

# Louis Zhang

MECHANICAL ENGINEERING STUDENT - POLYTECHNIQUE MONTREAL

## Profile

Mechanical Engineering Student at Polytechnique Montréal with a track record of delivering high-impact prototypes – from lunar transport systems to medical assistive robotics. I bridge the gap between mechanical design and intelligent control to solve real-world engineering challenges through iterative prototyping and technical rigor.

## Contact

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- [LinkedIn](#)
- [Github](#)

## Portfolio Contents

01

### Lunar Transport System

CSA LEAP Program · 3 pages

02

### Nursie – AI Nurse Assistant

ConUHacks X – Best Use of ElevenLabs · 2 pages

03

### Autonomous Reforestation Robot

RoboHacks 2026 – Unexpected Expedition Award · 1 page







3

Projects

2x

Hackathon wins

## Core Competencies

Domain	Tools & Competencies
<b>Design</b>	 CATIA V6, SolidWorks, GD&T (ASME Y14.5), DFM/DFA, Blender
<b>Analysis</b>	 FEA (Ansys, SolidWorks Simulation), MATLAB/Simulink, CFD
<b>Robotics</b>	 ROS 2, Python, C++, Sensor Fusion (mmWave, IMU, LIDAR)
<b>Hardware</b>	 Arduino, ESP32, Pi Pico, CNC Machining, Rapid Prototyping
<b>Software</b>	 Python, C++, React.js, MongoDB, Javascript
<b>Project Management</b>	 MS Project, BOM, CSA Compliance Documentation

## Internships

### Tesla

Manufacturing Engineering Intern  
June 2026 - January 2027

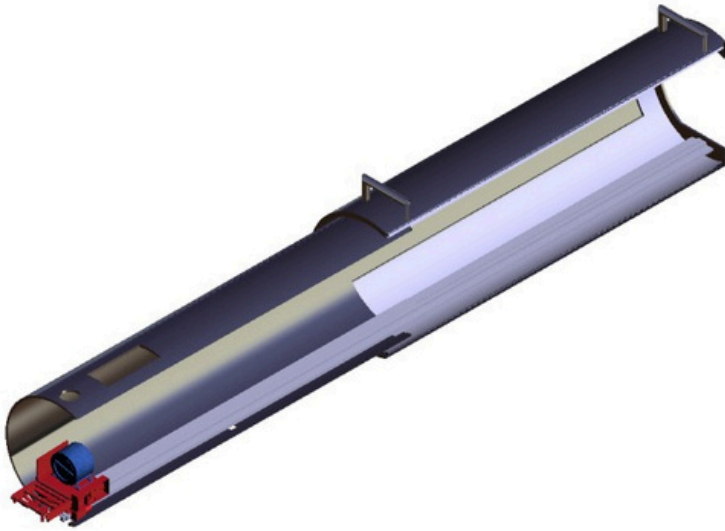
### Lockheed Martin

Mechanical Engineering Intern  
January 2026 - April 2026

### City of Montreal

Inspector  
May 2025 - August 2025

# LUNAR TRANSPORT SYSTEM



Section Cut CAD – Interior Detail, 3.1m System

- Directed end-to-end conceptualization and holistic integration of a **3.1 m lunar produce-transport system** under the Canadian Space Agency LEAP program. Orchestrated a cross-disciplinary engineering team from concept through physical build to meet **stringent CSA safety profiles**.

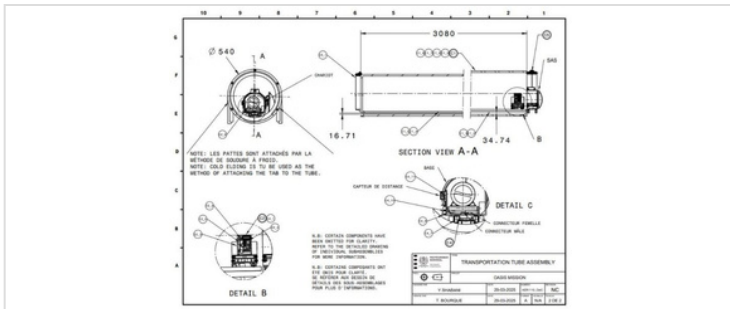
<b>3.1m</b> Telescopic Envelope	<b>-12%</b> Mass Reduction	<b>2.5×</b> Safety Factor	<b>50+</b> Part Interfaces
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PRIMARY TOOLSET

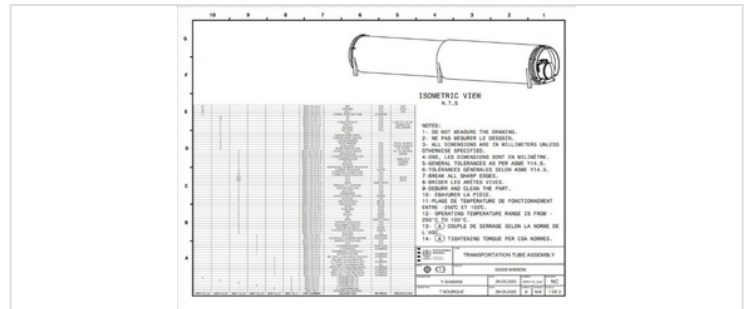
- CATIA V6
- SolidWorks
- Fusion 360
- GD&T
- MS Project
- Cold Welding

## DESIGN ARCHITECTURE

Constraint Management · Production Specification



TRANSPORTATION TUBE ASSEMBLY – SECTION VIEW A-A



TRANSPORTATION TUBE ASSEMBLY – ISOMETRIC VIEW & BOM

### Constraint Management

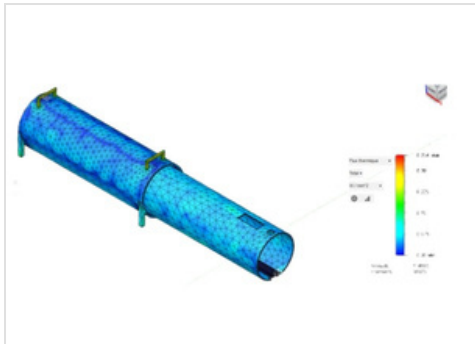
- Managed **50+ unique part interfaces** across the full system envelope – coordinating geometry conflicts between telescopic, structural, and thermal subsystems
- Iteratively optimized part geometry to achieve a **12% system mass reduction** while sustaining a **2.5× structural safety factor** under lunar load conditions
- Used **CATIA V6** parametric assemblies to enforce interface constraints and propagate design changes across dependent geometry
- Coordinated design freeze milestones with a **cross-disciplinary team** using MS Project, tracking interface dependencies across mechanical, thermal, and electrical subsystems

### Production Specification

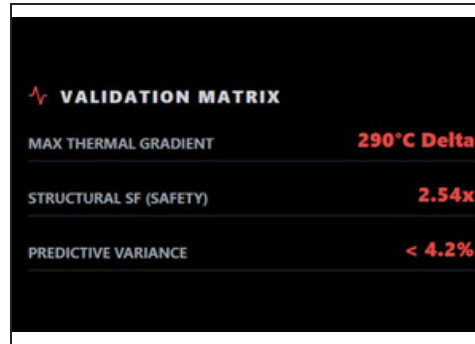
- Applied **GD&T** to all critical mating surfaces – defining flatness, perpendicularity and true-position tolerances for downstream manufacturing
- Defined **cold-welding assembly parameters** for tab-to-tube joints to eliminate thermal fatigue failure points in the vacuum operating environment
- Produced formal **manufacturing drawings** and assembly sequences aligned to CSA build standards
- Conducted tolerance stack-up analysis across all telescopic stages to verify fit under worst-case dimensional variation

FEA · THERMAL · KINEMATIC

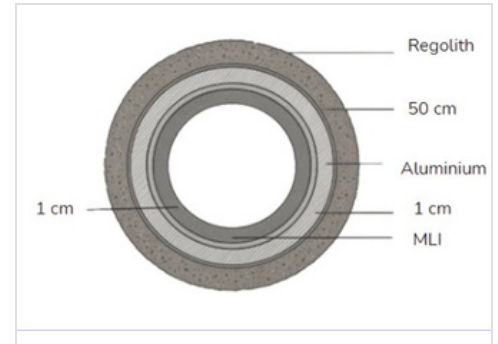
# PREDICTIVE SIMULATION & ANALYSIS



**THERMAL FEA**  
Heat distribution – 14-day lunar night cycle simulation



**VALIDATION MATRIX**  
Zero-interference validation across full 3.1m deployment



**MATERIAL STACK CROSS-SECTION**  
High-vibration launch profile – drive mechanism modal

## SIMULATION ANALYSES

Thermal Interface Control · Kinematic Integrity

### Thermal Interface Control

- Verified **heat retention limits** during 14-day lunar night cycle – ensuring produce viability through the full cold-soak period
- Identified and mitigated **thermal bridging** in telescopic aluminum joints through geometry modifications and MLI placement
- Iterative FEA-guided redesign to isolate conduction paths at each joint interface

### Kinematic Integrity

- Validated drive mechanism against **high-vibration launch profiles** – confirmed structural integrity under worst-case launch loads
- Verified **zero mechanical interference** across the full 3.1m telescopic deployment sweep through kinematic motion study
- Confirmed clearance margins at every discrete extension state across the deployment range

## MATERIAL STACK-UP ENGINEERING

Outer → Inner

### Layer 01 – Regolith Shielding

50cm radiation protection layer utilizing **local lunar regolith** for maximum passive thermal mass. Zero additional launch weight penalty – harvested in-situ.  
THICKNESS: 50cm · SOURCE: In-situ harvest · FUNCTION: Radiation + thermal mass

### Layer 02 – Al 6061 Pressure Vessel

High-strength structural core machined from **Aluminum 6061** – designed for internal atmospheric containment and primary load-bearing under operational pressure.  
MATERIAL: Al 6061-T6 · FUNCTION: Structure + pressure containment · SAFETY: 2.5x factor

### Layer 03 – Multi-Layer Insulation (MLI)

Reflective barriers optimized to minimize **radiative heat transfer** in high-vacuum operating conditions. Positioned at all critical interfaces to break thermal bridging paths.  
TYPE: MLI blanket · FUNCTION: Radiative barrier · ENVIRONMENT: High-vacuum

EMBEDDED LOGIC · POWER · INTEGRATION

# MECHATRONICS & FABRICATION

## MECHATRONICS & EMBEDDED LOGIC

### Power & Charging Interface

Designed the power routing and charging interface to maintain **electrical continuity across all telescopic extension states** – from stowed to full 3.1m deployment. Validated signal integrity throughout the complete motion envelope.

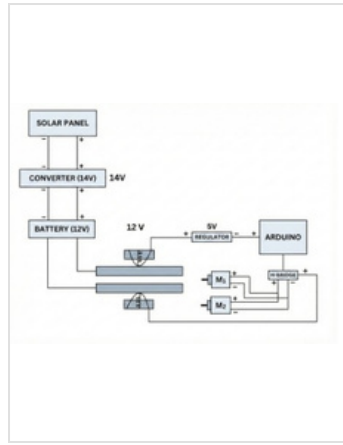
### DYNAMIC VALIDATION — CONFIRMED

**Electrical continuity** verified during live telescopic extension cycle.  
**Autonomous transport cycle** end-to-end – no manual intervention required.

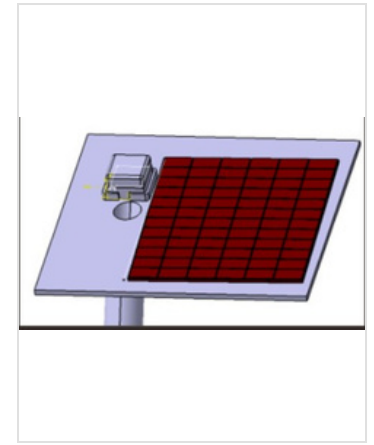
**LOGIC STACK INTEGRATION**

PRIMARY: ARDUINO (WAGON LOOP)

SECONDARY: PI PICO (CONVEYOR LOGIC)



POWER & CHARGING CIRCUIT



SOLAR PANEL ASSEMBLY

## PHYSICAL FABRICATION & ASSEMBLY

Served as **Lead Physical Integration** – coordinating mechanical, electrical, and thermal assembly sequences across all subsystems to meet CSA build specifications and test readiness milestones.

### FABRICATION SPECIALIZATIONS

AL-6061 Machining

MLI Fabrication

PCB Prototyping

Wiring Harnesses

▶ DYNAMIC VALIDATION – VIDEO 1

### Rail Conductivity Test

Validates electrical continuity across telescopic rail extension

[WATCH VIDEO →](#)

RAIL CONDUCTIVITY TEST

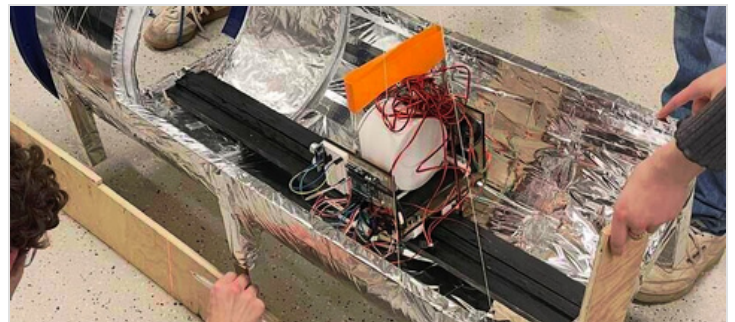
▶ DYNAMIC VALIDATION – VIDEO 2

### Full Assembly Demo

End-to-end autonomous transport cycle – full system operation

[WATCH VIDEO →](#)

FULL ASSEMBLY DEMO



PHYSICAL INTEGRATION – LAB BUILD

## TECHNICAL SUMMARY

At a glance

DISCIPLINE	SCOPE	OUTCOME
Systems Integration	50+ part interfaces, 3.1m envelope	~12% mass, 2.5x safety factor
Thermal Engineering	14-day lunar night cycle FEA	Heat retention verified, bridging mitigated
Mechatronics	PCB, wiring harness, embedded logic	Continuity validated across all states
Fabrication	AL-6061, MLI, PCB, wiring	Lead physical integration – CSA spec

## KEY COMPETENCIES DEMONSTRATED

Summary

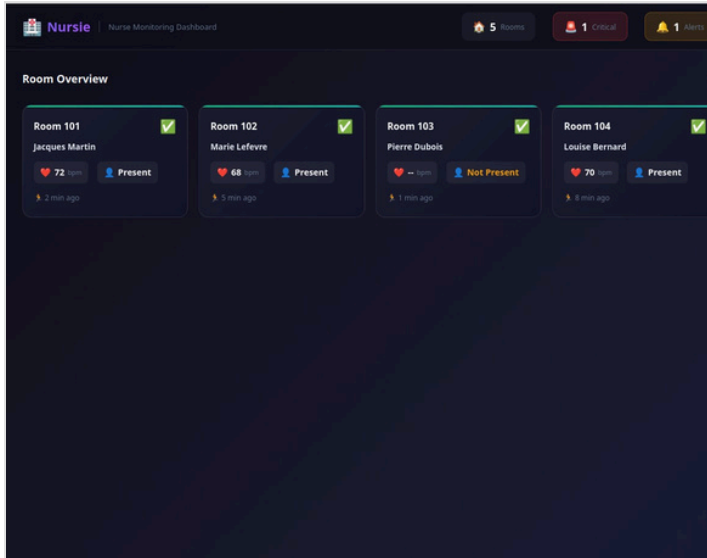
- ✓ Managed 3.1m telescopic deployment envelope under CSA safety constraints
- ✓ Validated electrical continuity across all telescopic motion states
- ✓ Advanced CAD modelling (CATIA V6) + FEA simulation (thermal & kinematic)
- ✓ Hands-on fabrication lead – machining, PCB, MLI, wiring, full assembly

HACKATHON PROJECT · LONG-TERM CARE · SENSOR FUSION · EDGE AI



# NURSIE

# AI NURSE



Nurse Monitoring Dashboard – Real-time room overview & active alerts

Built an **on-premises AI nurse assistant** for Quebec long-term care facilities (CHSLDs) that detects falls and monitors residents using privacy-preserving hardware – no cameras, no cloud. Falls among seniors (65+) are a leading cause of injury hospitalizations in Canada, rising **47% between 2008–2019**. Nursie addresses the gap between unwitnessed falls and delayed staff response.

<b>47%</b> RISE IN FALL HOSPITALIZATIONS	<b>3×</b> SENSOR REDUNDANCY	<b>0</b> CAMERAS USED	<b>LAN</b> LOCAL-ONLY ARCHITECTURE
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PRIMARY STACK



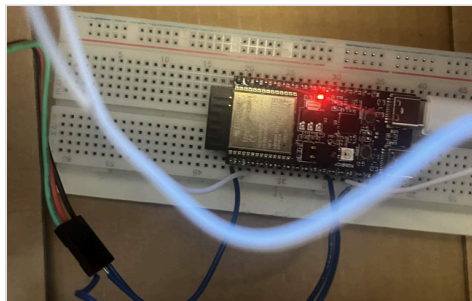
## SENSOR HARDWARE

Privacy-Preserving · Redundant · Edge-Processed



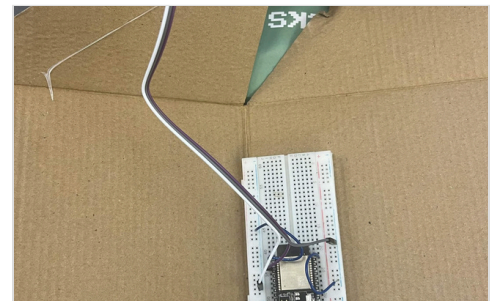
**MMWAVE RADAR (IWR6843)**

Continuous position & activity sensing via electromagnetic waves. Detects falls and tracks presence with no camera. Signal-processing tuned to reject curtain & object motion noise.



**ESP32 DOOR + PIR NODE**

Magnetic door sensor + PIR presence detector running FreeRTOS on ESP32. Publishes occupancy state over ROS 2 – flags night-time room exits for anomaly detection.



**FLOOR VIBRATION MAT NODE**

Detects floor-impact signature on contact. Fused with radar to distinguish a critical fall from a dropped object – reduces false-positive alerts for nursing staff.

## DESIGN PRINCIPLES

Architecture Rationale

**01 – FAST DETECTION FIRST**

High confidence + fast alerting is the system's core mission. Every design choice subordinates itself to detection latency and reliability.

**02 – SENSOR REDUNDANCY**

mmWave radar, floor vibration mat, and wearable fused together. No single sensor failure breaks detection. Confidence scoring gates alert escalation.

**03 – PRIVACY BY ARCHITECTURE**

All data stays on a local OpenWRT LAN. No camera. No raw data leaves the facility by default. Compliant with Québec Law 25 privacy framework.

AI PIPELINE · DASHBOARD · OUTCOMES

# ALERT PIPELINE & OUTCOMES

## AI & BACKEND PIPELINE

Gemini · ElevenLabs · MongoDB · ROS 2



[Watch Full Demo \(Youtube Video\)](#)

### Project Key Outcomes (Impact & Compliance)

- ▶ **Law 25 & Privacy-First:** Satisfies Québec’s personal information protection framework (on-premises, zero-cloud dependency).
- ▶ **Advanced SNR & Fall Detection:** Fuses mmWave radar + vibration mat for soft vs. critical fall discrimination. Optimized Signal-to-Noise Ratio (SNR).
- ▶ **Production-Ready Edge Design:** Scalable, low-latency design on OpenWRT LAN. LAN-local by design.

### The Engineering Story: Challenges & Solutions

#### 🔊 SIGNAL CLARITY (mmWave SNR Optimization)

Differentiating human heartbeat signatures from moving curtains. Custom signal processing algorithms and threshold tuning.

**Impact:** Repeatable sensor node performance and manufacturable design.

#### 📍 REAL-TIME RELIABILITY & LAN MESH

Resolving real-time telemetry instability and sensor fusion logic through an optimized ESP32 mesh network.

**Impact:** Integrated sensor node ready for deployment in high-reliability environments.

### Future Roadmap

#### 📱 Apple Watch Integration

Secondary vital-sign validation for high-risk patients.

#### 🚶 Predictive Gait Analysis

Using radar data models to estimate fall risk before an incident occurs.

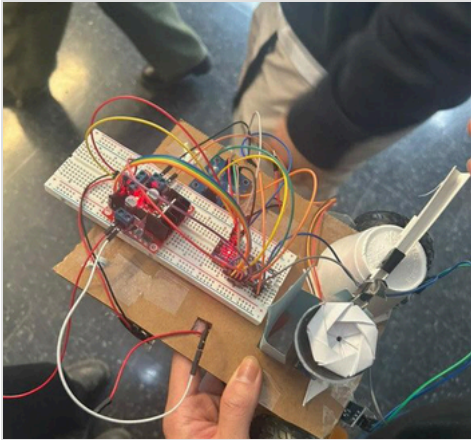
#### 🔧 Medical-Grade Hardware

CHSLD rollout plan, with a focus on manufacturing efficiency and scalability.

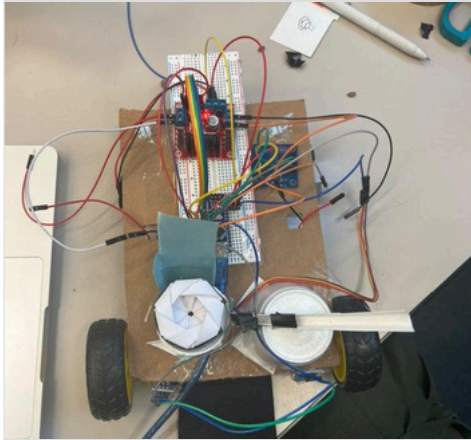
ROBOHACKS · FEB 2025 · ARDUINO · RECYCLED MATERIALS

 WINNER — UNEXPECTED EXPEDITION AWARD · 5th Place Overall

# AUTONOMOUS REFORESTATION ROBOT



Top view — breadboard, Arduino, IR sensors & seed dispenser



Presentation demo — full assembly on competition floor

Built a fully autonomous seed-planting robot in **24 hours** using recycled materials—cardboard chassis, plastic bottles, and a paper-engineered seed dispenser. Coded the entire navigation and dispensing sequence in **C++ on Arduino**, wiring all electronics from scratch.

<b>24h</b> BUILD WINDOW	<b>3</b> SENSORS INTEGRATED	<b>5th</b> PLACE OVERALL
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STACK

- Arduino C++
- IR Sensors
- Color Sensor
- DC Motors
- Recycled Materials

ENGINEERING & CODE 

Arduino · Sensors · Navigation

- ▶ **Autonomous navigation** — two infrared sensors fused with a color sensor for precise line-following along a designated black track
- ▶ **Motorized seed dispenser** — custom-engineered from paper and recycled materials; servo-actuated for accurate, timed seed placement
- ▶ **Full C++ codebase** — sensor polling loop, motor PID steering, and dispenser trigger sequence all written and debugged within the 24-hour window
- ▶ **Wire integration** — manually routed all electronics on a breadboard; confirmed signal integrity under live competition conditions

SUSTAINABLE DESIGN 

Recycled-First Construction

RECYCLED-FIRST PRINCIPLE





The robot's chassis was built entirely from **repurposed cardboard and plastic bottles**. The seed dispenser was engineered from paper — folded into a functional rotating mechanism with no 3D-printed or machined parts. Demonstrated that **functional robotics hardware** can be prototyped with zero-waste materials under competition constraints.

✓ Designed, built & coded full robot independently in 24h

✓ Award-winning recycled-material robot construction

KEY COMPETENCIES DEMONSTRATED

Summary

DISCIPLINE	SCOPE	OUTCOME
Embedded Systems 	Arduino C++, 3 sensors, motor control	Fully autonomous navigation & dispensing
Hardware Integration 	Breadboard wiring, IR + color sensor fusion	Reliable line-following under competition load
Sustainable Fabrication 	Cardboard, plastic bottles, paper dispenser	Zero-waste build —  Unexpected Expedition Award