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Delivering Better Projects on Time by Ensuring Requirements Quality Upfront

Eduardo Vaz, PhD.
Director, QRA Corp

www.incose.org/symp2018

Outline

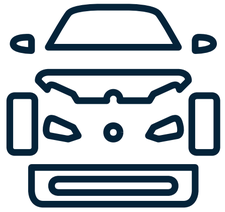
- **WHY** is it important to look at NLP technologies for requirements analysis? (NLP-RA tools)
- **WHAT** are NLP-RA tools?
- **HOW** is industry using NLP-RA tools (some use cases)?

Why NLP-RA?

History of Industrial Complexity

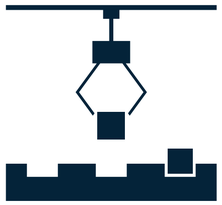
1st

Mechanization, water power, steam power



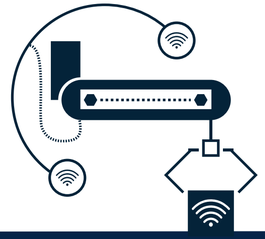
2nd

Mass production, assembly line, electricity



3rd

Computer and automation



4th

Cyber physical and autonomous systems

Why NLP-RA?

Complex systems with complex problems

40% resources spent on testing for complex systems

Boeing 787

$25B dev
$10B testing

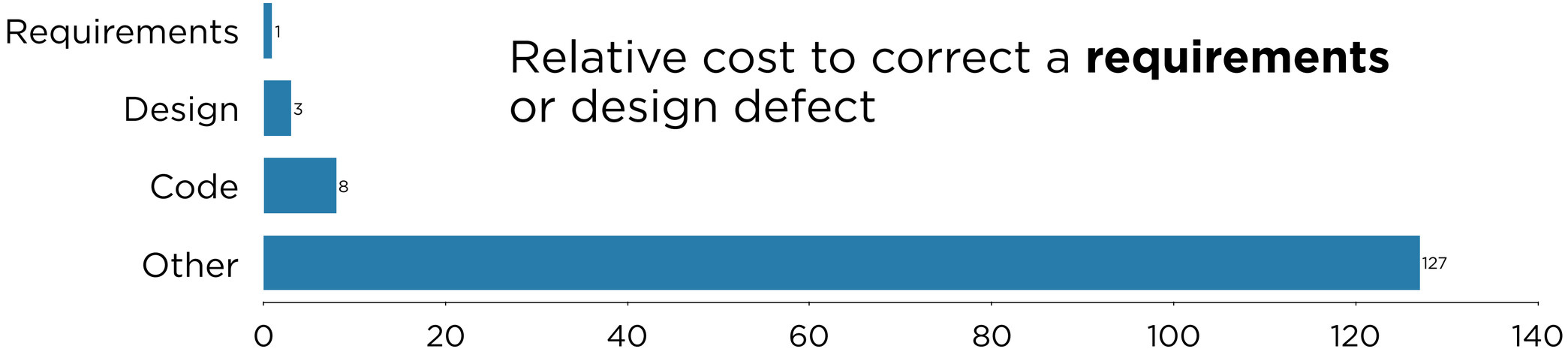
Airbus A350

$10B dev
$4B testing

Chevy Volt

$1.2B dev
$600M testing

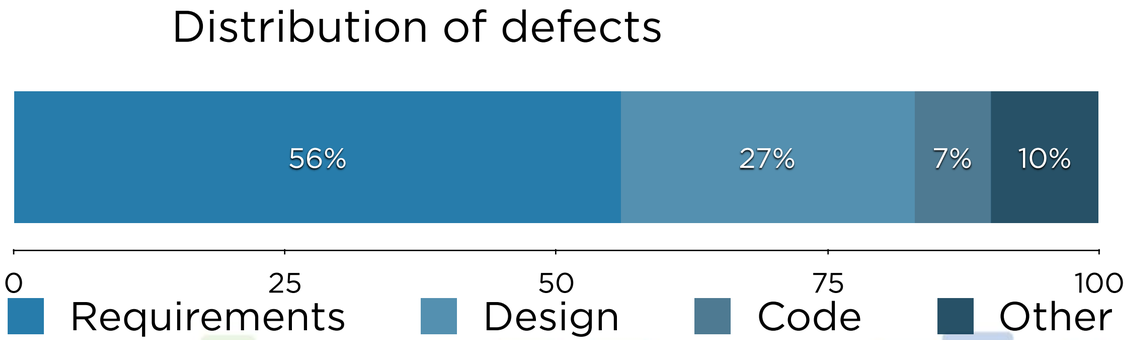
Why NLP-RA?



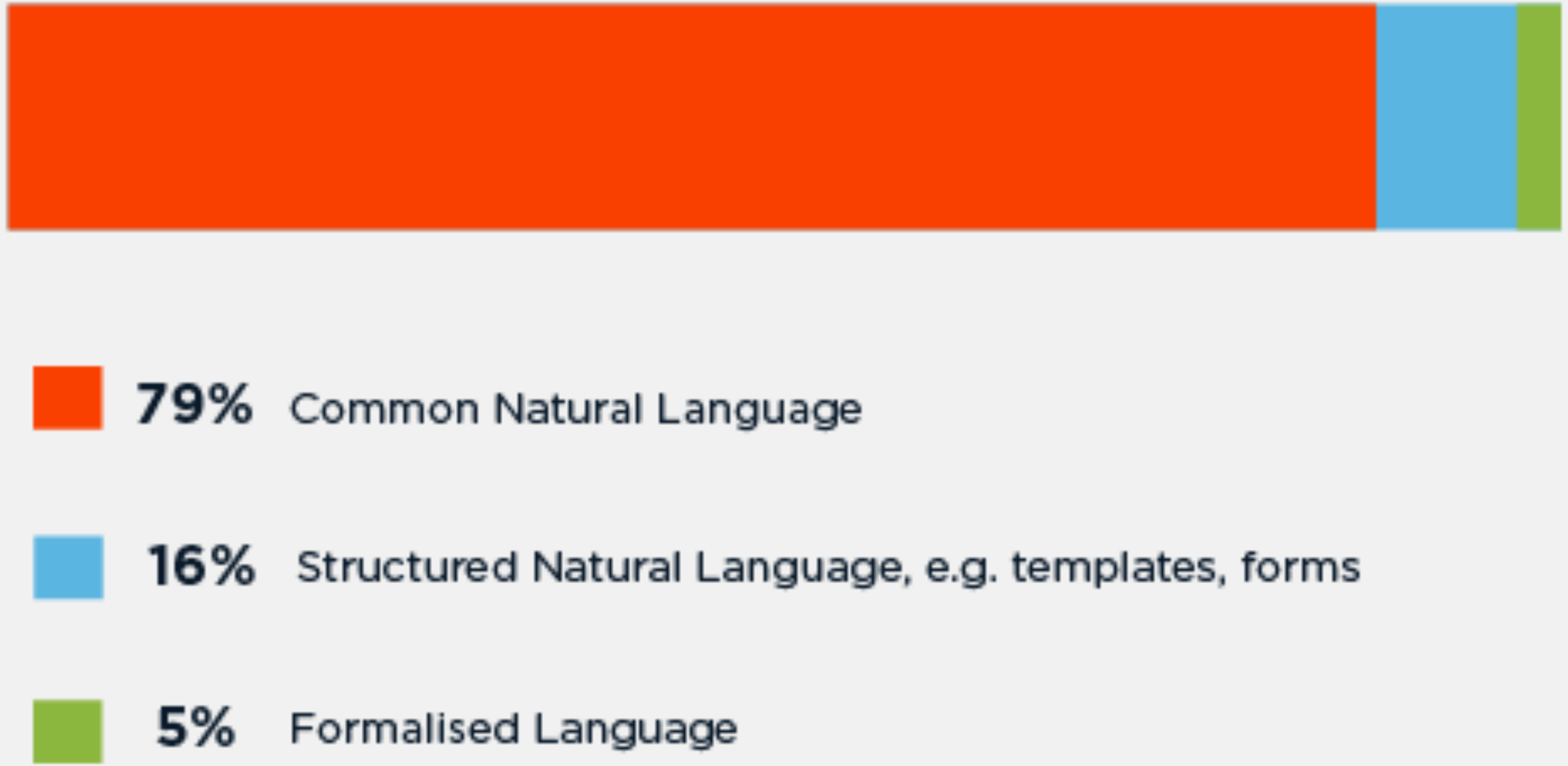
Relative cost to correct a **requirements** or design defect

Requirement defects are being found late in the development lifecycle. Costing companies over 100 times to fix than if they were caught at early stages.

>80% of defects in systems are due to requirements or design errors



How is Industry Writing Requirements?



Natural Language Requirements

- It is the language we know best
- Highly expressive
- Semantics are well embedded

But

- Not ideal language for requirements
- High ambiguity and vagueness
- Can be difficult to assess if logic is complete
- Difficult to verify

Current Approaches to RE

Approaches	Challenges
Structured and modelling languages: Templates, EARS, SysML	• Hard to learn and adopt • Still requires top level NLP requirements
Formal languages: LUSTRE, Parnas tables, math	• Hard to learn and adopt • Still requires top level NLP requirements • Specially difficult to convey semantics
Checklists: INCOSE's (44 rules), NASA's (38 rules), QRA (21 rules)	• Time-consuming, tedious, error-prone • Inefficient use of domain expert resources
Peer-review: multiple pairs of eyes approach	• Exacerbates the challenges of checklists times the number of reviewers

What is NLP-RA?

What is NLP-RA?

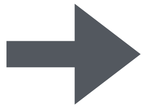
- Computational NLP technologies focus on automated language understanding:
    - **Lexical** (assess specific terminology)
    - **Syntactic** (assess terminology and sentence structure)
    - **Semantic** (assess relationships to other text)
- Many of the advances in NLP have come about from industry-led research for consumer electronics and social media platforms (Siri, Alexa, Google, Facebook).
- The focus of NLP-RA tools is on automating what can be automated (verification), and use the domain expert for the right tasks (validation).

Early NLP-RA: NASA ARM

- In the late 1990s NASA worked on a tool they called the Automated Requirements Measurement (ARM) tool.
- They determined that good requirements had a set of quality attributes:

Quality Attributes (hard to measure)

- **Complete**
- **Consistent**
- **Correct**
- **Modifiable**
- **Ranked**
- **Traceable**
- **Unambiguous**
- **Valid**
- **Verifiable**



Quality Indicators (easy to measure)

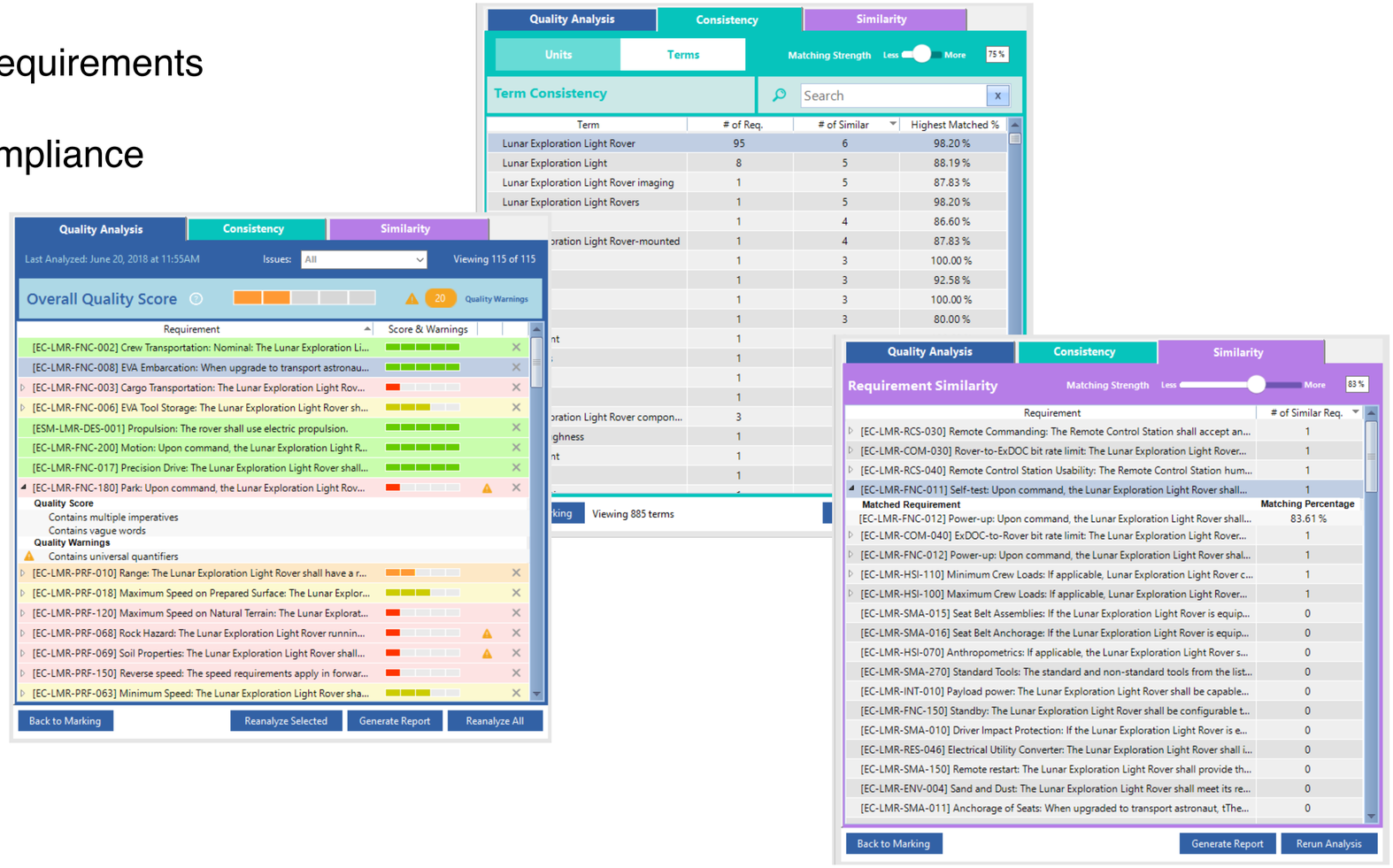
- **Imperatives**
- **Continuances**
- **Directives**
- **Options**
- **Weak phrases**

Lexical

- Size
- Readability
- Specification depth
- Text structure

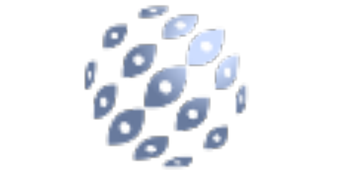
New-Generation NLP-RA Tools

- Smart detection and delineation of requirements
- Quality analysis for best practice compliance
- Domain specific ontologies
- Terminology analysis
- Measurement unit analysis
- Requirements similarity analysis
- Requirements export
- Enterprise and team collaboration
- Reporting



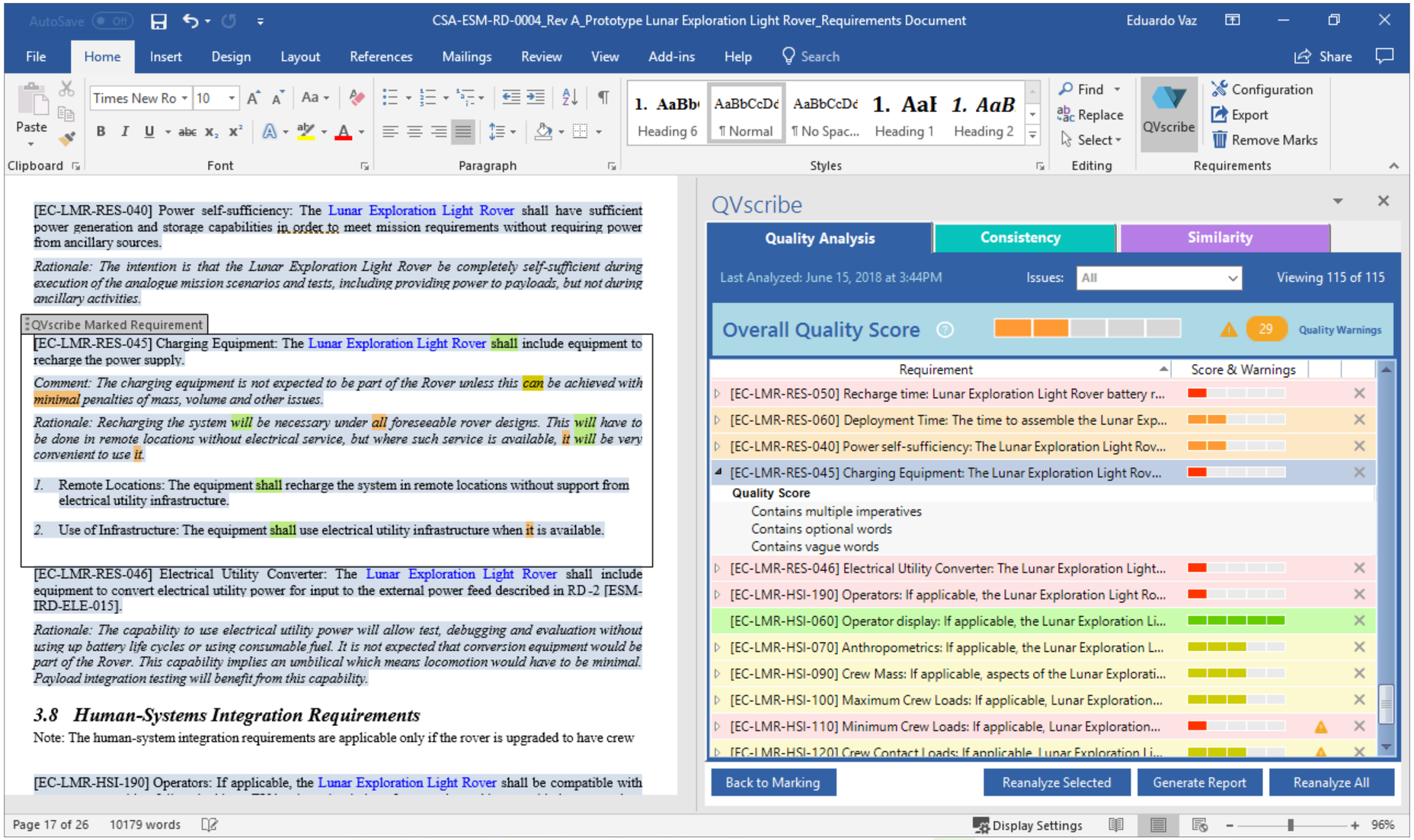
New-Generation NLP-RA Tools

RAT



STIMULUS

qvscribe for Microsoft Word



CSA-ESM-RD-0004

Canadian Space Agency

Exploration Surface Mobility Project

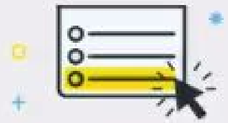
Prototype Lunar Exploration Light Rover Requirements Document

QVscribe

Your Requirements

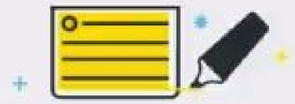
Add | Remove | Undo | Redo | Use Requirement Finder

Add your requirements here...



Double-click on single-paragraph requirements

OR



Select multi-paragraph requirements and press "Add Requirement"

Customize Your Analysis | Analyze 0 Requirements | See Previous Analysis

QVscribe Help Center

Number of Quality Warnings: 21

Score	# of Reqs.	Percentage	What should I do?
5	0	0%	**Very Low Risk** Includes clear and unambiguous terminology to express the requirement.
4	36	31%	**Low Risk** May include excessive use of continuances, and/or No directives. Check the flow and clarity of the requirement.
3	29	25%	**Medium Risk** Includes a single instance of a vague, subjective, or weak term, and/or a single negative imperative. Replace the negative or ambiguous term with a clear and concise term.
2	6	5%	**High Risk** Includes multiple instances of vague, subjective, or weak terms, and/or negative imperatives. Replace negative or ambiguous terms with clear and concise terms.
1	44	38%	**Very High Risk** **The requirement lacks an imperative, or contains multiple imperatives, and/or contains excessive vague terms. Consider rewriting the requirement or separating into multiple concise requirements.**

Analysis Breakdown

Quality Score	Percentage*	# of Occurrences
No Directives	94%	109
Vague Words	46%	53
Multiple Imperatives	24%	28
Optional Words	18%	21
Negative Imperatives	12%	14
No Imperatives	8%	10
Excessive Continuances	6%	8

Quality Warnings	Percentage*	# of Occurrences
Universal Quantifiers	18%	21

* Percentage is based on how many of the occurrences appear within the document. Some different warnings, and issues may overlap in different percentages since some requirements may contain both.

Individual Requirements

Score: 4
No Directives

[EC-LMR-FNC-002] Crew Transportation: Nominal: The Lunar Exploration Light Rover shall be designed to be upgradeable to transport one EVA-suited crew member.

Score: 4
No Directives

[EC-LMR-FNC-008] EVA Embarcation: When upgrade to transport astronaut, the Lunar Exploration Light Rover shall provide convenient access for EVA crew to embark and disembark.

Score: 1
No Directives
Multiple Imperatives
Vague Words
Unit(s) Found

[EC-LMR-FNC-003] Cargo Transportation: The Lunar Exploration Light Rover shall transport cargo items. 1. Cargo mass: The Lunar Exploration Light Rover shall transport up to 300 kg, including cargo, attached payloads and the nominal passenger complement. 2. Cargo Volume: The Lunar Exploration Light Rover shall transport cargo and attached payloads up to a volume of 1 m x 1.5 m x 1.5 m high.

Score: 3
No Directives
Optional Words

[EC-LMR-FNC-006] EVA Tool Storage: The Lunar Exploration Light Rover should provide a location for storing EVA tools. 1. EVA Access: EVA tools shall be accessible to the EVA crew.

Score: 4
No Directives

[ESM-LMR-DES-001] Propulsion: The rover shall use electric propulsion.

Score: 4
No Directives

[EC-LMR-FNC-200] Motion: Upon command, the Lunar Exploration Light Rover shall move forward, reverse, and steer.

Score: 4
No Directives

[EC-LMR-FNC-017] Precision Drive: The Lunar Exploration Light Rover shall, upon command, place itself so that a target of interest is within the workspace of a contact sensor or sampling device.

Score: 1
No Directives
Multiple Imperatives
Vague Words
Universal Quantifiers
Unit(s) Found

[EC-LMR-FNC-180] Park: Upon command, the Lunar Exploration Light Rover shall put itself in a safe waiting state (“parked”) in which locomotion is inhibited. 1. Parking Brake: The parked state shall hold the vehicle, at maximum gross vehicle weight, on a 31 degree slope facing in any direction. The vehicle shall be stopped on the slope, wheel motors or their equivalent turned off completely, and the rover held by the parking brake for no less than one minute in each direction.

Score: 1
Excessive Continuances
No Directives
Vague Words
Unit(s) Found

[EC-LMR-PRF-010] Range: The Lunar Exploration Light Rover shall have a range of at least 15 km with a target of 30 km between refueling or recharging stops on a traverse where the vehicle is loaded to maximum gross vehicle weight, it is traveling over level terrain with a surface roughness defined using the equation in [EC-LMR-PRF-120] Maximum Speed on Natural Terrain with C=3.0E-05 and N=2.0, it travels at a constant speed of 10 km/h between stops and it makes 50 starts and stops.

Score: 3
No Directives
Vague Words
Unit(s) Found

[EC-LMR-PRF-018] Maximum Speed on Prepared Surface: The Lunar Exploration Light Rover, loaded to maximum gross vehicle weight, shall be capable of maintaining a speed of not less than 15 km/h on a smooth, level, prepared surface.

How is industry using NLP RA tools?

NLP-RA Use Cases

Royal Canadian Air Force

- Document and requirements restructuring
- RE training for procurement personnel and BAs
- Ambiguity reduction
- Requirement similarity
- Requirements extraction from Word documents to compliance matrices
- Time savings in requirements review process of 60%-75%

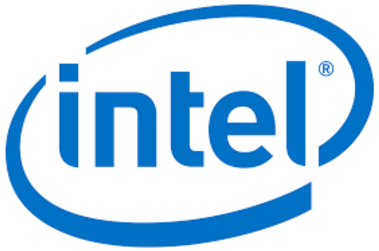
NLP-RA Use Cases

Ultra Electronics Maritime Systems

- Analysis and risk profile of RFPs
- Correctness and clarity of RFP response
- RE training for engineers
- Ambiguity reduction
- Requirement similarity
- Time/cost savings in procurement process 30%

NLP-RA Use Cases

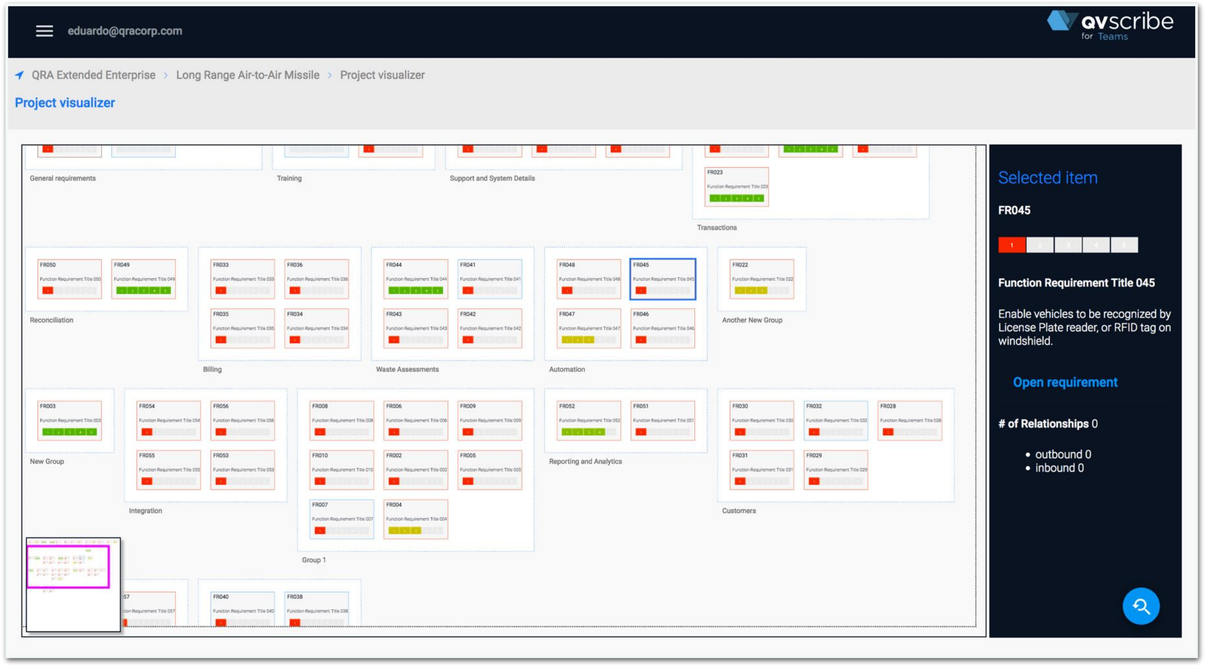
Intel / Honeywell



- Encoding of institutional knowledge
- Enforcement of internal practices
- DSTs for consistency across teams (in development)
- RE training
- Glossary creation
- Time/cost savings in requirement authoring stages… unknown

Next-Gen NLP-RA

- Semantic analysis for version control and requirements classification
- Domain specific ontology (via machine learning)
- Web-based centralized analysis and collaboration
- Assistant for formalization of reqs (for completeness analysis)



Thank you

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Eduardo Vaz
eduardo.vaz@qracorp.com