# Industrial Cellular VPN Router

## *NR500 Series*

# Failure Rate & MTBF Assessment Report



www.navigateworx.com
sales@navigateworx.com

# 1 Introduction

This document contains the failure rate and MTBF assessment for Industrial Cellular VPN Router NR500 and related P/N based on the same hardware.

# 2 Device Description

NR500 is the most trustable reliable Industrial 3G / 4G router that suitable for different kinds of IIoT applications. It is secure because it meets the toughest industrial standards and has restricted access features required in open networks. The hardware platform of NR500 series is basically the same except the embedded modem.

# 3 MTBF Summary

Predicted MTBF values are shown in Table 1.

| Temperature | Environment | Failure Rate | MTBF (hrs) | Details |
|---|---|---|---|---|
| 30 °C | GB, GC - Ground Benign, Controlled | 296.04 | 337791 | Appendix A |

**Table 1: MTBF SUMMARY**

The detailed analysis contained in Appendix A is available on request and under certain conditions (NDA agreement).

# 4 Reliability Assessment

## 4.1 Mathematical Models

The assessed device is made out of passive and active electronic components. In this particular case, the device structure does not justify to break it down in different sub-assemblies. Some specific parts (battery, gold-cap capacitor) have been excluded of the calculation either because they are normally subject to wear and are easily replaceable items. The optional modem is also excluded from the assessment. These sub-assemblies have been chosen from leading manufacturers to ensure consistent MTBF figures with NR500 Industrial router.

If an element failure rate is constant over time, the reliability for a single series element can be expressed as the following exponential distribution.

$$R(t)_i = e^{-\lambda_i t}$$

where:

$R(t)_i$ = the probability of survival for a single series element for a given operating time $t$
e = the base of the natural logarithm
$\lambda_i$ = a constant representing the ith element failure rate
t = the element operating time

If each exponentially distributed series element is independent, the series system reliability function can be expressed as the following product.

$$R(t)_{series} = \prod_{i=1}^{n} e^{-\lambda_i t}$$

where:

$R(t)_{series}$ = the probability of survival for a series system for a given operating time $t$.
e = the base of the natural logarithm
$\lambda_i$ = a constant representing the ith element failure rate
t = the element operating time

If each element is independent, it can be shown that the failure rate for an exponential distribution series system is the sum of the failure rates of the individual elements.

$$\lambda_{series} = \sum_{i=1}^{n} \lambda_i = \lambda_1 + \lambda_2 + \lambda_3 + \ldots + \lambda_n$$

where:

| | |
|---|---|
| $\lambda_{series}$ | = a constant representing a series system failure rate |
| $\lambda_i$ | = a constant representing the ith element failure rate |
| $\lambda_1$ | = a constant representing the first element failure rate |
| $\lambda_2$ | = a constant representing the second element failure rate |
| $\lambda_3$ | = a constant representing the third element failure rate |
| $\lambda_n$ | = a constant representing the last element failure rate |

and

$$R(t)_{series} = e^{-\lambda_{series} t}$$

where:

$R(t)_{series}$ = the probability of survival for a series system for a given operating time $t$

e = the base of the natural logarithm

= a constant representing the series system failure rate

t = the series system operating time

The mean time to failure ( $MTBF$ ) for an exponentially distributed single element or series system can be determined from the reliability function or, as shown below, directly from the failure rate.

$$MTBF = \int_0^\infty R(t)_i \, dt$$

$$MTBF = \int_0^\infty e^{-\lambda_i t} \, dt = \frac{1}{\lambda_i}$$

$$MTBF = \int_0^\infty e^{-\lambda_{seriessystem} t} dt = \frac{1}{\lambda_{seriessystem}}$$

where:

| | |
|---|---|
| $MTBF_i$ | = the mean time between failure of single series element |
| $MTBF_{seriessystem}$ | = the mean time between failure of the series system |
| $\lambda_i$ | = the constant failure rate of the ith element |
| $\lambda_{seriessystem}$ | = the constant failure rate of a series system |
| $e$ | = the base of the natural logarithm |
| $t$ | = the series system operating time |

For a series system with exponentially distributed elements the, MTBFseries can be expressed as shown below.

$$MTBF_{series} = \frac{1}{\lambda_1 + \lambda_2 + \lambda_3 + \ldots + \lambda_n}$$

where:

$MTBF_{series}$ = the mean time between failure for a series system

$\lambda_1$ = a constant representing the 1st series element failure rate

$\lambda_2$ = a constant representing the 2nd series element failure rate

$\lambda_3$ = a constant representing the 3rd series element failure rate

$\lambda_n$ = a constant representing the nth series element failure rate

## 4.2 Reliability Assessment Details

The results of the failure rate assessments at 30 °C environmental temperatures and 100 % duty cycle respectively are listed in separate documents available on request (subject to NDA agreement).



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