



# Smart Maintenance Engineering Decision Assist Tool (SMEDAT)

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# Smart Maintenance Engineering Decision Assist Tool (SMEDAT) - Abstract

- How to individually engage and make your organization stronger together utilizing Zachman framework for all levels of Engineering to align processes, train, onboard, develop proposals, and operationalize algorithms in semi-automated fashion.
- 5 areas of interest / pain points that are somewhat intertwined and can be viewed from a systems viewpoint:
  - Paradigm Shift Using Known Thought Constructs in Unique Ways
  - Integrated Digital Environment using Agile Iterative Processes and Communications
  - Gap Assessment Tool
  - Operationalizing PHM
  - Model-based Engineering Interdependencies
- SMEDAT was created by a small team to be a Smart Decision Assist Tool for assessing program / products maturity and readiness for Prognostics & Health Management (PHM) solutions along with a host of other capabilities centered around Digital Engineering implementation of operationalized PHM. The details were architected by uniquely applying the 5W1H in a Zachman framework architecture structure and thought construct. This structure identifies the key Who, What, When, Where, How, and Why's creating connections across all engineering levels. These connections are needed for a trained workforce to meet a program where it is at and mature it enough for PHM and Digital Engineering requirements. The layout specifically identifies the use cases for a diverse set of specialty engineering centered information across the full life cycle of equipment that can solve programs hard problems.
- This approach is an iterative approach that creates a living wiki or shared framework. Check for success is the percentage of your workforce that is utilizing the wiki and then how often do they come back to use it as a reference. What is the success rate of operationalizing algorithms or reduction in labor hours for creating deliverables.

# Agenda

- **Thought Constructs Background**
  - How all this framework came about?
  - Initial Wiki
  - Paradigm Shift Using Known Thought Constructs in Unique Ways
  - What is Zachman Framework?
  - What is a Use Case and Use Case Diagram?
  - What is the 5W1H or Six Ws?
  - Maslow's Hierarchy of Need Applied to Data Science
  - Integrated Digital Environment using Agile Iterative Processes and Communications
- **SMEDAT Organizational Thought Exercises**
  - Decide on your Perspectives / Actors/ Audience
  - Executive Perspective Example
  - Proposal Management Perspective – Example
  - Architecture Perspective – Example
  - Engineer Perspective – Example
  - Technician Perspective – Example
  - Enterprise Collaboration Perspective – Example
  - Gap Assessment Tool – Example
- **Operationalizing PHM**
  - Data Science Hierarchy
  - Incremental Analytics Approach
  - Predictive Analytics Process Flow
- **Model-based Engineering Interdependencies**
  - Embed Automation and Replication through Model Based Engineering Principles
  - Create Data Lake of Examples
  - Model-Based Engineering Interdependencies - Examples

# Thought Constructs Background



Microsoft Excel  
Worksheet

# How all this framework came about?

- Enabler for programs with requirements to adopt Condition Based Maintenance Plus (CBM+)
- Working multiple tasks in AIML / Mathematical Optimization with Digital Engineering program.
- Working with DevSecOPs MOSA requirements type software
- Answering all the inquiries that come from all levels of Engineering
- Distributed Teams across the nation
- Frequent Onboarding of new team members
- Need for Optimization of Labor

Creating and Disseminating Information Across a Large Organization for Training, Re-Use and Labor Optimization

# Initial Wiki

- Training / Onboarding
- POCs/ Groups
- Proposal / Request for Information Phase
- Development Program Phase
- Implementation Phase
- Sustainment Phases

[Too Much Information \(TMI\): the cognitive science behind why you can't read all your emails in a day.](#)

List based wikis or whitepapers are of the same types of reading.

Proposing better visual organization of information for ease of use.

TMI using a traditional Table of Contents Format Loosely based Program Phase / Use Case List

# Paradigm Shift Using Known Thought Constructs in Unique Ways

Use what we know in new ways to Optimize communication and labor hours through enablers and processes

- Zachman Framework
- What is the 5W1H or Six Ws?
- What is a Use Case and Use Case Diagram?
- Maslow's Hierarchy of Need Applied to Data Science
- Model Based Process Flow
- Integrated Digital Environment using Agile Iterative Processes and Communications

Yes, I know what they mean. But they are thought constructs and as such are not set in stone

# What is Zachman Framework?

- Originally a “Framework for Information Systems Architecture” later a “Framework for Enterprise Architecture”
- ***The Framework for Enterprise Architecture (or Zachman Framework) as it applies to Enterprises is simply a logical structure for classifying and organizing the descriptive representations of an Enterprise that are significant to the management of the Enterprise as well as to the development of the Enterprise’s systems, manual systems as well as automated systems.***
- It was derived from analogous structures that are found in the older disciplines of Architecture/Construction and Engineering/Manufacturing that classify and organize the design artifacts created over the process of designing and producing complex physical products (e.g. buildings or airplanes, etc.)

[The Framework for Enterprise Architecture: Background, Description and Utility by: John A. Zachman](#)



A Framework connecting all levels of the enterprise through Audience Perspectives asking What, How, Where, Who, When, and Why



# What is a Use Case and Use Case Diagram?

## **Purpose**

*The purpose of Use Case diagrams is to provide a high-level view of the subject system and convey the top-level system requirements in non-technical terms for all stakeholders, including customers and project managers as well as architects and engineers. Additional more rigorous SysML diagrams are needed to specify a scalable and simulated System Architecture Model (SAM).*

[SysML FAQ: What is a Use Case diagram \(UC\)?](#)



[What is Use Case Diagram? \(visual-paradigm.com\)](#)

*Use cases specify the expected behavior (what), and not the exact method of making it happen (how). Use cases once specified can be denoted both textual and visual representation (i.e., use case diagram). A key concept of use case modeling is that it helps us design a system from the end user's perspective. It is an effective technique for communicating system behavior in the user's terms by specifying all externally visible system behavior.*

Use Case / Use Case Diagram – an interaction or transaction between a User and a System

# What is the 5W1H or Six Ws?

- The Five Ws (sometimes referred to as Five W's and How, 5W1H, or Six W's)<sup>[1]</sup> are questions whose answers are considered basic in information gathering or problem solving. They are often mentioned in journalism, research, and police investigations.<sup>[2]</sup> According to the principle of the Five Ws, a report can only be considered complete if it answers these questions starting with an interrogative word.

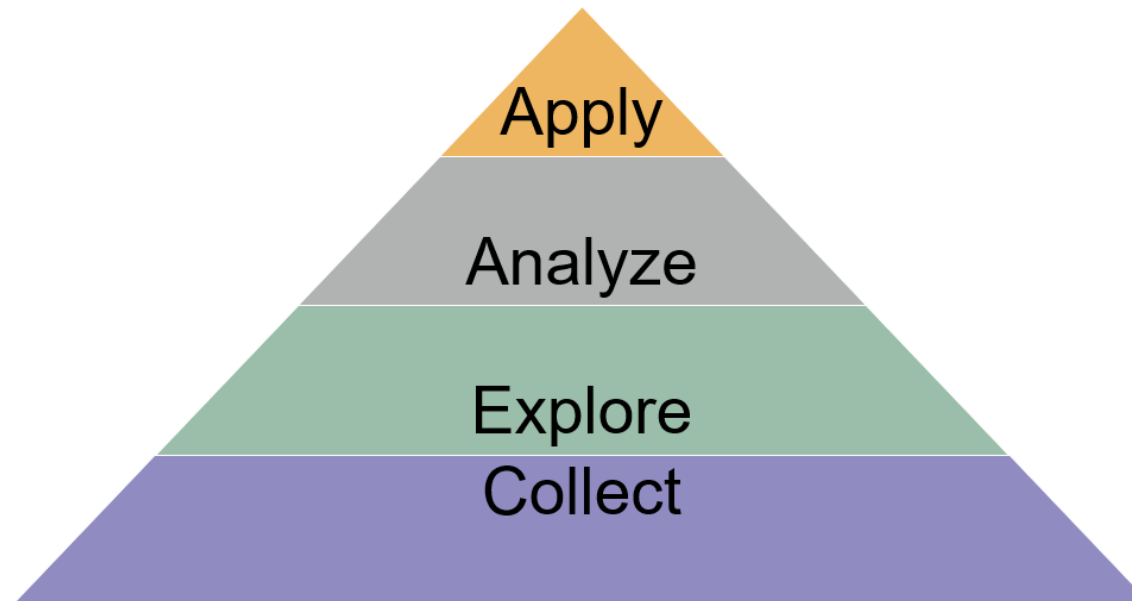
[Five Ws - Wikipedia](#)



An Iterative Approach Determining Cause and Effect

# Maslow's Hierarchy of Need Applied to Data Science

HackerMoon Article



Right now, our DoD Pyramid is inverted. People go straight for the Algorithm thinking that is what is needed.

# Integrated Digital Environment using Agile Iterative Processes and Communications

- Teams – pinned posts or shared files
- Atlassian – Confluence Wiki Format
- Jira – Stories, Epochs
- Quiet De-centralized communication for meeting intros or status tag-ups using Grids + Annotation
- Share drive
- Model Based thought constructs and tools
- Virtual lean coffee session

Name				
Status				

Unique Approaches for Innovation/ Optimization in the Era of Decentralized Teams

# SMEDAT Organizational Thought Example Exercises



Microsoft Excel  
Worksheet

# Decide on your Perspectives / Actors/ Audience

- Who is your Audience?
- What are their roles?
- What is the Scope?
- Do you have more than one topic pertinent to the Audience?

Note: Keep in mind Use cases specify the expected behavior (what). Therefore, who is your target and what knowledge area is your target?

Who is your target and what knowledge area is your target?

# Executive Perspective Example

Audience Perspective	What	How	Where	Who	When	Why	Scope	Definitions/ Notes
Executive / Overview Perspective - SMEDAT	What is SMEDAT? Advanced Sustainment Technologies Capabilities Page		Demo - Dashboard as seen on Demo July 2022  CBM+ Video Repository  Software Stack Capability Demo April 2022  PHM Development Capabilities Demo November 2021  6 - Capabilities & Roadmaps - links are 2020 developments, and 2022 plans is in the page	Any one who need an Exec level Summary of SMEDAT or the Advanced Sustainment Technologies	When SMEDAT ?	Why SMEDAT?  Digital Sustainment Return on Investment	SMEDAT	Connectivity  Why Use Predictive Analytics? - bold heading on page  Discussing where your program is in its Predictive Analytics Journey  Operational Integration  Program Specific Problem to Solve Hardware that enables PHM  Smart Product
Executive Perspective - Whole Life Digital Engineering	What if I want more information or a community about MBSE?		Where can I get Cameo?			Why do I use Digital Engineering / Model Based Engineering in Whole Life?	Digital Engineering for Whole Life	
	Inventory Sets	Process Flows	Distribution Networks	Responsibility Assignments	Timing Cycles	Motivation Intentions		

# Proposal Management Perspective – Example

Audience Perspective	What	How	Where	Who	When	Why	Scope	Definitions/ Notes
Proposal Mgmt Perspective	Automation Macros	Snippets for Thread Memos		Anyone working a proposal or Deliverable		Tech Volume Content Basis of Estimates - Bid examples	Proposal Artifacts	
	Inventory Sets	Process Flows	Distribution Networks	Responsibility Assignments	Timing Cycles	Motivation Intentions		



# Architecture Perspective – Example

Audience Perspective	What	How	Where	Who	When	Why	Scope	Definitions/ Notes
Architecture Perspective	<p>Architecture References</p> <p>Object Management Group (OMG) Certified Systems Modeling Professional (OCSMP)</p>	PHM model in Cameo	CBM+ Operational and Architecture Concept				CBM+ / PHM Architecture	
	Inventory Sets	Process Flows	Distribution Networks	Responsibility Assignments	Timing Cycles	Motivation Intentions		

# Engineer Perspective – Example

Audience Perspective	What	How	Where	Who	When	Why	Scope	Definitions/ Notes
Engineer Perspective: CBM+ Capabilities and Innovations	Fully learnable deep wavelet transform for unsupervised monitoring of high-frequency time series	Transfer learning Sparse Data 'Inference Engine				Software Stack Capability Demo April 2022	CBM+ Capabilities and Innovations	
Engineer Perspective: AIML Algorithms/ Enablers	AIML Algorithms Suites Trade Study for AIML Vendors and / or RTX Corporate Tools Available - Check list	Predictive Analytics Process Overview Whitepaper  Various Presentation and Tutorials 13th Annual PHM Society Conference  Notional Plan for Incremental Implementation of PHM/ CBM/ Predictive Analysis  Predictive Analytics Process Flow Diagram  Incremental Analytics Approach Process Flow Diagram & Explanation	AIML Vendor Review	Notional RASCI	Notional Plan for Incremental Implementation of PHM/ CBM/ Predictive Analysis	Notional BOE Prognostic Accuracy Improvements Capabilities Prognostics Strategy & List BOE in Digital Model form	AIML Algorithms/ Enablers	What are PHM Enablers?
Engineering Perspective: Learning & Collaboration	Whole Life Engineering Interdependence	Resources and Training, Engagement and Whole Life Domain Analysis	RMD Digital Transformation	Anyone	Any Program Phase	Learn More about Whole life & the all of the areas we cover.  More About Digital Transformation	Foundations of Raytheon Whole Life Digital Engineering	
Engineer Perspective: Digital Sustainment Engineering	PHM model in Cameo RAM Model	Digital Engineering for CBM+ / RAM/ FRACAS/ PHM	CBM+ Operational and Architecture Concept				Digital Sustainment Engineering	
Engineer Perspective: Digital Sustainment Engineering - Capital Project	AV-1 The following is the All Viewpoint 1 (AV-1) viewpoint from the Department of Defense Architecture Framework (DoDAF).	Systems Engineering Overview Sample for Program and Projects		Alignment with IRADs		Architecture Development References	Capital Project	
	Inventory Sets	Process Flows	Distribution Networks	Responsibility Assignments	Timing Cycles	Motivation Intentions		

# Technician Perspective – Example

Audience Perspectivte	What	How	Where	Who	When	Why	Scope	Definitions/ Notes
Technician Perspective - General	Tools Needed				All program Phases - Any Implementation of CBM+, AIML, Digital Engineering		Tool Components	
Technician Perspective - Implementing Algorithms / Training Data/ Infrastructure	Calculating HPC resources needed	High Performance Computing		Anyone Calculating Infrastructure Resources or Anyone planning to train Data	Development/ Sustainment/ IRAD	Cleaning Data, Training Data	Tool Components	
Technician / Practioner - Digital Engineering for Whole Life	What/ Where/ Who Digital Engineering Life Cycle Engineering Profile	How do I get Started Learning Cameo?	What/ Where/ Who Digital Engineering Life Cycle Engineering Profile	What/ Where/ Who Digital Engineering Life Cycle Engineering Profile	All program Phases		Tools / Profiles/ Training	
	Inventory Sets	Process Flows	Distribution Networks	Responsibility Assignments	Timing Cycles	Motivation Intentions		

# Enterprise Collaboration Perspective – Example

Audience Perspective	What	How	Where	Who	When	Why	Scope	Definitions/ Notes
Enterprise Collaboration Perspective	Collaboration for Data Science		Technology Networks POC for AIML	Anyone Interested in Collaboration on AIML		Digital Sustainment Return on Investment	Collaboration	
	Inventory Sets	Process Flows	Distribution Networks	Responsibility Assignments	Timing Cycles	Motivation Intentions		

# Gap Assessment Tool - Example

- When using the thought construct for a Gap Assessment where your gap is across multiple levels of your organization
- Why? Your Gap / Need
- Perspective – Target Audience
- What? Problem / Need
- Who? Person who interacts with target audience – Perspective Audience
- Where? Where in your organization is this gap or what part of the organization is affected from the Perspective of your Target Audience
- When? When would the Gap be apparent to the Perspective Audience
- How? How do you solve the problem – use capabilities not products

Looking at Gaps from Multiple Company Perspectives

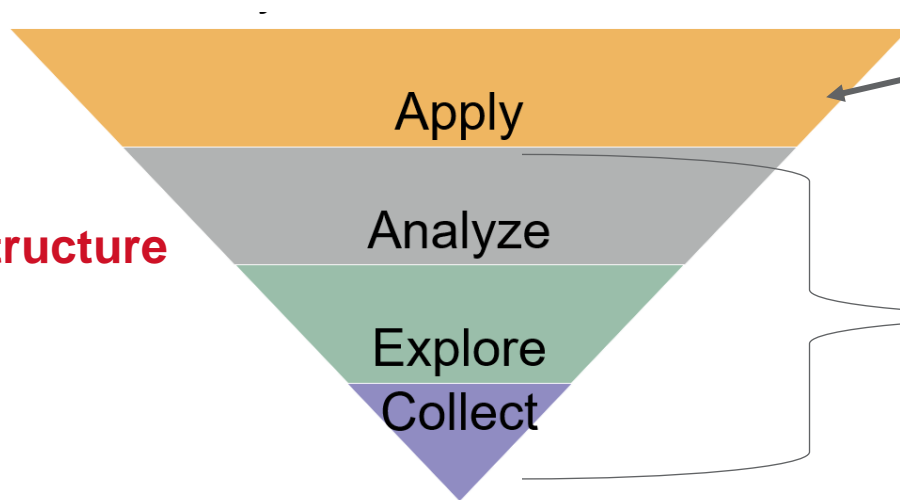
# Gap Assessment Tool - Example

Zachman Perspectives	RMD Business Perspective	Why	What (Problem/Need)	Who	Where	When	How (Capability - not Product, Avoid All or Nothings)
Executive Perspective	Multiple Area Director or Vice President	GAP - Need to identify what the <u>business</u> benefit is for each capability using ROI language and R&O from specific programs.	▪ Sustainment execution gaps / problems <u>by Grouping</u>	Director	▪ Pathfinder product lines	▪ EAC's	▪ Sustainment capabilities / solutions
Business Management Perspective	Area Director	GAP - Need to identify what the <u>business</u> benefit is for each capability using ROI language and R&O from specific programs.	▪ Sustainment execution gaps / problems <u>by Program</u>	Department Leads	▪ Product groups	▪ EAC's	▪ Sustainment capabilities / solutions
Architect Perspective	Chief Engineer, Tech Director	GAP - Need to identify what the business benefit is for each capability using R&O identification from specific program budgets or tech baseline gaps.	▪ Sustainment execution gaps / problems within the Program <u>Tech Baseline</u>	<u>GAP - Who talks to the Chief Engineer and/or TD in their language?</u>	▪ Programs	▪ EAC's	▪ Sustainment capabilities / solutions
Engineer Perspective	Cross Product Team Leads	GAP - Why will this make my job easier? How do we manage task leads / SL's who may have competing scope (Innovators Dilemma)?	▪ Sustainment execution gaps / problems <u>by WBS / NWA</u>	Task Leads	▪ Programs	▪ EAC generation ▪ R&O identification	▪ Sustainment capabilities / solutions
Technician Perspective	Task Leads	GAP - Why will this make my job easier? Will this make my job go away?	▪ Day to day execution frustrations and	Individual Contributor Engineers	▪ Execution tasks on specific NWA's	▪ EAC generation ▪ R&O identification	▪ Sustainment capabilities / solutions

# Operationalizing PHM

# Data Science Hierarchy

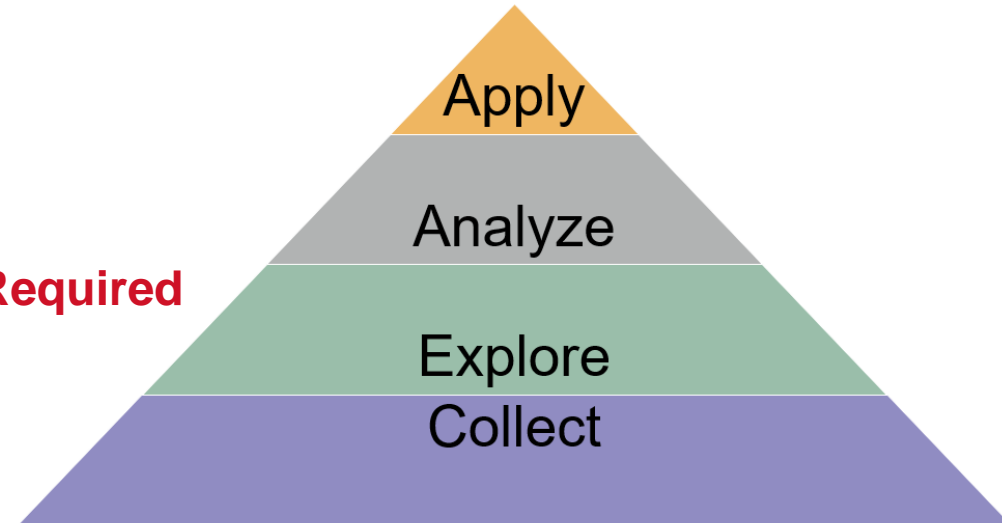
**Where we are:  
Limited Infrastructure  
Required**



Everyone goes straight to the Algorithms-  
R&D is at the Algorithm level

This should be the focus.  
The infrastructure, low  
code, no code solutions to  
enable use of Algorithms

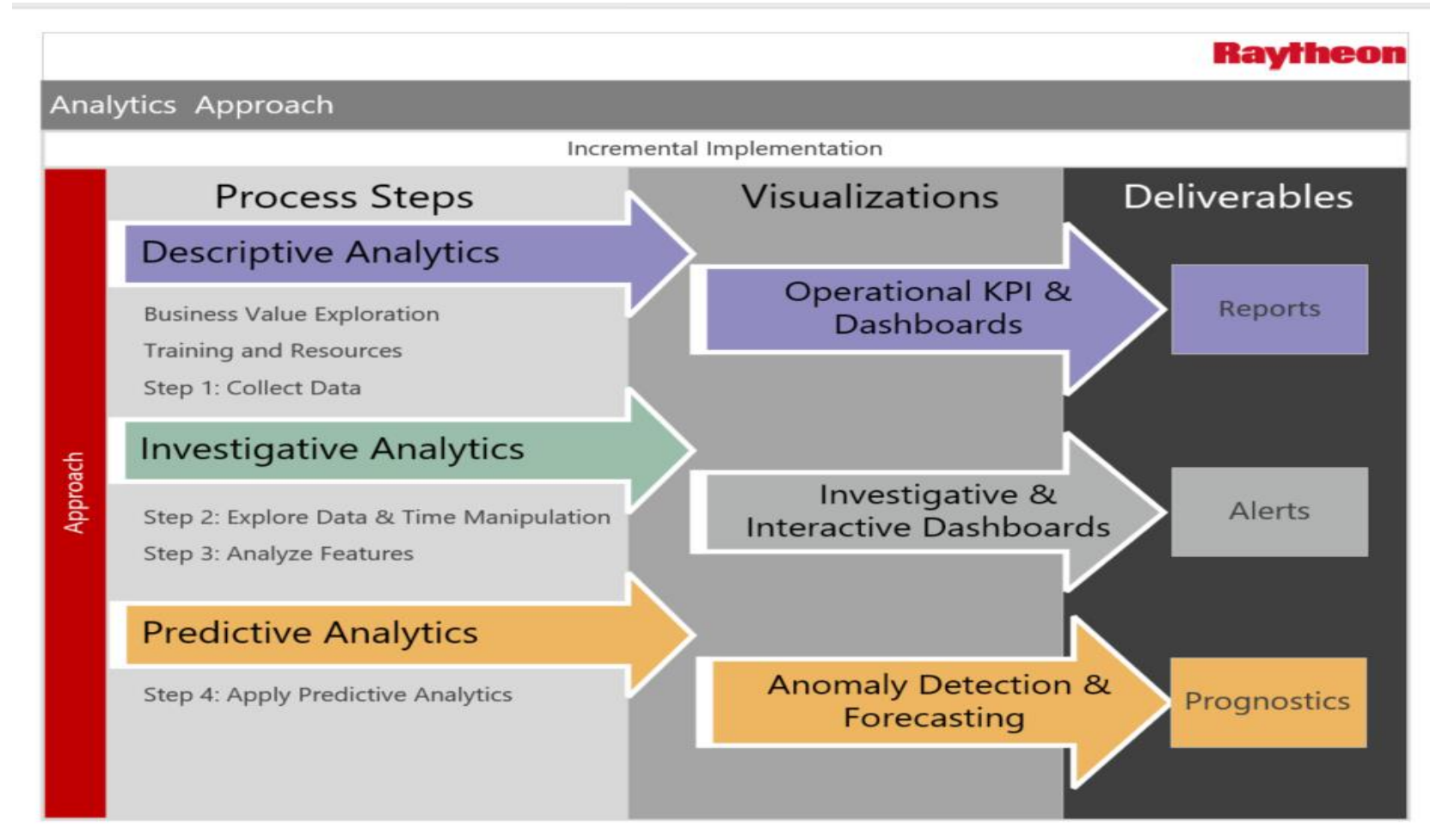
**Where we need to be:  
Extensive Infrastructure Required**



Data Science Hierarchy can be used to help programs understand how to manage and store data



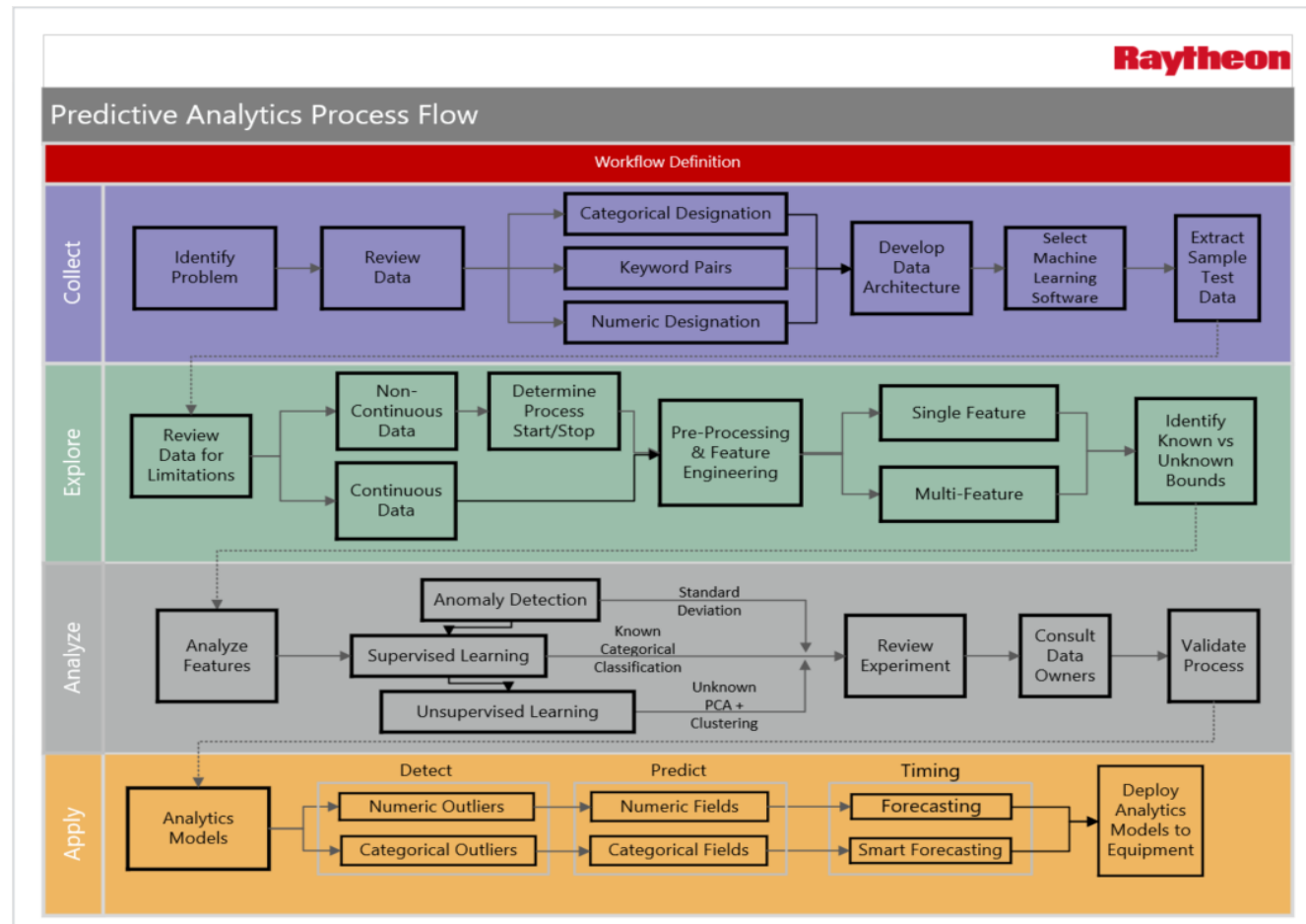
# Incremental Analytics Approach



Where we are:  
Limited Infrastructure  
Required

Meet programs where they are and work in incremental steps using Modular Open Systems Architecture to traverse the Hierarchy of Needs

# Predictive Analytics Process Flow



Repeatable Process that can be done as a low code no code solution once the initial set up is completed

# Model-Based Engineering Interdependencies

# Embed Automation and Replication through MBE Principles

- **What do you do repeatedly?**

- Review Packages
- Basis of Estimates
- Thread Memos
- Responses to Request for Proposals, Information
- White Papers
- Earned Value
- Estimate at Complete
- Data Analysis – same types of data
- RAM Analysis, Safety Analysis
- Other Analysis

Doesn't have to be in Cameo or Rhapsody  
Focus on the Data – down to the field and who is a user/ consumer  
How many things could be templated?  
Where can Office VBA automation fit in?  
Is the a read me for a template?  
Is the repository accessible?  
Put together a Jupyter notebook or something like it that explains the steps and can be used as a template.

Model Based

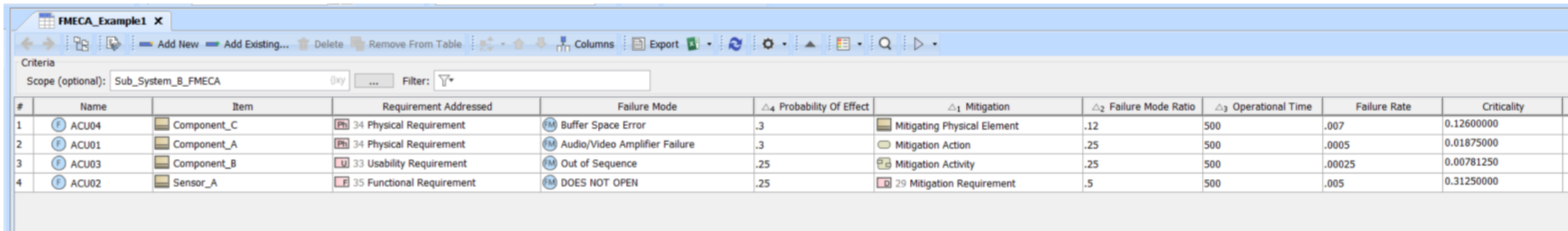
## Create Data Lake of Examples

- Abolish my rice bowl syndrome
- Have best practices examples easily accessible
- Practice Search Engine Optimization
- Communicate often
- Data isn't just numerical, could be processes, templates for Cameo, Code Snippets, etc..
- Models

Data Lake is not just numerical or equipment data, it can be processes, code snippets etc.

# Model-Based Engineering Interdependencies - Examples

- The drag and drop ability of Cameo for Scope of analysis, whether it be RAM, FMECA, Prognostics, Health Management, Sparing etc.. Makes things quick, you can see requirements addressed, MIL-STD addressed, Mitigations, Criticality for both Safety and RAM in a way that is easy to read and changes are visible upon commits.



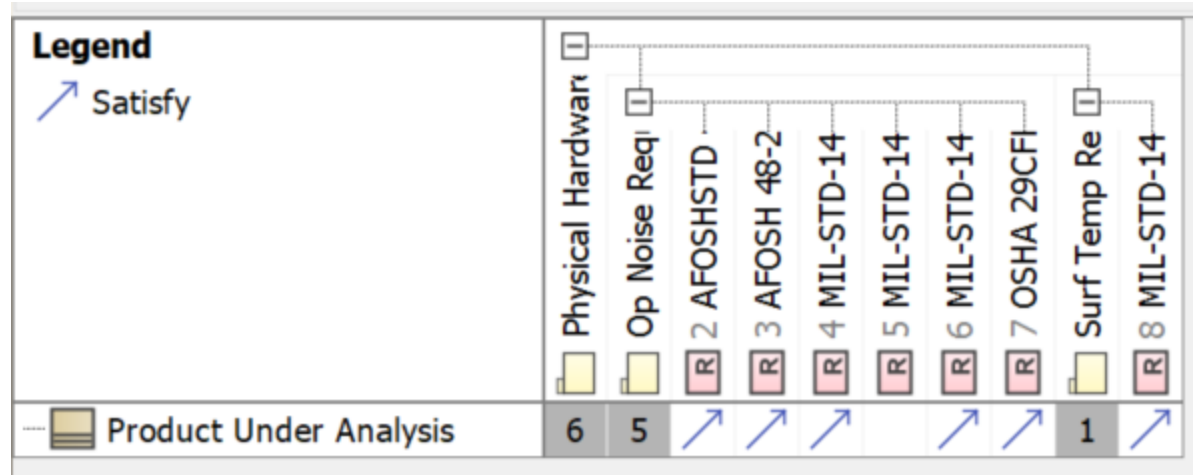
The screenshot shows a software interface titled "FMECA\_Example1" with a table of analysis results. The table has columns for #, Name, Item, Requirement Addressed, Failure Mode, Probability Of Effect, Mitigation, Failure Mode Ratio, Operational Time, Failure Rate, and Criticality. The data is as follows:

#	Name	Item	Requirement Addressed	Failure Mode	△ <sub>4</sub> Probability Of Effect	△ <sub>1</sub> Mitigation	△ <sub>2</sub> Failure Mode Ratio	△ <sub>3</sub> Operational Time	Failure Rate	Criticality
1	ACU04	Component_C	34 Physical Requirement	Buffer Space Error	.3	Mitigating Physical Element	.12	500	.007	0.12600000
2	ACU01	Component_A	34 Physical Requirement	Audio/Video Amplifier Failure	.3	Mitigation Action	.25	500	.0005	0.01875000
3	ACU03	Component_B	33 Usability Requirement	Out of Sequence	.25	Mitigation Activity	.25	500	.00025	0.00781250
4	ACU02	Sensor_A	35 Functional Requirement	DOES NOT OPEN	.25	29 Mitigation Requirement	.5	500	.005	0.31250000

BOM level models - Tables in the Model, Change when the design changes

# Model-Based Engineering Interdependencies - Examples

- Easily see Safety traceability to standards for products or LRUs



Verification through analysis becomes much more automated

# Thank you.

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