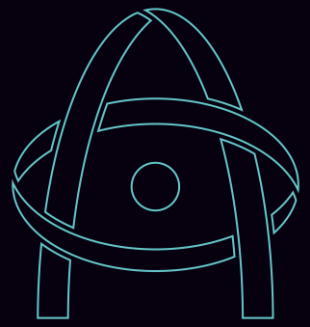

FROM DATA TO DECISIONS: AI ENHANCED ENGINEERING DESIGN SUPPORT

Jeroen Jordens

21/05/2026 – Highway session Ghent

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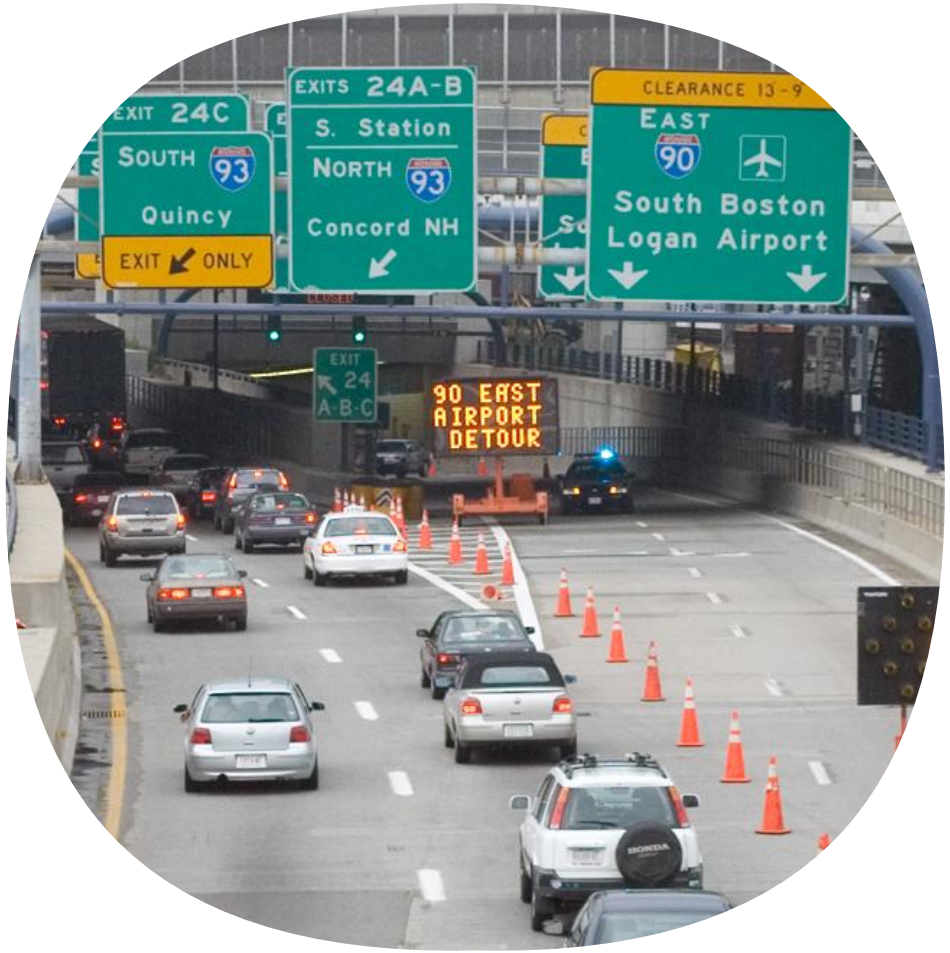
KU LEUVEN · DTAI · FLANDERS MAKE

AI FLANDERS BUILDING OUR DIGITAL FUTURE



Ceiling Collapse in the Interstate 90 Connector Tunnel
Boston, Massachusetts
July 10, 2006

TUNNEL CEILING COLLAPSES DUE TO SELECTION OF WRONG ADHESIVE

ACCIDENT REPORT
NTSB/HAR-07/02
PB2007-916203

National Transportation Safety Board

HTTPS://UPLOAD.WIKIMEDIA.ORG/WIKIPEDIA/COMMONS/6/65/BOSTON_TRAFFIC_RE-ROUTED_TED_WILLIAMS_TUNNEL%2C_2006.JPG

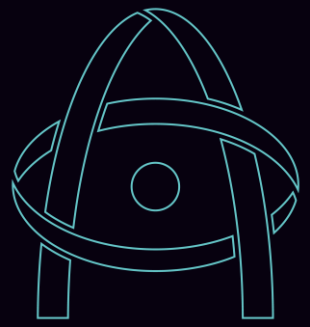
DATA EXISTED, BUT KNOWLEDGE WAS NOT USED FOR DECISION

Expertise is scarce + costly

Lot of complex parameters & data

Time & budget constraints

SUPPORT DESIGN DECISIONS WITH RELIABLE, EXPLAINABLE AI



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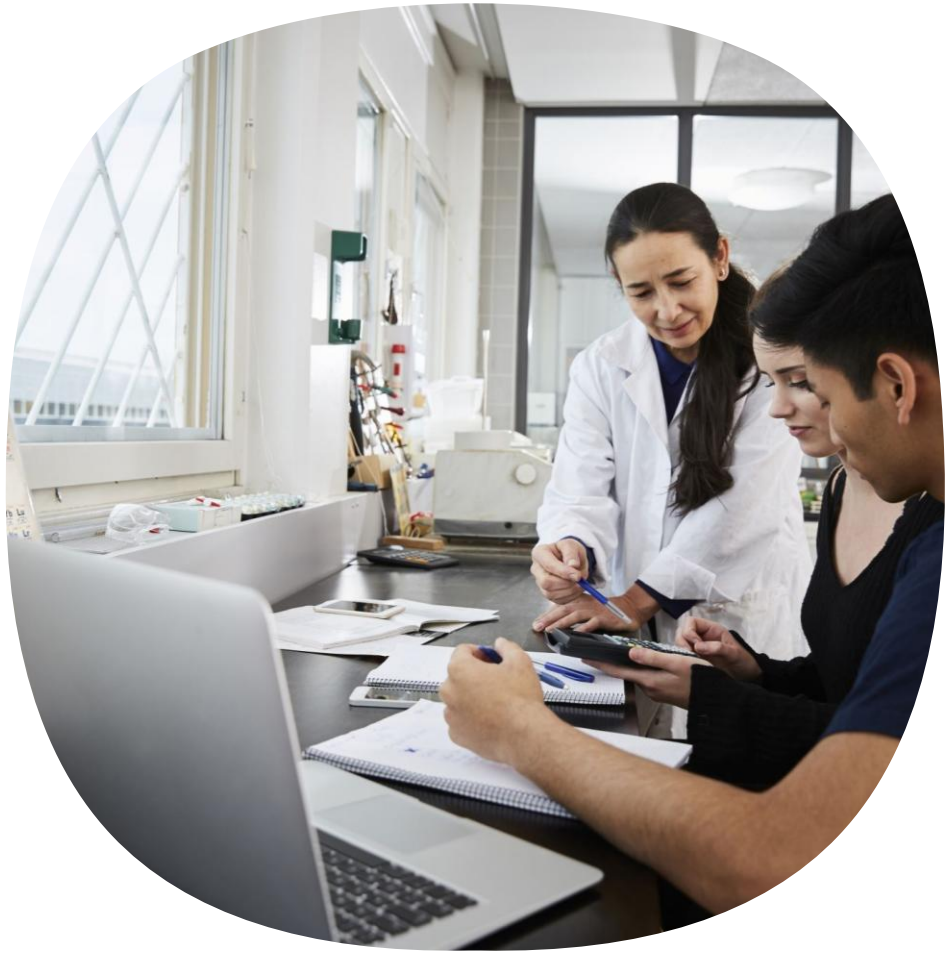


DESIGN DECISIONS MADE BASED ON EXPERT KNOWLEDGE

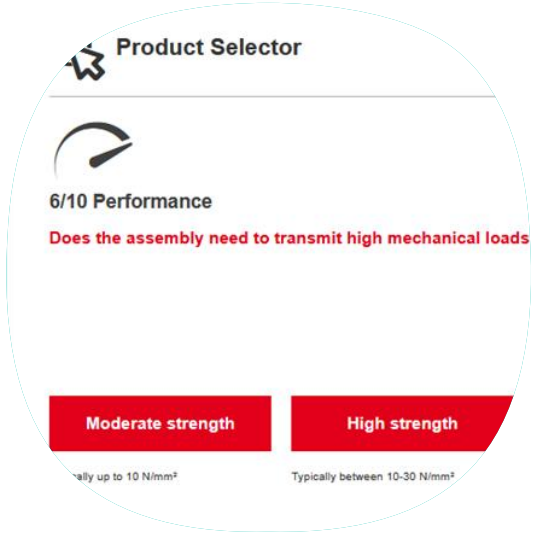
ADHESIVE SELECTION PROCESS

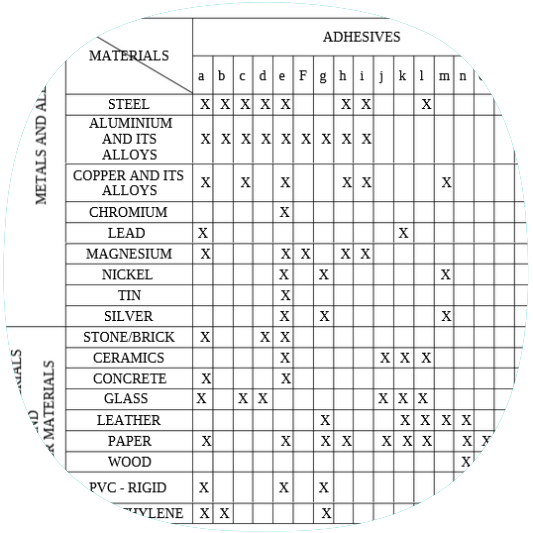
Identify requirements

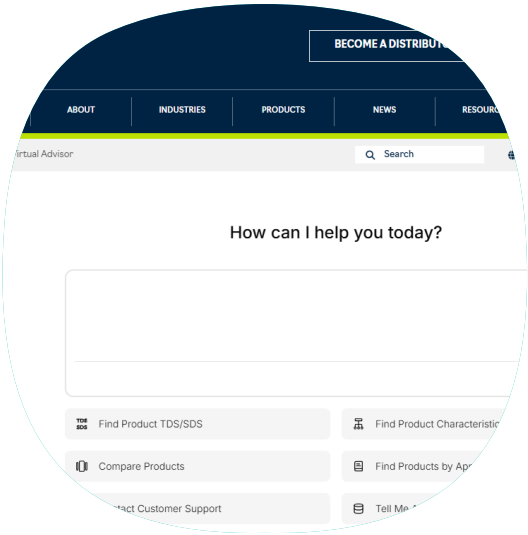
Initial selection

Testing of selected adhesives

SEVERE SHORTAGE OF SELECTION SOFTWARE







Websites

- Very simple interfaces
- Often only selection filter

Expert systems

- Low interpretability
- Low maintanability
- Low number of adhesives
- Not always back+ forward chaining

LLM

- Unpredictable
- Black box
- Illusion of reasoning

Ewen J.C., K. Key issues in selecting the right adhesive. In Dillard, D. A., editor, Advances in structural adhesive bonding 2010, Woodhead publishing in materials, pp. 3–19. Woodhead Publishing.

AI VIRTUAL ADVISOR

Parameter	Your Requirement
Field of application	Automotive
Adhesion to car paint	✅
Substrate: steel & plastic	✅
Panel dimensions (l x w)	Ca. 1m x 1m
Gap filling (1–2 mm)	Max 1–2 mm
Shear strength	≥ 0.1 MPa
Elongation at break	≥ 150%
Shock/impact resistance	Required
Temperature resistance	-40°C to +80°C
Water resistance	Required
Surface treatment	Degreasing only
Open time	Minutes
Handling strength	Hours
Full cure	≤ 24 h
Shelf life	≥ 6 months
Cure temperature	Room temperature

AI VIRTUAL ADVISOR

Parameter	Your Requirement	ISR 70-03
Field of application	Automotive	✅ Mobility market (roof, sunroof, corner profiles, flooring)
Adhesion to car paint	✅	✅ Compatible with alkyd & dispersion paints
Substrate: steel & plastic	✅	✅ Wide substrate adhesion, no primer typically needed
Panel dimensions (l x w)	Ca. 1m x 1m	
Gap filling (1–2 mm)	Max 1–2 mm	✅ Min. adhesive thickness 2 mm
Shear strength	≥ 0.1 MPa	✅ ~2.5 MPa
Elongation at break	≥ 150%	✅ ~200%
Shock/impact resistance	Required	✅ Elastic bonding, durable bonds
Temperature resistance	-40°C to +80°C	✅ -40°C to +110°C
Water resistance	Required	✅ Excellent UV, weather & temperature resistance
Surface treatment	Degreasing only	✅ Most substrates need only cleaning/degreasing
Open time	Minutes	✅ Assembly within 15 minutes
Handling strength	Hours	✅ Skin formation ~10 min; 3 mm cure depth in 24 h
Full cure	≤ 24 h	✅ ~3 mm cure depth at 24 h (covers 1–2 mm joint)
Shelf life	≥ 6 months	✅ 18 months (cartridge)
Cure temperature	Room temperature	✅ Moisture cure, +5°C to +35°C

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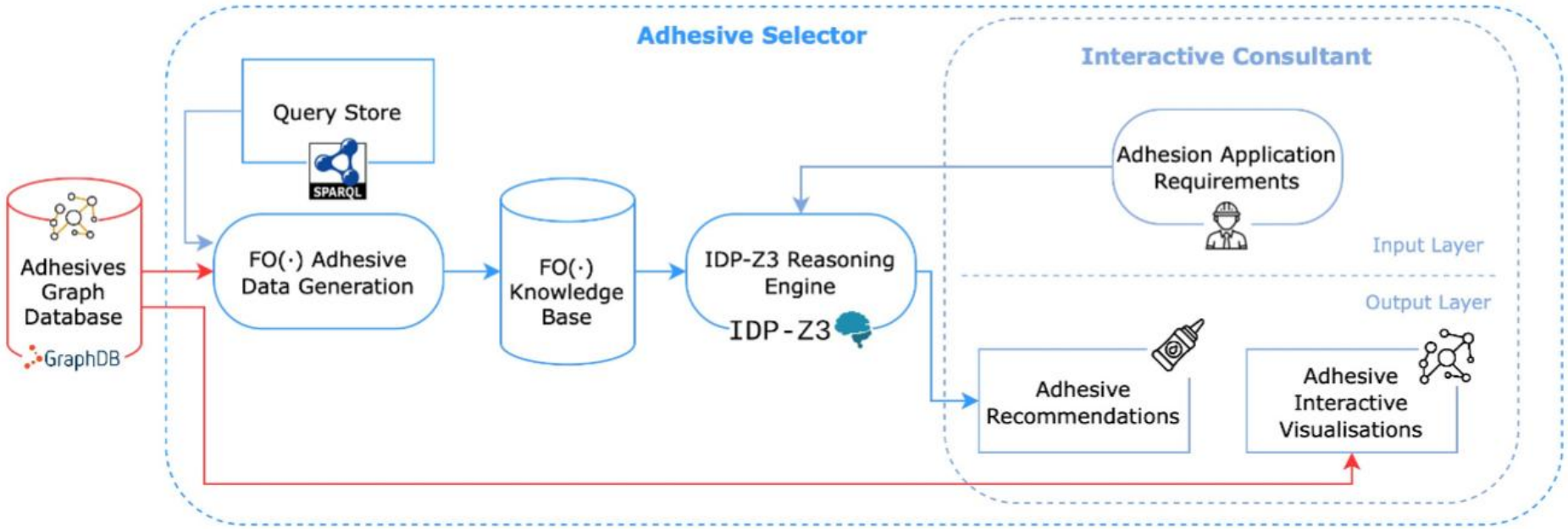
Moisture curing adhesive is unsuitable

SOLUTION

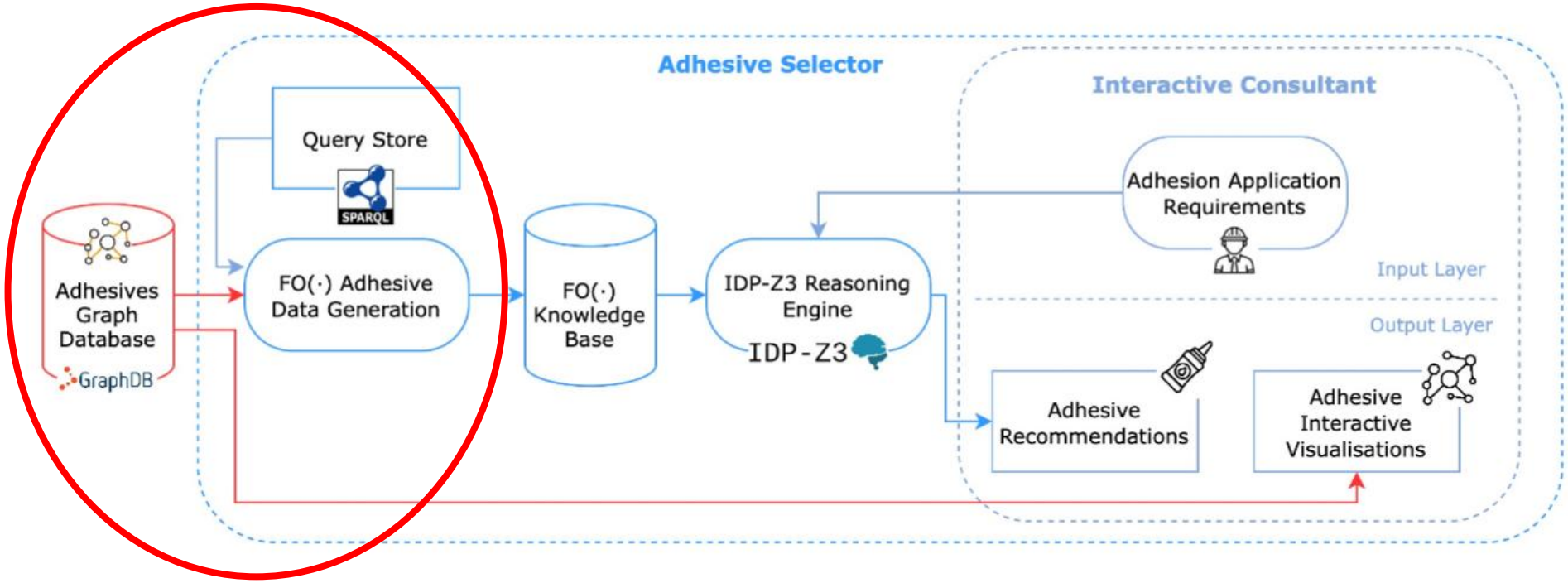


Knowledge graph

Expert Knowledge base

Reasoning engine

SOLUTION



Knowledge graph

Expert Knowledge base

Reasoning engine

UNPROCESSED ADHESIVES DATA ARE HARD TO USE

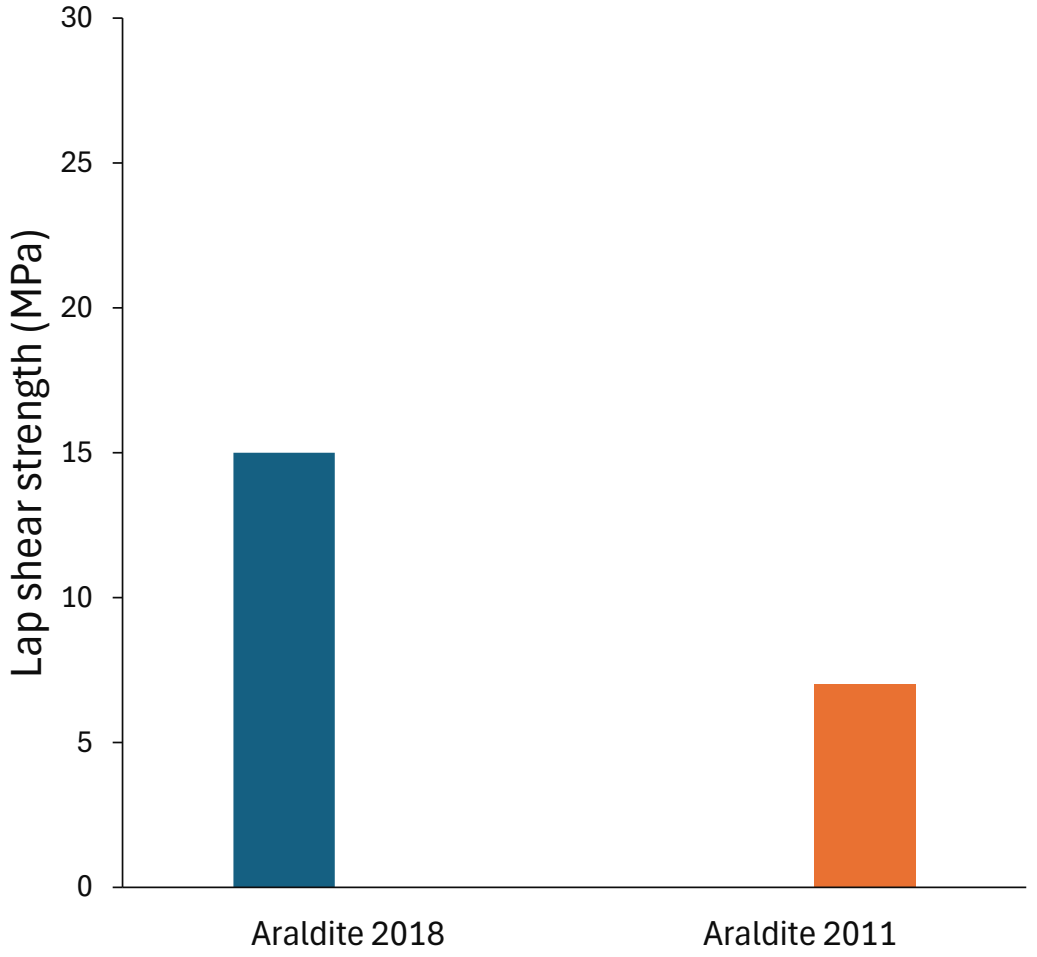
Typical Properties*

	TC-2002 A Resin	TC-2002 B Curative	Mixed
Appearance	Tan Paste	Gray Paste	Tan Paste
Viscosity, cP @ 25°C	600,000	325,000	500,000
Specific Gravity	1.71	1.24	1.67
Working Life, minutes @ 25°C	–	–	7-8

In-house adhesives data:

1. They often include complex hierarchies and relationships
2. They can include mistakes introduced by humans
3. Are difficult to use if not organized meaningfully

WHICH ADHESIVE IS THE STRONGEST?



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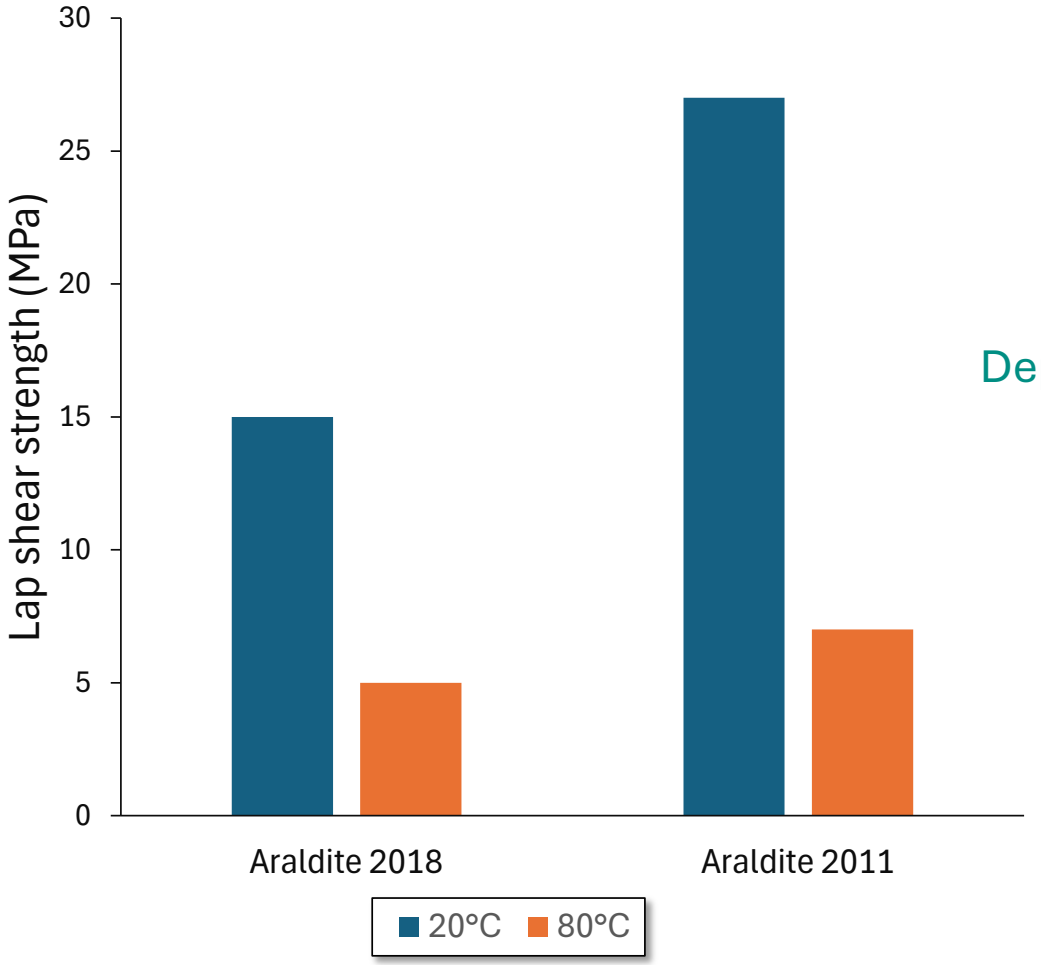
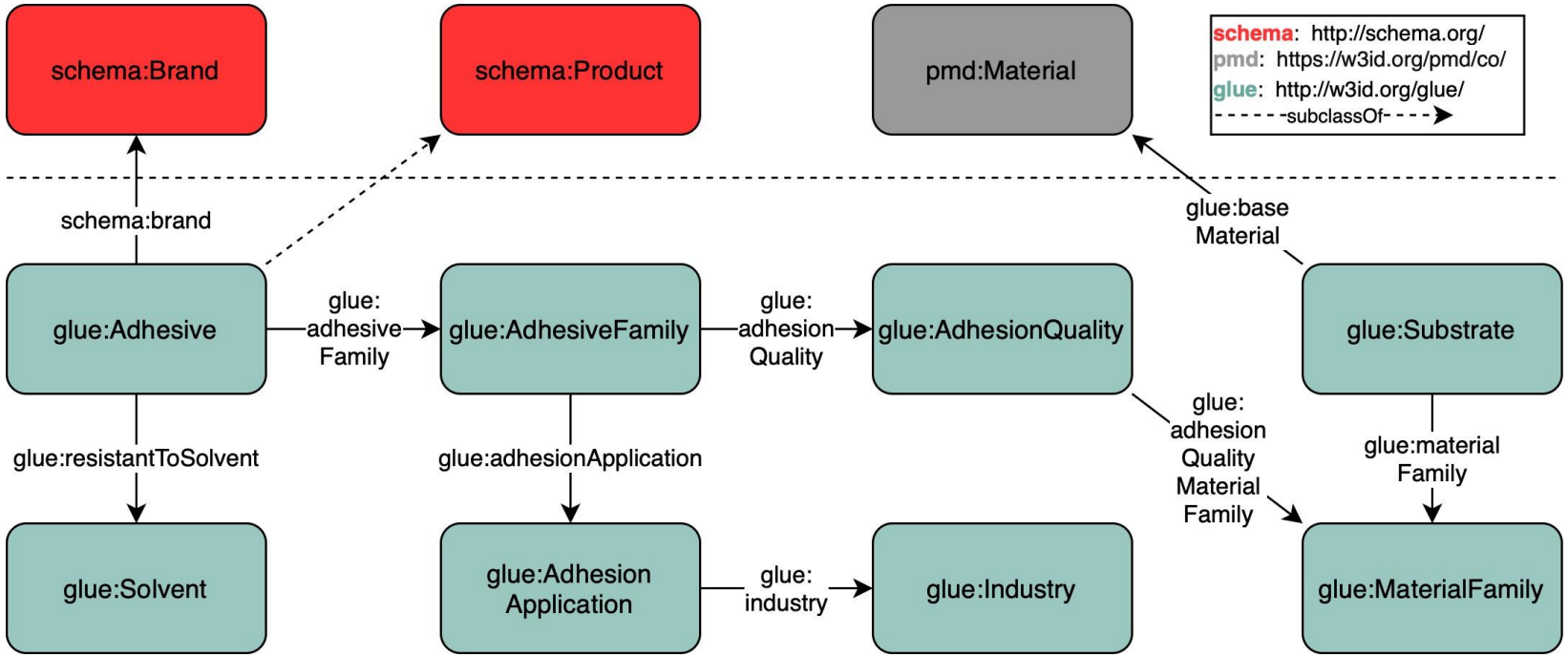


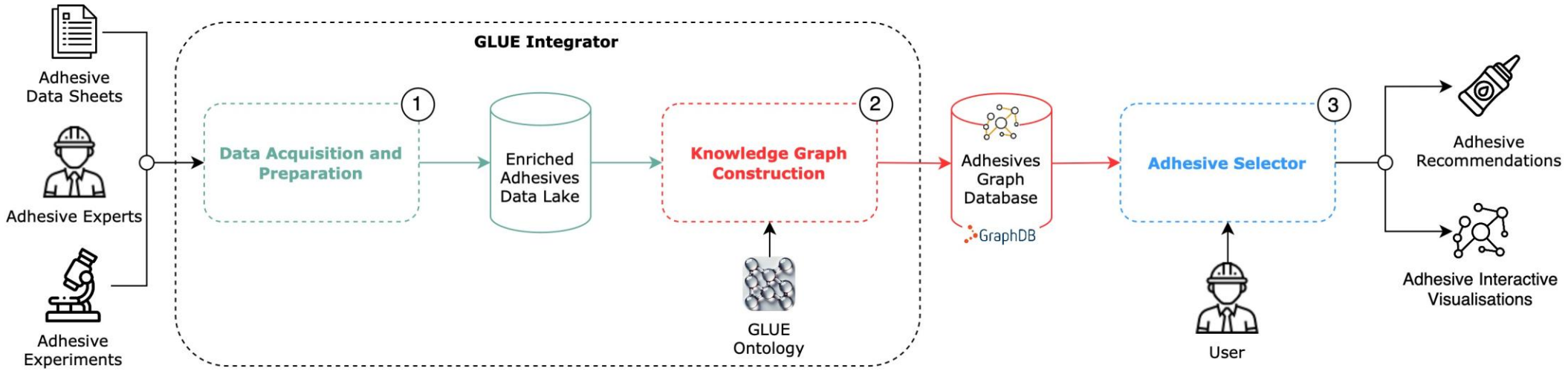
Depends on the conditions of the test!

DEVELOPMENT OF A DATA MODEL TO ORGANIZE ADHESIVE DATA MEANINGFULLY



GLUE Ontology: A data schema for adhesive concepts and relationships

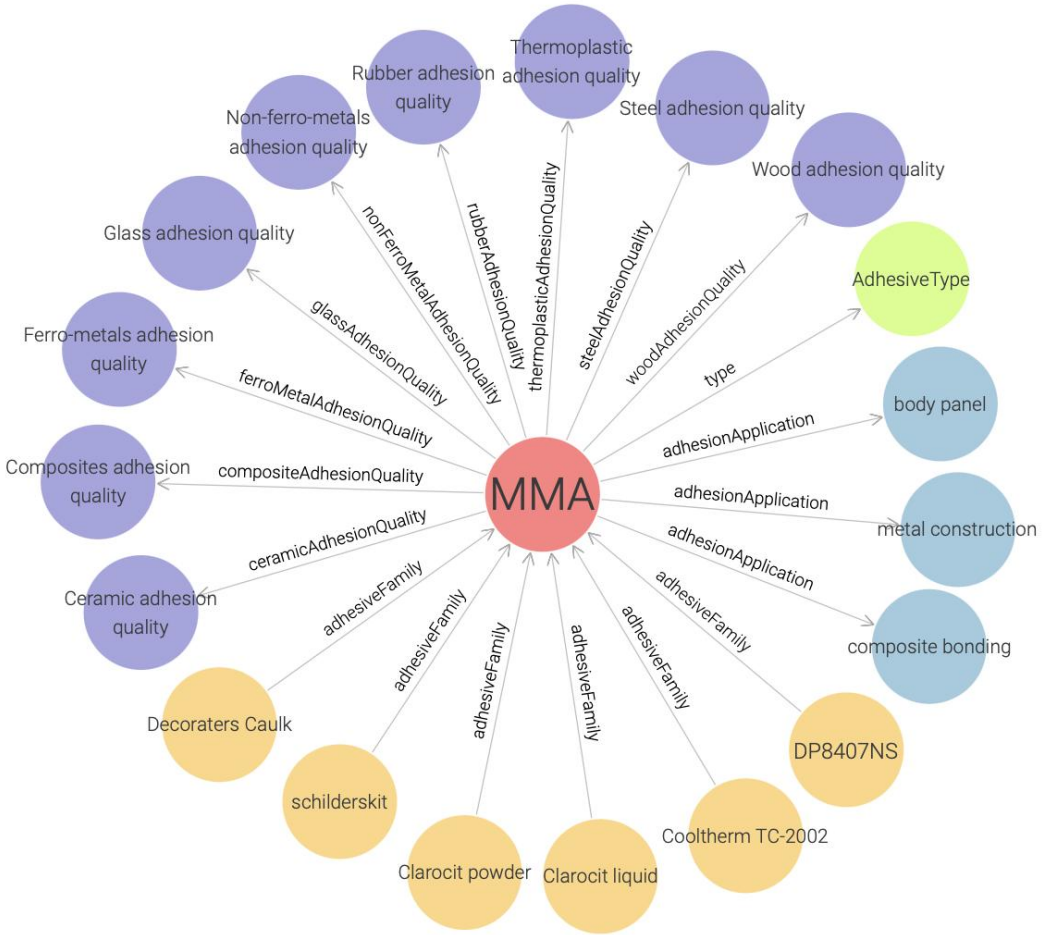
AUTOMATED DATA TRANSFORMATION PIPELINE STRUCTURES ADHESIVES DATA MEANINGFULLY TO PROVIDE VALUE



Adhesives data transformation pipeline:

1. Acquisition and pre-processing in collaboration with adhesive experts
2. Transformation of data to a graph database of adhesives
3. Usage of the graph database for adhesive recommendations and visualisations

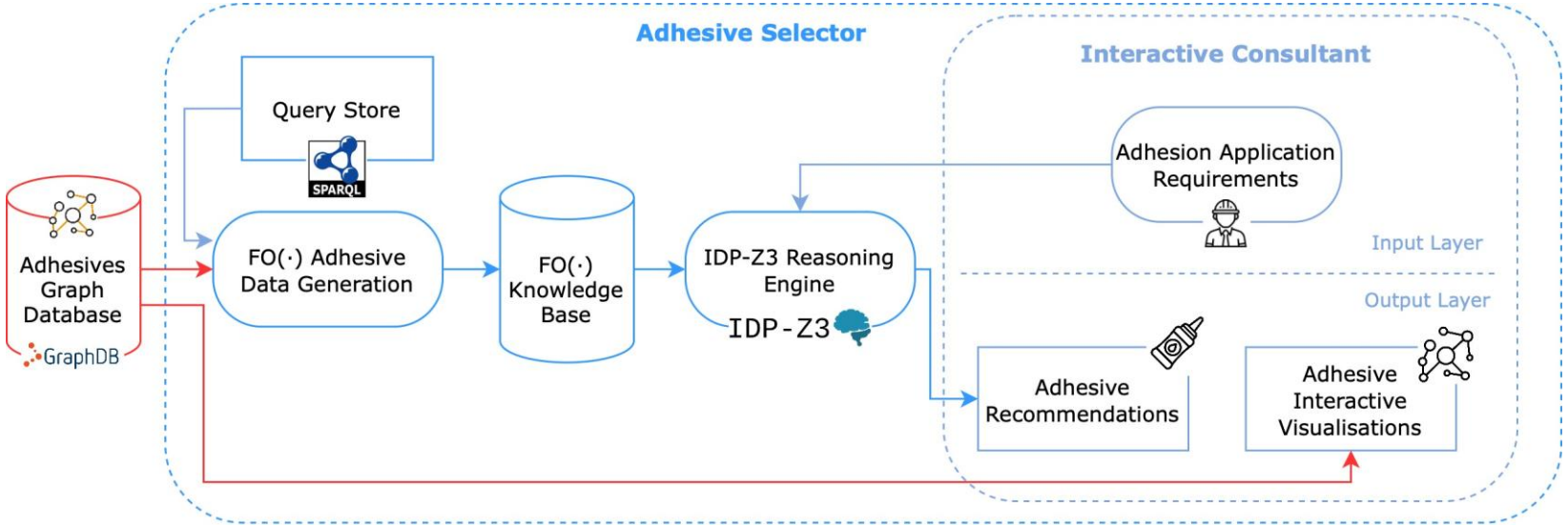
TRANSFORMING ADHESIVES DATA TO A KNOWLEDGE GRAPH FOR IMPROVED SEARCH AND RECOMMENDATION



Resulting knowledge graph:

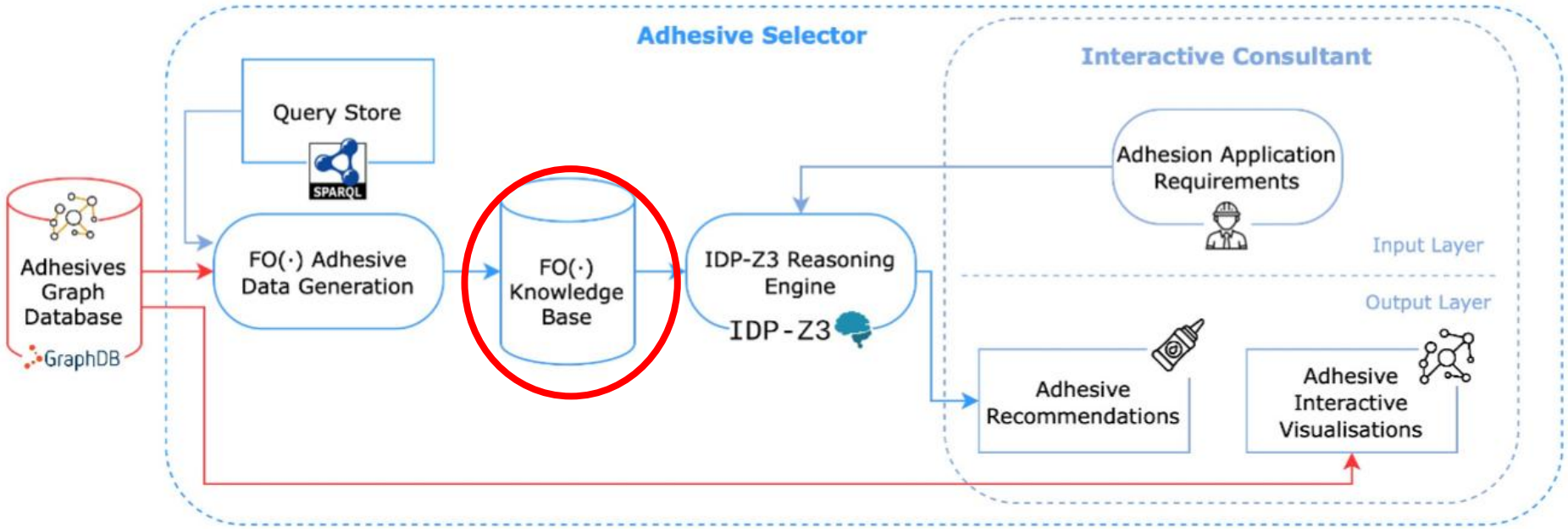
1. Based on a common flexible schema we have developed
2. Enables meaningful organization of in-house adhesive data

KNOWLEDGE GRAPH IS USED FROM THE ADHESIVE SELECTOR TO PROVIDE RECOMMENDATIONS



- Knowledge graph is queried by the Adhesive Selector to retrieve adhesive knowledge
- Recommendations are made by reasoning over user requirements

SOLUTION



Knowledge graph

Expert Knowledge base

Reasoning engine

EXPERT KNOWLEDGE BASE

KNOWLEDGE ARTICULATION WORKSHOPS

- Extraction of expert knowledge
- Extract knowledge from domain expert + formalized by knowledge engineer
- Formalised in common notation

COMMON NOTATION

constraint Decision Model and Notation (cDMN)

Decision table

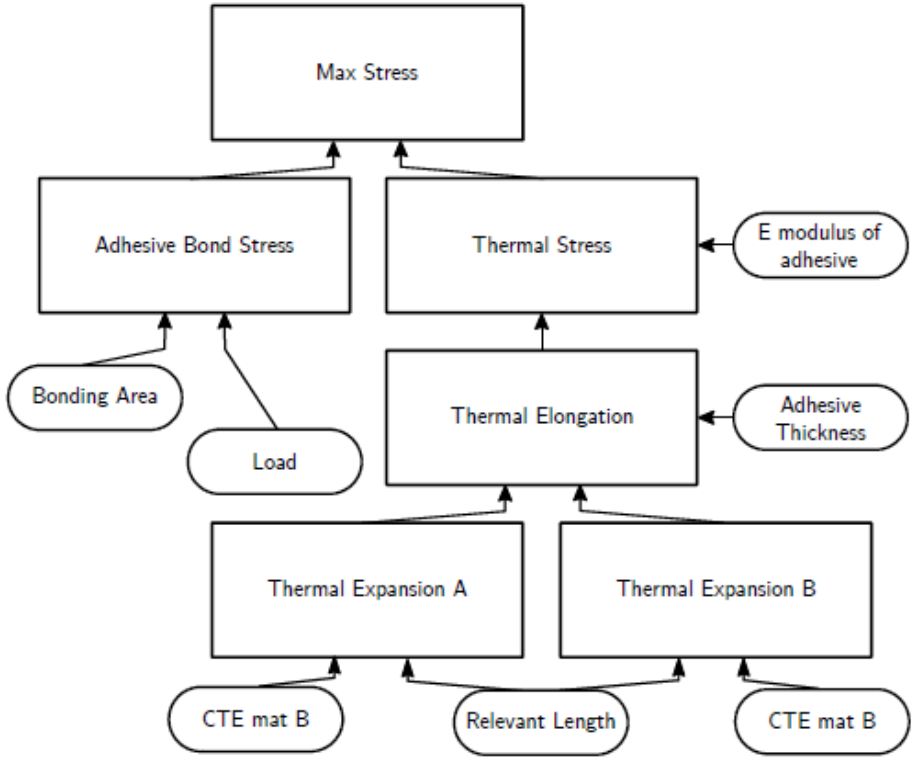
MinElongation		
U	Support	MinElongation
1	free	0.5 × deltaLength / BondThickness
2	fixed	deltaLength / BondThickness

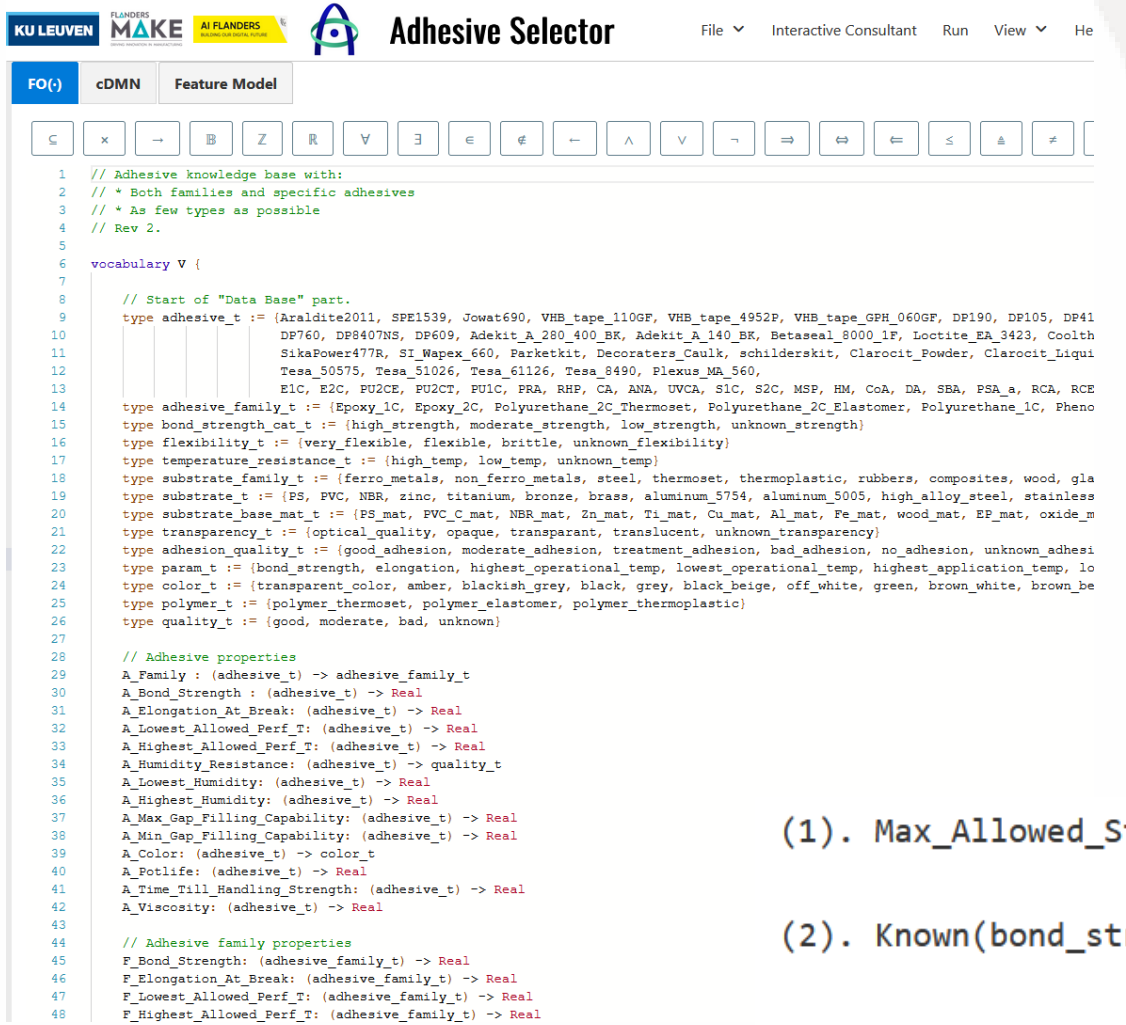
(a) Calculation of MinElongation

BondStrength constraint		
E*	Strength is Known	Max Stress
1	Yes	≥ MinStrength

(b) BondStrength constraint table.

Decision requirements diagram





EXPERT KNOWLEDGE BASE

Knowledge stored in knowledge base

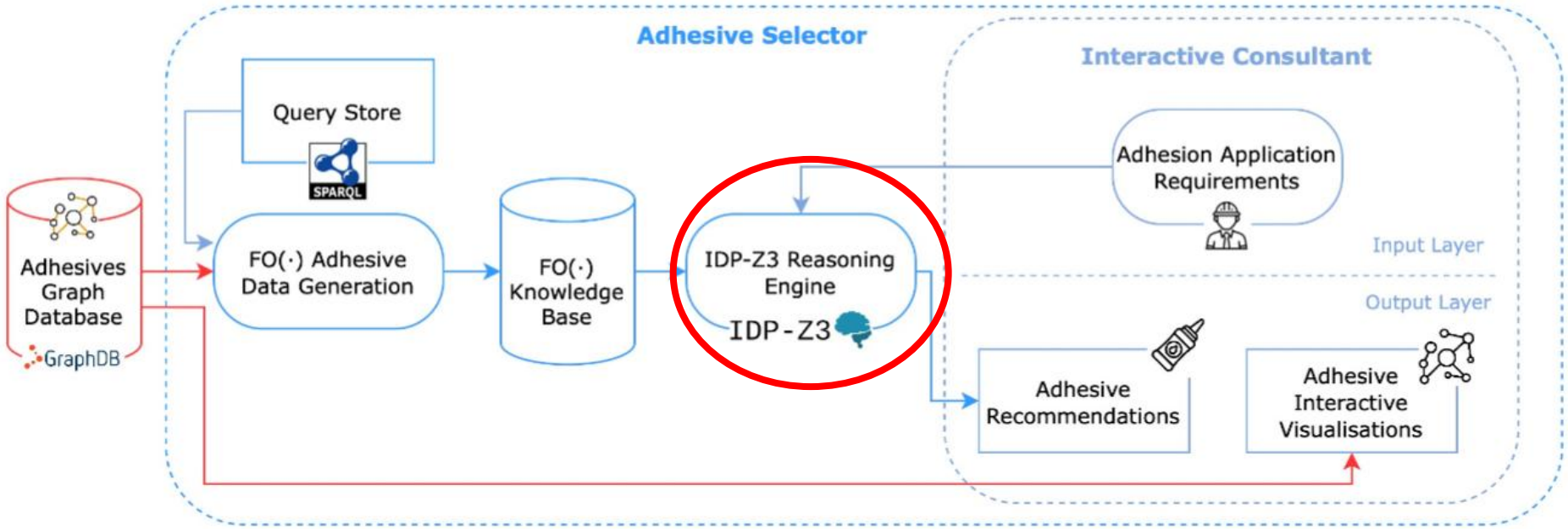
Represented in rich extension of First Order Logic (FO•)

(1). Max_Allowed_Stress() = Load()/Bonding_Area().

(2). Known(bond_strength) ⇒ Min_Bond_Strength() ≤ Bond_Strength().

(3). Adhesive_Family() ∈ {Radiation_Curing_Acrylates} ⇒ SA_Transparent_To_UV() ∨ SB

SOLUTION



Knowledge graph

Expert Knowledge base

Reasoning engine

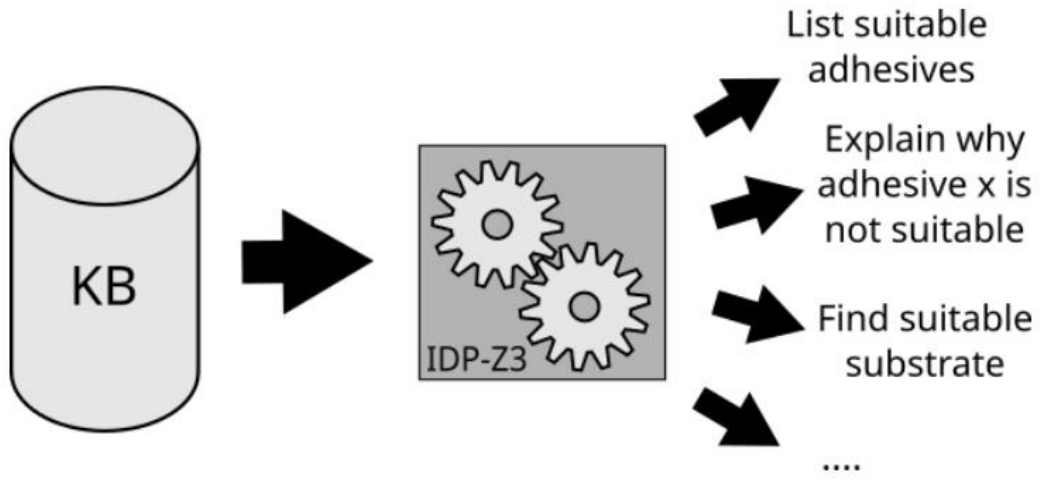
REASONING ENGINE

Knowledge base

use knowledge to solve a variety of problems

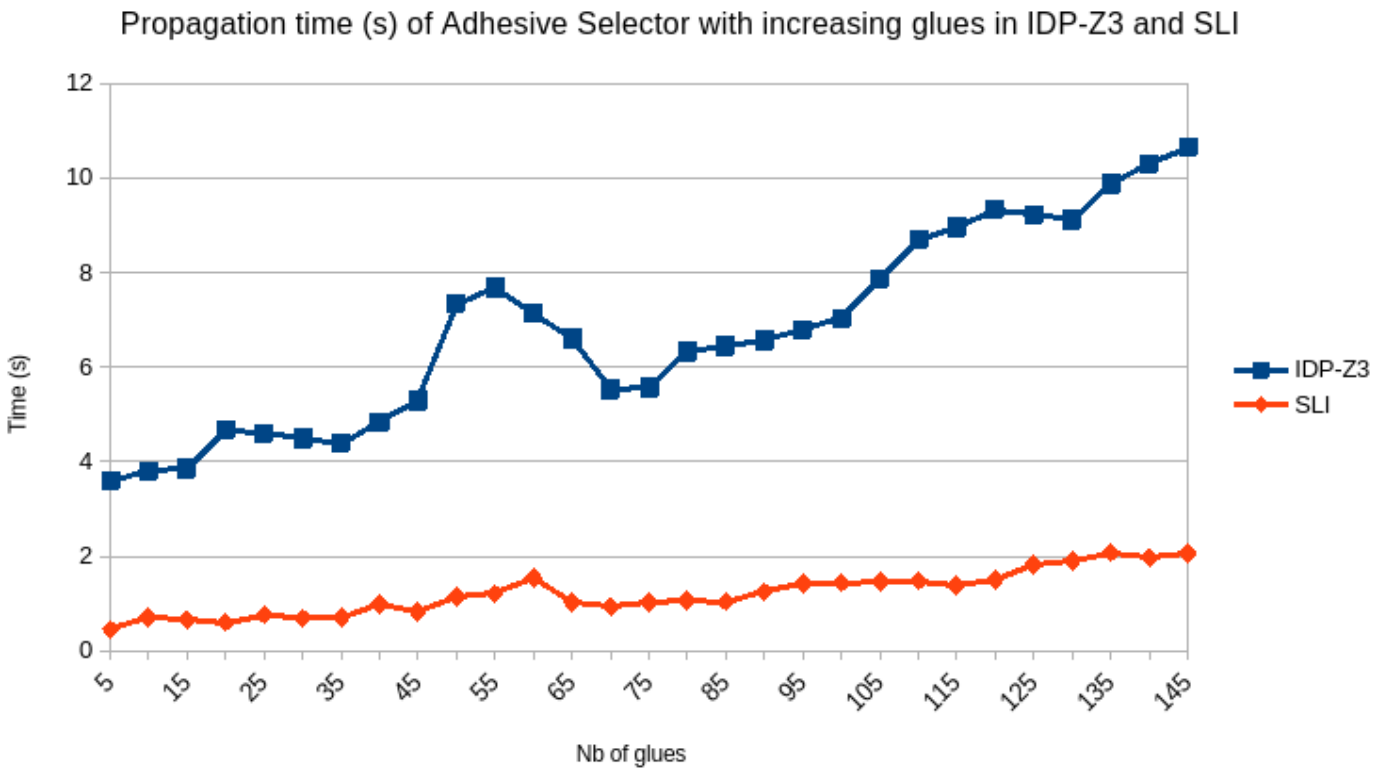
EXAMPLE REASONING TASKS

- find a list of suitable adhesives
- find the cheapest/strongest/most flexible/… adhesive suitable
- verify the applicability of a glue
- explain why a certain glue cannot be used
- choose a second substrate when the glue is already known

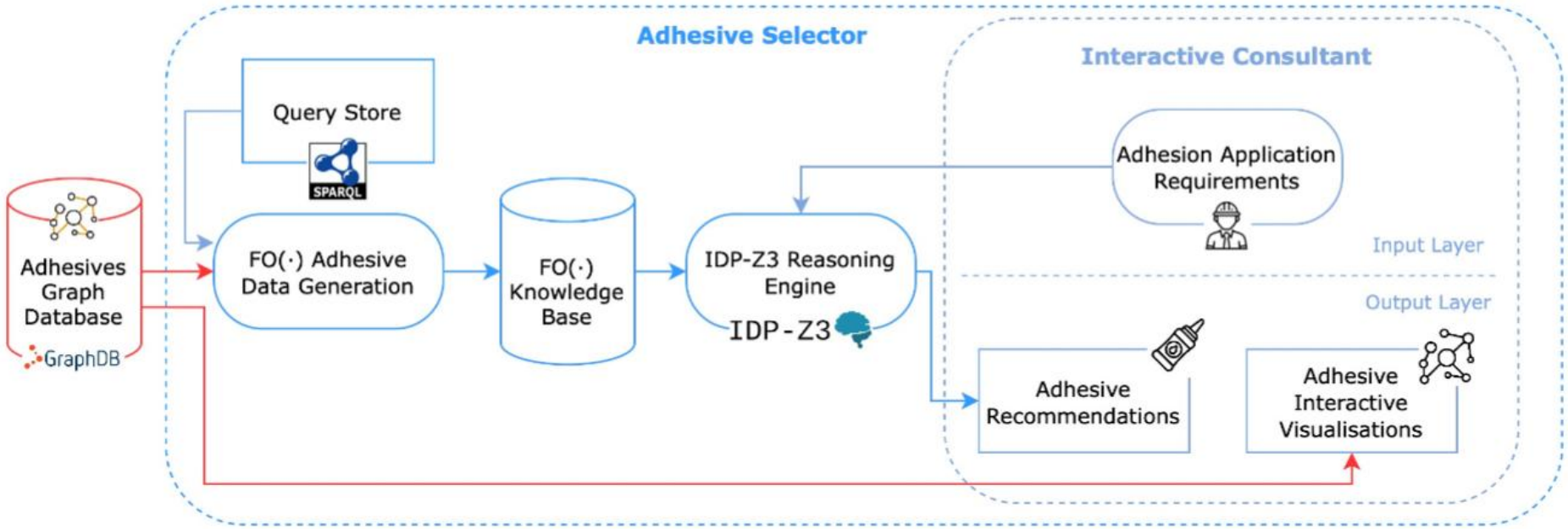


REASONING ENGINE

- IDP-Z3 reasoning engine limited amount of glues
- SLI reasoning engine scales much better



SOLUTION

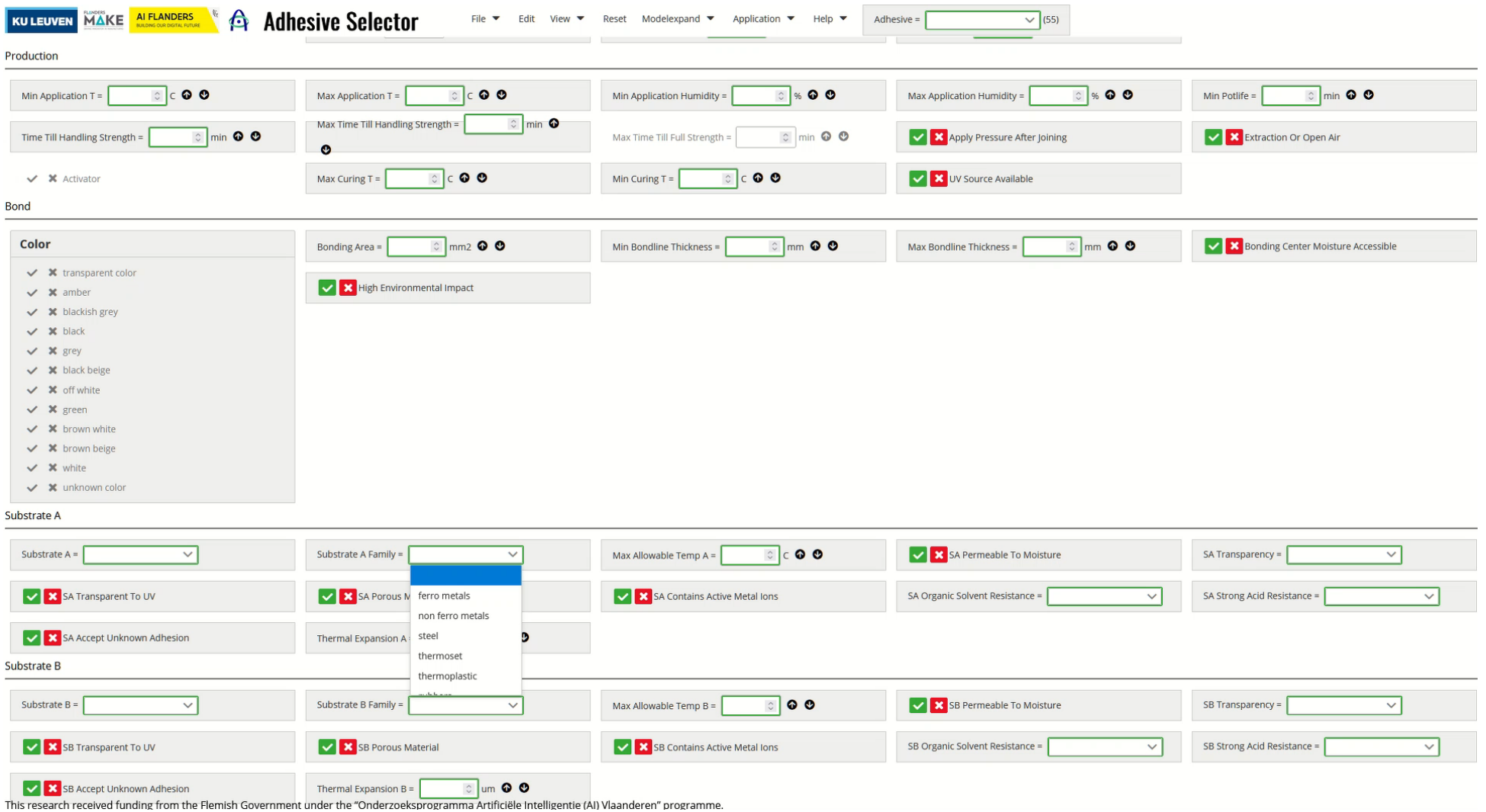


Knowledge graph

Expert Knowledge base

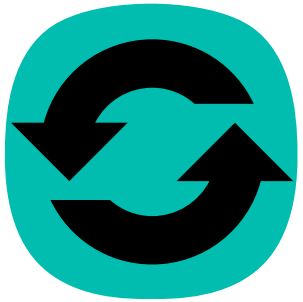
Reasoning engine

INTERACTIVE CONSULTANT



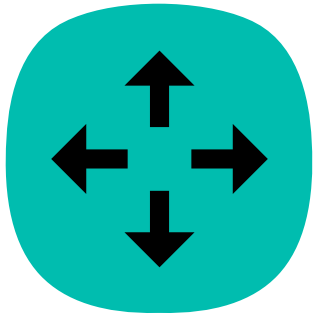
This research received funding from the Flemish Government under the "Onderzoeksprogramma Artificiële Intelligentie (AI) Vlaanderen" programme.

RELEVANCE



Reproducible

Knowledge driven



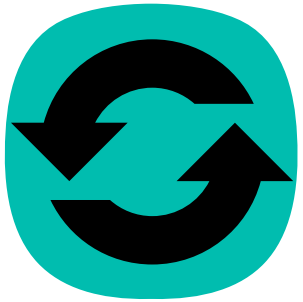
Adaptable

Easy maintainable via knowledge graph

Explainable

Able to explain reason of selection

RELEVANCE



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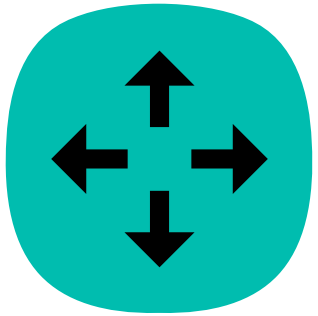

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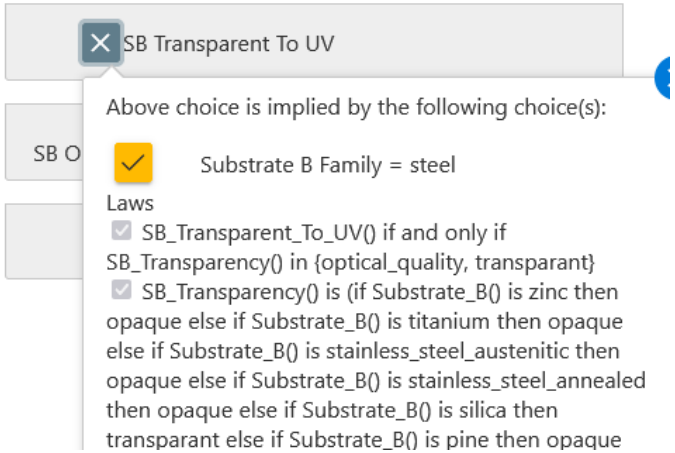


Explainable

Able to explain reason of selection

USER STUDY

Users if Joining & Materials Lab Flanders Make

Main positive points:

- Trust in systems
- Potential time gain
- Sufficiently fast

Main negative points

- Chaotic interface
- Difficult explanations

Code	1	2	3	4
Chaotic interface	✓	✓	✓	✓
Interactive Counter	✓	✓	✓	
Time gain	✓	✓	✓	✓
Avoiding Mistakes	✓			
Play around	✓		✓	
More certain	✓		✓	✓
Understandable	✓			
Trust in the system	✓	✓	✓	✓
Verify result	✓	✓	✓	✓
Sufficiently fast	✓	✓	✓	✓
Broader scope	✓		✓	✓
Understanding knowledge	✓			✓
Teaching tool	✓		✓	✓
Explainability	✓	✓	✓	
Difficult explanations	✓	✓	✓	✓
Extended DB required		✓	✓	
Choose specific adhesives		✓	✓	
Help in design		✓		
Expert in the loop		✓	✓	✓
Interactivity		✓	✓	
Relevancy		✓		
More detail		✓	✓	✓
User-added knowledge		✓		
Flexibility			✓	
Immediate feedback			✓	
Central place for knowledge				✓
Total codes	15	16	19	13
Data saturation	58%	88%	96%	100%

NEXT STEPS: TURN ADHESIVE SELECTOR INTO PRACTICAL INDUSTRY-READY TOOL

Enhance user interactions

- LLM chatinterface
- Easier explainability
- Application filters

Extend data & knowledge base

- Automated datasheet parsing
- Company specific knowledge

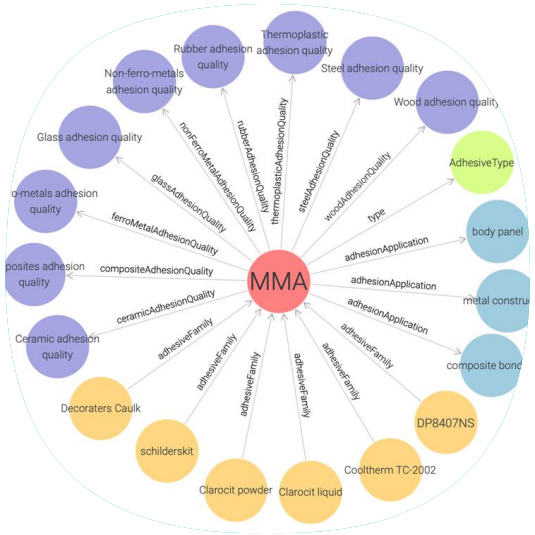
novatech international

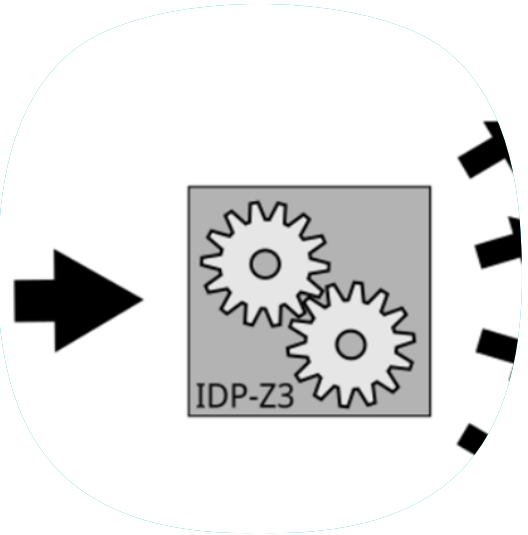
MAVOM SPECIALTY CHEMICALS

Develop & test company specific versions

- Develop company specific demo’s
- Testing

FROM DATA TO DECISIONS





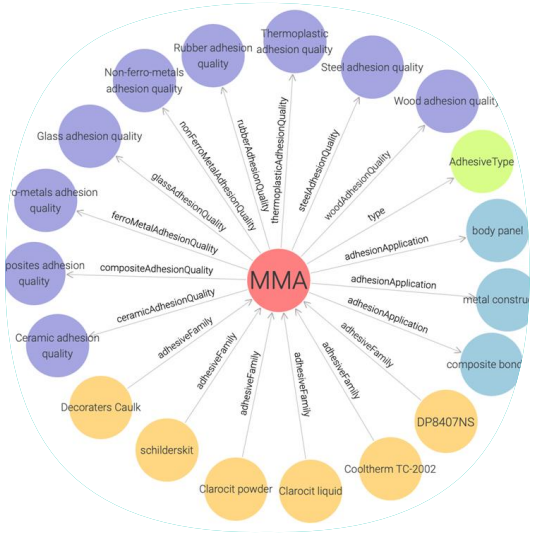
Structured data in knowledge graph

Captured domain knowledge

Reasoning engine

SUMMARY

Potential for knowledge capturing + training of new people



Way to visualise data & automate data retrieval + maintenance

Potential to reduce time & costs

INTERESTED IN FUTURE DEVELOPMENTS?

www.flandersairesearch.be

Jeroen.jordens@flandersmake.be