



31st Annual **INCOSE**
international symposium

virtual event

July 17 - 22, 2021

Requirement Patterns in the Construction Industry



Requirement Patterns in the Construction Industry

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Premise

Paragraphs ¶ are the curse of Requirements Management (RM)



Before

7. Operating Handles for Outdoor Switches
 - a. A large percentage of fatal accidents from voltage gradients are associated with manual operating handles of disconnect switches, etc.
 - b. A metal grounding plate or mat (operating platform), shall be placed where the operator must stand on it to operate the device. The operating handles shall be grounded by connecting a ground conductor (preferably flexible wire, braid strap) from the vertical operating pipe to the supporting structure, then continuing another stranded ground conductor to the switch operating platform. It is reiterated that the operating handle and the platform shall not be directly connected to the grounding grid but instead both connected to the support structure which in turn shall be connected to the grounding grid at least at two diagonally opposite points.
8. Terminal Transmission Tower Grounding
 - a. Terminal transmission towers located adjacent to the substation shall be connected to the substation grounding grid at two diagonally opposite points. The shield wire shall be connected to the tower structure, which in turn is connected to the grounding grid as discussed above.
9. Lightning Masts
 - a. Metal lightning masts shall have one safety ground.
10. Oil Tanks and Oil / Water Piping
 - a. All oil tanks shall be grounded at two points with bolted cable connections to two different points of the grounding grid. Oil piping shall be grounded at intervals of 12 m. Runs shorter than 12 m shall be grounded at least at two points.
 - b. Water piping shall be connected to the grounding system at all service points. In addition, two copper conductors of adequate size shall be connected to the main water pipe from two separate points of the grounding grid.

Streamlining: Brilliant!



8. Operating Handles for Outdoor Switches
 - a. Place a metal grounding plate or mat (operating platform) where the operator must stand to operate an electrical device.
 - b. Ground the operating handles by connecting a ground conductor (preferably flexible wire, braid strap) from the vertical operating pipe to the supporting structure, then continuing another stranded ground conductor to the switch operating platform.
 - c. Do not connect the operating handle and the platform directly to the grounding grid but connect both instead to the support structure.
 - d. Connect the support structure to the grounding grid to at least two diagonally opposite points.
9. Terminal Transmission Tower Grounding
 - a. Ground towers located adjacent to the substation to the substation grounding grid at two diagonally opposite points.
 - b. Connect the shield wire to the tower structure, which is connected to the grounding grid as discussed above.
10. Metal Lightning Masts: One safety ground.
11. Oil Tanks: Ground at two points with bolted cable connections to two different points of the grounding grid.
12. Oil Piping: Ground at intervals of 12 m. Ground runs shorter than 12 m to at least at two points.
13. Water Piping
 - a. Connect to the grounding system at all service points.
 - b. Connect the main water pipe with two copper conductors of adequate size to two separate points of the grounding grid.

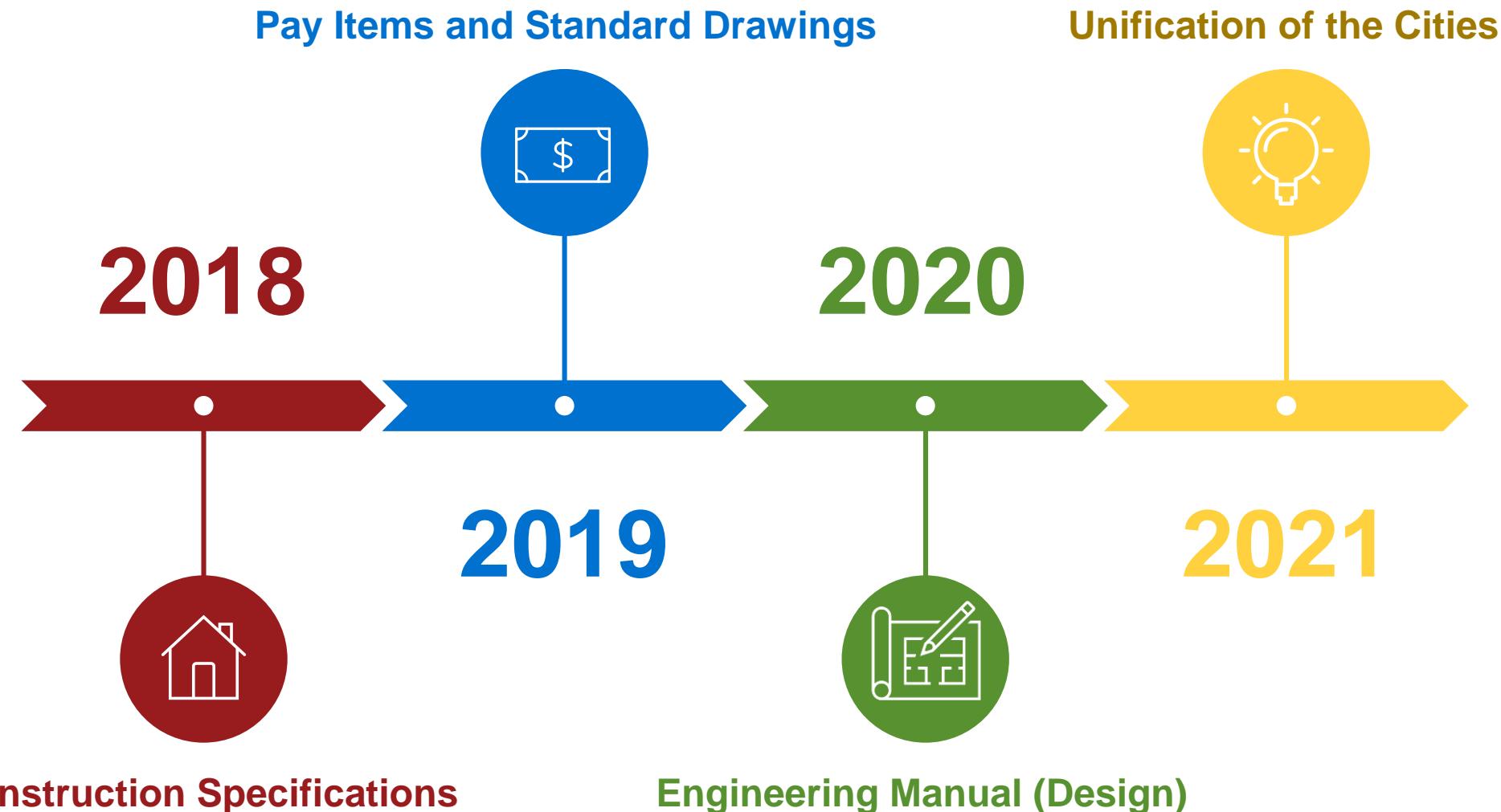


Background: Industrial Infrastructure





Progression of SE at the Royal Commission





Unification of Technical Requirements



1. Engineering Manual
2. Construction Specifications
3. Standard Drawing Details
4. Pay Item Descriptions



Problem Statement



An “elegant” system (NASA):

- Robust
- Efficient
- Meets client intent
- Structured
- Easy to use



Derivation of an “Elegant” System

Review

- Software packages
- Templates
- Examples
- BIM Forum
- Algorithms

Standards

- INCOSE Guide
- Construction Specifications Institute (CSI)
- Uniclass (classification)



Upgrading Legacy Specifications

- Derived correctly
- Consistent from project to project
- Design development
- Design verification
- Purchasing activities
- Field verification
- Modification
- Incorporate in models (e.g. BIM) and databases

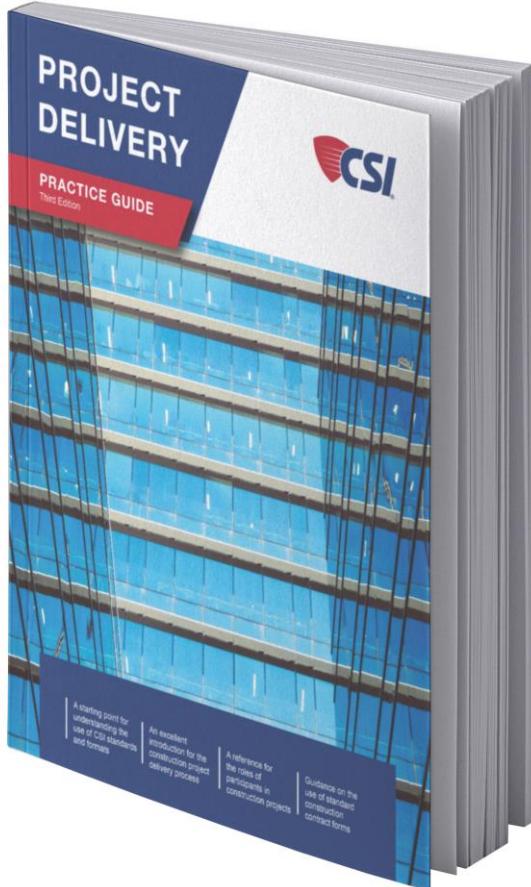


Options for Software

- MasterSpec files with Word addins
- Commercial, off-the-shelf (COTS) software
- Author-developed automation
 - Build on past success
 - Train junior engineers in RM
 - Minimize training required for new software



Streamlining



Concept: Eliminate words that add no value.

Examples of streamlined requirements:

- **Adhesive:** Spread with notched trowel.
- **Equipment:** Install plumb and level.
- **Portland Cement:** ASTM C150, Type 1.



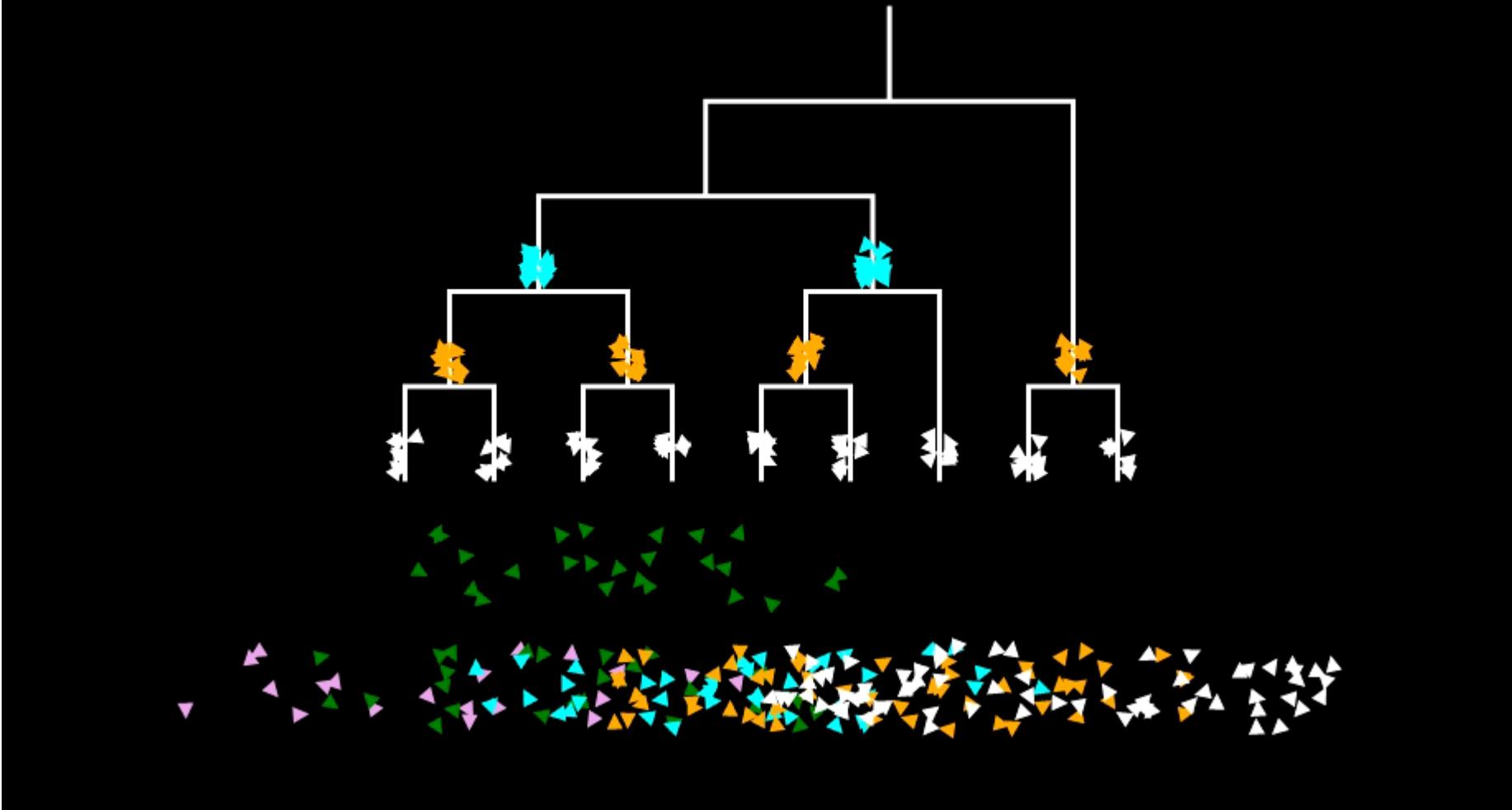
Comparison to the INCOSE Guide

Characteristics
of Good
Requirements



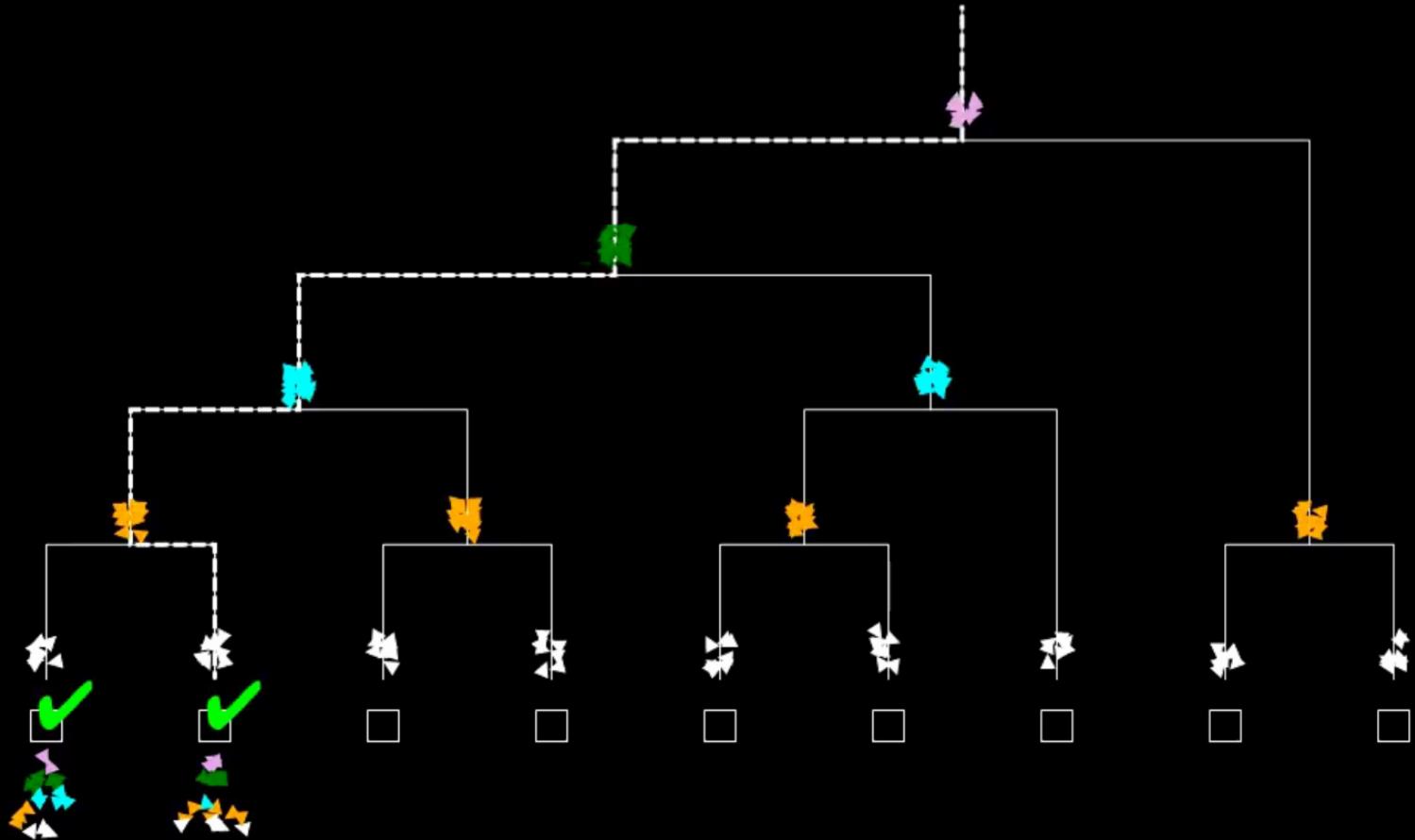


Agglomerative Hierarchical Clustering



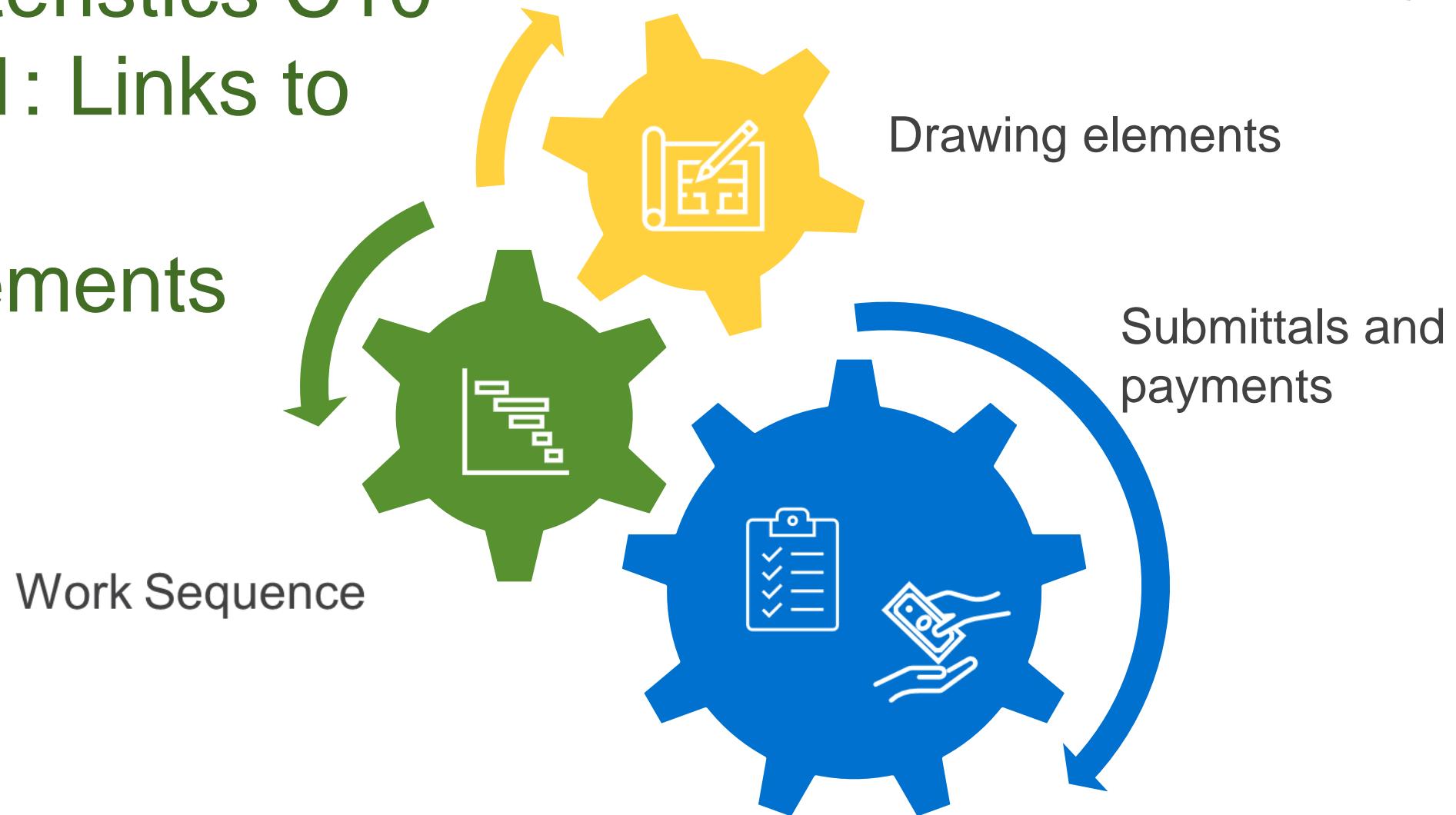


Collecting Applicable Requirements





Characteristics C10 and C11: Links to Related Requirements





Streamlining Using Visual Basic for Applications (VBA)

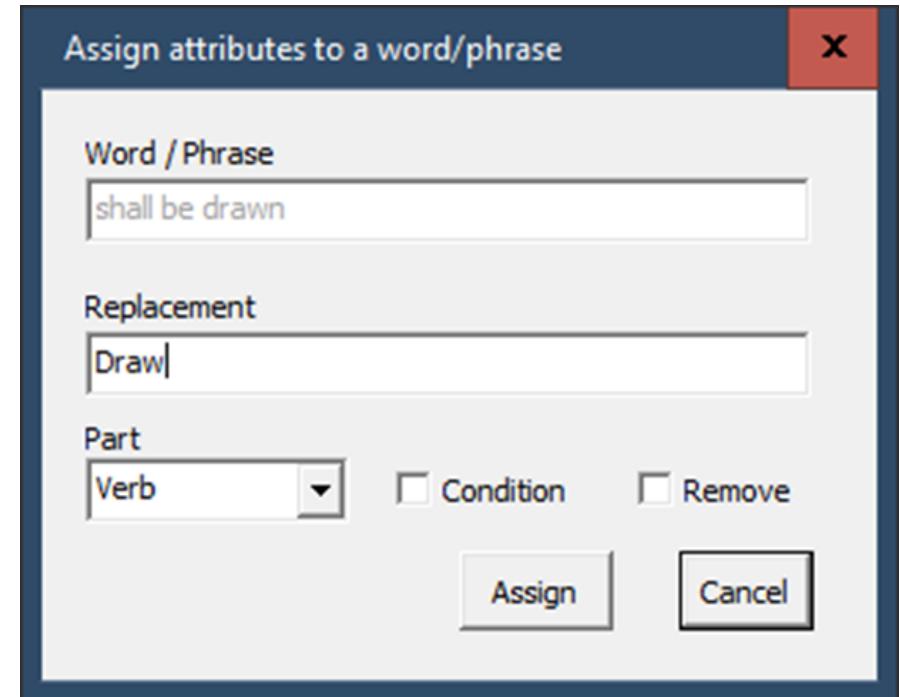
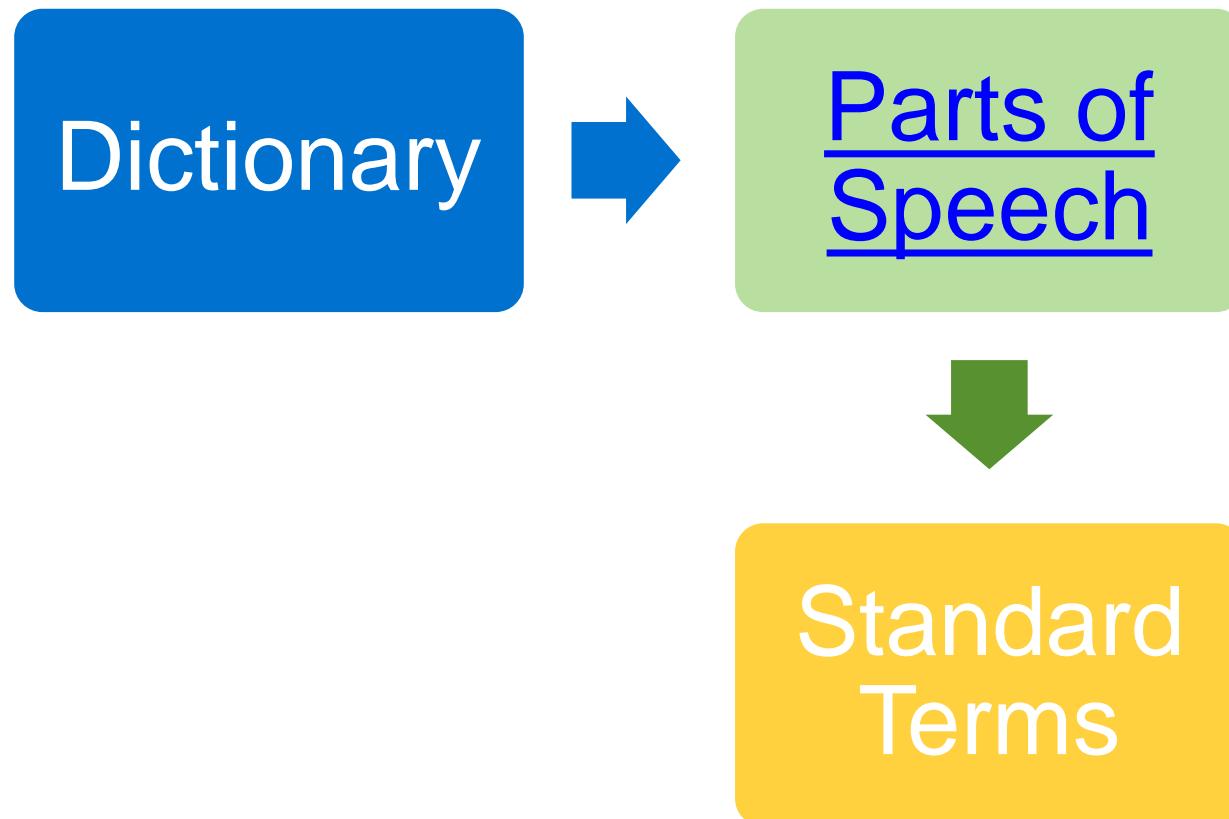
1. Database

2. Files

3. Learning

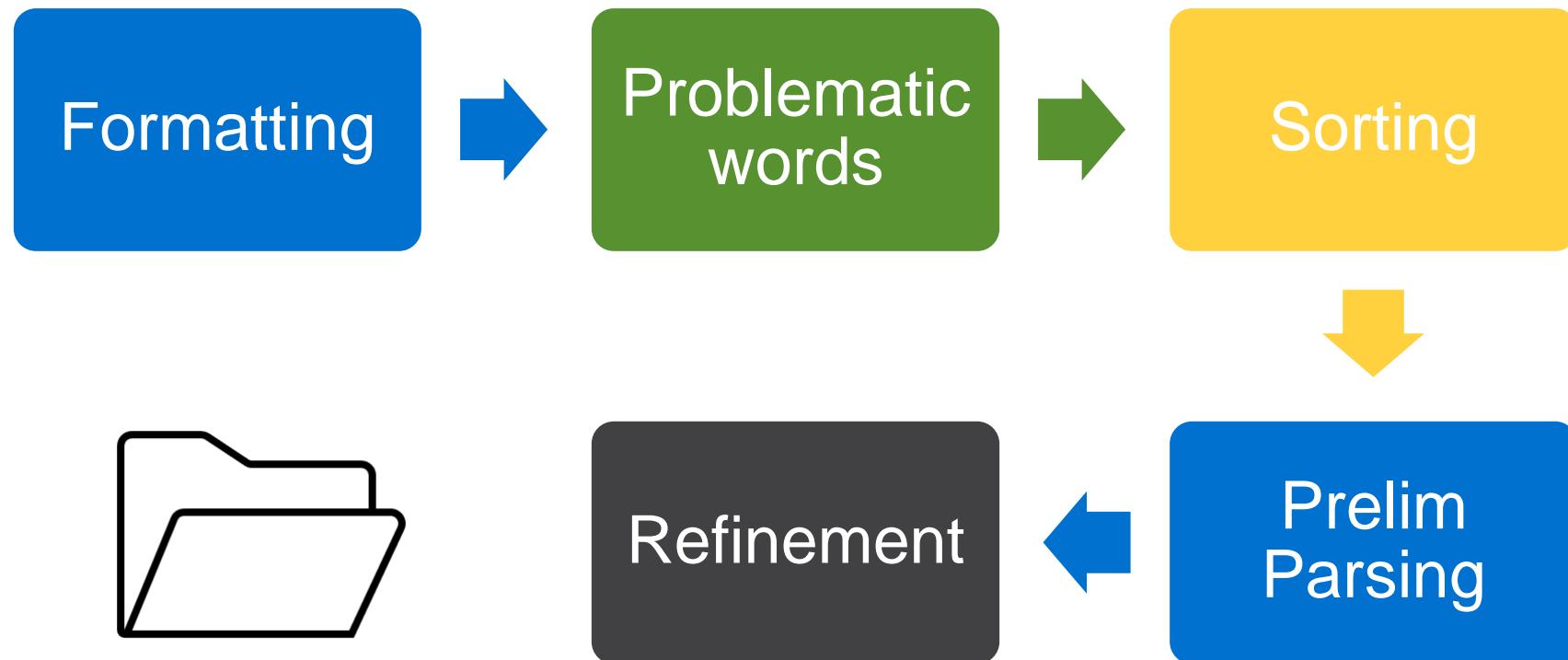


1. Setting up the database





2. Preparing the files





3. Learning

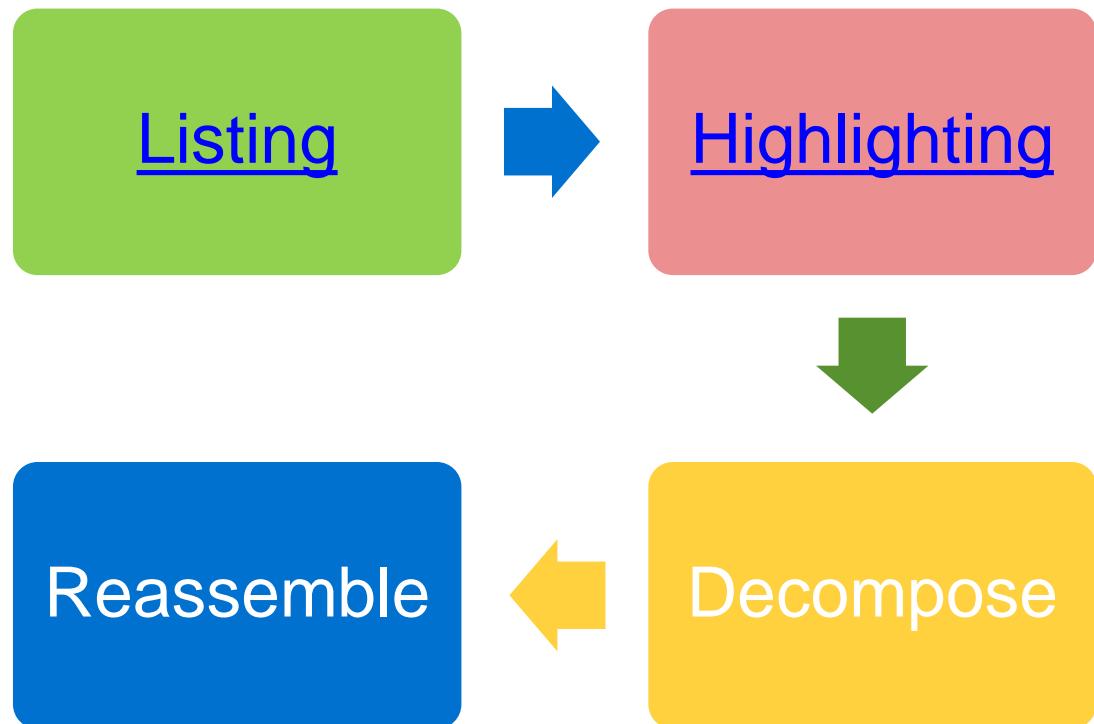
Assign attributes to a word/phrase x

Word / Phrase
shall be drawn

Replacement
Draw

Part
Verb Condition Remove

Assign Cancel

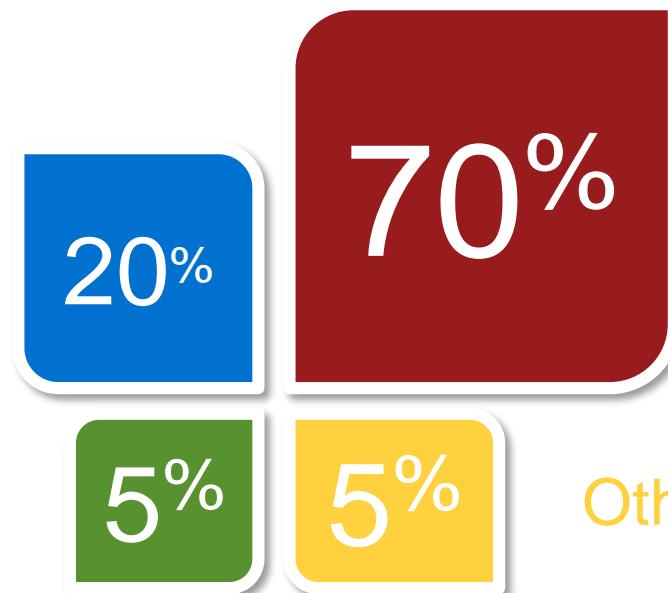




Results

Quantify differences between the automated rewrite and the final edit using the Longest Common Substring algorithm (~20 specifications)

Text is too mangled or too wordy for automated interpretation

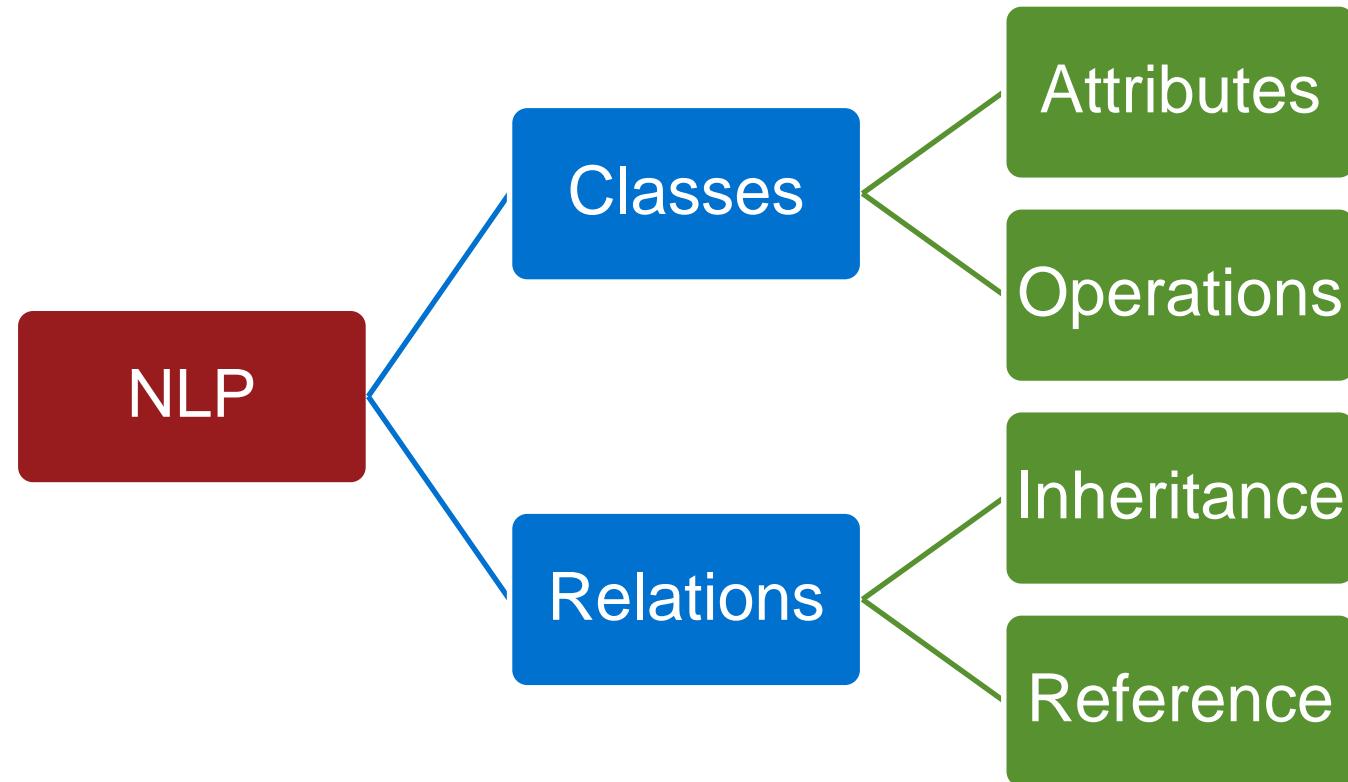


Longest common string approximates the edited version.

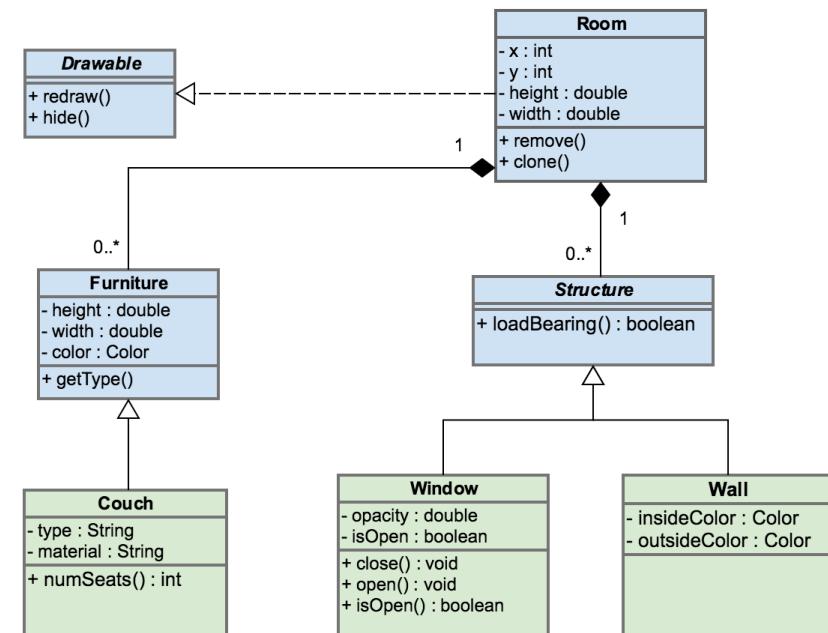
Requirement has technical issues.



Using NLP to create

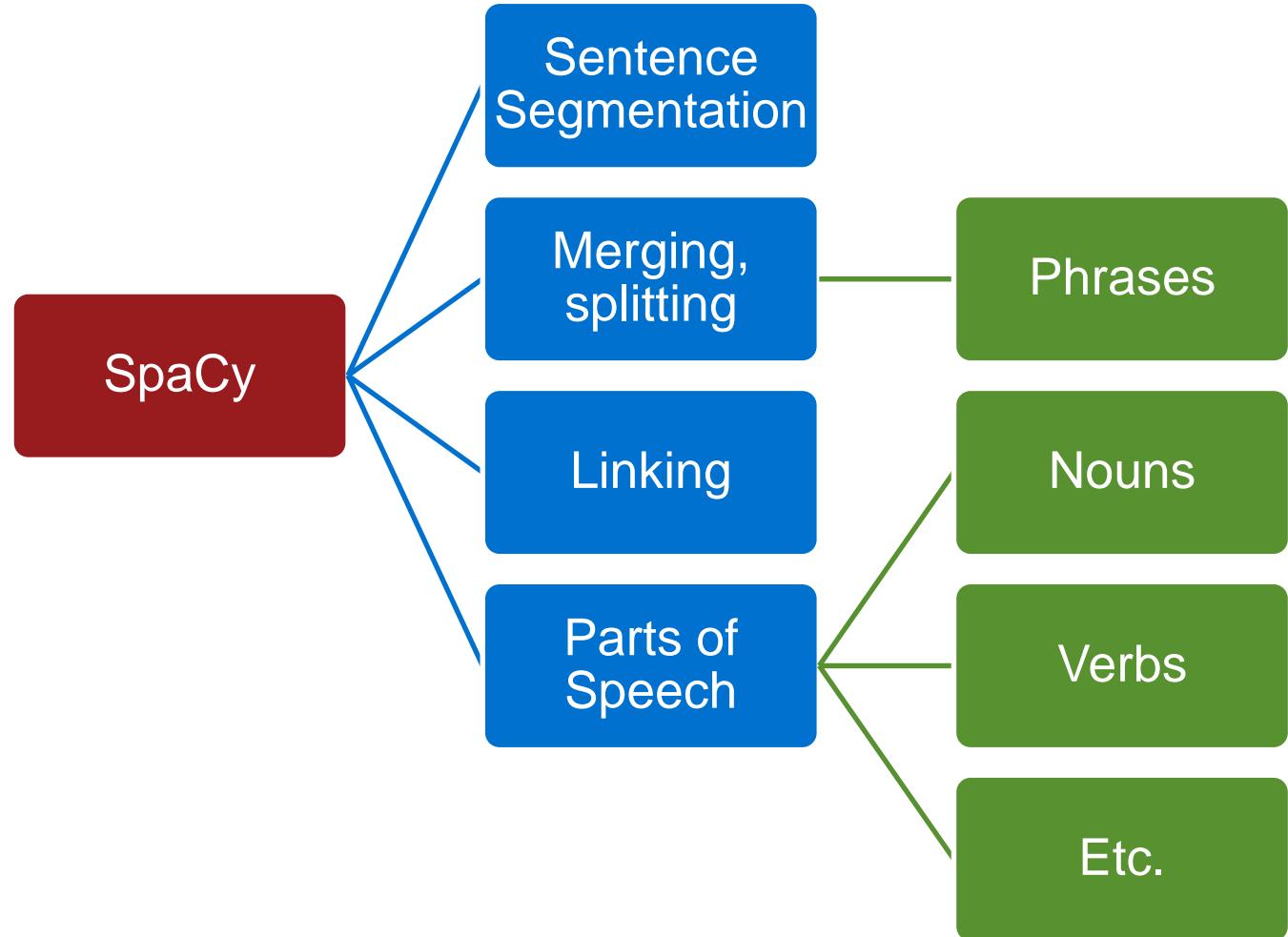


UML diagrams



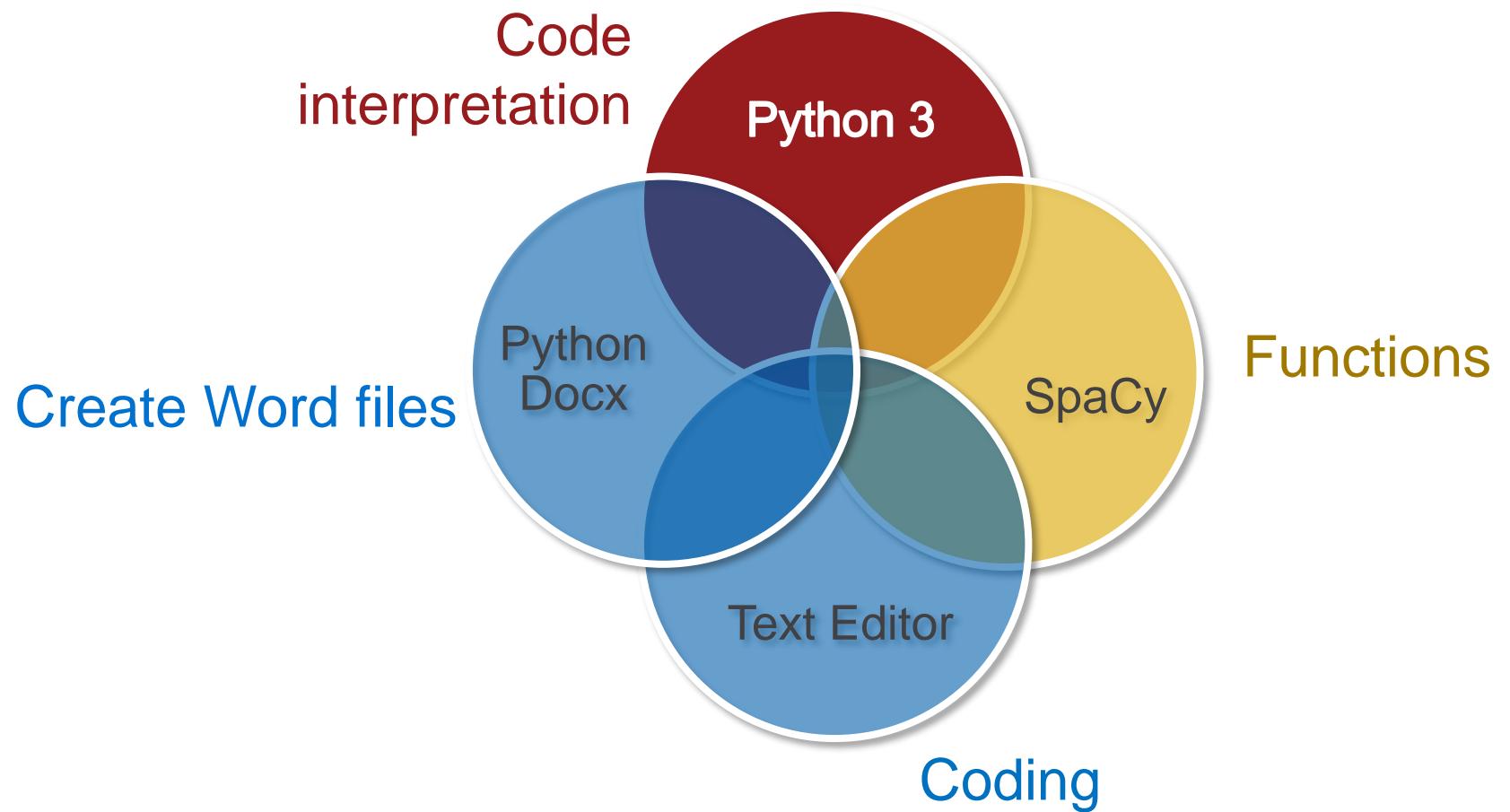


Python SpaCy NLP Library





Required Technologies





Python-based Process

Read the Word file

Apply SpaCy Pipeline
Processing

Analyze the sentence

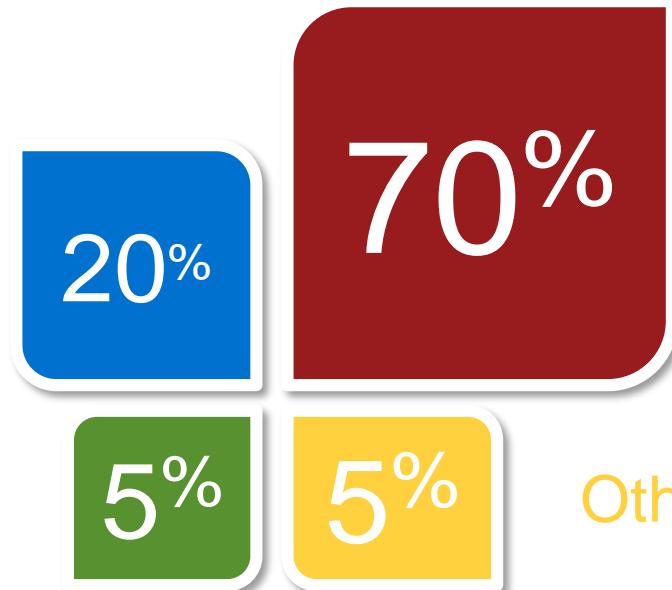
Write sentence to the Word
documents



Results

Similar to VBA

Text is too mangled or too wordy for automated interpretation



Longest common string approximates the edited version.

Requirement has technical issues.

Other issues

So what did we learn?



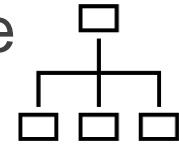
VBA	Python
Bulk operations	Bulk operations
Effective “first pass” at streamlining	Effective “first pass” at streamlining
Scalable, modifiable dictionary	Static library
Minimal NLP functions	Robust NLP functions
No generalization of phrases	Generalization of phrases
Handles tables and figures	Poor handling of tables and figures
Streamlining in place	Requires extraction and reassembly



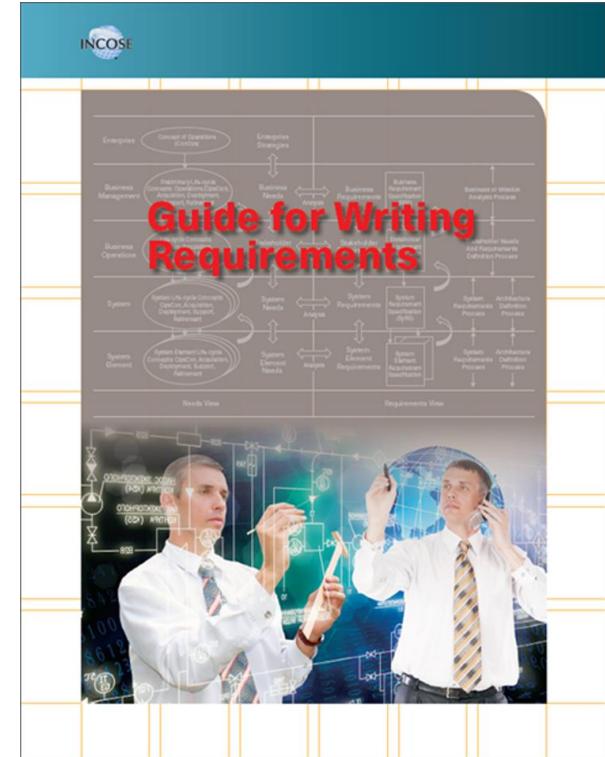
Conclusions

Streamlining: An extension of the INCOSE Guide for Writing Requirements

Streamlined Requirements: Structure



Structure: Efficiency in downstream processes





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www.incos.org/symp2021



Acquire	Parse the paragraphs	Streamline
Definitions Noun: A person, place, or thing. Verb: An action, state, or occurrence. Adjective: An attribute / property of a noun. Adverb: A word that modifies or qualifies an adjective, verb, or other adverb.	Definitions (continued) Preposition: A word preceding a noun expressing a relation to another word. Conjunction: A word used to connect groups of words. Determinant: Determines which noun as in: a, an, the, their.	
1.4 ACTION SUBMITTALS A. Product Data: Manufacturer, drawings, and original technical catalog to indicate numbers of conductors and accessories and lengths of insulated cable required.	Product Data: Manufacturer, drawings, and original technical catalog to indicate numbers of conductors and accessories and lengths of insulated cable required.	Product Data: Manufacturer, drawings, and original technical catalog to indicate numbers of conductors and accessories and lengths of insulated cable required.
1.4 ACTION SUBMITTALS B. Samples of cables and accessories	Samples of cables and accessories	Samples of cables and accessories
1.4 ACTION SUBMITTALS C. Manufacturer Calculations: Effective cross-sectional area of the metallic shield and its short circuit current carrying capability	Manufacturer Calculations: Effective cross-sectional area of the metallic shield and its short circuit current carrying capability	Manufacturer Calculations: Effective cross-sectional area of the metallic shield and its short circuit current carrying capability
1.4 ACTION SUBMITTALS D. Manufacturer's Drawings: Show the outline of the splice or termination, together with all pertinent dimensions. Indicate Any variations in these dimensions due to manufacturing tolerances.	Manufacturer's Drawings: Show the outline of the splice or termination, together with all pertinent dimensions. Indicate Any variations in these dimensions due to manufacturing tolerances.	Manufacturer's Drawings: Show the outline of the splice or termination, together with all pertinent dimensions. Indicate Any variations in these dimensions due to manufacturing tolerances.
1.5 INFORMATIONAL SUBMITTALS A. Certificate of compliance	Certificate of compliance	Certificate of compliance
1.5 INFORMATIONAL SUBMITTALS B. Delegated Design Submittals: Calculations for cable sizing to justify the proposed cables.	Delegated Design Submittals: Calculations for cable sizing to justify the proposed cables.	Delegated Design Submittals: Calculations for cable sizing to justify the proposed cables.
1.5 INFORMATIONAL SUBMITTALS C. Test and Evaluation Reports: Field test reports after the completion of Testing and Commissioning	Test and Evaluation Reports: Field test reports after the completion of Testing and Commissioning	Test and Evaluation Reports: Field test reports after the completion of Testing and Commissioning
1.5 INFORMATIONAL SUBMITTALS D. Manufacturer Instructions: Installation instructions for cable and accessories	Manufacturer Instructions: Installation instructions for cable and accessories	Manufacturer Instructions: Installation instructions for cable and accessories
1.5 INFORMATIONAL SUBMITTALS E. Quality Control Program: As outlined in SECTION 01 45 00	Quality Control Program: As outlined in SECTION 01 45 00	Quality Control Program: As outlined in SECTION 01 45 00
1.5 INFORMATIONAL SUBMITTALS F. Factory test reports 1. Methods: Test all conductors and cables and their accessories at the factory in accordance with the latest approved manufacturing codes and standards. 2. Notification: Notify the Royal Commission in writing not less than 30 days prior to the scheduled starting date of the factory tests	Methods: Test all conductors and cables and their accessories at the factory in accordance with the latest approved manufacturing codes and standards. Notification: Notify the Royal Commission in writing not less than 30 days prior to the scheduled starting date of the factory tests	Methods: Test all conductors and cables and their accessories at the factory in accordance with the latest approved manufacturing codes and standards. Notification: Notify the Royal Commission in writing not less than 30 days prior to the scheduled starting date of the factory tests
1.5 INFORMATIONAL SUBMITTALS F. Factory test reports 3. Witnessing: The Royal Commission reserves the right of deputing their representative for witnessing the factory testing	Witnessing: The Royal Commission reserves the right of deputing their representative for witnessing the factory testing	Witnessing: The Royal Commission reserves the right of deputing their representative for witnessing the factory testing
1.5 INFORMATIONAL SUBMITTALS F. Factory test reports 4. Timing: Upon completion of factory tests, and before shipment of the conductors and cables and their accessories, submit 5 certified copies of test reports not later than 10 days after the completion of all factory tests for review and approval by the Royal Commission	Timing: Upon completion of factory tests, and before shipment of the conductors and cables and their accessories, submit 5 certified copies of test reports not later than 10 days after the completion of all factory tests for review and approval by the Royal Commission	Timing: Upon completion of factory tests, and before shipment of the conductors and cables and their accessories, submit 5 certified copies of test reports not later than 10 days after the completion of all factory tests for review and approval by the Royal Commission



Quantification of Success

Σ Common strings (no highlight or strikeout)

Length of the longest string

Before Streamlining	Automated Streamlining	Subsequent Manual Edit
Pulling loops shall be used to pull single conductor cable smaller than 70 mm ² .	Pulling Loops: Used to pull single conductor cable smaller than 70 mm ² .	Pulling Loops: For single conductor cable smaller than 70 mm ² .
All buried plug valves shall have a remote position indicator in the valve box showing position of the valve.	Buried Plug Valves: Has a remote position indicator in the valve box showing position of the valve.	Buried Valves: Remote position indicator in the valve box showing position of the valve. (the “plug” type is already in the heading)



Learning

Assign attributes to phrase

Assign attributes to a word/phrase X

Word / Phrase
shall be drawn

Replacement
Draw

Part
Verb Condition Remove

Analyze the collection

Word	Replacement
shall be clearly shown	Show clearly the
shall also be shown	Show also the
shall not be shown	Do not show
shall be shown	Show
shall appear	Show
shall show	Show



The Case for Streamlined Requirements

- Ease of use
- Imperative mood
- Default actor
- Construction submittals
- Culture independent
- Model development and validation

