUESTIONS?

References

[1] *Zoa Engineering*. [Online]. Available: https://www.zoaeng.com/. [Accessed: 10-Sep-2021].

[2] "RESORT ready: Portable Rope Tows: Towpro Lifts," *Towpro Lifts LLC*. [Online]. Available: https://www.towpro-lifts.com/resort-ready. [Accessed: 10-Sep-2021].

[3] *Rewinch*. [Online]. Available: https://rewinch.com/. [Accessed: 10-Sep-2021].

[4] C. Westin and R. A. Irani, "Cable-Pulley Interaction with Dynamic Wrap Angle Using the Absolute Nodal Coordinate Formulation," *Avestia*, 21-Aug-2017. [Online]. Available: https://avestia.com/CDSR2017_Proceedings/files/paper/CDSR_133.pdf. [Accessed: 09-Sep-2021].

[5] D. Sisson, "Australian ski lift Directory: Details of 500 lifts & Ropeways," *Australian mountains*. [Online]. Available: https://www.australianmountains.com/australianskilifts#2 . [Accessed: 09-Sep-2021].

[6] Edvard, "Comparison of motor speed control methods - eep," *EEP - Electrical Engineering Portal*, 12-Sep-2017. [Online]. Available: https://electrical-engineering-portal.com/comparison-of-motor-speed-control-methods. [Accessed: 09-Sep-2021].

[7] Barthelson, K., Darhele, S., Mitra, M. and Sondhi, P., 2018. *Design of a Ski*

Lift Inspection & Maintenance System [online] Catsr.vse.gmu.edu. Available at: <https://catsr.vse.gmu.edu/SYST490/495_2018_SkiLift/SkiLift_Final_Report.pdf> [Accessed 9 September 2021].

References continued

[8] C. Dwyer, *Aerial Tramways, Ski lifts, and Tows: description and terminology*. Washington, D.C.: U.S. Government Printing Office, 1975.

[9] R. Budynas and J. Nisbett, Mechanical Engineering Design. 10th ed. New York: McGraw-Hill Education, 2015.

[10] Colbeck, S. (1988). The Kinetic Friction of Snow. *Journal of Glaciology, 34*(116), 78-86. doi:10.3189/S0022143000009096

[11] D. R. Cooper and J. M. Allwood, "The influence of deformation conditions in solid-state aluminium welding processes on the resulting weld strength," *Journal of Materials Processing Technology*, vol. 214, no. 11, pp. 2576–2592, 2014.

[12] R. C. Hibbeler, *Engineering mechanics: Dynamics*. Pearson, 2019.

[13] "The home Depot," *The Home Depot*. [Online]. Available: https://www.homedepot.com/. [Accessed: 10-Sep-2021].