SYSTEMS PLANNING AND ANALYSIS, INC.

Inventory Decision Support Process for Aircraft Inventory Management

October 2022

Systems Planning and Analysis (SPA)

For more than 50 years, SPA has provided innovative and data-driven solutions in support of complex U.S. and Allied security programs and priorities.

DOMAIN EXPERTISE

- ✓ Air, Land, Surface, and Undersea Warfare and Operations
- ✓ Nuclear Deterrence, Safety & Security
- ✓ Radar and Sensor Systems
- ✓ Ballistic Missile Systems
- ✓ Department of Defense Processes
- ✓ Industrial Base Policy
- ✓ Space Systems
- ✓ Hypersonics
- ✓ Cyber Operations and Security Policy
- ✓ Analytic Software Development
- ✓ Unmanned Systems and Counter-Systems
- ✓ Intelligence, Surveillance & Reconnaissance
- ✓ Counter Weapons of Mass Destruction

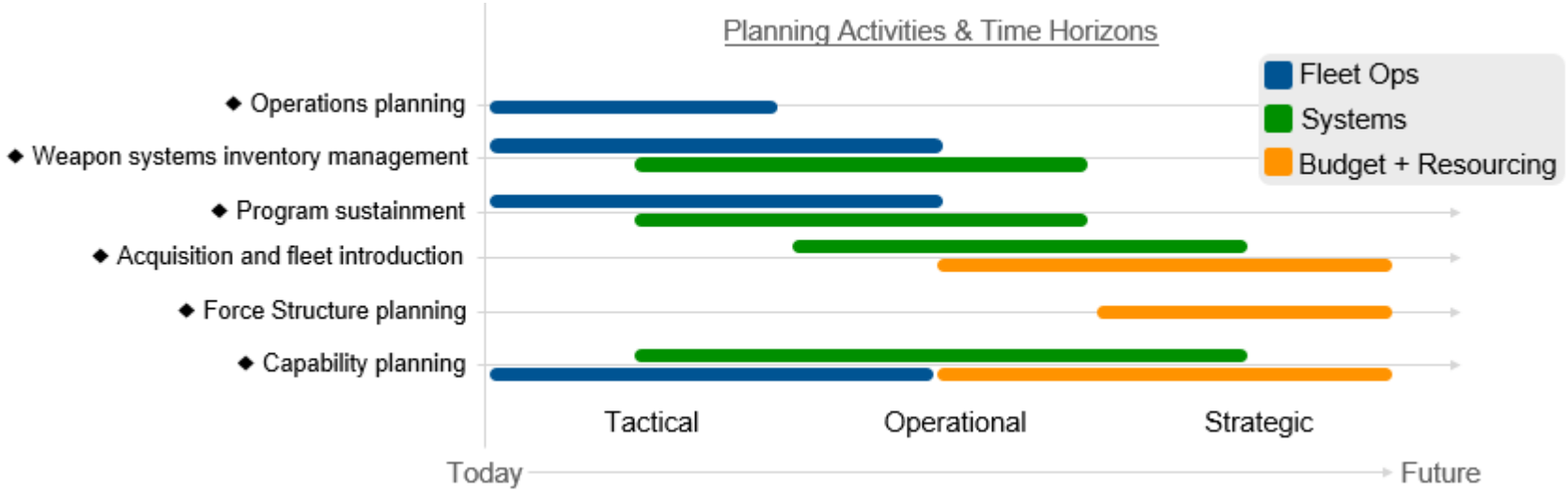
Inventory Management Challenges

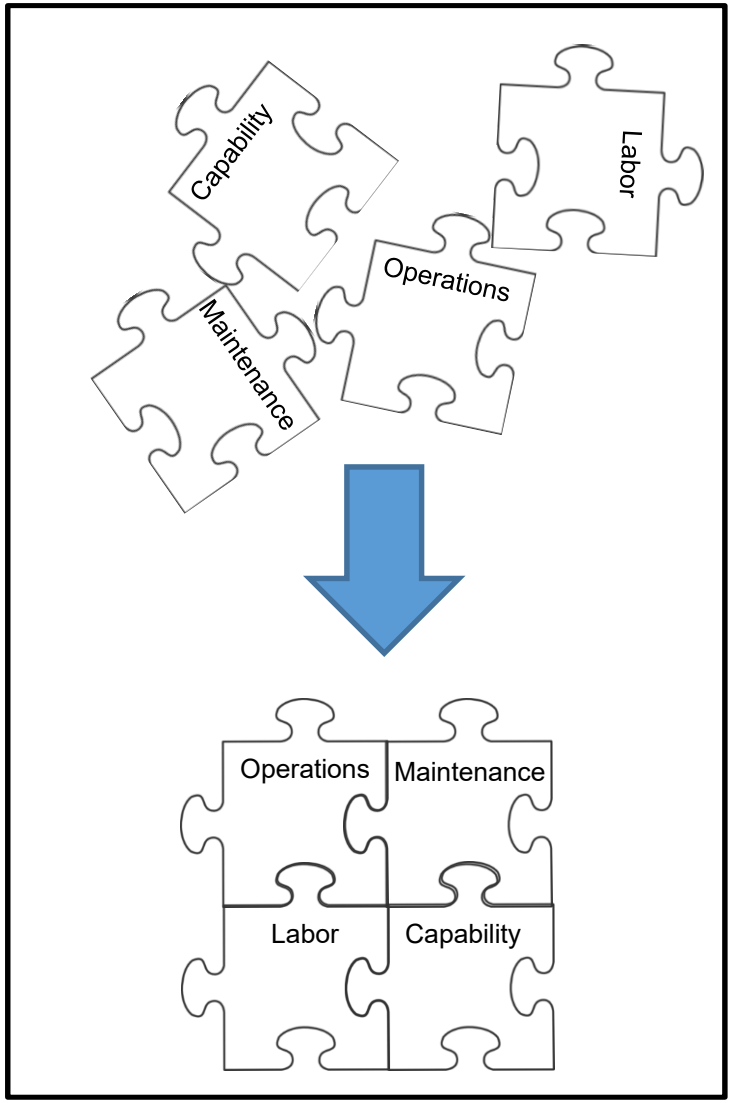
Constant rebalancing between competing priorities

- *Near-term support vs. long-term capability improvement*
- *Maintenance execution vs. surge readiness preservation*
- *Consistent touch-labor demand vs. expedited capability upgrade*

Priorities change over time

- *Area of emphasis is dynamic*
- *Political and economic landscapes shift*
- *Enemy gets a vote*





IDSP Concept for Aircraft Inventory Management

Inventory Decision Support Process (IDSP) Concept

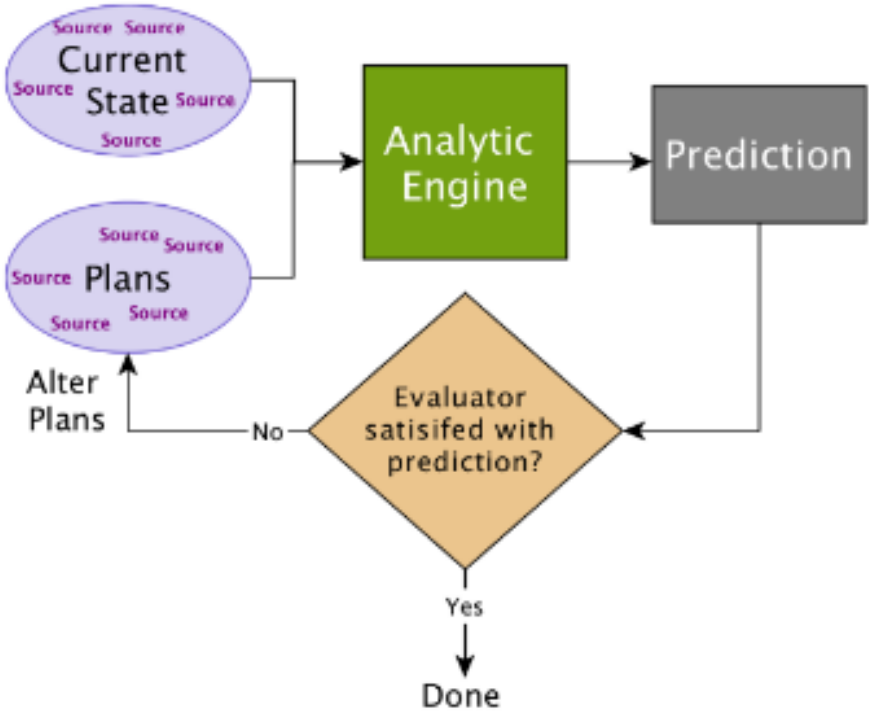
Implement a prescriptive analytics decision process for all aspects of aircraft inventory planning.

IDSP's approach enables data-driven decisions based on aligning plans and resources across the enterprise.

- *Inputs and assumptions come from appropriate authoritative stakeholders*

The IDSP process provides a "Forward-looking Common Operating Picture."

- *Eliminates fighting over which view of the future is correct*
- *Provides demonstrated value to stakeholders at all echelons of command (for instance, offset $40M in unnecessary maintenance costs for the F/A-18 program between FY16-19)*
- *Provides defensible requirements by **explicitly** linking budget marks to future shortfalls*

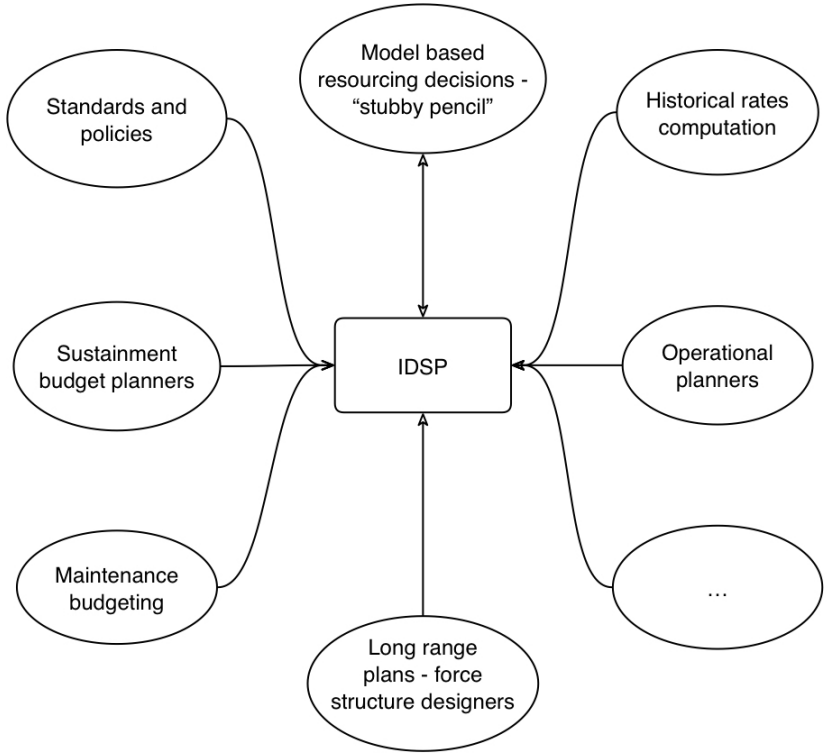


Example case study (hyperlink): IDSP for E-2 Hawkeye

Stakeholders

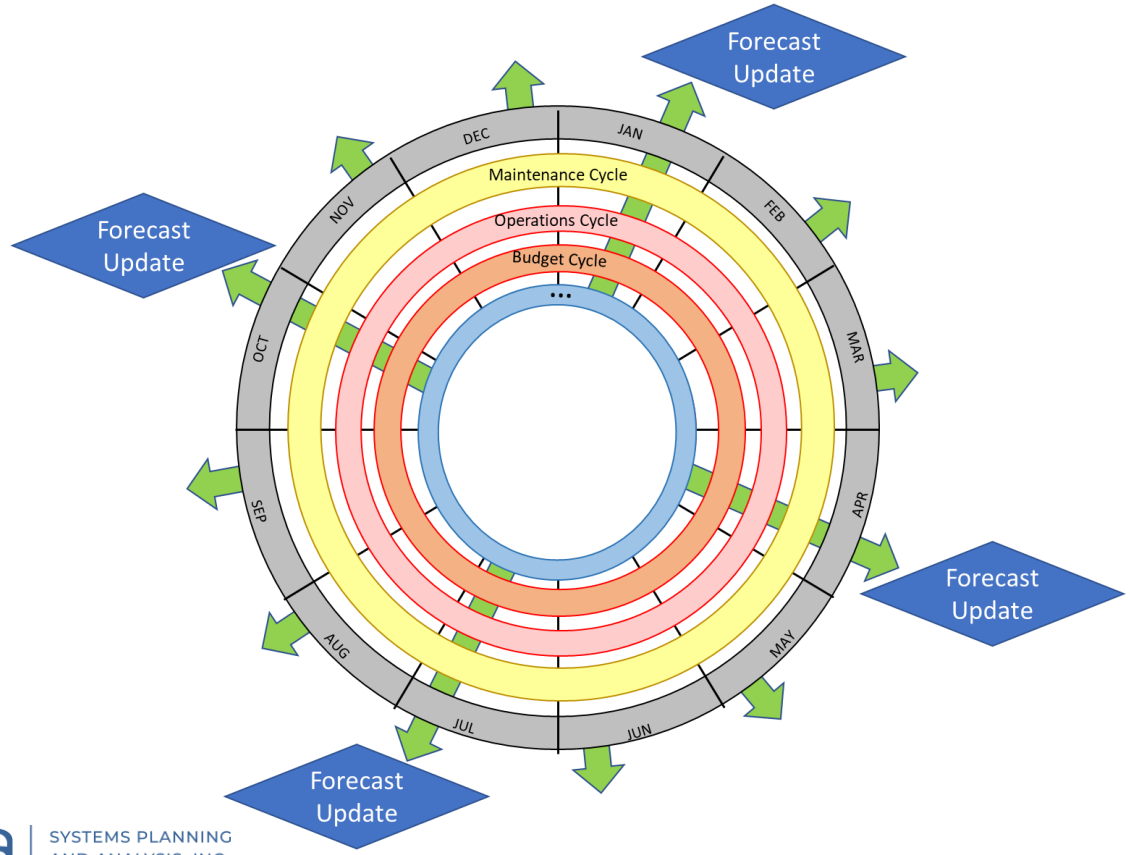
Objectively Capturing Stakeholders' Roles

- Understand each stakeholder's challenges
- Reflect their paradigm in the model and outputs
- Know what they control; they own that data and assumptions



Regular Engagement

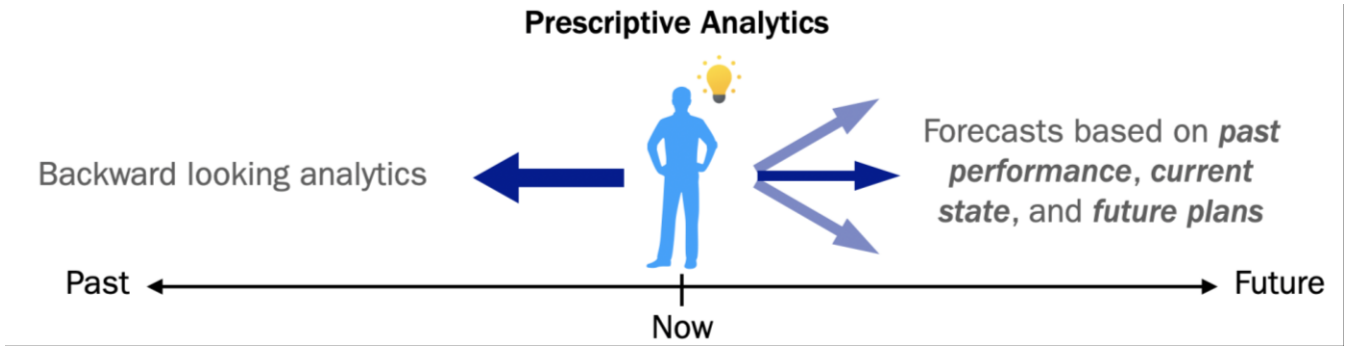
- Refreshes forecast often with new inputs
- Enables meaningful "what if" analyses

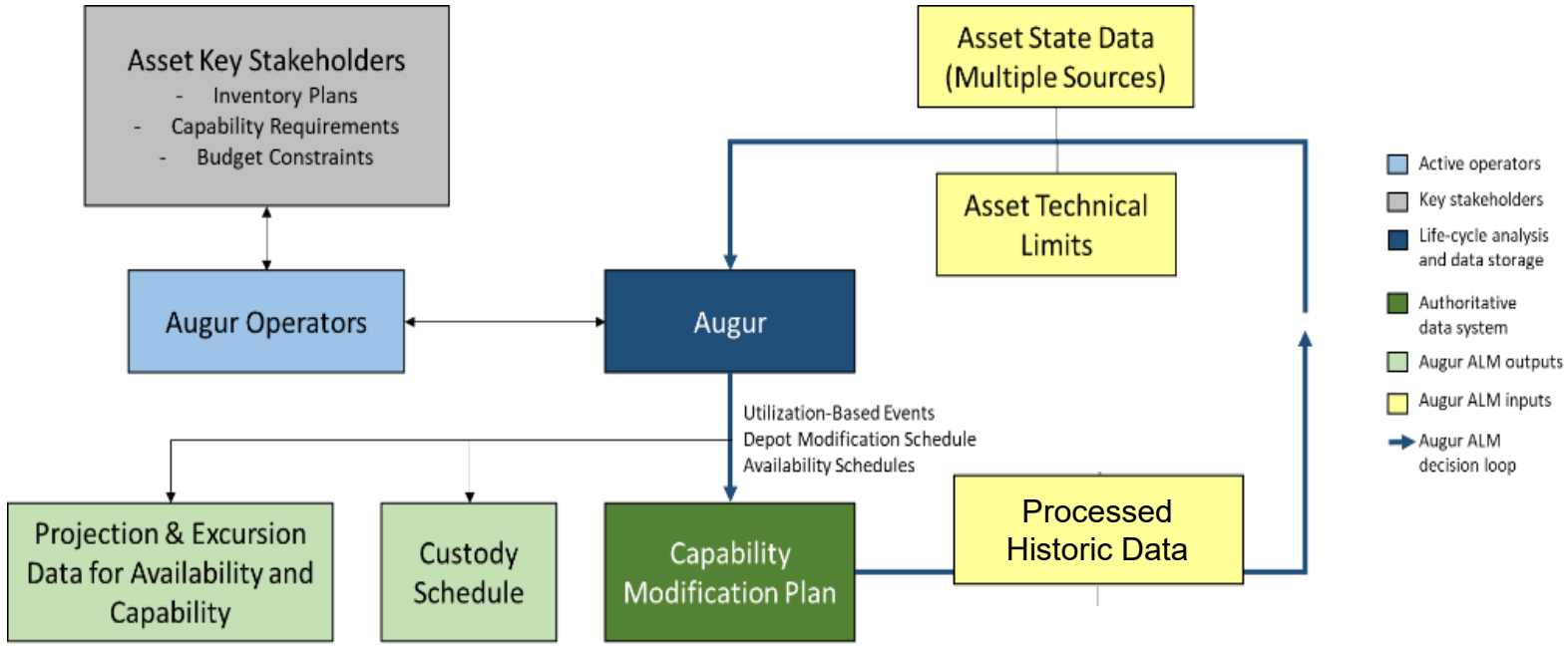


Augur Overview

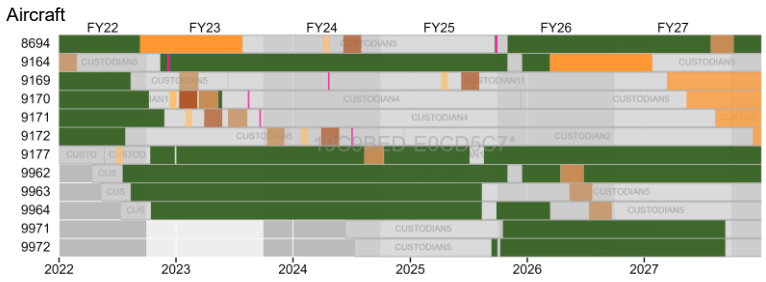
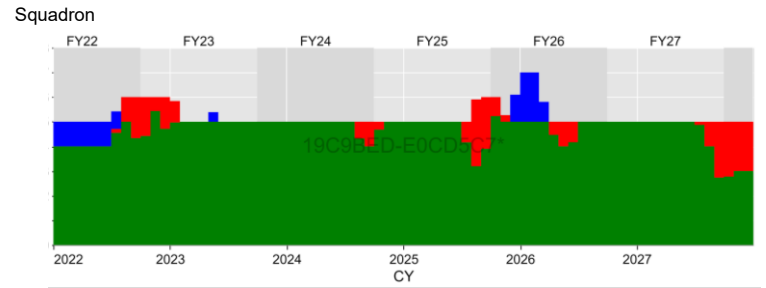
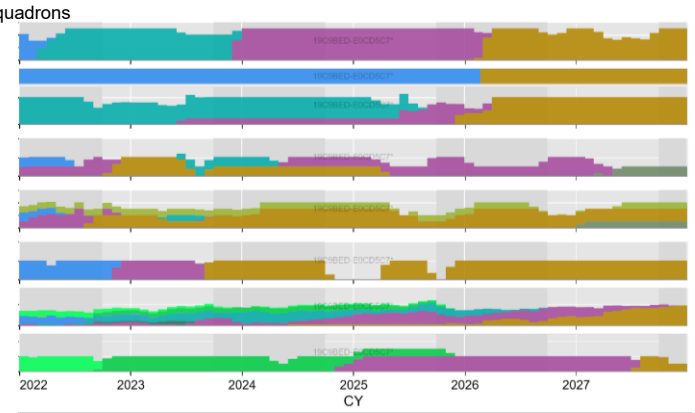
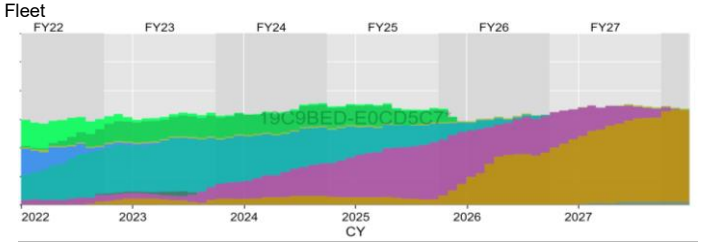
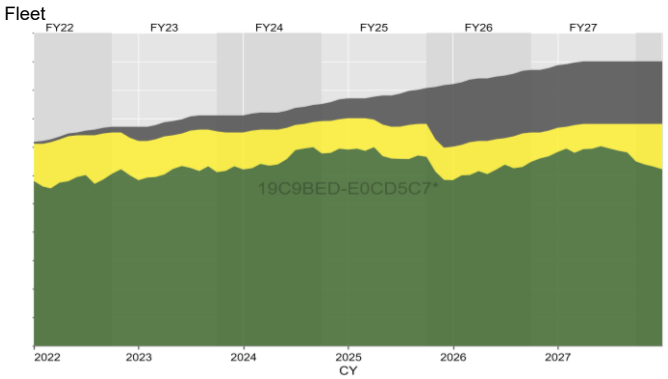
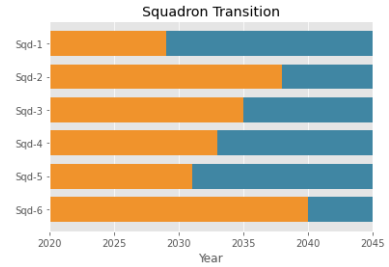
Augur is a deterministic engine enabling prescriptive analytics

- Initial conditions establish anticipated outcome
- More control through the manipulation of specific variable(s) for sensitivity analysis
- Findings are actionable and based on the best information available





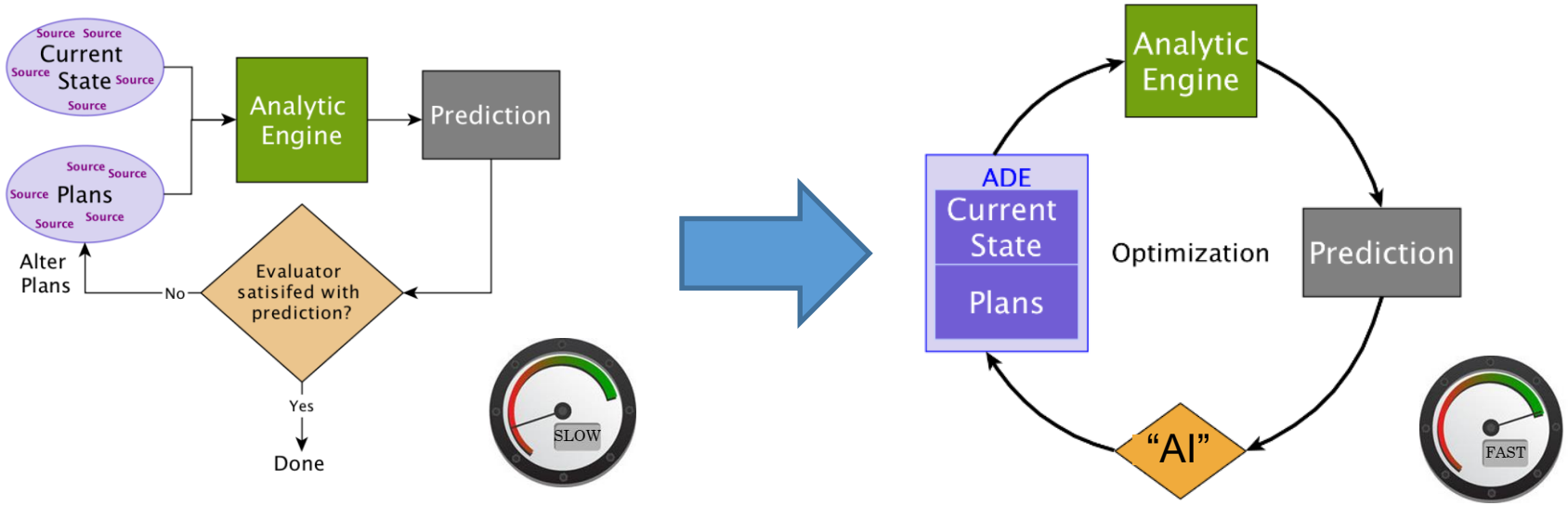
IDSP with Augur – Aligned Decision Making

	0–12 Months	1–5 years	5–30 years
Actions	• Operations planning • Custody management	• Program sustainment • Capability integration • Acquisition & fleet introduction	• Force structure planning • Capability planning • Acquisition & Fleet introduction
Decision Support Viz	Aircraft  Squadron  	Squadrons  Fleet  	Fleet  Follow-on Platform 

Tactical → Operational → Strategic

Searching for the Optimal Plan

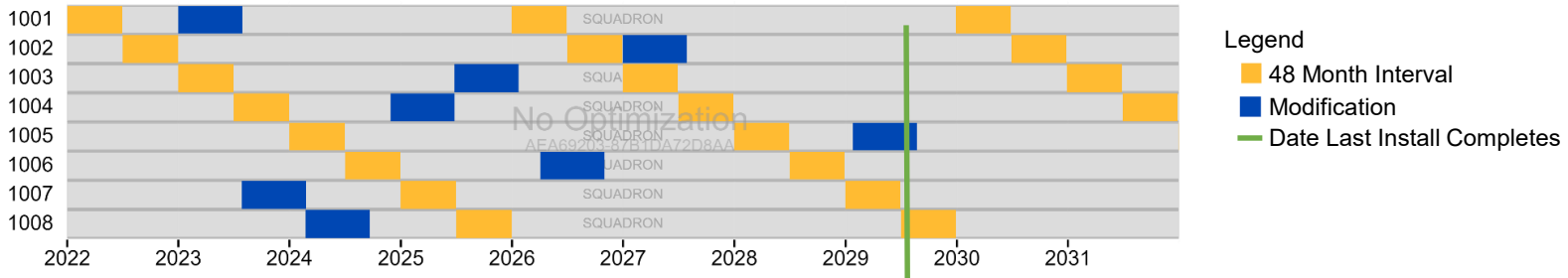
Strategy: Establish an objective function that can be calculated, and use the computer to generate optimal plans



"Goods"	"Others"
• Less human-in-the-loop time required • Guaranteed best solution found • Can be implemented in deterministic model (Augur) with off-the-shelf tools (e.g., Google's OR-Tools)	• "Optimal" is relative—it depends who you are, where you sit, and when you're looking • Combining costs between stakeholders is more art than science

Example of Optimizing

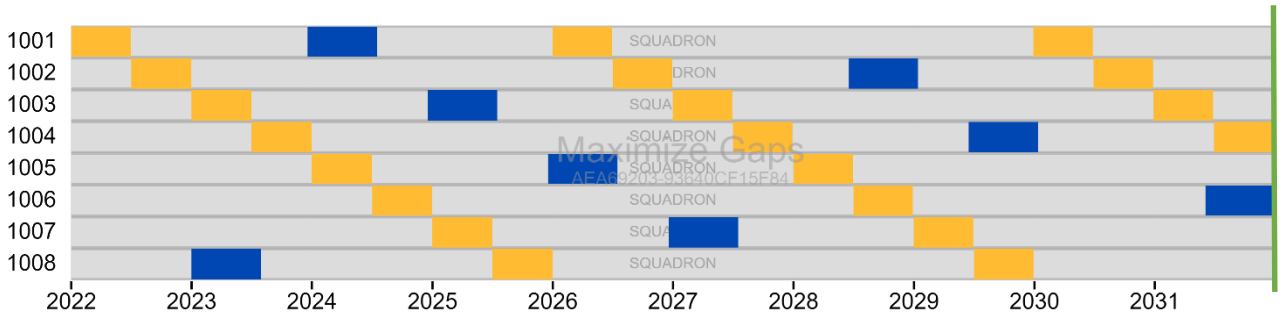
- **Automated optimization can achieve local optima (best option for each choice) and/or global optimum (best set of options)**
  - These may not be identical; implementing global optimum requires stability (in priorities, execution, etc.)
- **Working with all the stakeholders in the enterprise we can build optimized plans that balance the desires of each stake holder**
  - Squadrons need aircraft to perform operations and maintain pilot training
  - Operational commanders need advanced capabilities deployed across the fleet
  - Program offices need to maintain and upgrade aircraft within budget
- **Example**
  - A squadron has 8 aircraft that require regular maintenance work every 48 months
  - They would like to install a new capability modification on each aircraft



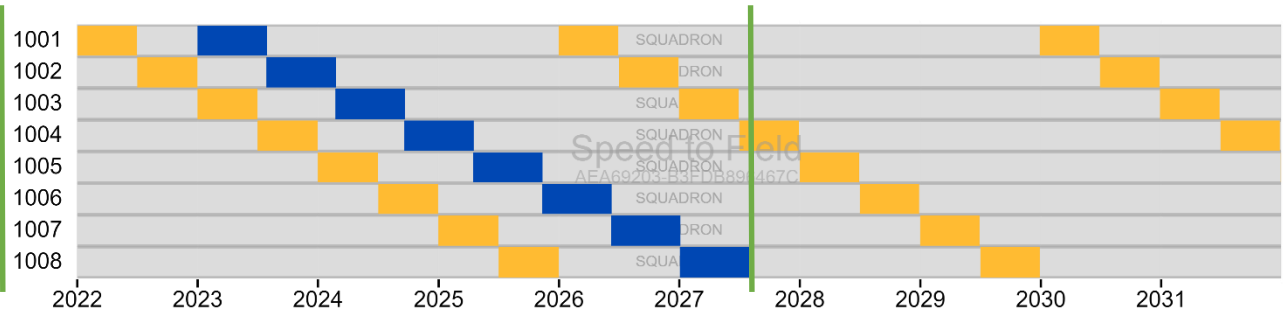
Modifications are scheduled without any optimization goals.

Multiple Optimization Targets

Using an integer programming constrained optimization solver (e.g., CP-SAT from OR-Tools), we can optimize against various objective functions.



Maximize time between concurrent events for each aircraft.

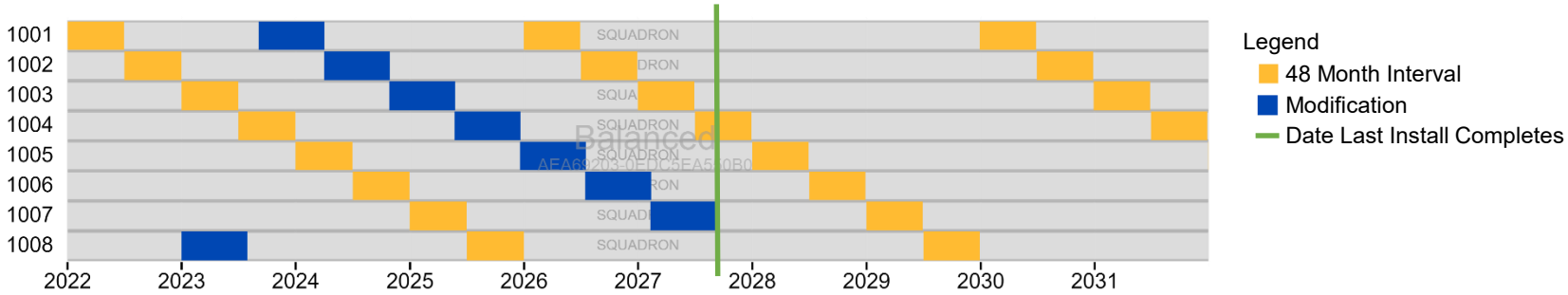


Minimize total time to upgrade all aircraft.

$$O = \sum_{i}^{n} G_i^2 - 1000 \max\{F_i\}$$

G is the gap duration (days) between events.

F is the number of days after simulation start of final installation.



Combine both objectives

- Do not induct aircraft too soon after another event
- Complete installs in a timely manner

Summary

- **Automating optimization of future plans has benefits and drawbacks**
  - Pros: Speed, emotionless, data-driven, ensure best outcome
  - Cons: Difficult to combine different priorities
- **Deterministic engine, such as Augur, captures rules of the enterprise and identifies conflicts in stakeholder plans**
  - Model is the source of truth for all stakeholders; allows for meaningful “what-if” analysis
- **IDSP, with Augur as engine, allows for common language and understanding between stakeholders**
  - The inputs and assumptions are owned by the specific decision makers
- **SPA has over a decade supporting the USN and USAF with inventory management support using IDSP**

Questions?

Links

- https://spa.com/news-insights/naval-synchronization-toolset-initiative/
- https://spa.com/news-insights/e2-inventory-management-with-augur/
- https://spa.com/news-insights/managing-the-f-16-collision-of-mods-with-the-inventory-decision-support-process/
- https://spa.com/news-insights/optimizing-fleet-readiness/

Example Aircraft supported with IDSP discussed in the links above.

F/A-18A-F E-2D F-16