# Augmented Intelligence for Cost Estimation

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#### Focus on New Implementation New models aren't needed to improve output

#### Reparameterization

System level WBS breakdown based on simulated requirements decomposition

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#### **Improved Data Utilization**

System granularization increases applicability of already available data

#### GALORATH



#### **Standardized**

Automated Bayesian inferential models reduce bias and enable upscaling of data

### Introduction

We will discuss the use of AI and ML as data imputation techniques to assist in Cost estimation of small dataset domains



#### Focus on New Implementation New models aren't needed to improve output



It looks like you're trying to perform a cost estimate.

No



Would you like help?

Yes



### Introduction

We will discuss the use of AI and ML as data imputation techniques to assist in Cost estimation of small dataset domains

### Objective

Toolset accepts system-level requirements as inputs

Yields as an output, a detailed product-oriented work breakdown structure



NASA WBS Elements	Le
System Name	
Project Management	1
Systems Engineering	1
Safety and Mission Assurance	1
Science/Technology	
Payload(s)	
Payload Management	
System Engineering	
Payload Product Assurance	
Instrument n	
Instrument // Management	
Instrument / Systems Engineering	
Instrument // Assurance	
Antenna	
Optics	
Sensors/Detectors	
Structures & Mechanisms	
Thermal Control	
Electronics	(
Power	
Pointing Subsystem	
Harness & Cabling	
C&DH	
Ground Support Equip	
Integration, Assembly Test & Check out	
Flight System I Spacecraft	
Flight System Project Management	
Flight System Systems Engineering	:
Flight System Product Assurance	:
Spacecraft	;
Spacecraft Management	
Spacecraft Systems Engineering	
Spacecraft Product Assurance	
Spacecraft Structures & Mechanisms	
Spacecraft Thermal Control	
Spacecraft Electrical Power &	
Spacecraft GN&C	
Spacecraft Propulsion	
Spacecraft Communications	
Spacecraft C&DH	
Spacecraft Software	
CSCIName 1	ţ
CSCI Name 2	ļ
Software Subsystem I&T	ļ
Spacecraft I&T	
Entry/Decent/Lander	

Power Distribution Board Input Power 61.7 – 84.0 W Output Power 4 – 8 W

Central Processing Board Clock Speed 600 – 1000 MHz

Tx/Rx Board Voltage Gain +9.7 – 11.6 dB Frequency

8.2 – 8.6 GHz

Backplane Data Rate 160 – 200 Mbit/s

### Goals

To achieve:



#### What are the parts of the system?

Conceptual linkage between system-level specifications and the presence of specific subordinate-level hardware, software, and firmware



### What drives the complexity of each of these parts?

Qualify/characterize each respective subordinate-level WBS based on requirements flow-down



#### How complex is each of these parts?

Quantify each respective subordinate-level WBS performance metric(s) based on requirements flow-down



### **Descriptive Prediction Model**

#### Conceptual

Automated WBS Generation and Performance Estimation

#### **Historical**

Based on and describes real decision-making processes

#### **Realistic**

(X)

Non-normative Non-prescriptive

#### **Supplemental**

Workflow Tool and ROM Concept Generation



### **Bayesian Inference**



#### **Broad Applicability**

Uses range from heuristics to artificial neural networks

#### **Statistical Process**

Describes how prior knowledge can be used to predict future probabilities

#### **Bayes Theorem**

Where the predictive probability distribution of the hypothesis, given a set of data, is the product of the prior probability distribution and a likelihood function.

### Neural and Bayesian Networks



Describes learning, or the updating of a hypothesis given additional data



### Artificial Intelligence

Recently AI has made great advancements in learning and generation within a variety of domains

- Image
- Video
- Music





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Artificial intelligence, or AI, is technology that enables computers and machines to simulate human intelligence and problem-solving capabilities



### AI Evolution





### Decomposition



ALOR

# Recipe Example

Please give me a recipe for a chocolate cake...

## Recipe Example

Please give me a recipe for a flourless, low-carb, keto-friendly chocolate cake...











### Case Study

#### **Optical Communications System**

1000 Iterations sampling of pseudorandom seeded trials Reconstructed highest likelihood WBS child elements High variance in naming conventions

#### **Optical Subsystem**

Telescope Lens Mirror Filters, Collimators, etc...

#### **Receiver Assembly**

Photodetector Signal Amplifier Demodulator Signal Processing

**Electronics** Power Distribution Control Electronics







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#### Median Rate of Occurrence



01

03

05

### Conclusions



#### Integrated Solution

Process can be integrated into existing workflow

End-to-end integrated solution requires optimal Systems Engineering AI

#### **Deeper Analysis**

ROM Imputation process ideal for qualitative analysis of small data domains

Established domains and quantitative analysis steps best served via other methods





#### GALORATH

### Variational Autoencoder

