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My Life with Fat-Fingers: Tying Resources to Readiness with a Reproducible Pipeline

Benjamin Ashwell and Kyle Remley, Project Leaders

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Executive Summary

High-fidelity simulations of the U.S. Navy's sustainment system are powerful tools for understanding how resource decisions (e.g., funding, manpower) influence readiness outcomes. However, there are three major challenges to the widespread adoption of sustainment modeling: the complexity of the model input, the difficulty of obtaining key data elements in a repeatable manner, and a lack of standardization in model assumptions and structure. In these slides, we show examples of tools, standards, and processes we have built to help address these challenges.

First, we have developed a human-readable model standard (HRMS) that stores all key modeling information in a text-based, non-proprietary format. Separating the modeling data from the specific implementation of a model simplifies the process of building and reviewing models, and the approach is future-proof against changes to specific modeling software. HRMS is also compatible with *stinger*, an open-source tool IDA has developed that automatically translates HRMS data into OPUS/SIMLOX input, streamlining the process of updating models and reducing the risk of fat-finger errors.

Second, we have developed an end-to-end data processing pipeline for modeling naval aviation. We start by curating the raw Navy data to ensure data integrity and repeatability. Then we process the curated data through our *honeybee* tool to generate ground truth for modeling in an HRMS format. This automatic pipeline allows us to keep our aviation models up to date with little manual intervention, and it ensures consistency and repeatability in how our model inputs are generated.

Finally, we are developing modeling guidelines and best practices to help the community of analysts standardize model assumptions and structures wherever reasonable. In general, models that serve the same purpose and that are based on the same data should make similar assumptions, and models that make similar assumptions should be structurally similar as well. This level of standardization makes collaboration and model review much more straightforward.

My Life with Fat-Fingers: Tying Resources to Readiness with a Reproducible Pipeline

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April 16, 2024

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- The U.S. government owns IDA's deliverables and has unlimited use privileges
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- IDA is free from conflicts of interest

The DOD needs tools that answer questions ranging from the tactical to the strategic

- How many propellers should NAVSUP purchase?
- What combination of spares will best allow an aircraft carrier to operate in a resupply-denied environment?
- How can DLA best pre-position spares to support cross-service operations?
- How can we most efficiently boost availability by adjusting the balance of maintainer ratings/specialty codes/MOSs in a unit?
- What long-term improvements (e.g., depot throughput increase, failure rate reduction) should the JPO pursue to ensure the long-term health of the F-35 fleet?
- What readiness shortfalls are likely to exist in 202X for a given OPLAN, and what are the root causes behind those shortfalls?

DLA – Defense Logistics Agency; JPO – Joint Program Office; MOS – Military Occupational Specialty; NAVSUP – Naval Supply Systems Command; OPLAN – Operation Plan

There are three major challenges to the widespread adoption of sustainment modeling

Building and updating models is challenging.

Even a simple SIMLOX model can have thousands of rows of input, discouraging manual updates and increasing the risk of fat-finger errors.

This barrier to adjusting models discourages analysts from using the models to answer "what if" questions.

It is hard to generate ground truth for modeling.

Simply obtaining key data elements (e.g., configuration data, demand rates, stock levels) is challenging.

Mismatches between "authoritative" data sources must often be disentangled manually, which takes time and leads to a lack of consistency.

It is hard for a community of practice to grow without standardization.

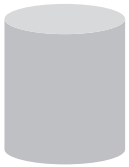
A lack of standardization of structures (i.e., models don't "look" the same) makes review and collaboration difficult.

A lack of standardization of assumptions (e.g., how to implement a single-echelon model for COSAL optimization) makes cross-model optimization an apples-to-oranges affair.

We have developed tools, standards, and processes to address these challenges.

COSAL – Coordinated Shipboard Allowance List

We have built a large-scale data processing pipeline that creates an unequaled view of the complete sustainment system



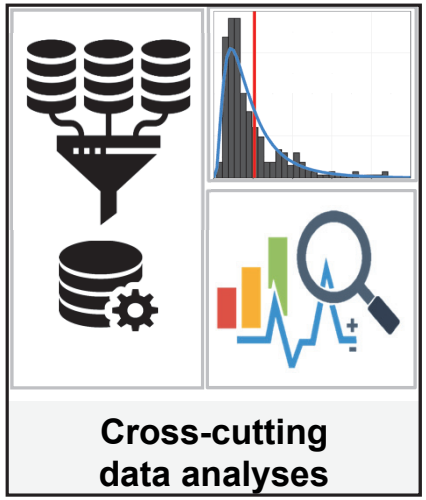
1. Collect raw data

2. Curate raw data for processing

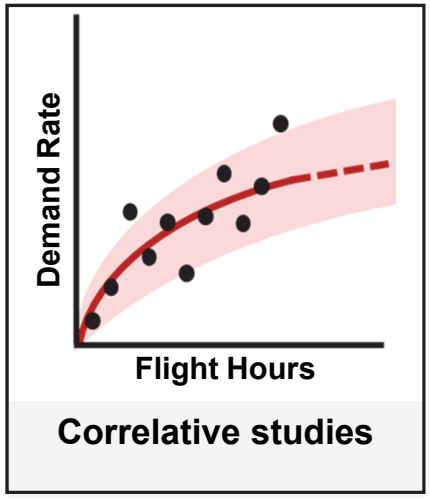
3. Process raw data into item-level metrics

4. Translate human-readable files into models

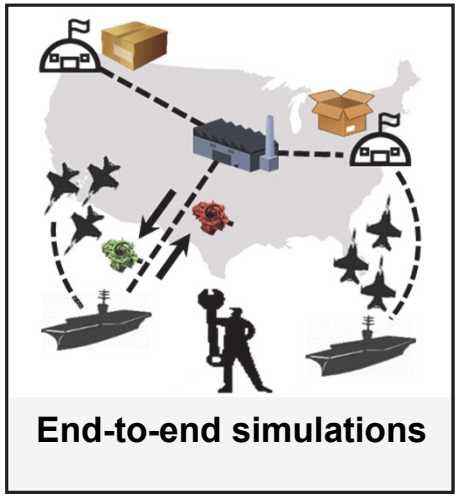
Our data workflow is a force multiplier that allows analysts to pursue a wide range of different analyses



Cross-cutting data analyses



Correlative studies



End-to-end simulations

We aim to use data everyone has to generate insights no one has.

Building and updating models is challenging.

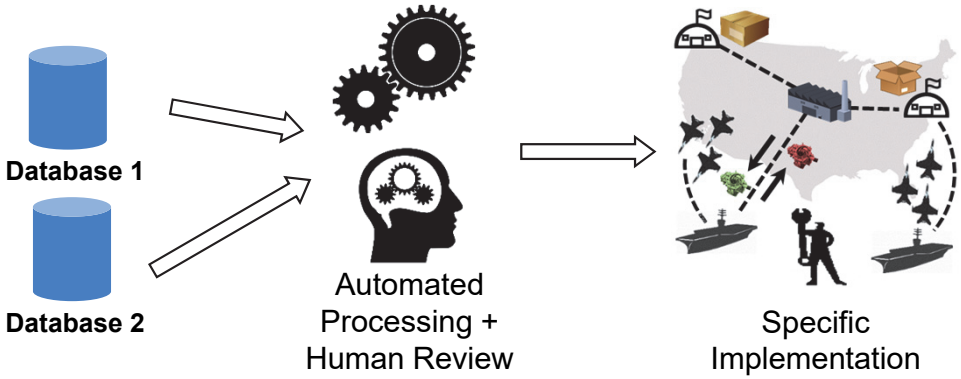
Even a simple SIMLOX model can have thousands of rows of input, discouraging manual updates and increasing the risk of fat-finger errors.

This barrier to adjusting models discourages analysts from using the models to answer "what if" questions.

The Human-Readable Model Standard (HRMS) and *stinger*

Maritime example

The DOD should store its “ground truth for modeling” separately from any specific model implementation



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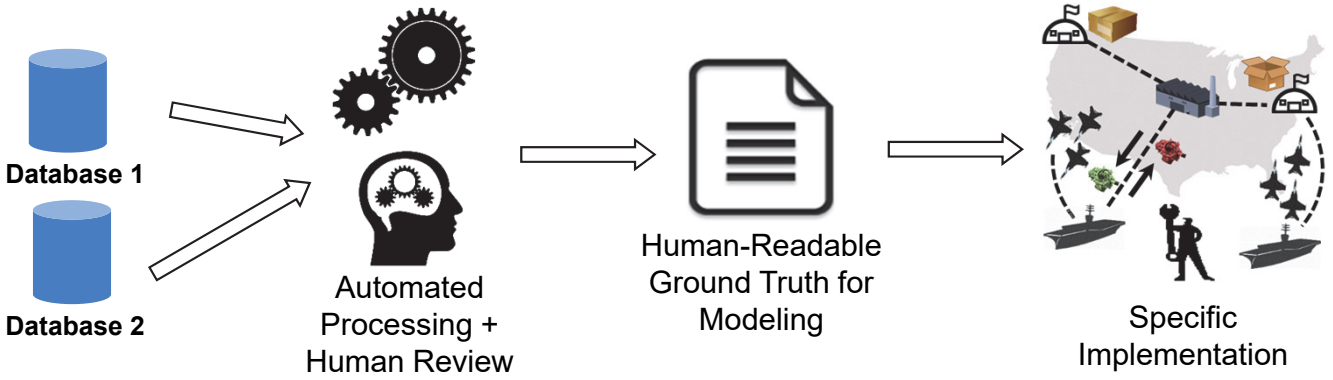
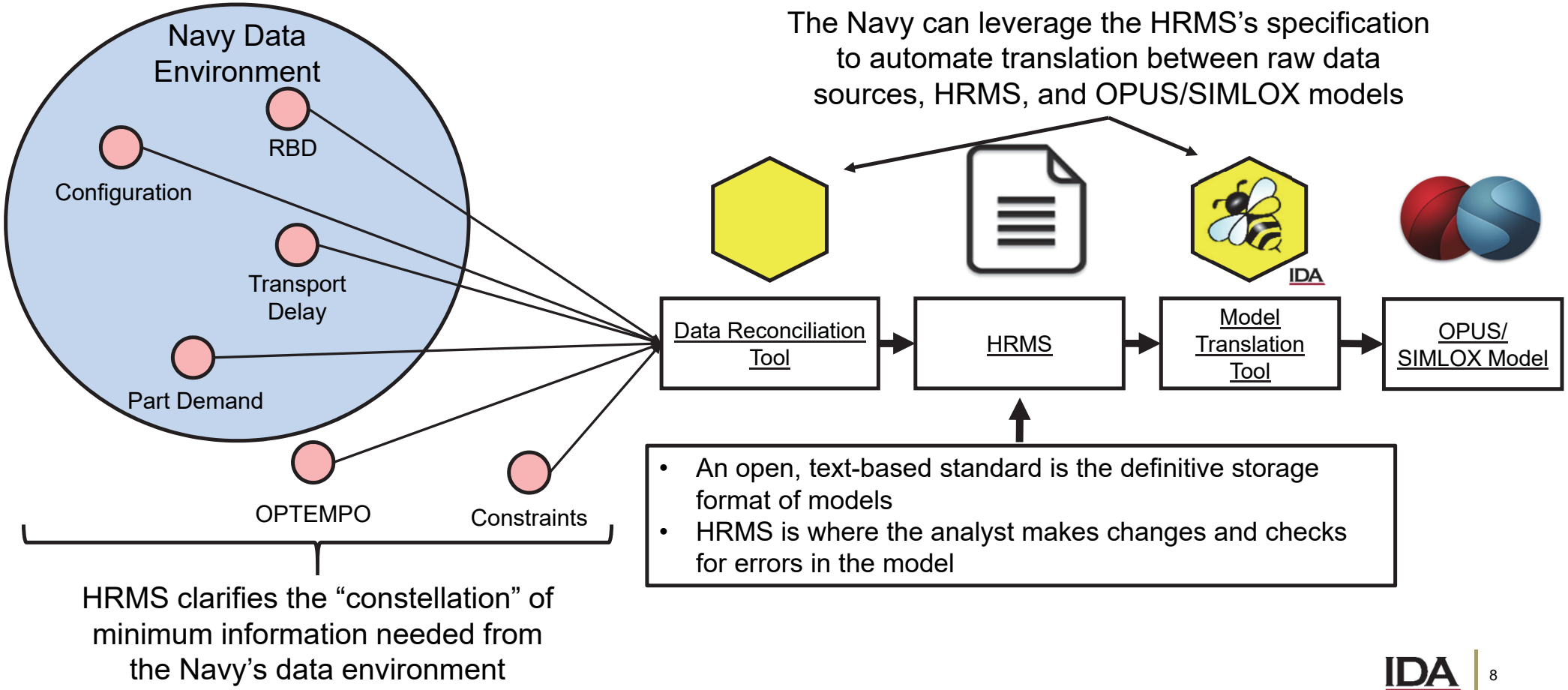


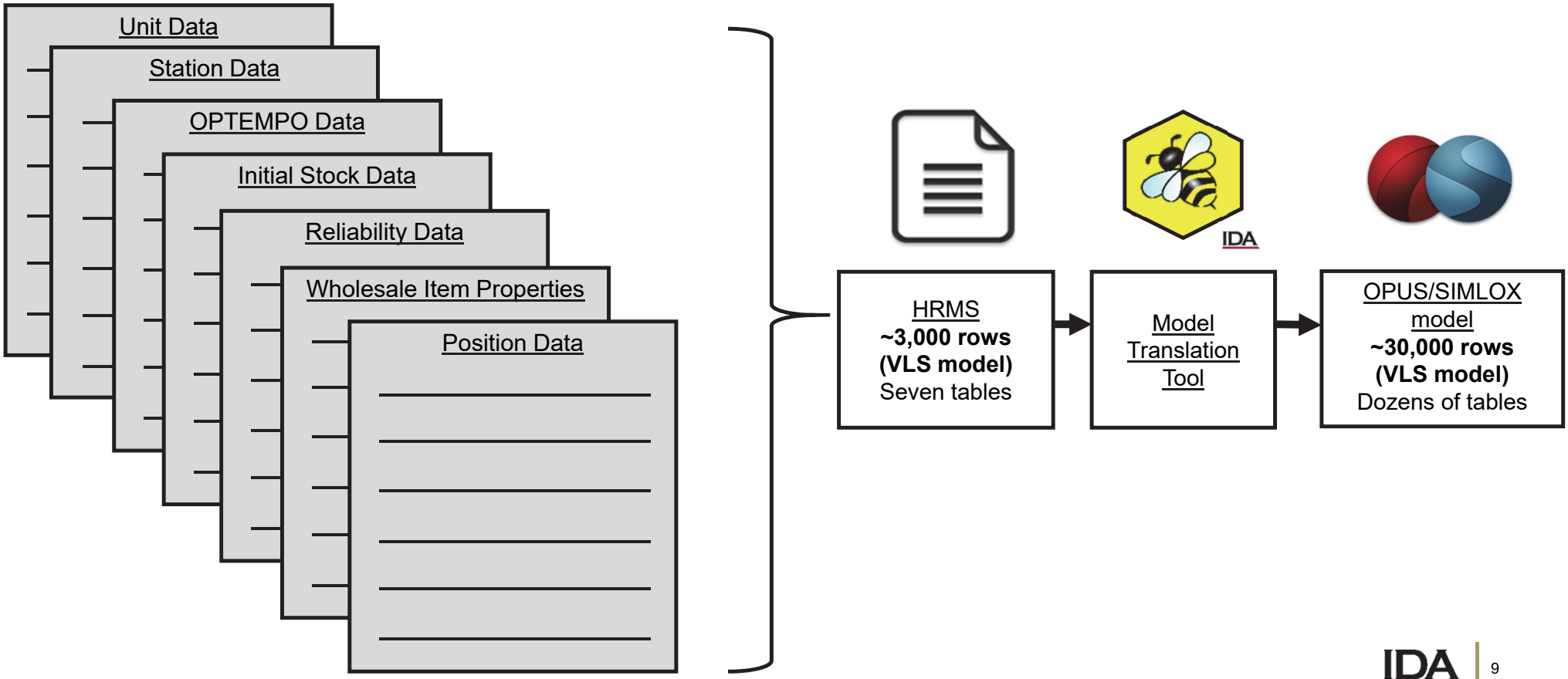
- This process breaks one complex step into two simpler steps
- Analysts do not require knowledge of detailed model-isms to read or update the ground truth
- A text-based format is future-proof against software changes and is compatible with version control tools

The human-readable model standard (HRMS), coupled with automation, lowers the barrier to entry for building good models in a repeatable manner



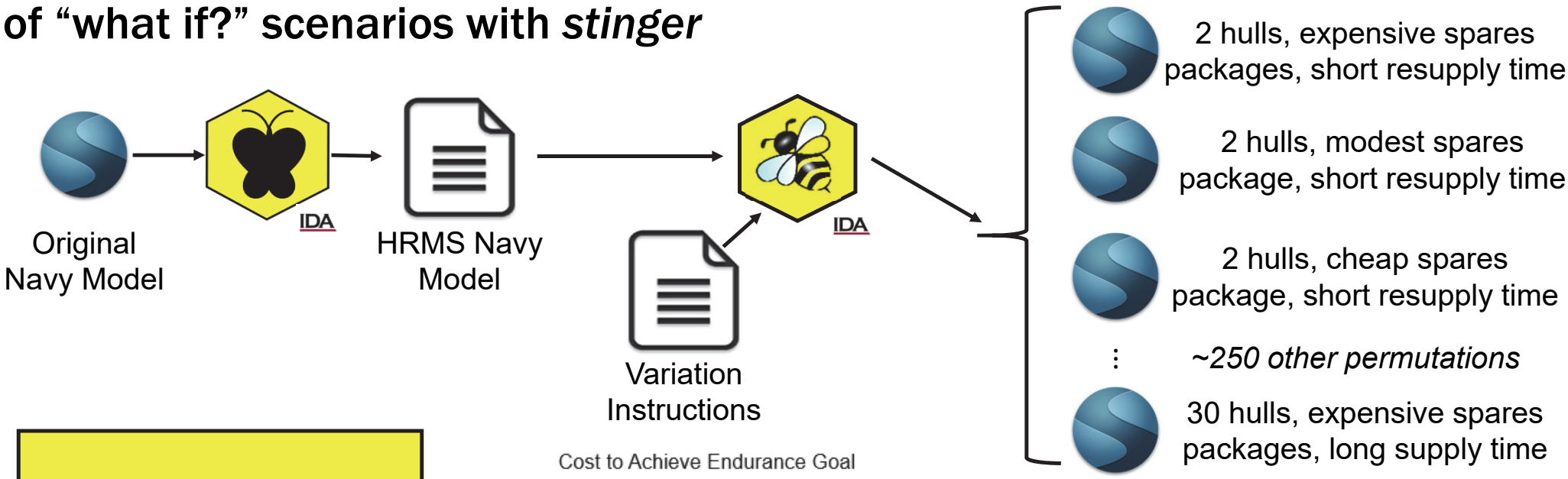
OPTEMPO – Operational Tempo; RBD – Reliability Block Diagram

HRMS consolidates the data needed to build OPUS/SIMLOX models into seven Excel-readable input tables

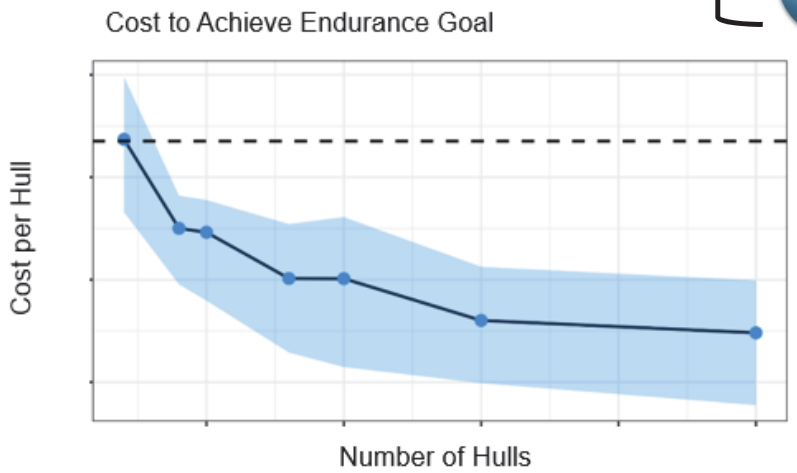


HRMS – Human-Readable Model Standard; OPTEMPO – Operational Tempo; VLS – Vertical Launch System

Once a model is in the HRMS format, it is fast and easy to run *hundreds* of "what if?" scenarios with *stinger*



After initial HRMS conversion, this pipeline takes just hours to get meaningful answers to hard modeling questions.



It is hard to generate ground truth for modeling.

Simply obtaining key data elements (e.g., configuration data, demand rates, stock levels) is challenging.

Mismatches between "authoritative" data sources must often be disentangled manually, which takes time and leads to a lack of consistency.

Reproducible Pipeline for Model Construction

Aviation example

The link between authoritative data and model inputs should be clear, and it should be automated

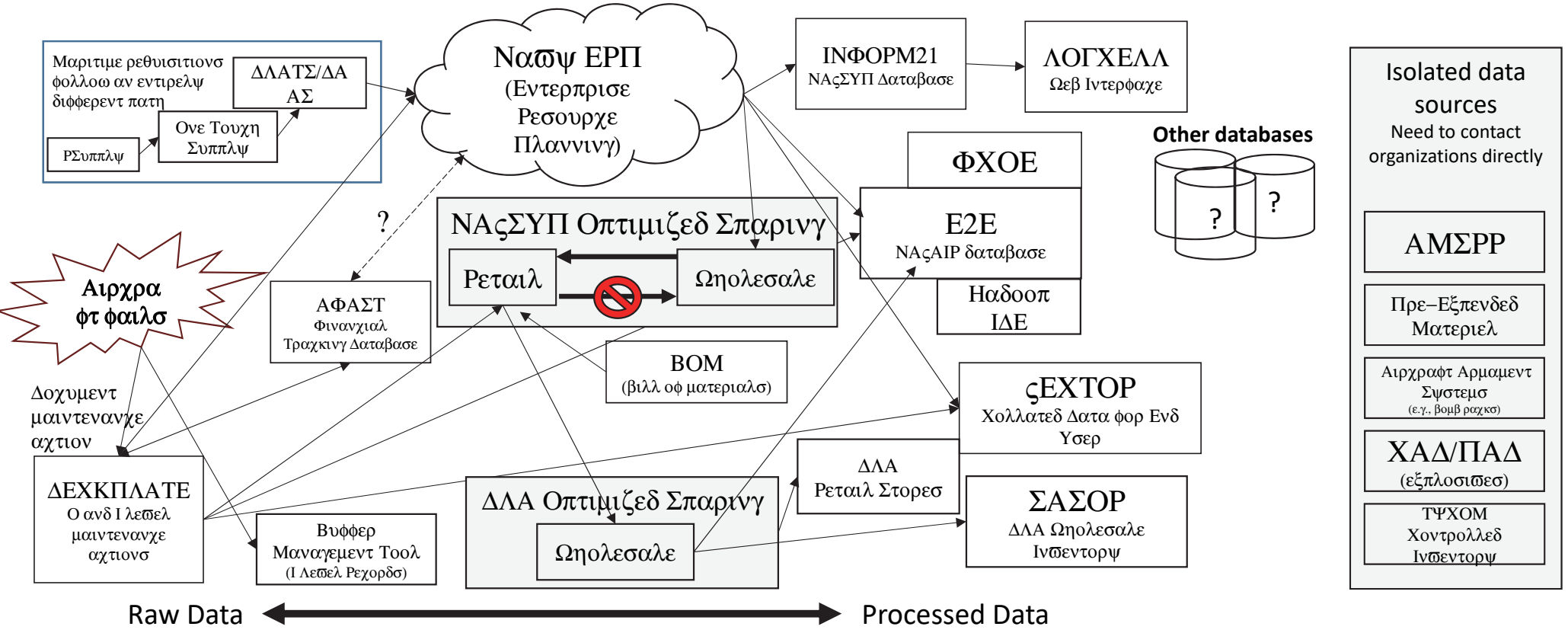
No matter how good an initial model is, the data within it will eventually grow stale. If the model is to remain relevant, it must **be easy to update with new data!**

Additionally, a set of documented, repeatable procedures for processing raw data into model inputs improves confidence in the models.

One of our earliest projects was building a Super Hornet readiness model

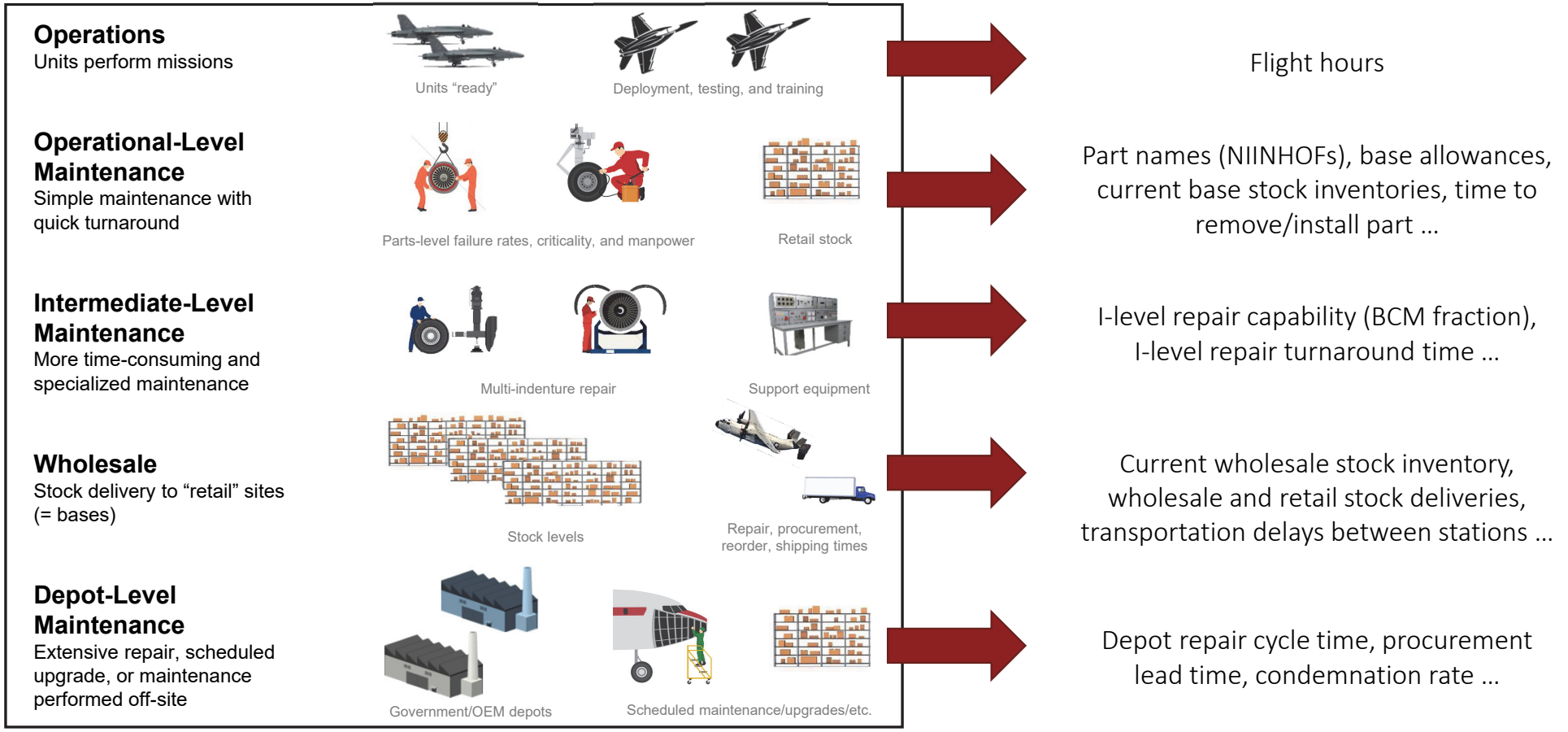
Initial discussions with the Navy implied four major databases should provide all the parts and maintenance data needed

In reality, there is no “one-stop-shop” for all databases in the DoD



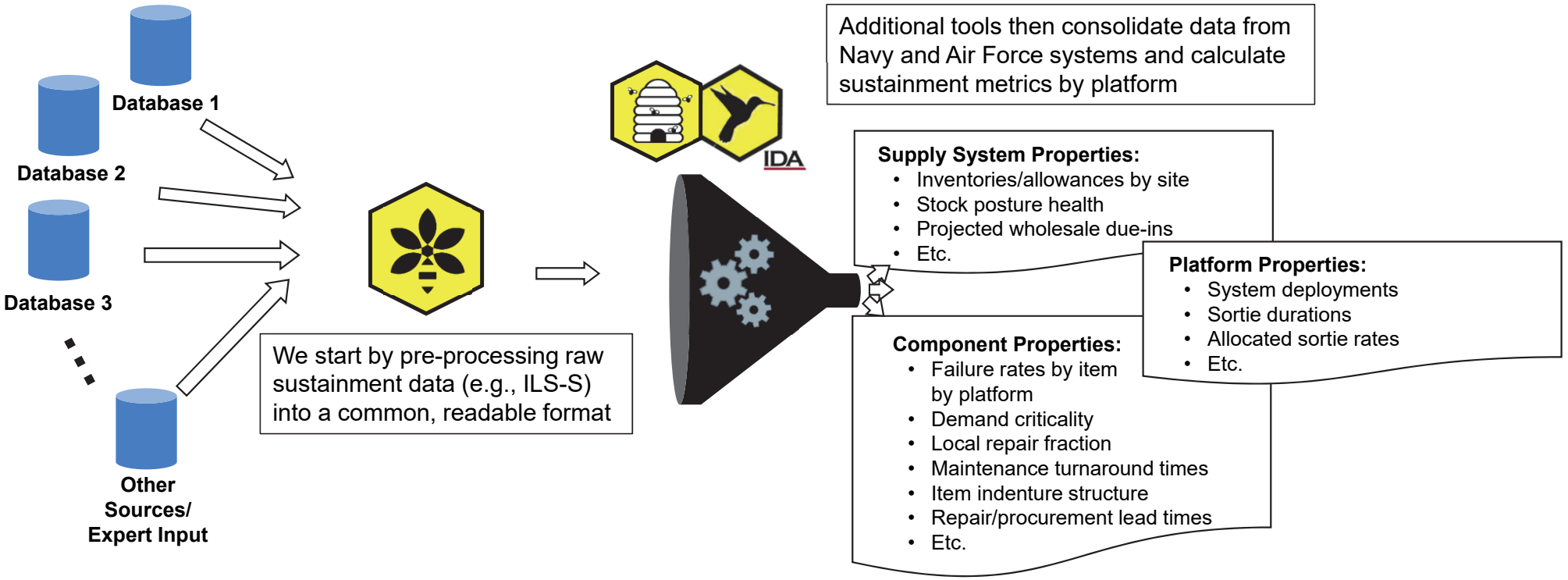
Even knowledge is stovepiped. Many databases are cryptic and poorly documented, and knowledge is often passed down by word of mouth.
Having the data isn’t enough; you have to be able to interpret that data.

A tremendous amount of information is required to populate a multi-echelon model!



BCM – Beyond Capability of Maintenance; NIINHOF – National Item Identification Number, Head of Family; OEM – Original Equipment Manufacturer

We have developed a reproducible data management procedure that allows us to interpret sustainment data and generate our "ground truth for analysis"



Updating all of these metrics without automation is difficult and prone to fat-finger errors. A well-documented, community-reviewed, repeatable workflow is key to building confidence that the model is up to date and has been fed with good information.

A standardized workflow makes updating existing models largely automatic

Once the baseline model has been built for a given system, our tools make updating the underlying data (e.g., demand rates, stock levels) largely a “hands off” process.

It is hard for a community of practice to grow without standardization.

A lack of standardization of structures (i.e., models don't "look" the same) makes review and collaboration difficult.

A lack of standardization of assumptions (e.g., how to implement a single-echelon model for COSAL optimization) makes cross-model optimization an apples-to-oranges affair.

Standardizing Structures and Assumptions

Aviation and Maritime example

There should be one – and preferably only one – obvious way to do it.
— The Zen of Python

1) Models that are built on the same raw data sources and that make similar assumptions should "look" similar unless there's a good reason for them not to.

2) Models that are built on the same raw data sources, and that have the same intended use (e.g., COSAL optimization), should make similar assumptions unless there's a good reason for them not to.

Standardization of structure makes collaboration and review easier, and standardization of assumptions makes outputs from different models easier to compare.

COSAL – Coordinated Shipboard Allowance List

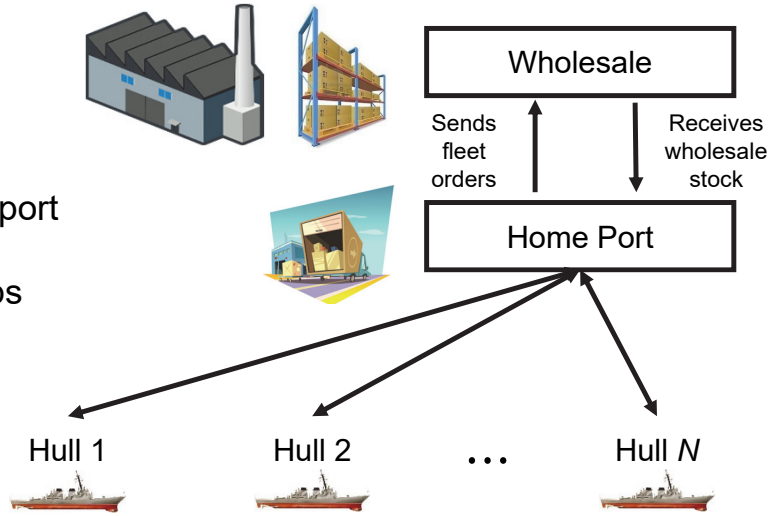
Consistent implementation of assumptions improves the readability of models for the community of analysts

Model A

Wholesale: Give wholesale 1,000 of all items, and treat reorders and repairs as effectively instantaneous

Transport Delay: Assume instant transport between wholesale and home port, but assume 15 days from home port to ships

Item Properties: Treat items as a mix of consumables and repairables



Model B

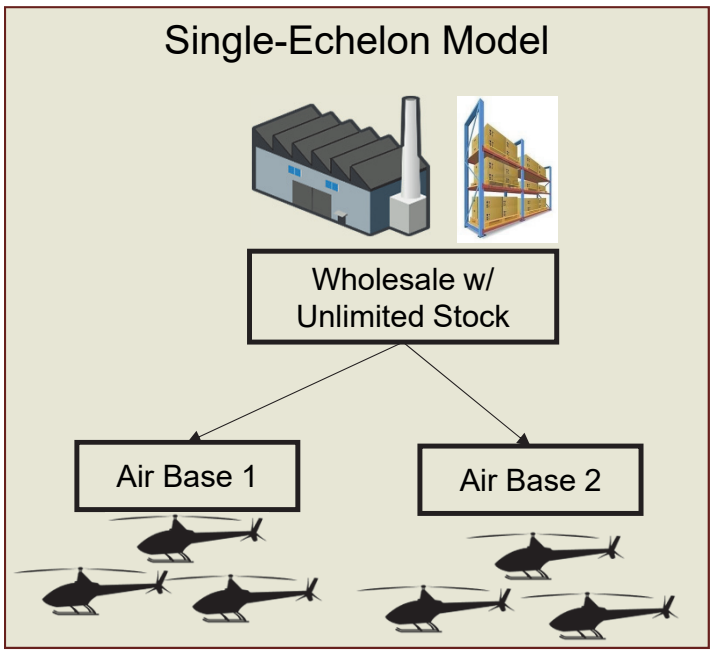
Wholesale: No stock; set all reorder lead times to 15 days

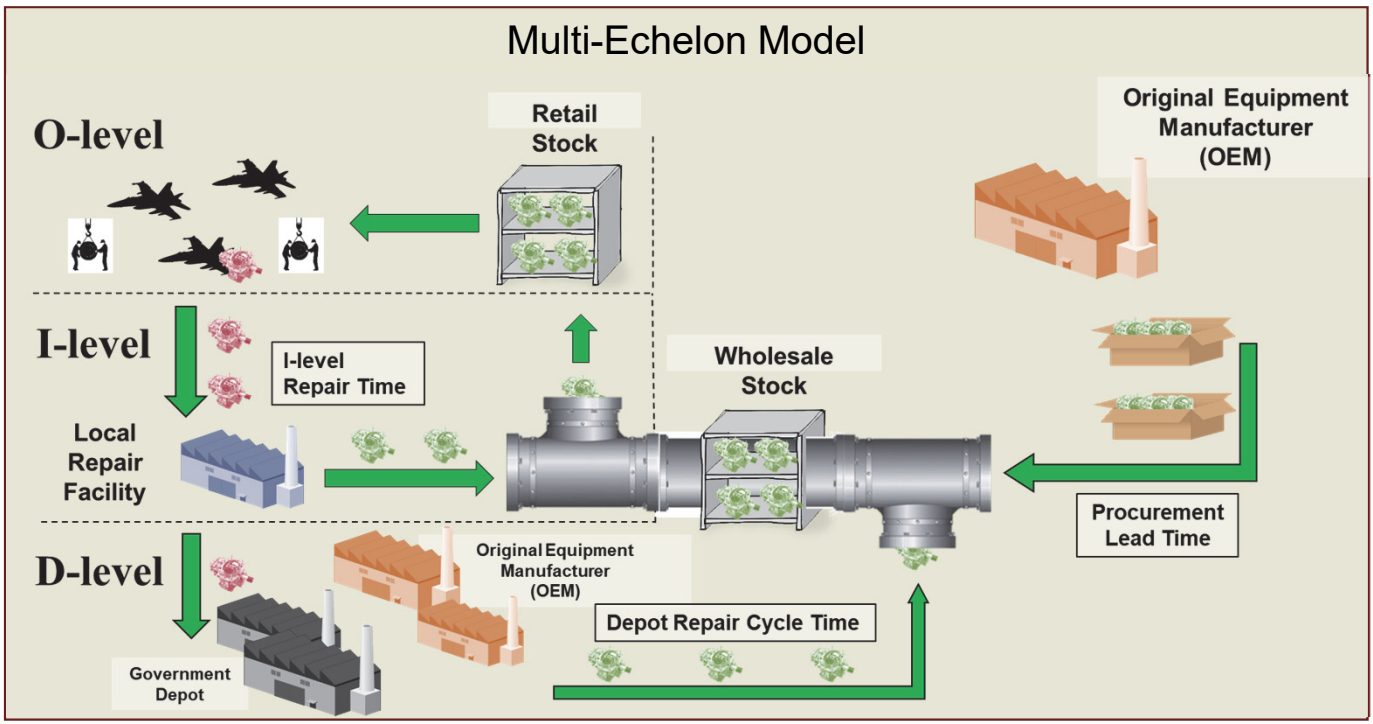
Transport Delay: Assume instant transport

Item Properties: Treat all items as consumables

These models make similar assumptions but they implement those assumptions very differently, making direct comparisons difficult.

Models built for similar purposes should, generally, be built on the same fundamental assumptions





The fundamentally different assumptions built into these two models make apples-to-apples comparisons nearly impossible.

There are three major challenges to the widespread adoption of sustainment modeling

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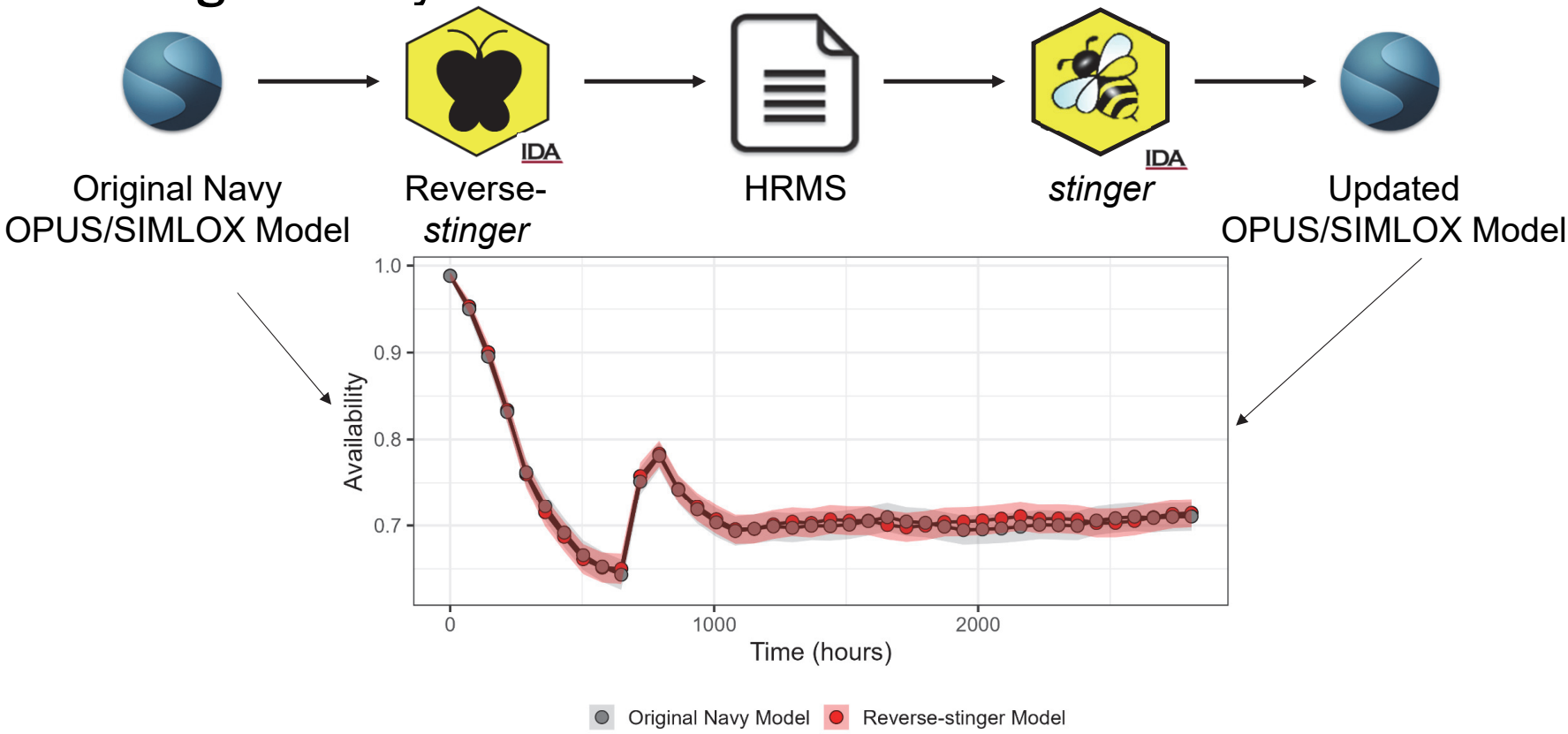
Backup Slides

We verified that the HRMS format retained fidelity to the predicted A_o from the original Navy model



We verified the HRMS files by ensuring that the predicted A_o for both models is within the expected deviation inherent to discrete event simulations.

A_o – Operational Availability; HRMS – Human-Readable Model Standard

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14. ABSTRACT

High-fidelity simulations of the sustainment system are powerful tools for understanding how resource decisions (e.g., funding, manpower) influence readiness outcomes. However, there are three major challenges to the widespread adoption of sustainment modeling: the complexity of the model input, the difficulty of obtaining key data elements in a repeatable manner, and a lack of standardization in model assumptions and structure. In these slides, we show examples of how we have built tools, standards, and processes that help to address these challenges.

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Sustainment, readiness, resource-to-readiness, OPUS, SIMLOX, Systecon

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