Highly Standardized SV/LV Interface Standard Big Data and AI Analyses for MVP 2

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AI/Big Data Analysis for a Standard PL/LV Electrical Interface

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Context

- The Space Systems Modular Open Systems Approach (MOSA) Interface Standards Alliance committee fore Space Vehicle/Launch Vehicle Interfaces is developing ISTO STD MOSA-IF-S-005, “Highly Standardized Payload to Launch Vehicle Interfaces for National Security Space Launch (NSSL)-Class Missions”
  - We have completed Volume 1: Mechanical Interfaces, and are now working on Volume 2: Electrical Interfaces
- Historically, each mission has designed a unique payload-to-launch vehicle (PL/LV) electrical interface.
  - Large mission-to-mission variation in wire count, wire capacities (max. voltage, current, and resistance), connector selection, etc., presents a major challenge to finding a “one size fits most” solution.
- We are targeting a standard design to accommodate 80% of future missions.
  - A higher coverage goal would necessitate a very heavy, expensive standard harness, much of which would go unused for most missions.
- To find an 80% solution, we are referencing a large library of current and recent PL/LV interface control documents (ICD)
  - Over 60 ICDs covering 50 missions (some multi-manifest missions have separate ICDs for each space vehicle)
- The opportunity is significant, as standardization will dramatically reduce PL/LV integration time and cost, simplify operations and allow late swap of a PL from one LV to another.

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The Challenge

- Every mission ICD is unique, with distinct electrical requirements
- Unfortunately, mission uniqueness extends to the way the requirements are documented
  - ICD file format (PDF, Excel), table formatting, wire specification format/structure, signal naming convention, etc.
- **Manual data aggregation would be an extremely laborious task**
  - Tens of thousands of data elements across hundreds of tables in ICDs of varying formats, structure, and conventions
  - Dozens of current and historical missions with overlapping requirements
- Aggregated, parsed and normalized data is needed to identify an optimal electrical interface design that meets the needs of a pre-established proportion of missions
- We know from engineering experience that, despite the variability in ICD formats, patterns and a significant degree of commonality exist beneath the surface.
  - We need to find those patterns in thousands of signal requirements across dozens of missions.
- **What standard harness design would satisfy most missions' needs without excessive recurring cost and wasted mass?**

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The Process

- Our Artificial Intelligence (AI)-powered ICD Wiring Analysis tool transforms 12,000+ signal requirements from over 50 missions (over 60 ICDs) into actionable intelligence.

1. **Understand the Landscape**
   - Where is the data complete? Where are the gaps?
   - What are the aggregate commonalities among missions?
   - What functions are truly bespoke?
2. **Find the Patterns**
   - Clustering analysis and visualization reveals natural groupings in electrical requirements
   - "Standard" specifications emerge across multiple missions
   - Outliers become visible – signals that truly need special handling
3. **Optimize for Impact**
   - Set your target: What percentage of historical missions should a candidate standard harness satisfy?
   - Algorithm identifies the minimum set of physical wires needed
   - Smart substitution logic: higher-spec wires can cover lower requirements
   - Optimize the design for weight, cost, function etc.

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AI Analysis User Interface – Dashboard and ICD Data Analysis

Analysis dashboard provides a clean, intuitive user interface

Wiring Analysis page displays completeness of wire specifications in the ICD(s) for each mission

- Allows selection and filtering of data sources, wire functional groups (T-0, airborne, etc.), individual missions, etc.

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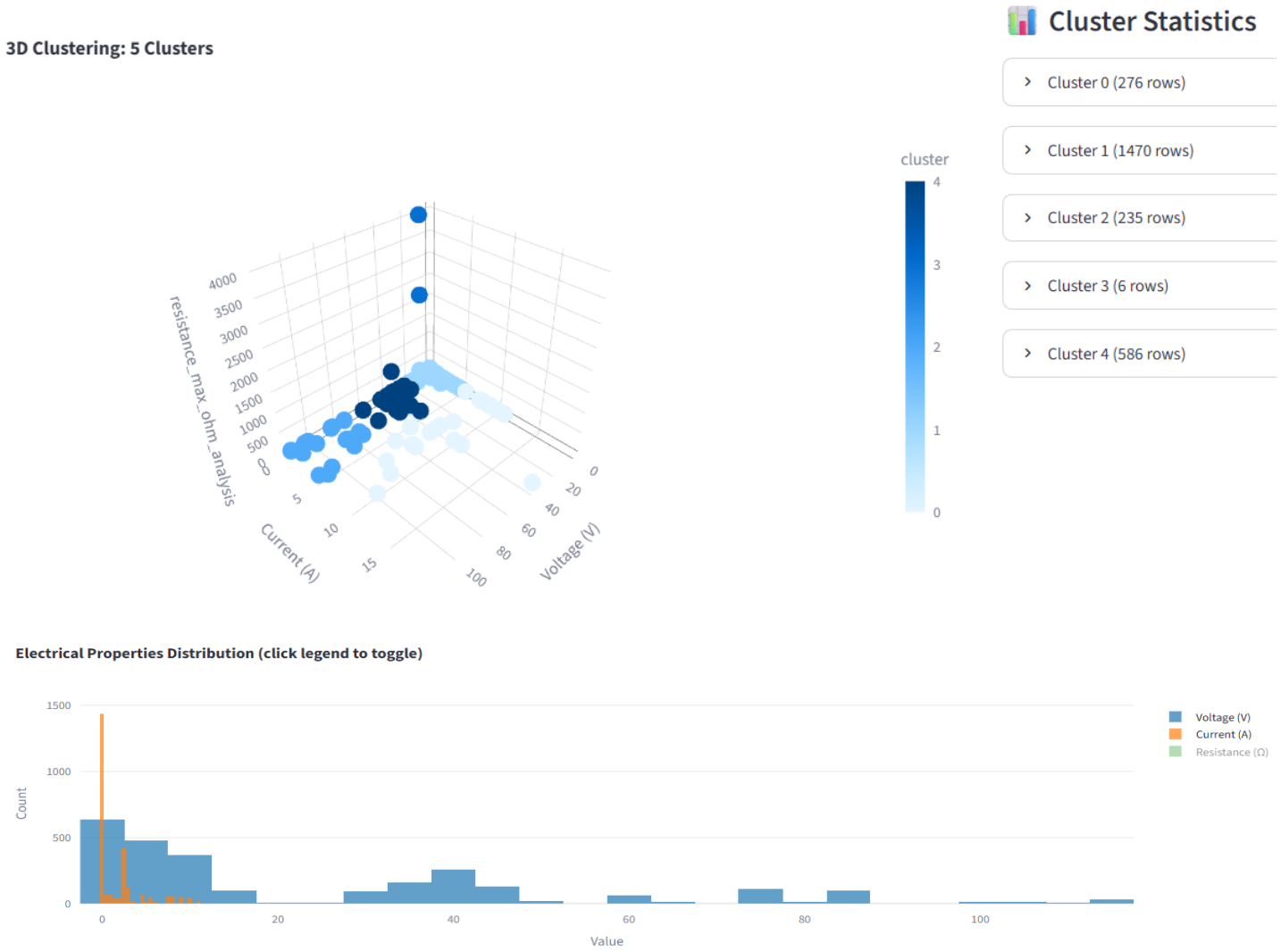
AI Analysis User Interface – Clustering Visualizations

Clustering Analysis page reveals groups of wires with similar capacity, informs selection of standard interface wiring



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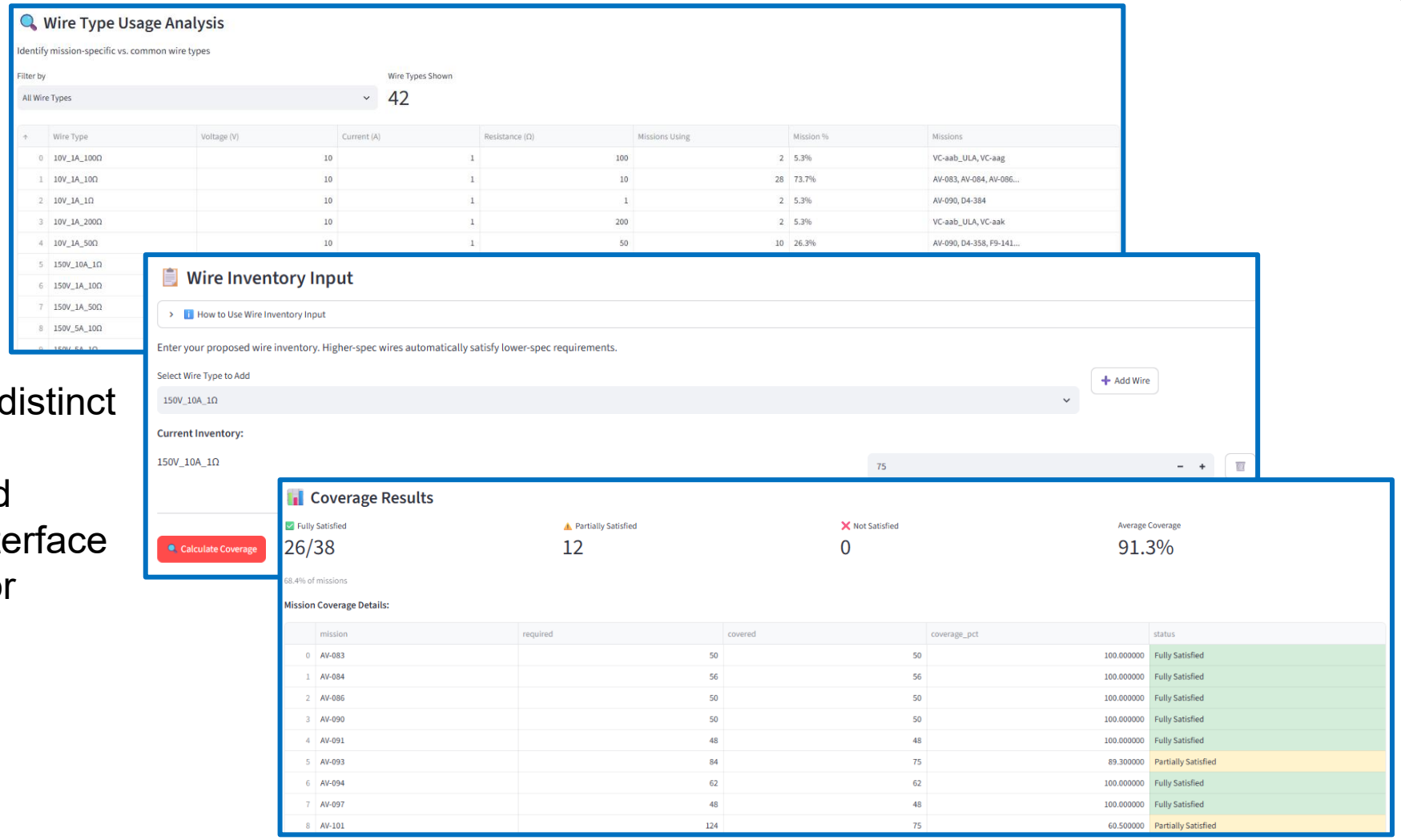
AI Analysis User Interface – Standard Electrical Interface Design

Standard Harness Design page is where the interface design takes shape

- Provides inventory of each distinct wire type for each mission
- Allows designer to build and modify a standard wiring interface
- Returns coverage results for proposed design



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Value Proposition

- AI-orchestrated deterministic parsing of PDFs and other documents to extract and organize unstructured and tabular content into a form that is richly presented for analysis
  - Can continue to parse and organize future mission requirements and contribute to iterative design of future standards
- Well-defined schema for extracted ICD data allows for high-trust AI interaction allowing SMEs to intelligently “chat” with a technical corpus
  - Guardrails to ensure that the output is simple to both understand and validate, limiting the occurrence of AI hallucinations and other false generations.
- Tremendous amount of time saved by engineers performing the analysis
  - AI-powered smart querying of extracted data to enable instant insights and iterative analysis
  - Learning techniques to automatically explore and identify emergent categories of wiring based on real mission compositions
  - Automated electrical harness standard generation tool that fits a best candidate standard harness to satisfy missions as specified by the analyst
  - Provides a concrete, high-confidence basis for tuning and iteration based on cost, weight, complexity etc.
- Fast validation of proposed wiring harness standard against all historical missions.
  - “We’ve defined a standard electrical interface; how would it have fared had it been applied to past & present missions?”
  - This becomes a 5 second activity, as simple as uploading the proposed standard and fitting it to historical missions