

# PRELIMINARY DESIGN PRESENTATION

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# NEEDS ANALYSIS

## Needs Statement:

Industrial and building systems require a safe, cost-effective and reliable method to remove mineral scale build-up from  $\varnothing$ 100-150mm pipes, where existing solutions such as chemical cleaning, pigging, and jetting are either hazardous, resource intensive or ineffective at hard deposits.

## Problem Definition:

Design a low-cost robotic system that can navigate  $\varnothing$ 100-150mm pipe, mechanically remove scale and improve flow performance while being able to adapt to varying pipe sizes and geometries.

# DESIGN SPECS: Objectives

Criteria	Objectives	Unit of Measurement	Notes
Pipe diameter compatibility	$\leq \varnothing 90$	mm	
Water sealed electronic enclosure	IP54	-	Solids (5): Dust protection Liquids (4): splashing water
Navigation of bends	90	Degrees	
T-Junction entry	$\geq 80\%$ success	%Trials	Ability to enter branch on demand
Scale removal effectiveness	$\geq 50$	%	Removal of $\text{CaCO}_3$ /rust deposits
Cost	$\leq 750$	\$	University allocated budget
Traction/adhesion force	$\geq 5$	N	Maintain grip while engaged
Movement speed	$\geq 0.1$	m/s	Continuous travel without stalling
Mass	$< 20$	kg	Lightweight for retrieval and mobility
Live video transmission	480p, 10fps	pixels, fps	Assists in operator navigation of pipe system

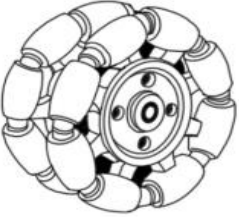
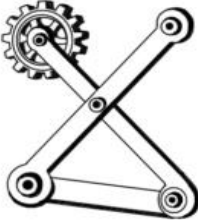
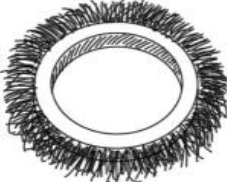
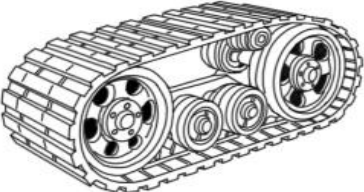

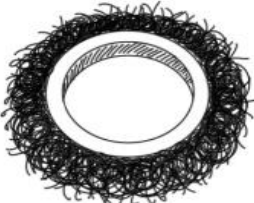
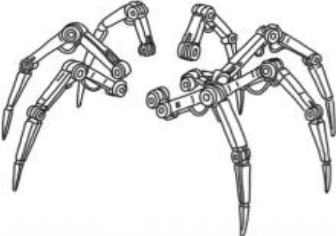
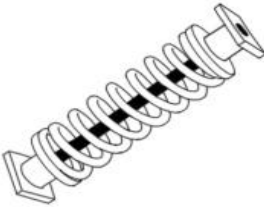
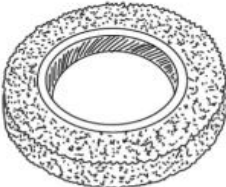
# DESIGN SPECS: Constraints

Criteria	Constraint
Size/Operation	<ul style="list-style-type: none"><li>• The system must fit within <math>\varnothing 100\text{mm}</math> inner pipe diameter</li><li>• The system must operate reliably in wet conditions</li></ul>
Cleaning Performance	<ul style="list-style-type: none"><li>• The system must mechanically remove <math>&gt;50\%</math> of simulated mineral scale</li><li>• The system must complete one cleaning cycle without permanent pipe damage</li></ul>
Safety & Reliability	<ul style="list-style-type: none"><li>• The system must be retrievable via tether in the event of power loss or failure</li></ul>
Monitoring & Feedback	<ul style="list-style-type: none"><li>• The system must transmit live video</li></ul>

# DESIGN SPECS: Criteria

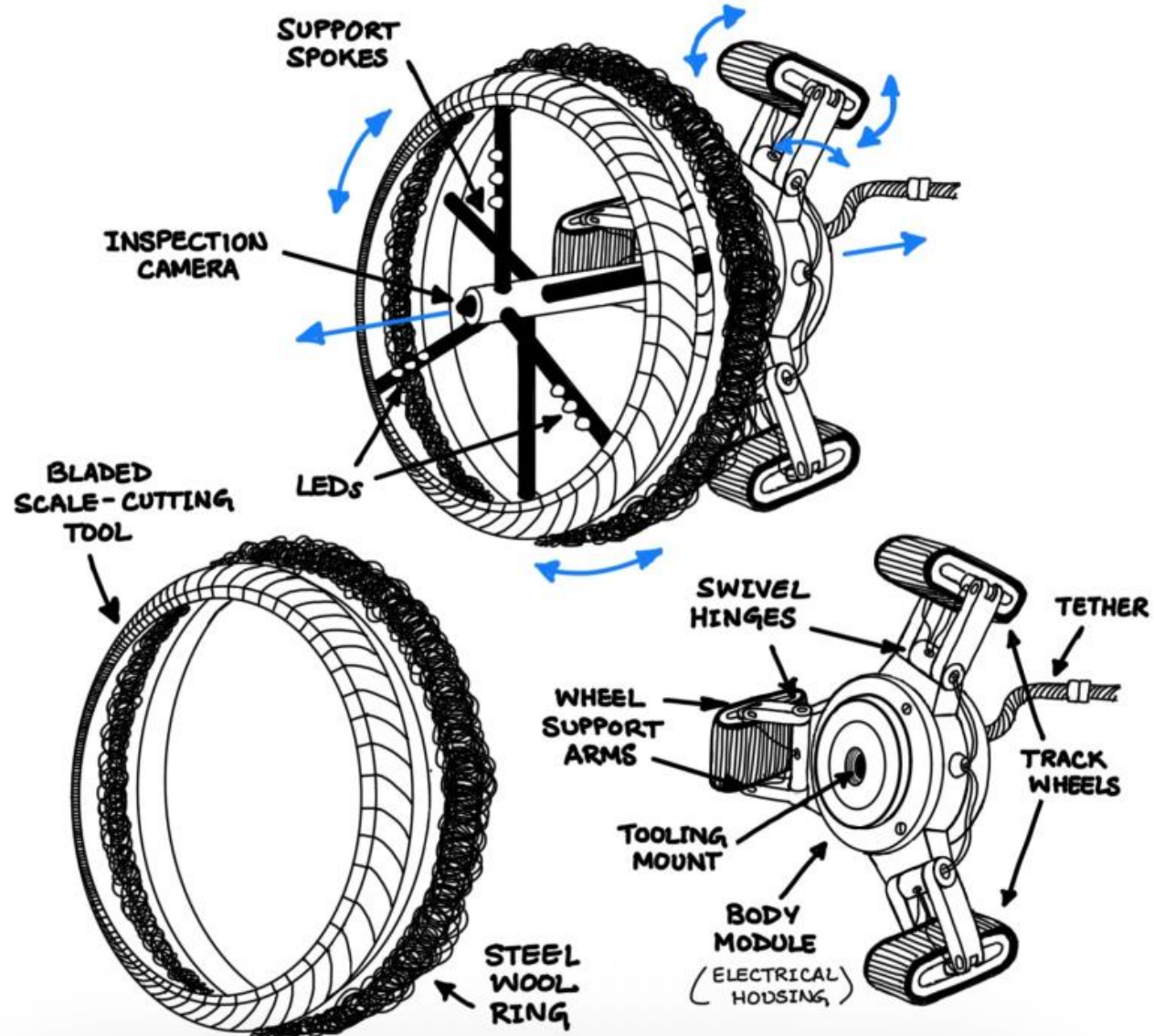
Criteria	Reason
Size	Size of robot must be small enough to fit comfortably in $\varnothing 90\text{mm}$ pipes
Mass	Light weight robot allows for easy transport
Speed	Move as efficient as a water jetting machine
Cost	Overall cost of the solution must be within budget
Manufacturability	Minimal number of parts and simple mechanism
Waterproofing	Work in damp/water splashing conditions
Mobility	Ability to move smoothly within pipes, including bends and junctions
Durability	Resistance to abrasion, chemicals, moisture
Precision	Ability to clean without damaging pipe walls

# MORPHOLOGICAL CHART

OPTION	MOVEMENT	SIZING	CLEANING
①	 OMNI-DIRECTIONAL WHEELS	 GEAR-LINKAGE MECHANISM	 PLASTIC BRISTLES
②	 TRACK WHEELS	 SHUTTER MECHANISM	 STEEL WOOL
③	 SPIDER LEGS	 SPRING LOADED	 SANDING ATTACHMENT

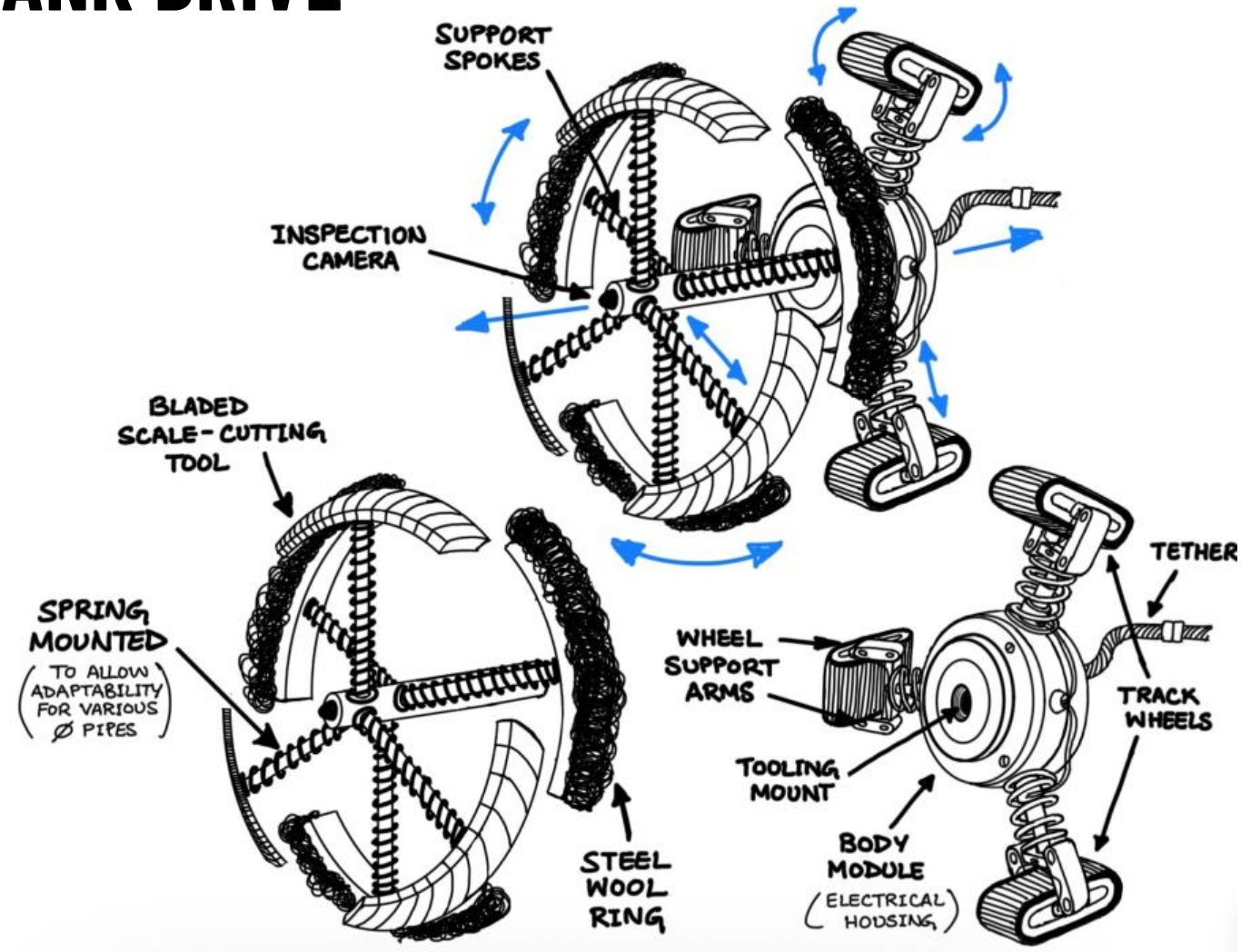


# FOUR-BAR LINKAGE TANK DRIVE



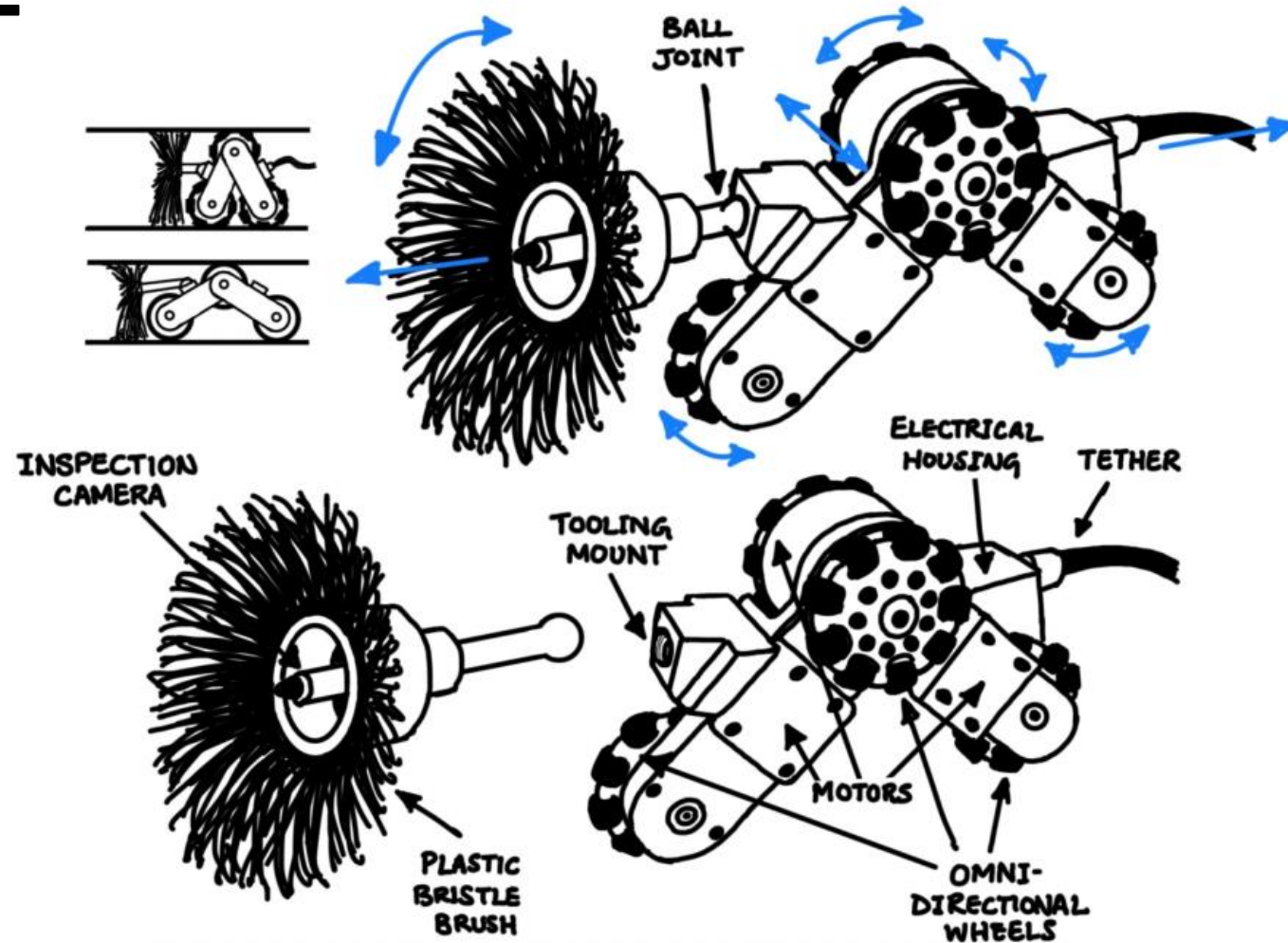


# SPRING LOADED TANK DRIVE

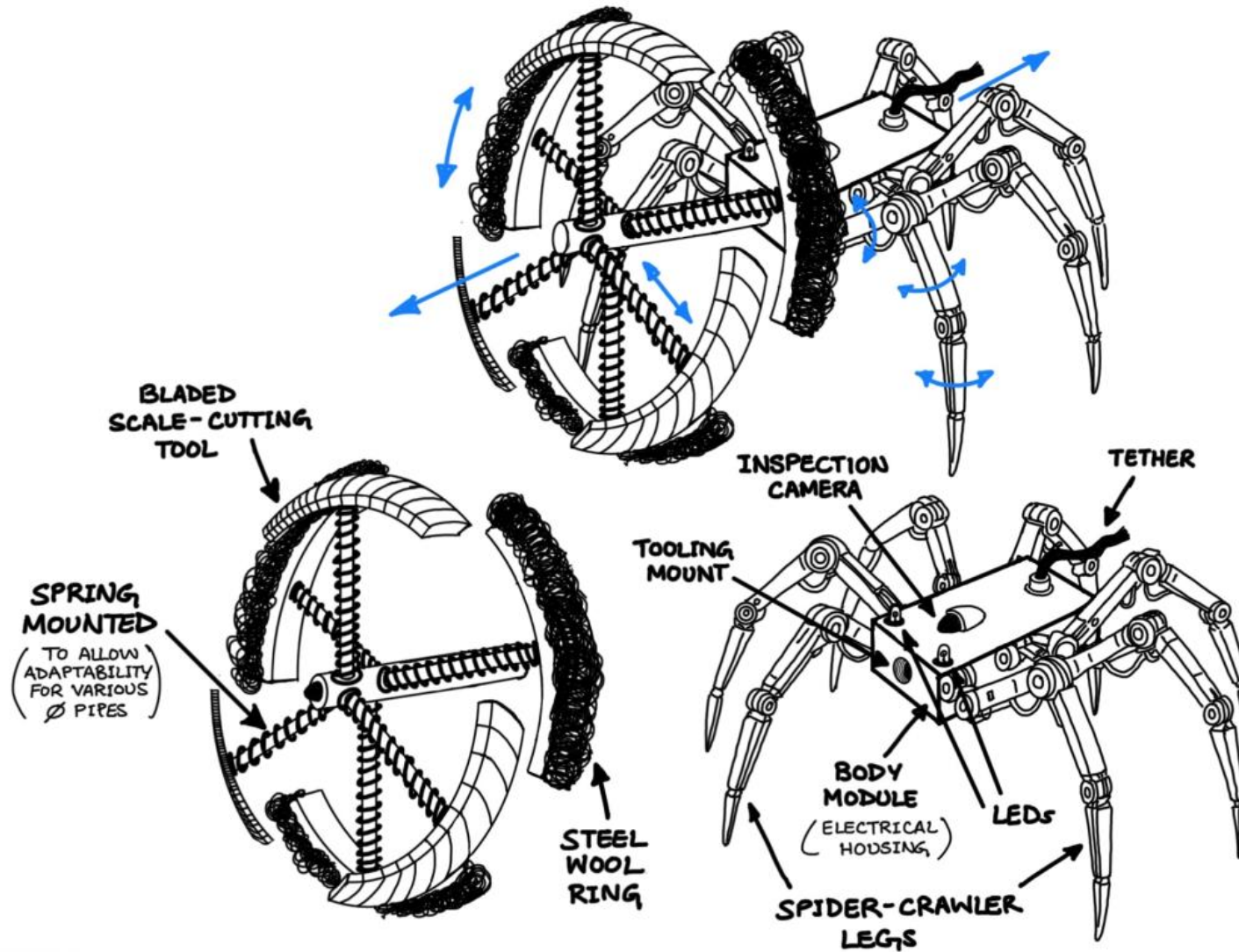




# V-SPLAY DRIVE

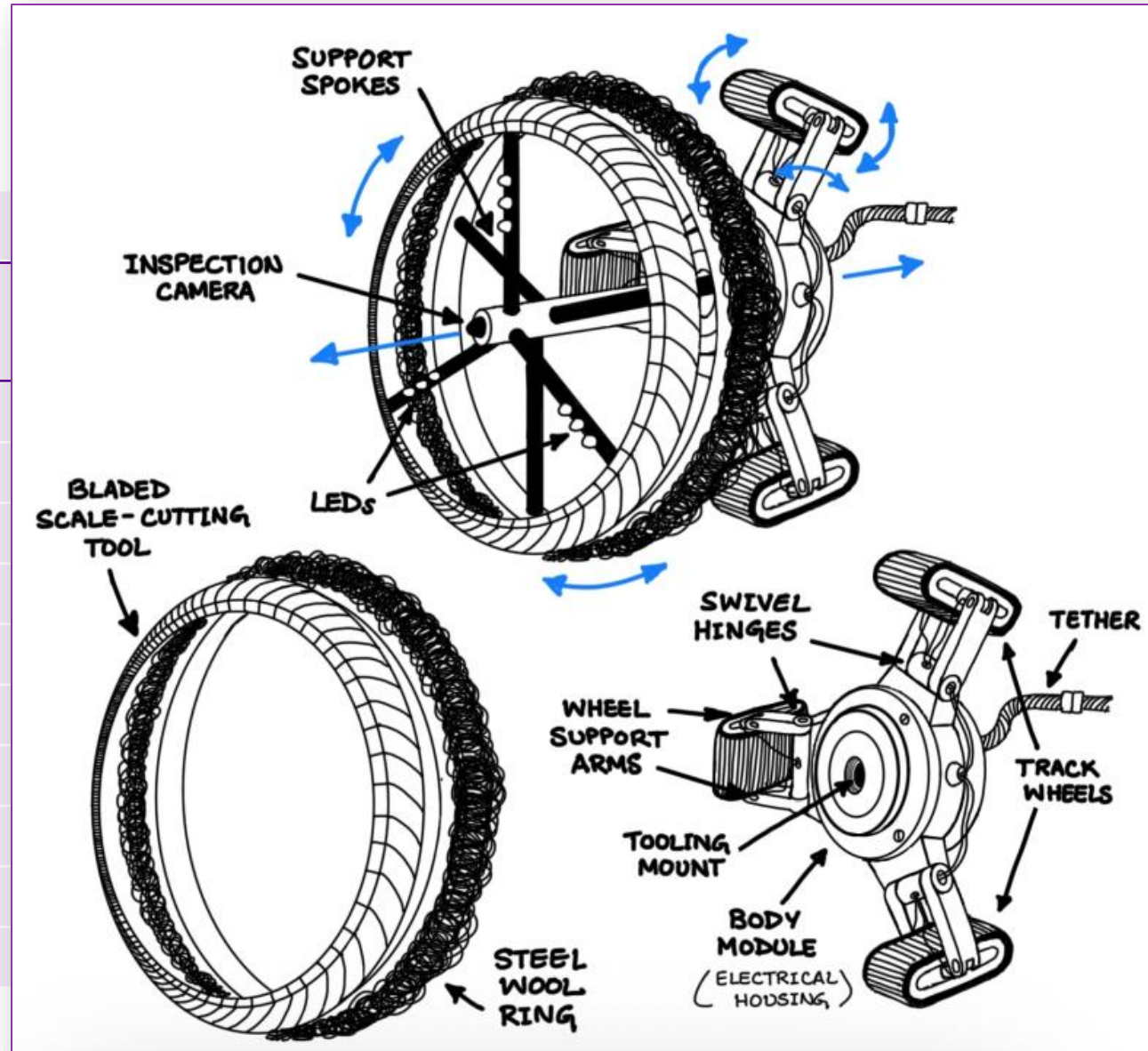


# SPIDER



# DESIGN MATRIX

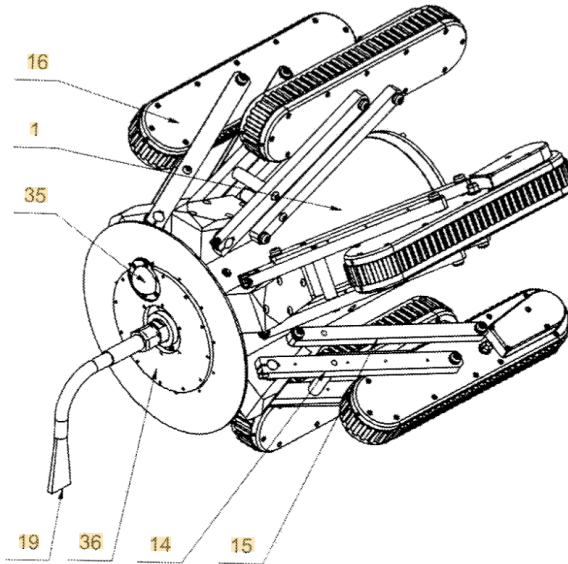
Criteria	Priority	Linkage Tank Tread	
		Rating	Weighted Score
Size	1 (x11)	3	33
Mobility	2 (x9)	4	36
Waterproofing	3 (x7)	3	21
Durability	4 (x6)	4	24
Cost	5 (x5)	3	15
Speed	6 (x4)	2	8
Manufacturability	7 (x3)	2	6
Mass	8 (x2)	1	2
Precision	9 (x1)	4	4
TOTAL			149





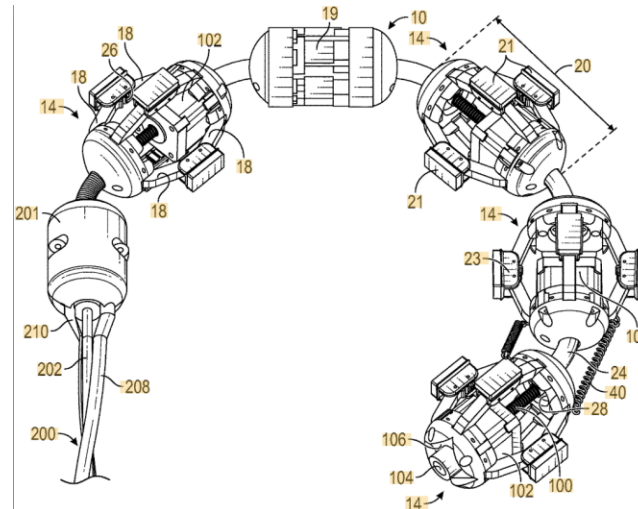
# PATENT RESERACH

Jetty Robot 6  
[US9101967B2]



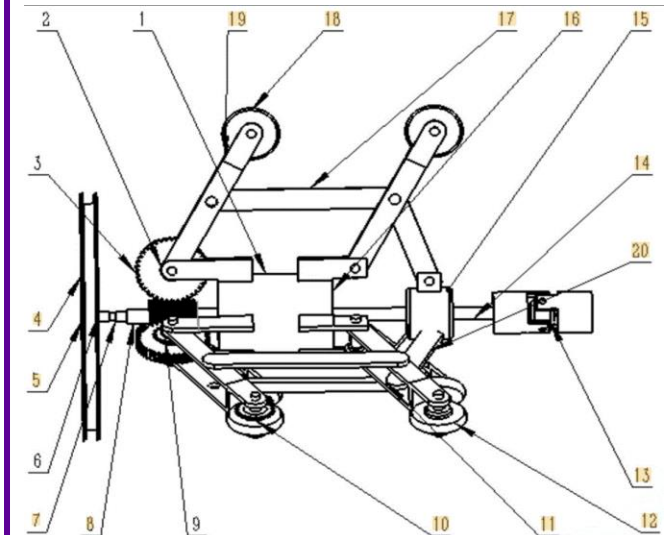
- Self-centering
- Constant-force expansion
- Operator-guided bend control
- Auto-reverse
- Unique radial drive system

Modular Robotic Crawler  
[US11781698B2]



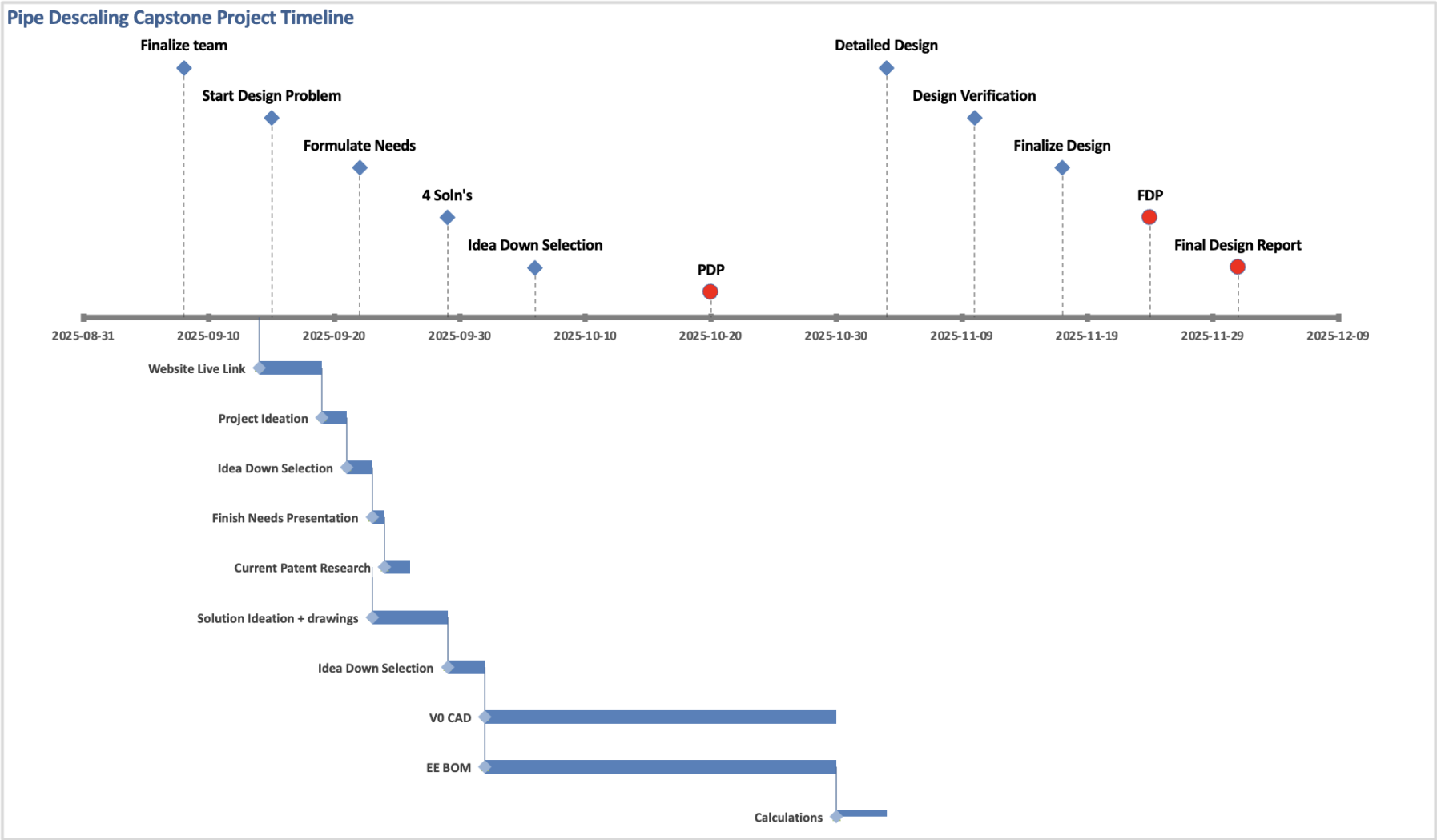
- Hybrid extension mechanism
- Multi-segment architecture
- Designed for small diameter pipes

Adaptable Pipe  
Cleaning Robot  
[CN107649470B]



- Synchronized radial actuation
- Modularity/Hot-swap features
- Sensor feedback loop

# PROJECT TIMELINE



# QUESTIONS?

