

Environmental operating context and its impacts on maintenance schedule and cost.

Key benefits

- ▶ Standardised approach to defining and describing operating environment
- ▶ Consistent framework for applying impact of environment to maintenance cost
- ▶ Rapid generation of trade-studies for understanding emergent scenarios

Key features

- ▶ Taxonomy of environmental factors
- ▶ Defining the sensitivity of a system to environmental factors
- ▶ Identifying overall differences in operating environment strengths
- ▶ Scaling maintenance estimates to understand potential costs

The Problem: The environmental context in which a system operates ('Operating Environment') is a major variable that can impact upon the likelihood and timing of potential system failures. As sustainment represents up to 80% of the total ownership cost of a system, it is necessary to understand the potential impact of an Operating Environment/s on the specific maintenance requirements of a system and optimise the design accordingly.

The Solution: MADe allows the user to describe Operating Environments based on the conditions that may reduce or extend a system's life (environmental factors) to calculate an Environmental Scaling Impact (ESI). The system of interest is analysed in terms of its sensitivity to environmentally induced failures (which factors will impact most greatly on the systems reliability and supportability costs?) and the characteristics of the defined Operating Environment (which factors are present, and to what degree) to adjust identified maintenance requirements.

Maintenance informed by operational use case

Name	Rating
Acceleration	Medium (5)
Electromagnetic Radiation	High (6.5)
Gaseous Contamination	Medium (5)
Humidity	Low (3.5)
Liquid Contamination	Medium (5.5)
Nuclear Radiation	Medium (5)
Pressure	High (7.5)
Shock	Medium (5.6)
Solid Contamination	Low (3)
Temperature [Low Temperature]	Very High (9)
Vibration	Low (3)

Figure 1: Operating environments are defined through their taxonomy of factors.



Where in the system lifecycle Environmental Scaling be applied?

Understanding the the impact of Operating Environments on maintenance costs will inform engineering and management decisions throughout a system's lifecycle:

- ▶ Product Acquisition – vetting competing products against standardised operating environments.
- ▶ Conceptual Design – early identification of high maintenance cost systems and sub-systems that should be targetted for redesign.
- ▶ Maintenance and Logistics Planning – trade-studies on operating costs to compare against contractual or internal targets.

How does this compare to traditional approaches?

The process of estimating system maintenance costs varies extensively depending upon the industry, engineering domain, and organisational maturity of the OEM. Utilisation of the Environmental Scaling Impact in a systems engineering process presents a consistent framework and method for defining operating environments and transparently adjusting the maintenance costs of the system due to changes in environmental conditions.

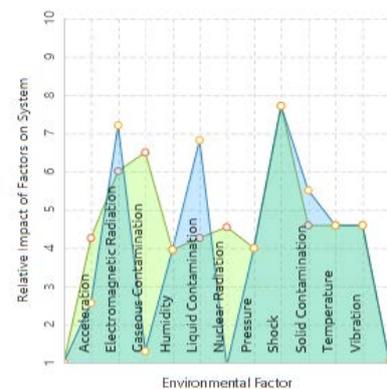
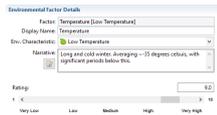


Figure 2: Comparative analyses of operating environments and the contributing factors.

How MADE considers environment in context of analysis

Comparison of overall environmental impact

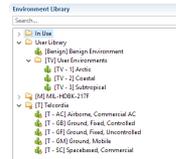
Create Environment



Define System Sensitivity

Electromagn...	General Co...	Humidity
Acceleration	Equally As	Equally As
Electromagne...	Moderately	Equally As
Acoustic Cont...		Marginally
Humidity		

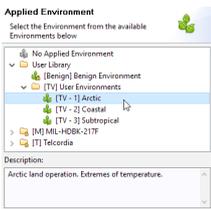
Save Environments in Library



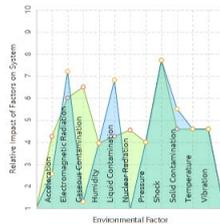
- 1) Describe multiple potential Operating Environments using the MADE taxonomy.
- 2) Define the relative impact of environmental factors on a system.
- 3) Operating Environments are saved in the application library.

Apply scaling impact to Maintenance Cost Estimates

Apply Environment



Compare Scenarios



Generate Cost Estimates

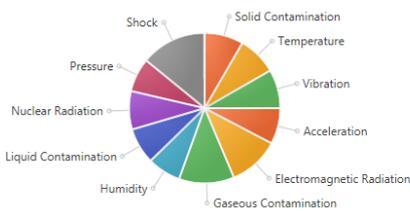
Name	Total cost	Cost per hour
APC Platform	\$2,742,348.41	\$7.82
Diesel Engine	\$797,196.12	\$2.59
Driveline System	\$389,108.94	\$1.12
Electrical System	\$12,289.58	\$0.04
Fire-Suppression System	\$83,483.33	\$0.24
Fuel Storage	\$221,204.23	\$0.63
HVAC System	\$418,478.41	\$1.19
On-board Computer System	\$7,788.38	\$0.02
Sensor System	\$576,782.26	\$1.64
Weapon System	\$230,698.13	\$0.66

- 1) Select baseline and applied Operating Environments to the system.
- 2) Compare overall impact on the system.
- 3) Maintenance costs are scaled based upon the relative strength of the applied environment.

Features of the Environmental Scaling Impact capability

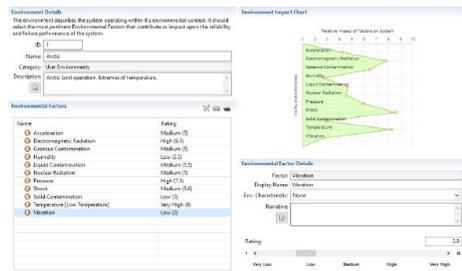
System sensitivity to environment

Relative Sensitivity to Factors



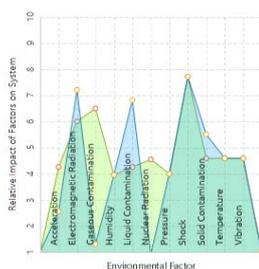
Which environmental conditions is the system prone to?

Operating environment definition



A standardised method for describing an external Operating Environment

Comparison of environments



Identify and mitigate for highly impactful environments.

Scaling maintenance estimates

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Scaling of cost estimates based on overall environmental impact.