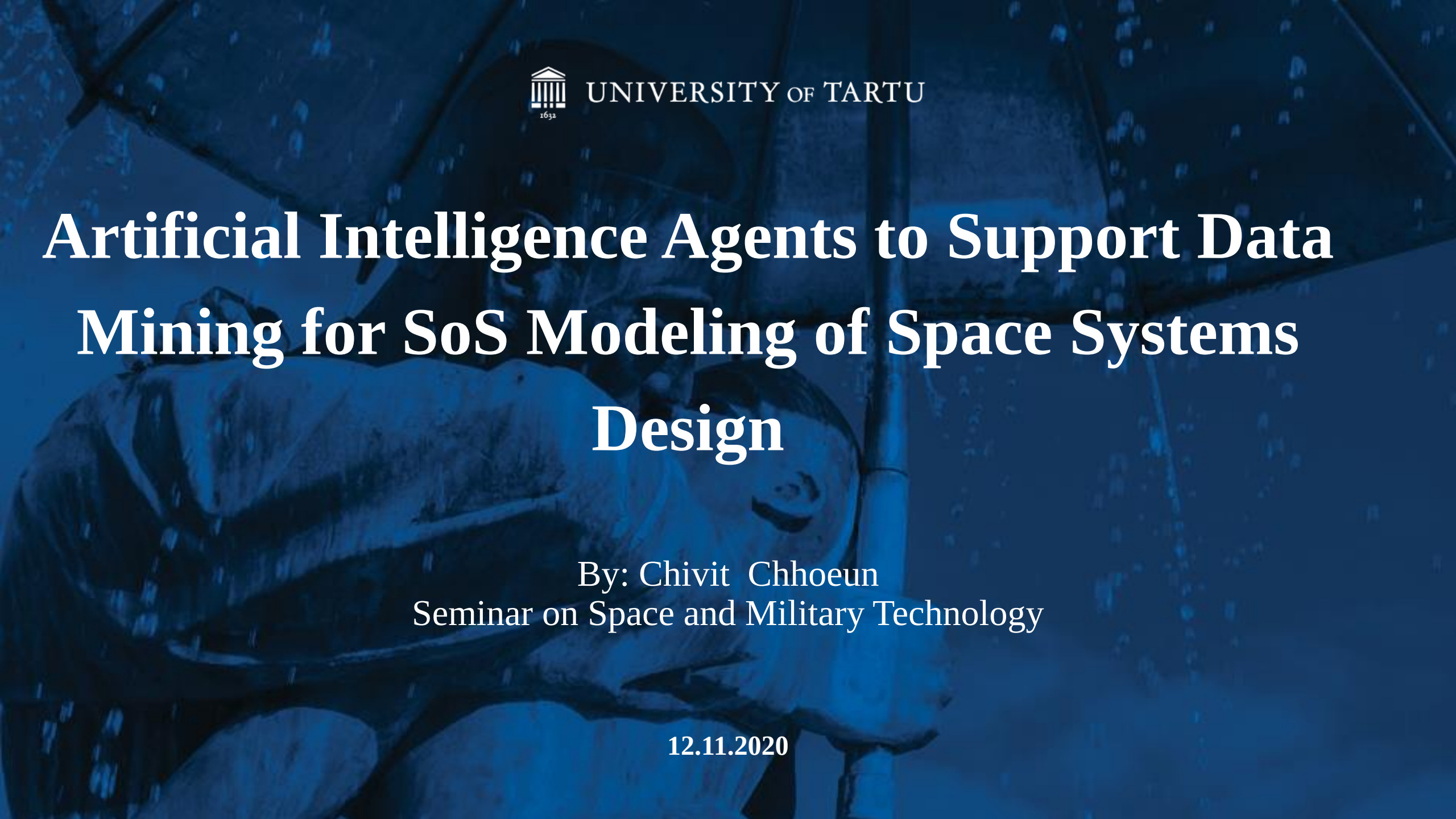


UNIVERSITY OF TARTU

Artificial Intelligence Agents to Support Data Mining for SoS Modeling of Space Systems Design

By: Chivit Chhoeun

Seminar on Space and Military Technology

12.11.2020

UNIVERSITY OF TARTU

Table of Contents

UNIVERSITY OF TARTU

Introduction

- System-of-Systems (SoS) problem
- Tools: SoS Analytic Work Bench (AWB)
- Large space mission size and complexity still results in bottleneck.

Proposed Solution

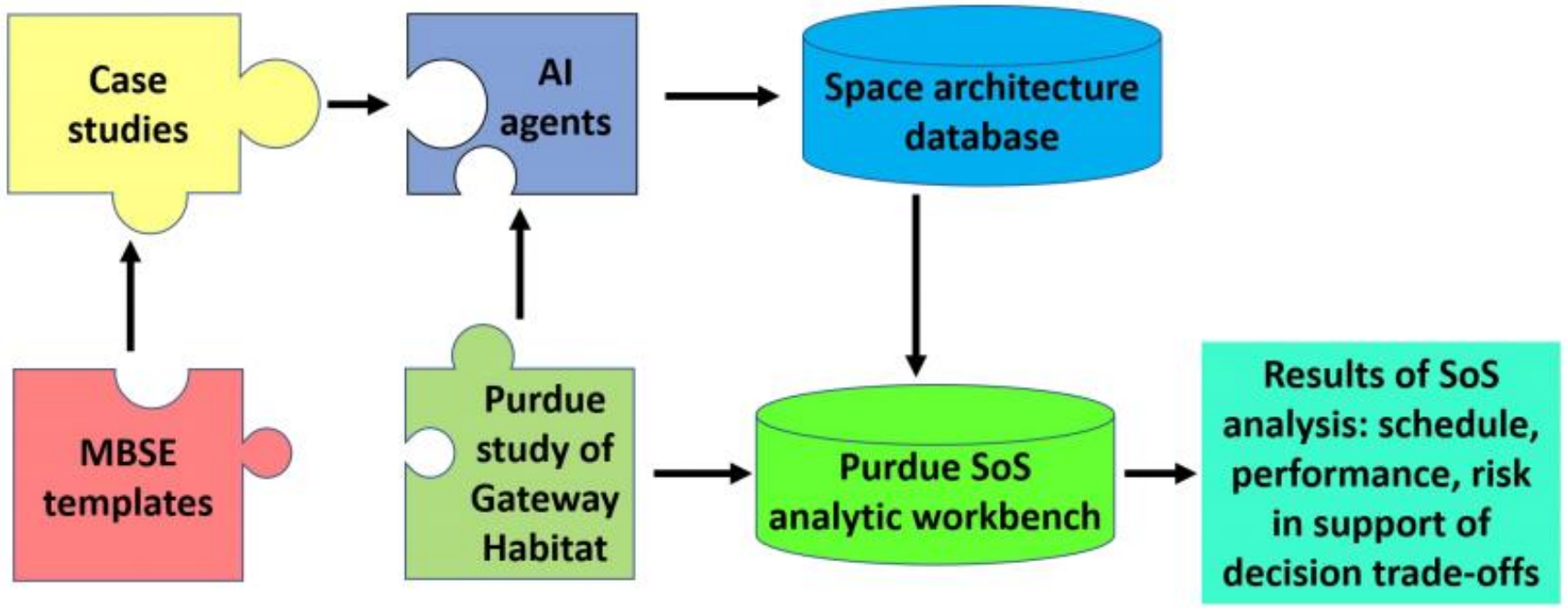


Figure 1: Combining application of Artificial Intelligence and SoS Analytic Work Bench

UNIVERSITY OF TARTU

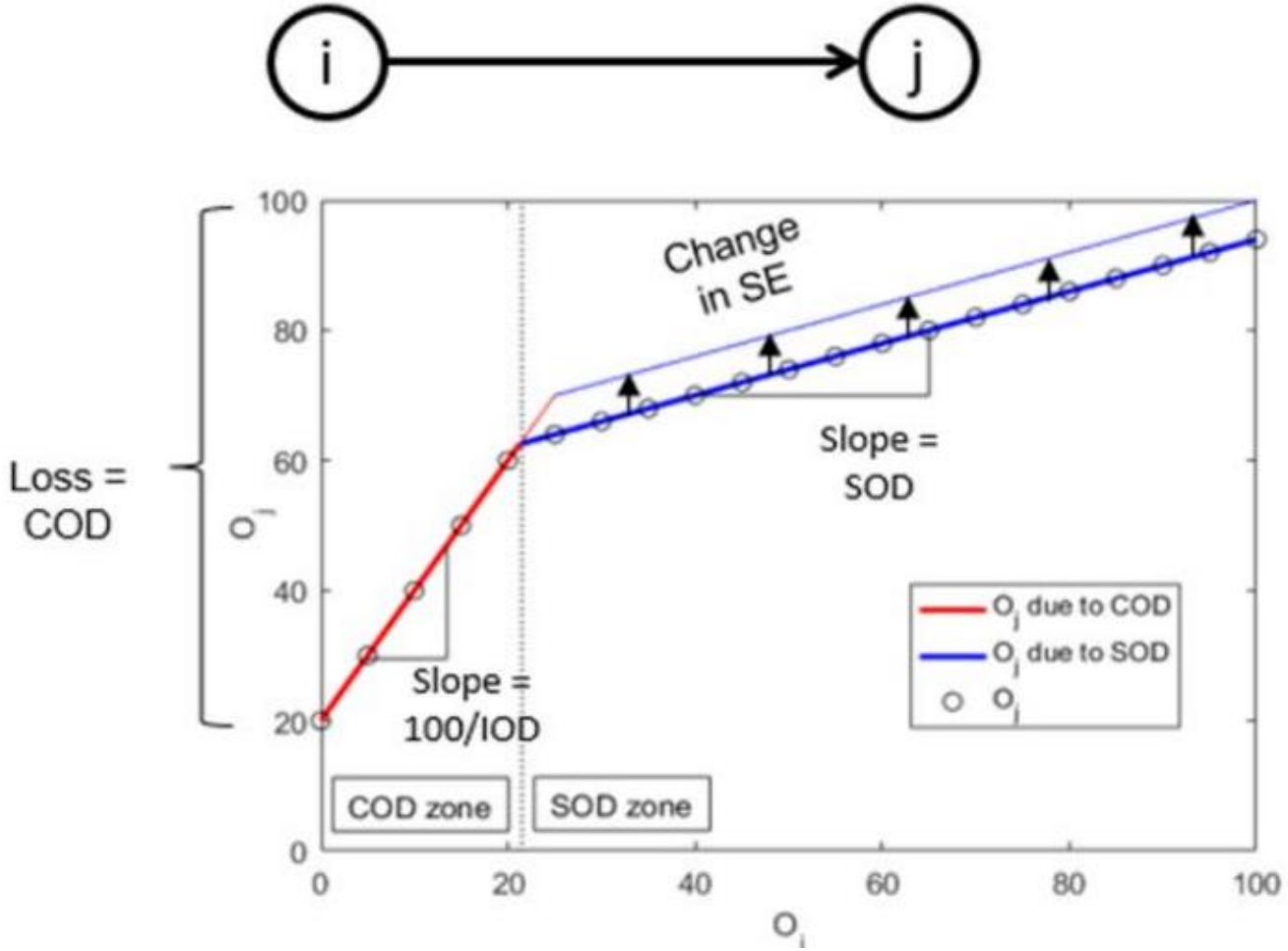
System-of-Systems Analysis and Synthesis: Analytic Work Bench and Previous Steps

- SoS cannot always be analyzed with conventional Systems Engineering methodology.
- Analytic Work Bench (AWB) was developed to meet the need of the DoD.
- Features:
  - Assess the developmental risks and uncertainty in time and resources, and policy contextual questions.
  - Other tools and methodologies that provide information on the operational aspects of complex architectures

UNIVERSITY OF TARTU

Systems Operational Dependency Analysis

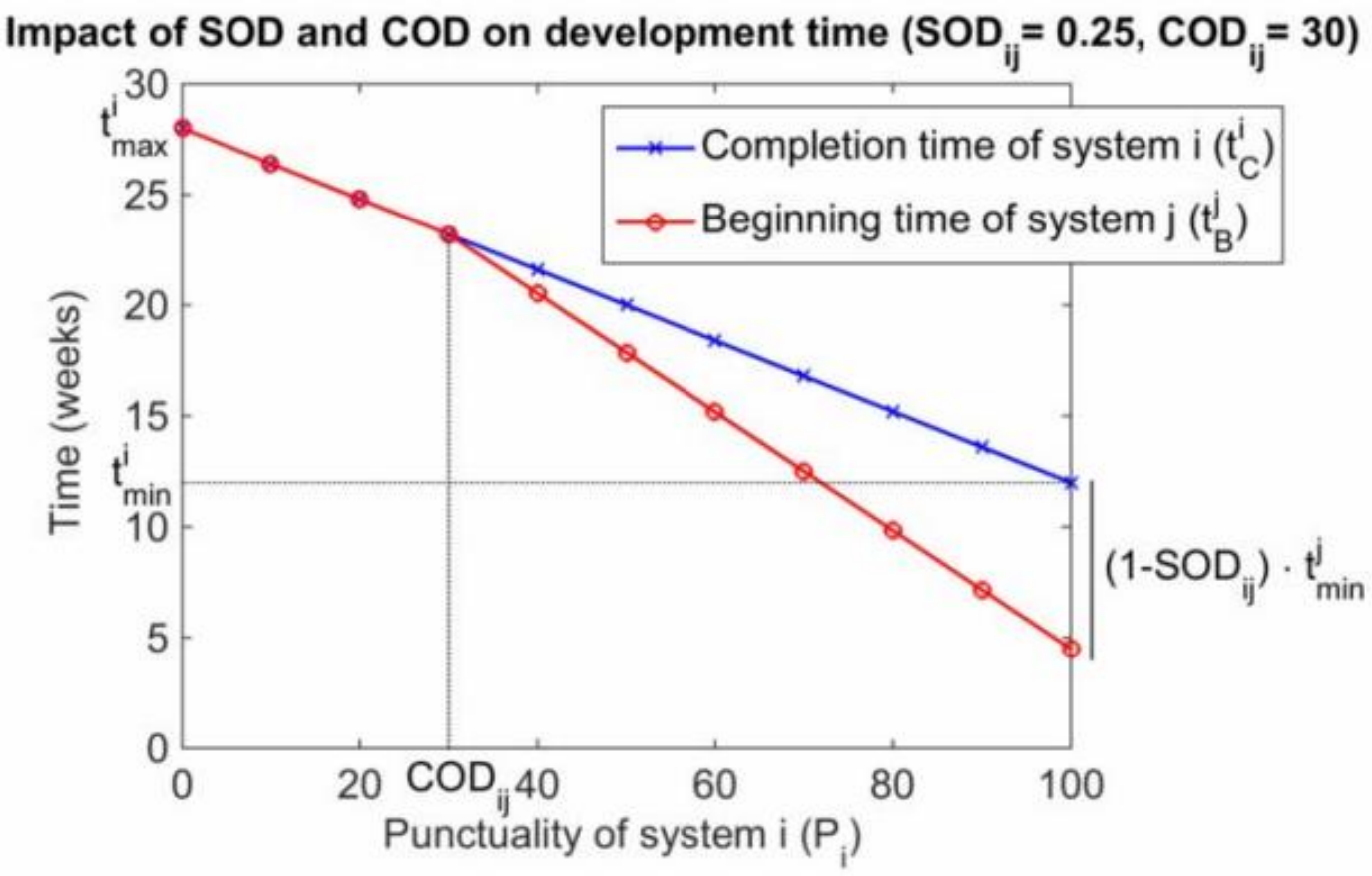
- Provide analysis of the impact of dependencies in the system
- A set of parameters is used to produce a simple model of the dependencies between each system
  - The Strength of Dependency (SOD): a linearized operational dependency between systems in the case of small disruptions.
  - The Criticality of Dependency (COD): the loss of operability due to major disruptions.
  - The Impact of Dependency (IOD): the boundary between the small disruption regime and the major disruption regime.



SODA piecewise linear model of dependency of the operability of system *j* on the operability of system *i*.

Systems Developmental Dependency Analysis

- Applied to the developmental domain.
  - Model of the interactions between constituent systems of a SoS for what concerns development and schedule.
  - The Strength of Dependency (SOD) in SDDA model evaluates the fraction of development time of a system that is dependent on inputs by other systems.
  - The Criticality of Dependency (COD) models the level of punctuality below which partial parallel development of systems is not acceptable.



Completion time of system *i* and beginning time of system *j* in function of the parameters of the developmental dependency between the two systems. Due to partial dependency, system *j* can begin its development before completion of system *i*, unless *i* is critically late.

UNIVERSITY OF TARTU

Artificial Intelligence Agents

- Contents in NASA Technical Reports Server (NTRS)
- Utilized supervised machine learning.
- Each of the agents analyzes millions of paragraphs in the 60,000 papers and returns a similarity score for each.
- Detection of concepts, topics or themes at the paragraph and/or sentence level
- Natural Language Programming (NLP) and computational linguistics.

UNIVERSITY OF TARTU

Case Study: The NASA Gateway Habitat

- Objective: Use results from the *AI agents* search to retrieve useful information that can be fed into tools of the AWB for analysis of SoS features of the habitat architecture.
- Steps:
  - Training of the AI agents
  - Utilization of the agents to identify relevant sources and extraction of the necessary information
  - Analysis of the habitat architecture with AWB tools.

Workflow

1. Extract the text fields/document paragraphs and create library via API or drag/drop
2. Create & train agents
3. Score docs/data & generate analyses
4. Export scores via API or CSV
5. Use BI dashboard or customize to analyze and publish

AI agents training phases

	A	B	C	D	E
1	PDF Link	Relevant?	Title		
2	http://hdl.handle.net/2060/20190001833	N	JSC-Rocknest: a Large-Scale Moja		
3	http://hdl.handle.net/2060/20180001134	Y	Plasma Methane Pyrolysis for Spa		
4	http://hdl.handle.net/2060/20160014040	Y	Design, Development, and Testing		
5	http://hdl.handle.net/2060/20160009705	Y	Development of a Microwave Re		
6	http://hdl.handle.net/2060/20160009119	Y	Self-Cleaning Boudouard Reactor		
7	http://hdl.handle.net/2060/20160008970	Y	Self-Cleaning Boudouard Reactor		
8	http://hdl.handle.net/2060/20160008967	Y	Self-Cleaning Boudouard Reactor		
9	http://hdl.handle.net/2060/20160008027	Y	Bosch Reactor Development for I		
10	http://hdl.handle.net/2060/20160008003	Y	Atmosphere Resource Recovery a		
11	http://hdl.handle.net/2060/20160003489	Y	HESTIA Phase I Test Results: The		
12	http://hdl.handle.net/2060/20160002633	Y	NASA Advanced Explorations Syst		
13	http://hdl.handle.net/2060/20150021503	Y	Thirsty Walls: A New Paradigm fo		
14	http://hdl.handle.net/2060/20150018353	Y	Self-Cleaning Boudouard Reactor		
15	http://hdl.handle.net/2060/20150016512	Y	Advanced Oxygen Recovery via Se		
16	http://hdl.handle.net/2060/20150003021	N	Biological Water Processor and F		
17	http://hdl.handle.net/2060/20140017200	N	Support of LAVA Integration and		

... (ntrs) Atmosphere Management v5 (ntrs) Command & Data Handling

Spreadsheet showing part of the results of version 5 of the AI agent for Atmosphere Management. The literature sources have been reviewed by Subject Matter Experts, who indicated whether the source is relevant to the topic or not.

UNIVERSITY OF TARTU

Conclusion

- Illustrated an application of Artificial Intelligence to create a preliminary space architecture database and to retrieve useful sources of data used to feed a set of SoS tools.
- Future work:
  - Implementation and Training of AI agents capable of interpreting natural language descriptions
  - Use of filters on the sources identified by each agent provided information about disruptions and failures of specific subsystems.

UNIVERSITY OF TARTU

Thank You!!

UNIVERSITY OF TARTU

References

1. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9172802
2. https://www.sebokwiki.org/wiki/Systems_of_Systems_(SoS)
3. https://towardsdatascience.com/super-learner-versus-deep-neural-network-aa78547aabd7
4. https://en.wikipedia.org/wiki/Natural-language_programming