1 Guidance Note on Reliability Of DTS Systems

1.1 Introduction

The purpose of this document is to provide guidance to partners and customers as to the reliability of the Bandweaver FireLaser and T-Laser DTS systems

2 Mean Time Between Failures (MTBF)

One of the metrics of reliability are the MTBF calculations. There are 2 principles that Bandweaver use in calculating MTBF figures.

2.1 MTBF Using Telcordia SR232

Reliability Predictions are often used in product design and development as part of reliability and quality continuous improvements efforts. To perform a reliability prediction analysis, a standard is employed. Each Reliability Prediction standard offers a set of mathematical formulas to model and calculate the failure rate of a variety of electromechanical components that make up a product or system.

These equations were built by analyzing a huge amount of field data over a long period of time. Statistical analysis was then used to determine the equations which best modeled the failure characteristics of the accumulated data.

The variables used in the reliability calculation formulas to calculate component failure rates vary, but include data such as device ratings, temperatures, operating parameters, and environmental conditions. The result of a reliability prediction analysis is the predicted failure rate or Mean Time Between Failures (MTBF) of a product or system, and of its subsystems, components, and parts.

The two most popular global standards are Mil-HDBK-21 and Telcordia SR232

The Bandweaver FireLaser DTS has an MTBF of no less than 255,368 hours (29 years) according to the Telcordia SR232 standard as detailed in a report by Anbotek (2018).

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2.2 MTBF According to field data

Bandweaver has been recording the return and repair data of all DTS systems from 2017 to 2025 (the current generation of FireLaser). The current MTBF is ~560,000 Hrs (64 years) Below you can see the graph of the MTBF data according to this data. This is based on more than 28 million operational hours.

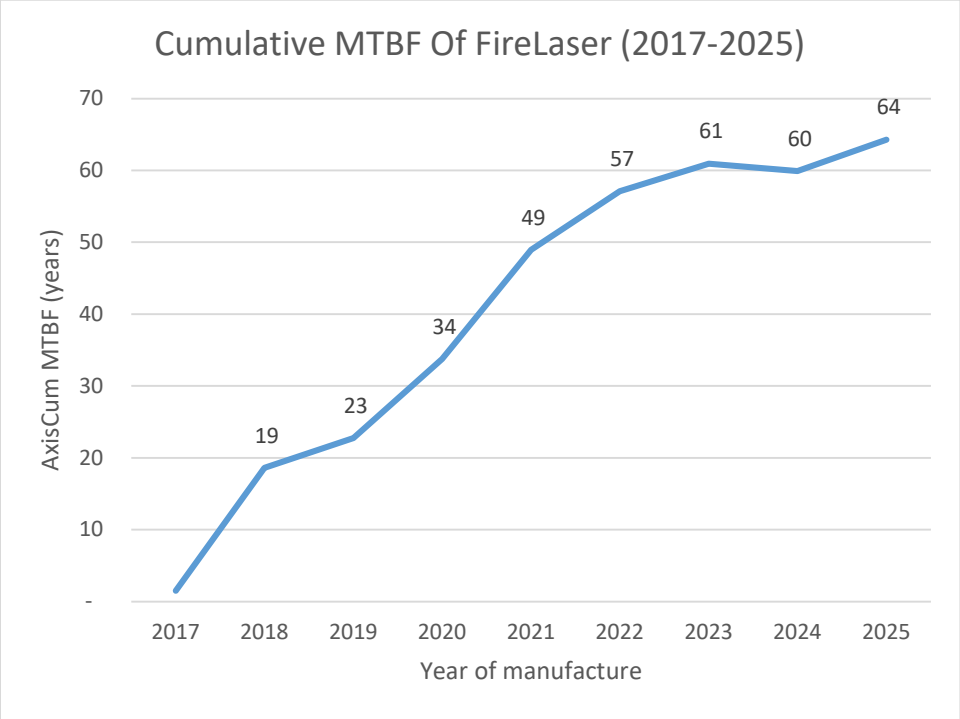

Figure 1 - MTBF data based on operational data (> 25 million hours)

The current MTBF for installed systems is currently at >90,000 hours (>11 years). As you can see from the trend this level is increasing every year and the limiting factor at present is the amount of years the data has been collected. It is anticipated that the MTBF will continue increasing for the foreseeable future.

3 Safety Integrity Level (SIL)/ IEC 61508:2010 / IEC 61511:2016

Safety integrity level (SIL) is defined as a relative levels of risk-reduction provided by a safety function, or to specify a target level of risk reduction. In simple terms, SIL is a measurement of performance required for a safety instrumented function (SIF). SIL levels are typically used in industrial applications where safety and reliability are critical (e.g. petrochemical pipelines).

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The requirements for a given SIL are not consistent among all of the functional safety standards. In the functional safety standards based on the IEC 61508 standard, four SILs are defined, with SIL 4 the most dependable and SIL 1 the least. The applicable SIL is determined based on a number of quantitative factors in combination with qualitative factors such as development process and safety life cycle management.

PFD (probability of dangerous failure on demand) and RRF (risk reduction factor) of low demand operation for different SILs as defined in IEC EN 61508 are as follows:

SIL	PFD	PFD (power)	RRF
1	0.1–0.01	$10^{-1} – 10^{-2}$	10–100
2	0.01–0.001	$10^{-2} – 10^{-3}$	100–1000
3	0.001–0.0001	$10^{-3} – 10^{-4}$	1000–10,000
4	0.0001–0.00001	$10^{-4} – 10^{-5}$	10,000–100,000

Figure 2 - Definition of Safety Inegrity Levels (SIL)

The FireLaser and T-Laser have the following safety integrity levels according to ECM (2021 report)

- SIL Level 2 1 out of 1 voting configuration
- SIL Level 3 1 out of 2 voting configuration

4 Practical Use of Reliability Data

Some of the questions Bandweaver receives from customers are as follows and we attempt to answer them here in a practical and simple manner

4.1 How often should a user budget to change the DTS?

As can be seen from the above MTBF figures, the figures range from 29 years (Telcordia) to 64 years (Field data). At this point in time the Bandweaver recommendation is that 10 years is a good figure to budget for. The main reasons for this are as follows:

- Current data suggests that budgeting for a 10 year lifetime means that there is a low chance of probability of failure within this lifetime.
- Technology trends including industrial protocols, tend to change and develop over time and 10 years is a reasonable upgrade cycle for this kind of technology.

4.2 What can a user do to maximise the operating lifetime?

The key to maximising operating lifetime is operating within the operating specifications of the unit and to maintaining a regular maintenance schedule (see operations manuals for details).

Having said that in order to maximise lifetime, some of the key considerations are:

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- Operating temperature: If operating temperature is exceeded this can cause thermal stresses of the components
- Humidity: Operating within the humidity constraints as detailed in the datasheet will reduce the probability of any corrosion or effects due to formation of condensation
- Power conditioning: The system should always be operated using conditioned power. Wherever possible a an Uninterruptible power supply (UPS) should be used as not only does it provide continuous operation (even if there are power outages) but also provides a power conditioning function.

4.3 What components are most likely to need replacing?

The Bandweaver DTS systems do not have any cooling fans or mechanical moving parts which means the lifetime of the key components are much higher.

Bandweaver uses Pareto analysis as a reliability management tool. This means constantly analysing components which are responsible for system failures and implementing engineering changes to address the specific issues. This means that throughout the history of the Bandweaver DTS systems there is not a consistent component that is a weak link.

For a system that is under continuous operation it is anticipated that the laser will be the component that may endure the highest thermal stresses. The best advice is to follow the guidance detailed in section 4.2 in order to maximise the lifetime of this component.

4.4 Does Bandweaver offer spare parts?

Bandweaver systems are built in a modular basis and so it is relatively straightforward for an authorised Bandweaver service center to change out the respective boards. However, these services centers require specialised test, measurement and repair equipment (e.g. oscilloscopes, fusion splicers, optical sources…). Without the appropriate facility and equipment it is not possible to carry out the root cause analysis and carry out the replacement and recalibration of the unit. Therefore it does not make for end users to carry spare parts at the modular level at their own facility. Typically when projects use multiples DTS units, sometimes the end user will keep full units as an additional spare to minimise any downtime when a system requires repair or maintenance.

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