

Simulation Modeling with Simio at Lockheed Martin Aeronautics

Applications and Challenges

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Overview

- One of the world's leading defense contractors
- Developed and produced iconic military aircraft such as the U-2, SR-71, F-16, C-130, and F-117 stealth fighter.
- Current largest contract is the F-35 Joint Strike Fighter
 - 5th generation, multi-role stealth fighter
 - CTOL, STOVL, and CV



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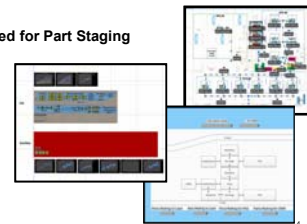
Modeling Challenges

- Very fluid production line
 - Increasing rate (low rate to full-rate)
 - Changing factory configurations as capacity increases
 - Production line never truly reaches steady-state before the next configuration is introduced
 - As production flow changes, the cadence, work schedules, and manpower requirements change, each reflected in an analysis.
- 3 different aircraft designs flowing through same production line
- Performance of the system over the entire simulation does not fully capture the performance of the system over time.
 - Time-phased statistics at pre-defined periods of time
 - Allows us to assess the system as the configuration, work schedules, and cadence changes.

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Types of Projects

- Capacity Analysis
 - Program Shutdown and Restart
 - Machining Center
 - Monorail
- Factory Material Flow
 - Amount of Floor Space Required for Part Staging
 - Material Delivery
 - Layout Confirmation
- Theory of Constraints
 - Strategic Buffers
 - Managing the Bottleneck
 - Process Improvements



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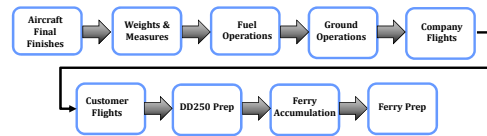
Recent Applications

- F-35 Flight Line
 - Flight Forecast & Capacity Analysis
- Fastener Prep and Kitting System (FastPAKS)
 - Design & Optimization

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F-35 Flight Line Simulation

- Objective: Forecast the ferry schedule and identify flight line capacity requirements



- Additional Factors: nonstandard work, weather delays, ground aborts and amount of unplanned flights

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Model Parameters

- Forecast the Ferry Schedule
 - Identify the impact of different Ferry Plans
 - Amount of Jets that Ferry together
 - Country
 - Ferry Location
 - Maximum Time Threshold
- Unconstrained Capacity
 - Allowing the model to determine requirements
 - Number of Run Stations
 - Number of Flights
 - Number of Pilots

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Results

The value is the ability to model the schedule with variation and view the effect of Ferry Accumulation for Flight Line Capacity

- Expected Max: Number of Run Stations
- Average WIP and Span for every Station
- Ferry Forecast
- Number of Pilots
- Total Number of Flights per Month
- Span and Cost Control: Time Critical Maintenance, Confidence Runs/Flights

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FastPAKS Simulation - Background

- The F-35 FastPAKS is a proposed semi-automated system that decrease time to prepare and kit fasteners for production line
 - Semi-automated sorting
 - Cleaning
 - Kitting into required quantities
- Once fasteners are chemically treated they must be bagged within 2 hours and installed on the aircraft within 5 days

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FastPAKS Simulation - Flow



- 1 Sorting into Trays
- 2 Stacking Trays into A Tower
- 3 Transport Tray Stack to Chemical Process
- 4 Chemical Processing
- 5 Transport Stack to Bagger Input
- 6 Input Fasteners into Bagger
- 7 Organize Fasteners for Delivery To Line
- 8 Tray Cleaning Station

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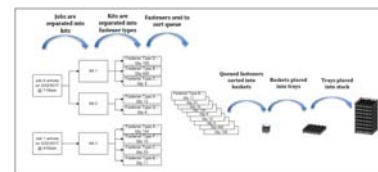
FastPAKS Simulation – Model Details

- Tracks flow of fasteners from the time the job arrives to be sorted until all fasteners are kitted and sent to the production line.
- Demand of fasteners arriving to the system is generated with arrival table of scheduled jobs
 - Individual jobs have specific due date
 - Each job consists of multiple kits
 - Each kit consists of different types and number of fasteners.
- Arrival table linked to multiple data tables
 - Jobs converted to kits
 - Kits broken down into fastener types of varying quantities and dimensions

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FastPAKS Simulation – Model Details

- Vertical carousel presents fasteners to worker for manual sort
- Multiple levels of combining, then separating, were required
 - Group fasteners into baskets
 - Group baskets into trays
 - Group trays into stacks



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FastPAKS Simulation - Metrics



- Annual system requirements were determined from 2018 through 2022
 - Number of vertical carousels
 - Number of cleaning and promoter tanks
 - Number of bagging stations
 - Number of sorters, chemical workers, and baggers
 - Optimal number and size of baskets, trays, and stacks

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FastPAKS Simulation - Optimization



- OptQuest was utilized to conduct the multi-objective optimization to determine ideal basket, tray and stack sizes:

Maximize % of kits that completed on promoter day
 AND
 % of kits that complete on sort day

s.t. Number of baskets per tray (between 24 & 36)
 Number of trays per stack (between 3 & 8)
 Full tray must meet ergonomic requirements
 1 and 2 vertical carousels

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