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QUANTIFYING THE FUTURE

Projecting Program Spare Parts Sustainment with Incomplete Data

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Agenda

Contents

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Introduction

Bryan Anderson

- Management Consultant and Programmer at Cobec Consulting
- B.S. in Economics and Mathematics from Augsburg College
- M.S. in Industrial & Systems Engineering from the College of Science and Engineering at the University of Minnesota – Twin Cities
- Over 5 years of experience in industrial engineering and systems engineering in the private and public sectors
- Leading database development efforts for Cobec Consulting's Innovation Center

George Bayer

- Director of FAA Programs at Cobec Consulting
- Currently leads investment analysis consultant teams developing costs, benefits, and business cases for FAA acquisitions
- B.S. in Finance from the University of Florida
- MBA in Corporate Finance from The University of Texas at Austin
- Project Management Institute (PMI) Project Management Professional (PMP)
- Over 20 years of Finance experience in capital investment valuation, forecasting & budgeting, cost estimation, benefits quantification, and business case development
- Developed discounted cash flow models in Investment Appraisal for major Power Generation capital investments at ConocoPhillips
- Evaluated major capital investments/acquisitions in the Business Case Group of Investment Planning & Analysis at the FAA

Capital Investments & AMS Process

- Federal Aviation Agency (FAA) has agency-specific capital investments evaluation process called Acquisition Management System (AMS).
  - Focus on Cost-Benefit Analysis to justify investments
  - Brings private industry investment rigor to the agency for investment decisions
    - Identify the agency need
    - What is the problem or “shortfall” to be solved?
    - Quantify the shortfall
    - Identify alternative solutions (at least 3 alternatives)
    - Develop requirements
    - Quantify both costs and benefits for each alternative
    - Develop Legacy reference case
    - Evaluate with Finance metrics – NPV, IRR, Payback, B/C ratio

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FAA Business Case – Legacy System

Legacy Case

- Estimates how agency would continue operations for entire project lifecycle (10-20 years) with limited capital investment not making the acquisition
- Either estimates system obsolescence or estimates required sustainment needs to maintain system with limited investment
- Estimates increasing sustainment costs – corrective and preventative maintenance, failure analyses, parts' replacement, etc.
- Used as basis of "cost avoidance benefits"
  - Difference in Ops costs between each alternative and legacy case
  - Avoided legacy costs if instead invested in the project

FAA Business Case – Shortfall

Project Shortfall

- For FAA business cases, estimate program benefits to agency, airlines and private companies, and flying public
- What is the problem that the proposed program will solve?
  - Define problem
  - Quantify & monetize problem
  - Difficulty to sustain existing operations (i.e., failure & sustainment analysis)

Project Benefits

- National Airspace (NAS) efficiencies
  - More direct approach to airports resulting in less direct operating costs and less fuel burned
- Increases in productivity
  - New information technology tools for air traffic controllers to use to conduct more air traffic operations
- Increase effectiveness
  - Improving technology to allow controllers to fit more planes in airport approach queues

Legacy Case Development Challenges

- Aging legacy system in the NAS
  - Need to calculate annual failures, failure growth rates, and cost to procure and replace spare parts to maintain system
- Inefficient Supply Chain System
  - Maintenance and Supply systems do not share information efficiently
  - Data fidelity impacted by lack of field spares transparency
  - Inventory at facility local levels not effectively tracked
  - Budget-based spare parts field supply as opposed to demand-based supply
  - Encourages hoarding parts in the field, reduces fidelity in supply chain
  - Approximated Mean-Time-Between-Failure
  - "Demand" is used as a proxy for failures
- Required legacy cost estimate for long lifecycle (10-20 years)
  - Legacy parts sustained long past intended useful life
  - Bathtub curve difficult to estimate
  - Lifetime buy vs. Extended sustainment of parts

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Business Case Problem

- **FAA Infrastructure Business Case**
  - Need to estimate number/type of parts needed to sustain existing legacy system
  - Using failure analysis, demonstrate timing of system obsolescence and system failure
  - Demonstrate urgency of business case and associated cost avoidance benefits
  - Inform agency of timing of needed F&E capital funds
- **Problems with Data**
  - Data not completely accurate – shortcomings of Supply Chain (no MTBF)
  - Demand as proxy for failures – results in choppy year-over-year failure forecasts and less correlation in failure growth rate curves
  - Change from CDLS to CRS supply contract
  - Limited data sample size
  - New agency supply chain system to monitor and distribute spare parts' inventory – system had challenges with failure and inventory count accuracy post-implementation
- **Subject Matter Expert (SME)** failure and failure growth rate **estimates** a subjective approximation; could be skewed to user bias

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Analysis Approach

Business Case Failure Analysis Approach

- Extrapolate historical data and develop trend analyses
  - Develop failure projections based on historical data
  - Estimate statistical fit curves based on historical data
- Leverage SME assumptions for failures and failure growth rates
  - For information not captured in historical data
  - SMEs can offer expectations of inventory turnover and upper and lower failure bounds
  - From experience with other systems sustained past usable life, SMEs offer timing of bathtub curve failure trends

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Exponential Growth

$$d(t) = d_0 * (1 + r)^t$$

Where:

$d(t)$	The demand function of period t.
d_0	The demand at time 0.
r	Rate of demand growth.
t	Period t.

Linear Growth

$$d(t) = d_0 + m * t$$

Where:

d(t)	The demand at amount time t.
d_0	Demand constant at period 0.
m	Demand growth rate (constant).
t	Period t.

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Results – R^2

Exponential R Squared

NSN	SME	Data
6130-01-596-5636	0.33	0.60
7025-01-567-4461	0.46	0.74
5895-01-574-2109	-1.21	0.57
6685-01-567-2854	0.37	0.46
6140-01-596-7734	-1.49	0.60

Linear R Squared

NSN	SME	Data
6130-01-596-5636	-0.18	0.56
7025-01-567-4461	-1.98	0.74
5895-01-574-2109	-4.03	0.65
6685-01-567-2854	0.05	0.34
6140-01-596-7734	-3.63	0.71

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Results – Exponential Lifetime Buys

SME Models

NSN	Low	Expected	High
6130-01-596-5636	737	1214	1671
7025-01-567-4461	752	1239	1705
5895-01-574-2109	202	287	420
6685-01-567-2854	188	310	426
6140-01-596-7734	239	376	619

Data Models

NSN	Low	Expected	High
6130-01-596-5636	17	4574	1237145
7025-01-567-4461	85	827	8027
5895-01-574-2109	2	109	7284
6685-01-567-2854	1	84	8499
6140-01-596-7734	1	110	10501

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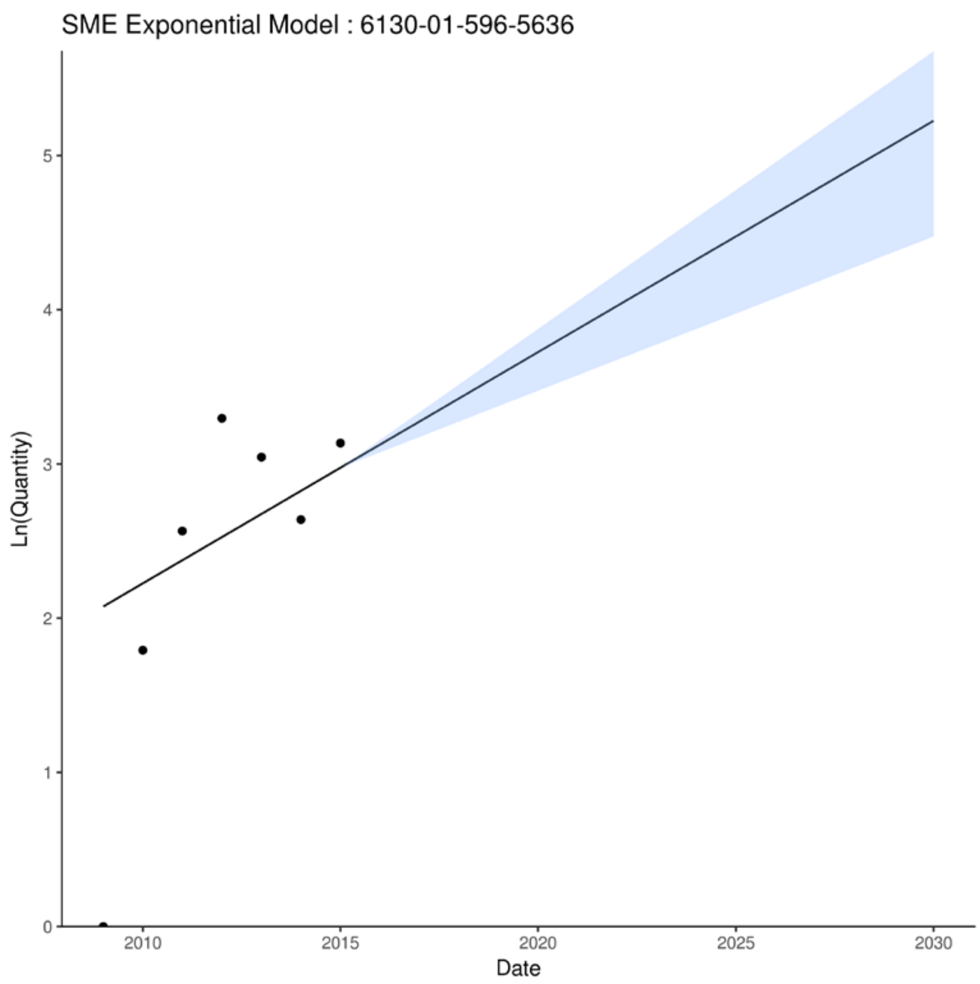
Results – SME Exponential



SME Exponential model forecast mode (in logarithmic units). Points represent actual data and solid line represents the expected outcome. The red shaded zone represents the 95% level prediction interval.

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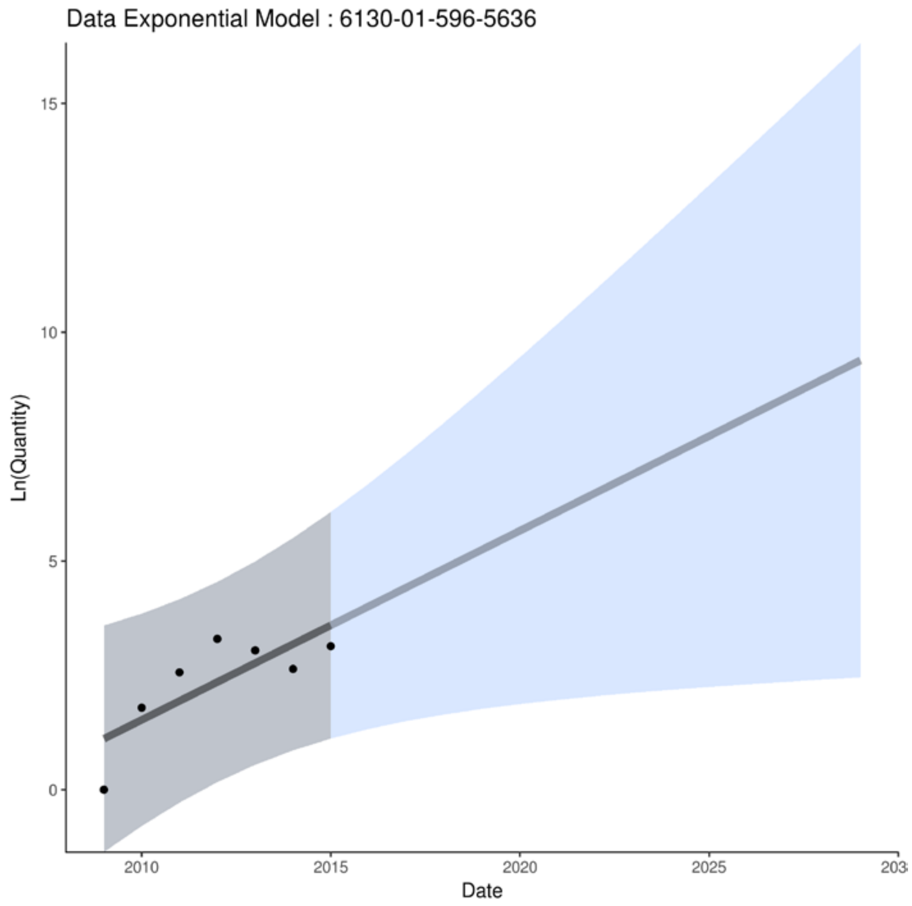
Results – Data Exponential



Data Exponential model forecast mode (in logarithmic units). Points represent actual data and solid line represents the expected outcome. The red shaded zone represents the 95% level prediction interval.

Results – Linear Lifetime buys

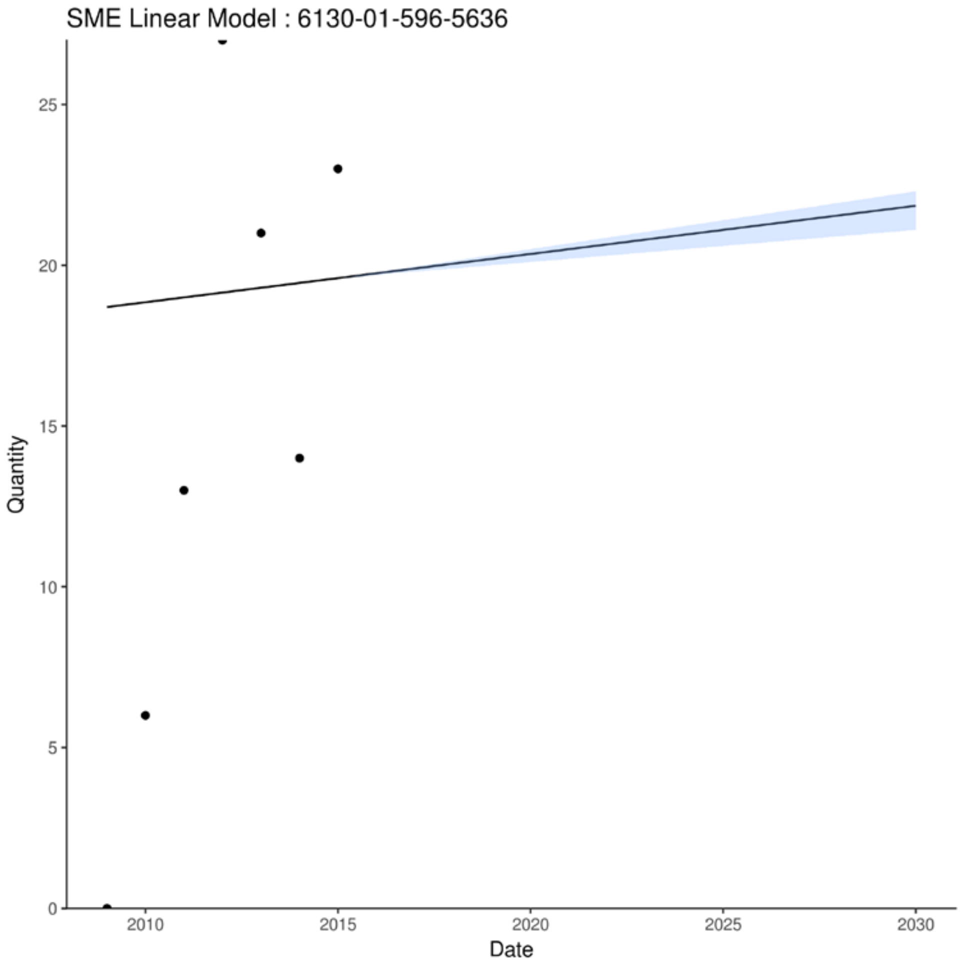
SME Models

NSN	Low	Expected	High
6130-01-596-5636	326	332	335
7025-01-567-4461	332	338	342
5895-01-574-2109	210	214	219
6685-01-567-2854	92	98	102
6140-01-596-7734	166	172	178

Data Models

NSN	Low	Expected	High
6130-01-596-5636	10	60	109
7025-01-567-4461	21	45	68
5895-01-574-2109	3	23	44
6685-01-567-2854	-9	18	45
6140-01-596-7734	4	19	34

Results – SME Linear



SME Exponential model forecast mode (in logarithmic units). Points represent actual data and solid line represents the expected outcome. The red shaded zone represents the 95% level prediction interval.

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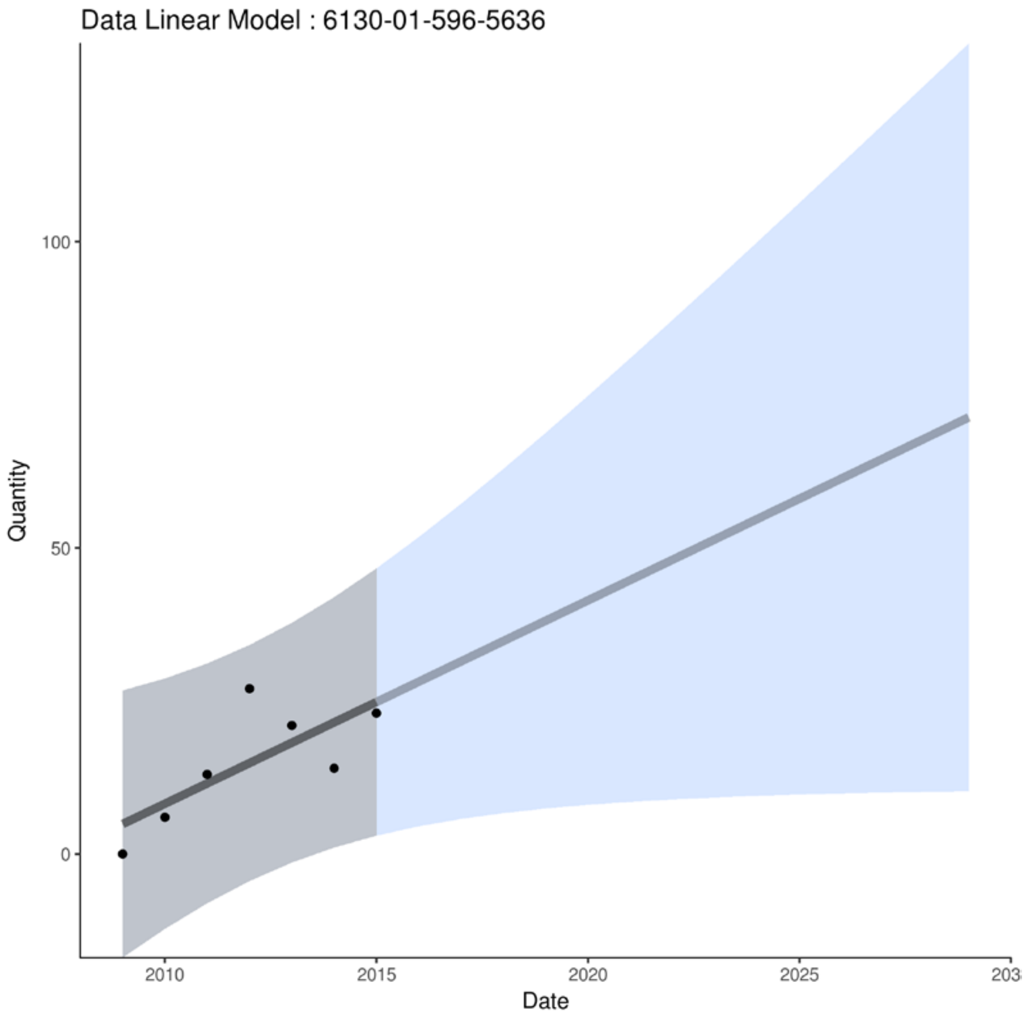
Results – Data Linear



Data Exponential model forecast mode (in logarithmic units). Points represent actual data and solid line represents the expected outcome. The red shaded zone represents the 95% level prediction interval.

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Conclusion

- Legacy System cost estimate is required in the FAA by the OMB.
- Forecasting demand in the FAA has several challenges:
    - Supply chain system doesn't track the data needed to calculate the MTBF.
    - Alternative demand data is costly to gather and still low fidelity of information.

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Conclusion - Results

- Results
  - Ability of the data driven models to explain variances (R^2) performed relatively the same.
  - THE SME parameters were under the data driven estimates for exponential growth while over the data parameters for the linear growth case.
  - SME models had tighter prediction intervals than the data driven model.

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Recommendation

- Recommended approach:
  - Combine statistical projections from historical data with constraints provided by subject matter experts to estimate failure growth trends. Use weighted-average approach.
  - Limit annual failures by expected inventory turnover
  - Focus on few parts which drive overall sustainment costs for legacy case
- For this business case we used statistical fit curves based on historical data for our failure projections
  - Limited the maximum failure rates to complete inventory turnover in 3 years, based on SME projections
  - Some exceptions – batteries and proprietary parts