Optimization Overview

Presented by

Boeing

Regulatory Background

International Maintenance Review Board Issue Paper 44 (IP-44)

- Purpose: To standardize scheduled maintenance program evolution/ optimization across all OEMs.
- Issued by International MRB Policy Board (IMRBPB)… (a team of regulatory authorities: FAA, EASA, TC,…)
- Mandated to all OEM ISC/MRB process
- Issued: April 25, 2008
- Effective: April 2009

IP44 Guidelines Overview

1.0 Introduction

- **This guidance shall be applied for evolution / optimization activities … after April 2009.**
- **The OEM/TCH Evolution/Optimization process does not assume any operation control over an operator's maintenance program**

3.0 Comprehensive data

- **In-service data both scheduled and unscheduled maintenance findings related to the intent of the MSG-3 task should be evaluated.**

4.3 Data Format

- **The OEM/TCH shall utilize in-service data in a standardized format (ATA SPEC2000 Chapter 11 format or equivalent)…**

7.2 Statistical Analysis

- **OEM/TCH shall develop and implement a statistical analysis system to provide justification that a 95% level of confidence has been achieved …**

- **Statistical analysis should be supported by engineering judgment.**

SASMO Development

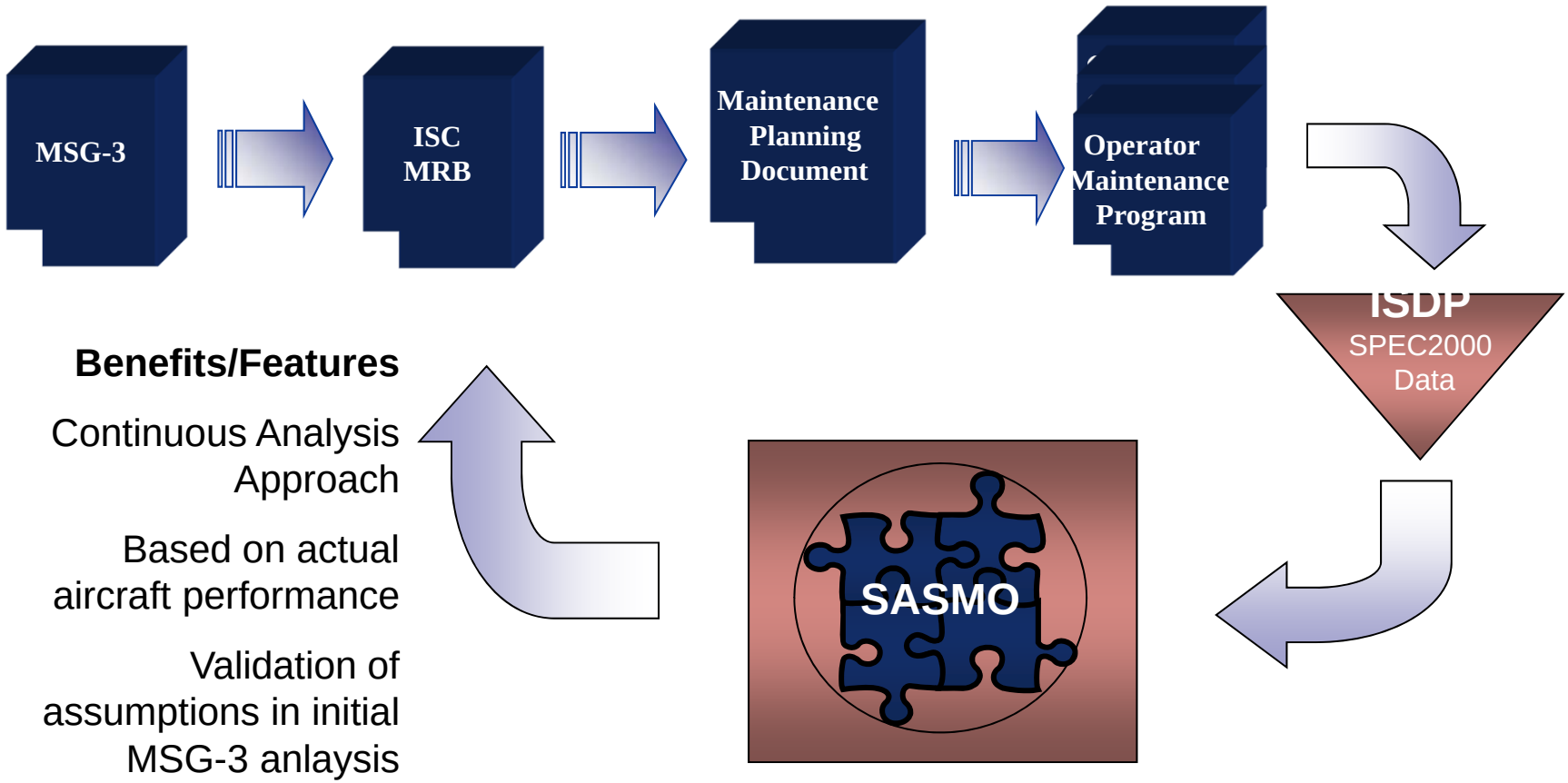
- Boeing Research and Technology team
  - Developed Advanced Predictive modeling techniques (statistical analysis)
  - Extensive Peer Review by experts in statistics and reliability analysis
- Boeing Maintenance Engineering
  - Developed Task Analysis Methodology
  - Developed SASMO Program Interface
  - Regulatory and ISC engagement
- Boeing CAS IT
  - Infrastructure and database design
  - SASMO Integration with other Boeing resources
- Industry Participation
  - Pilot program with 737NG operators
  - Industry Input by ISC members

Regulatory Engagement

- Concept review with FAA AFS-302 and AEG

- Accepted as a solution for Task Evolution Optimization by multiple regulatory (meeting IP-44 Guidelines)
- Methodology and Procedure described in Policy and Procedure Handbooks (PPH) for multiple Boeing models

SASMO Analysis Process



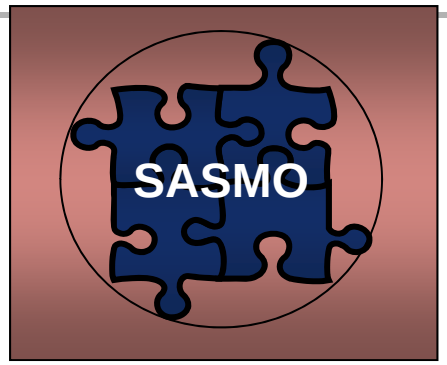
Benefits/Features

Continuous Analysis Approach

Based on actual aircraft performance

Validation of assumptions in initial MSG-3 anlaysis

Components of SASMO Analysis



SASMO Analysis is composed of three major components

- Operator In-Service Data
- Boeing MPE Analysis
- Boeing Design Community

Operator In-Service Data

Data Collection

- Operator In-Service data is the most important component of Optimization/Evolution using SASMO
  - SASMO requires data to be provided in a ATA Spec2000, Chapter 11 format (or equivalent)
    - Industry developed standard for data transmittal/collection
    - Specification contains 243 separate data elements
    - SASMO requires 8 of the fields to be used for analysis (S/N, Date, Finding, etc.) – Remainder is optional

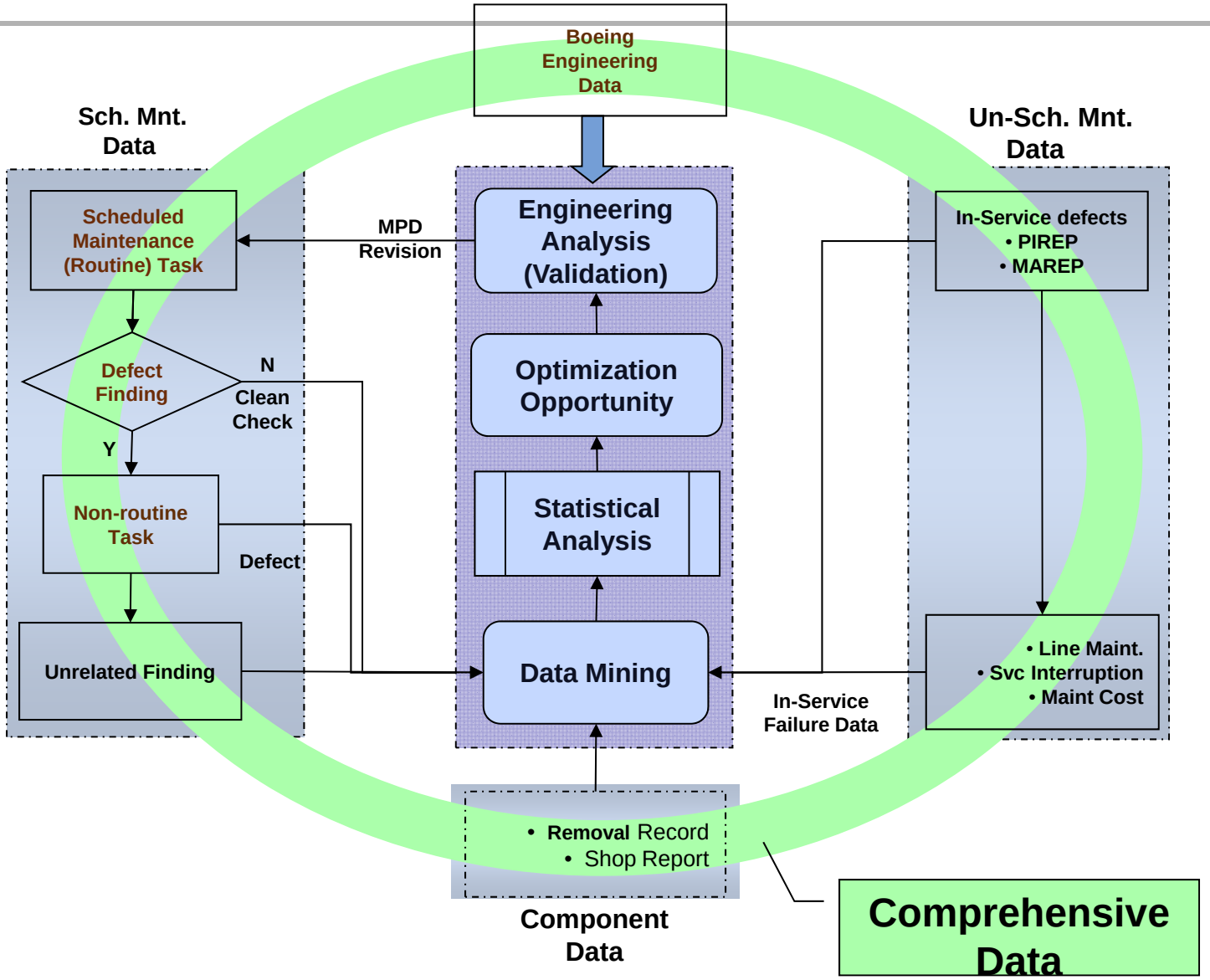
Importing Data in SASMO

- **Operator Data comes into SASMO via two methods:**

1. Operator data feed via ISDP (preferred method)
   - Requires operator participation in ISDP (In-Service Data Program)
   - Scheduled & Unscheduled maintenance data
   - Continuous data stream
2. Manual Entry using Standard excel format
   - Temporary approach until operators convert to automated Spec2000 feed
   - On-demand data feed (based on ISC)
   - Standard electronic format
   - Conversion to Pseudo-SPEC2000 format by Boeing MPE (Sch Maint. Data only)

Boeing MPE Analysis

Analysis Overview



Part Mapping

- **The part mapping process is what determines what data is used in the SASMO Analysis (pre-analysis)**
- **The MSI/SSI/LHSI described in the analysis will be used for part mapping**

Task Type	Part Mapping Definition
Systems	Maintenance Significant Item (MSI) Failure Cause
Structures	Structurally Significant Item (SSI)
Zonal	Precluded SSI/MSI Inspection Requirements
L/HIRF	Lightning/High Intensity Radiated Field Significant Item (LHSI)

Data Mining

For MSI/SSI/LHSI maintenance records are text mined from Operator data

Scheduled Maintenance

- *Structured Data*
- Scheduled Mx Task Performance
- *Text Analytics*
- Performance of other scheduled maintenance tasks

Unscheduled Maintenance

- *Structured Data*
- Component Removals
- Delays and Cancellation
- *Text Analytics*
- Component Removals
- Logbooks
- PIREP/MIREP
- Delay's and Cancellations
- Shop Reports

Engineer Review

- **MPE Engineer reviews all findings**
  - Determine applicability and severity of finding
  - Determine specific component/part involved (if possible)

- **Each record is categorized in one of four ways**
  - Not Applicable
  - Minor
  - Significant
  - Non-Failure

Examples Risk / Opportunity

Structures

Opportunity	Risk
Latent defects, structural dents/scratches (accidental damage), level 1 corrosion	Functional failures, major repairs, level 2 corrosion or any finding which has a significant economic / airworthiness impact on the operator.

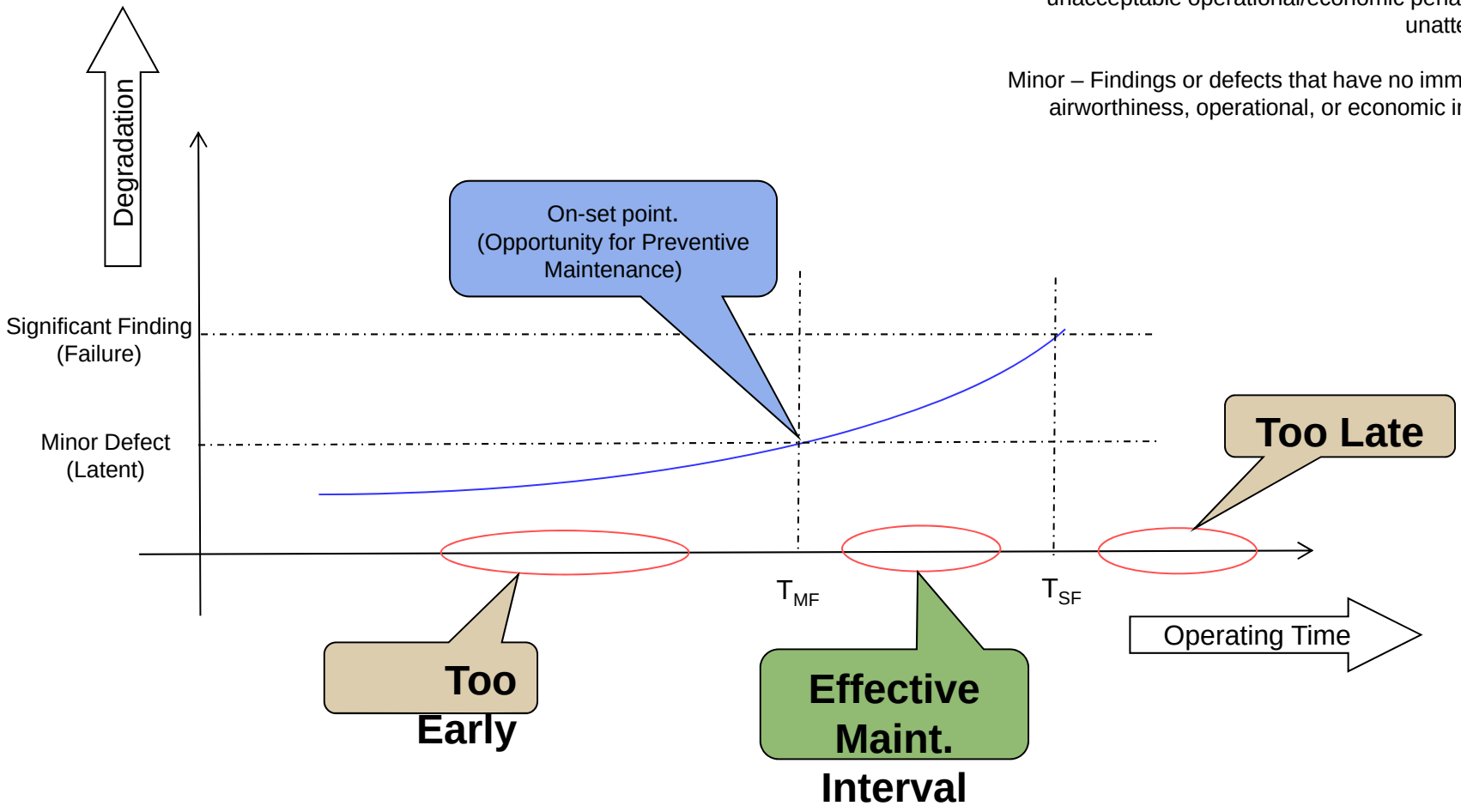
Zonal

Opportunity	Risk
Structural dents/scratches, level 1 corrosion, damage to support structure such as brackets, dust build up	Visibly damaged of failed wiring (EZAP only), SSI damaged exceeding SRM limits, corrosion level 2, precluded system item failure.

SASMO Approach

Significant – Findings that would result in potential reduction in airworthiness, or lead to unacceptable operational/economic penalties, if unattended.

Minor – Findings or defects that have no immediate airworthiness, operational, or economic impact,



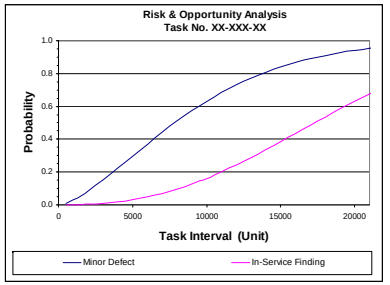
Lifetime Measurement

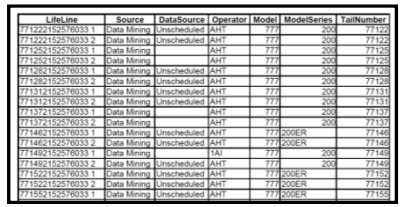
- **SASMO uses a series of algorithms and statistical methodologies to determine probability of T_{MF} and T_{SF} for each task**

Operator In-Service Data

•Reliability Distribution Models

•Confidence Analysis



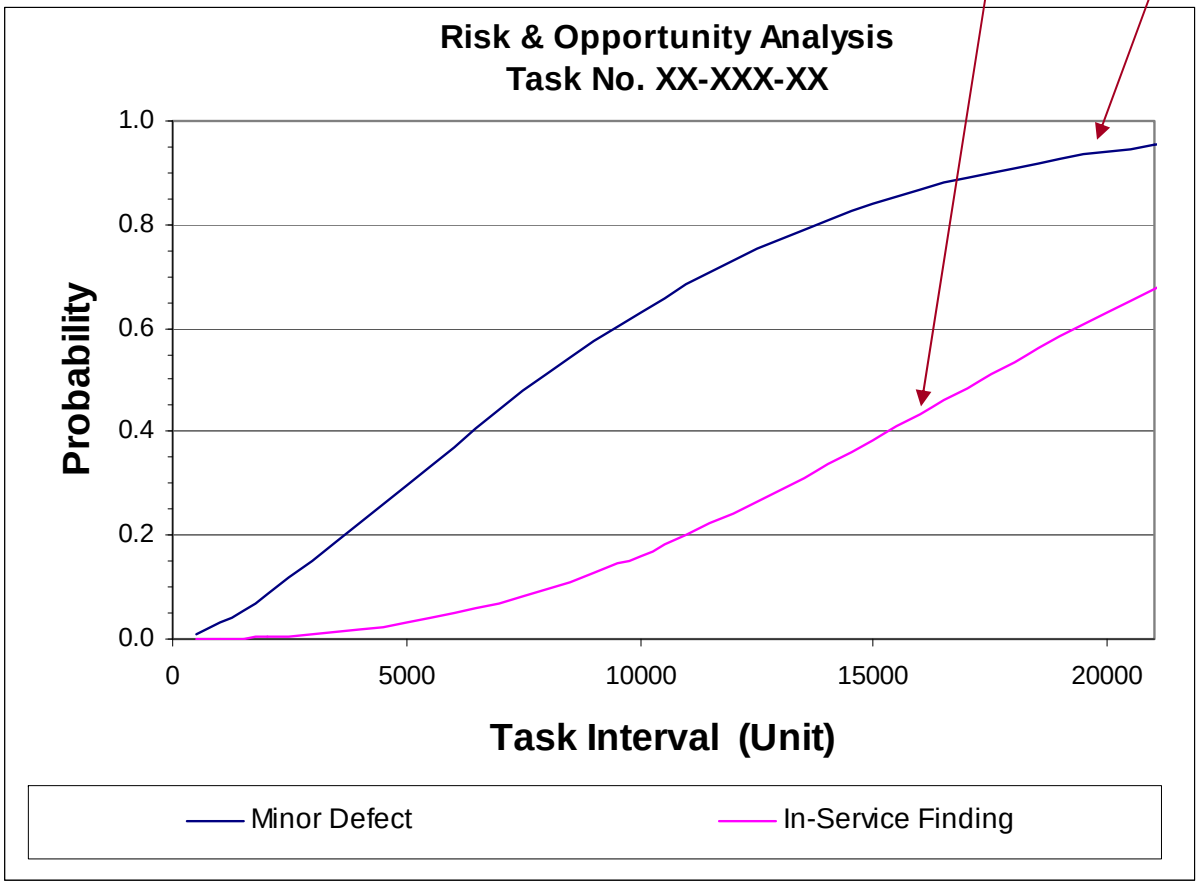


LifeLine	Source	DataSource	Operator	Model	ModelSeries	TailNumber
771222152576033 1	Data Mining	Unscheduled	AHT	777	200	77122
771222152576033 2	Data Mining	Unscheduled	AHT	777	200	77122
771252152576033 1	Data Mining		AHT	777	200	77125
771252152576033 2	Data Mining		AHT	777	200	77125
771282152576033 1	Data Mining	Unscheduled	AHT	777	200	77128
771282152576033 2	Data Mining	Unscheduled	AHT	777	200	77128
771312152576033 1	Data Mining	Unscheduled	AHT	777	200	77131
771312152576033 2	Data Mining	Unscheduled	AHT	777	200	77131
771372152576033 1	Data Mining		AHT	777	200	77137
771372152576033 2	Data Mining		AHT	777	200	77137
771462152576033 1	Data Mining	Unscheduled	AHT	777	200ER	77146
771462152576033 2	Data Mining	Unscheduled	AHT	777	200ER	77146
771492152576033 1	Data Mining		1AI	777	200	77149
771492152576033 2	Data Mining	Unscheduled	AHT	777	200	77149
771522152576033 1	Data Mining	Unscheduled	AHT	777	200ER	77152
771522152576033 2	Data Mining	Unscheduled	AHT	777	200ER	77152
771552152576033 1	Data Mining	Unscheduled	AHT	777	200ER	77155

Statistical Analysis

Risk Analysis Chart

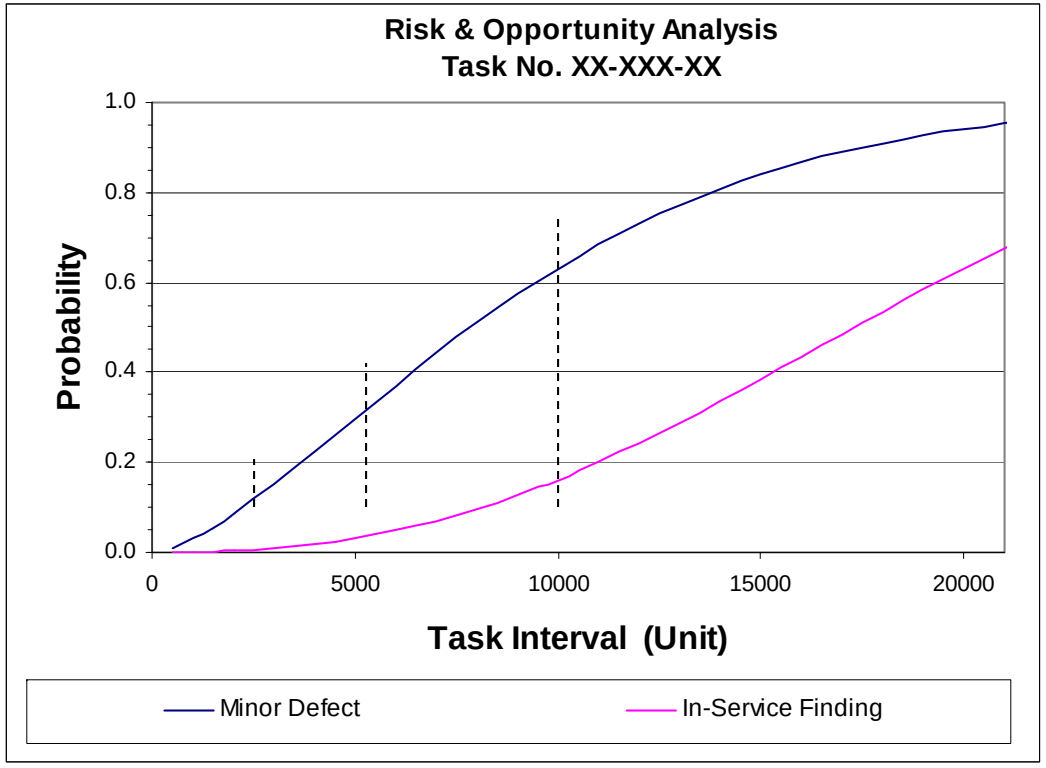
- **Probability of capturing defects during schedule maintenance. (Opportunity)**
- **Probability of significant finding or in-service failure (Risk)**



Interval Selection

Typically, an interval is a tradeoff between the opportunity and risk

- **As Opportunity increases, Risk increase (though not at the same rate)**
- **As Risk decreases, opportunity decreases**
- **<u>Proper interval selection is a balance between these factors</u>**



Interval	Opportunity	Risk
2500	10%	1%
5000	31%	4%
10000	68%	15%

SASMO Statistical Analysis

- **SASMO purpose is to provide statistical analysis to aid in selection of an appropriate and effective maintenance interval.**

- **SASMO does not select an interval (There is no “SASMO number”)**

Interval Selection

- **Interval selected is performed using information in the risk analysis chart. Interval will be selected which:**
  - minimizes the likelihood of “significant findings” such as functional failure, major repairs, level 2 corrosion or any finding which has a significant economic or airworthiness impact on the operator.

  -AND-

  - allows for capturing and rectification of “minor findings” such as latent defects, structural dents/scratches, level 1 corrosion, etc.
- **Interval selected will be corroborated and supported by Boeing Design Engineering.**

Interval Selection

The following guidelines are used as a starting point in determining an interval selection. The probability of significant findings is the primary factor considered.

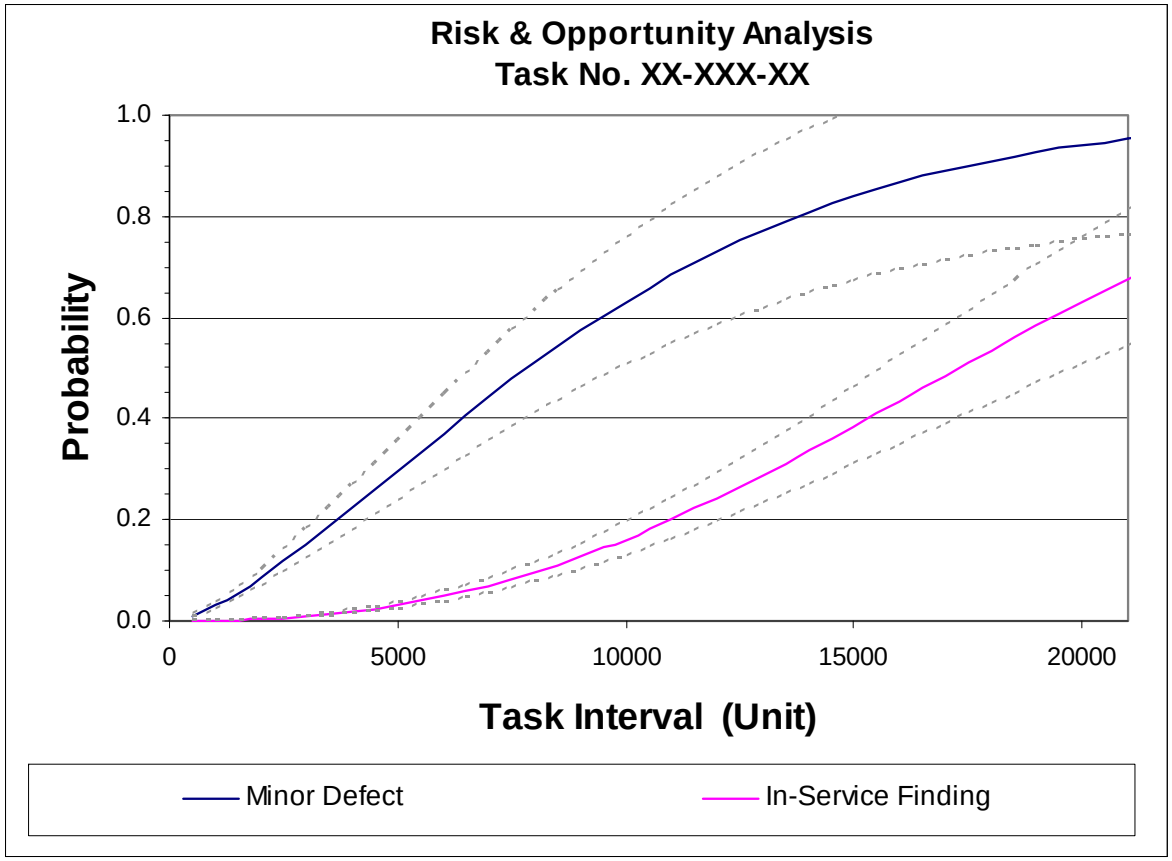
Task Type (FEC)	Standard Risk Profile (Opportunity / Risk)
Safety (5, 8, S)	40% / 10%
Operational (6)	50% / 20%
Economic (7, 9)	60% / 30%

If the Minor Finding probability is high, this represents a long exposure time to latent defects, which depending on the system being analyzed, can lead to increased repair costs and potential for in-service issues.

Confidence Level Analysis

Confidence level is a measure of uncertainty. The level of uncertainty (a.k.a. confidence bound) depends on the sample size and variability of the data.

- **SASMO calculates the 95% confidence bound (lower and upper bound) as shown (uncertainty zone)**
- **Calculated separately for Minor Defect and Significant Defects**



95% Confidence

- **IP-44 Requirement:**
  - OEM/TCH shall develop and implement a statistical analysis system to provide justification that a 95% level of confidence has been achieved for the Evolution /Optimization exercise on a task by task basis.
  - “Confidence level refers to the likelihood that the overall fleet performance lies within the range specified by the sample fleet performance.”
  - “For example, a 95% confidence level implies that the probability that the fleet parameter lies within the confidence interval is 95%.”

Confidence Level Analysis

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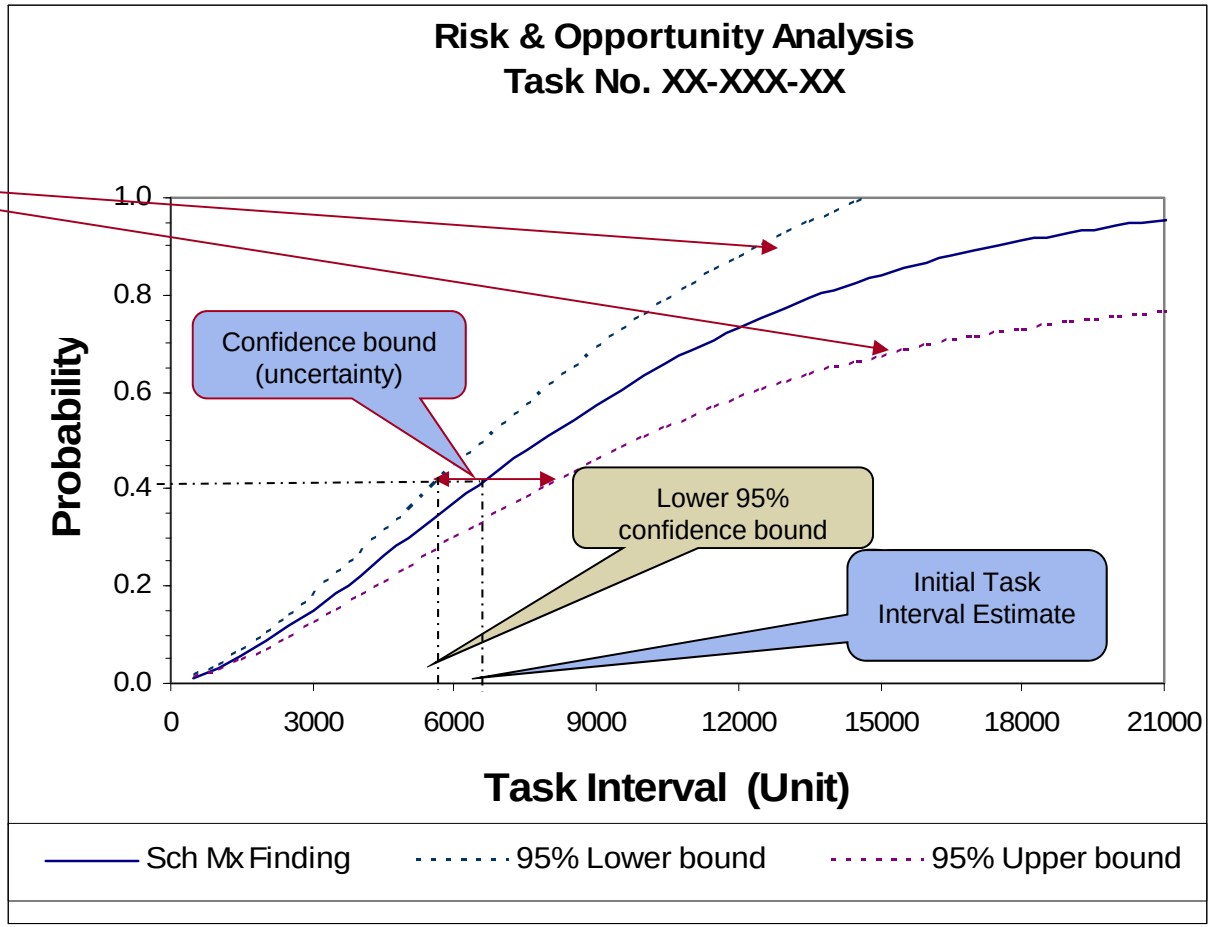


Investigating Factors Affecting the Interval

- **SASMO produces charts with regards to several factors that might influence the optimum interval:**
  - Aircraft age
  - Operating Region/Environment
  - Fleet distribution of the data collected

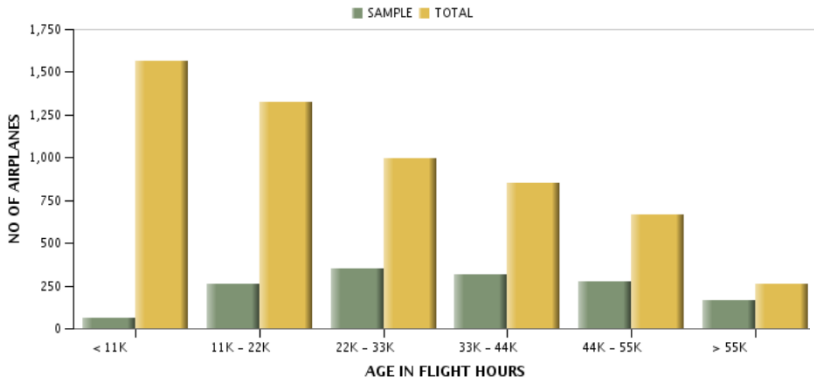
Final Recommendation

- **MPE Engineers analyze each task and develop a recommendation taking into account:**
  - Review of In-Service Data
  - Verifies appropriate sample of Regions/Operators
  - Statistical Analysis Output
  - MSG-3 Analysis
  - Review of Service Documents (SB, AD, FTD, etc)

Sample SASMO Summary Report

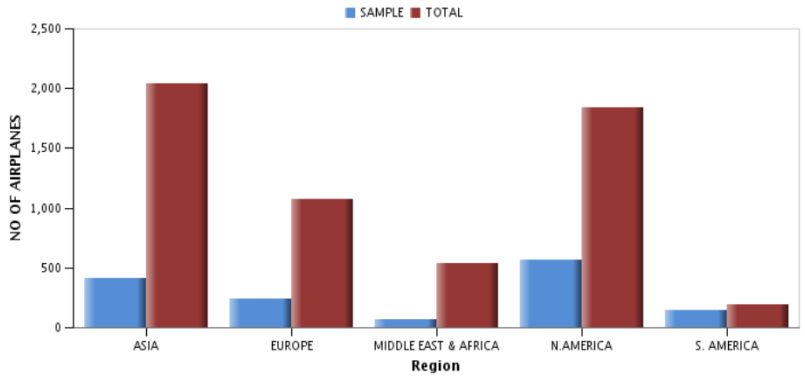
AGE SAMPLE SIZE

Model No: 737-678 Task.No: 21-020-00



REGION SAMPLE SIZE

Model No: 737-678 Task.No: 21-020-00



Data Summary	
Fleet Size	5682
Total Hrs Accumulated	62,850,948
Evaluation Period	Nov-2010 Nov-2016
No. of Operators Reviewed	45
No. of Aircraft Reviewed	1430
Scheduled Checks	1280
Scheduled Checks with Findings	2
% of Checks with Findings	0
Unsch. Maint. Between Checks	204
Fleetwide Unsch. Maint	781
Non-Failure Removals	560

Summary of Findings

SERVICE DOCUMENTS:
No service document impacted this analysis.

SCHEDULED MAINTENANCE:
The majority of the scheduled maintenance are clean check. The only scheduled maintenance that was not a clean check is related to E/E cooling exhaust fan. (E/E cooling exhaust fan and E/E cooling supply fan shares the same P/N)

UNSCHEDULED MAINTENANCE:
The majority failure found in unscheduled maintenance are fan failure due to low flow, overheat, and inop/unsatisfied. The fan failures are mostly caught by low flow indicating lights and low flow warning horns.

Minor findings are bad relays, clogged filters, and troubleshooting.

Non-failure/not applicable findings consists of primary/alternative exhaust fan failure and part robs/swaps.

Analysis Results	Current Interval		Significant Quantile: 30 Minor Quantile: 60 Statistical Interval (at 95% Confidence Level)		Recommended Interval	
	Threshold	Repeat	Threshold	Repeat	Threshold	Repeat
Interval	8000 FH	8000 FH	19733 FH	19733 FH	16000 FH	16000 FH

Confidence Level Analysis

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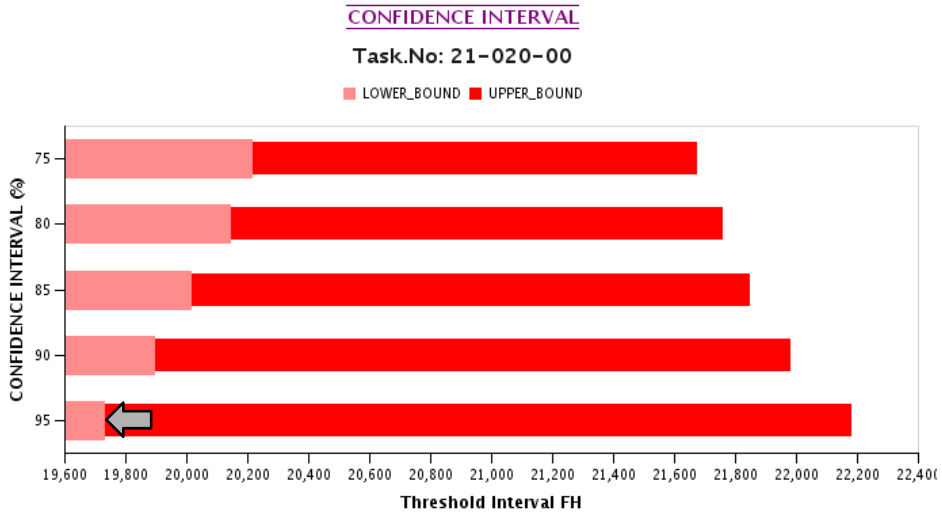

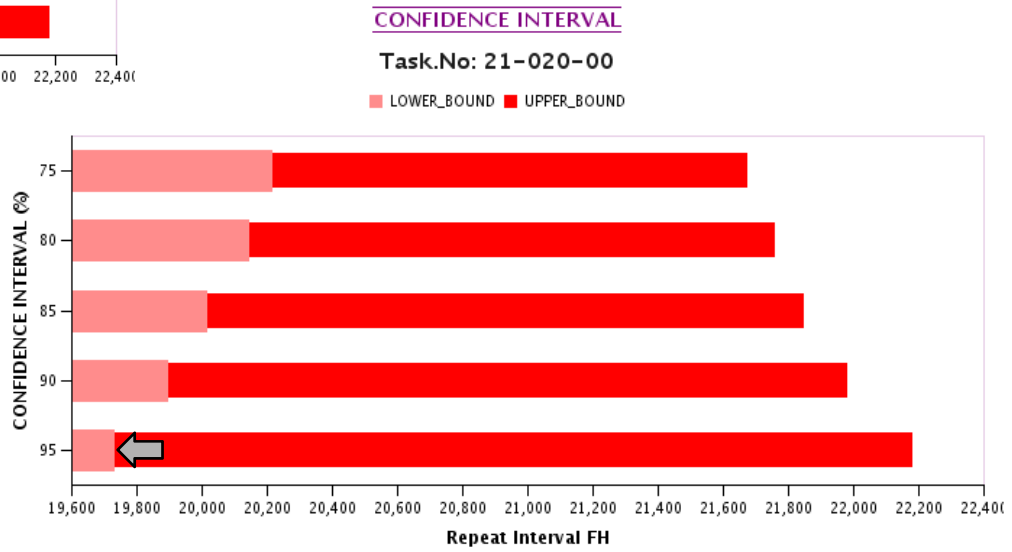

Unsch. Maint. Between Checks

- **The total number of unique unscheduled maintenance findings used in the analysis for airplanes which have relevant schedule maintenance data used in the analysis.**

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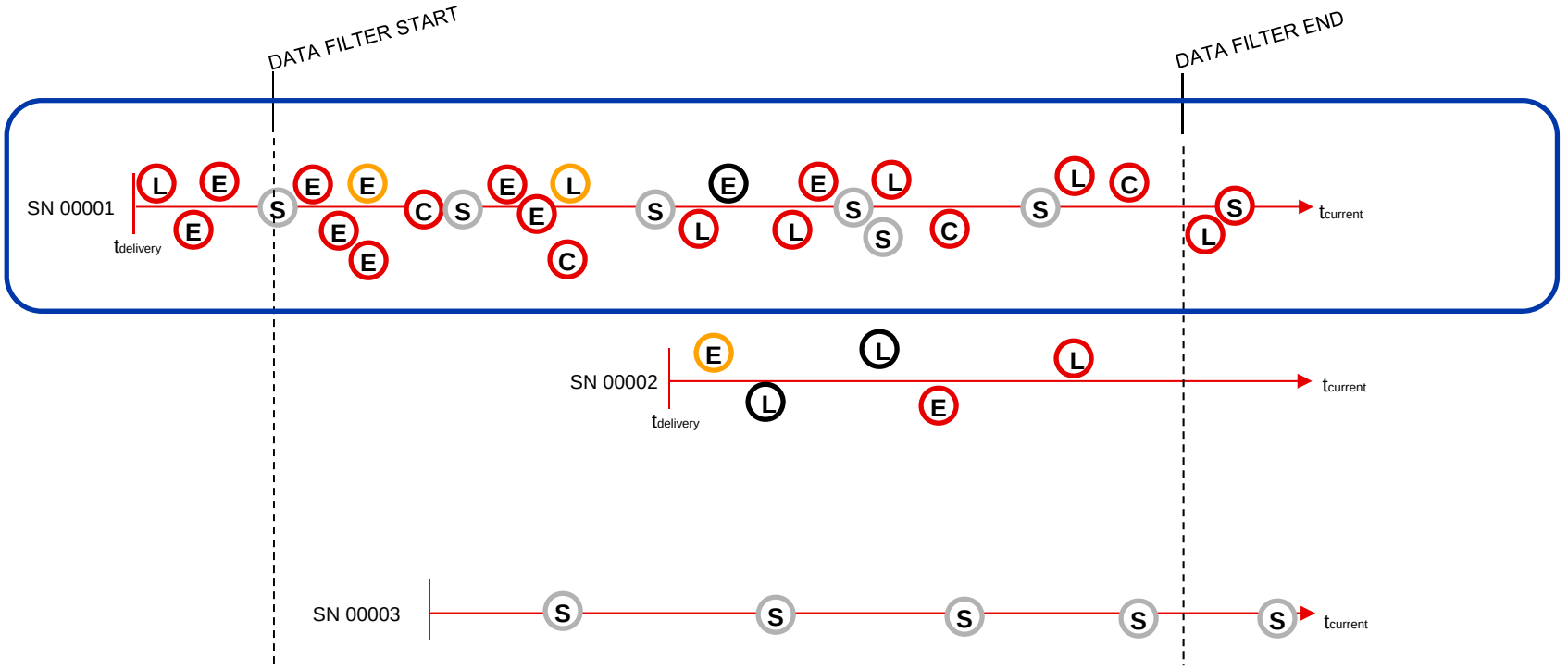

Fleetwide Unsch. Maint.

- **The total number of all unique unscheduled maintenance within the analysis evaluation period used in the analysis**

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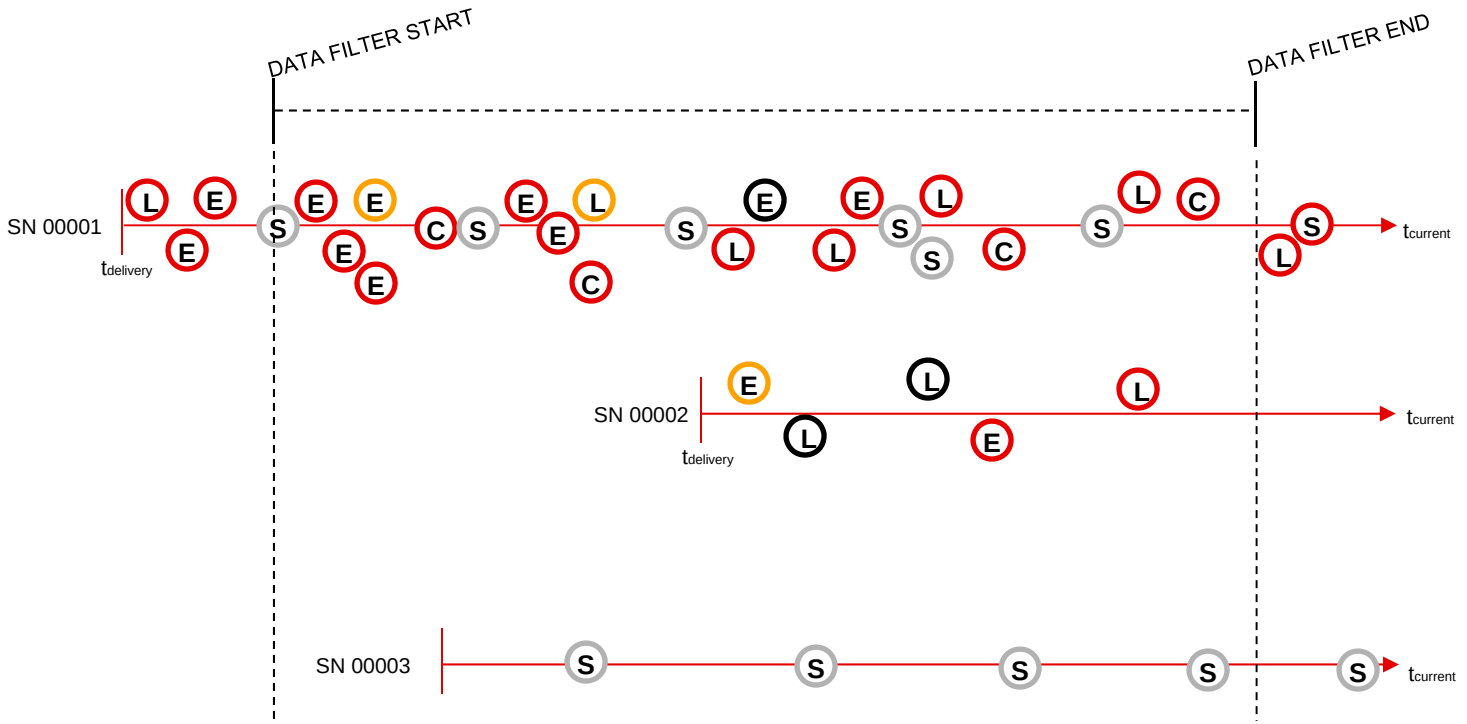

Design Community Review

Boeing Engineering Community Review

- **Each task recommendation is reviewed by the Boeing design community**
- **This community review consists of**
  - If new recommendation is within certification requirements such as System Safety assessment (SSA), Supplement Inspection Program, FAR 26
  - Address any “emerging” fleet issues which may not be present in the fleet data used in the statistical analysis
  - Overall concurrence and support of the proposal

Summary

- **Interval recommendation is based on statistical analysis and evaluation of in-service data**
- **Proposal is Reviewed and Accepted by ISC**
- **MRB Chairman approves the document before publishing**


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