Digitalization and reasoning over engineering textual data stored in spreadsheet tables – the case for OTTR

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Motivation

ISO14224_FailureModeCode	ISO14224_FailureMode	ISO14224_FailureMode_Description
AIR	Abnormal instrument reading	False alarm, faulty instrument indication
BRD	Breakdown	Serious damage (Seizure, breakage)
DOP	Delayed operation	Delayed response to commands
ELF	External leakage - fuel	External leakage of supplied fuel / gas
ELP	External leakage - process medium	Oil, gas condensate, water
ELU	External leakage - utility medium	Lubricant, cooling water
ERO	Erratic output	Oscillating, hunting, instability
FCO	Failure to connect	Failure to connect

WOType	BscStartDa	ACtStartDa	ShortText
PM01	10/07/2005	10/07/2005	replace lube tank fill hose.
PM01	10/07/2005	10/07/2005	checked rotary head alignment
PM01	10/07/2005	10/07/2005	reweld shock sub to rotary head
PM01	27/07/2005	28/07/2005	centre tank not filling with water
PM01	2/07/2001	2/07/2001	hydraulic pump failure
PM01	1/07/2001	2/07/2001	pump drive box coupling and shaft u/s.

Subsystem & Function	Component	Sub-Component	Potential Failure Mode	Potential Effects of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Current Controls	Detection	RPN	Recommended Action
Power Train	Upbox	Housing	Wearing	Damage to upbox components	4	Physical Impact, incorrect installation	2	Visual inspection	2	16	Inspect for optimal replacement interval of component.
		Gears	Wearing	Damage to gear teeth or bearings	3	Physical Impact, incorrect installation	3	Oil sample wear test	4	36	Training for correct installation, investigate methods to better utilise oil samples
		Coupling	Wearing	Possible excess vibrations or complete failure of joint	3	Physical Impact, incorrect installation	3	Visual inspection	3	27	Inspect for optimal replacement interval of component.
		Lubrication	Incorrect Lubrication	Increased wear of heating of components	2	Servicing error	2	Oil Sample Wear Test regular oil change and oil storage management	4	16	
			Degradation of Lubrication	Increased wear of heating of components	1	Blocking of breather cap, poor storage or mixing of oils	2	Oil Sample Wear Test	4	8	
		Sensors	Wearing	Loss of function of sensor	3	Physical Impact, incorrect installation	3	Investigated upon component failure	3	27	

A vast amount of engineering text data is stored in SPREADSHEET TABLES

The data is not machine-interpretable

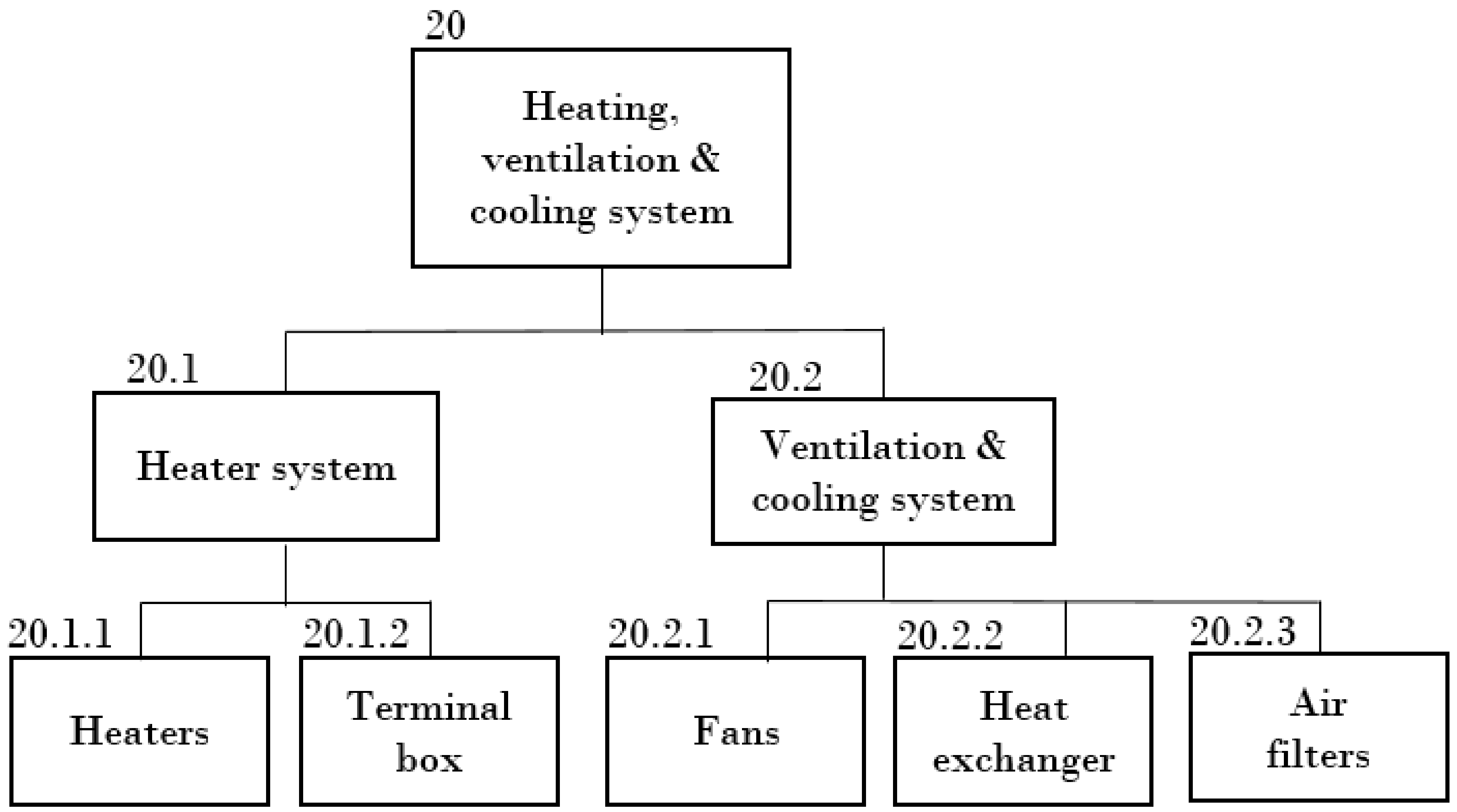
Context

Subsystem & Function	Component	Sub-Component	Potential Failure Mode	Potential Effects of Failure

Ref.	Component	Function	Failure mode	Failure effect

- Tables used by engineers for knowledge capture are schema-less but have implicit structure
- The structure is often related to engineering standards and practices
- Column headings are ad-hoc but relate to standards or widely used relational databases
- Data are semi- or unstructured

Use case – Equipment hierarchy



	Heating, ventilation & Cooling system	Heater system	Ventilation & cooling system
Heater system	X		
Ventilation & cooling system	X		
Heater		X	
Terminal box		X	
Fans & fan hubs			X
Heat exchanger			X
Air filters			X

Example from IEC60812. (2006). IEC 60812: Analysis Techniques for System Reliability-Procedure for Failure Mode and Effects Analysis (FMEA).

Use case - FMEA

Ref.	Component	Function	Failure mode	Failure effect
20.1.1	Heaters	To heat up unit	a) overcurrent	Loss of all heating.
			b) short circuit	
			c) earth fault	Loss of all heating
20.1.2	Terminal box	Connect supply to heaters	a) overcurrent	Loss or reduction of heating
			b) short circuit	Loss of all heating
			c) cable failure	Loss or reduction of heating

- FMEA widely used risk assessment process
- Organisations have hundreds of FMEA

Can we extract the implicit knowledge captured in the FMEA tables to support quality control and re-use?

Our approach

DEVELOP ONTOLOGY MODULES

- Assess data sets and map classes present in the data
- Select an upper ontology to align to
- Decide on ontology modules
- Identify explicit and latent classes needed for knowledge representation and reasoning
- Build and test ontologies
- Ingest data FROM different FMEAs (using OTTR patterns)

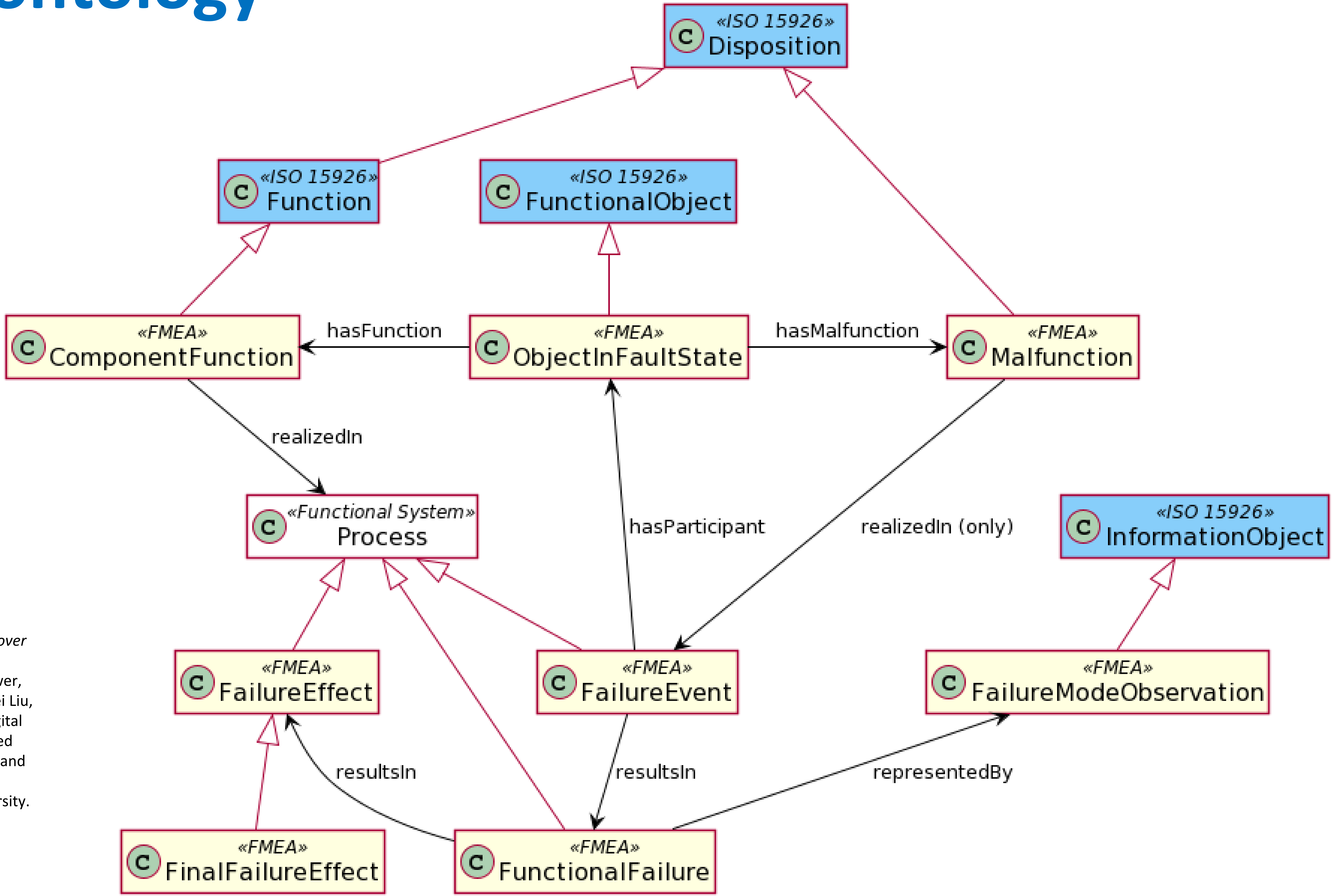
INGEST DATA:

- Represent rows and columns as Resource Description Framework triple

isFunctionalPartOf			
	Heating, ventilation & Cooling system	**Heater system**	**Ventilation & cooling system**
Heater system	X		
Ventilation & cooling system	X		
Heater		X	
Terminal box		X	
Fans & fan hubs			X
Heat exchanger			X
Air filters			X

F = (heaterSystem; hasFunctionalPart; heater)

FMEA ontology



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