INSTITUTE FOR DEFENSE ANALYSES

Tools for Building End-to-End Readiness Models with OPUS/SIMLOX

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April 2020

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Executive Summary

Bottom-up emulations of real sustainment systems that explicitly model spares, personnel, operations, and maintenance are a powerful way to tie funding decisions to their impact on readiness, but they are not widely used. The simulations require extensive data to properly model the complex and variable processes involved in a sustainment system, and the raw data used to populate the simulation are often scattered across multiple organizations.

The Navy has encountered challenges in keeping the desired number of F/A-18 Super Hornets in mission-capable states. IDA was asked to build an end-to-end model of the Super Hornet sustainment system using the OPUS/SIMLOX suite of tools to investigate the strategic levers that drive readiness. IDA built an R package ("honeybee") that aggregates and interprets Navy sustainment data using statistical techniques to create component-level metrics. IDA built a second R package ("stinger") that uses these metrics to automatically generate the input tables necessary to run OPUS/SIMLOX; the effect of both of these packages is that IDA has lowered the barrier for entry into building these large end-to-end sustainment models. We present a summary of these tools and techniques to the OPUS user community in this briefing.

Tools for Building End-to-End Readiness Models with OPUS/SIMLOX

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April 16, 2020

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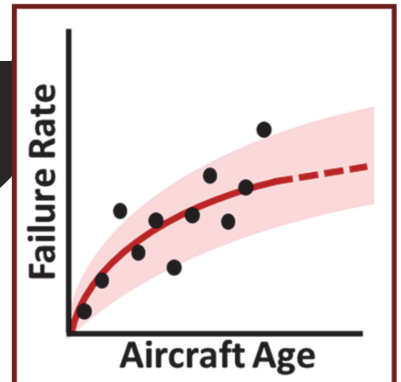
End-to-End Simulation/Forecasting Model

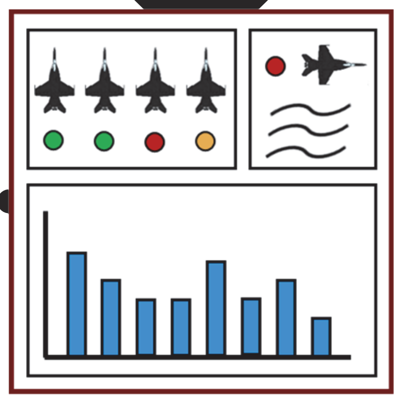
Bottom-up emulation of real sustainment system that explicitly models spares, manpower, operations, and maintenance to understand the impact of decisions on readiness

+ Tie $ spent to readiness outcomes

- Heavy lift to build initial model

Data-Driven Decisions





Correlative Studies

Identify factors that drive performance through statistical approaches like machine learning

+ Search historical data to reveal hidden trends that may potentially predict future performance

- Abstract equations do not tie results to actionable recommendations (e.g., specific spares purchases)

Data Visualization/Dashboards

Make statuses available to user community via dashboards

+ Provides accessible ground truth

- Does not connect decisions to outcomes

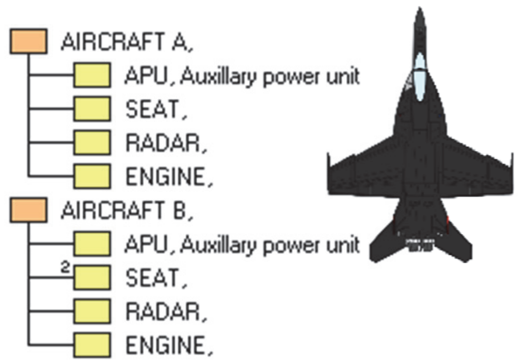
The number of mission-capable F/A-18 Super Hornets has remained relatively steady in the last few years, despite adding new aircraft to the fleet and increasing funding for readiness.

The goal of IDA's study is to build a readiness model to identify the major strategic levers that drive Super Hornet readiness.

All data in this presentation are notional and for demonstration purposes.

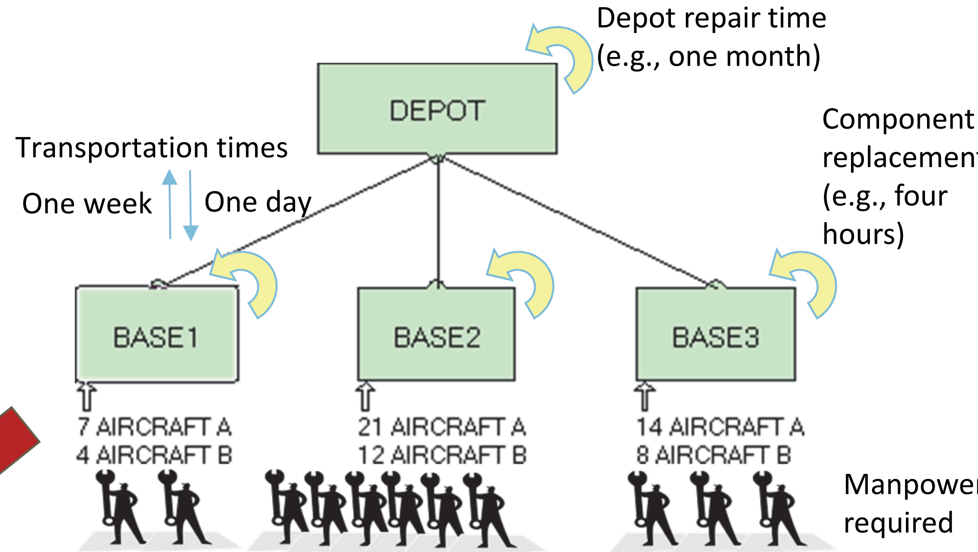
SIMLOX Requires Detailed Information from Different Sources

Technical system data:



Failure rates
Repair costs
Purchase costs
Common parts
Time to repair
Condemnation rates
Preventative maintenance
Dependencies on support equipment

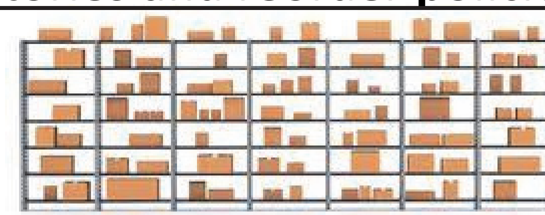
Sustainment and ops organization:



OPUS (sparing)

SIMLOX (MC vs. time)

Stock inventories and reorder policies

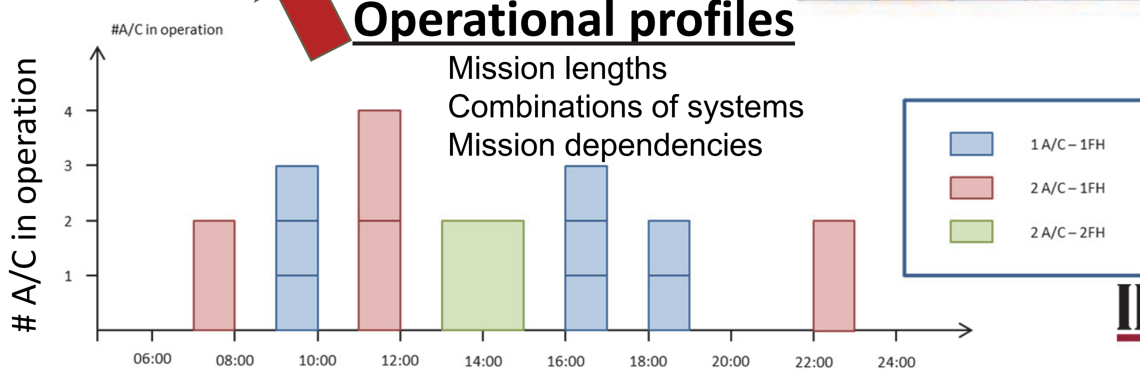


Fleet dynamics:

Modification/depot plans
New A/C delivery schedule
Transfers/trading
Deployments

Operational profiles

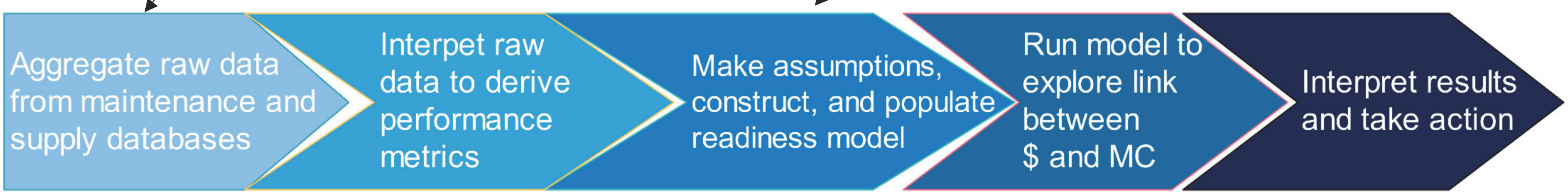
Mission lengths
Combinations of systems
Mission dependencies



How to connect raw data to readiness decision making

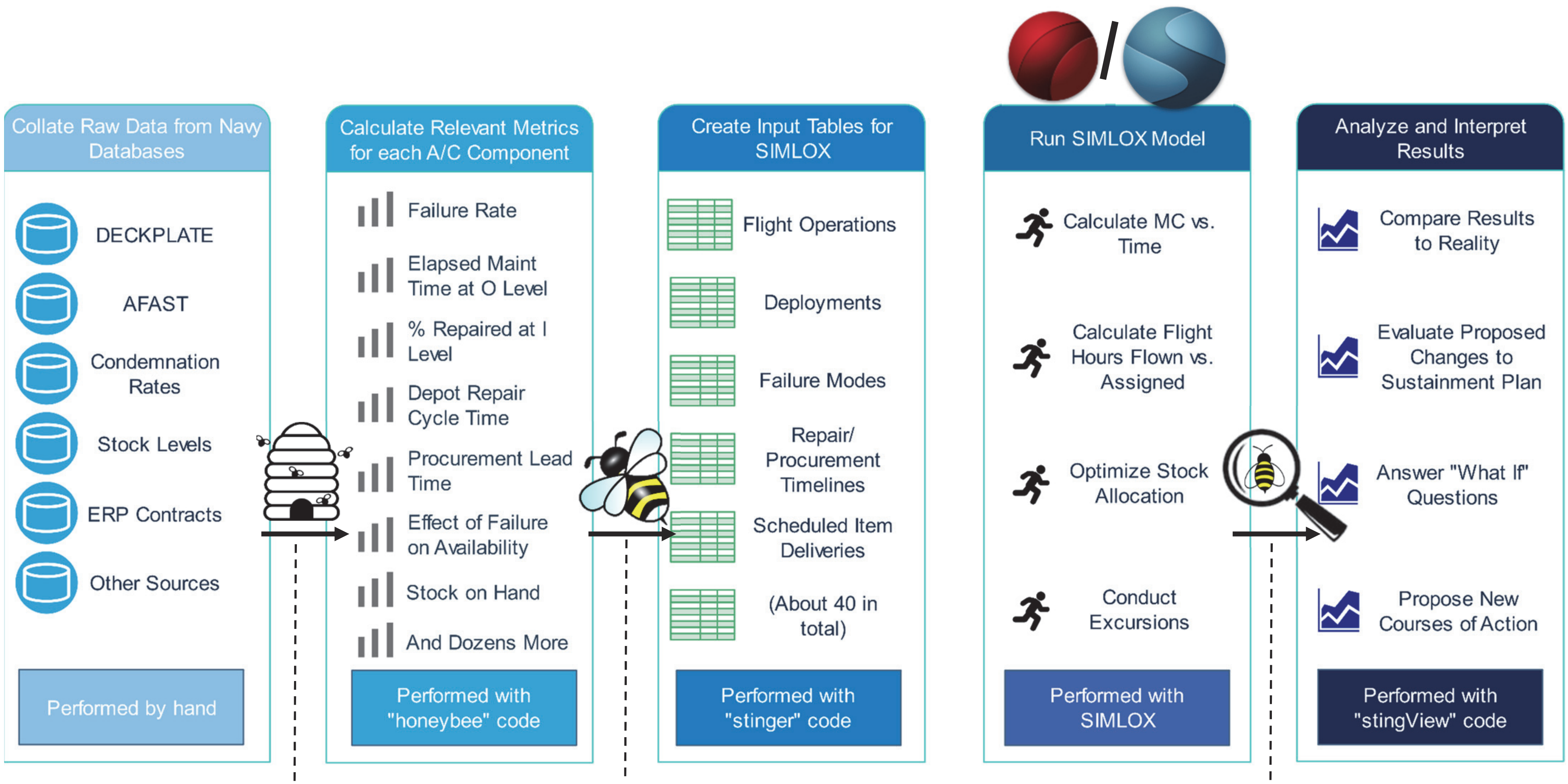
Stovepiped databases and institutional disconnects can make this time consuming

You have to understand in detail how the model will use the information you give it (“model-isms”)



Existing metrics should only be used if you understand the math/logic behind them, and ideally you should be able to check the raw data yourself

How to connect raw data to readiness decision making

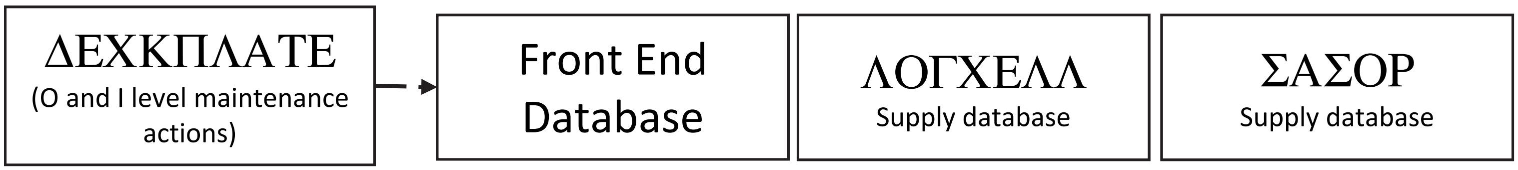


IDA's tool **honeybee** interprets raw data from Navy databases to create component-level metrics

IDA's tool **stinger** converts human-readable files into the verbose input required by SIMLOX, and automatically handles complicated operational profiles and deployments

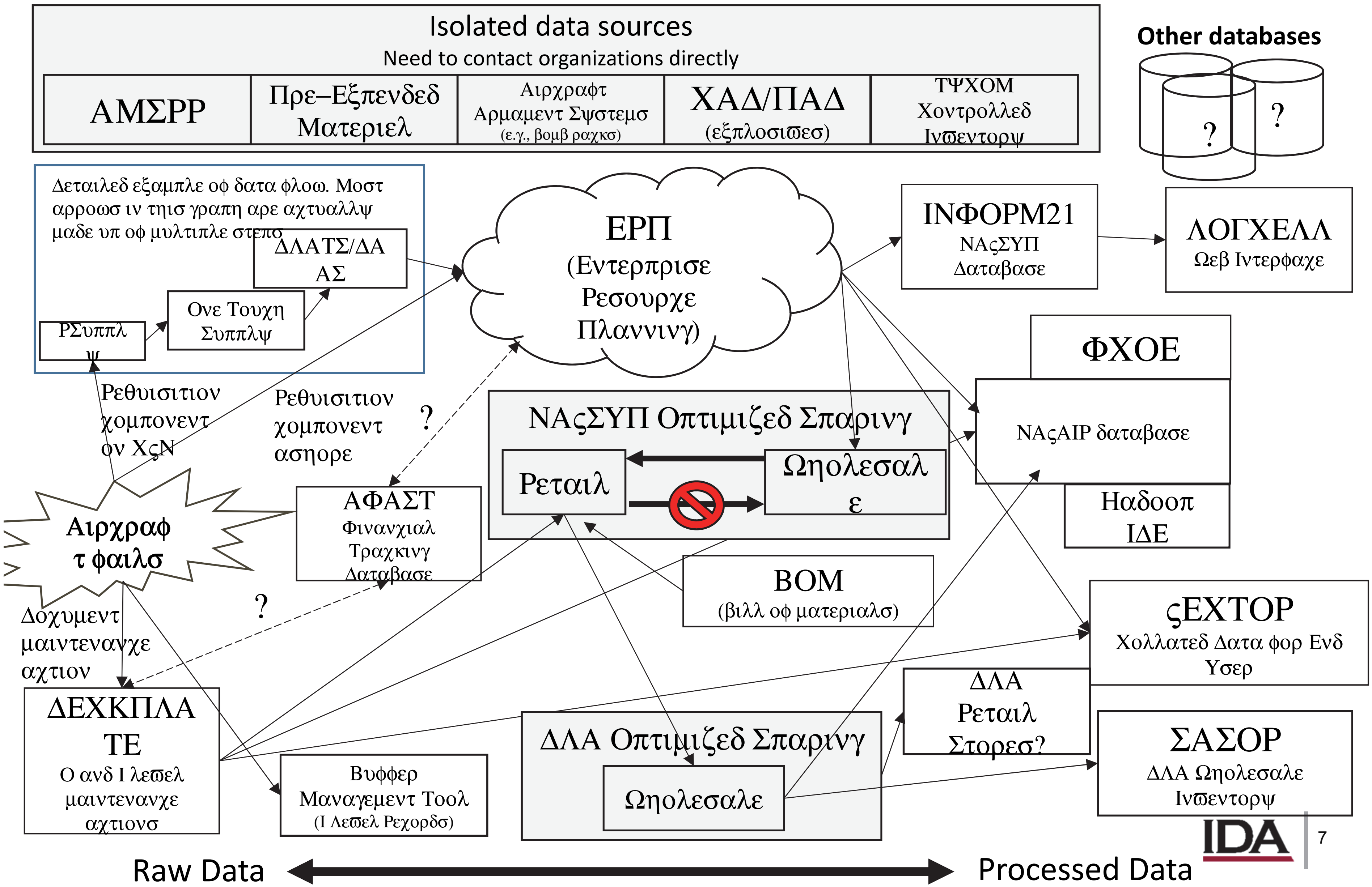
IDA's tool **stingView** helps visualize and analyze the results

Initial discussions with Navy implied that four major databases should provide all the parts and maintenance data needed to populate a SIMLOX model



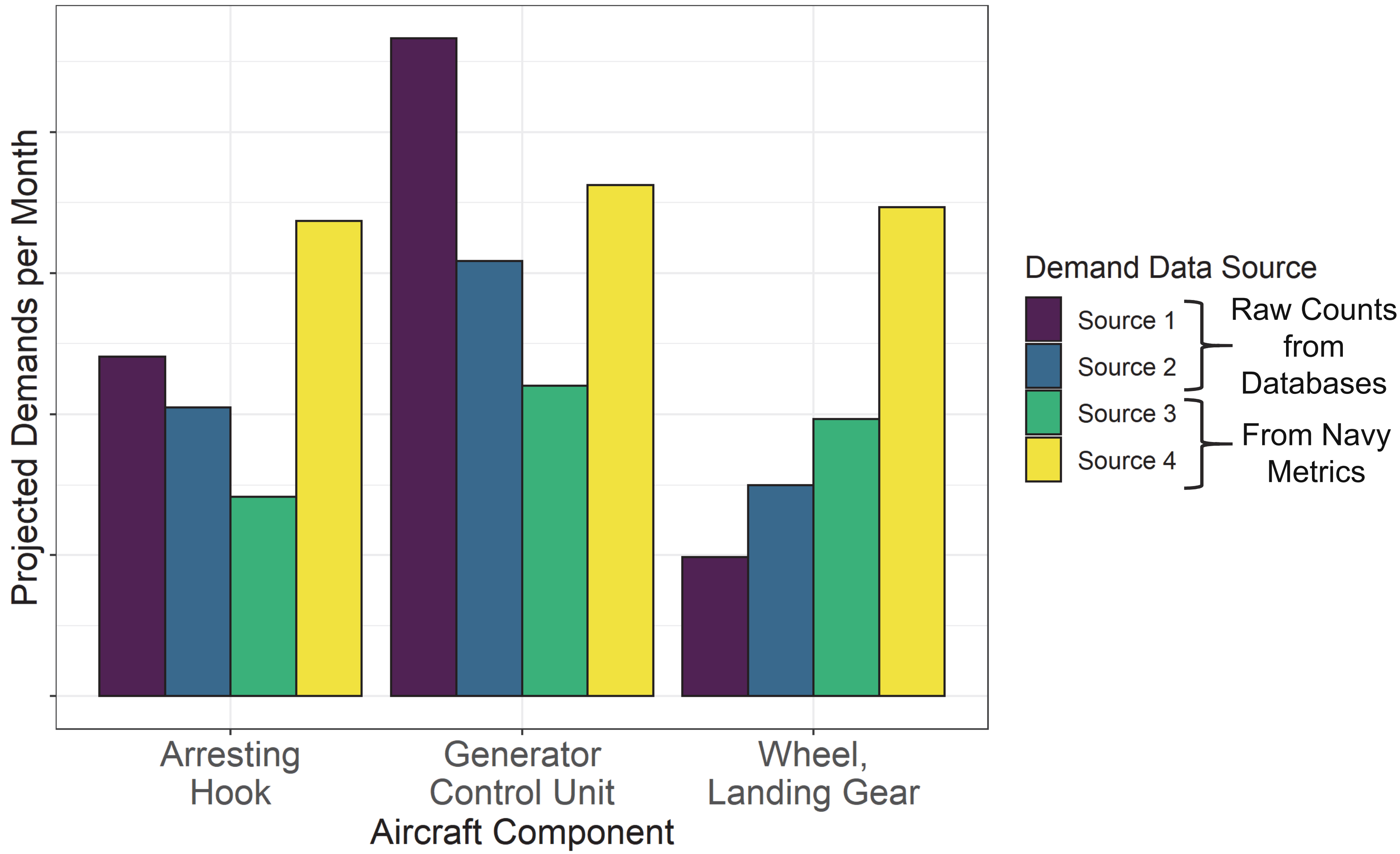
This is reality: many databases, with overlap and ambiguous data

Within the Naval Aviation Enterprise, managers get a view that is limited by the tool they are using

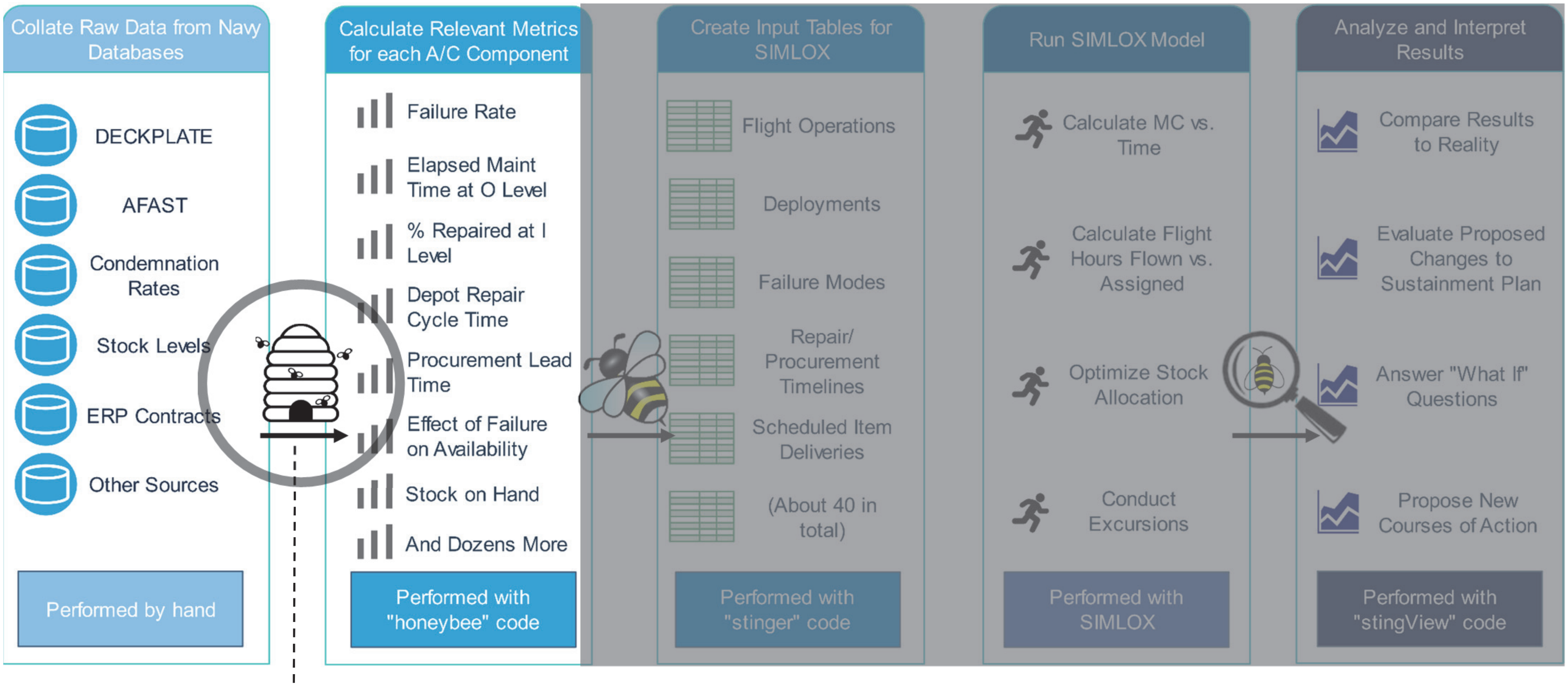


IDA

Different data sources and different rules for interpreting the data lead to divergent demand predictions



How to connect raw data to readiness decision making



IDA's tool **honeybee** interprets raw data from Navy databases to create component-level metrics

honeybee inputs

AFAST
uniqueName
COG
TEC
JCN
MCN
BUNO
JCN Date
ProjectCode
ActionOrg
Status
ExtendedPriceChar
Qty

DECKPLATE
uniqueName
TEC
JCN
MCN
BUNO
WUC5
EMT
WhenDiscovered
Manhours
ActionTakenCode
ReceivedDateTime
MaintenanceLevel
ReceivedEOC

BOM
uniqueName
TEC
Level 1 uniqueName
Level 2 uniqueName
Level 3 uniqueName
Level 4 uniqueName
Level 5 uniqueName
Level 6 uniqueName

Condemnation Rate
uniqueName
Condemnation Rate

Dictionary
uniqueName
NIIN
NIINHOF
COG
LRC
LRC First Letter

priceData
uniqueName
New Price
Repair Price

Wholesale Stock
uniqueName
Station
SOH

Station Mapping
realStation
simloxStation
stockClass

Commodity Curve
minWindow
maxWindow
repairProportion

Retail Stock
uniqueName
Station
SOH
Allocation

Contract Data
NIIN
PR Date
PO Date
Repair or Procurement
Delivery Date
Latest Delivery Date
Items Outstanding
Sched Delivery Date

AFAST
uniqueName
COG
TEC
JCN
MCN
BUNO
JCN Date
ProjectCode
ActionOrg
Status
ExtendedPriceChar
Qty

DECKPLATE
uniqueName
TEC
JCN
MCN
BUNO
WUC5
EMT
WhenDiscovered
Manhours
ActionTakenCode
ReceivedDateTime
MaintenanceLevel
ReceivedEOC

BOM*
uniqueName
TEC
Level 1 uniqueName
Level 2 uniqueName
Level 3 uniqueName
Level 4 uniqueName
Level 5 uniqueName
Level 6 uniqueName

priceData
uniqueName
New Price
Repair Price

Contract Data
NIIN
PR Date
PO Date
Repair or Procurement
Delivery Date
Latest Delivery Date
Items Outstanding
Sched Delivery Date

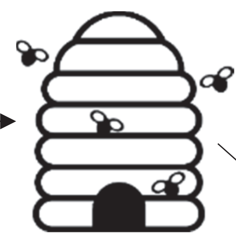
Condemnation Rate
uniqueName
Condemnation Rate

Station Mapping
realStation
simloxStation
stockClass

Commodity Curve
minWindow
maxWindow
repairProportion

Wholesale Stock
uniqueName
Station
SOH

Retail Stock
uniqueName
Station
SOH
Allocation



honeybee

TMS-agnostic analysis tool for Navy aircraft written in R

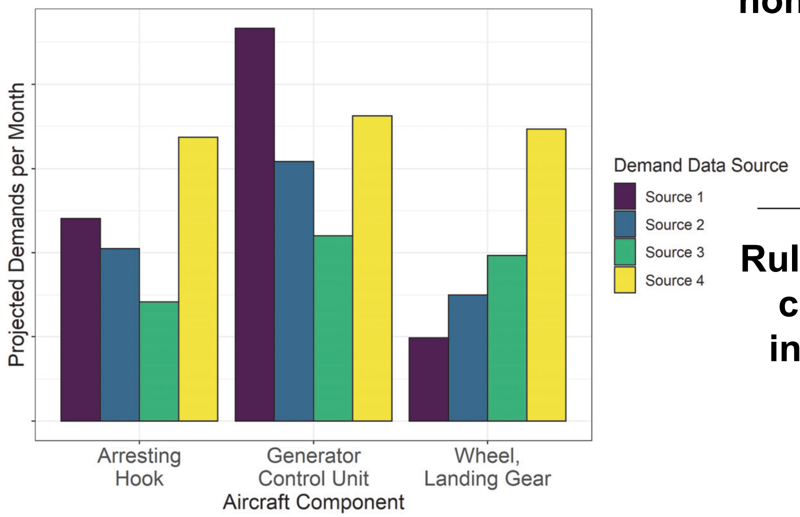
User-defined settings and filters
Date range
Aircraft types (honeybee is TMS-agnostic)
What counts as a failure?
Which requisition codes indicate NMCS?
Which Action Taken Codes indicate a repair?
What do we do about missing I level repair times?
Etc.

Calculate Relevant Metrics for each A/C Component

- Failure Rate
- Elapsed Maint Time at O Level
- % Repaired at I Level
- Depot Repair Cycle Time
- Procurement Lead Time
- Effect of Failure on Availability
- Stock on Hand
- And Dozens More

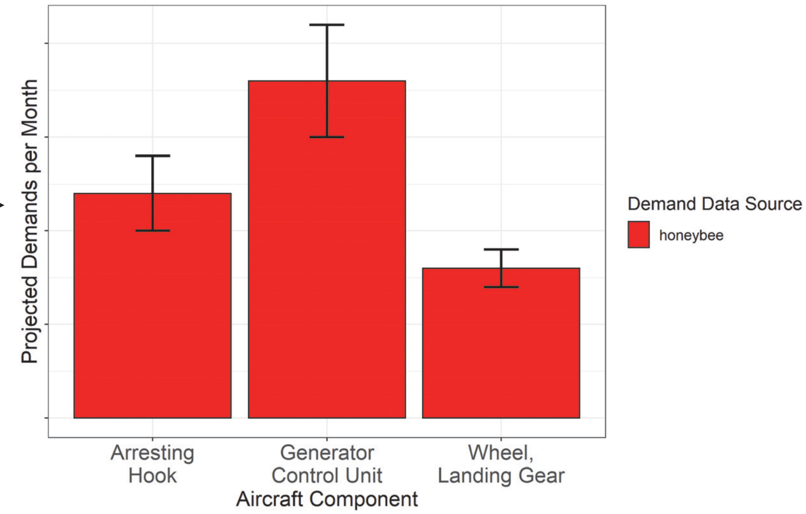
Performed with "honeybee" code

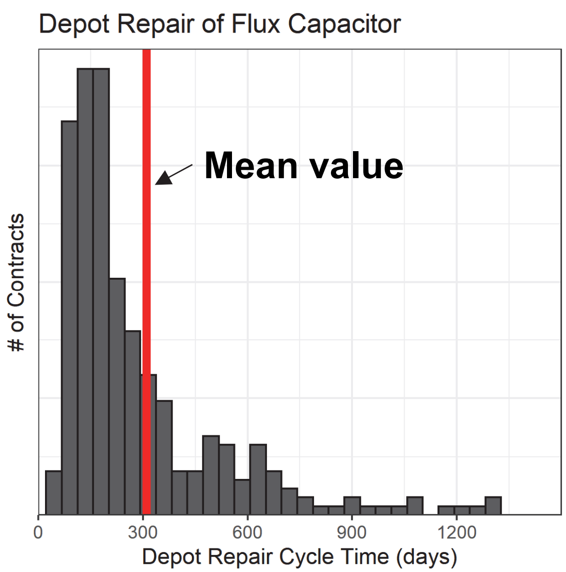
We need an adjudicated, trusted data source to overcome the balkanization of current databases



honeybee logic

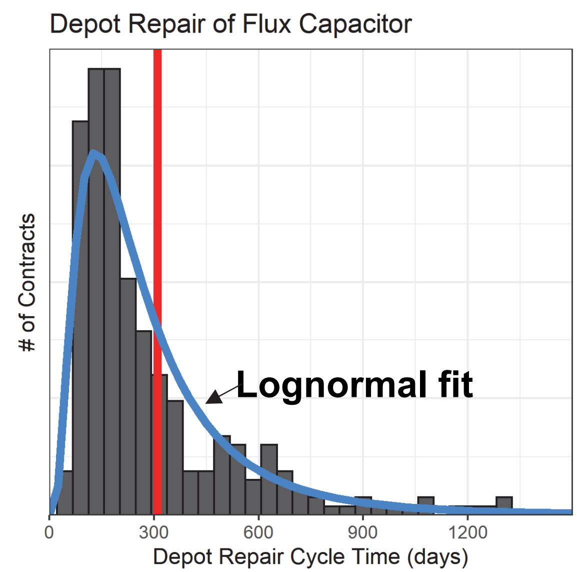
Rules built with community involvement



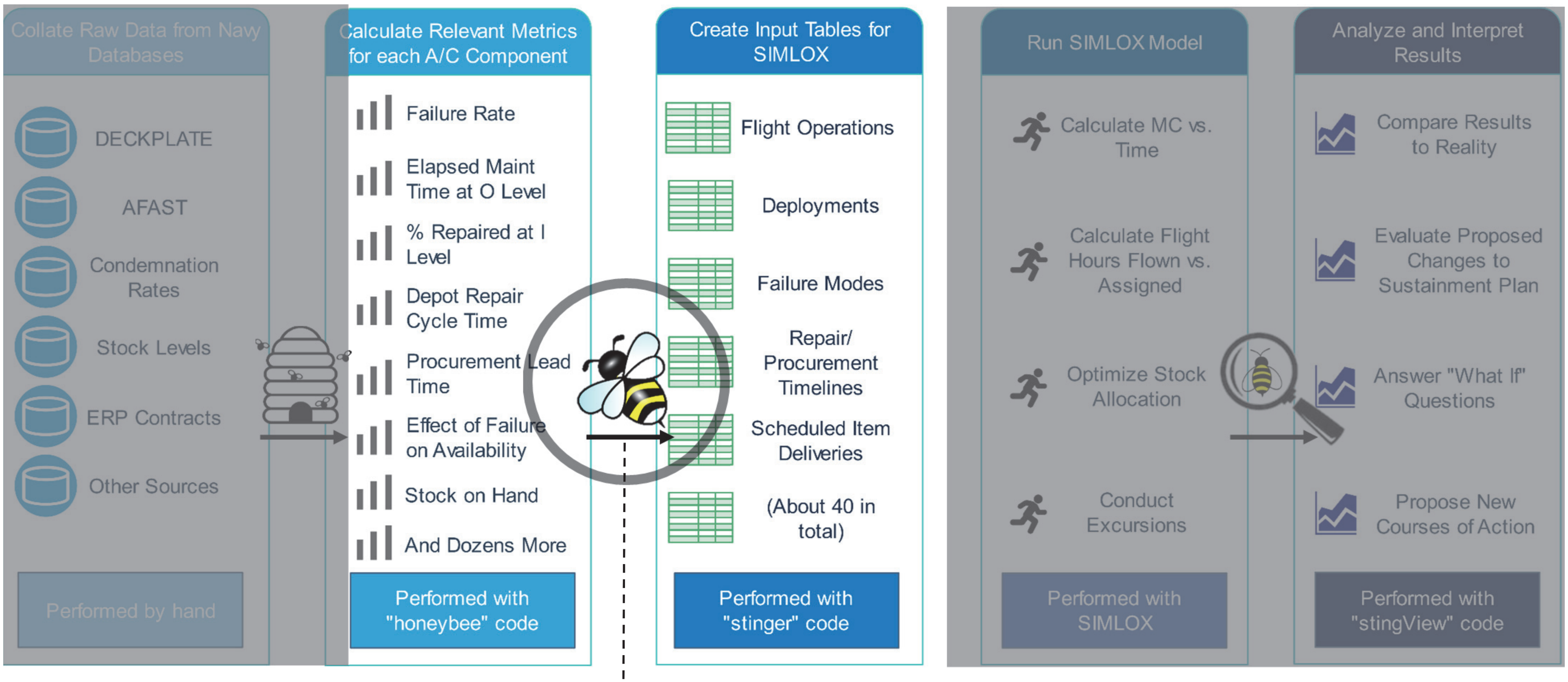


honeybee logic

Statistical best practices



How to connect raw data to readiness decision making



IDA's tool **stinger** converts human-readable files into the verbose input required by SIMLOX, and automatically handles complicated operational profiles and deployments

One file is used to populate many SIMLOX input tables

“Unit Data” stinger input file

	A	B	C	D	E	F	G	H
1	Unit Name	Land Base	CVW Name	System Type	Quantity	Land-Based Profile	Deployed Profile	Deployable
2	VAQ-130	NAS Whidbey	CVW-3	F18G	5	CVW-3 Land Profile - Growler	CVW-3 Deployed Profile	TRUE
3	VAQ-131	NAS Whidbey	CVW-8	F18G	5	CVW-8 Land Profile - Growler	CVW-8 Deployed Profile	TRUE
4	VAQ-133	NAS Whidbey	CVW-9	F18G	5	CVW-9 Land Profile - Growler	CVW-9 Deployed Profile	TRUE
5	VAQ-136	NAS Whidbey	CVW-2	F18G	5	CVW-2 Land Profile - Growler	CVW-2 Deployed Profile	TRUE
6	VAQ-137	NAS Whidbey	CVW-1	F18G	5	CVW-1 Land Profile - Growler	CVW-1 Deployed Profile	TRUE
7	VAQ-139	NAS Whidbey	CVW-17	F18G	5	CVW-17 Land Profile - Growler	CVW-17 Deployed Profile	TRUE
8	VAQ-140	NAS Whidbey	CVW-7	F18G	5	CVW-7 Land Profile - Growler	CVW-7 Deployed Profile	TRUE
9	VAQ-141	Iwakuni	CVW-5	F18G	5	CVW-5 Land Profile - Growler	CVW-5 Deployed Profile	TRUE
10	VAQ-142	NAS Whidbey	CVW-11	F18G	5	CVW-11 Land Profile - Growler	CVW-11 Deployed Profile	TRUE
11	XVAQ-1	NAS Whidbey	XVAQ-1	F18G	5	XVAQ-1 Land Profile	None	FALSE
12	XVAQ-2	NAS Whidbey	XVAQ-2	F18G	5	XVAQ-2 Land Profile	None	FALSE
13	XVAQ-3	NAS Whidbey	XVAQ-3	F18G	5	XVAQ-3 Land Profile	None	FALSE
14	XVAQ-4	NAS Whidbey	XVAQ-4	F18G	5	XVAQ-4 Land Profile	None	FALSE
15	XVAQ-5	NAS Whidbey	XVAQ-5	F18G	5	XVAQ-5 Land Profile	None	FALSE
16	FRS-West-G	FRS West	FRS-West	F18G	86	FRS Land Profile - Growler	None	FALSE
17	VFA-2	NAS Lemoore	CVW-2	F18F	12	CVW-2 Land Profile - Rhino	CVW-2 Deployed Profile	TRUE
18	VFA-11	NAS Oceana	CVW-1	F18F	12	CVW-1 Land Profile - Rhino	CVW-1 Deployed Profile	TRUE
19	VFA-14	NAS Lemoore	CVW-9	F18E	12	CVW-9 Land Profile - Rhino	CVW-9 Deployed Profile	TRUE
20	VFA-22	NAS Lemoore	CVW-17	F18F	12	CVW-17 Land Profile - Rhino	CVW-17 Deployed Profile	TRUE
21	VFA-25	NAS Lemoore	CVW-7	F18E	10	CVW-7 Land Profile - Rhino	CVW-7 Deployed Profile	TRUE
22	VFA-27	Iwakuni	CVW-5	F18E	12	CVW-5 Land Profile - Rhino	CVW-5 Deployed Profile	TRUE
23	VFA-31	NAS Oceana	CVW-11	F18E	12	CVW-11 Land Profile - Rhino	CVW-11 Deployed Profile	TRUE
24	VFA-32	NAS Oceana	CVW-3	F18F	12	CVW-3 Land Profile - Rhino	CVW-3 Deployed Profile	TRUE
25	VFA-34	NAS Oceana	CVW-17	F18E	10	CVW-17 Land Profile - Rhino	CVW-17 Deployed Profile	TRUE
26	VFA-37	NAS Oceana	CVW-8	F18E	12	CVW-8 Land Profile - Rhino	CVW-8 Deployed Profile	TRUE
27	VFA-41	NAS Lemoore	CVW-9	F18F	12	CVW-9 Land Profile - Rhino	CVW-9 Deployed Profile	TRUE
28	VFA-81	NAS Oceana	CVW-1	F18E	10	CVW-1 Land Profile - Rhino	CVW-1 Deployed Profile	TRUE
29	VFA-83	NAS Oceana	CVW-7	F18E	10	CVW-7 Land Profile - Rhino	CVW-7 Deployed Profile	TRUE
30	VFA-86	NAS Lemoore	CVW-3	F18E	10	CVW-3 Land Profile - Rhino	CVW-3 Deployed Profile	TRUE
31	VFA-87	NAS Oceana	CVW-8	F18E	10	CVW-8 Land Profile - Rhino	CVW-8 Deployed Profile	TRUE
32	VFA-94	NAS Lemoore	CVW-17	F18F	10	CVW-17 Land Profile - Rhino	CVW-17 Deployed Profile	TRUE
33	VFA-97	NAS Lemoore	CVW-9	F18E	10	CVW-9 Land Profile - Rhino	CVW-9 Deployed Profile	TRUE
34	VFA-102	Iwakuni	CVW-5	F18F	12	CVW-5 Land Profile - Rhino	CVW-5 Deployed Profile	TRUE
35	VFA-103	NAS Oceana	CVW-7	F18F	12	CVW-7 Land Profile - Rhino	CVW-7 Deployed Profile	TRUE
36	VFA-105	NAS Oceana	CVW-3	F18E	12	CVW-3 Land Profile - Rhino	CVW-3 Deployed Profile	TRUE
37	VFA-113	NAS Lemoore	CVW-17	F18E	12	CVW-17 Land Profile - Rhino	CVW-17 Deployed Profile	TRUE
38	VFA-115	Iwakuni	CVW-5	F18E	10	CVW-5 Land Profile - Rhino	CVW-5 Deployed Profile	TRUE
39	VFA-131	NAS Oceana	CVW-3	F18E	10	CVW-3 Land Profile - Rhino	CVW-3 Deployed Profile	TRUE
40	VFA-136	NAS Lemoore	CVW-1	F18E	10	CVW-1 Land Profile - Rhino	CVW-1 Deployed Profile	TRUE
41	VFA-137	NAS Lemoore	CVW-2	F18E	12	CVW-2 Land Profile - Rhino	CVW-2 Deployed Profile	TRUE
42	VFA-143	NAS Oceana	CVW-7	F18E	12	CVW-7 Land Profile - Rhino	CVW-7 Deployed Profile	TRUE
43	VFA-146	NAS Lemoore	CVW-11	F18E	10	CVW-11 Land Profile - Rhino	CVW-11 Deployed Profile	TRUE
44	VFA-151	NAS Lemoore	CVW-9	F18E	10	CVW-9 Land Profile - Rhino	CVW-9 Deployed Profile	TRUE
45	VFA-154	NAS Lemoore	CVW-11	F18F	12	CVW-11 Land Profile - Rhino	CVW-11 Deployed Profile	TRUE
46	VFA-192	NAS Lemoore	CVW-2	F18E	10	CVW-2 Land Profile - Rhino	CVW-2 Deployed Profile	TRUE
47	VFA-195	Iwakuni	CVW-5	F18E	10	CVW-5 Land Profile - Rhino	CVW-5 Deployed Profile	TRUE
48	VFA-211	NAS Oceana	CVW-1	F18F	12	CVW-1 Land Profile - Rhino	CVW-1 Deployed Profile	TRUE
49	VFA-213	NAS Oceana	CVW-8	F18F	12	CVW-8 Land Profile - Rhino	CVW-8 Deployed Profile	TRUE
50	FRS-East	FRS East	FRS East	F18E	11	FRS Land Profile - Rhino	None	FALSE
51	FRS-East	FRS East	FRS East	F18F	5	FRS Land Profile - Rhino	None	FALSE
52	FRS-West	FRS West	FRS West	F18E	12	FRS Land Profile - Rhino	None	FALSE
53	FRS-West	FRS West	FRS West	F18F	5	FRS Land Profile - Rhino	None	FALSE
54	TOP GUN	TOPGUN	TOP GUN	F18E	4	TG Land Profile	None	FALSE
55	TOP GUN	TOPGUN	TOP GUN	F18F	2	TG Land Profile	None	FALSE
56	VX-E	TEST COM	VX-E	F18E	17	TC Land Profile	None	FALSE
57	VX-F	TEST COM	VX-F	F18F	8	TC Land Profile	None	FALSE
58								

Here we define each squadron with its composition, location, profiles, etc.

5-24-2019 All Items, All Failure Modes_GeoMapLayer <SystemDeployment>

	SID	USTID	QTYPS	UTIL	PRIOF	PLID	NOTE
	System identifie	Unit or	Quantity	Utilization	Priority	Prelife	User
1	F18G						
2	F18G						
3	F18G						
4	F18G						
5	F18G						
6	F18G						
7	F18E						
8	F18F						
9	F18E						
10	F18F						
11	F18E						
12	F18F						
13	F18E						
14	F18F						
15	F18E						
16	F18E						
17	F18F						
18	F18G						
19	F18F						
20	F18E						
21	F18F						
22	F18E						
23	F18G						
24	F18F						
25	F18E						
26	F18E						
27	F18G						
28	F18F						
29	F18E						
30	F18E						
31	F18E						
32	F18G						
33	F18E						
34	F18E						
35	F18F						
36	F18E						
37	F18G						
38	F18E						
39	F18E						
40	F18F						
41	F18G						
42	F18G						

5-24-2019 All Items, All Failure Modes_GeoMapLayer <Unit>

	UNID	DESCR	STID	MAXPM	MAXPMP	NOTE
	Unit identifier					ser ote
1	VAQ-130					
2	VAQ-131					
3	VAQ-133					
4	VAQ-136					
5	VAQ-137					
6	VAQ-139					
7	VAQ-140					
8	VAQ-141					
9	VAQ-142					
10	XVAQ-1					
11	XVAQ-2					
12	XVAQ-3					
13	XVAQ-4					
14	XVAQ-5					
15	FRS-WEST					
16	VFA-2					
17	VFA-11					
18	VFA-14					
19	VFA-22					
20	VFA-25					
21	VFA-27					
22	VFA-31					
23	VFA-32					
24	VFA-34					
25	VFA-37					
26	VFA-41					
27	VFA-81					
28	VFA-83					
29	VFA-86					
30	VFA-87					
31	VFA-94					
32	VFA-97					
33	VFA-102					
34	VFA-103					
35	VFA-105					
36	VFA-113					
37	VFA-115					
38	VFA-131					
39	VFA-136					
40	VFA-137					
41	VFA-143					
42	VFA-146					
43	VFA-151					
44	VFA-154					

5-24-2019 All Items, All Failure Modes_GeoMapLayer <UnitGroupMember>

	UGID	USTID	PRI	XTIME	NOTE
	Unit group identifier	Unit or station identifier	Priority	Additional mission out and	User Note
1	CVW-3				
2	CVW-8				
3	CVW-9				
4	CVW-2				
5	CVW-1				
6	CVW-17				
7	CVW-7				
8	CVW-5				
9	CVW-11				
10	CVW-2				
11	CVW-1				
12	CVW-9				
13	CVW-17				
14	CVW-7				
15	CVW-5				
16	CVW-11				
17	CVW-3				
18	CVW-17				
19	CVW-8				
20	CVW-9				
21	CVW-1				
22	CVW-7				
23	CVW-3				
24	CVW-8				
25	CVW-17				
26	CVW-9				
27	CVW-5				
28	CVW-7				
29	CVW-3				
30	CVW-17				
31	CVW-5				
32	CVW-3				
33	CVW-1				
34	CVW-2				
35	CVW-7				
36	CVW-11				
37	CVW-9				
38	CVW-11				
39	CVW-2				
40	CVW-5				
41	CVW-1				
42	CVW-8				

5-24-2019 All Items, All Failure Modes_GeoMapLayer <Operations>

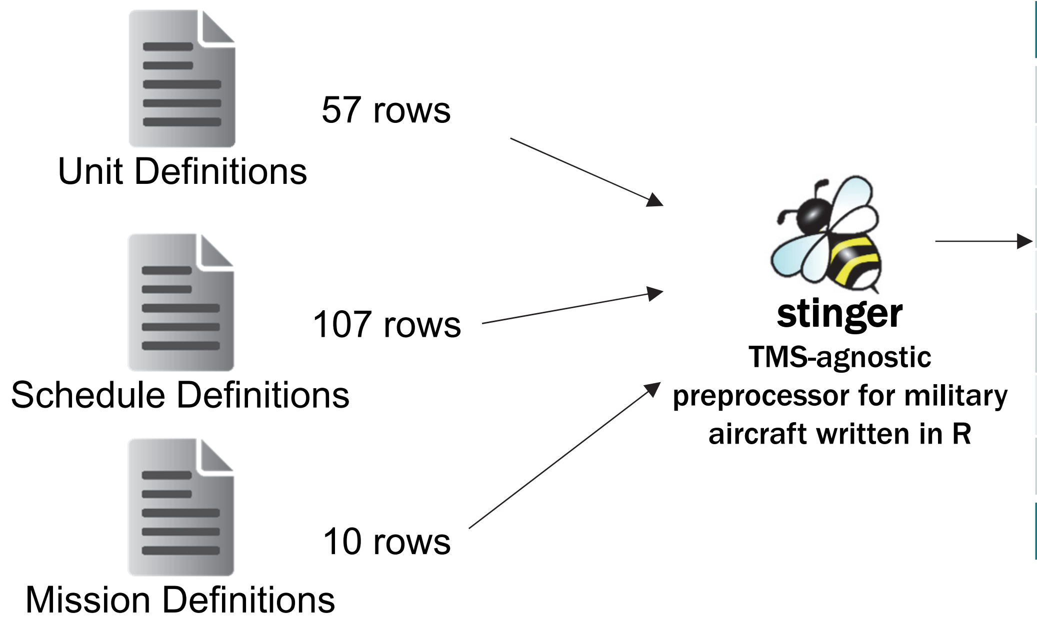
	USTID	PRID	NOTE
	Unit or station identifier	Profile identifier	User Note
1	VAQ-130	CVW-3 LAND PROFILE - GROWLER	
2	VAQ-131	CVW-8 LAND PROFILE - GROWLER	
3	VAQ-133	CVW-9 LAND PROFILE - GROWLER	
4	VAQ-136	CVW-2 LAND PROFILE - GROWLER	
5	VAQ-137	CVW-1 LAND PROFILE - GROWLER	
6	VAQ-139	CVW-17 LAND PROFILE - GROWLER	
7	VAQ-140	CVW-7 LAND PROFILE - GROWLER	
8	VAQ-141	CVW-5 LAND PROFILE - GROWLER	
9	VAQ-142	CVW-11 LAND PROFILE - GROWLER	
10	XVAQ-1	XVAQ-1 LAND PROFILE	
11	XVAQ-2	XVAQ-2 LAND PROFILE	
12	XVAQ-3	XVAQ-3 LAND PROFILE	
13	XVAQ-4	XVAQ-4 LAND PROFILE	
14	XVAQ-5	XVAQ-5 LAND PROFILE	
15	FRS-WEST-G	FRS LAND PROFILE - GROWLER	
16	VFA-2	CVW-2 LAND PROFILE - RHINO	
17	VFA-11	CVW-1 LAND PROFILE - RHINO	
18	VFA-14	CVW-9 LAND PROFILE - RHINO	
19	VFA-22	CVW-17 LAND PROFILE - RHINO	
20	VFA-25	CVW-7 LAND PROFILE - RHINO	
21	VFA-27	CVW-5 LAND PROFILE - RHINO	
22	VFA-31	CVW-11 LAND PROFILE - RHINO	
23	VFA-32	CVW-3 LAND PROFILE - RHINO	
24	VFA-34	CVW-17 LAND PROFILE - RHINO	
25	VFA-37	CVW-8 LAND PROFILE - RHINO	
26	VFA-41	CVW-9 LAND PROFILE - RHINO	
27	VFA-81	CVW-1 LAND PROFILE - RHINO	
28	VFA-83	CVW-7 LAND PROFILE - RHINO	
29	VFA-86	CVW-3 LAND PROFILE - RHINO	
30	VFA-87	CVW-8 LAND PROFILE - RHINO	
31	VFA-94	CVW-17 LAND PROFILE - RHINO	
32	VFA-97	CVW-9 LAND PROFILE - RHINO	
33	VFA-102	CVW-5 LAND PROFILE - RHINO	
34	VFA-103	CVW-7 LAND PROFILE - RHINO	
35	VFA-105	CVW-3 LAND PROFILE - RHINO	
36	VFA-113	CVW-17 LAND PROFILE - RHINO	
37	VFA-115	CVW-5 LAND PROFILE - RHINO	
38	VFA-131	CVW-3 LAND PROFILE - RHINO	
39	VFA-136	CVW-1 LAND PROFILE - RHINO	
40	VFA-137	CVW-2 LAND PROFILE - RHINO	
41	VFA-143	CVW-7 LAND PROFILE - RHINO	
42	VFA-146	CVW-11 LAND PROFILE - RHINO	
43	VFA-151	CVW-9 LAND PROFILE - RHINO	
44	VFA-154	CVW-11 LAND PROFILE - RHINO	
45	VFA-192	CVW-2 LAND PROFILE - RHINO	

stinger outputs – 40 OPUS/SIMLOX tables

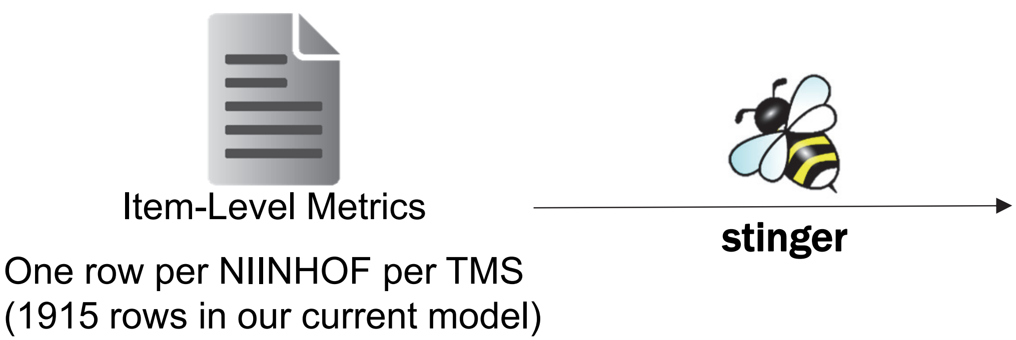
OPUS/SIMLOX Table Name		
Control	OperationProfile	Station
ControlParameters	Operations	StationStructure
CMLocation	PMActivation	StockAllocation
CMReplacement	PMFailureMode	StockExist
FailureMode	PMLocation	SystemDeployment
Item	PMReplacement	SystemTransfer
ItemReorder	Prelife	System
ItemRepair	PrelifeData	TaskResource
ItemTransfer	PrelifeDataAge	Tasks
Lateral Support	Problem Description	TimeDistributions
MaterielPM	Resource	TransportPolicyProfile
MaterielPosition	ResourceAllocation	Unit
MaterielStructure	ResourceStation	
MissionType	ResourceTransfer	

stinger creates all of the tables our model requires

stinger simplifies creating a complex model



SIMLOX Table	# of rows
MissionType	10
OperationProfile	50,049
Operations	97
System	3
SystemDeployment	100
SystemTransfer	1,461
Unit	96
Total	**51,813**

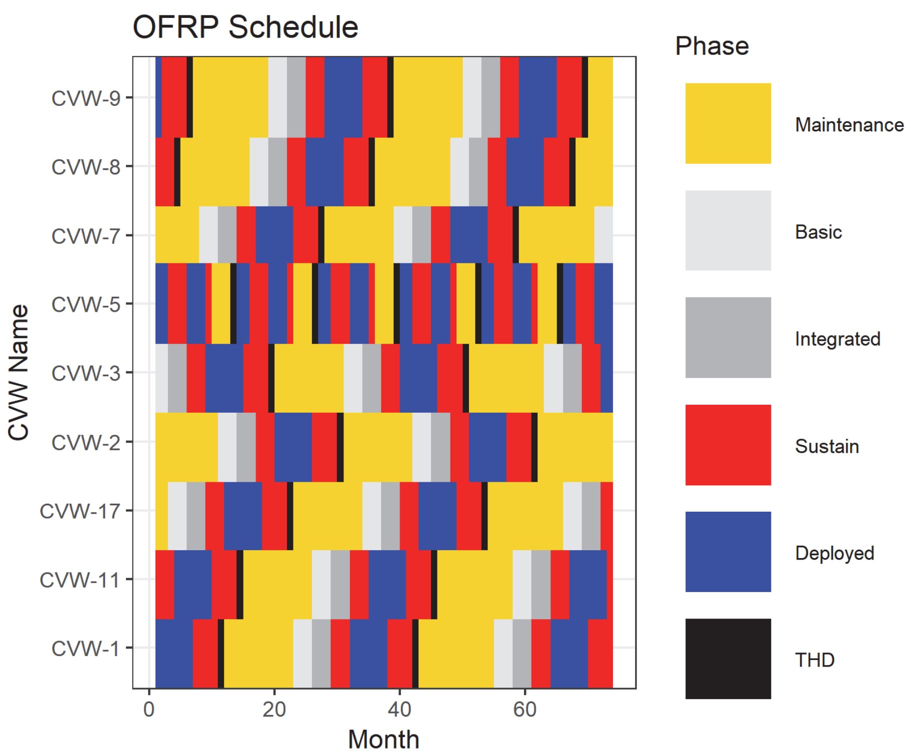


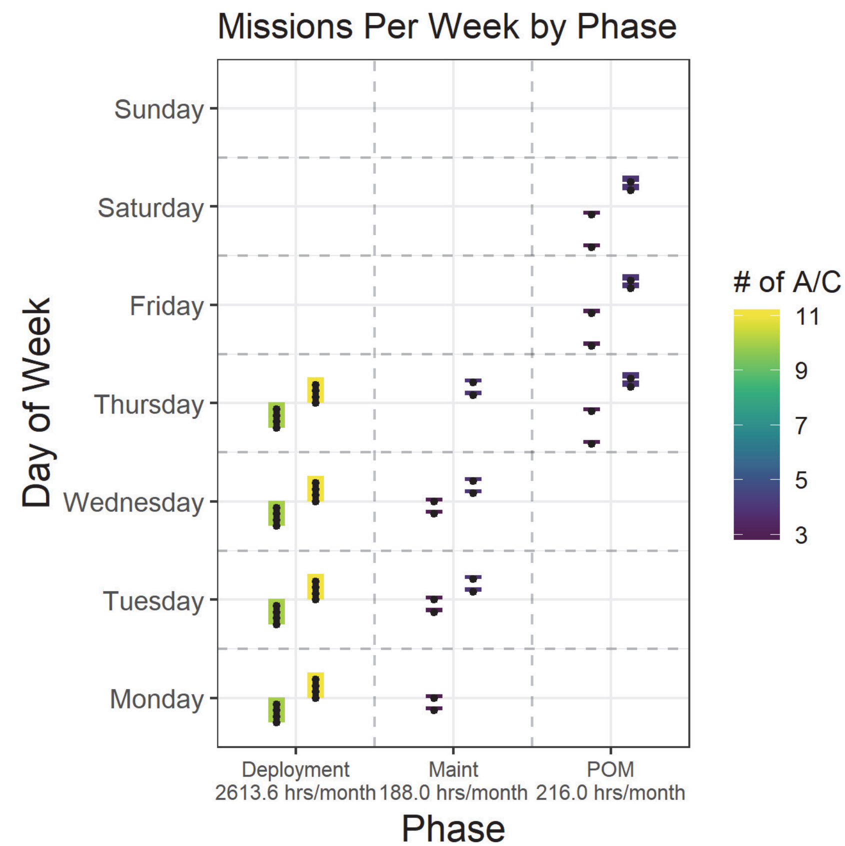
SIMLOX Table	# of rows
CMLocation	9,198
CMReplacement	3,945
FailureMode	4,897
Item	771
ItemReorder	771
ItemRepair	771
MaterielPosition	1,914
MaterielStructure	3,828
TimeDistributions	1,389
Total	**27,484**

stinger lowers the barrier to entry to build complex readiness models in SIMLOX

IDA's Super Hornet model includes a detailed representation of real-world fleet operations

- F-18 model implements variable hours to reflect land/sea operations
  - Improves spares projections and captures "real world" cueing problems
  - Models 2+2 deployment schedule



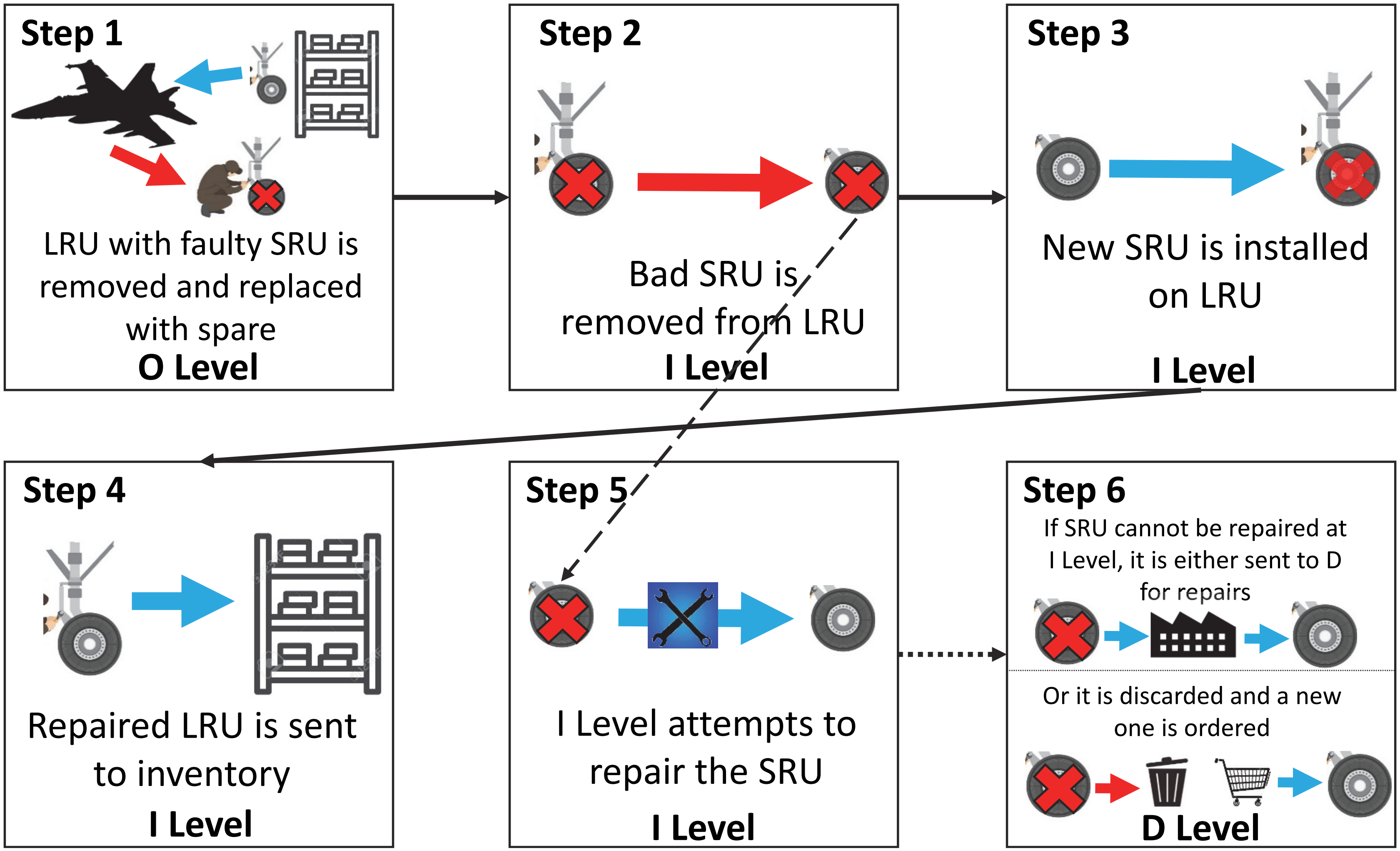


These profiles can easily be adjusted for excursions (e.g., wartime operations)

Deployed units have differences that matter for a sustainment model

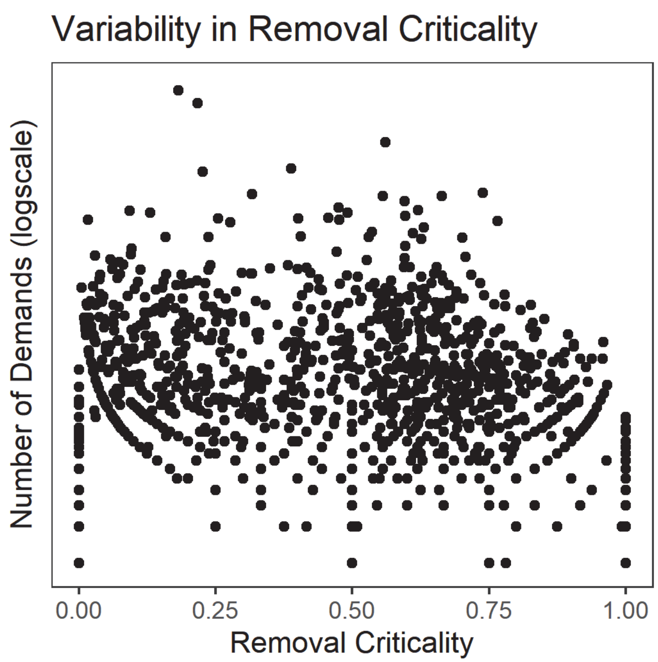
Aspect of deployment	Feature Status
Deployed squadrons have a different item transport profile	Implemented
Squadrons draw from different spares pool when deployed	Implemented
Squadrons *always* begin deployed period with all aircraft operational	Implemented
Squadrons deployed together can “cover” for each other on missions	In Progress
Repair facilities at deployed locations have different capabilities	Planned
Failure rates are different on deployment	Planned

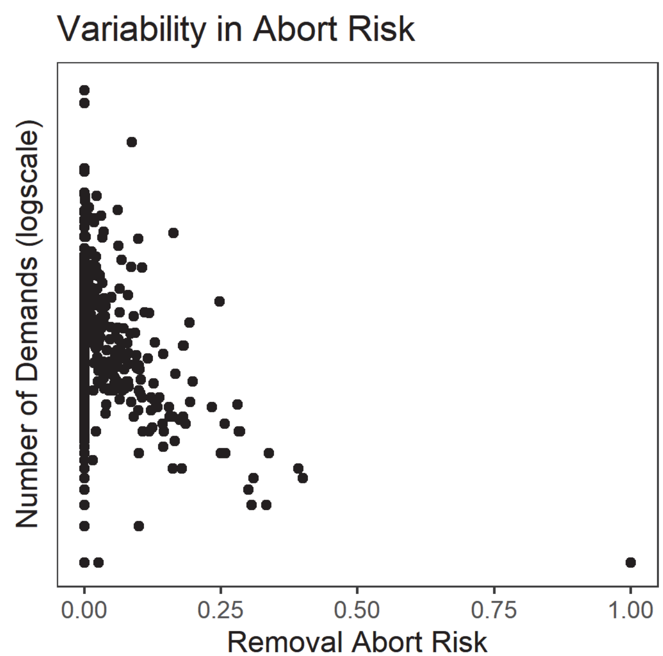
IDA's model closely mimics the Navy's O-I-D sustainment concept



The failure rates and repair times are calculated using Navy data

Not all failures are created equal





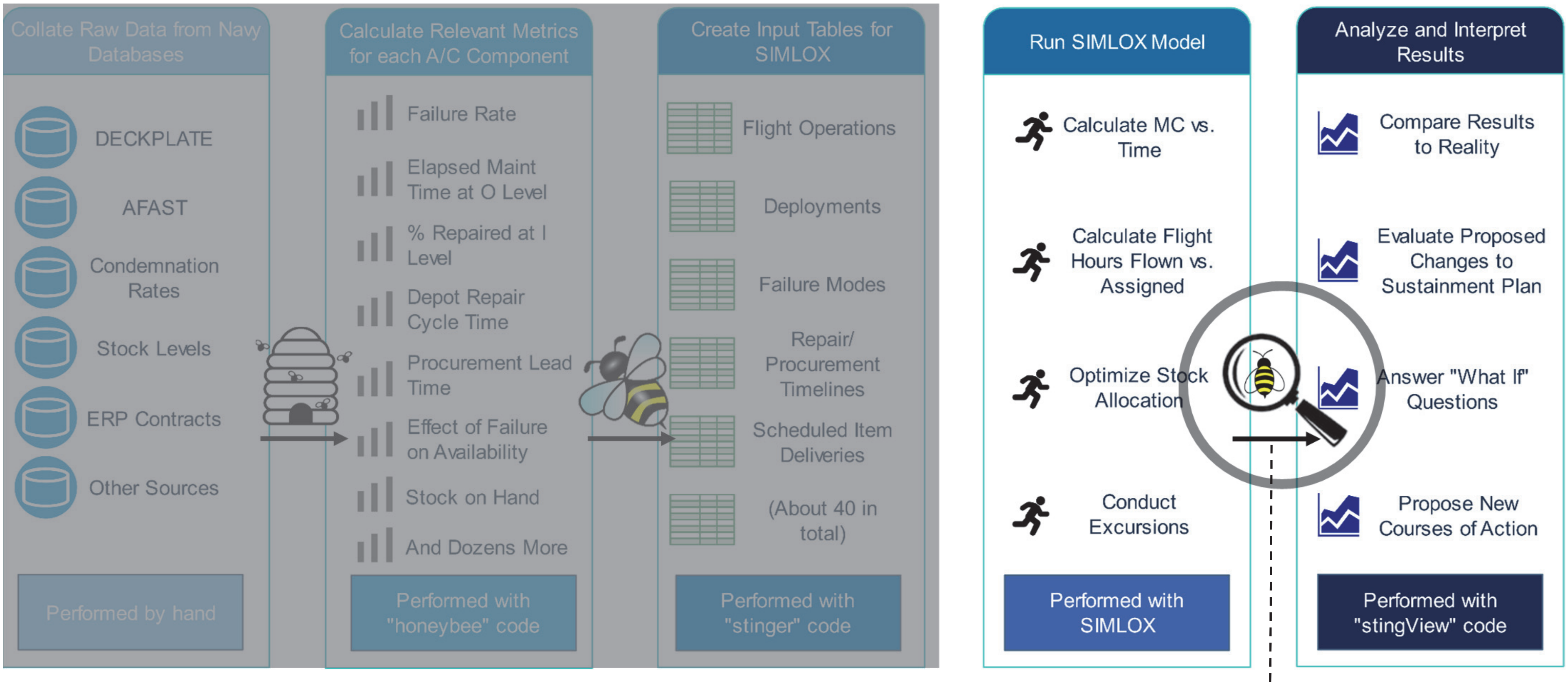
The effect of a given item's failure on readiness is not binary

Few items consistently cause mission aborts upon failure

We use up to 6 failure modes per item to capture the different possible outcomes of a failure, as well as modeling aircraft-level failures separately

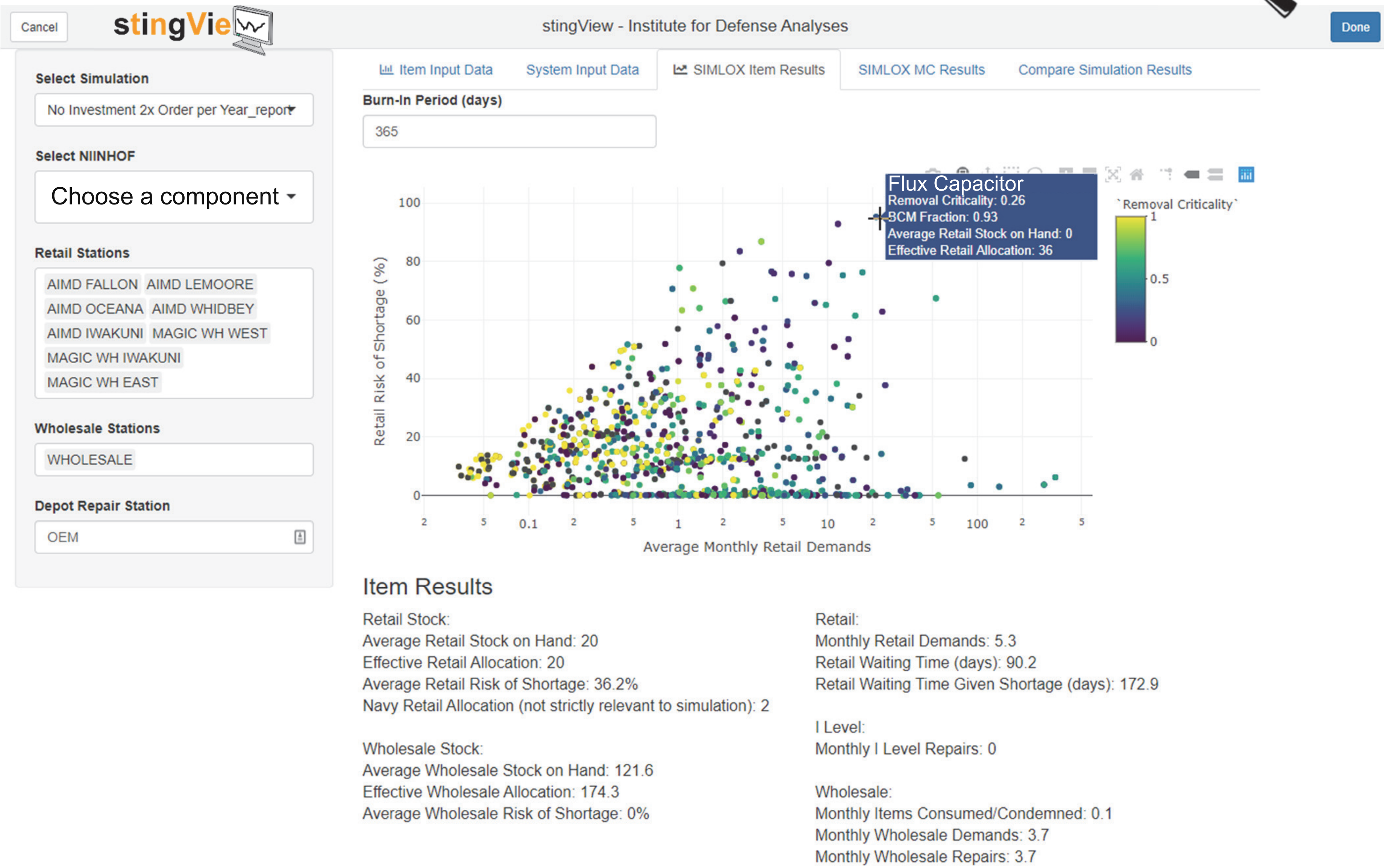
Critical	Critical Touch Event (on-aircraft maintenance, no spares required)	Critical Failure Repair at I Level (allows for SRU replacement at I Level)	Critical Failure Repair at D Level (no SRU replacement anywhere)	Critical System CM (maintenance on the airframe/parts we aren't modeling)
Non-Critical	Non-Critical Touch Event (on-aircraft maintenance, no spares required)	Non-Critical Failure Repair at I Level (allows for SRU replacement at I Level)	Non-Critical Failure Repair at D Level (no SRU replacement anywhere)	Non-Critical System CM (maintenance on the airframe/parts we aren't modeling)
	Item-level failure modes			Aircraft-level failure modes

How to connect raw data to readiness decision making

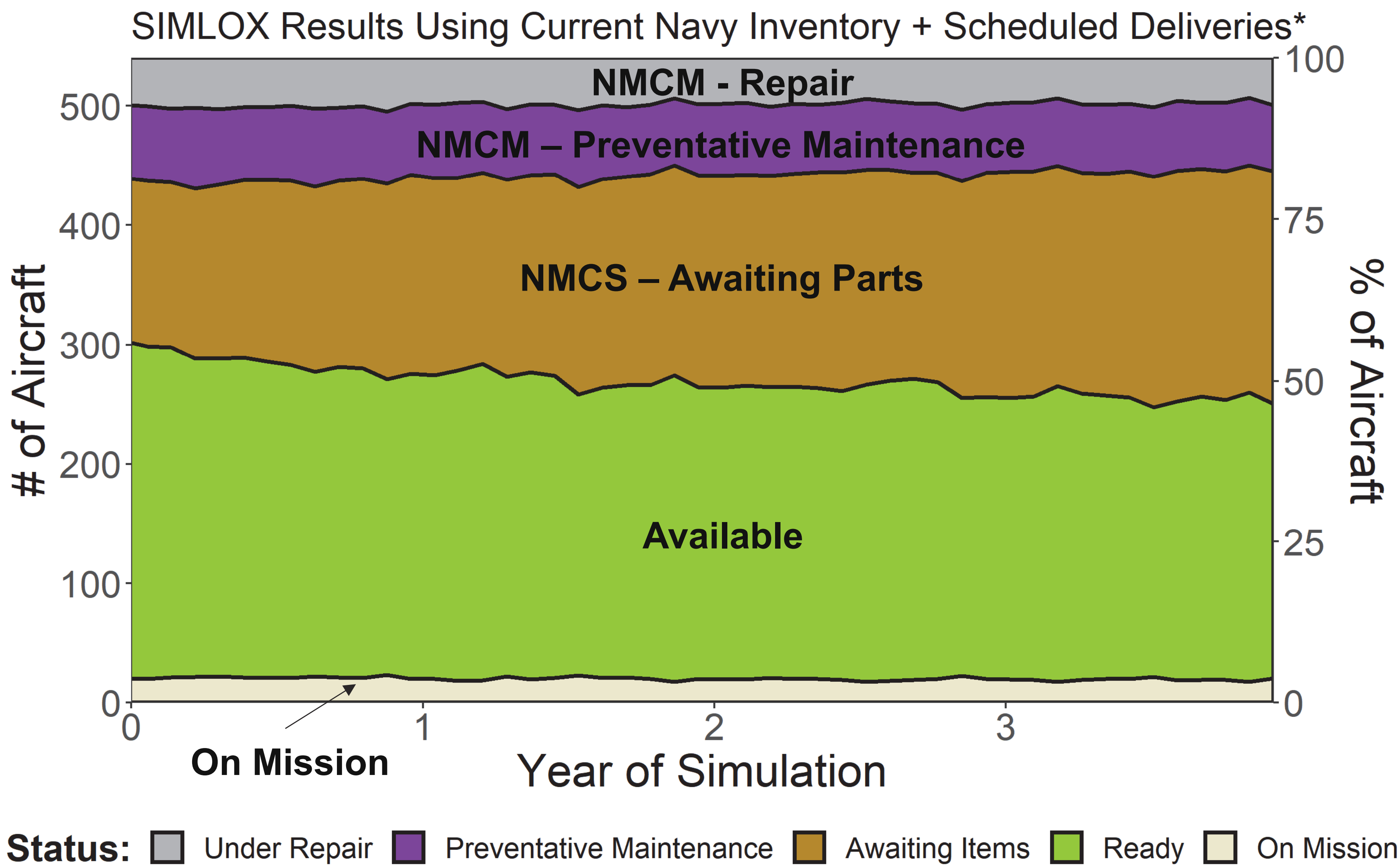


IDA's tool **stingView** helps visualize and analyze the results

stingView provides interactive graphs to examine simulation results

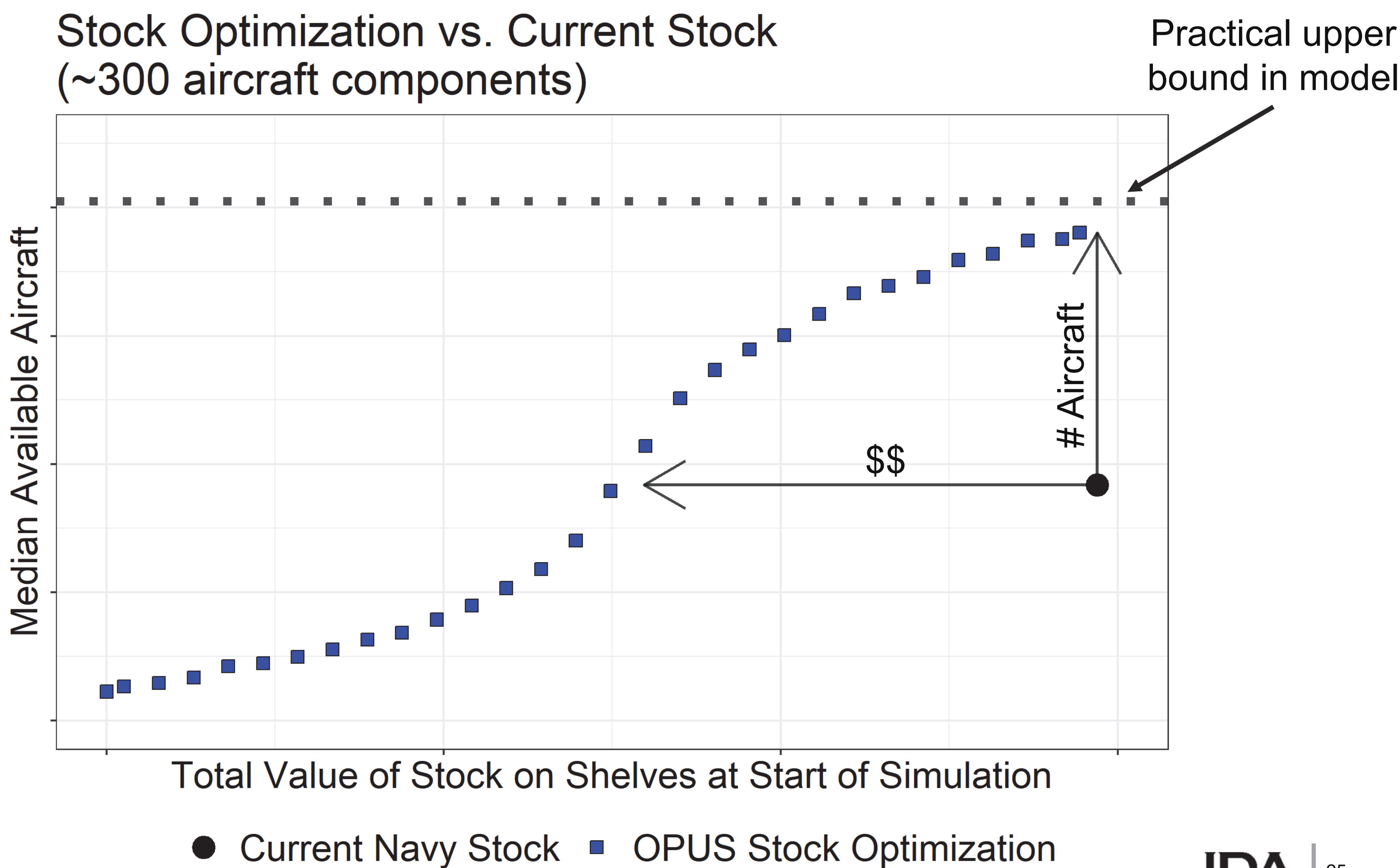


We have built a functioning model, down to the part level, that can support funding questions



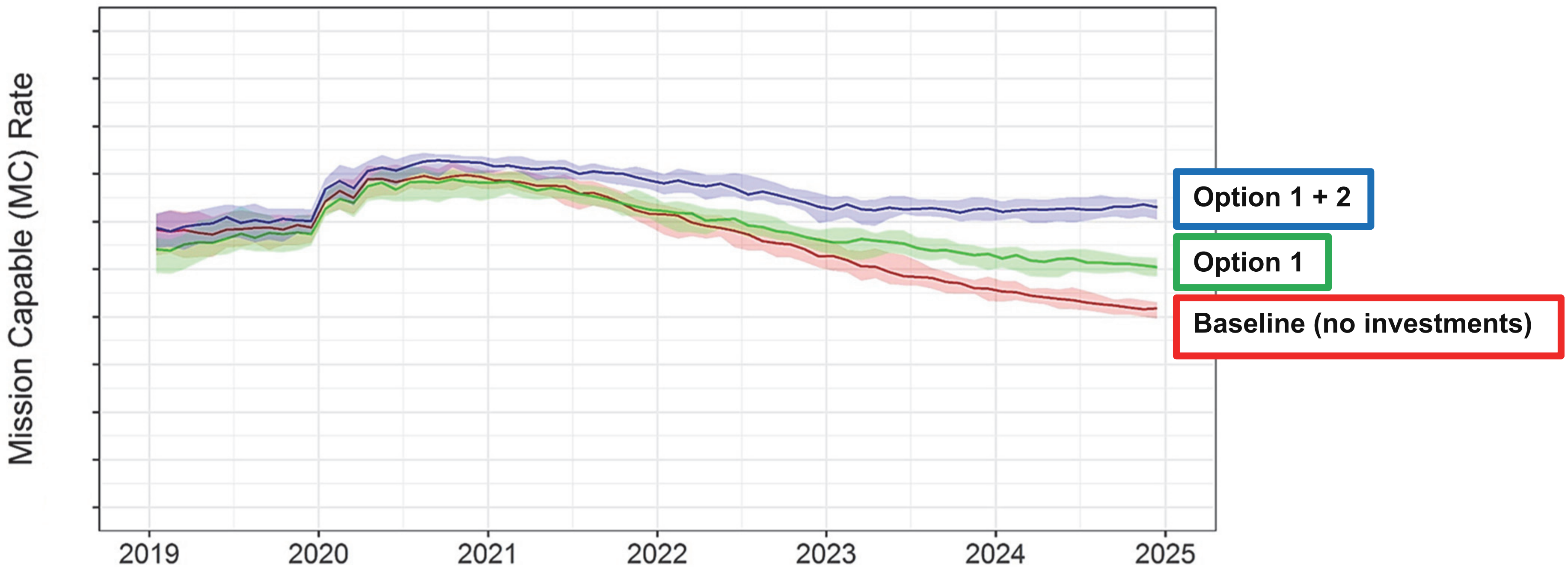
*Includes purchases estimated to arrive before July 2021

The data suggest that the Navy is not buying the right parts (too many of some, too few of others)



Example Results from the F-35 SIMLOX Model:

Availability projections and options costed



Option	FY20 delta	FY21 delta	FY22 delta	FY23 delta	FY24 delta	Total delta over FYDP	Availability improvement over FYDP
Investment option #1	$$	$$	$$	$	$	$$$$	X%
Investment option #2	$$	$$	$$	$$	$$$	$$$$	XX%

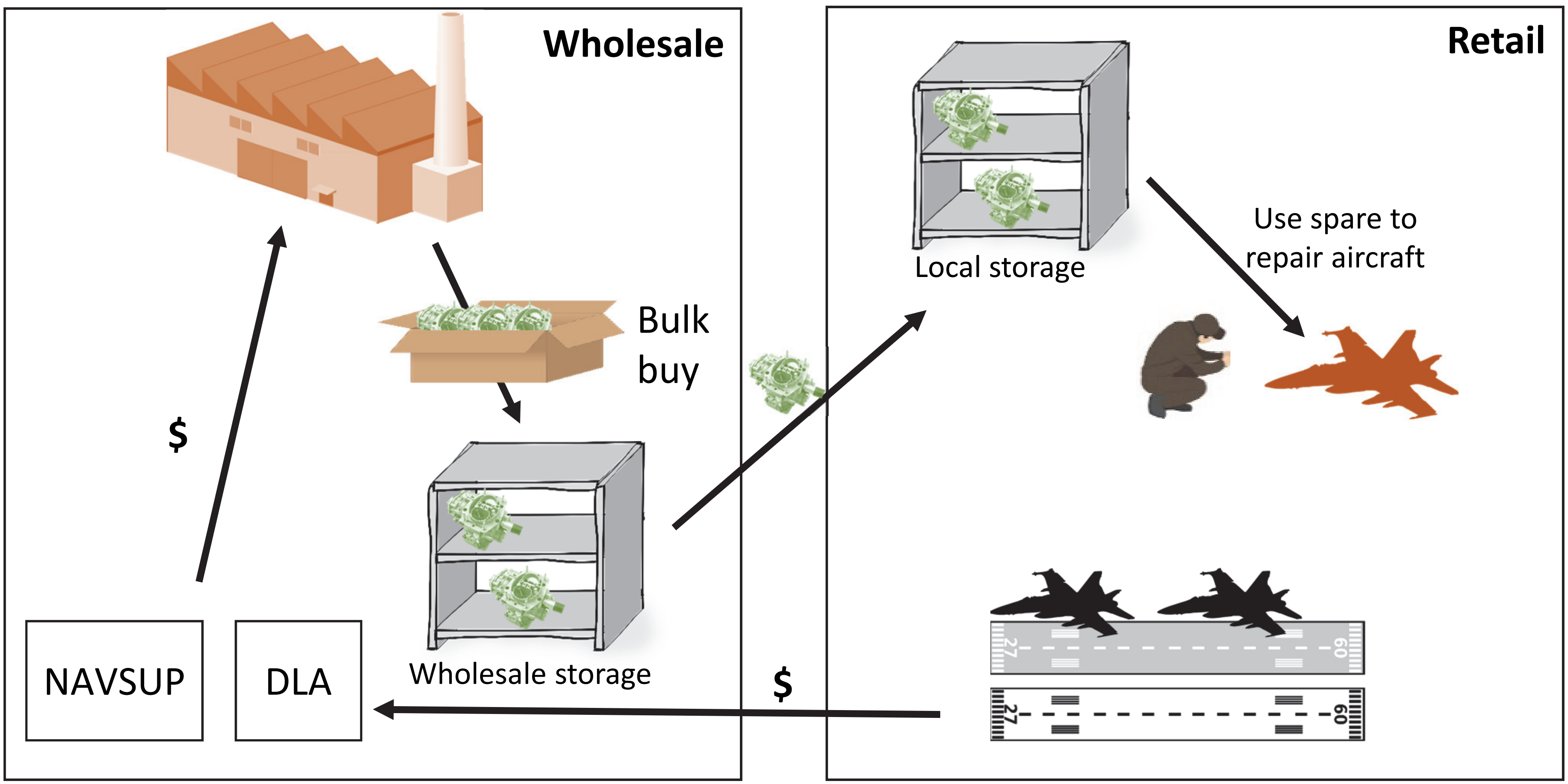
A bottom-up, end-to-end forecasting model is a powerful way to tie dollars spent to sustainment outcomes

The key role of the analyst is assembling, interpreting, and applying rigorous, reproducible methods when populating the model

Tool development builds consensus within the sustainment community

IDA

Retail and Wholesale



NAVSUP and DLA spend money from their working capital funds to procure new parts and (in NAVSUP's case) repair broken carcasses. They attempt to buy in advance of need based on forecasted demand.

Individual units and bases usually buy spare parts from wholesale with money from their operational funds to keep the retail shelves stocked.

Scrutinize your data

Cancel | stingView - Institute for Defense Analyses | Done

Select Simulation

Next Dollar - F18 Point 1 Value 0 M

Select NIINHOF

Choose a component

Retail Stations

AIMD FALLON, AIMD LEMOORE, AIMD OCEANA, AIMD WHIDBEY, AIMD IWAKUNI, MAGIC WH WEST, MAGIC WH IWAKUNI, MAGIC WH EAST

Wholesale Stations

WHOLESALE

Depot Repair Station

OEM

Item Input Data | System Input Data | SIMLOX Item Results | SIMLOX MC Results | Compare Simulation Results

NIINHOF/TMS-Level Properties

name	F18F	F18E	F18G	Weighted Total
Num Demands	21	43	18	82
Num Touch Events	39	32	25	96
MFHBR	4125.95	2623.15	3355.7	3168.82
Removal Criticality	0.52	0.47	0.29	0.44
Touch Criticality	0.82	0.81	0.88	0.83

NIINHOF-Level Properties

Item Type: LRU, COG: 7R

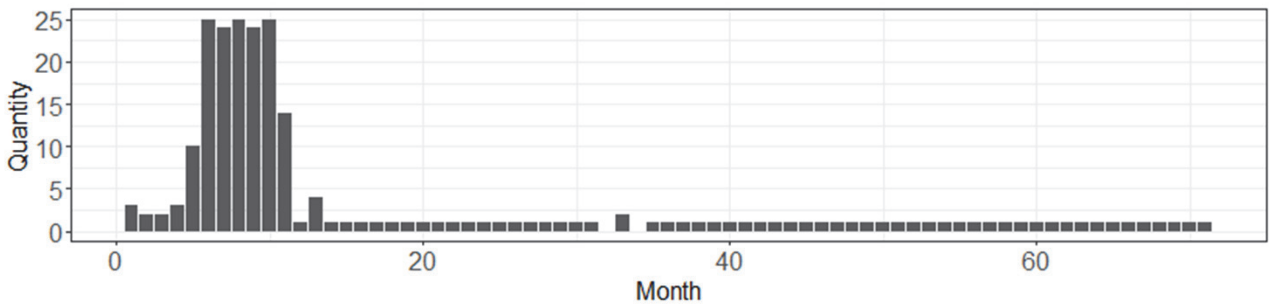
name	value
Condemnation Rate	0.02
bcmFraction	1
DRCT Point Estimate (days)	269.85
PCLT Point Estimate (days)	753.23

These values are inputs to the simulation and provide a handy way to view the properties of individual items

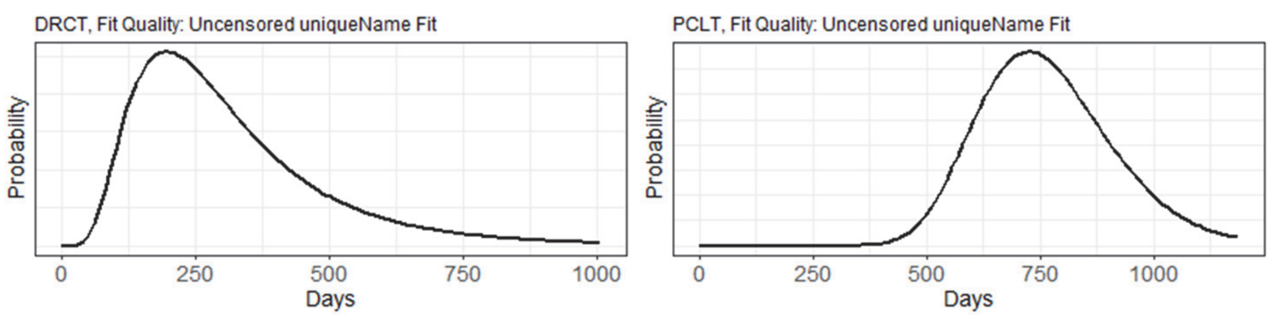
Stock Information

name	value
Retail Stock Levels at t=0	2
Navy Retail Stock Allocation	20
Wholesale Stock Levels at t=0	1
Total Due In	219

Scheduled Deliveries



DRCT and PCLT



The Scheduled Deliveries and DRCT/PCLT (repair and procurement lead time) graphs provide an at-a-glance overview of the supply system

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14. ABSTRACT
Bottom-up emulations of real sustainment systems that explicitly model spares, personnel, operations, and maintenance are a powerful way to tie funding decisions to their impact on readiness, but they are not widely used. The simulations require extensive data to properly model the complex and variable processes involved in a sustainment system, and the raw data used to populate the simulation are often scattered across multiple organizations. The Navy has encountered challenges in keeping sustaining the desired number of F/A-18 Super Hornets in mission capable states. IDA was asked to build an end-to-end model of the Super Hornet sustainment system using the OPUS/SIMLOX suite of tools to investigate the strategic levers that drive readiness. IDA built an R package (“honeybee”) that aggregates and interprets Navy sustainment data using statistical techniques to create component-level metrics. IDA built a second R package (“stinger”) that uses these metrics to automatically generate the input tables necessary to run OPUS/SIMLOX; the effect of both of these packages is that IDA has lowered the barrier for entry for building these large end-to-end sustainment models. We present a summary of these tools and techniques to the OPUS User community in this briefing.

15. SUBJECT TERMS
Sustainment; Super Hornet; Naval aviation; SIMLOX; OPUS; Readiness-based sparing; Readiness

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