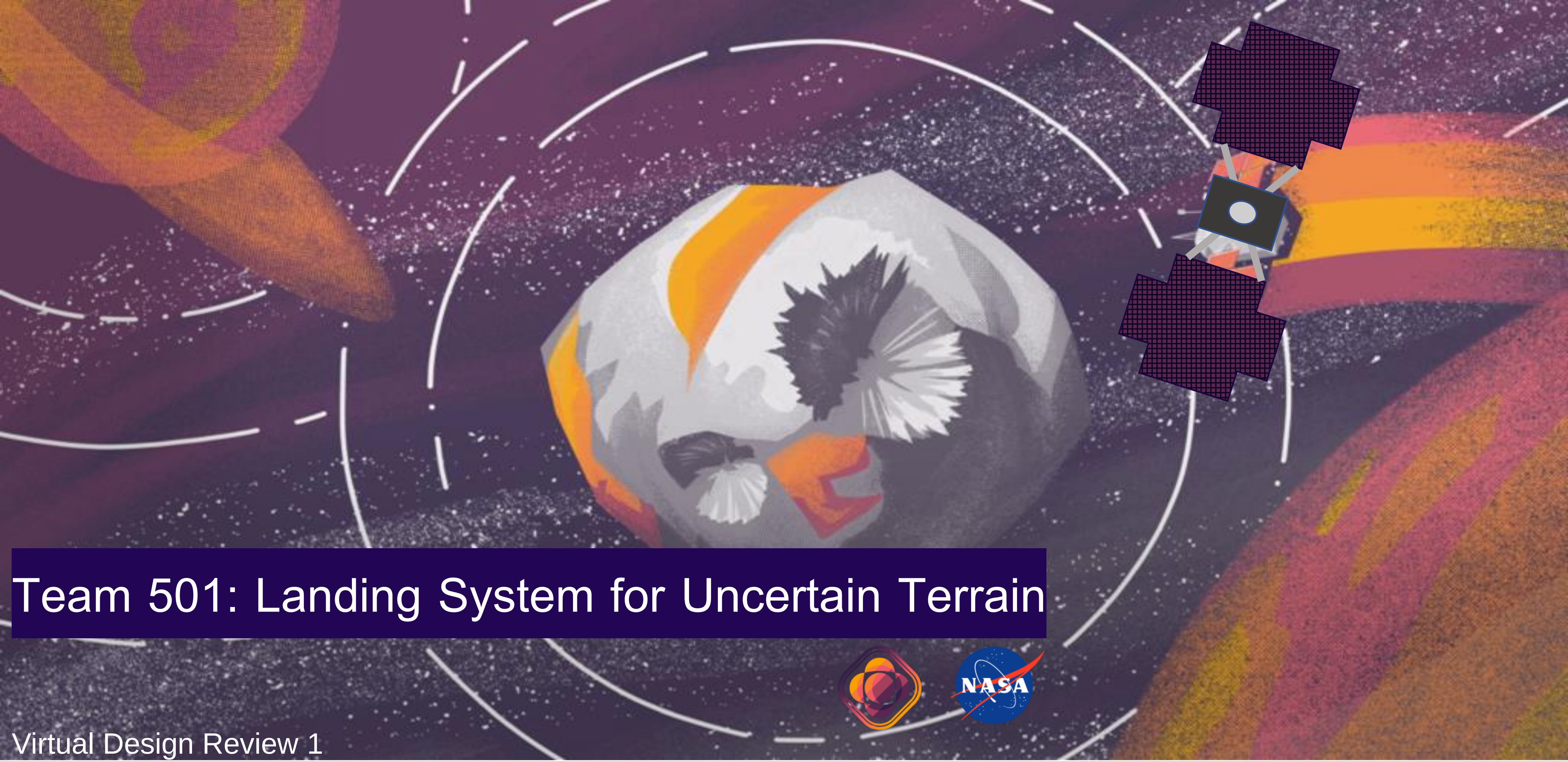


Team 501: Landing System for Uncertain Terrain

Virtual Design Review 1

Team Introductions

Saralyn Jenkins
Mechanical Systems Engineer

Elzbieta Krekora
Materials Engineer

Andrew Sak
Controls Engineer

Julio Velasquez
Manufacturing Engineer

Saralyn Jenkins

Sponsor and Advisor

<u>Engineering Mentor</u>
Cassie Bowman, Ed.D.
Associate Research Professor, ASU

<u>Academic Advisor</u>
Camilo Ordóñez, Ph.D.
ME Teaching Faculty

Saralyn Jenkins

Objective

The objective of this project is to design a landing system capable of safely landing on the assumed range of hypothesized surfaces and terrains of 16 Psyche.

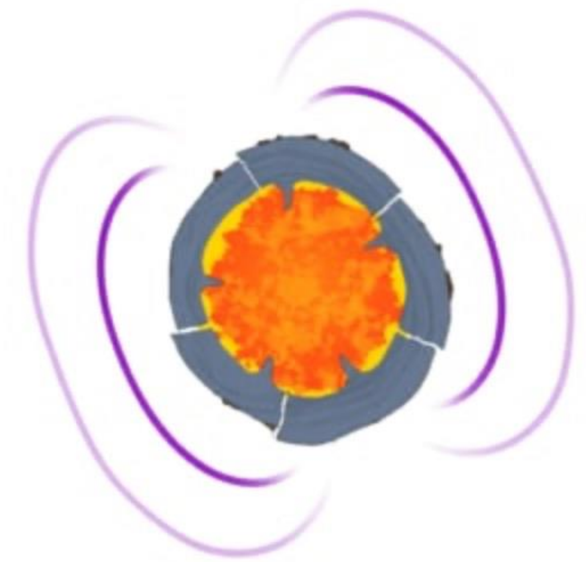
Saralyn Jenkins

About Psyche

Believed to be an exposed core of an early planet that lost its rocky outer layers due to violent collisions billions of years ago

First mission to investigate a world of metal rather than of rock and ice

Offers possibility of finding information on planet cores



Saralyn Jenkins

About the Mission

Current Mission

Set to launch August 2022 to survey Psyche closer

Future Mission

If findings found to be interesting a lander will be sent at a future date

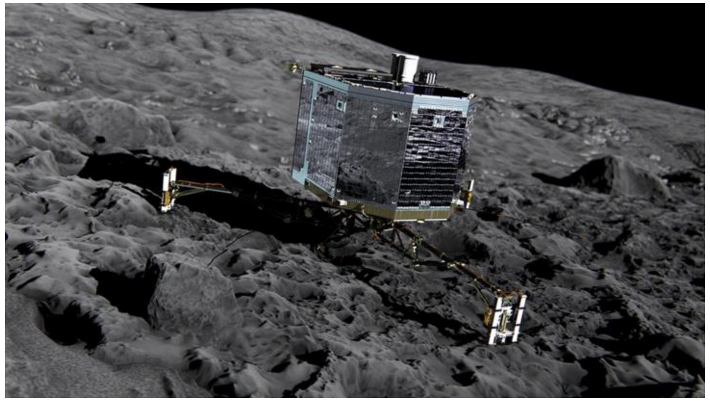
Our Mission

To design the landing gear for the future landing space craft

Saralyn Jenkins

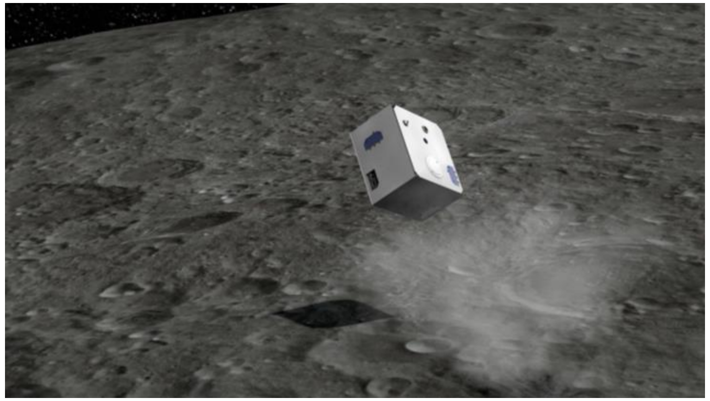
Initial Research of Past Landers

Philae



- Landed on a comet 67P; contained ice
- Legs support the lander
- Drilled into surface
- Mass: 100kg

MASCOT



- Landed on Ryugu asteroid
- Rocky surface
- Box shape, swinging arm inside to ”hop” or flip
- Mass: 10kg

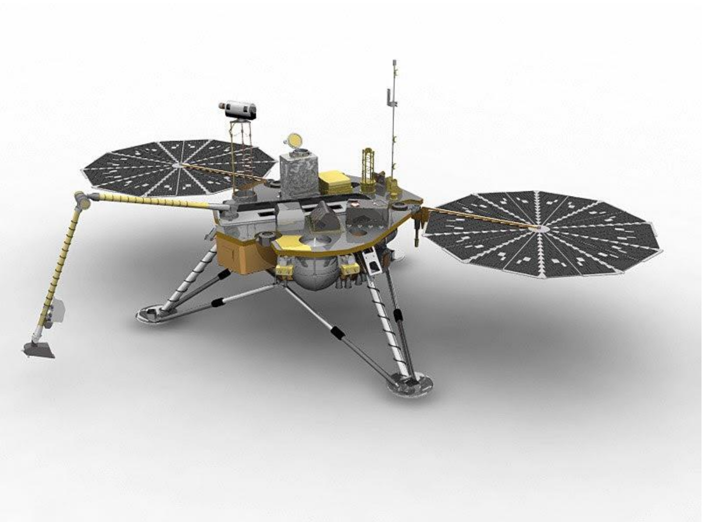
Saralyn Jenkins

Initial Research of Past Landers

Lunar Module Eagle

- Landed on the moon
- Flat surface
- Manually controlled thrusters
- Mass: 7,327 kg

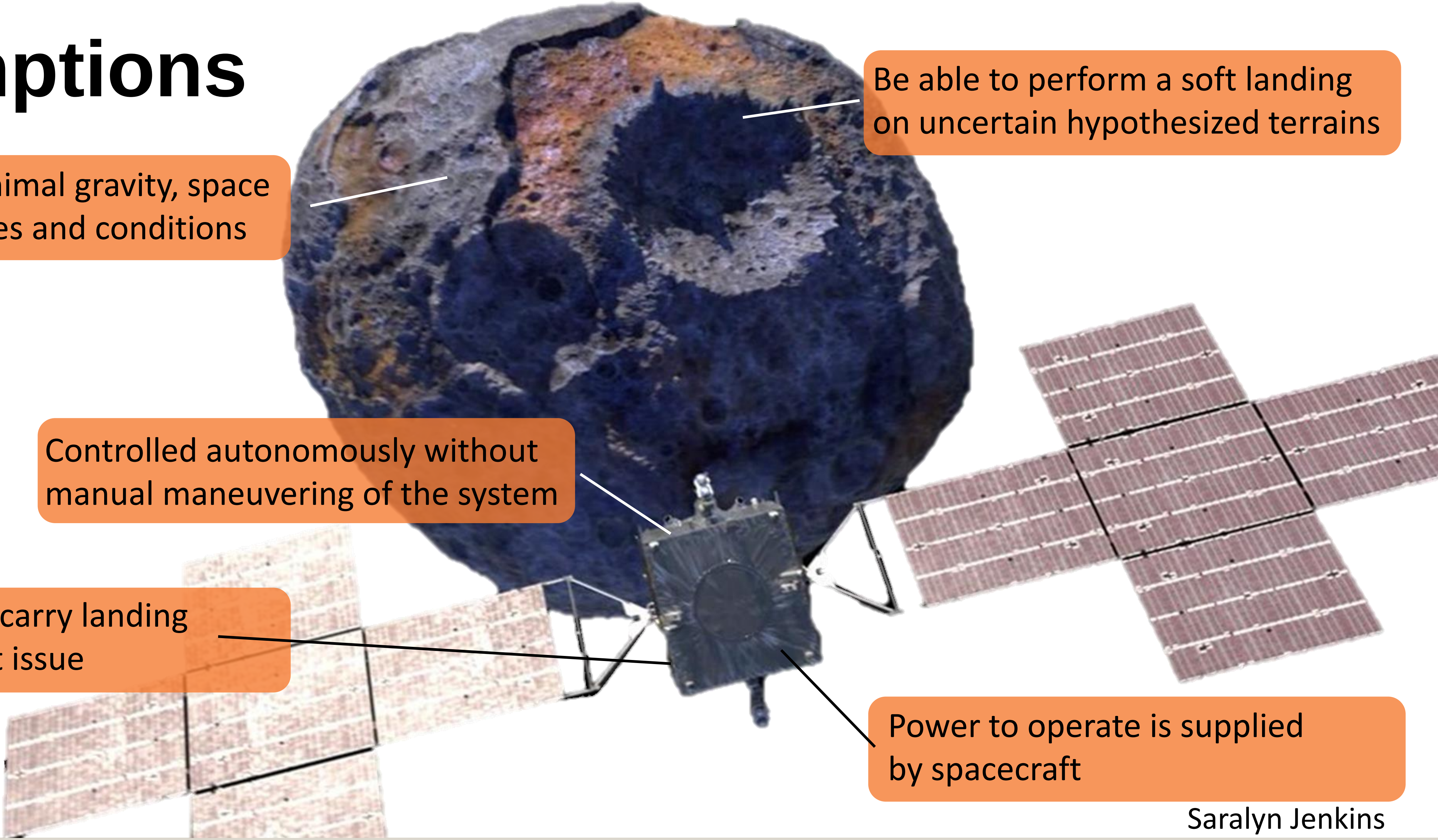
Phoenix



- Landed on Mars
- Rocky flat surface
- Set of 3 legs with 3 components
- Mass: 350kg

Saralyn Jenkins

Assumptions



- Be able to perform a soft landing on uncertain hypothesized terrains
- Operated in minimal gravity, space like temperatures and conditions
- Controlled autonomously without manual maneuvering of the system
- Spacecraft will carry landing system without issue
- Power to operate is supplied by spacecraft

Saralyn Jenkins

Key Goals

Account for various terrains such as high relief terrain with rocky debris, and metallic terrain

Protec… d from damage … landing

Prevent spacecraft from tipping and flipping

Absorb impact velocity upon landing

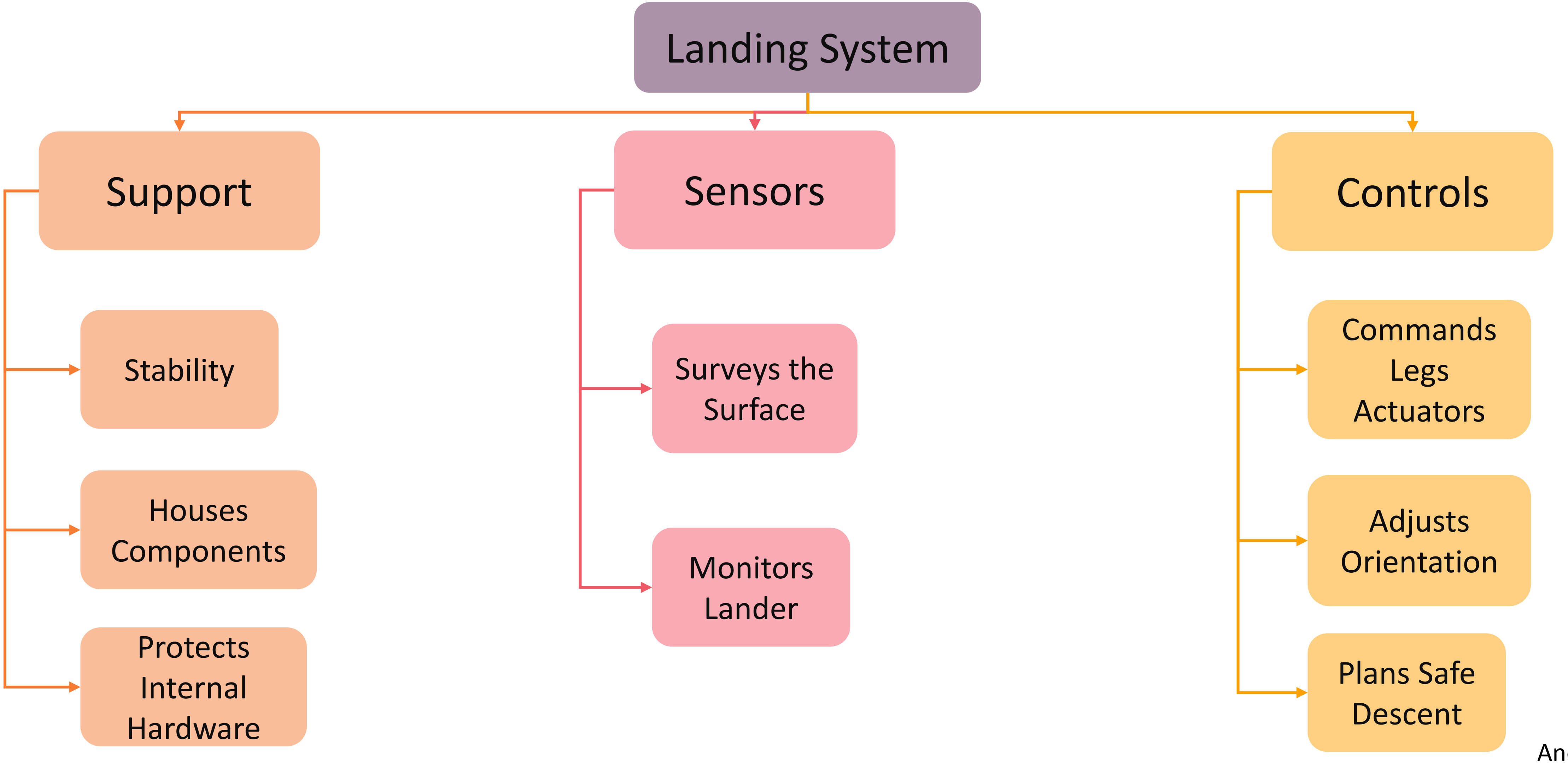
Saralyn Jenkins

Customer Needs

- The system is capable of successfully landing on the hypothesized terrains of Psyche.
- The device can withstand or dissipate the potential energy from the fall and impact velocity.
- The system is autonomous.
- The system can support the CHONK-E Rover without damaging it.
- The landing system supports the weight/size of the spacecraft based off previous missions.
- The system does not have to be reusable.

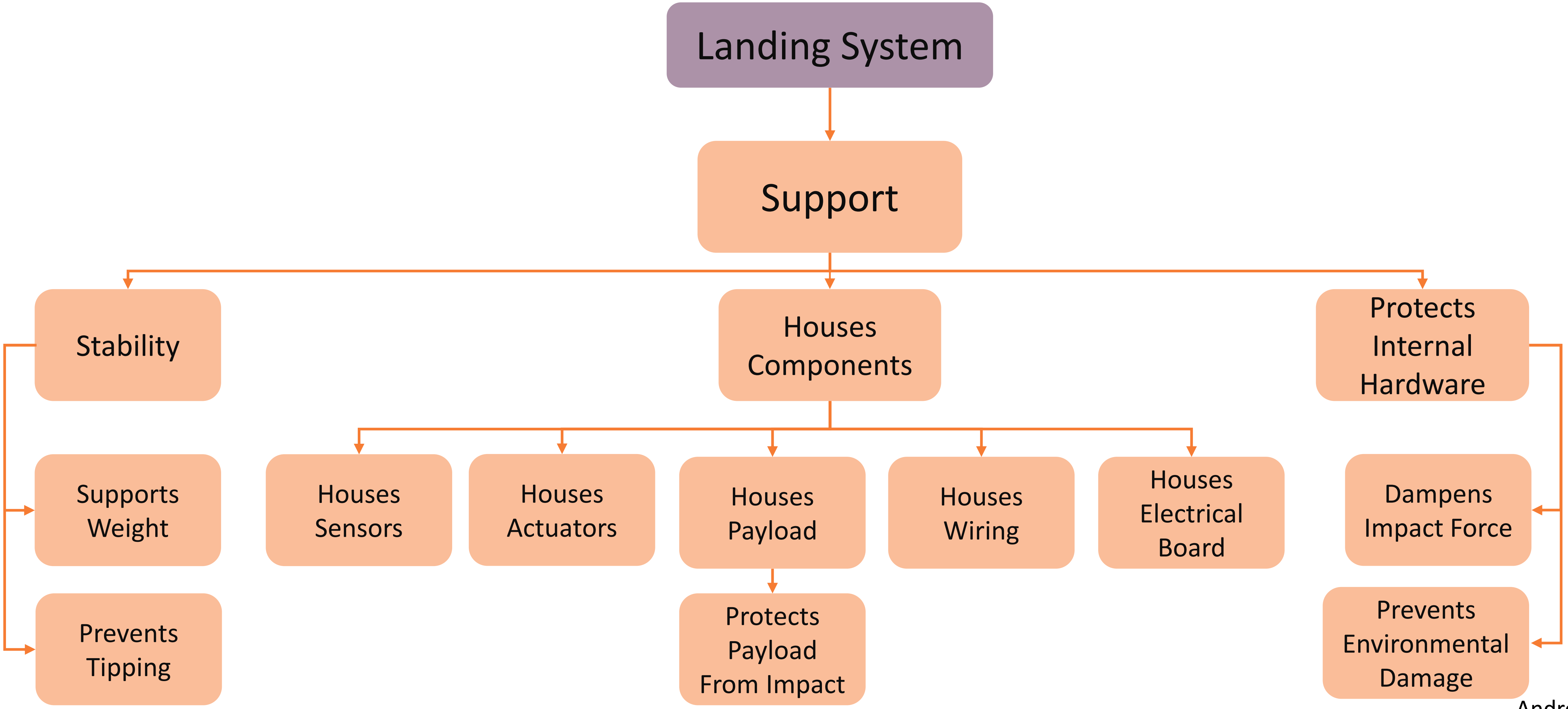
Andrew Sak

Functional Decomposition



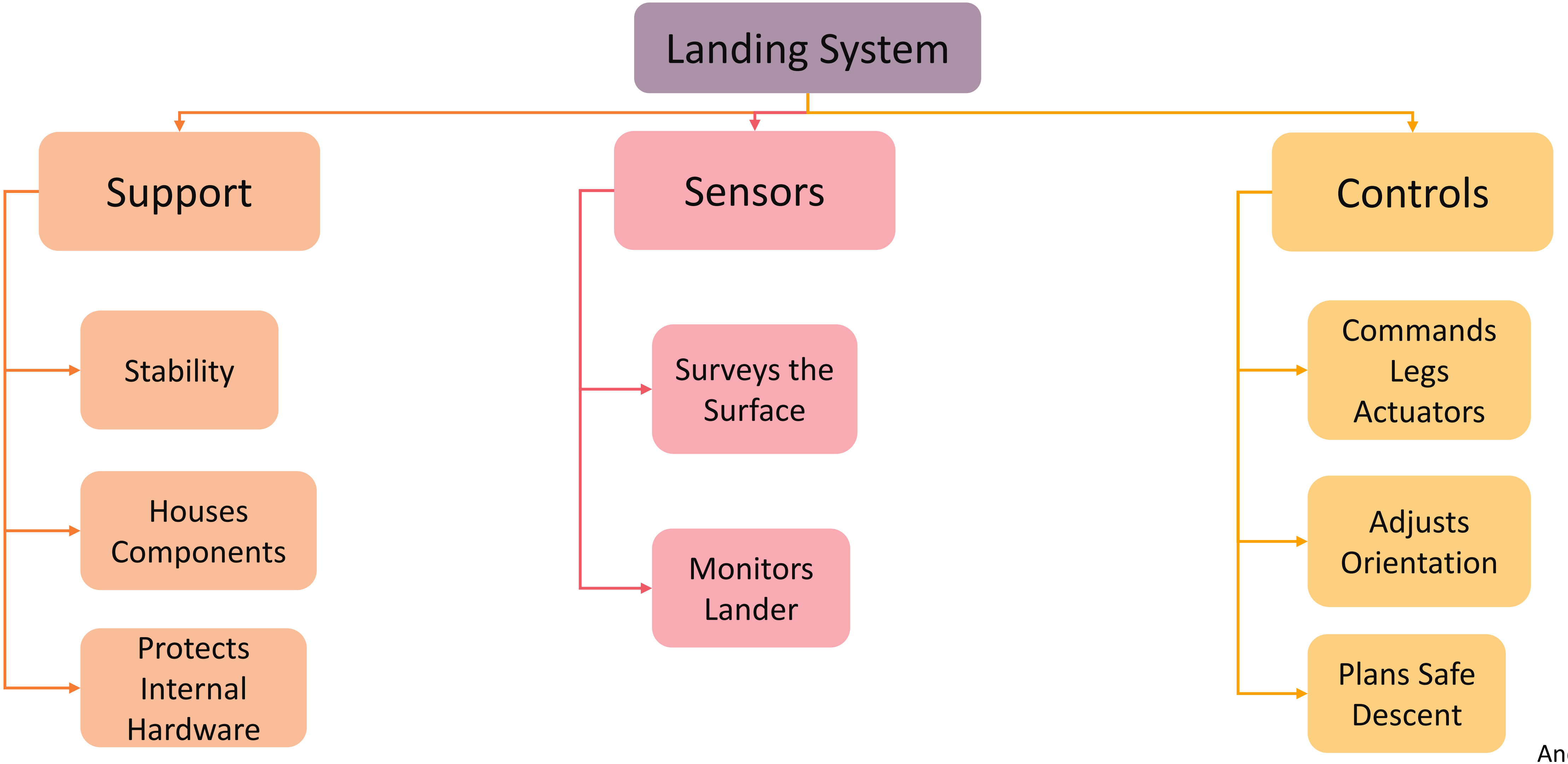
Andrew Sak

Functional Decomposition



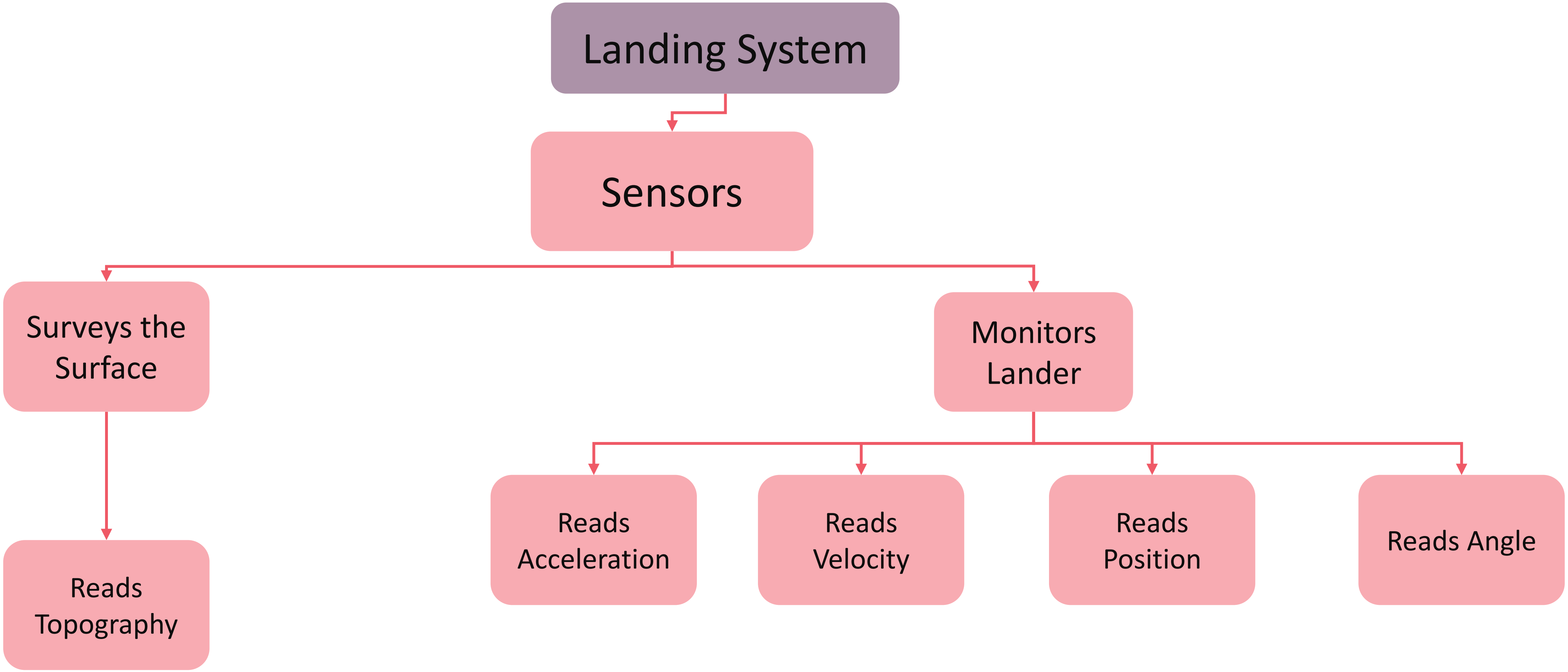
Andrew Sak

Functional Decomposition



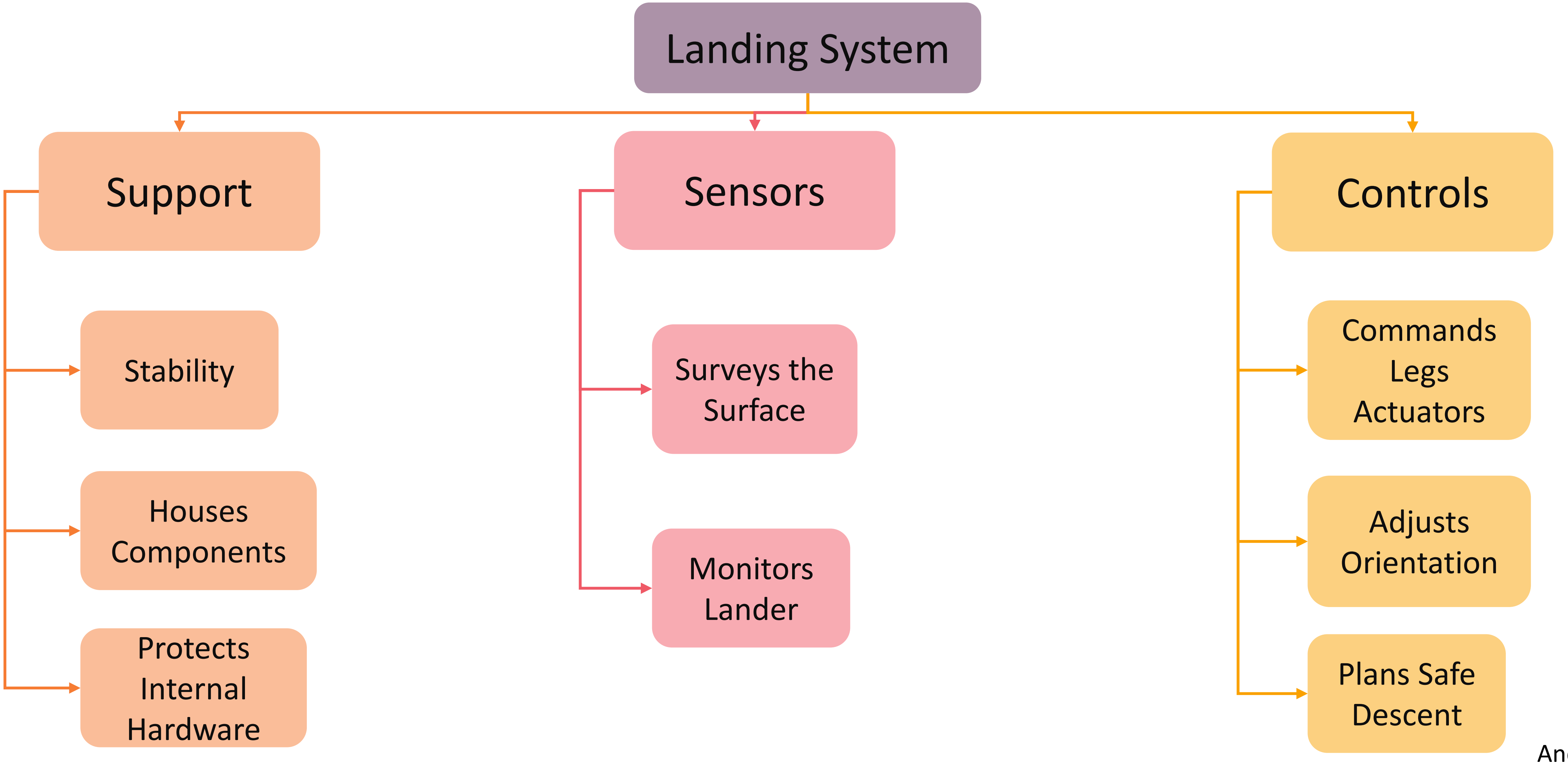
Andrew Sak

Functional Decomposition



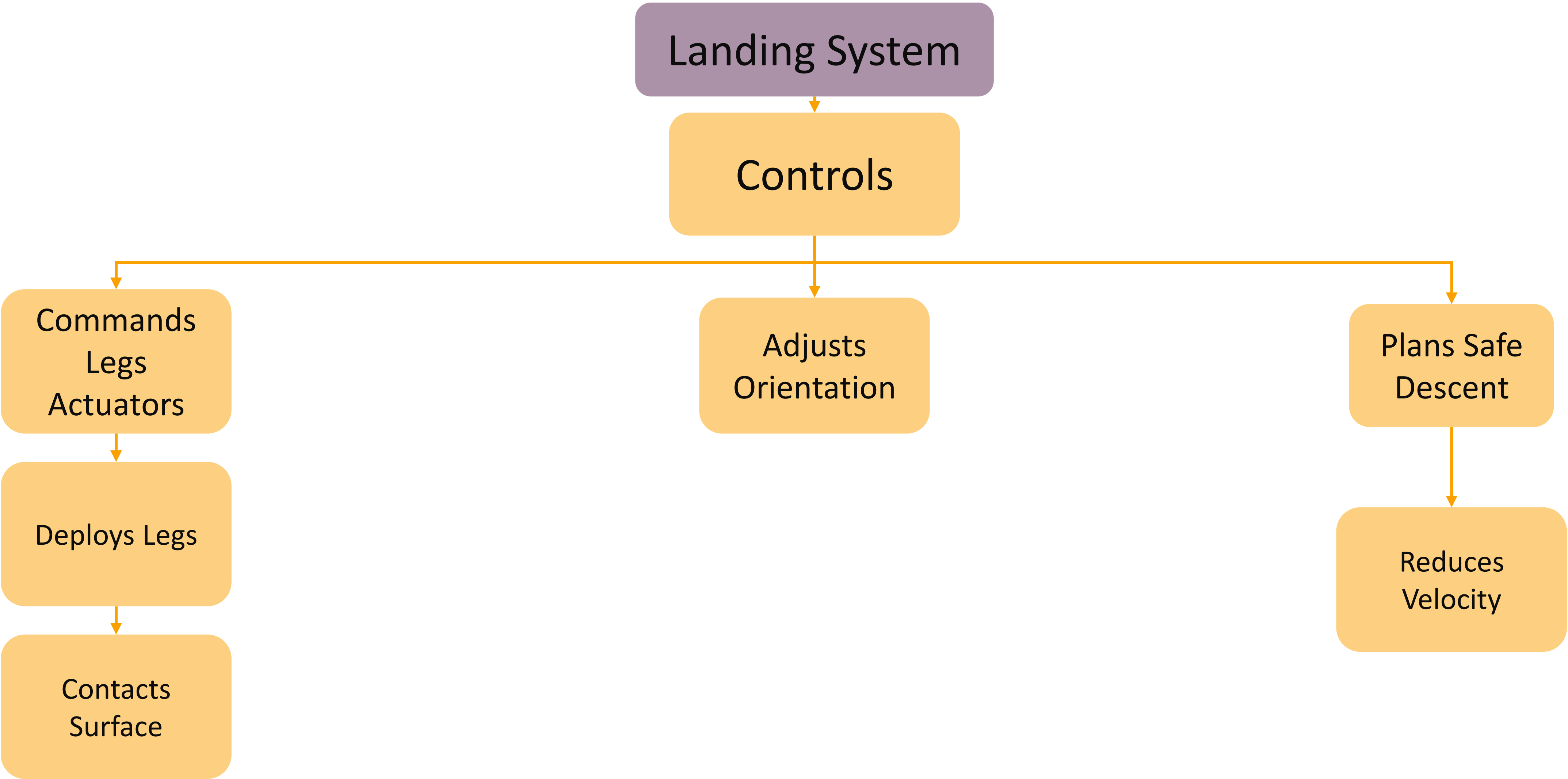
Andrew Sak

Functional Decomposition



Andrew Sak

Functional Decomposition



Andrew Sak

Functional Decomposition Matrix

Minor Functions	Support	Sensors	Controls
	System/Major Functions		
Houses Payload	X		
Houses Sensors	X		
Houses Actuators	X		
Houses Electrical Board	X		
Houses Wiring	X		
Prevents Tipping	X	X	X
Supports Weight	X		
Prevents Environmental Damage of Hardware	X		
Dampens Impact Forces	X		
Reads Velocity		X	
Reads Position		X	
Reads Angle		X	
Reads Topography		X	
Deploys Legs	X	X	X
Reduced Velocity		X	X

Andrew Sak

Further Research of Lander Components

Decided to divide into components of what we consider is the main areas of the landing system.

Suspension

- Dampening system
- Crushable components

Legs

- Geometry
- Number of legs
- Adaptability

Feet

- Ability to grip
- Ability to adjust to uneven terrain
- Size of feet

Sensors

- Orientation
- Acceleration
- Position

Base

- Position of attachment of legs
- Type of connection

Andrew Sak

Future Work

Research of More Specific Components Found During Brainstorming

Narrow Down Ideas and Evaluate Combinations of Ideas

Simulate Select Ideas

Prototype Components of Ideas or System

Andrew Sak

References

In Depth | 16 Psyche –. (2018). NASA Solar System Exploration. https://solarsystem.nasa.gov/asteroids-comets-and-meteors/asteroids/16-psyche/in-depth/

In Depth | Rosetta & Philae –. (2014). NASA Solar System Exploration. https://solarsystem.nasa.gov/missions/rosetta-philae/in-depth/

Mission, N. P. (2018). *Psyche v15-2*. Vimeo. https://vimeo.com/246338699

NASA Psyche Mission Wallpaper | Virtual Backgrounds. (2020, July 14). Psyche Mission. https://psyche.asu.edu/psyche-wallpaper-backgrounds/

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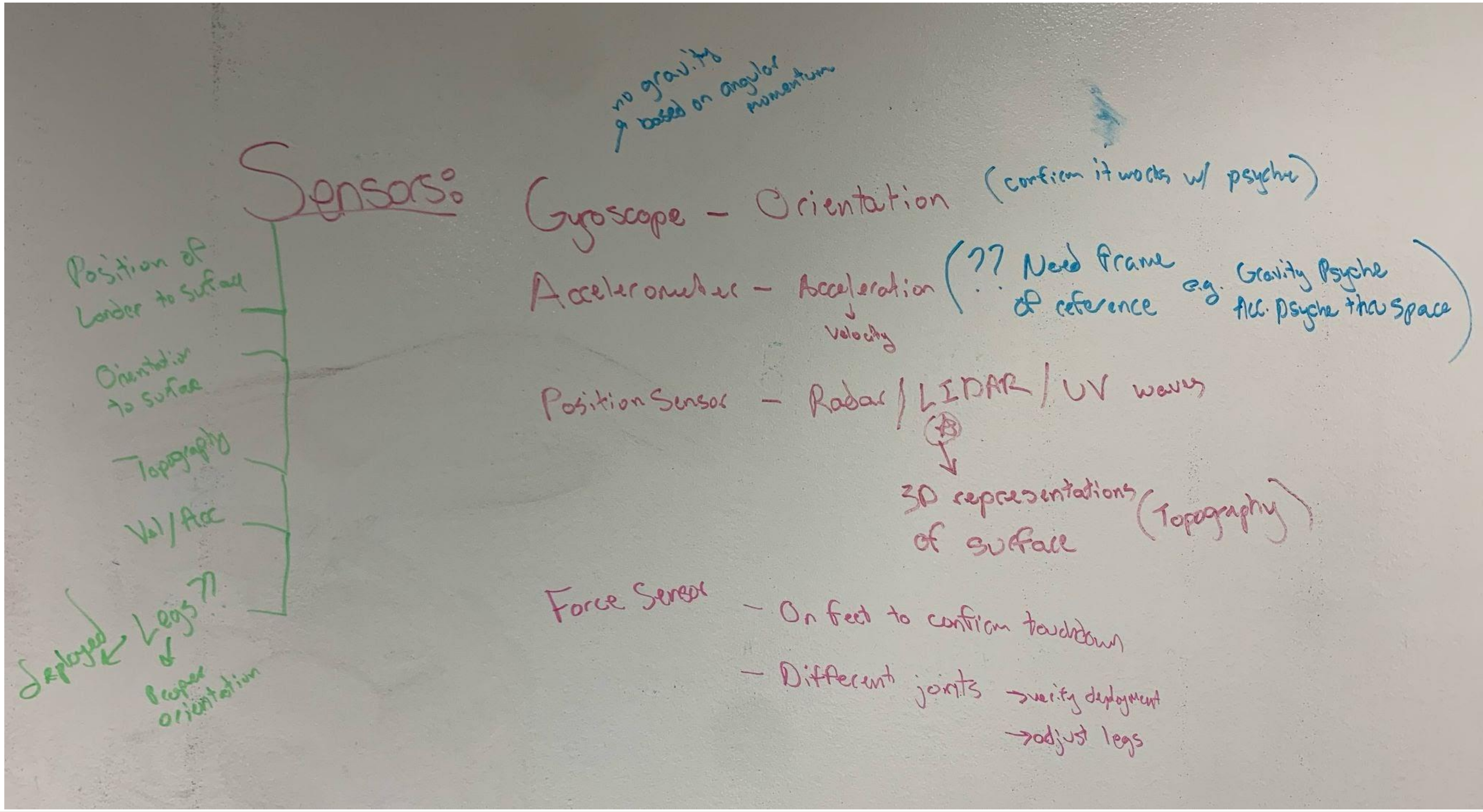
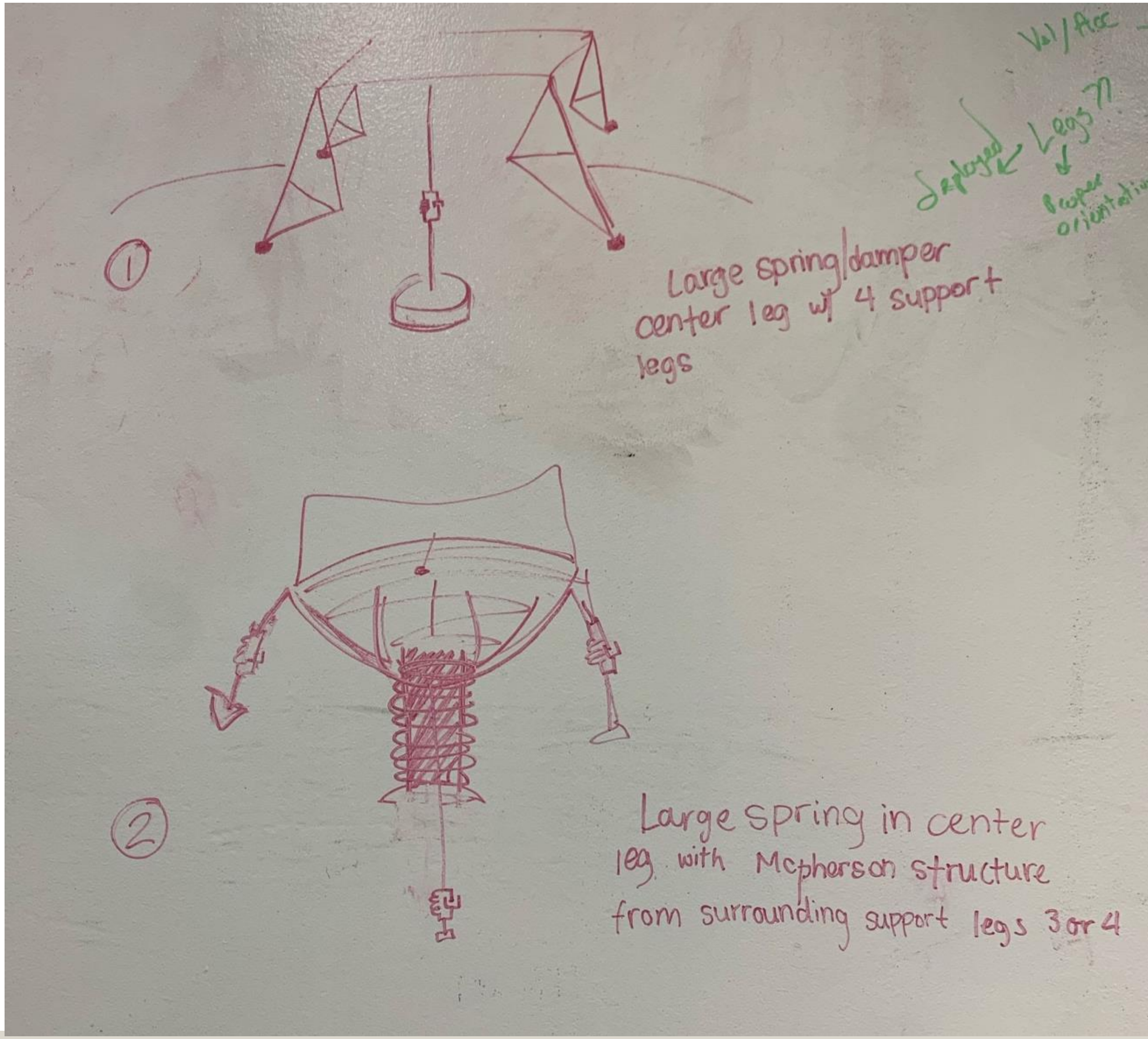
Backup Slides

Sensors

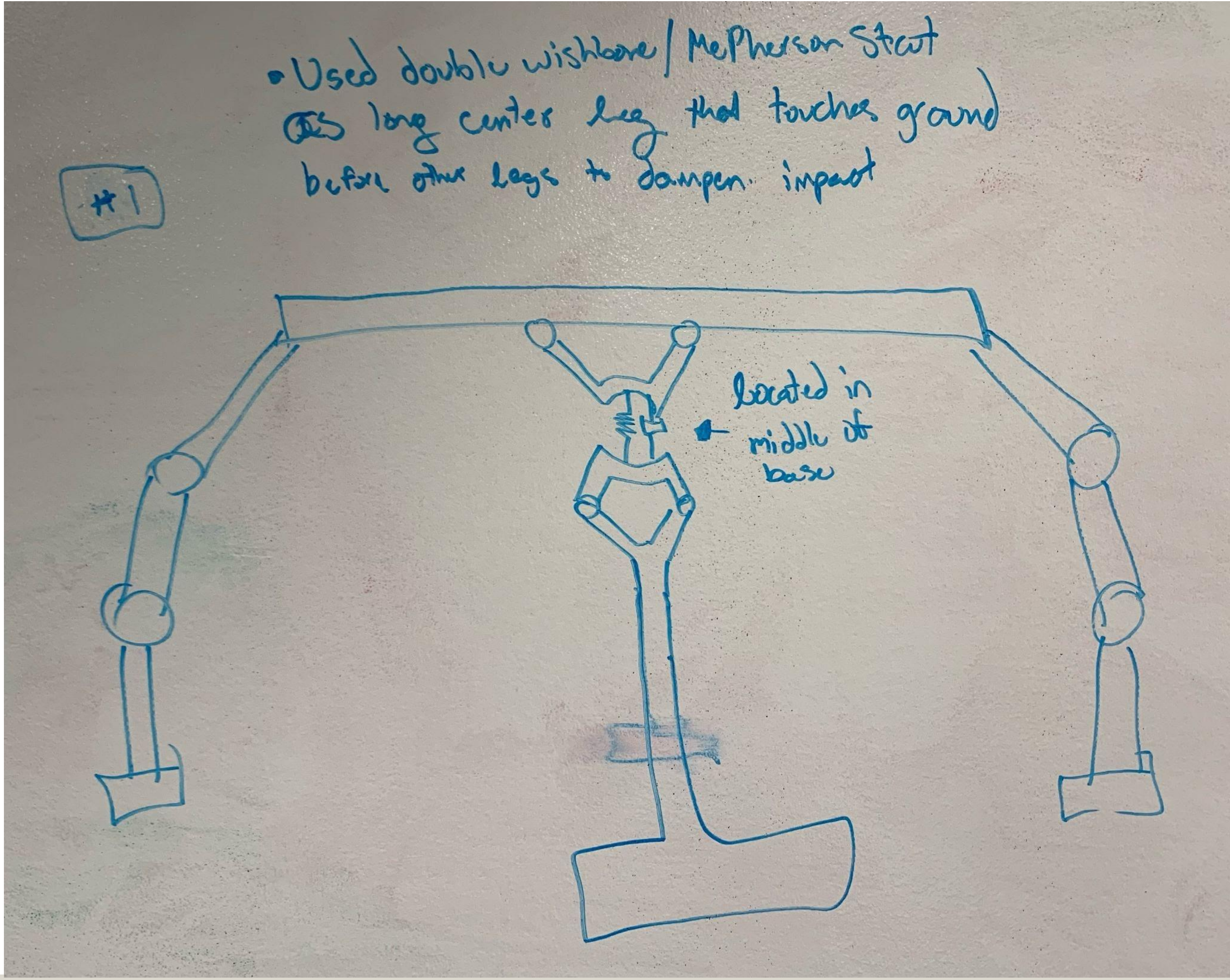

no gravity
based on angular momentum
Sensors:
Gyroscope - Orientation (confirm it works w/ psyche)
Accelerometer - Acceleration
Velocity
(?? Need frame of reference e.g. Gravity Psyche Acc. psyche thru space)
Position Sensor - Radar / LIDAR / UV waves
3D representations of surface (Topography)
Force Sensor - On feet to confirm touchdown
- Different joints → verify deployment → adjust legs
Position of Lander to surface
Orientation to surface
Topography
Vel/Acc
Legs??
Deployed
Proper orientation

Concept 1



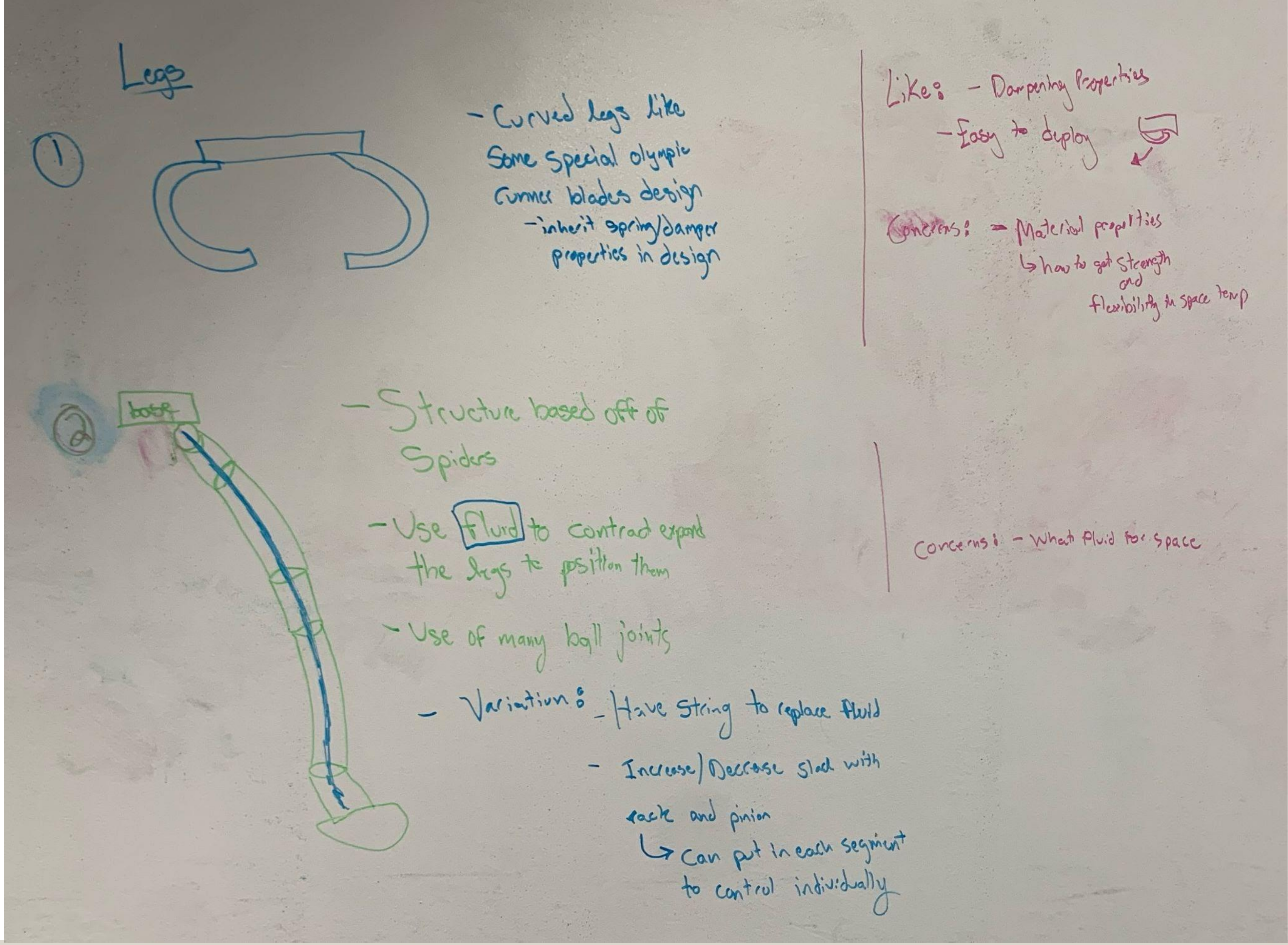
Vel/Acc
Deployed
Legs??
Proper orientation
1
Large spring/damper center leg w/ 4 support legs
2
Large spring in center leg with Mcpherson structure from surrounding support legs 3 or 4

Concept 1

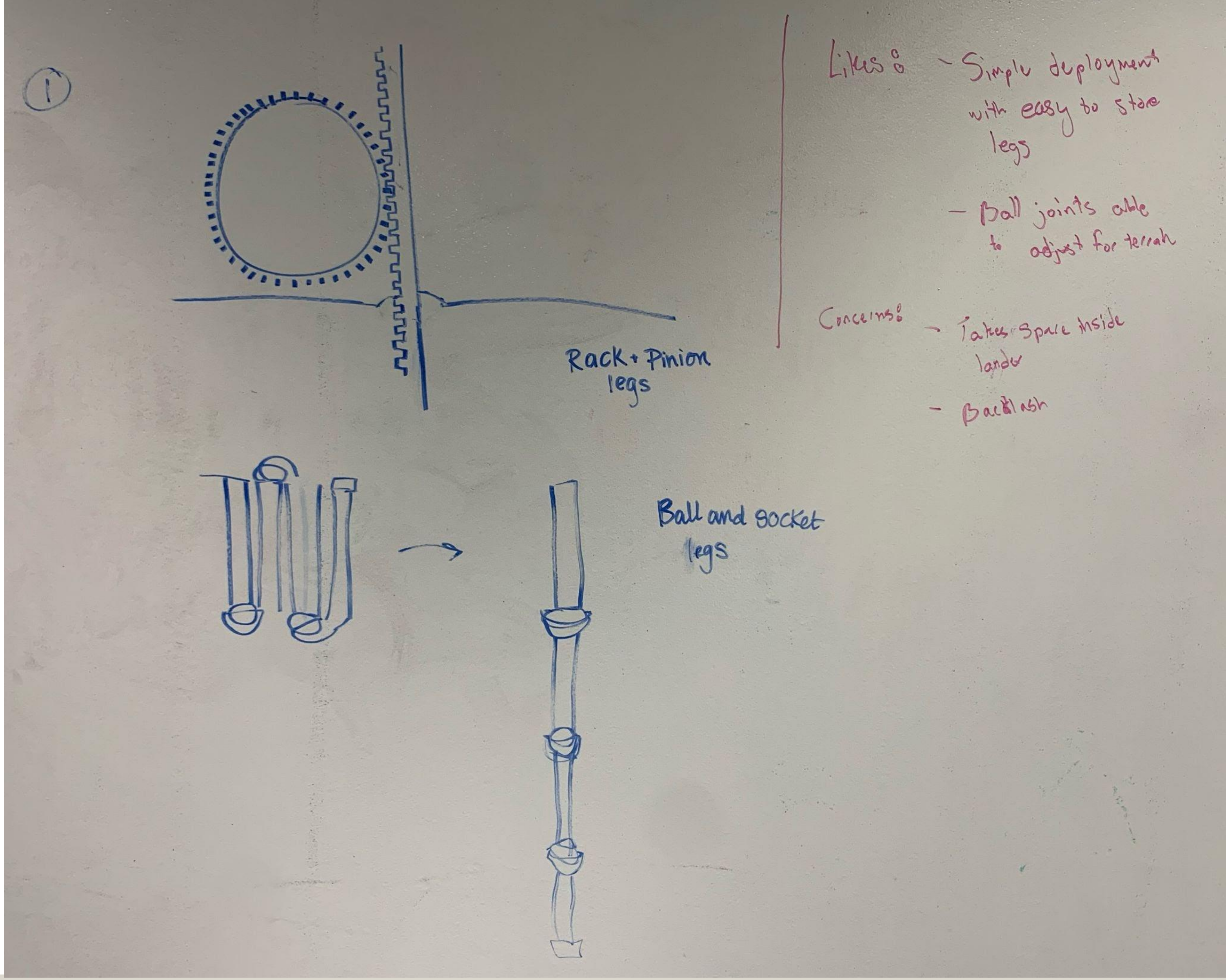


• Used double wishbone / McPherson Strut
long center leg that touches ground
before other legs to dampen impact
#1
located in
middle of
base

Legs

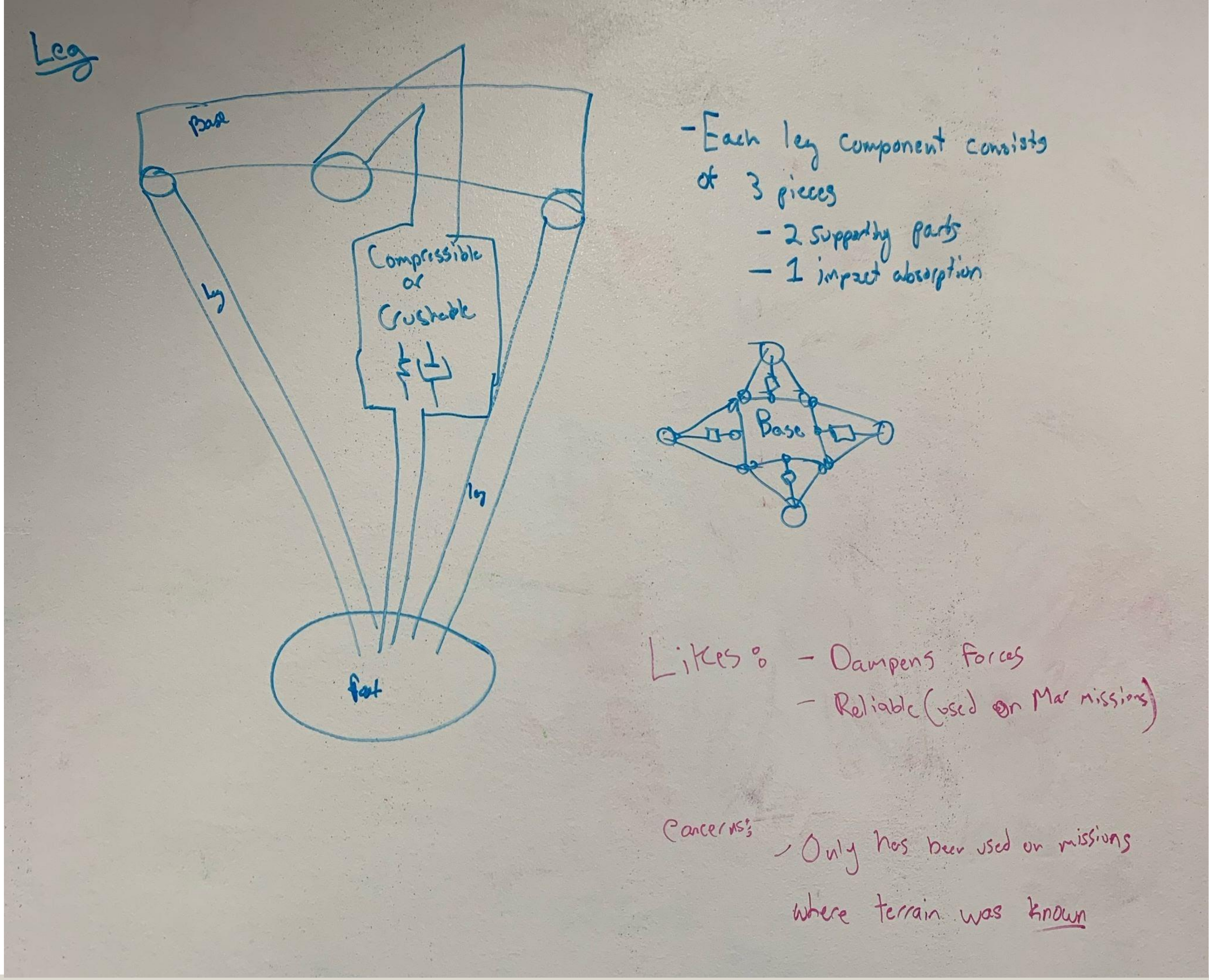

Legs
1
- Curved legs like
Some special olympic
runner blades design
- inherit spring/damper
properties in design
Like: - Dampening Properties
- Easy to deploy
Concerns: - Material properties
↳ how to get strength
and
flexibility in space temp
2
base
- Structure based off of
Spiders
- Use fluid to contract expand
the legs to position them
- Use of many ball joints
- Variation: - Have string to replace fluid
- Increase/Decrease slack with
rack and pinion
↳ Can put in each segment
to control individually
Concerns: - What fluid for space

Legs

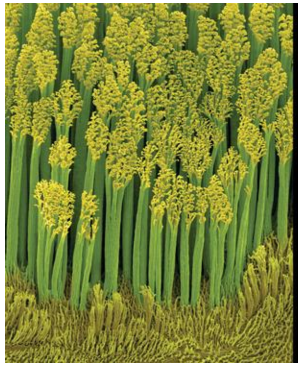


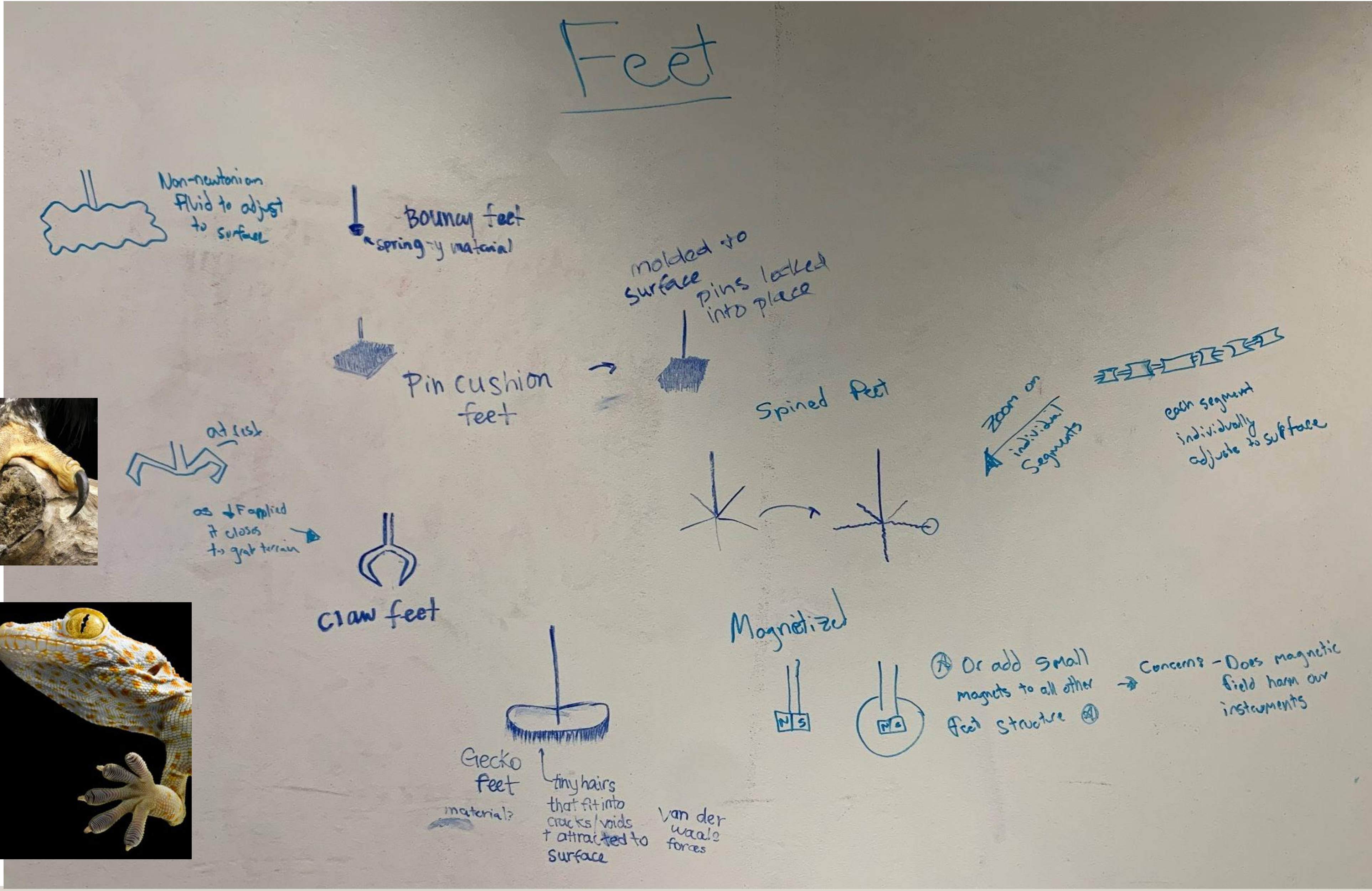
1
Rack + Pinion legs
Ball and socket legs
Likes:
- Simple deployment with easy to store legs
- Ball joints able to adjust for terrain
Concerns:
- Takes space inside lander
- Backlash

Legs

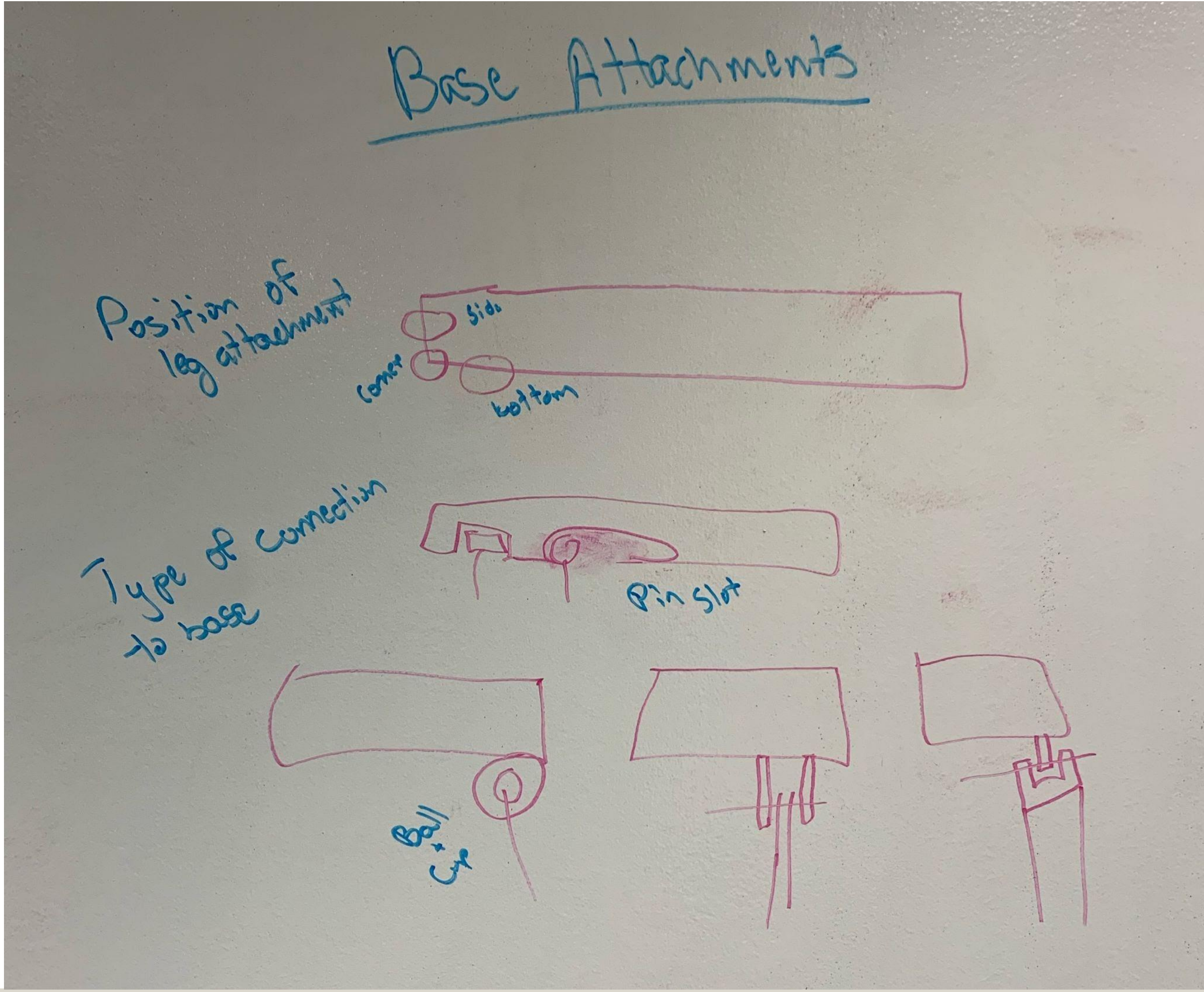

Leg
Base
Compressible or Crushable
Leg
Leg
Foot
-Each leg component consists of 3 pieces
- 2 supporting parts
- 1 impact absorption
Base
Likes: - Dampens forces
- Reliable (used on Mar missions)
Concerns: - Only has been used on missions where terrain was known

Feet

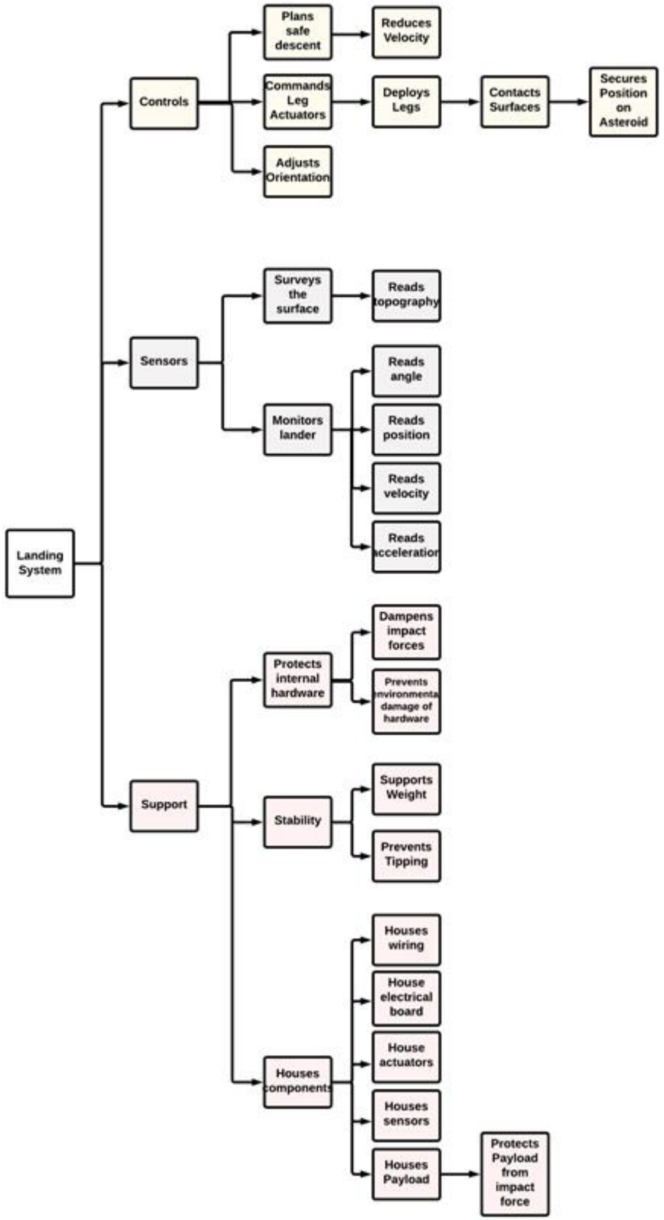



Feet
Non-newtonian fluid to adjust to surface
Bouncy feet
*spring-y material
molded to surface
pins locked into place
Pin cushion feet
Spined feet
Zoom on individual segments
each segment individually adjusts to surface
at first
as F applied it closes to grab terrain
Claw feet
Magnetized
N S
Or add small magnets to all other feet structure
Concerns - Does magnetic field harm our instruments
Gecko feet
material?
tiny hairs that fit into cracks/voids + attracted to surface
Van der waals forces

Base


Base Attachments
Position of leg attachment
side
corner
bottom
Type of connection to base
Pin slot
Ball + Cup

Functional Decomp Backup


Landing System
Controls
Plans safe descent
Reduces Velocity
Commands Leg Actuators
Deploys Legs
Contacts Surfaces
Secures Position on Asteroid
Adjusts Orientation
Sensors
Surveys the surface
Reads topography
Monitors lander
Reads angle
Reads position
Reads velocity
Reads acceleration
Support
Protects internal hardware
Dampens impact forces
Prevents environmental damage of hardware
Stability
Supports Weight
Prevents Tipping
Houses components
Houses wiring
House electrical board
House actuators
Houses sensors
Houses Payload
Protects Payload from impact force

Functional Decomposition Matrix

MINOR FUNCTIONS	SYSTEM		
	Major Function		
	Support	Sensors	Controls
Houses Payload	X		
Houses Sensors	X		
House Actuators	X		
Houses Electrical Board	X		
Houses Wiring	X		
Prevents Tipping	X	X	X
Supports Weight	X		
Prevents Environmnetal Damage of Hardware	X		
Dampens Impact Forces	X		
Reads Velocity		X	
Reads Position		X	
Reads Angle		X	
Reads Topography		X	
Deploys Legs	X	X	X
Reduces Velocity		X	X

Customer Needs

Question Asked	Customer Statement	Interpreted Need
What is the possible size/weight of the spacecraft the landing gear will support?	"Look at previous missions to small planets for reference sizes. Look at other landers and the rovers they carried, but we don't want to send something big and expensive."	The landing system supports the weight/size of the spacecraft based off of previous missions.
Does the spacecraft have storage underneath?	"Yes, look at the rover previously made by a FAMU-FSU Team for a reference size."	The system can support the CHONKE Rover without damaging it.
What is the estimated impact velocity of the spacecraft?	"It will be similar to that of previous space missions to land on small planets."	The device can withstand or dissipate the potential energy from the fall and impact velocity.
What are the possible landing sites at Psyche?	"Let everyone know that the lander will be able to handle the hypothesized terrains. Better knowledge of where to land will come after completion of the upcoming orbiter mission. From the orbiter we can determine where the best place is to land and set the lander to go there."	The system is capable of successfully landing on the hypothesized terrains of Psyche ie. rocky, mostly metal, ect.
Is the team responsible for the control of the impact velocity of the spacecraft?	"Assume the lander has been brought to a reasonable impact velocity by other equipment. This impact velocity would be based off previous space missions and what you conclude."	Ability to withstand impact and land from assumed impact velocity.
Is the spacecraft returning to Earth? If so, is the team responsible for the landing system for the return?	"No, assume the spacecraft is staying on Psyche."	The system does not have to be reusable.
Does the landing system require any remote controls for manual maneuvering?	"The system needs to be autonomous. Psyche is too far to pilot any spacecraft."	The system is autonomous.