33rd Annual INCOSE international symposium

hybrid event

Honolulu HI USA

On Model Re-Use: Best Practices for the Application and Configuration of Model-Based Patterns

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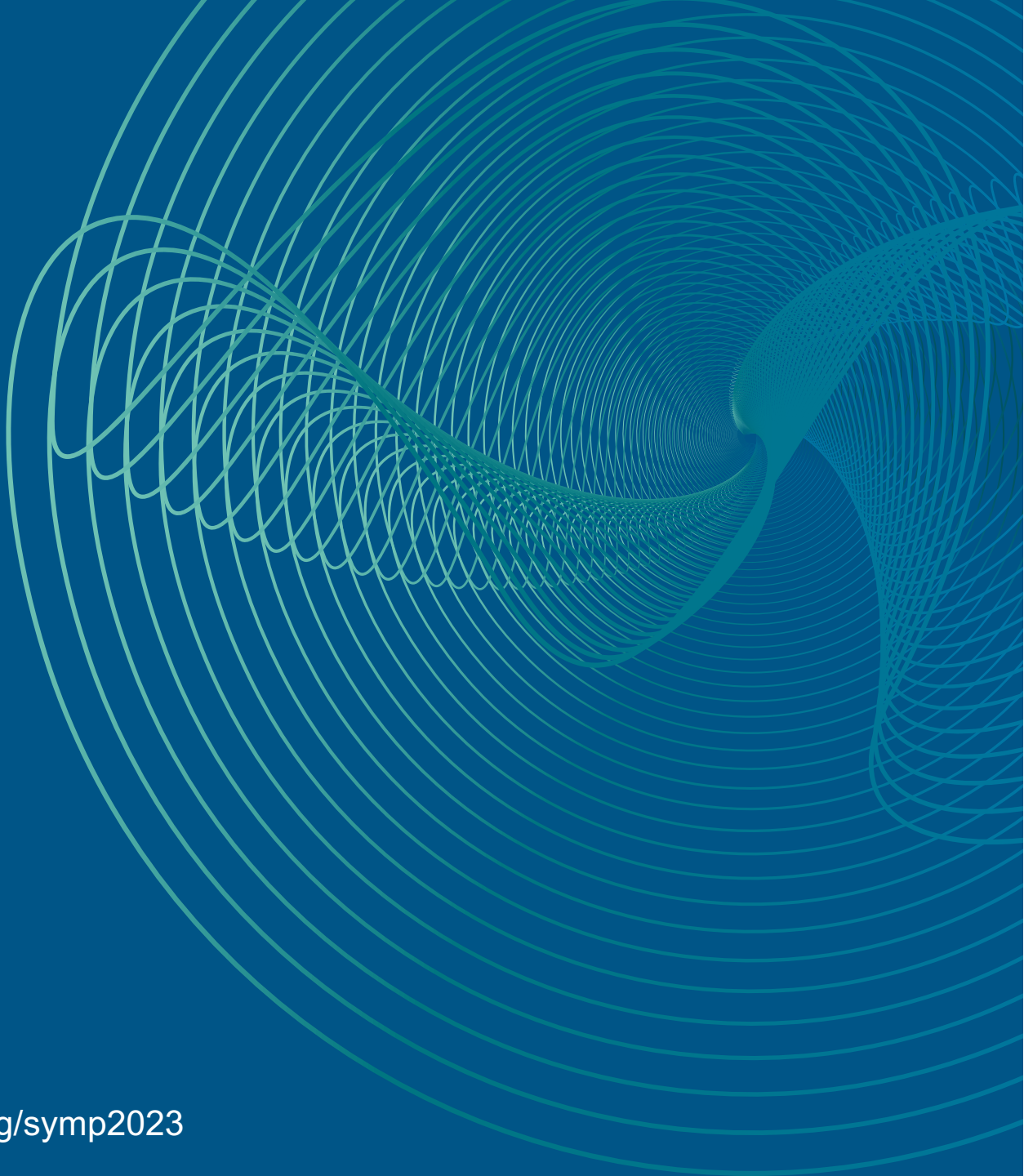
Raise Your Hand If…

You Have Ever Captured Lessons Learned?



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A Peek Into The Future

35 ≠

"By 2035, a family of unified, integrated MBSE-Systems Modeling and Simulation (SMS) frameworks exist. They leverage digital twins and are fully integrated into the enterprise digital thread foundation. This enables efficient ***pattern-based model composition*** *and seamless "cradle to grave" virtual exploration."*

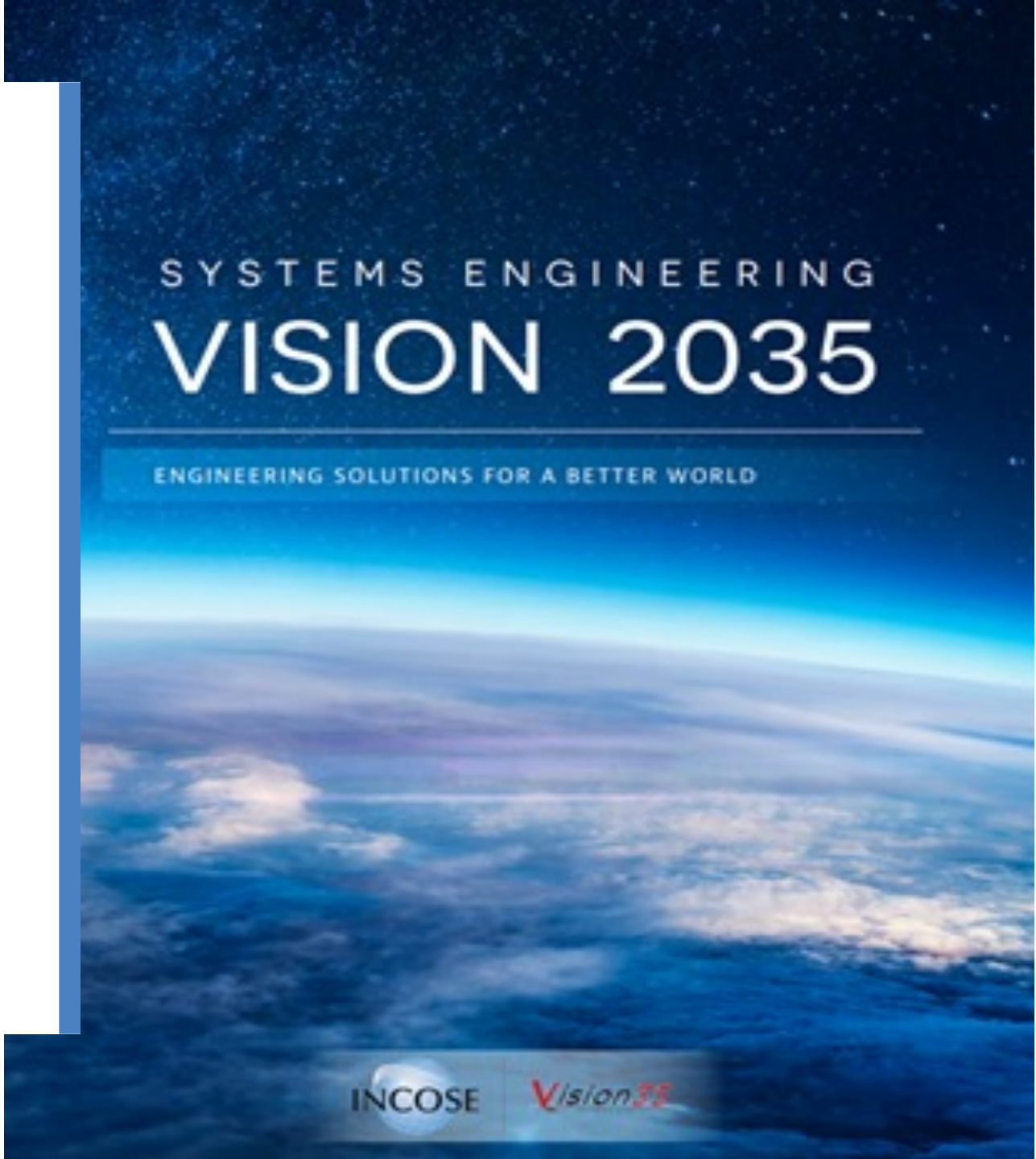
-INCOSE Systems Engineering Vision 2035

5 + 30

References to **Patterns** / **Re-Use** in Vision 2020

References to **Patterns** / **Re-Use** in Vision 2035

We **Must** Accelerate Adoption!



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A Look Into The Past

Humans are **Pattern-Recognition** machines.

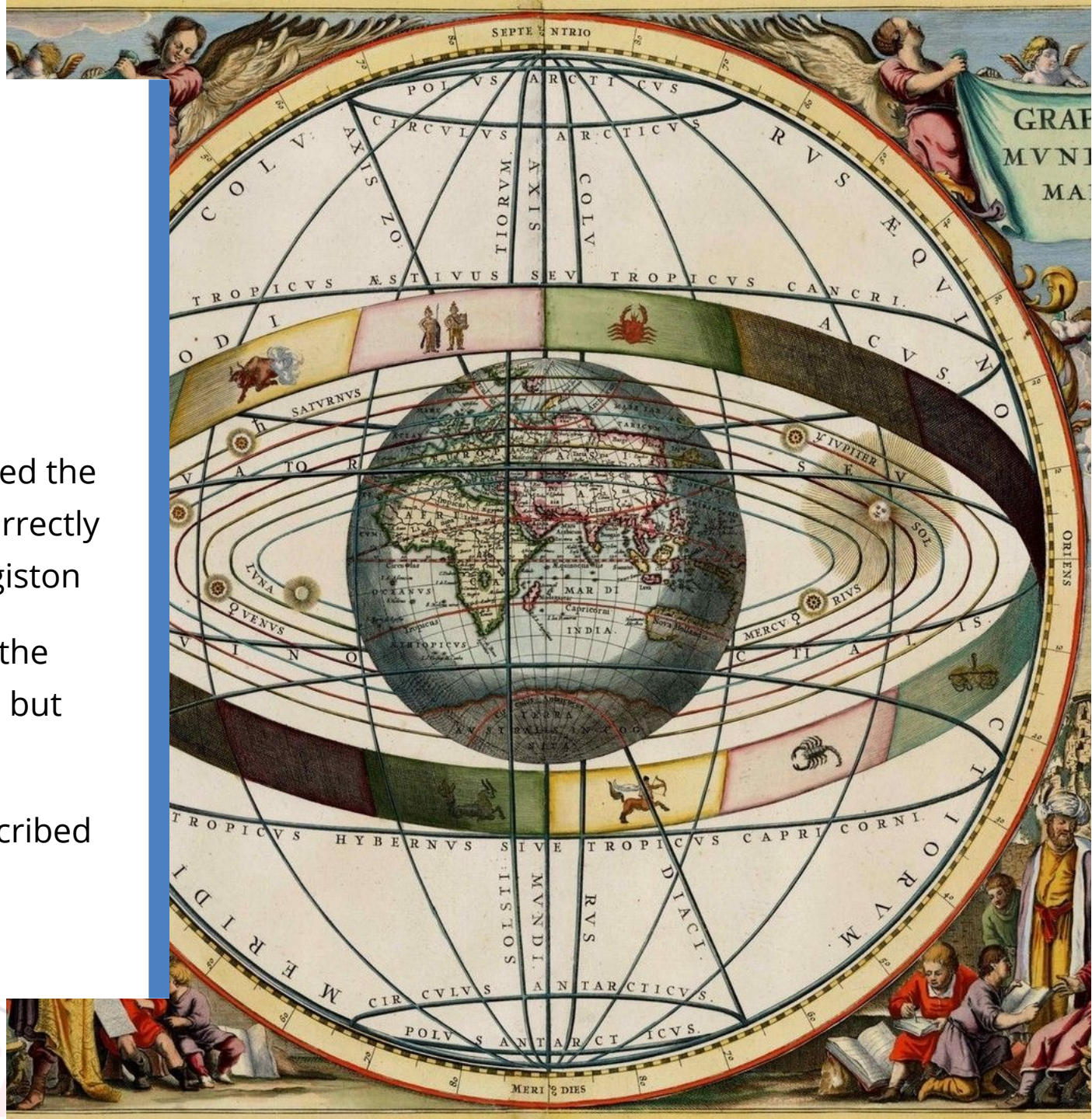
We *identify* patterns before we *understand* the models that explain them.

Some historical examples:

Combustion: J.J. Becher and G. Stahl described the pattern of combustion relying on air, but incorrectly required the existence of the element—phlogiston

Evolution: Jean-Baptiste Lamarck described the pattern of traits developing over generations, but incorrectly attributed it to trait usage

Astronomy: Early Astronomers correctly described patterns of celestial motion, but incorrectly identified the Earth as the center



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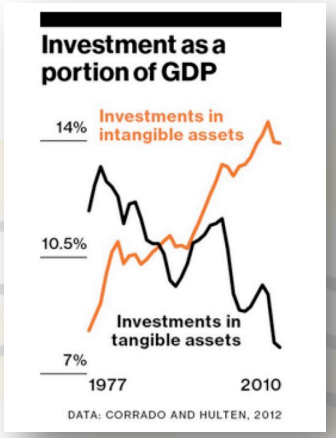
Anchoring on the Present

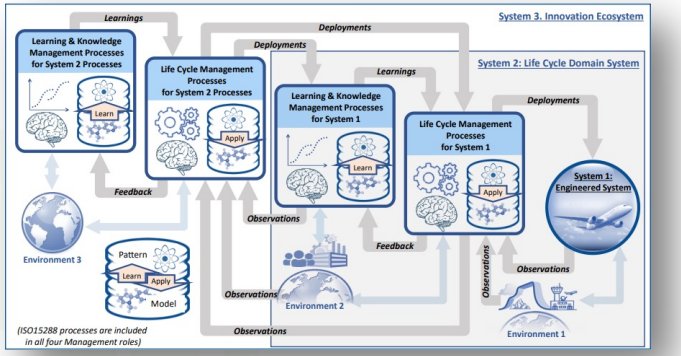
We have a LONG way to go to achieve INCOSE Vision 2035

Why Should We Build Patterns?



Industry is transitioning from investing in physical assets to **investing in information** and digital assets

How Are We Thinking About Patterns?



The Agile Systems Engineering Lifecycle Model (ASELCM) pattern describes a series of **interlocking learning loops** to produce information

Where Are We Building Patterns?

As of this presentation, examples of pattern development and/or use are **sporadic** and **anecdotal**.

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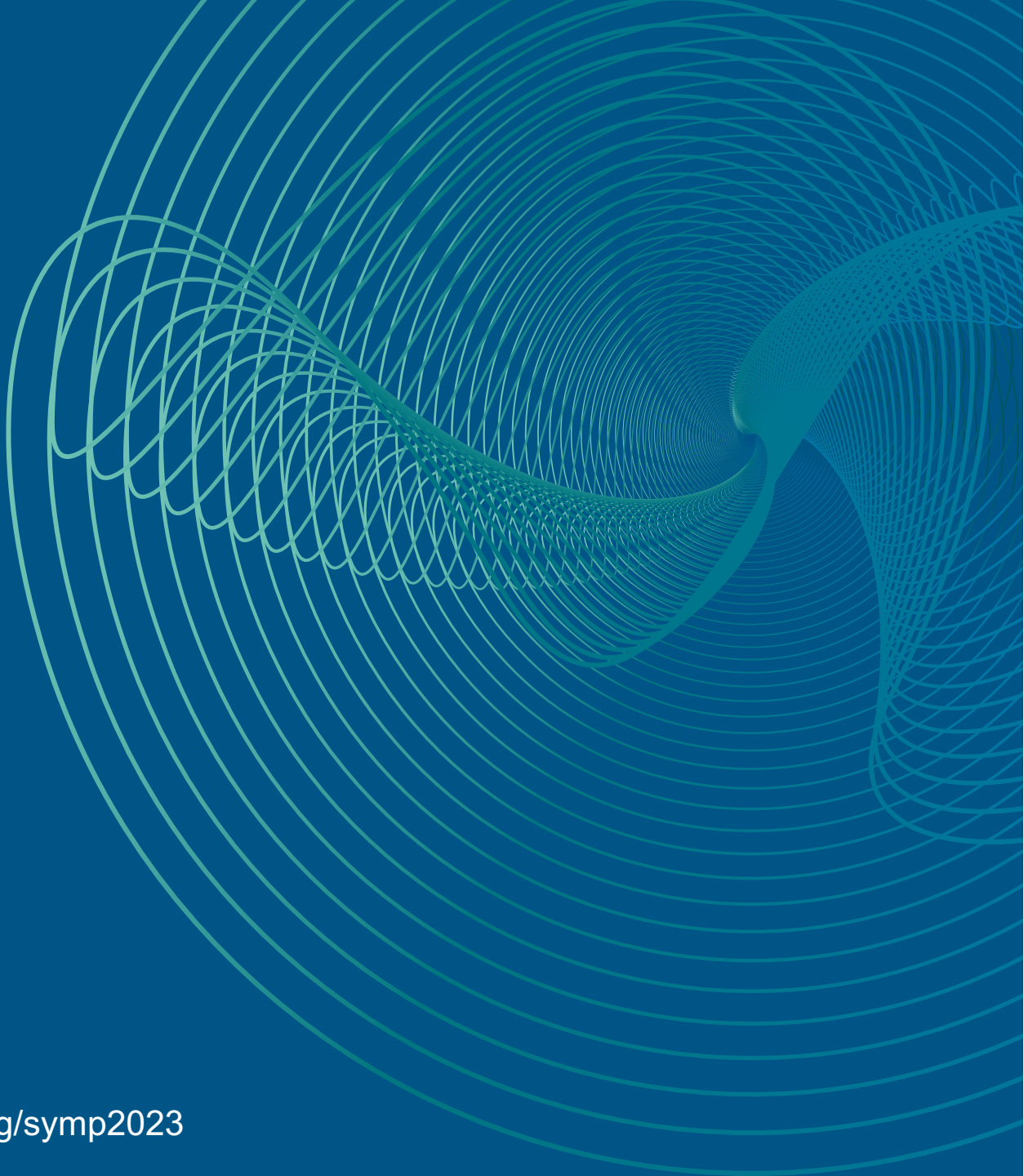
Raise Your Hand If…

You Have Captured the Same Lesson Learned More Than Once?



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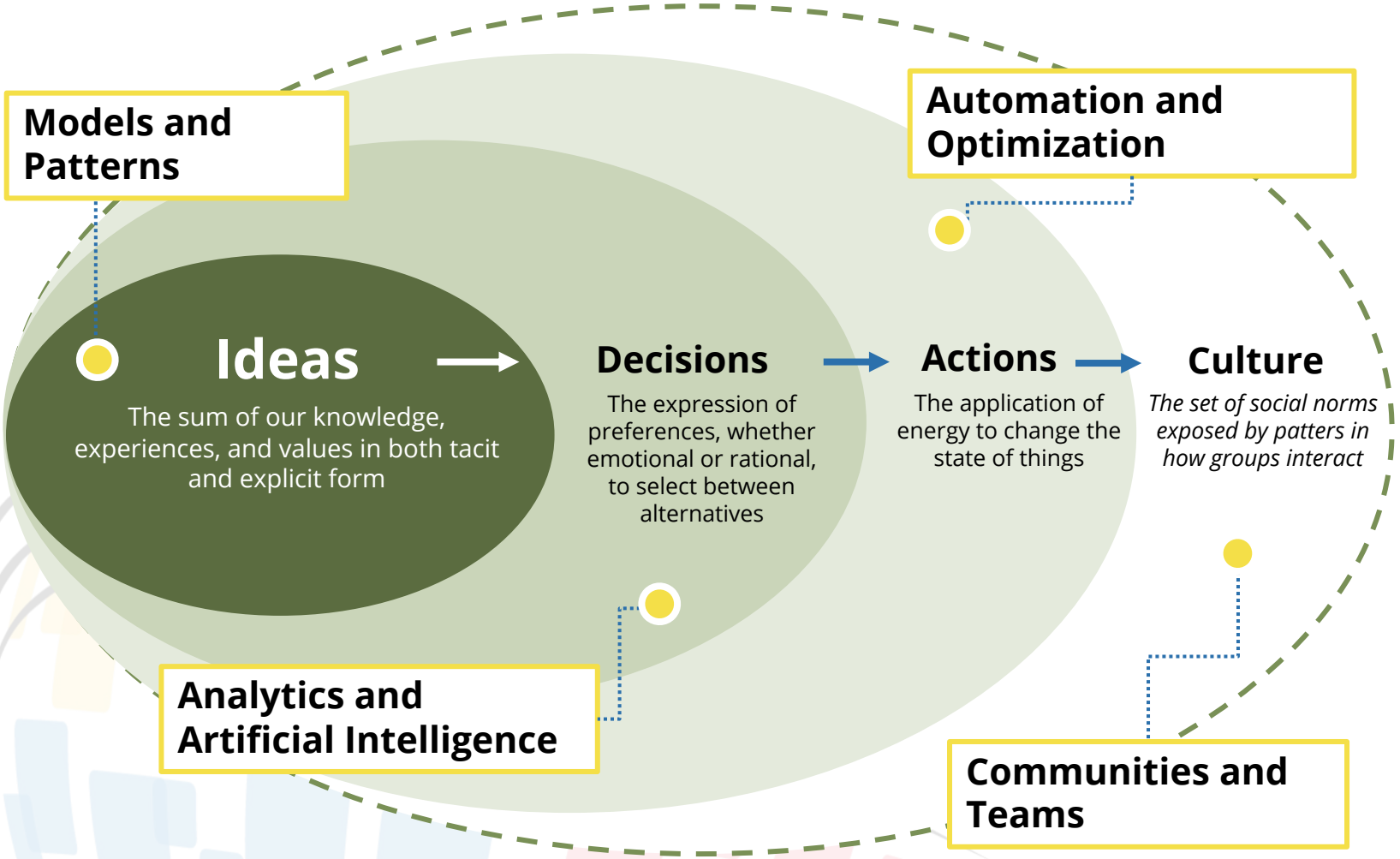
How Does Knowledge Drive Value?

We go from Idea to Action…through decisions.

Ideas inform Decisions. Decision inform Actions. Patterns of Actions align to values, which expose Culture.



> *Innovation is achieving the same results through a different pattern!*
>
> **- Bill Schindel**

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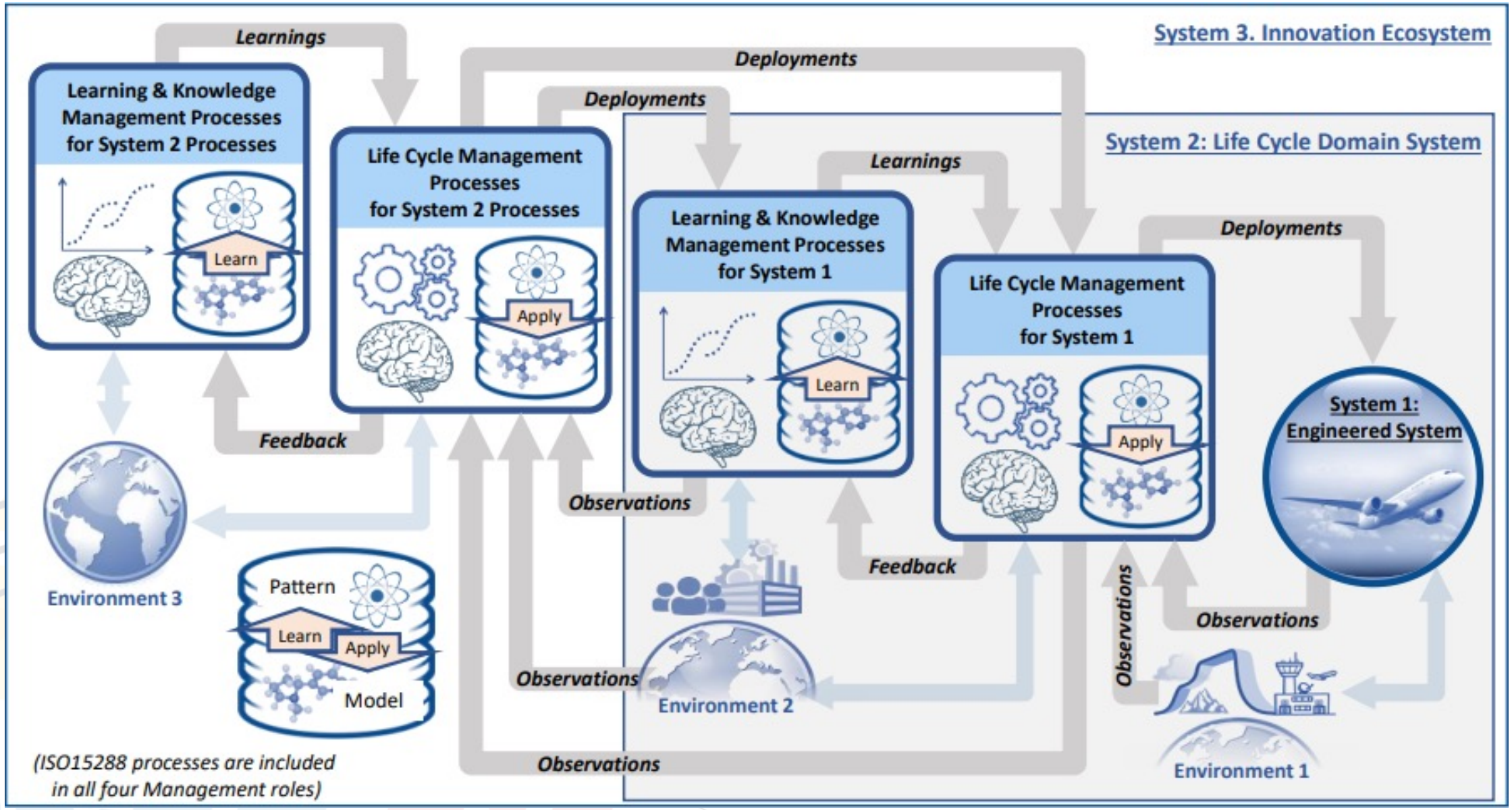
INCOSE ASELCM Level 1 Reference Model



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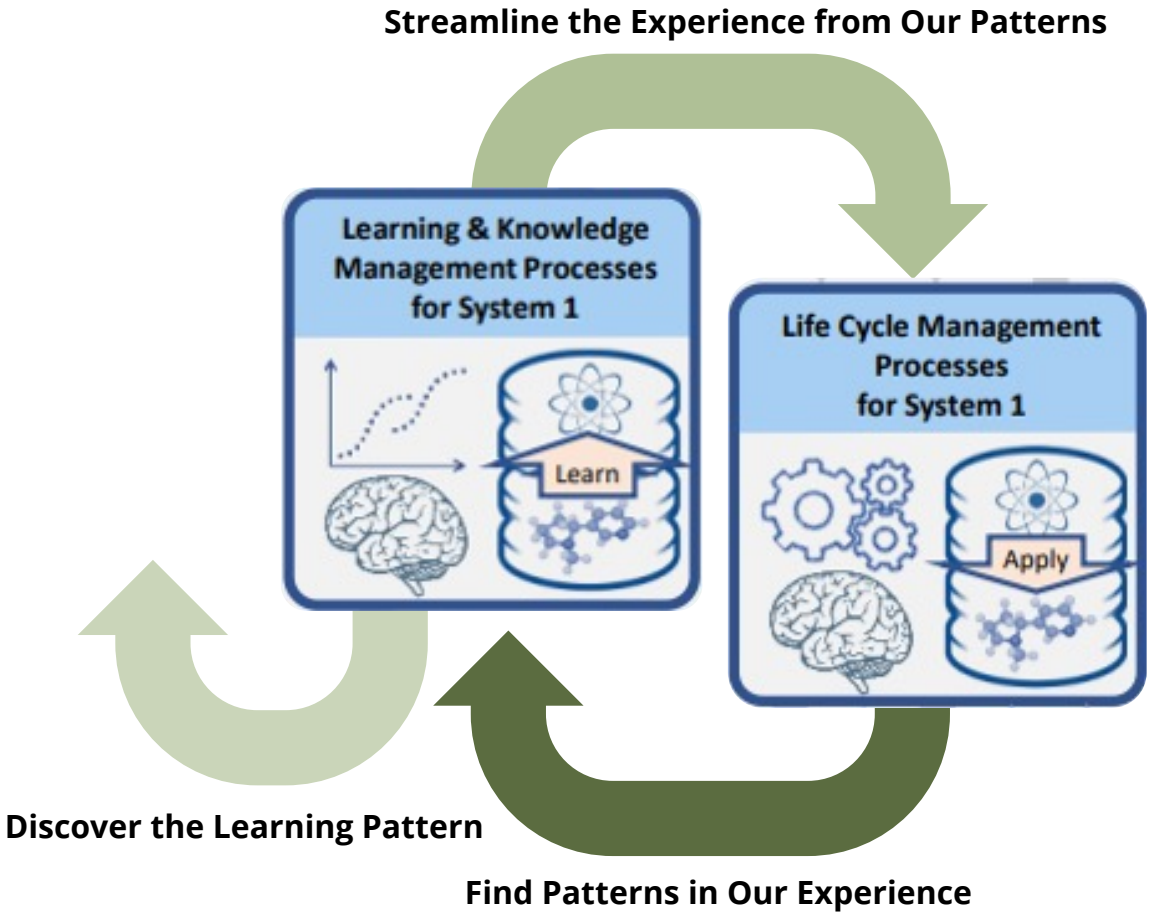
INCOSE ASELCM Level 1 Reference Model and the "Pattern of Patterns"

We have to separate our understanding of the **Information** from the **Action** on that Understanding

INCOSE is driving how we learn and **describe patterns** in models through the Patterns Working Group and the ASELCM Reference Model

The **Engineering Community** needs to drive how we **apply patterns** and **re-use models** through the definition of Re-Use and Configuration Best Practices

All of Us should add **"How-To" Guidance** to our models to aid the next model user



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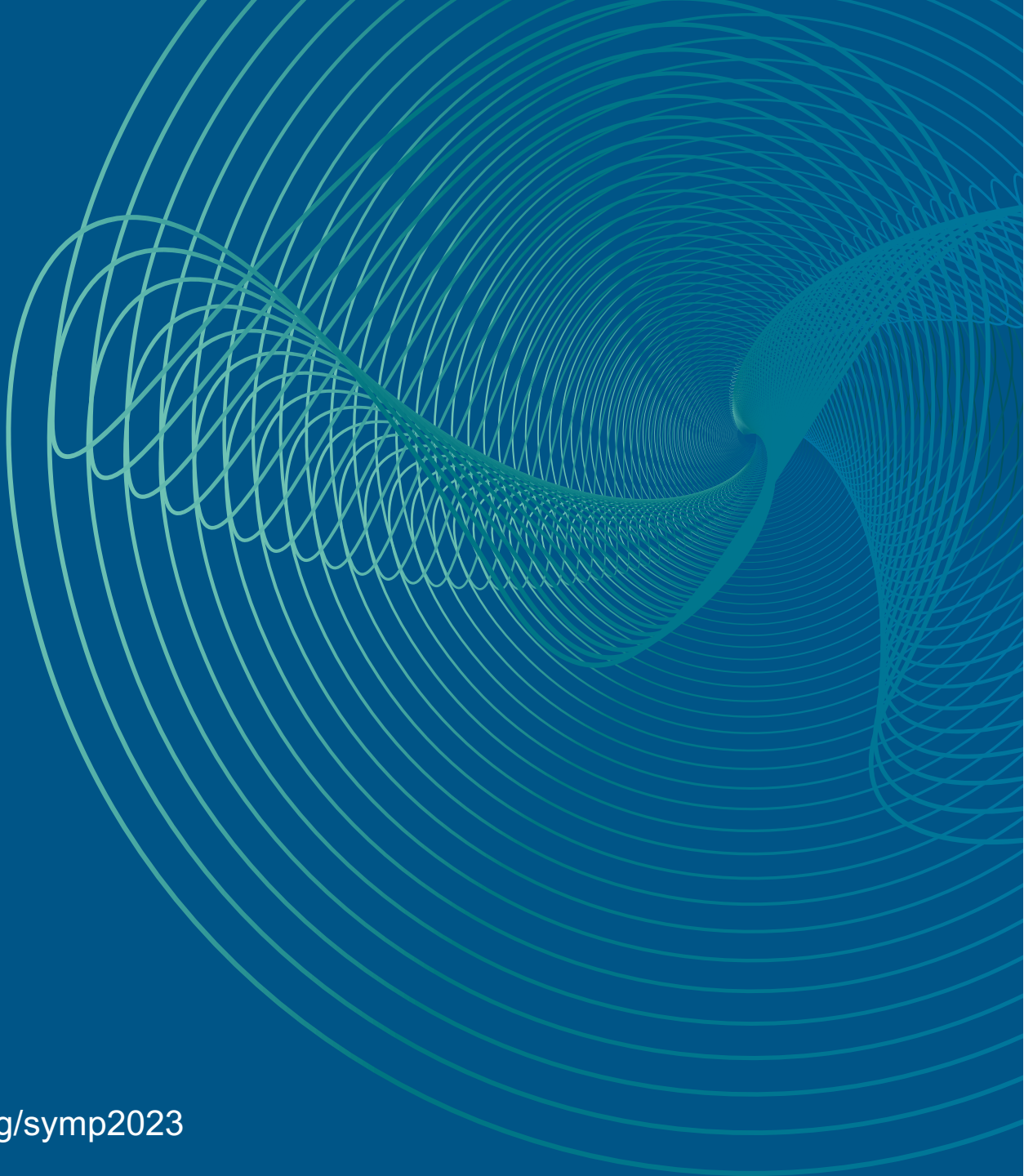
Raise Your Hand If…

You Have Ever Built Something to be Re-Used…And It Stayed on the Shelf?



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From Personal Experience…

The Failed Pattern

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The Anti-Pattern: Suitability Analysis

2019 Developed a **Suitability Pattern** to streamline Operational Availability (A_O) from **Failure Mode Effects Analysis** (FMEA).

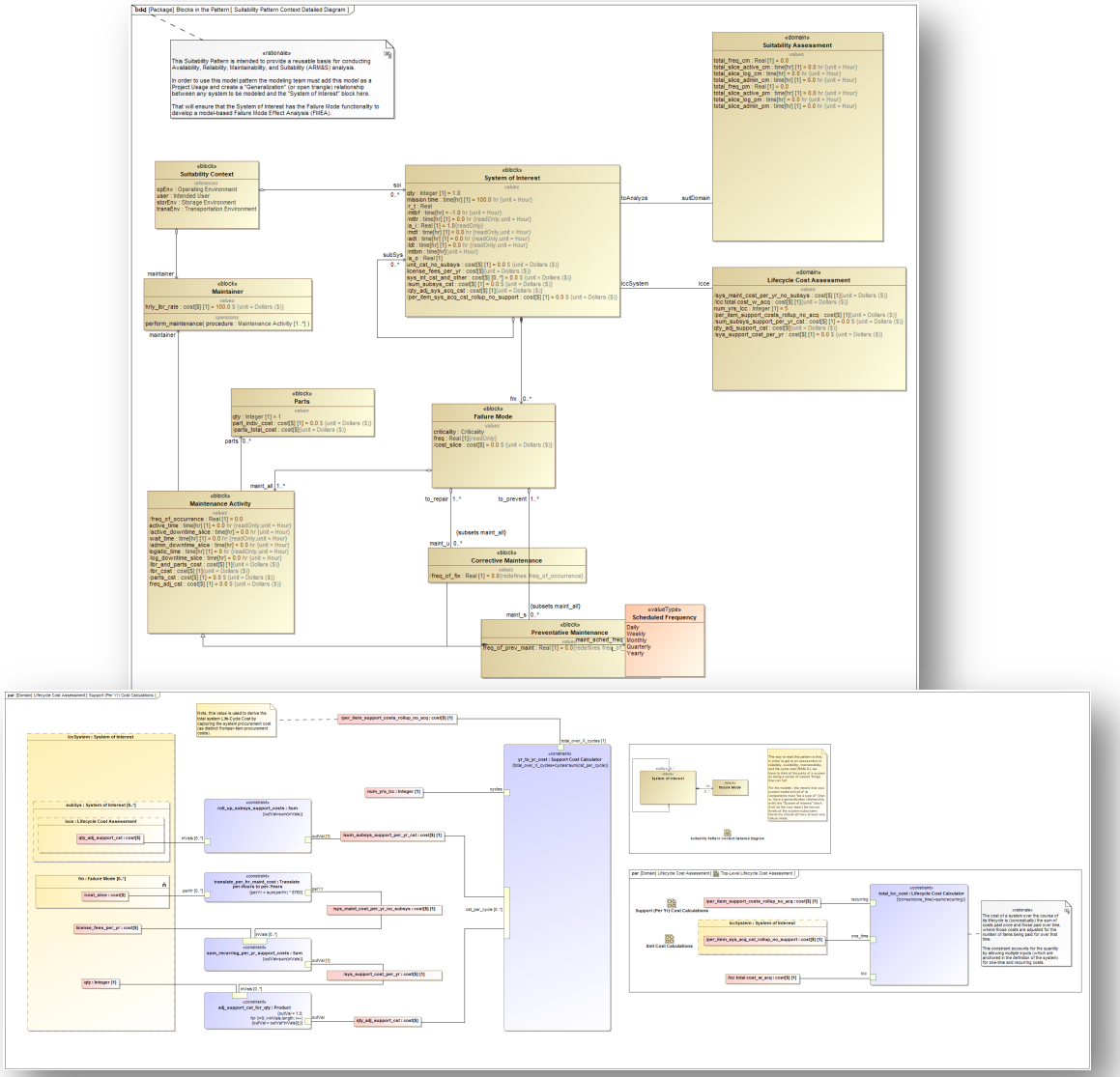
Deployed Suitability Pattern for one (1) **Defense Agency** and one (1) **Security Agency** project models.

2020 **Redeployed** Suitability Pattern for Security Agency project model.

2021 Added **Lifecycle Cost Analysis** to Pattern for second Defense Agency project.

Project Team could not execute either Lifecycle Cost Analysis or FMEA.

2022 **Redeployed** Suitability Pattern for first Defense Agency project.



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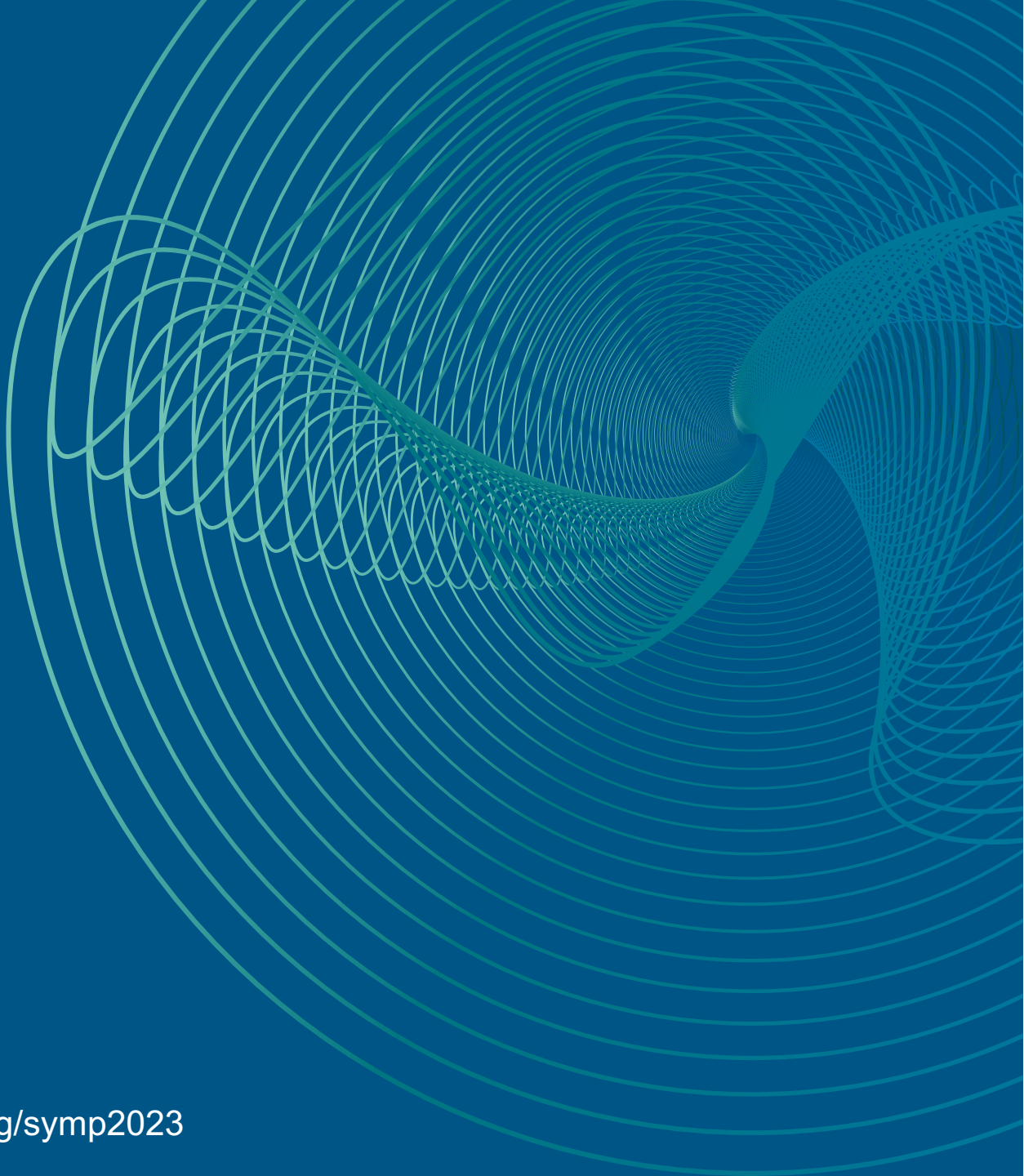
Raise Your Hand If…

You Have Ever Applied a Model Pattern?



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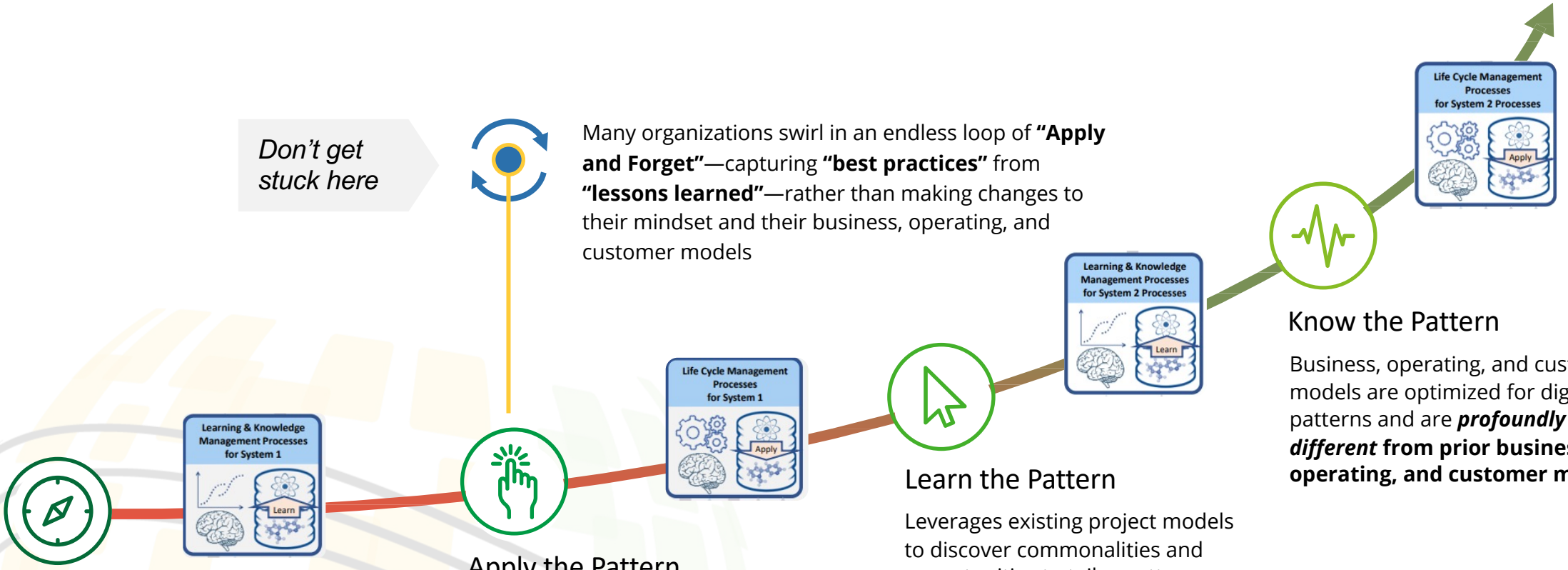
From Explicit to Implicit Knowledge: The Pattern of Patterns



Don't get stuck here

Many organizations swirl in an endless loop of **"Apply and Forget"**—capturing **"best practices"** from **"lessons learned"**—rather than making changes to their mindset and their business, operating, and customer models

Identify the Pattern

Capture pain points and strategies to automate existing capabilities using data and technology. ***No real change*** **to the organization**

Apply the Pattern

Modifies processes to improve individual capabilities and team performance, but ***largely in isolation from other*** **business, operating, and customer models**

Learn the Pattern

Leverages existing project models to discover commonalities and opportunities to tailor patterns rather than developing bespoke models—becoming more synchronized and less siloed—with ***more advanced changes*** **to current business, operating, and customer models**

Know the Pattern

Business, operating, and customer models are optimized for digital patterns and are ***profoundly different*** **from prior business, operating, and customer models**

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A Process of Model-Based Patterns

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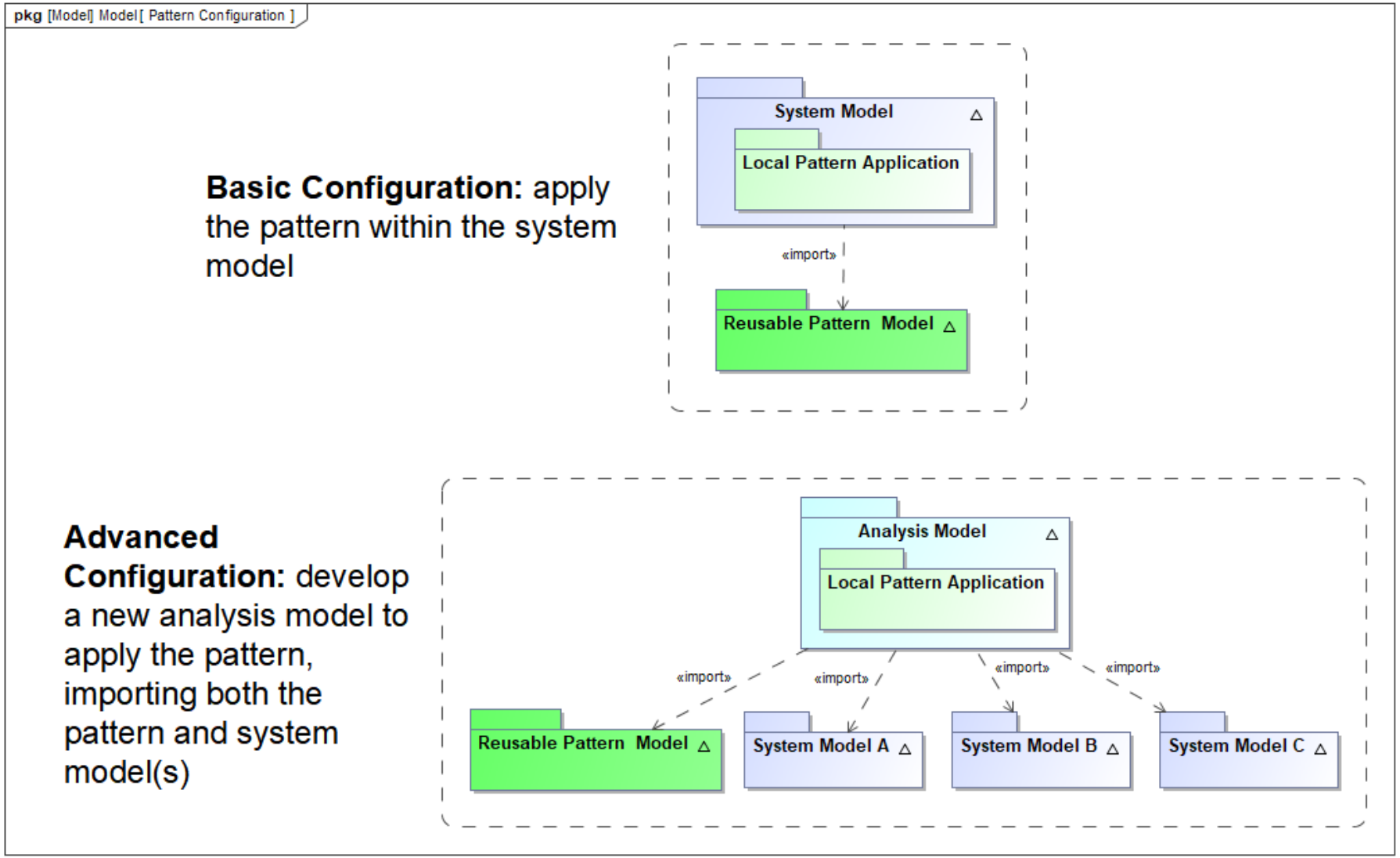
Model Configuration for Pattern Application



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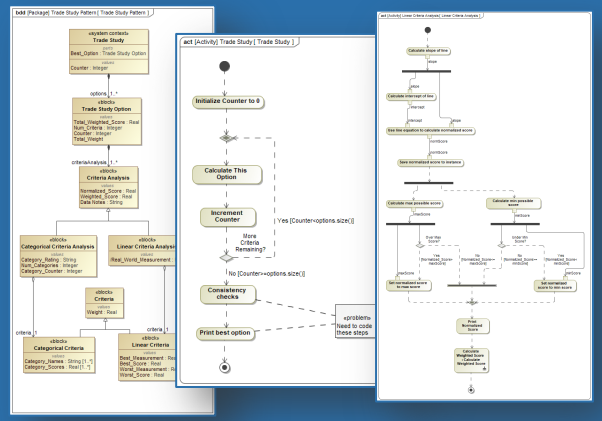
Trade Study Pattern Model Overview

The goal of the trade study pattern model was to develop a **model-based analysis of alternatives** in a **reusable format** that could be **applied to any trade study**

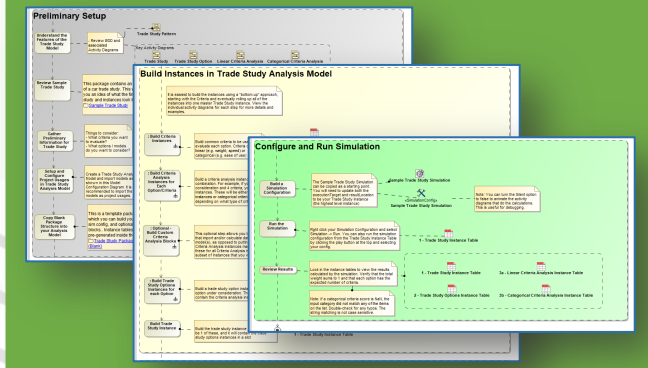
Reusable Pattern Blocks

Reusable blocks and activities facilitate the trade study calculations in the model



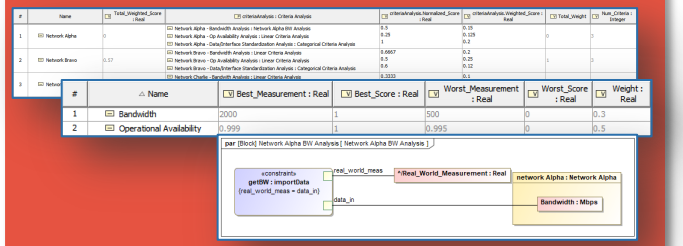
How-To Guide

The How-To Guide shows users **how to apply the pattern** to their trade studies



Example Implementation

An **integrated example** of a sample trade study demonstrates and **tests the pattern implementation methodology**



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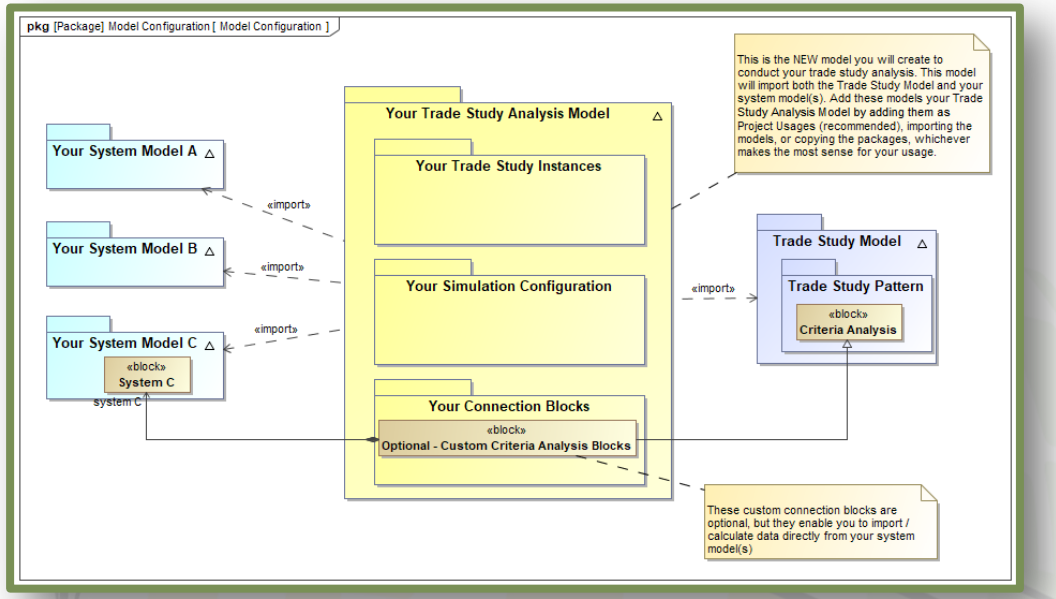
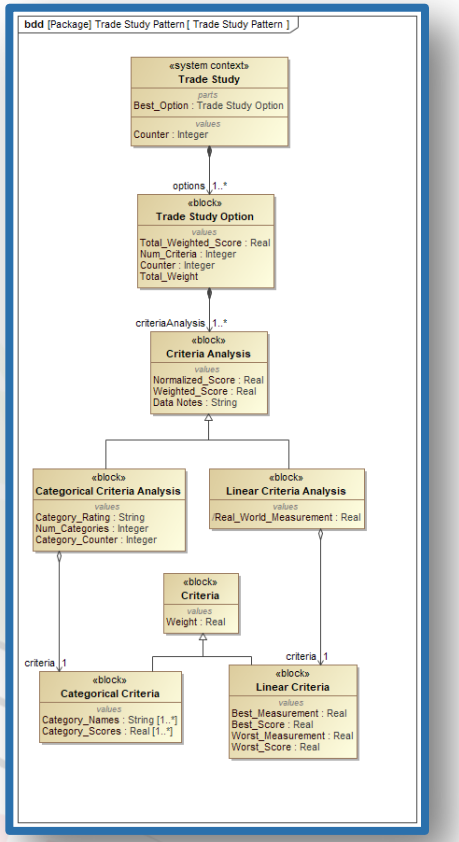
Trade Study Pattern Structure and Configuration

The Trade Study Analysis Model applies the Reusable Pattern Model to analyze the System Model. With this model configuration, neither the System Models nor the Trade Study Pattern Model will need to be modified to execute the analysis.

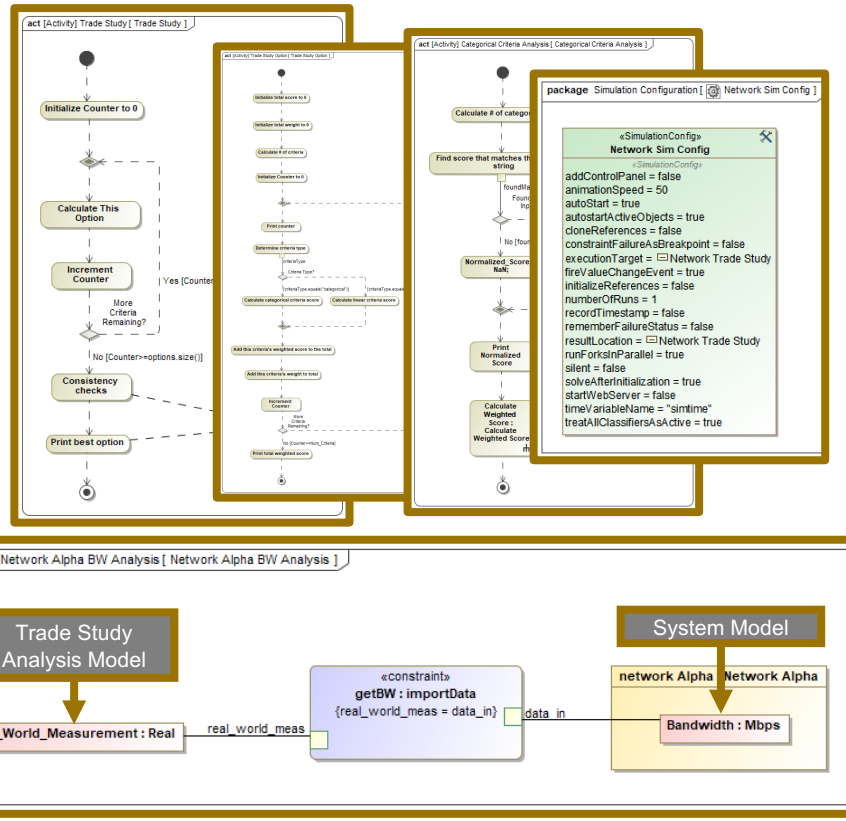
The **Trade Study Analysis Model imports** both the **Pattern Model** and **Multiple System Models** to be analyzed



A **hierarchy** of **interconnected instances** stores the **inputs** and **outputs** of the trade study



Activities and **Parametrics** drive the **trade study calculations**



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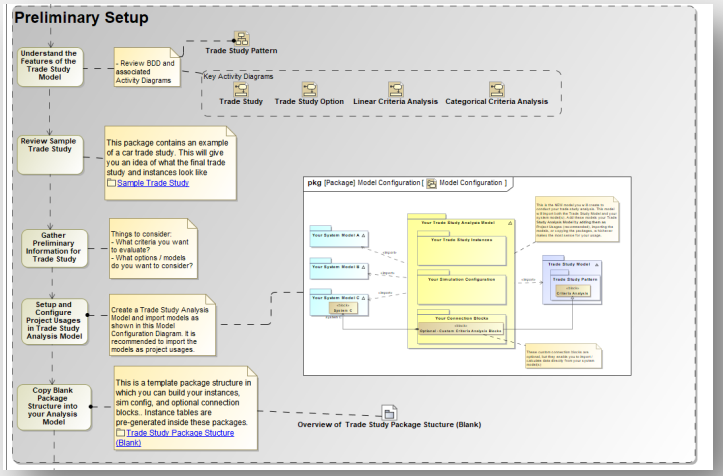
How-To Guide

The How-To-Guide was a key tool in facilitating user adoption of the new trade study pattern

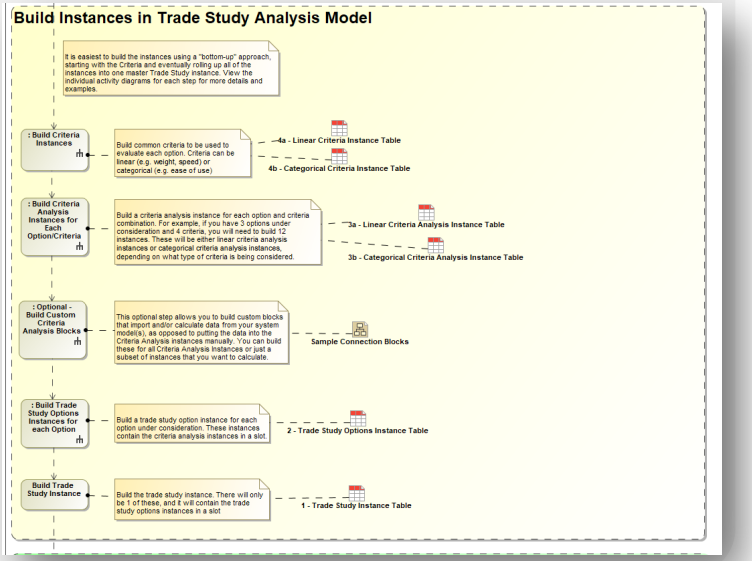
1. Preliminary Setup

- Study and understand the Trade Study Pattern Model
- Create Trade Study Analysis Model
- Configure Project Usages to import the Trade Study Pattern model and the System Model(s)



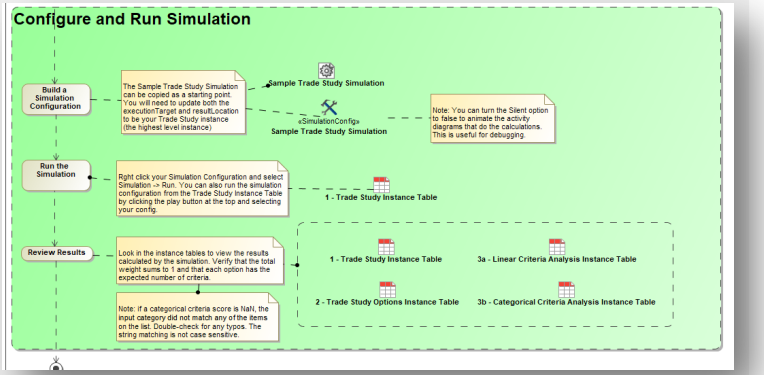
2. Build Instances

- Build up structure of instances from bottom to top
- Create parametrics and/or activities that can import / calculate the needed data from the System Model



3. Simulate & Analyze Results

- Build Simulation Configuration
- Run the Simulation
- Validate inputs
- Analyze the calculated results



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Lessons Learned: Best Practices for Pattern Models

While developing a pattern model may require an initial upfront investment, pattern models can pay off in the long-run if they are developed thoughtfully with user-friendly how-to guides

Utilize Best Practices

- **Capture best practices** such as algorithms, data types, structures, etc. in the pattern model
- **Consult SMEs** and **invest in up-front effort** to ensure pattern structure and **methodology is sound**
- **Review, test, and validate** the pattern to ensure accuracy

Repeatable Across Multiple Use Cases

- Pattern should be **generic** enough to be **applicable to multiple use cases**
- **Saves time** when **encountering the same types** of problems or analysis needs
- **Individuals don't have to do their own research** and spend time developing their own methodology

User-Friendly Design

- A **detailed how-to guide** can make the pattern **user-friendly** and easy to apply to a new use case
- Ideally, **anyone with basic MBSE knowledge** should be able to **take the pattern** and **apply it to their particular use case**

A good pattern model utilizes best practices, can be applied to multiple use cases, and is user-friendly

Deloitte.

Devon Clark has 23+ years of experience in Systems Engineering, Integration, and Test focusing on advanced operational concepts for Defense, Security, and Justice government agencies. He holds a Bachelors degree in Physics from Georgia Tech and a Masters degree in Systems Engineering from the Naval Postgraduate School. Devon is currently a leader in Deloitte Consulting's Digital Engineering Community of Practice (CoP) specializing in Model-Based Systems Engineering (MBSE), System of Systems Modeling, Digital Transformation (and karaoke).

Kasey Hill is a Systems Engineer with over 10 years of experience working in the defense industry. She has proven success in leading systems engineering and test teams to solve problems and achieve operational mission success. With specialties in Model Based Systems Engineering and Test and Evaluation, she enjoys optimizing tools and processes to make Systems Engineering and Testing more accurate and efficient.

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[1] INCOSE Vision 2035, released 2022

[2] INCOSE Vision 2020 v2.03, released 2007

[3] Cellarius ptolemaic system c2 - Superseded theories in science - Wikipedia

[4] Phlogiston theory – Wikipedia

[5] Lamarckism - Wikipedia

[6] Bloomberg Businessweek, *"The Rise of the Intangible Economy, US GDP Counts R&D, Artistic Creation"* by Peter Coy, 2013

[7] Object Management Group (OMG) Wiki "*Semantic Technologies for Systems Engineering (ST4SE) Project*" v1.10.6 released by INCOSE Patterns Working Group Oct. 2022.

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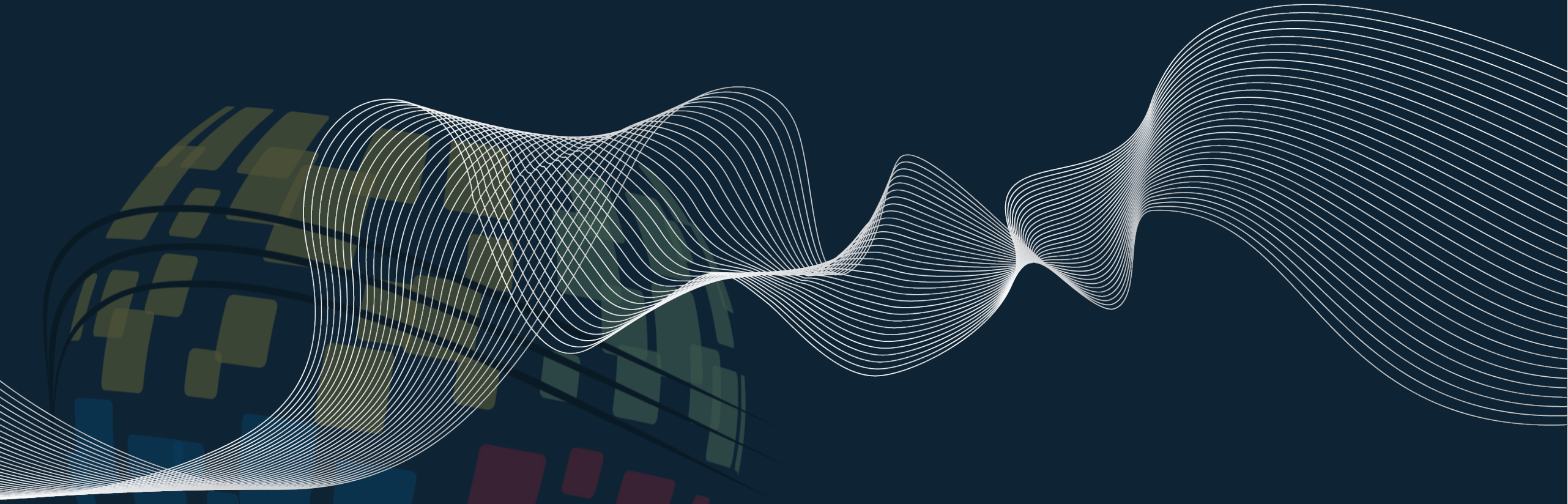
Questions?



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