DOLLY LLAMA

03/21/19

Interim Project Report

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1. Introduction

A key problem that people face when moving heavy objects up and down stairs, is to how to do so without damaging the objects or the space around them and without hurting themselves. A normal dolly is incapable of carrying large pieces, and a large dolly is not ideal for indoor use as it cannot fit into small stairways. Our team aims to design an electric dolly system that can load large objects onto an adjustable frame with multiple wheels that can mechanically lift objects, utilizing an electric motor, upstairs without causing strain on the person moving the object. The lift function of the dolly can move heavy objects up and down stairs. The frame is lightweight, making it easily transported when not in use.

To accomplish this goal, a frame and electric motor combination were devised that could navigate tight corners and provide enough power to lift objects vertically upstairs with minimal effort by the user. This is done by having the electric motor power a chain that controls the "hoof"; the hoof is a mechanism that grabs the ledge of the step that the user would like to lift an object onto and provides assistance in lifting as the hoof follows the chain around.

Research was conducted to gain better understanding of the market as well as competitive products. Other products exist that can accomplish these goals, but none can accomplish all that is required by the customer. Some can lift the weight but are far too bulky, some can maneuver but face severe limitations when it comes to weight capacity, and a common thread throughout is that all of them cost over $1,000. Our company aims to undercut the price of all competitors while providing comparable stats in vital areas such as maximum capacity, ease of use, reliability, lift height and maneuverability.

The key research points of market analysis, constraints and design are covered in detail in this report. Drawings of the concepts discussed are provided in the mentioned appendices and the house of quality, customer requirements, design parameters and product specifications are all covered in this report.

2. Market Analysis Information

2.1 General Needs for Product

We are going to design an electronic dolly system to help people easily move heavy objects. The dolly system consists of a lifting system, wheels, fixing frames, a towing handle and a battery. The lifting system enables people to move objects up and down stairs in a safe manner. The wheels are used to give clearance on the stairs and to move the dolly up the stair depth. The fixing frame helps retain relative position of the wheels and provide an attachment point for the towing handles. The towing handle provides a place to hold and for a human to direct the towing of dolly, while minimizing human power input. A battery provides the power for the dolly to lift and clear the stair depth.

2.1.1 Deficient Designs

Two existing designs we found are manual dolly and a shoulder dolly. These designs have disadvantages which the Dolly Llama can overcome.

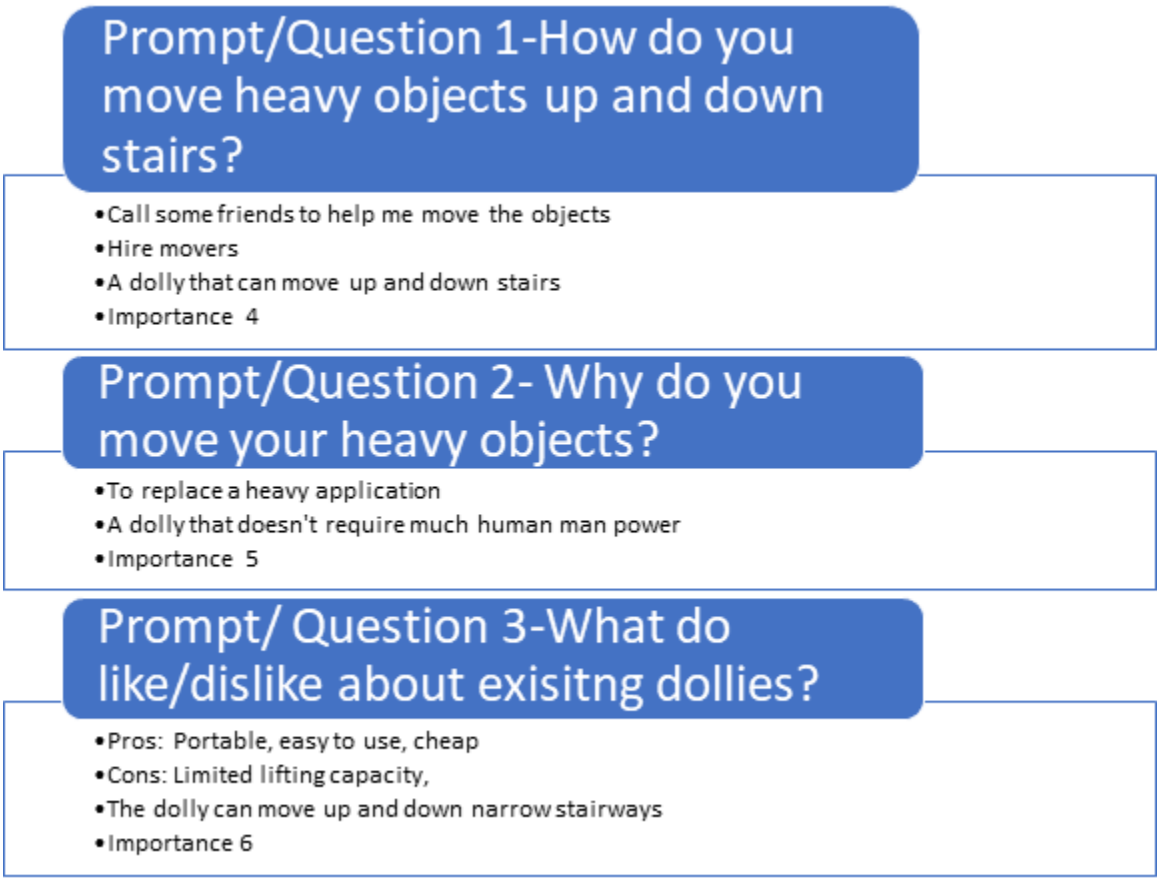
Manual dollies (also known as hand truck, two-wheeler, stack truck, trundler, etc.) are a platform to set objects with two wheels and a handle. To move the objects, they are tilted forward, and the platform is slid underneath and then titled back to rest on frame with the wheels taking the bulk of the weight. A disadvantage of this model is the dolly can only move things that are touching the ground, this means they cannot be used to move furniture that has clearance from the ground. Another disadvantage is that the dolly can only objects that have a relatively small footprint.

Shoulder Dollies are lifting straps that are placed under and around the object and the weight is distributed between two people lifting. This design has a few disadvantages. One is long time use can result in backache and potential spinal damage. Another disadvantage is the smallest tilt can shift the weight almost completely to one person.

2.1.2 Examples of Market Needs

"Pivot!" - Ross Gellar [1]

2.1.3 Interview



2.2 Description and Estimation of Market Size

Around the world, people are injured trying to move heavy objects up and down stairs. We are committed to helping people to move their objects and limit the potential for injury. Our company sells electronic dollies that will allow people to do so. Normal electronic dollies are sold for $5000, we our selling our dolly $1500. We sell a high-quality dolly for a cheaper price. Around the world, ~10,000 are sold annually. [2]

2.2.1 Global Company

We are a prestigious worldwide company supplying people with the capabilities to move heavy objects up and down stairs. Our company, Dolly Llama, goal to help people move objects with minimum human effort required.

2.3 Benchmarking on Competitive Products

Wesco Power LiftKar HD Truck [2]

- Straight frame that can accept a 4-wheel support
- Upper handle angle can be adjusted
- Edge-of-step braking system - automatically applies brake when wheels are at edge of step
- Brake can be shut off for use on level ground
- Single step and continuous climb controls for control or speed, respectively
- 24 V Quick-Charge battery pack
- 6 or 10 steps/min climbing speeds
- Greater than 100 steps on a full charge with a load of 725 lb
- 725 lb load capacity
- 47” Tall Frame
- Noseplate Width - 21”
- Noseplate Depth - 7.25”
- Maximum vertical clearance - 8.25”
- 97 lb unloaded weight
- 1-year warranty on parts
- 6-month warranty on battery
- Cost ranges from $4,629.00 to $6,249.48

- 59” Tall Frame
- Straight back
- Dual Shepherd handle with vinyl sleeve
- Noseplate Width - 23”
- Noseplate Depth - 5.32”
- 10” wheels
- Optional 4th-wheel attachment
- 600 lb Capacity (2 Wheel)
- 800 lb Capacity (4 Wheel)
- 70 lb unloaded weight
- Cost of $1050.70

2.4 Opportunities for Competitive Advantage

- Greater climbing speed
    - This will allow for tasks to completed more quickly allowing for more frequent trips or greater free time.
- Greater load capacity - 800 lb
    - Allows for heavier objects to be lifted upstairs.
- Greater noseplate depth - 12”
    - Provides a more stable base for objects to rest on and allows for the moment generated by the pivot of the dolly to be more under the center of gravity for bulkier items.
- Greater vertical clearance - 15”
    - Allows for objects to be lifted onto short ledges where stairs may not be readily available and allows for clearance of taller stairs.
- Lighter unloaded weight
    - Easier to move around and load into vehicles for transport.
- Lower cost
    - Greater potential market.
- Longer warranty
    - Better customer satisfaction.
- Overall height not deemed important
    - The footprint is more important for storability.
- 4 Wheel attachments
    - This is not a primary concern for our company at this stage, this could be a potential option in future iterations of the product.

3. Design Parameters

3.1 Customer Requirements

The customer requirements were pulled from a customer survey we conducted to determine the product specifications.

1. My Stairwells are too tight to move furniture by myself
2. My apartment is on the 7th floor and moving is to hard
3. I have bad joints and lifting is painful
4. My fridge is huge and heavy
5. I don't want my husband throwing out his back: safety
6. A dolly slipped from my hand once while going down stairs
7. Stand up dollies are hard to maneuver

We designed the Dolly Llama to navigate small stairwells, this allows for the user to move heavy appliances up and down narrow staircases. The Dolly Llama also requires little human effort, that allows the user to safely move heavy appliances and avoid injuries.

3.2 Functional Requirements

- Total height of the dolly system should be less than 50 inches
- The lifting system can lift up to 800 lb. to at least 7 inches, and maintain stability for the duration of the movement
- Structural components of the dolly can support 1200 lb. without failure and has a safety factor of at least 3
- Human force input to operate the lifting should be no more than 6 lbf
- Wheels should work on all types of surfaces and stairs (and a stair height of 7 inches)
- The dolly system is reusable

3.3 Engineering Characteristics

1. The dolly will be able to turn 180° tied down with a load
2. Dolly will have a “huff system” to help down and up stairs
3. Dolly will lift up to 800 lb.
4. Dolly will be large enough to maintain stability when moving large items.
5. Materials used will be safe enough to balance and support loads tied to it.
6. Dolly will have hand grips to grab. This used with the huff system will deter the dolly from slipping
7. Dolly will have a drive-assist system to rotate with a load in standing position.

3.4 Constraints

3.4.1 Functional

- The dolly can rotate about a single point to maneuver through tight stairwells.
- The wheels of the dolly can rest fully on a typical stair step.
- The lifting mechanism of the dolly can clear 15 inches of vertical height.
- The dolly can lift ~800 lb.

3.4.2 Safety

- The materials must be durable and strong with an ultimate tensile strength 25% above the weight limit of the dolly. [4]
- The weight capacity must be clearly labeled and permanently affixed on the dolly.

3.4.3 Quality

- The dolly must be functional for lifting large heavy objects.
- The dolly must not weigh more than 25 lb. so that it is easy to transport.

3.4.4 Manufacturing

- All parts should be easy to repair or manufacture to reduce cost.
- The assembly of the dolly should be intuitive.

3.4.5 Economic

- The dolly should have a total manufacturing cost of no more than $300.
- The dolly should sell at a consumer cost of no more than $500.

3.4.6 Timing

- The “climb time” should be no more than 5 seconds per stair.
- The charge time should be no more than 3 hours to complete a full charge.

3.4.7 Ecological

- All parts must be able to be reused or recycled when the dolly is disposed of.

3.4.8. Life Cycle

- The motor of the dolly should last for several years of use with minimal repair required.
- The frame of the dolly should last many decades barring misuse.
- The motor should be able to be replaced without having to replace the frame.

3.4.9. Legal

- The dolly must be a unique design and not contain any type of patent infringement or legal concerns.

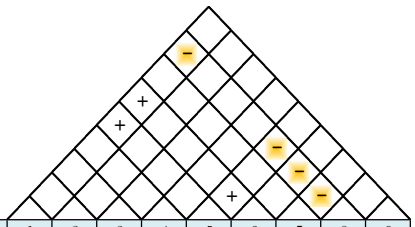
4. House of Quality

Project: The Dolly Llama
Revision: 03/19/2019
Date: 03/19/2019

Correlations	
Positive	+
Negative	−
No Correlation	

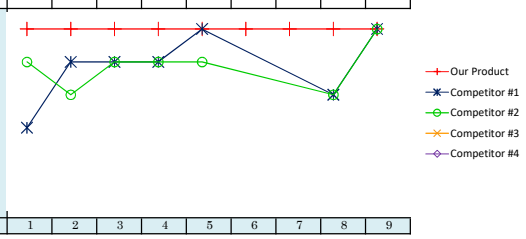
Relationships	
Strong	●
Moderate	○
Weak	▽

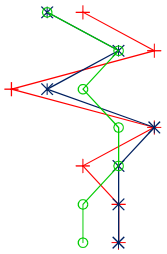
Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼



Row #	Weight Chart	Relative Weight	Customer Importance	Maximum Relationship	Customer Requirements \ Functional Requirements	1. Weight of the Dolly	2. Load Capacity	3.width of Dolly	4. Height of Dolly	5. Length of Dolly	6. Safety factor	7. Horse Power	8 Step Clearance	9. Turn ability	Our Product	Competitor #1: *Wesco LiftKar*	Competitor #2: Magliner Appliance T	Competitor #3: *Product Name*	Competitor #4: *Product Name*	Row #
	Column #					1	2	3	4	5	6	7	8	9						
	Direction of Improvement					▲	◇	◇	◇	▲	▲	▼	▼	◇	Customer Competitive Assesment					
1	|||||||	18%	6	1	1. My Stairwells are too tight to move furniture by myself			▽	▽	▽					3	2	2			1
2	||||||	15%	5	9	2. My apartment is on the 7th floor and moving is to hard		○					○	●		5	4	4			2
3	||||	9%	3	9	3. I have bad joints and lifting is painful	●	○								1	2	3			3
4	|||	6%	2	9	4. My fridge is huge and heavy		●								5	5	4			4
5	||||||	12%	4	9	5. I don't want my husband throwing out his back safety		○				●	○			3	4	4			5
6	||||||||||	27%	9	3	6. A dolly slipped from my hand once while going down stairs								○		4	4	3			6
7	||||||	12%	4	9	7. Stand up dollies are hard to maneuver									●	4	4	3			7
	Target					less thant 50 lbs	Max lift 800 lbs	less than 20 ins wide	Height Less than 50 in	less than 30 in	Safter Factor of 3	max torque at 400 HP	clear 15 in	make 180°						
	Max Relationship					9	9	1	1	1	9	3	9	9						
	Technical Importance Rating					81.82	163.6	18.18	18.18	18.18	109.1	81.82	218.2	109.1						
	Relative Weight					10%	20%	2%	2%	2%	13%	10%	27%	13%						
	Weight Chart					≣	≣	_	_	_	≣	≣	≣	≣						
	Our Product					5	5	5	5	5	5	5	5	5						
	Competitor #1: Wesco LiftKar					2	4	4	4	5			3	5						
	Competitor #2: Magliner Appliance Truck					4	3	4	4	4			3	5						
	Competitor #3: *Product Name*																			
	Competitor #4: *Product Name*																			
	Column #					1	2	3	4	5	6	7	8	9						

Technical Competitive Assesment





5. Target Specifications

Metric Number	Metric	Units	Target	Actual
1	Weight of the Dolly	lb	50	25
2	Carrying Capacity	lb	800	800
3	Width of Dolly	in	20	20
4	Height of Dolly	in	50	50
5	Length of Dolly	in	26	26
6	Safety Factor	-	3	3
7	Torque	ft-lb	409	409
8	Step Clearance	in	15	15
9	Turn ability	degrees	90	180

6. Concept Design

Concept 1

Chosen Concept

Detailed design drawing of concept 1 can be found in Appendix A

Pros

- Lower cost of production
- Heavy lifting capacity
- Short wheel radius
- Small footprint
- All terrain
- Low maintenance cost

Cons

- Moderate cost
- Heavy design

Concept 2

Detailed design drawing of concept 2 can be found in Appendix B

Four Wheeled Powered Dolly

Pros

- All terrain
- Heavy lifting capacity

Cons

- Expensive design
- Large footprint
- Difficult to manufacture
- Weight is to heavy
- Not able to make tight corners in a small area
- More suited to the outdoors
- Difficult to move

Concept 3

Hydraulic Design

Detailed design drawing of concept 3 can be found in Appendix C

Pros

- Heavy lifting capacity

Cons

- Hydraulic jack can leak
- High cost of maintenance
- Environmental concern when the hydraulic jack leaks.
- Makes the lift heavy
- Moves very slow
- Expensive to manufacture
- Unstable due to a single hydraulic jack

The concept chosen was due to the inexpensiveness compared to the benefits. It was determined that speed and power were at a preferred output for the consumers needs. A smaller footprint allows for easier storing, the speed allows for small tasks to be completed more efficiently and the small turning radius allows for easy maneuvering through tight spaces that household consumers may face. With a lower manufacturing cost, the potential market increases as the savings can be passed on to the consumer in the form of a lower front-end cost. Other concepts can lift more, but sacrifice maneuverability, cost, speed and, in the case of concept 3, stability. It is due to these factors that concept 1 was chosen.

REFERENCES

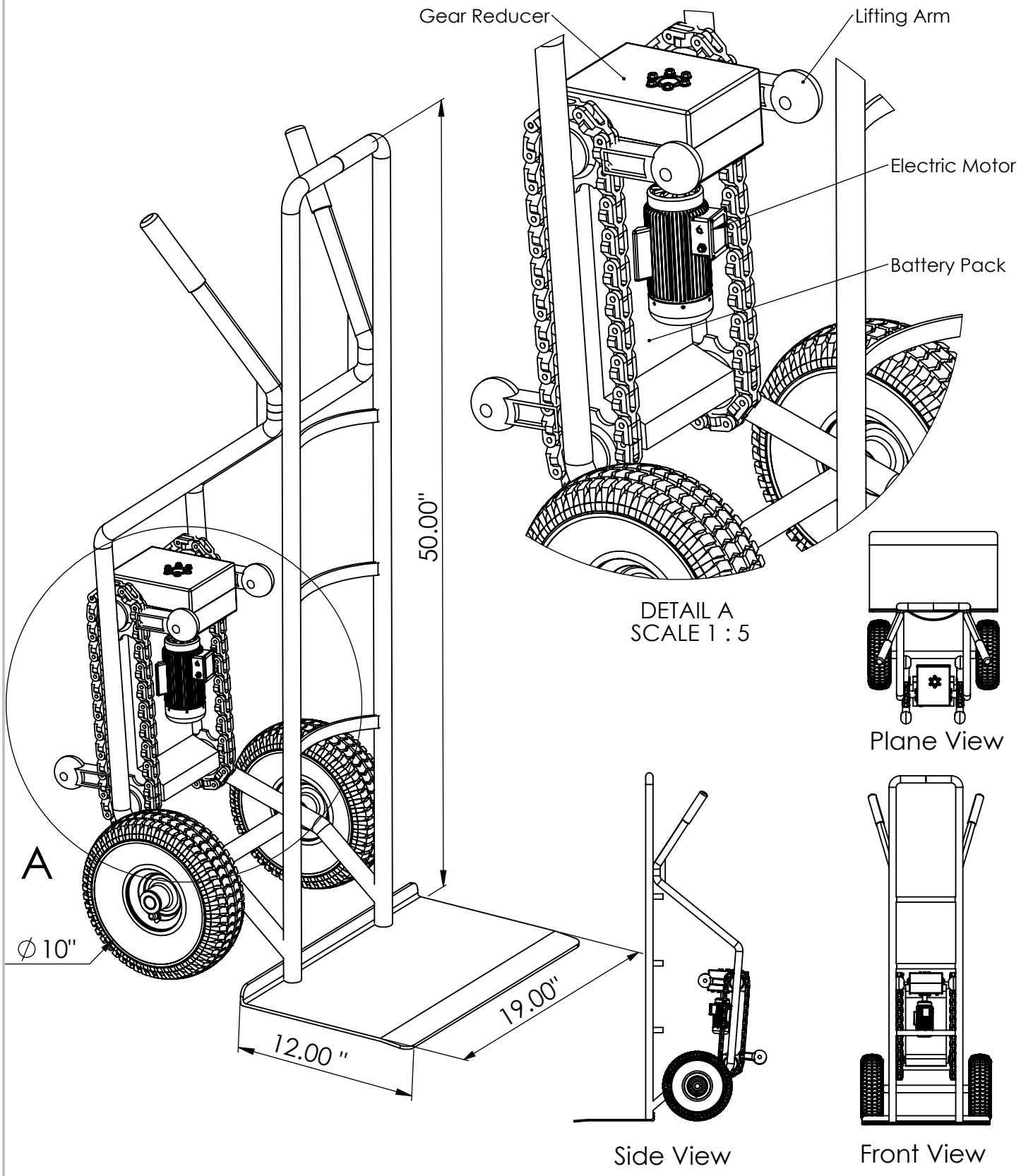
[1] "The One with the Cop." *Friends: The Complete Fifth Season*. Writ. Gigi McCreery and Perry Rein. Dir. Andrew Tsao. Warner Brothers, 1999. DVD.

[2] Wesco Industrial Products, LLC. Power LiftKar HD Truck, Part No. 274101. (2019). taken from https://catalog.wescomfg.com/item/hand-trucks/-hand-trucks-power-liftkar-hd-stairclimbing-trucks/274101

[3] Magliner. Appliance Truck w/4th Wheel Attachment. (2019). Taken from: https://www.magliner.com/appliance-hdarb5cm1ec11rls?gclid=EAIaIQobChMIgv690Y6N4QIVGbbACh1ASAG0EAQYCiABEgIF8fD_BwE

[4] United States Department of Labor, Regulation 1926.251(a)(4). (2006). Taken from: https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.251

APPENDIX A



DETAIL A
SCALE 1 : 5

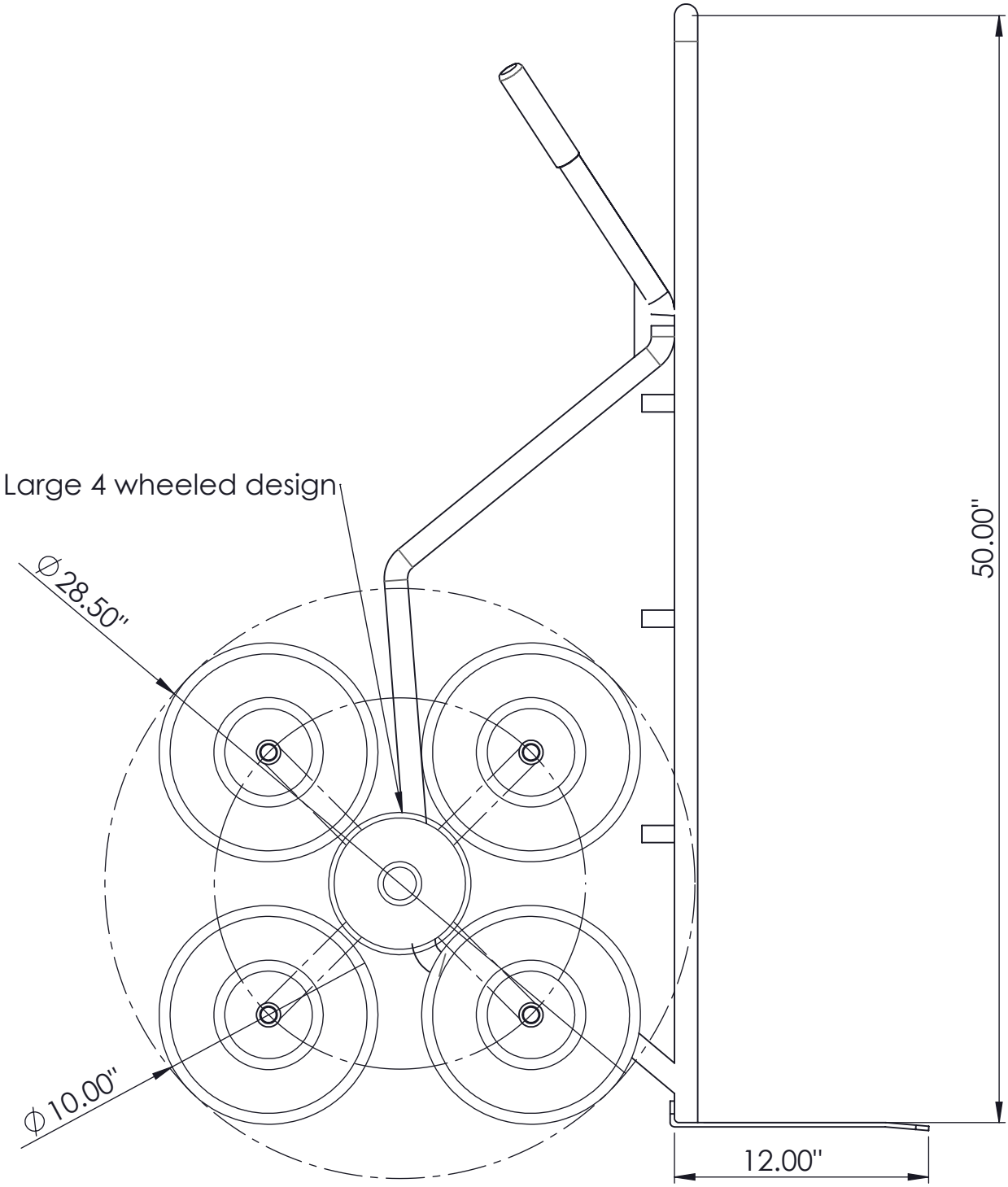
Plane View

Side View

Front View

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		FINISH:		DEBUR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION: 00
	NAME	SIGNATURE	DATE		TITLE:	
DRAWN					Dolly Llama	
CHK'D						
APPV'D						
MFG						
Q.A				MATERIAL:	DWG NO. 031919-001	A4
				WEIGHT:	SCALE:1:20	SHEET 1 OF 1

APPENDIX B



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Concept 2

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

MATERIAL:

TITLE:

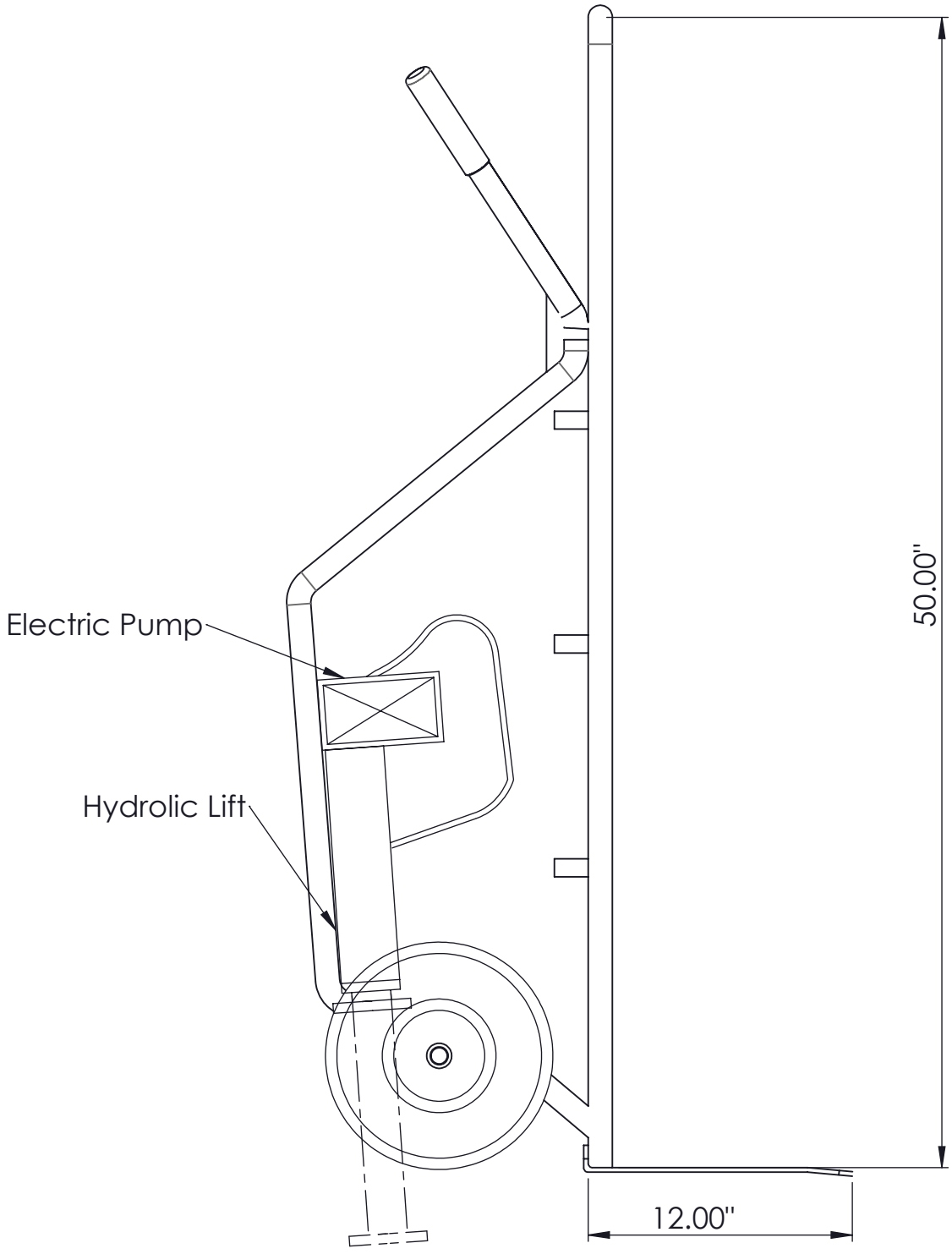
Dolly Llama 4 Wheeled

DWG NO. 031919-002

A4

SCALE:1:20

SHEET 1 OF 1



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Concept 3

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

MATERIAL:

TITLE:

Dolly Llama Hydraulic

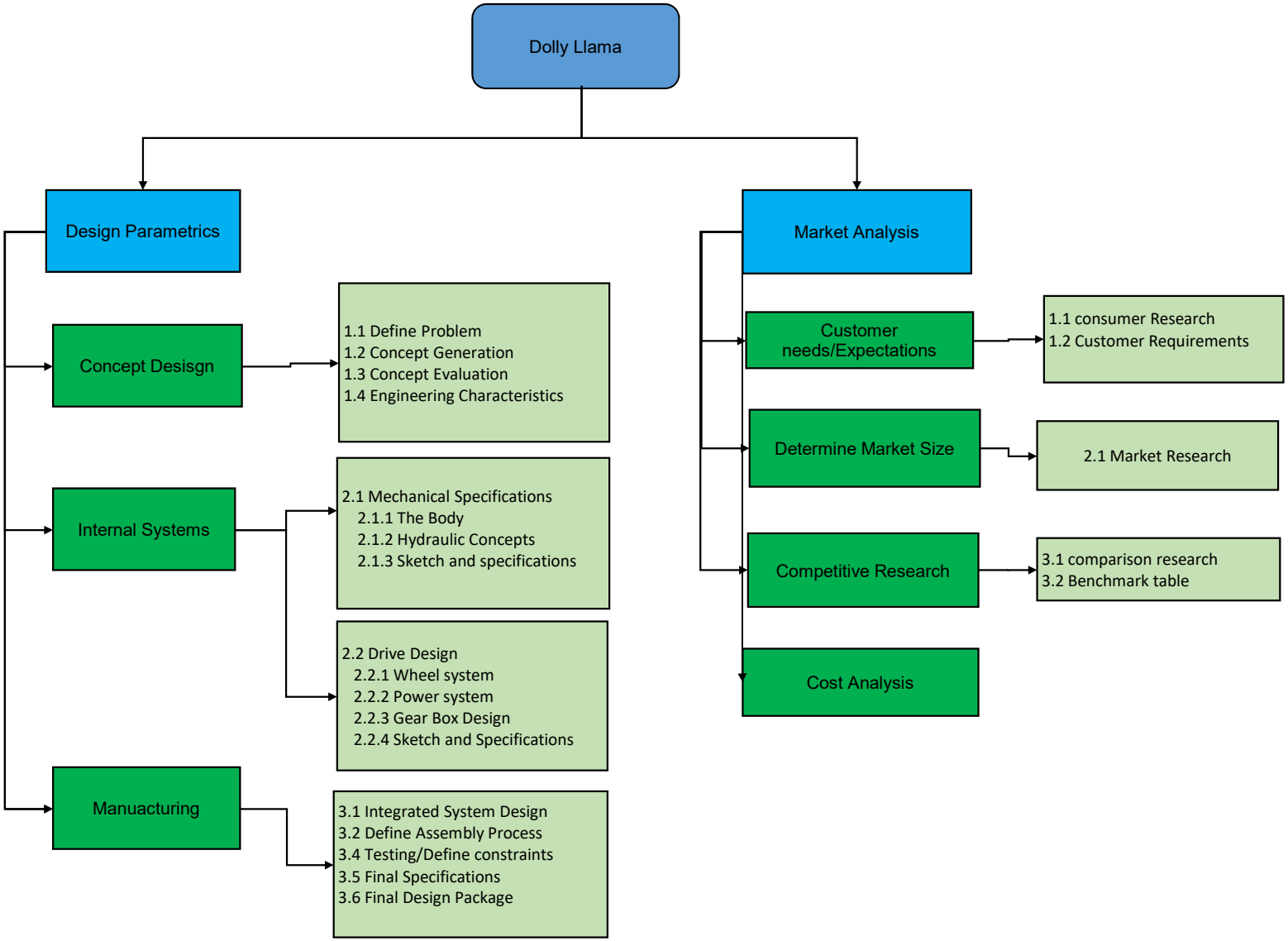
DWG NO. 031919-003

A4

SCALE:1:20

SHEET 1 OF 1

APPENDIX D


Dolly Llama
Design Parametrics
Concept Desisgn
1.1 Define Problem
1.2 Concept Generation
1.3 Concept Evaluation
1.4 Engineering Characteristics
Internal Systems
2.1 Mechanical Specifications
2.1.1 The Body
2.1.2 Hydraulic Concepts
2.1.3 Sketch and specifications
2.2 Drive Design
2.2.1 Wheel system
2.2.2 Power system
2.2.3 Gear Box Design
2.2.4 Sketch and Specifications
Manuacturing
3.1 Integrated System Design
3.2 Define Assembly Process
3.4 Testing/Define constraints
3.5 Final Specifications
3.6 Final Design Package
Market Analysis
Customer needs/Expectations
1.1 consumer Research
1.2 Customer Requirements
Determine Market Size
2.1 Market Research
Competitive Research
3.1 comparison research
3.2 Benchmark table
Cost Analysis

Dolly Llama Project Schedule

APPENDIX E

[Company Name]

Project Start Date: 1/29/2019 (Tuesday) | Display Week: 1 | Project Lead:

WBS	TASK	LEAD	START	END	DAYS	% DONE	WORK DAYS
1	**Design Parametrics**			-			-
1.1	Concept Design	[Name]	Tue 1/29/19	Mon 2/04/19	7	100%	5
1.1.1	. . Define Problem		Wed 1/30/19	Mon 2/04/19	6		4
1.1.2	. . Concept Generation		Thu 1/31/19	Mon 2/04/19	5		3
1.1.3	. . Concept Evaluation		Fri 2/01/19	Mon 2/04/19	4		2
1.1.4	. . Engineering characteristics		Tue 1/29/19	Mon 2/04/19	7		5
1.2	. Internal Systems		Mon 2/04/19	Sun 2/24/19	21		15
1.2.1	. . Mecanical Design		Tue 2/05/19	Sun 2/10/19	6		4
1.2.1.1	. . . The Body		Wed 2/06/19	Sun 2/10/19	5		3
1.2.1.2	. . . Hydraulic Concepts		Thu 2/07/19	Sun 2/10/19	4		2
1.2.1.3	. . . Sketch and Specifications		Fri 2/08/19	Sun 2/10/19	3		1
1.2.2	. Drive Design		Thu 2/07/19	Tue 2/26/19	20		14
1.2.2.1	. . . Wheel system		Thu 2/28/19	Fri 3/01/19	2		2
1.2.2.2	. . . Power system		Thu 2/14/19	Thu 2/21/19	8		6
1.2.2.3	. . . Gear Box Design		Thu 2/14/19	Sat 2/23/19	10		7
1.2.2.4	. . . Sketch and Specifications		Thu 2/07/19	Fri 2/08/19	2		2
1.3	. Manufacture		Mon 3/04/19	Sun 3/24/19	21		15
1.3.1	. .Integrated System Design		Mon 3/04/19	Thu 3/07/19	4		4
1.3.2	. .Define Assembly Process		Mon 3/04/19	Wed 3/06/19	3		3
1.3.3	. .Testing/Define constraints		Mon 3/11/19	Fri 3/15/19	5		5
1.3.4	. .Final Specifications		Fri 3/15/19	Wed 3/20/19	6		4
1.3.5	. .Final Design Package		Wed 3/20/19	Sun 3/24/19	5		3
2	**Market Analysis**						-
2.1	Customer Needs/Expectations		Thu 2/07/19	Sun 2/10/19	4	0%	2
2.1.1	. . Consumer Research		Mon 2/11/19	Thu 2/14/19	4	0%	4
2.1.2	. . Customer Requirements		Tue 2/12/19	Fri 2/15/19	4	0%	4
2.2	Determine Market Size		Sun 2/10/19	Wed 2/13/19	4	0%	3
2.2.1	. . Market Research		Sun 2/17/19	Wed 2/20/19	4	0%	3
2.3	Competitive Research		Thu 2/21/19	Sun 2/24/19	4	0%	2
2.3.1	. . comparison research		Sat 2/23/19	Tue 2/26/19	4	0%	2
2.3.2	. . Benchmark table		Sun 2/24/19	Wed 2/27/19	4	0%	3
2.4	Cost Analysis			-			
1	**[Task Category]**			-			-
1.1	[Task]		Tue 1/29/19	Tue 1/29/19	1	0%	1
1.2	[Task]		Wed 1/30/19	Wed 1/30/19	1	0%	1
1.3	[Task]		Thu 1/31/19	Thu 1/31/19	1	0%	1
1.4	[Task]		Fri 2/01/19	Fri 2/01/19	1	0%	1
1.5	[Task]		Sat 2/02/19	Sat 2/02/19	1	0%	0
							-
							-