An Agentic AI Approach to Space Harness Component Selection

Qiana Curcuru, Jasmin Lim, Jon Williamson, Jacob La Rocca, Matthew Zaluski, David Tang, Brendyn Sang

6th Space Passive Component Days (SPCD) 2026

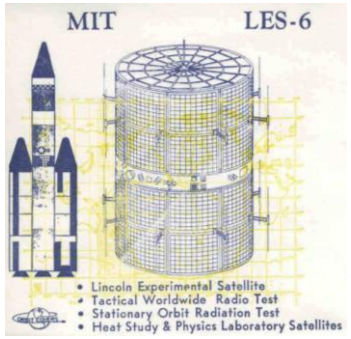
14 October 2026

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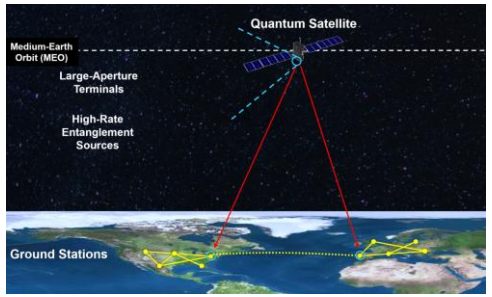
Technology Consistently Requires Us to Evolve



LES-6 (1960s)



Lunar Laser Communications Demonstration (2010s)

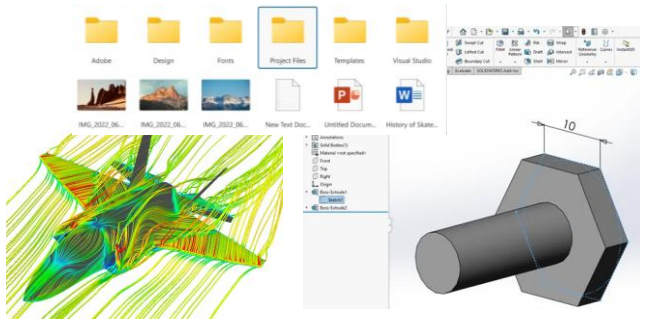


Quantum Satellite
Marconi 2.0 (2020s)

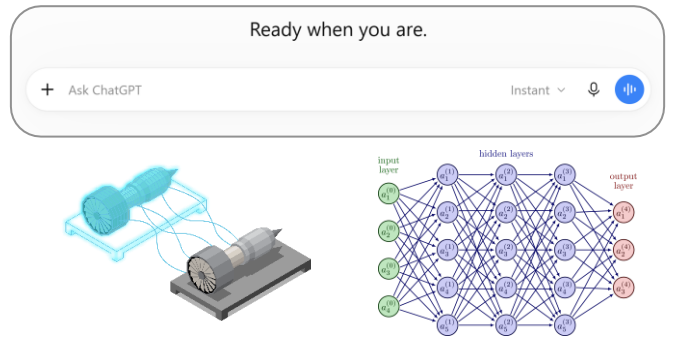
Physical



Digitalization



Digital Engineering & AI



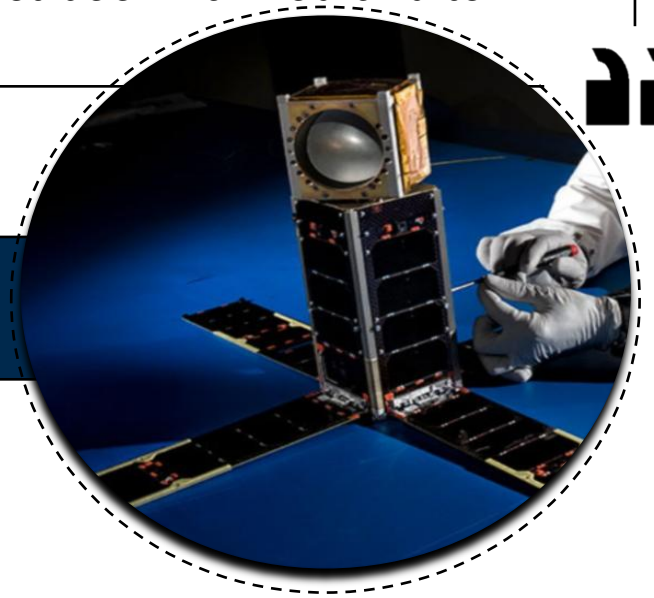
Increasingly complex challenges and accelerated timelines are driving the need for new methodologies

Cable Design is Imperative to Mission Success

Problem: Subpar cable design can lead to detrimental consequences without proper support

> *A cable shorted to ground during TVAC testing. We were lucky, and the payload was not harmed, but it took a while to prove that. We definitely had to stop testing for a while (few days) to determine the payload had not been harmed and to modify the cable set-up before proceeding.*

Anne Vogel, Assistant Group Leader
Payload Engineer MicroMAS, MIT LL

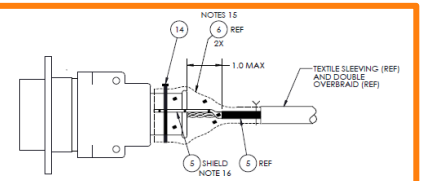


Make cable design support accessible to programs of all sizes with AI-assisted cable harness part selection to improve accuracy and reduce design lead time

Cable Design Anatomy

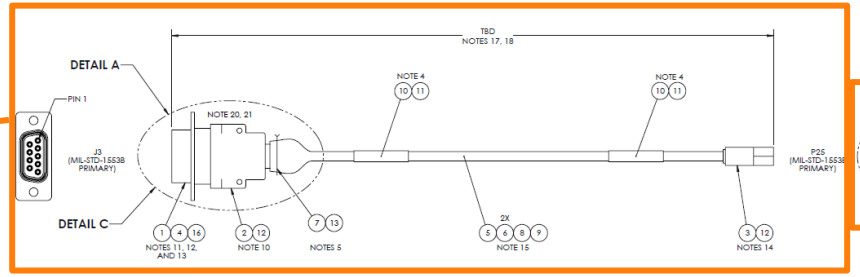
Bill of Materials

ITEM NO.	QTY.	PART NUMBER	PART NAME	VENDOR	VENDOR NUMBER	REMARKS/REFDES
1	1	E1166762	CONNECTOR,PLUG, ELECT,9 PIN,HIPER D-SUB	GLENAIR INC	280-018P159MEGN-429A	J3
2	1	E1164055	BACKSHELL,HYPER-D,EMI,TOP ENTRY C,SIZE 1	GLENAIR INC	289T006M1 C-NNN	J3
3	1	E1167057	CONN CABLE PLUG TRIAX	SABRITEC	311P826-02	P24
4	2	E1167072	CONTACT ELECT PIN CRIMP 20-24 AWG		G10P1	
5	AR	E1167101	CABLE TWINAX JCKTD		M17/176-00002	
6	AR	E9030578	SLVR PLATED COPPER TUBULAR BRAID .250ID		A-A-59569R3650250	
7	AR	E9031550	TAPE LACING/TYING POLYESTER LOW OUTGAS		18DPTH	
8	AR	E9030706	SLEEVING TEXTILE ELECT 0.120-.370 ID	PANDUIT	SE25PFR-TRO	
9	AR	E9030615	SOLDER Sn63Pb37 3.3%/285 .015 18 SPL	KESTER SOLDER CO.	24-6337-9703	
10	AR	E9031166	LABEL TEDLAR WHT 1.00 WIDE X 85FT LG	BRADY	B33C-1000-437	
11	AR	E9031168	PRINT RIBBON BLK 4.33 WIDE X 200 FT LG	BRADY	B30-R4300	
12	AR	E1055480	ADH EC-2216 B/A GRY MS(5B:7A:0.24MS)3.9G	APPLI-TEC	3EE-BF-3109-3.9	
13	AR	E1117121	ADH 5753A/B(LV-FD)/TX MD THIX 3CC ESD 3G	APPLI-TEC	3EE-BF-3304-003	
14	1	E1105322	BAND-IT SHIELD TERMINATION MICRO STD LEN	GLENAIR	600-057	
15	AR	E9030593	INSULATION SLEEVING SHRINK 0.375 ID CLR		M23053/8-007-C	
16	AR	E1225104	TAPE, 3M COPPER 1181, 1/2" WIDE	DUNMORE CORP	TR01491 0.5A	



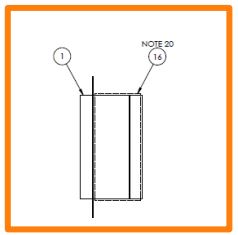
DETAIL A
VIEW SHOWN WITHOUT
ITEM 9 TEXTILE SLEEVING

Assembly Diagram



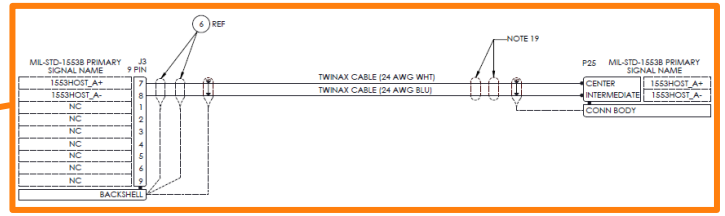


DETAIL B



DETAIL C
BACKSHELL ITEM 2 NOT SHOWN

Schematic



Notes

NOTES:

1. MATERIAL: SEE PARTS LIST.
2. CABLE ASSEMBLY TO BE FABRICATED WITH THE FOLLOWING STANDARDS. USE CURRENT STANDARDS VERSION AT THIS DRAWING. ORIGINAL RELEASE DATE.
   - NASA-STD-8739.1 REQUIREMENTS FOR CONFORMAL COATING AND STAKING OF PRINTED WIRING BOARDS AND ELECTRONIC ASSEMBLIES.
   - NASA-STD-8739.4 CRIMPING, INTERCONNECTING CABLES, HARNESS, AND WIRING.
   - IPC/J-STD-001FS OR CURRENT REVISION OF SPACE APPLICATIONS FOR SOLDERED ELECTRICAL AND ELECTRONIC ASSEMBLIES.
3. PER NASA-STD-8739.4 PARA 18.2.6 REVISE DIELECTRIC WITHSTANDING TEST VOLTAGE RANGE TO 500 PLUS OR MINUS 40 VDC.
4. MARKING: MARK PER LL SPEC PS-7-1, CLASS XIV, TYPE II, METHOD AS SHOWN IN MARKER CHART.
5. TRIM LACING TAPE ITEM 7 AS REQUIRED AND APPLY ARATHANE ITEM 13 TO ENDS.
6. PRECISION CLEAN PER LL SPEC PS-3-26.
7. MATERIAL VACUUM OUTGASSING SHALL BE DETERMINED IN ACCORDANCE WITH ASTM E-595. ONLY MATERIALS THAT HAVE A TOTAL MASS LOSS (TML) <1.00% AND A COLLECTED VOLATILE CONDENSABLE MASS (CVCM) <0.10% ARE ALLOWABLE.

   VACUUM BAKE PER LL SPEC PS-3-22 AT +90 DEG/C FOR A MINIMUM OF 3 DAYS. INITIAL OUTGASSING RATE (MZ/HR) ESTABLISHED BY SACHI CONTAMINATION CONTROL ENGINEER. TERMINATION RATE SHALL BE AN OUTGASSING RATE CHANGE LESS THAN 5%/HR. THE OUTGASSING WILL BE MONITORED WITH A TQCM TEMPERATURE AT -40 DEG/C AND PART TEMPERATURE OF +55 DEG/C. SACHI CONTAMINATION CONTROL ENGINEER APPROVAL IS REQUIRED PRIOR TO TERMINATION.
8. PROCURED FASTENERS SHALL COMPLY WITH S41-PG-8072.2.2 GSFC FASTENER INTEGRITY REQUIREMENTS.
9. STANDARD PARTS SHALL BE USED AS DEFINED IN EEE-INST-002 FOR LEVEL 1 FLIGHT HARDWARE. STANDARD PARTS SHALL BE LEVEL 1 PARTS OR UPSCREENED LEVEL 2 PARTS SELECTED FROM THE NASA PARTS SELECTION LIST (NPSL).
10. AFTER CABLE TEST, TORQUE AND STAKE BACKSHELLS USING ITEM 12. TORQUE BACKSHELL HARDWARE 4.0 - 4.5 IN-LBS.
11. DISCARD CONTACTS SUPPLIED WITH ITEM 1 AND REPLACE WITH ITEM 4.
12. FOR REFERENCE:
    FOR PIN CONTACTS ITEM 4:
    CRIMP TOOL: M22520/2-01
    POSITIONER: M22520/2-08
    INSERTION/EXTRACTION TOOL: MB1969/1-02
13. DO NOT POPULATE ALL UNUSED POSITIONS WITH THE APPROPRIATE CONTACTS.
14. ASSEMBLE ITEM 3 PER SABRITEC ASSEMBLY INSTRUCTIONS #AI-1041.
15. USE DOUBLE OVERBRAID.
16. USE SHIELD EXTRACTOR (JENSEN TOOL #81-1-100, JONARD M-724-A OR EQUIVALENT) TO EXTRACT PRIMARY CONDUCTORS FROM SHIELDED CABLE TO LEAVE APPROX 2 - 2.5 INCHES OF BRAID PIGTAIL TO TERMINATE TO BANDING PORCH PER DETAIL A.
17. LENGTH TO BE DETERMINED USING SACHI CUSTOM FIXTURE E1214427.
18. CABLE LENGTH TOLERANCES PER IPC/WHMA-A-620B, TABLE 11-1.
19. FOR THE FLOATING INNER AND OUTER OVERBRAID ENDS ITEM 6, TRIM BOTH LAYERS OF OVERBRAID .25-.38 FROM REAR OF CONNECTOR P24 AND SECURE TRIMMED BRAID END WITH SLEEVING ITEM 15.
20. WRAP ONE LAYER OF COPPER TAPE ITEM 16 AROUND REAR PORTION OF CONNECTOR ITEM 1 AT GROOVED AREA TO ACCOMMODATE FOR LOOSE FITTING BACKSHELL. USING ORANGE STICK OR EQUIVALENT CAREFULLY FORM THE COPPER TAPE TO THE GROOVE AS REQUIRED SO THE GROOVE IS VISIBLE FOR APPROPRIATE BACKSHELL ASSEMBLY REGISTRATION.
21. PRIOR TO FINAL DRESSING OF TEXTILE SLEEVING ON TO BANDING PORCHES, PERFORM BONDING RESISTANCE TEST. RESISTANCE BETWEEN INSTALLED BANDING CLAMP, ITEM 14 AND CORRESPONDING CONNECTOR SHELL ITEM 1 TO BE LESS THAN OR EQUAL TO 10 MILLIOHMS. USE MILLI-OHM METER PROVIDED BY THE SACHI PROGRAM.

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Cable Details

CONN END	MARKING
J3	W13 - J3 (A0-P3) MIL-STD-1553B PRIMARY E1167046, REV [ ] S/N [ ]
P25	W13 - P25 (A0-225) MIL-STD-1553B PRIMARY E1167046, REV [ ] S/N [ ]

NOTE: [ ] INDICATES CURRENT REVISION LETTER OR SERIAL NO.

CABLE MARKING CHART

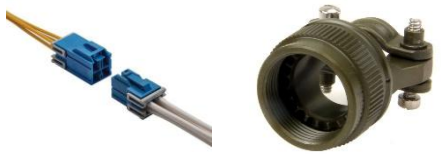
DESIGNED	C. WOOTEN	LINCOLN LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY LEXINGTON, MASSACHUSETTS	
ENGINEER	C. HART		
PROJECT	ECM-SOF2V2	TITLE	W13 CABLE ASSY
THIRD ANGLE PROJECTION	RELEASED 06/19/2019	SIZE D	CAGE CODE 3G050
PROGRAM	SACHI	SCALE 3:2	DO NOT SCALE DWG
		PART NUMBER	E1167046
		REV	C
		SH 1 OF 1	

Legend

- Text data
- Image data

Bill of Materials (BOM) Breakdown

ITEM NO.	QTY	Part Number	Part Name	Vendor	Vendor Number
1	1	E1166762	CONNECTOR,RCPT, ELECT,9 PIN,HIPER D-SUB	GLENAIR INC	280-018P1S9MEGN-429A
2	1	E1164055	BACKSHELL,HYPER-D,EMI,9 POS,TOP ENTRY C	GLENAIR INC	289T005ME1C-NNN
3	1	E1167057	CABLE PLUG, TRIAX	SABRITEC	311P826-02
4	9	E1167072	CONTACT, ELECT, PIN, CRIMP, 20-24 AWG		G10P1
5	AR	E1167101	CABLE, TWINAX		M17/176-00002
6	AR	E1193231	COMPOSITE SHIELD BRAID .125 - .312ID	GLENAIR INC	103-027-008S
7	AR	E9031550	TAPE LACING/TYING POLYESTER LOW OUTGAS		18DPTH
8	AR	E9030706	SLEEVING TEXTILE ELECT 0.120-.370 ID	PANDUIT	SE25PFR-TR0
9	AR	E9030615	SOLDER .015" LEAD ALLOY SN63PB37-285 RMA	KESTER SOLDER CO.	24-6337-9703
10	AR	E9031166	LABEL TEDLAR WHT 1.00 WIDE X 85FT LG	BRADY	B33C-1000-437
11	AR	E9031168	PRINT RIBBON BLK 4.33 WIDE X 200 FT LG	BRADY	B30-R4300
12	AR	E1055480	ADH EC-2216 B/A GRY M5(5B:7A:0.24M5)3.9G	APPLI-TEC	3EE-BF-3109-3.9
13	AR	E1117121	ADH 5753A/B(LV-FD)/TX MD THIX 3CC ESD 3G	APPLI-TEC	3EE-BF-3304-003
14	1	E1177350	BAND-IT SHIELD TERMINATION, STD	GLENAIR INC	600-052



Connectors, Pins & Backshells

Always on BOM

- Wire
- EMI Braid
- Lacing Cord
- Sleeve shrink
- Solder

Labels

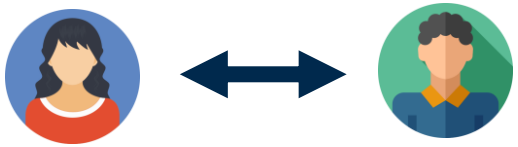
Adhesive

Banding porch

Cable BOMs contain repeatable categories of components, making this a good case for AI automation

AR: As Required
BOM: Bill of Materials

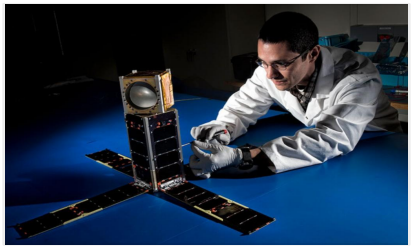
Cable Design Workflow



Engineer

Cable Designer

Part Selection



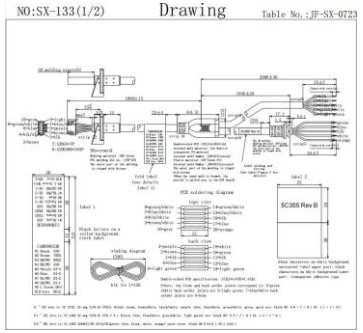
Select parts that meet program requirements

Procurement

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14	1	E1177350	BAND-IT SHIELD TERMINATION, STD	GLENAIR INC	600-052

Buy and receive parts from suppliers

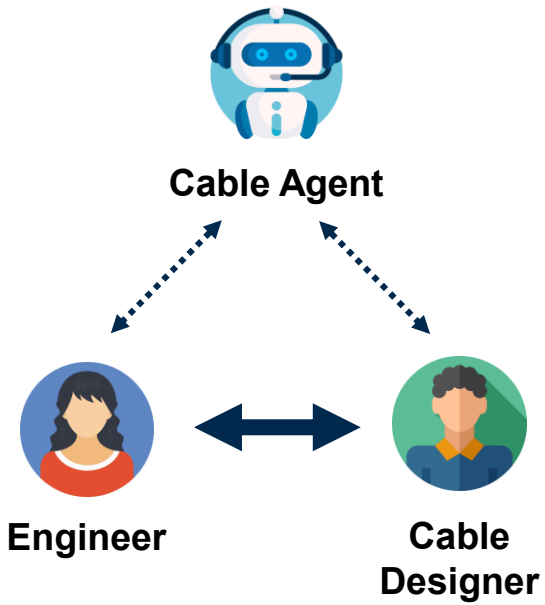
Cable Design



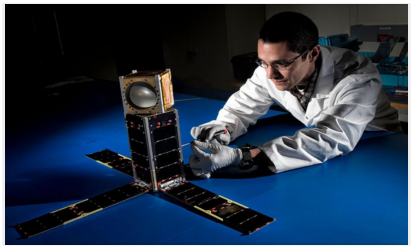
Create technical package and drawings

- ✓ Part selection is performed part-by-part, constrained by human search capacity
- ✓ This limits procurement options and can create lead-time bottlenecks

Cable Design Workflow



Part Selection



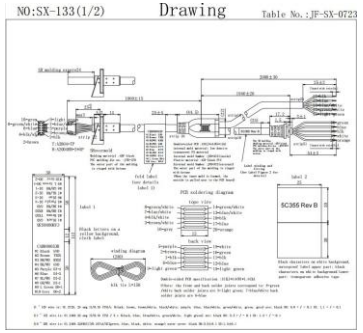
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13	AR	E1117121	ADH 5753A/B(LV-FD)/TX MD THIX 3CC ESD 3G	APPLI-TEC	3EE-BF-3304-003
14	1	E1177350	BAND-IT SHIELD TERMINATION, STD	GLENAIR INC	600-052

Buy and receive parts from suppliers

Cable Design



Create technical package and drawings

- ✓ The cable agent performs comprehensive searching of parts within defined requirements
- ✓ Exposes viable alternatives and driving faster procurement times

Outline

- Introduction
- **Multi-Agent Framework**
- Results
- Conclusion

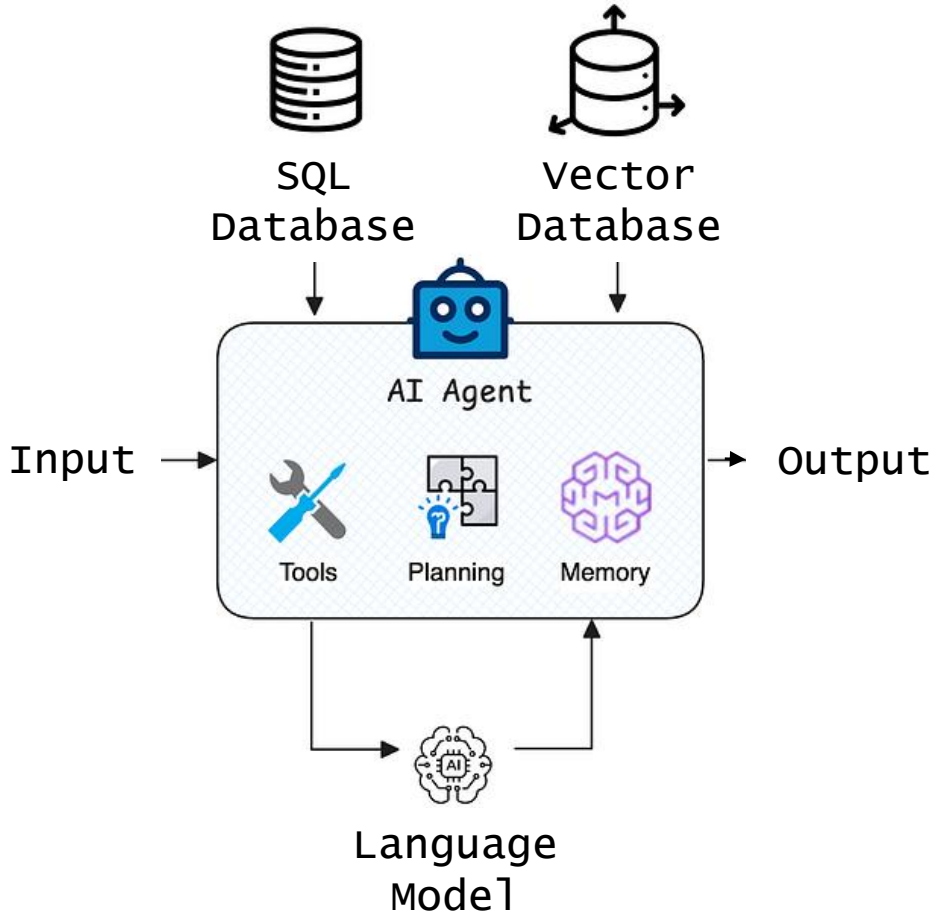
AI Agents for Task Automation

Autonomy

- An *Agent* is a software product that uses AI to pursue goals and **complete tasks** on behalf of users
- Powered by a core **Language Model (LM)** to reason, plan actions, and call tools

Modularity

- Agents have **access to data sources and tools** to achieve specific objectives outside of itself
- **Retrieval Augmented Generation (RAG)** is a technique that enables agents to retrieve new information without additional training
- Easy to extend and scale by plugging in new agents later



Multi-agent systems combine specialized workers into one cohesive team

Cable Agent Design Progress

Approach

Meet with cable design SMEs

- Translate expert decision-making processes into structured logic
- Include wire ratings, connector standards, environmental requirements

Knowledge Sources

MIL/NASA Specifications

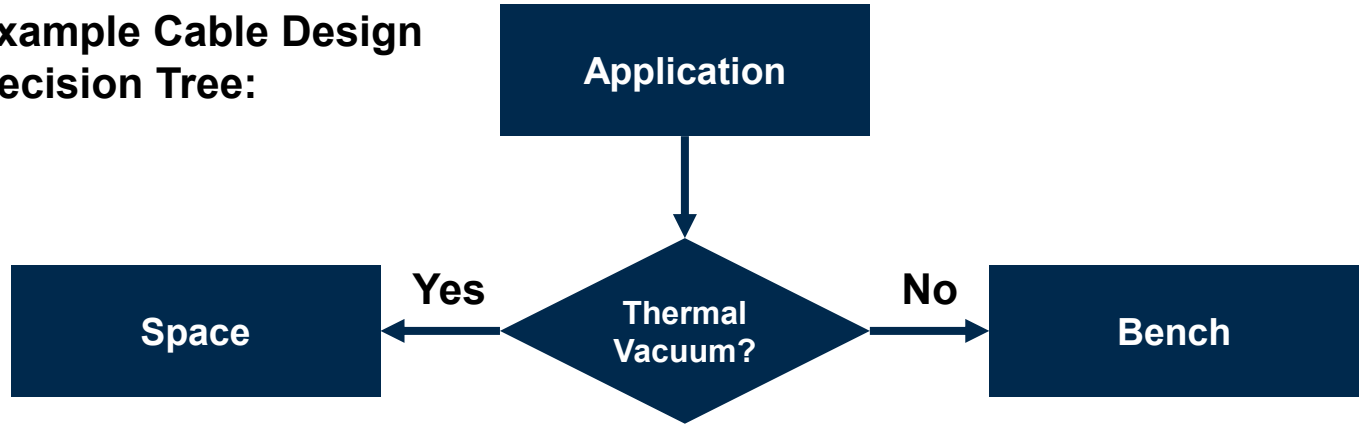
- Wire part specifications stored in Vector database for semantic search
- Connector part specifications stored in SQL database for structured search

Implementation

High-level cable design decision trees explorable by agents

- Agents traverse decision tree to determine what to look for
- Agents access database to find which specific part numbers match criteria

Example Cable Design Decision Tree:



Agents rely on existing decision-tree logic and external databases, mitigating the need to re-train the LLM

LLM: Large Language Model
MIL: Military

NASA: National Aeronautics and Space Administration
SME: Subject-Matter Experts

Knowledge-Informed Agentic Autonomy

RAG

Retrieval Augmented Generation

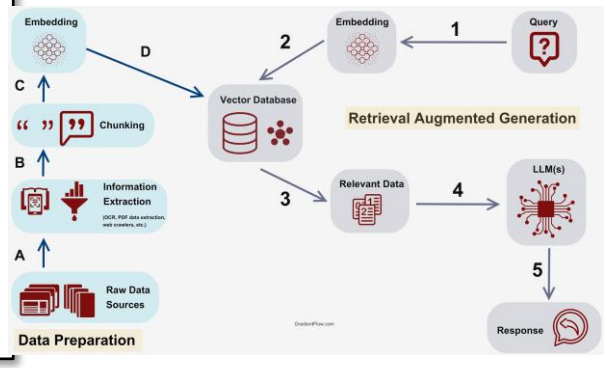
- Technique that allows LLMs to retrieve information from external documents
- Reduces hallucinations by creating a source of truth for agents to access



Vector Database

ChromaDB

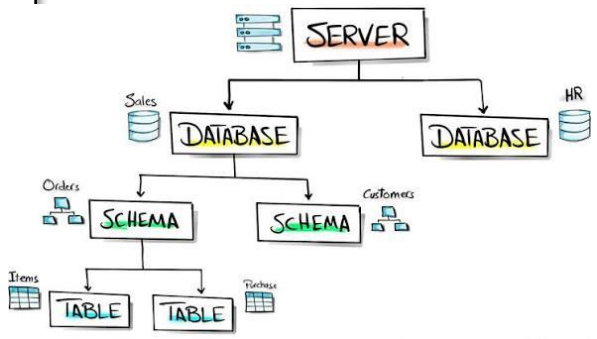
- Documents are chunked and embedded as numerical representations
- Enables fast semantic search and support for unstructured documents



Relational Database

SQL

- Tables stored with rows, columns for precise queries and linked together by keys
- Query parts with exact filtering criteria and matching



External Knowledge Grounds Agent Results and Logic

Wire: Technical Documents

Wire specification documents are converted into textual embeddings and stored for semantic retrieval.

Wire Size (AWG)	Single Wire Current (I_{SW}) (Amps)	Remark
30	1.3	1. Current ratings are based on wires at +70°C in a hard vacuum (10^{-6} to 10^{-9} torr).
28	1.8	2. When wires are bundled, the max design current for each individual wire shall be derated according to:
26	2.5	
24	3.3	For $1 < N \leq 15$: $I_{BW} = I_{SW} * ((29 - N)/28)$
22	4.5	
20	6.5	For $N > 15$: $I_{BW} = (0.5) * I_{SW}$
18	9.2	
16	13.0	Where: N = number of wires I_{BW} = current, bundled wires I_{SW} = current, single wire
14	19.0	
12	25.0	3. Deratings listed are for Teflon® insulated wire (Type TFE) rated for +200°C
10	33.0	
8	44.0	a. For 150°C wire, use 80% of value shown in table. b. For 135°C wire, use 70% of value shown in table. c. For 105°C wire, use 50% of value shown in table.
6	60.0	
4	81.0	
2	108.0	4. Dielectric withstanding voltage rating required: at least two times the highest application voltage.
0	147.0	5. Derating values listed apply only to single round conductors on helically wound bundles. See EEE parts engineer for derating information for ribbon cable and flat conductors.
00	169.0	

Wire Specification Documents (EEE-INST-002, NASA, MIL Specs)

Database (ChromaDB)

Connectors: Parts Database

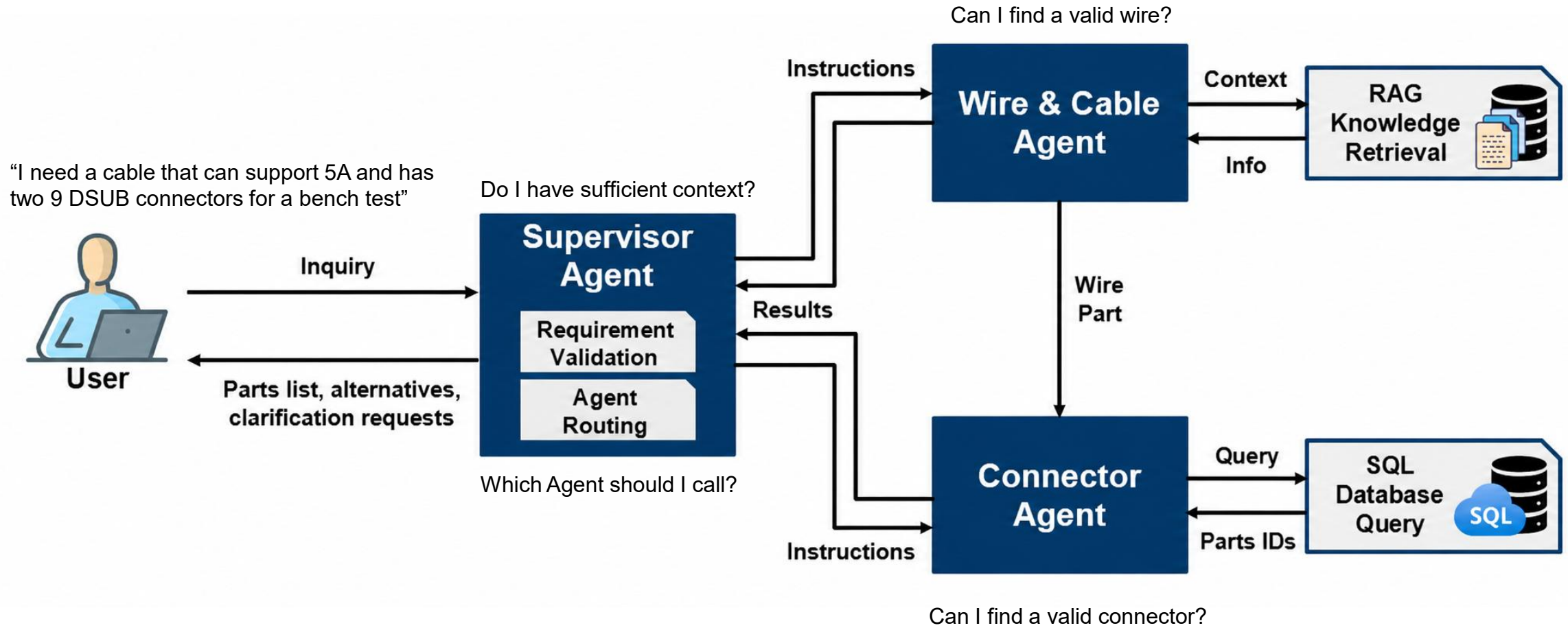
Connector data is stored in a relational database for structured queries

Parts	
Part Number	MWDM2L-130S-6K7-18M-429A

Part Attributes	
Part Number	MWDM2L-130S-6K7-18M-429A
Gender	PLUG
Number of Contacts	9
Connector Type	MICRO-D
Wire AWG	26
Material & Finish	Nickel

Wire specs require contextual document retrieval, connector data is suited for direct filtering queries

Cable Agent Architecture



Agents don't generate answers, they navigate defined logic and retrieve from controlled data sources

LINCOLN LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Outline

- Introduction
- Multi-Agent Framework
- **Results**
- Conclusion

Connector Part Selection (1/3)

User: I need 2 micro-ds, 1 plug and 1 receptacle 9 contacts each

Connector Part Selection (2/3)

```
Connector Agent:
For your NASA upscreened, 26 AWG prewire, backshell-compatible, 9-pin application, I have provided matched connector pairs (PLUG
+ RECEPTACLE):

End 1 - PLUG Connectors: Found 4 option(s)

1. MWDM2L-9P-6J7-18B-429A
   Supplier: GLENAIR

2. MWDM2L-9P-6K7-18B-429A
   Supplier: GLENAIR

3. MWDM2L-9S-6J7-18B-429A
   Supplier: GLENAIR

4. MWDM2L-9S-6K7-18B-429A
   Supplier: GLENAIR

Note: J vs K indicates wire type.
-6J7: M22759/33 wire (recommended for LEO - higher radiation tolerance)
-6K7: M22759/11 wire (lower radiation tolerance, acceptable for non-LEO)

End 2 - RECEPTACLE Connectors: Found 0 option(s)
```

Yields search results from the parts database

Connector Part Selection (3/3)

```
These parts also meet your requirements but do not have NASA upscreening and may be more readily available:


End 1 - PLUG Alternatives: 7 option(s)

1. M83513/03-A03N
   Supplier: Multiple Vendors

2. M83513/03-A03P
   Supplier: Multiple Vendors

3. M83513/03-A04N
   Supplier: Multiple Vendors

4. M83513/03-A04P
   Supplier: Multiple Vendors

5. MWDM2L-9P-6J7-18B
   Supplier: GLENAIR

6. MWDM2L-9P-6K7-18B
   Supplier: GLENAIR

7. MWDM2L-9S-6J7-18B
   Supplier: GLENAIR

End 2 - RECEPTACLE Alternatives: 4 option(s)

1. M83513/04-A03N
   Supplier: Multiple Vendors

2. M83513/04-A03P
   Supplier: Multiple Vendors

3. M83513/04-A04N
   Supplier: Multiple Vendors

4. M83513/04-A04P
   Supplier: Multiple Vendors

Please research cost and lead times independently to make your final selection.
```

Alternate options provided

Wire-Connector Part Selection (1/2)

User: What is the cable description for 5A space application in LEO

Wire-Connector Part Selection (2/2)

Connector Agent: Based on your space application cable with 9 conductors at 20 AWG, I recommend:

Primary Recommendation:
M24308/2-516: CONN DSUB 9 SKT CRIMP
- Pins: 9 (exact match)
- Gender: PLUG
- Shell: DA (smallest DSUB size)
- Mass: 7.0g
- Why: This is the lightest possible connector that exactly matches your 9-conductor requirement, making it ideal for space applications where weight is critical.

Alternative Option:
M24308/3-516: CONN DSUB 9 PIN CRIMP
- Pins: 9 (exact match)
- Gender: RECEPTACLE
- Shell: DA (same size)
- Mass: 7.0g
- Tradeoff: This is the mating RECEPTACLE version if you need both connectors for a complete assembly.

Technical Details:
- Contact Size: 20 (perfect match for your 20 AWG conductors)
- Both options are space-rated for your LEO application
- DA shell is optimal for minimizing mass in space applications

Do you need a PLUG (male) or RECEPTACLE (female) connector, or would you like both for a mating pair?

User:

Outline

- Introduction
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Towards Full BOM Generation

Multi-Agent Framework

- Wire and connector part selection based on decision-tree logic, technical documents, and parts database access
- Enables updates without LLM re-training

Grounded Recommendations

- Mitigated hallucination risks by grounding outputs with evidential information
- Validated preliminary results with experienced cable designers

Practical Engineering Usage

- Conversation interface support iterative design logic
- Evidence-based decision support, not autonomous generation and automation

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Generating Bill of Materials...
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```

Bill of Materials - Cable Assembly

Item	Part Number	Qty	Description
Cable/Wire	M22759/11-16	1	Wire assembly, 9 conductors, 3.0 ft
Connector - End 1 (PLUG)	M24308/2-516	1	9 pin DSUB connector
Connector - End 2 (RECEPTACLE)	M24308/3-516	1	9 pin DSUB connector

Expand to complete full BOM

```
Assembly Summary:
  Conductors: 9
  Current: 5.0A (per_conductor)
  Length: 3.0 ft
  Application: bench
  Shielding: No

✓ BOM saved to: cable_assembly_bom.txt
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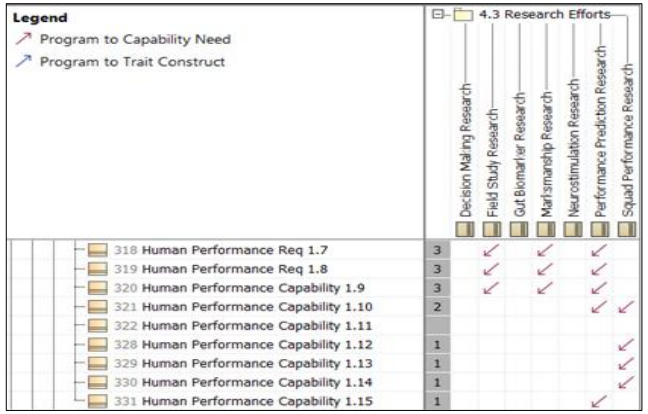
Initial framework demonstrates a promising approach to using AI for cable harness part selection

BOM: Bill of Materials

Future Work

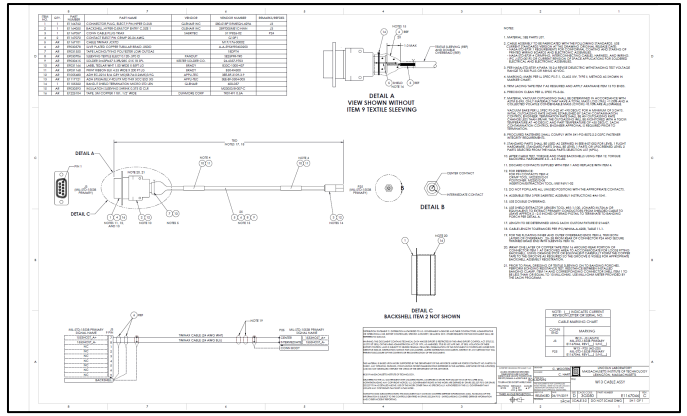
Validate & Verify Reliability

- Test and verify diverse cable configurations, environmental conditions, and constraints
- Verify recommendations meet requirements



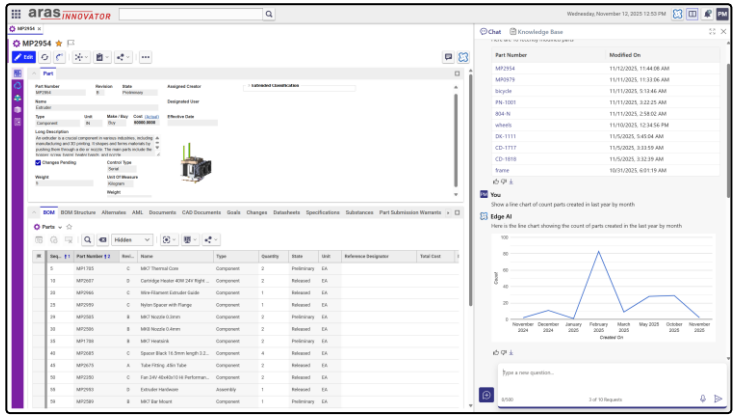
Expand Capabilities

- Backshell and shielding selection with bundle dimension calculations
- Generate cable notes and pictorial drawings



Integration

- Connect to digital engineering platform synced part status
- Direct import of parts lists into existing design software



Establish review and approval protocols to maintain human oversight in engineering decision-making

An Agentic AI Approach to Space Harness Component Selection

Qiana Curcuru, Jasmin Lim, Jon Williamson, Jacob La Rocca, Matthew Zaluski, David Tang, Brendyn Sang

Questions to: Jasmin.Lim@ll.mit.edu

Corresponding Conference Paper to be Published in Proceedings



EXTRA

Language Models

	Novelty & Advantages	Deployment Challenges
Language Models (LMs)	• Process natural language and possess real-world knowledge • Can interpret semantic meaning	• Commercial AI products are not trained on military or NASA specifications, especially those not publicly available • Do not possess expertise in high reliability cable design • Do not natively contain organization-specific information such as unique IDs of part numbers

Equip LMs with internal specifications, parts catalogues, and Engineer-verified decision logic

Example Flow of a User Query

