Improving Inventory Management through Process Enhancement

IE3100R/IE3100M Systems Design Project | Department of Industrial Systems Engineering and Management

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Company Background

SIAEC provides aircraft maintenance, repair and overhaul (MRO) services to over 80 international airlines together with its 24 joint ventures and subsidiaries across eight countries. Our group has been working with SIAEC to improve their spares inventory management process.

Project Objectives

To reduce the chances of Aircraft–On-Ground (AOG) incidents by developing a system that uses historical data to generate forecasts of the monthly requests for rotable spare parts.

Problem Overview

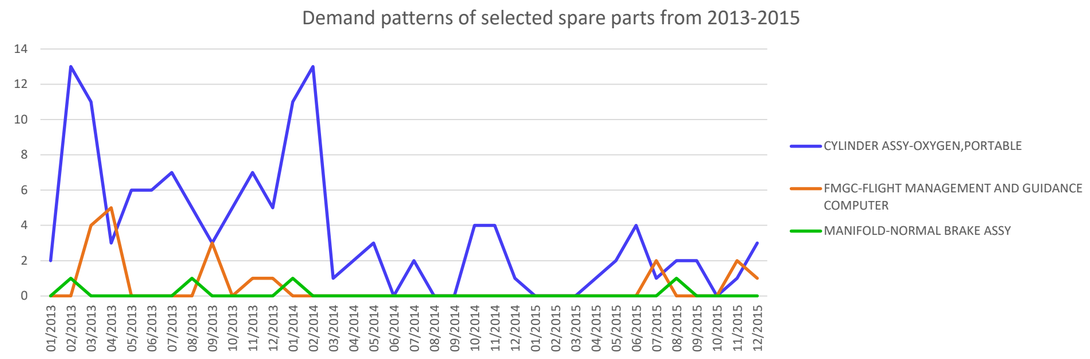
The occasional shortage of spare parts upon request can hinder the work process to a large extent, as aircraft checks must follow procedure and cannot proceed without completing the previous tasks. In the event where a replacement is required but there is no stock available in inventory, the company has to source for replacements causing further delays.

Significant losses are incurred in the form of:
- Higher costs for ad hoc purchase requests
- Penalty from customers
- Congestion in hangars due to delays, impeding the checks of incoming aircrafts
- Loss of goodwill and negative impact on company image
- Loss of competitiveness in offering future contracts to potential clients

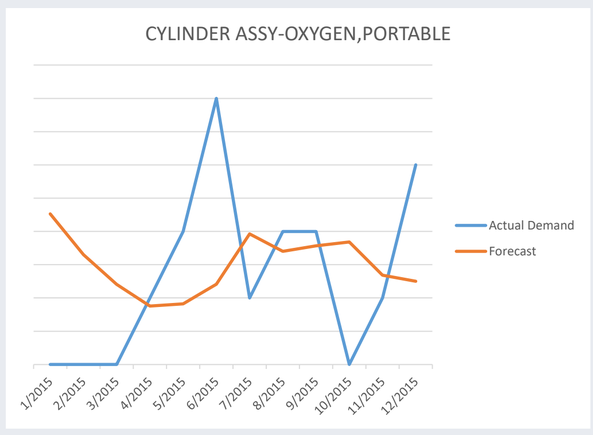
Solutions

The demand for spare parts can be low or intermittent (occurring at irregular intervals), as seen for the selected spare parts in the following graph.
Thus, we used 3 methods designed to handle such demand patterns:
1) Simple Exponential Smoothing
2) Croston's Method
3) ARIMA

Subsequently, the 3 methods were aggregated into a final forecast using a Combined Non-Linear Program.

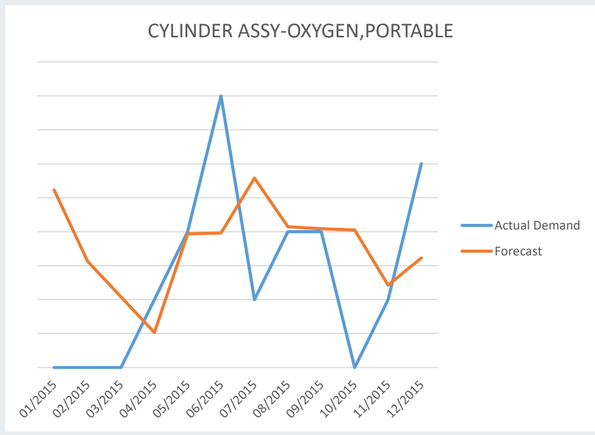


Simple Exponential Smoothing (SES) is a method that aims to remove random variation from historical demand with the use of a smoothing parameter α.



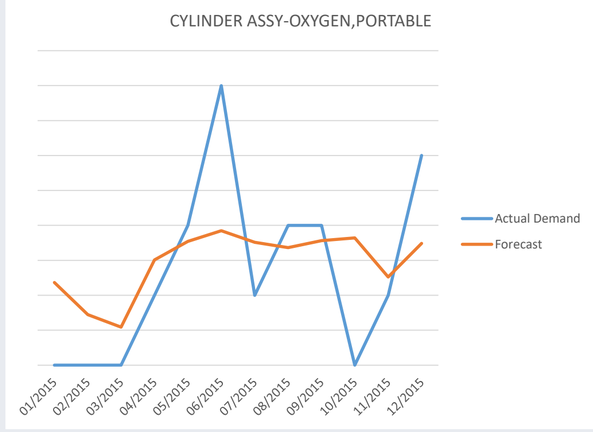
MSE = 2.16

Croston's Method is a popular method for dealing with intermittent demand patterns. A Linear Exponential Smoothing (LES) variant was included in the formulation, to account for biasness in the forecast and obsolescence (when a fixed non-zero demand is forecasted across periods of zero demand).



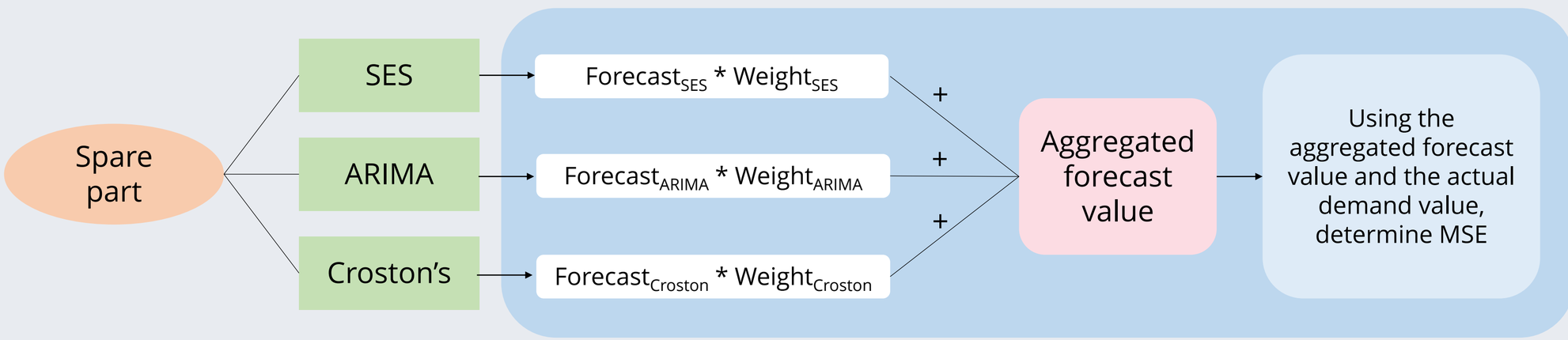
MSE = 1.99

Auto-Regressive Integrated Moving Average (ARIMA) fits a model to a set of time-series data as well as possible.
- "Auto-Regressive": the variable of interest is regressed on its own lagged values
- "Integrated": each data value is replaced with the difference between itself and the previous value
- "Moving Average": the regression error is a linear combination of error terms whose values occurred at the same time and at various times in the past

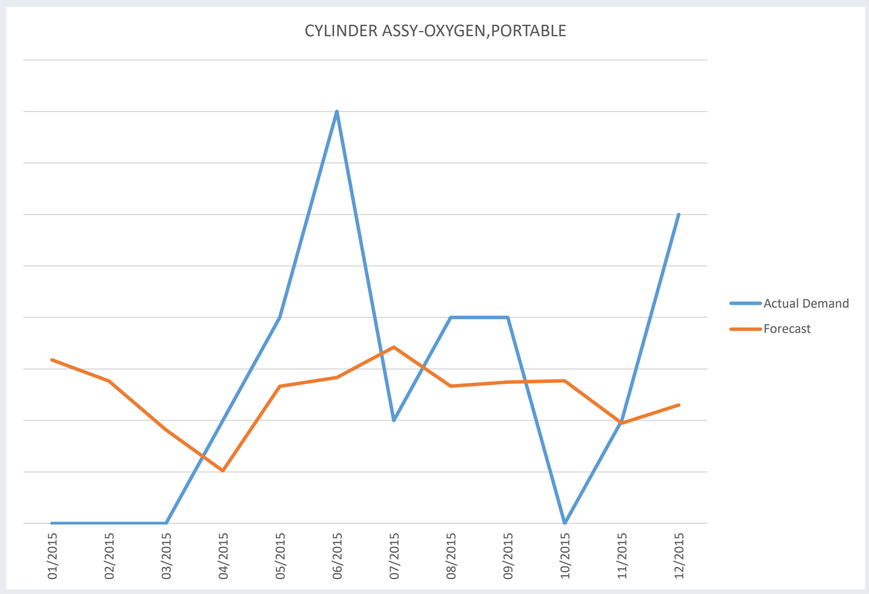


MSE = 1.67

The Combined Non-Linear Program is used to aggregate the results of the three forecasting methods. As there are thousands of spare parts with variations in the demand patterns, it is difficult to determine a single best forecasting method to apply across all parts.
The three methods are thus applied to each spare part, then combined by assigning a weight to the forecast of each method. The value of each weight is determined by a non-linear program, where the objective function is to minimize the mean square error (MSE). For example, for a particular spare part, if a method is more accurate in its forecasts, it will be weighted more heavily than the other methods.



Non-linear program to determine the respective weights for the three forecasting methods, by minimizing MSE



MSE = 1.61

Impact of Project

With the non-linear program to combine various forecasting methods, better forecasts of the monthly requests for rotable spare parts can be generated with lower MSE.

An AOG incident is estimated to cost around USD$10,000 per hour. This sum includes additional airline operating costs, load/reload bags costs, catering costs, and technical costs such as part replacement/repair costs, part shipping costs, and labor costs.

The combined non-linear program is thus suited to produce robust forecasts that will allow SIAEC to improve inventory management and reduce the number of AOG incidents, thereby preventing the company from incurring significant losses.