Life Cycle Cost Modeling of High-Speed Commercial Aircraft

Final Review – MIDAS Development & Demo

August 3rd, 2023 | NASA Langley Research Center

Ami Patel
Software Technical Director & Senior Software Engineer
ami.patel@spaceworks.aero | 770-573-3533

Hayden Magill
PI & Economic Analyst

Aaron Boysen
Sr. Economic Analyst

John Bradford
Principal Engineer

NASA SBIR Contract #80NSSC22C0008

Agenda

11:00 – 12:15	Executive Summary	John Bradford
12:15 – 1:00	*Lunch*	
1:00 – 1:45	**MIDAS Development & Demo**	**Ami Patel**
1:45 – 3:50	Key Findings	Hayden Magill / Aaron Boysen
3:50 – 4:30	Recommendations & Discussion	Hayden Magill / All

All times Eastern

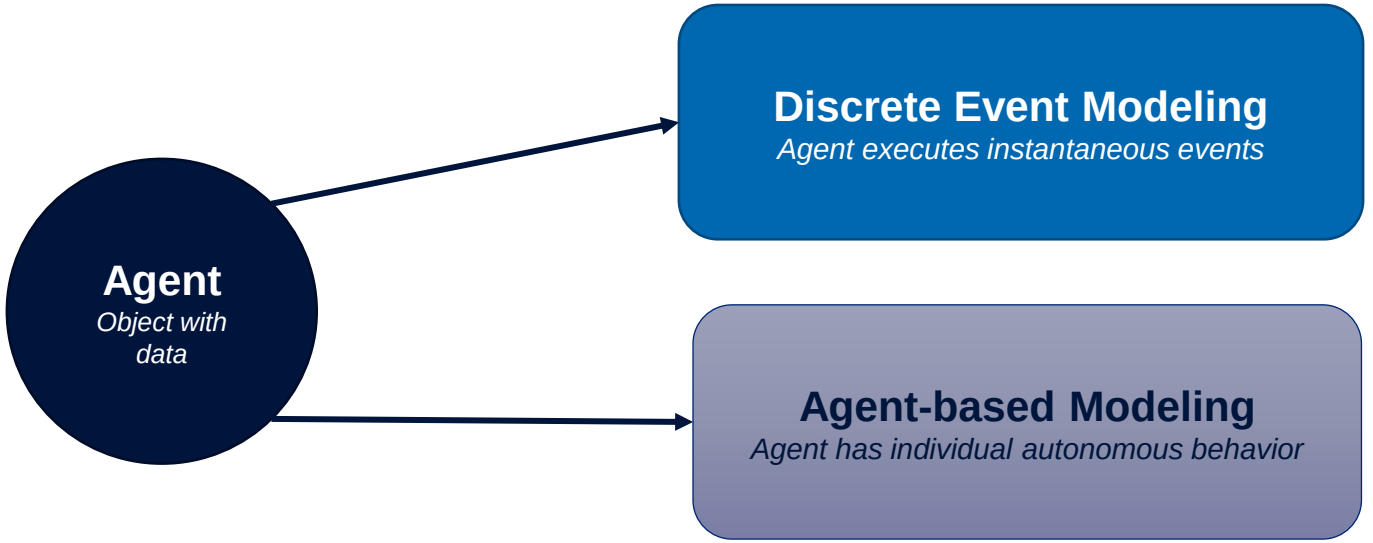
NASA SBIR Contract #80NSSC22C0008

MIDAS | Overview

- **SpaceWorks developed a modeling and simulation (M&S) tool called Multi-Market Integrated Dynamic Aerospace Simulation (MIDAS)**
- **MIDAS provide greater insight and analysis into fleet operations and economic behavior using AnyLogic and is derived from the HSCA ROSETTA Model**
- **AnyLogic is a multi-method modeling software for discrete event simulation (DES) modeling, agent-based modeling, and system dynamics modeling**
  - For a given project, any combination of these modeling types can be used
- **MIDAS will focus on the economic side of the ROSETTA Model only**
- **For the base effort, MIDAS roughly matched ROSETTA capability, and for the add-on effort development has been hand-in-hand with deliverables**
- **Where feasible, benchmarked MIDAS behavior against results generated from ROSETTA**

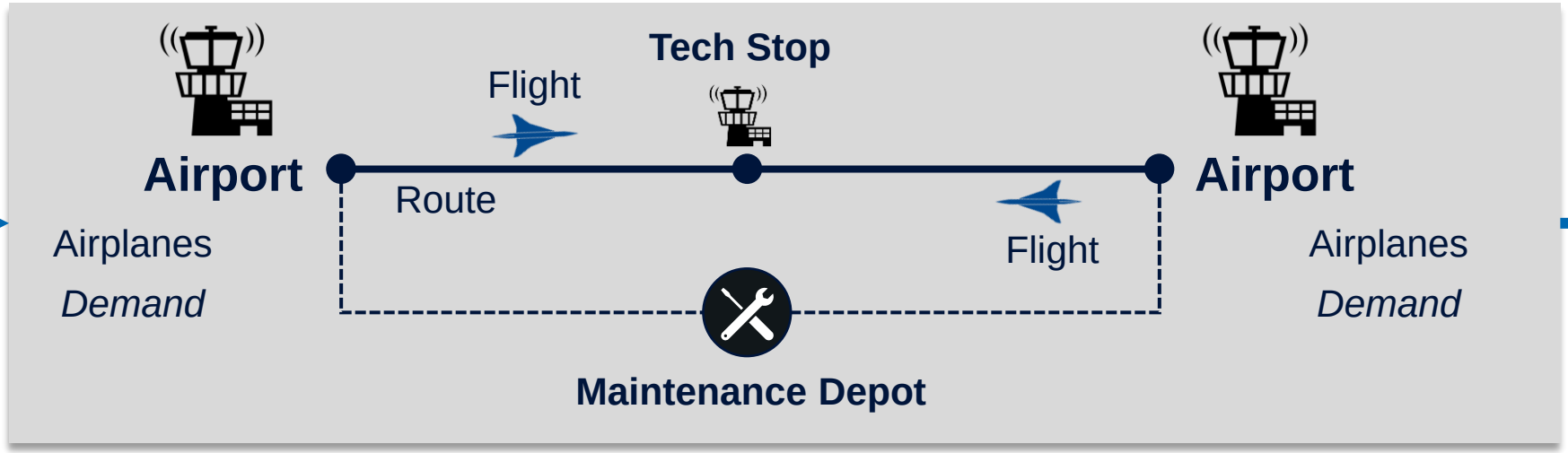
MIDAS | Terminology

- **The term Agent represents any object with data in the AnyLogic simulation**
- **The high-speed flight study uses a mix of Agents leveraging discrete event (DES) and agent-based modeling techniques**
  - **Discrete event**: Instantaneous events progressing through time
  - **Agent-Based**: Individual objects with local behavior
- **Aircraft Type is used for a specific combination of Mach number, range, and passenger capacity**



MIDAS | Roadmap

MIDAS add-work development complete

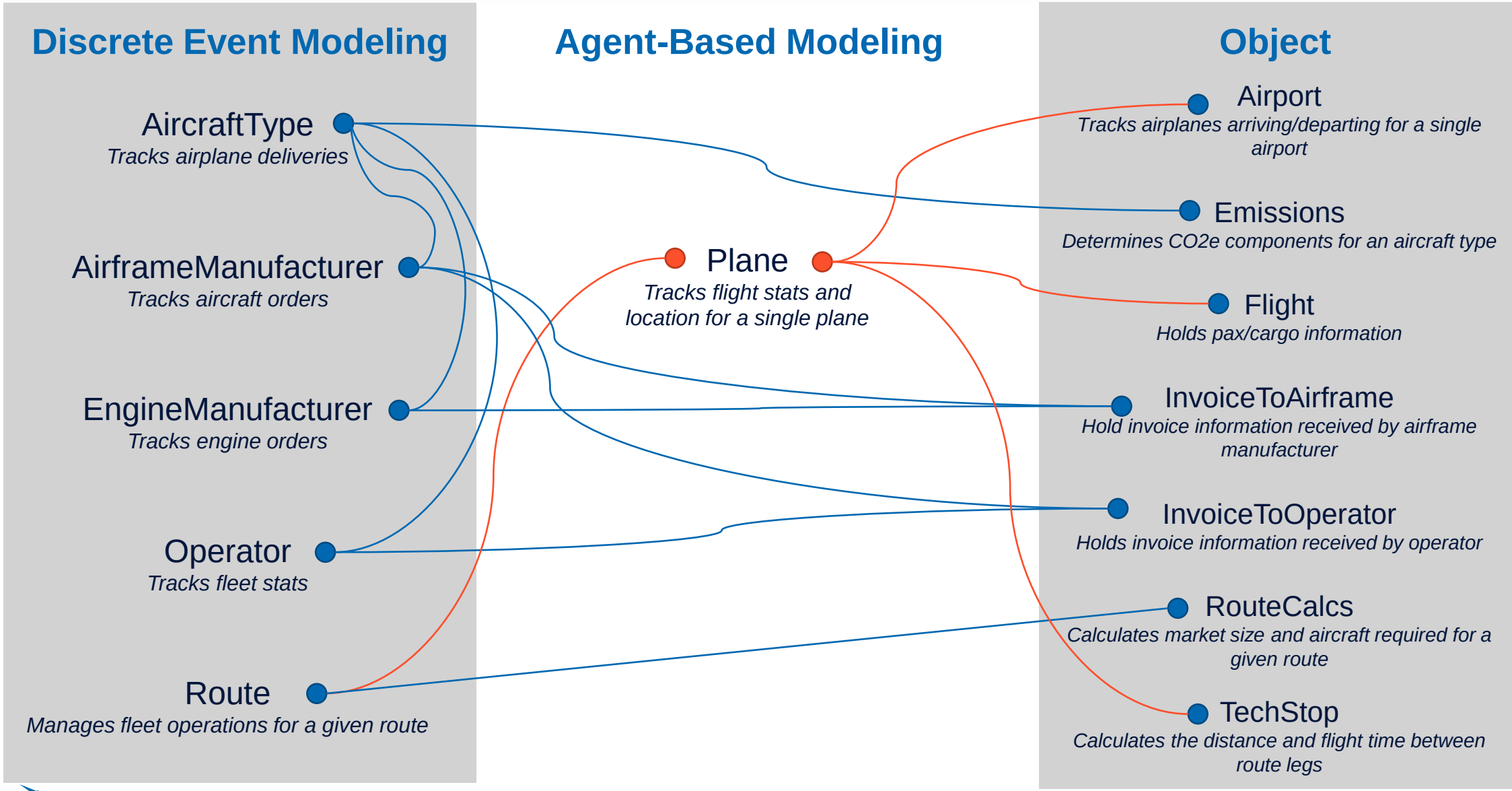


Inputs	Initialization	Demand & Flights	Maintenance & Purchase	Outputs
Route Inputs	Initialize each Route	Model demand for each Route	Add/Remove Airplanes per maintenance	Revenue
Aircraft Inputs	Initialize each Airplane	Generate Flight per demand	Add/Remove Airplanes per demand growth	Cost
Airport Inputs	Initialize each Airport	Determine Fleet utilization		IRR, NPV
Operator Inputs	Initialize each Tech Stop	Set AircraftType for Routes		Emissions
	Initialize each Operator	Implement Flight Scheduling		

Base Work | Add-Work

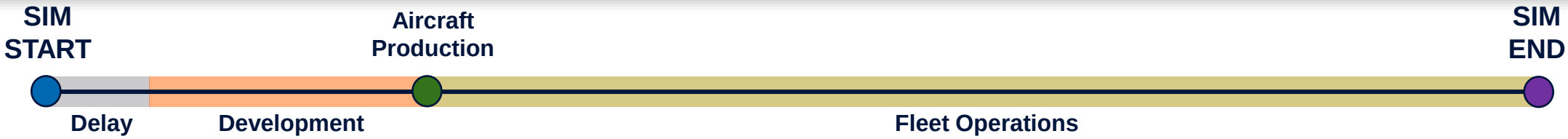
NASA SBIR Contract #80NSSC22C0008

MIDAS | Key Agents



NASA SBIR Contract #80NSSC22C0008

MIDAS | Model Operations



Initialize Routes

- For each **Operator** and each **Route**, determine applicable **AircraftType**
- Calculate number aircraft needed for viable routes

Initialize Operator

- Initialize **Operator** with initial fleet size
- For each **AircraftType** supported, initialize **AirframeManufacturer** and **EngineManufacturer**

Aircraft Development

- Development begins after specified delay period
- DDT&E applied for manufacturers
- Down payment flows from **Operator** to **Manufacturers**

Aircraft Production

- Production rates vary throughout model
- Military aircraft are delivered first
- **Routes** become active as **Planes** are delivered

Fleet Operations

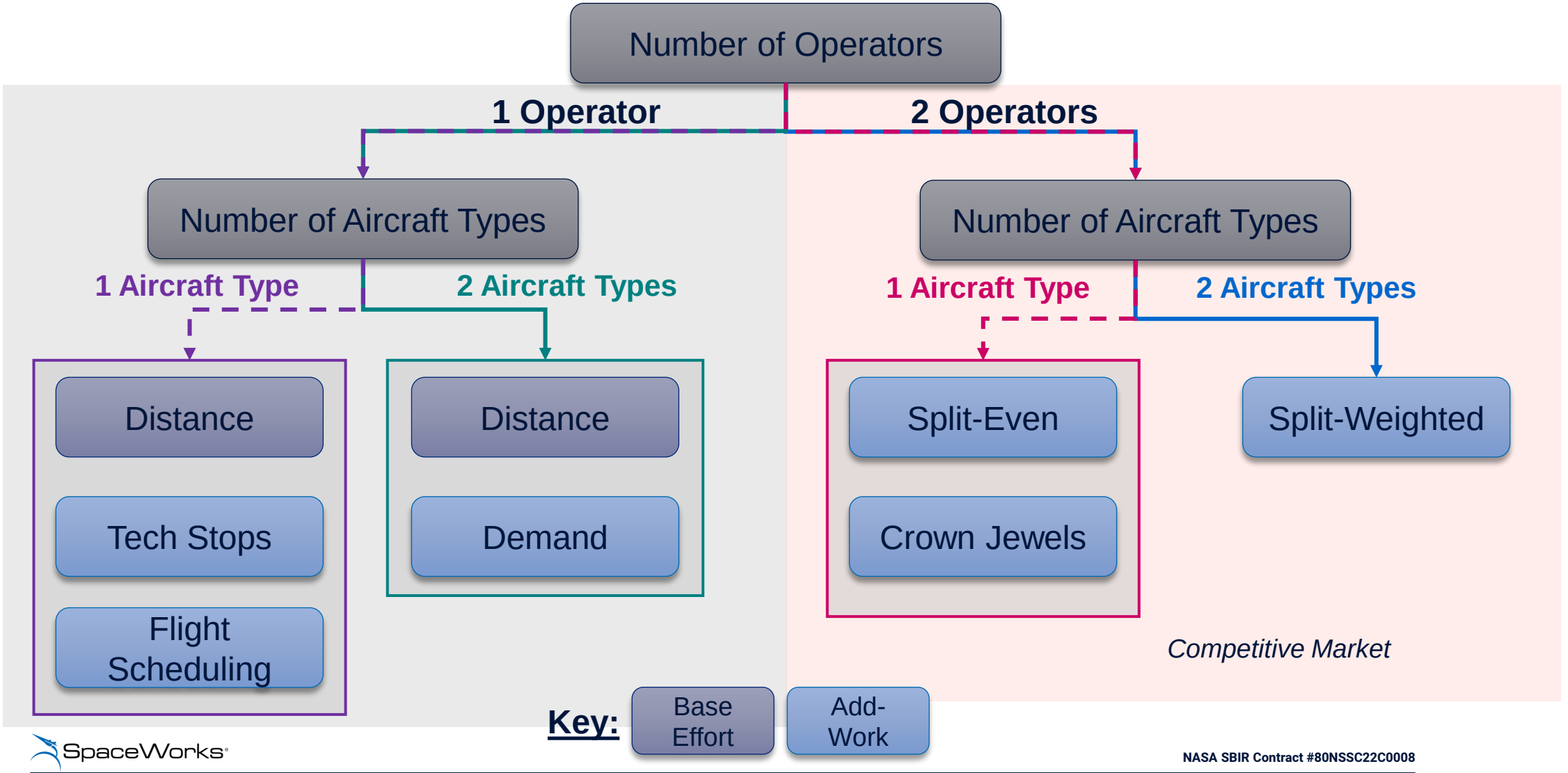
- Each **Plane** has a pre-service delay
- **Planes** retired based on flight hours
- New **Planes** purchased per market growth or retirement

Business Metrics

- At simulation end, business metrics (NPV, IRR, Max Exposure) are calculated for **Operator** and **Manufacturers**

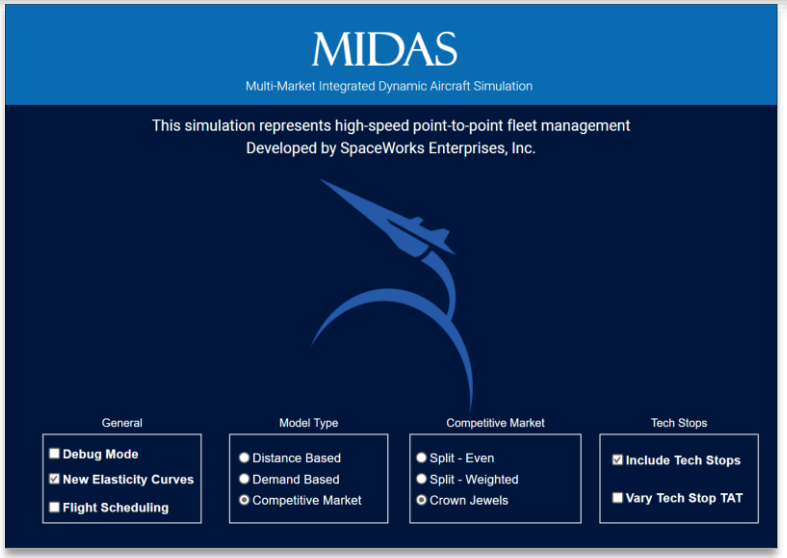
NASA SBIR Contract #80NSSC22C0008

- **Model architecture allows for flexibility in selecting a simulation scenario**



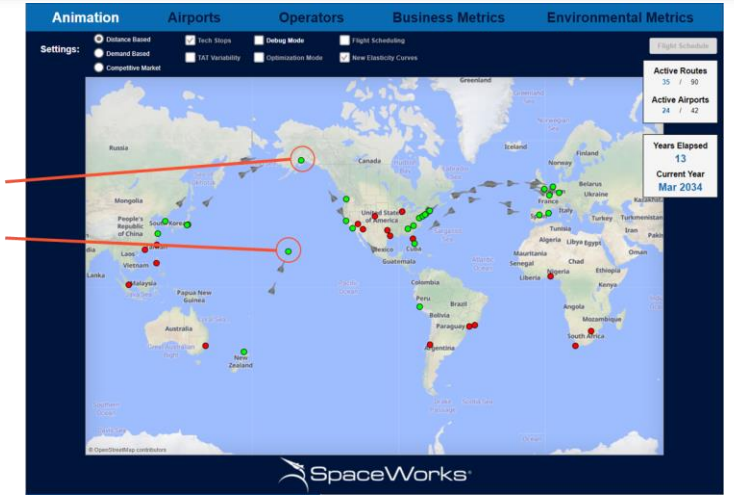
MIDAS | Dashboards

- Information is displayed on a series of “dashboards” representing a key object/agent in the model
- Metrics are updated during run-time live (e.g. cash flow charts)
- Information varies on dashboards based on the scenario selected

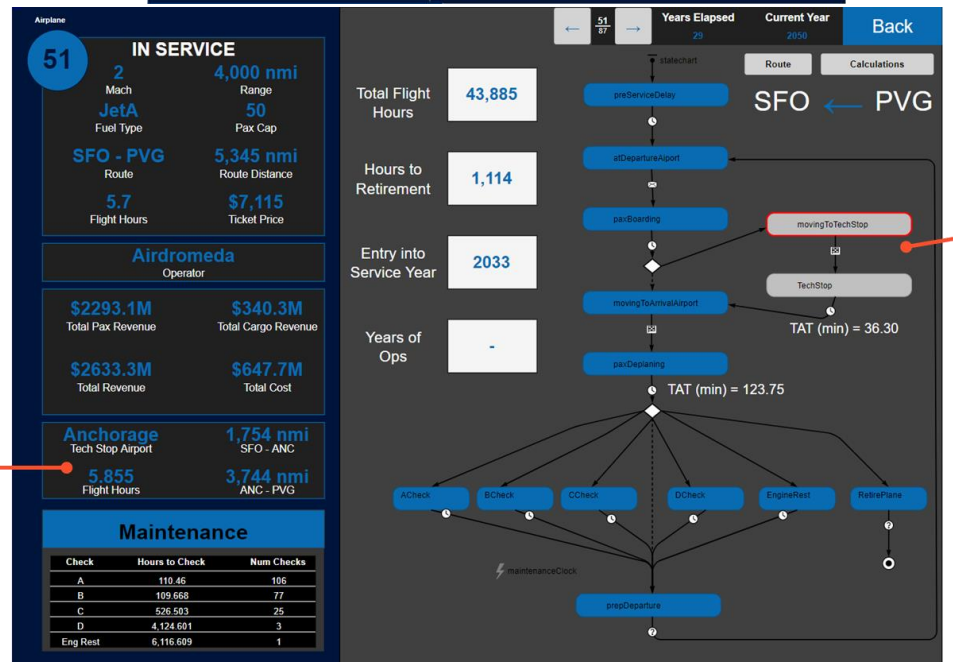


MIDAS | Tech Stops

- **Added tech stop options for relevant transpacific routes**
  - Anchorage, Alaska
  - Honolulu, Hawaii
- **Tech stops used to help shorter-range aircraft service longer routes**
- **Modified Plane logic to account for flying to tech stops if enabled**



Added **Anchorage** (AK) and **Honolulu** (HI) as tech stop airports

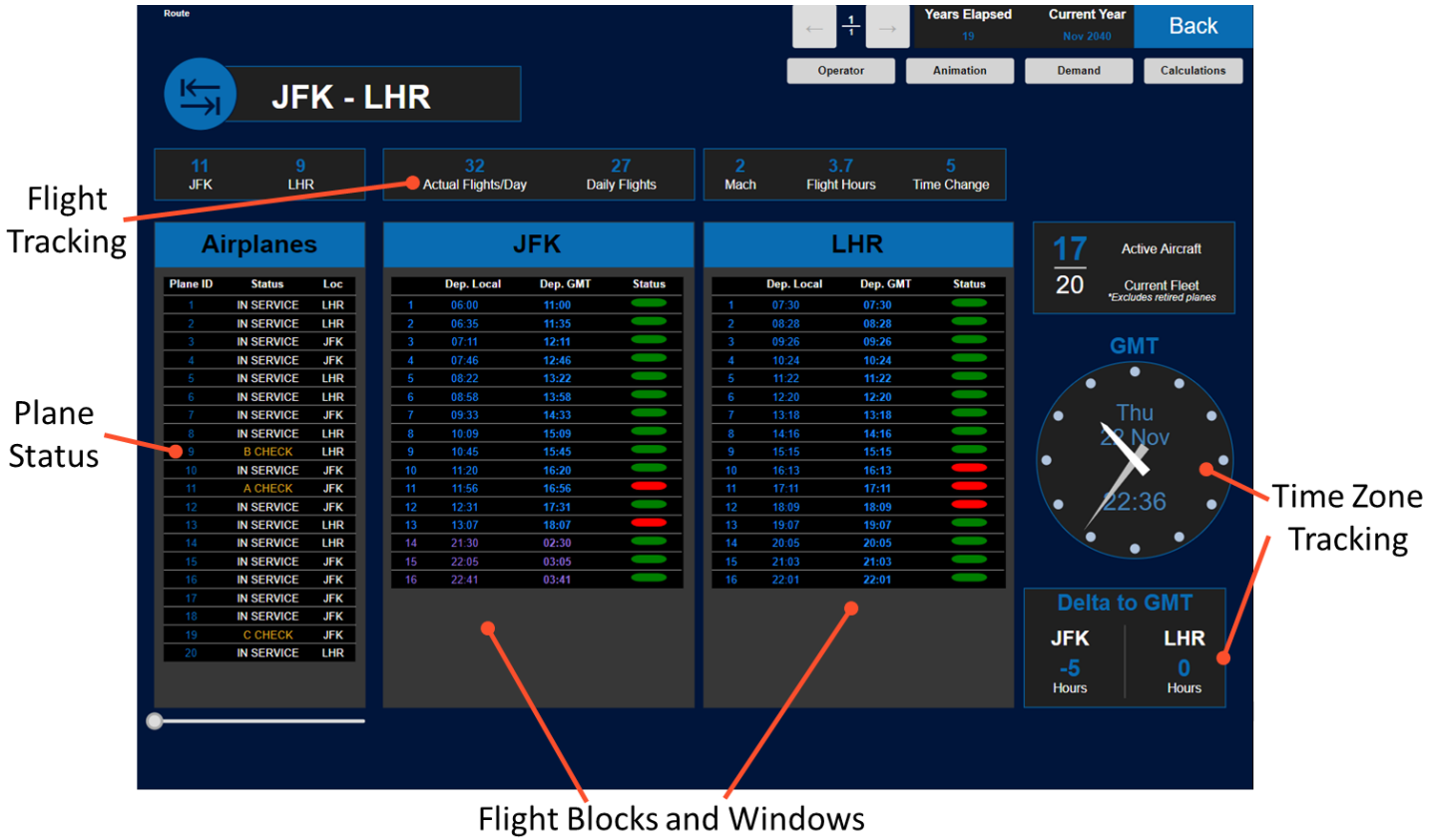


Additional logic for flying to tech stop

Added tech stop airport information

MIDAS | Flight Scheduling

- **Implemented flight scheduling scenario in MIDAS**
- **Current status for all planes servicing a given route shown**
- **Flights per day tracking metrics shown**
- **Operational flight blocks and flight windows calculated per airport**
- **Time zone accounting implemented**
- **“Missed” flights tracked as unsatisfied demand**



NASA SBIR Contract #80NSSC22C0008

Implemented multiple competitive market scenarios

1. **Split-Even**: Two operators and one set of manufacturers exist. Each operator addresses 50% of the market and use the same aircraft
2. **Split-Weighted**: Two operators and two sets of manufacturers exist. One operator utilizes a short-range aircraft on viable routes while the other operator utilizes a long-range aircraft on viable routes but can compete on the short-range routes as well
3. **Crown Jewels**: Two operators and one set of manufacturers exist. One operator addresses “crown jewel” routes while the other operator addresses all other routes within range including those that can be reached with a tech stop

Plane color reflects Operator

= 1st

= 2nd

Plane highlight reflects AircraftType

= 1

= 2

MIDAS Live Demo | Crown Jewel Scenario

Plane color reflects Operator

= 1st

= 2nd

SpaceWorks®

SPACEWORKS.AERO

info@spaceworks.aero | 3980 Dekalb Technology Parkway
Suite 760 | Atlanta, GA 30340 USA | 770.379.8000

NASA SBIR Contract #80NSSC22C0008