

# Tuxera Flash Memory Testing Services

Reduce your hassle and frustration in selecting flash memory

Embedded systems designers struggle to find the time, resources, and expertise to adequately validate flash memory vendor specs. This struggle is often diverted by simply choosing more expensive flash parts than needed “just in case.” Or worse – you may end up with a flash solution that seems suitable after limited testing, but later leads to product recalls or other costly outcomes due to field failures.

At Tuxera, we aim to support you in making knowledgeable product design choices that will truly satisfy your performance and lifetime requirements. We have decades of experience working with car manufacturers, Tier-1 suppliers, and device OEMs, helping them to develop the optimal storage stack for their needs.

## Data management and storage services overview

Our experts are ready to guide you in selecting storage technologies to meet your requirements for cost-effective, highly performant, and robust products, using the workloads specified by you and your specific use case. This guidance helps OEMs calculate realistic estimates of flash storage needs, potentially saving on bill of materials (BOM) costs, while lowering testing overhead for your team. Our advanced system-level testing provides insights beyond common benchmark testing. Tuxera’s testing may also reveal unexpected flash device behavior under the planned use case and identify possible failure points early in the development phase.

Tuxera Data Management and Storage Services target embedded flash memory devices. Our test packages are customized to your needs, combining performance, lifetime, and power fail-safety testing. Regular status updates give you on-time information about the progress. Once the testing is complete, we provide a detailed report of the findings to guide you in choosing the best storage solution for your systems.

Our test offering consists of several individual packages including Workload Analysis, Lifetime Testing, Cost Analysis, Power Fail-Safety Testing, and Environmental Testing.

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## Workload Analysis

### Analyze and validate configurations for meeting performance and lifetime targets

With Workload Analysis, we find opportunities to improve the efficiency of your platform. Working together with you, we do a deep-dive analysis of the project workload in the context of your performance and lifetime targets. The end result is a set of configurations optimal for your system and data management solutions.

Workload Analysis consists of discovery, analysis, and recommendations. In the discovery phase, we explore and evaluate the goals for your project, which may include lifetime, performance, power fail-safety (data integrity), or boot-time targets. Tuxera engineers then analyze configurations and execute test cases to validate system behavior. After analysis, we provide recommendations for system configuration and Tuxera's data management software.

## Lifetime Testing and Cost Analysis

### Validate storage lifetime under custom workloads to make informed product decisions for managed flash devices

Each generation of a new managed flash device – such as eMMC, UFS, or NVMe SSD – behaves differently internally. This adds uncertainty in how new storage devices handle existing and future use cases. When testing the lifetime of the system, it's important to consider the whole storage stack.

While vendor datasheets are reliable sources of technical product documentation, they do not give a holistic estimate of flash lifetime. There are, in fact, several misconceptions related to flash lifetime. One common myth is that for maximum lifetime, it's enough to know the finite numbers of specifications such as program and erase (P/E) cycles and terabytes written (TBW). However, flash lifetime is the sum of many factors.

A critical determining factor is understanding which applications interact with the storage device. This is where the amount of data written and the write pattern both matter. All writes, however, are not the same.

Writing data to the media is handled by a file system. File systems also play a very crucial role in achieving the maximum lifetime of the flash media. A file system manages where files and file metadata are placed, while also tracking where free space is currently available on the storage device.

#### Workload Analysis in a nutshell:

- Detailed analysis of findings during the exploration of your system
- Analysis of product/project configuration and behavior under expected workloads
- Product and Linux kernel configuration recommendations to reach your desired targets
- Clear statement of achievable lifetime and performance under expected workloads

#### Workload Analysis answers questions such as:

1. Should I use discards or fstrim and how does this affect my system?
2. How often should caches be flushed?
3. Should I use fsync or similar?
4. How much of my CPU resources are used by IO?

#### Lifetime Testing and Cost Analysis in a nutshell:

Comparative lifetime analysis of storage devices

- File system-based workloads
- Customizable test workloads matching real-world use cases
- Flash memory vendor-specific information

#### Testing lifetime

- Existing workloads
- Feasibility of new use cases
- Tweaking parameters

#### Predefined workloads

- Camera workloads
- Sequential and random workloads

#### Lifetime Testing and Cost Analysis answers questions such as:

1. How long is the expected device lifetime?
2. Is the use case feasible for lifetime goals?
3. How many data writes per day/week/month can be expected while still meeting the lifetime goal?
4. Which configuration is best?

Therefore, when considering lifetime testing, it's important to test how the file system, flash device, and applications all work together.

Tuxera's Lifetime Testing uses file system-based workloads, offering the flexibility to test various workloads and patterns, while considering the overhead of different file systems. This way we can test multiple scenarios with different parameters and file systems, while collecting and analyzing lifetime data from the flash device. Lifetime Testing enables customers to verify new flash devices with existing workloads, or verify a new use case without the need to build a full system.

Information from the lifetime testing process can also be used to determine the best-suited flash devices for the use case. In our Cost Analysis service, we use lifetime benchmarks and market pricing to compare various flash hardware and software storage combinations, in order to identify potential BOM cost reductions and determine optimal warranty times.

## Power Fail-Safety Testing

### Comprehensively test fault tolerance to ensure system and data reliability

Embedded devices often operate under conditions in which sudden power interruptions and other hazards may occur at any time. As the data storage needs of these devices has increased dramatically over the years, unreliable data storage can be a significant contributor to field failures. Unexpected power losses can lead to corrupted data – or even worse – corrupt the whole partition. Understanding how the flash device and file system work together in power loss scenarios is crucial.

Tuxera's Power Fail-Safety Testing uses our proprietary test suite to simulate several real-world power-down cases. The result is a comprehensive understanding of how fault tolerant the storage device and file system are. While our Storage Test Suite focuses on stressing the pure storage device in power-loss situations, our File System Fail-Safety Test Suite stresses the file system within a wide range of scenarios involving ungraceful shutdowns.

5. What kinds of BOM cost reductions could be achieved?
6. What is the optimal warranty time for the device?

#### Power Fail-Safety Testing in a nutshell:

Validate system parts and file system configuration

- Stress testing in multiple power-loss scenarios
- Automated test execution and verification
- File system stress testing in taxing conditions
- Storage device power cycling over extended periods

#### Power Fail-Safety Testing answers questions such as:

1. How does my system handle ungraceful shutdown?
2. How does the chosen file system handle ungraceful shutdown?
3. Does the storage device do write reordering on the controller?
4. How can the risks of ungraceful shutdown be mitigated?

## Environmental and Data Retention Testing

### Validate device behavior throughout lifetime under different environmental conditions

Embedded device manufacturers have long lifetime requirements for their products. Some devices, like satellites, may even sit idle for long periods without powering on, and are subjected to sometimes extreme environmental conditions. As a flash device ages, its capacity to retain data decreases drastically, which can lead to memory corruption. This can, in turn, be an issue when data stored on the device is crucial for its operation.

Tuxera's Environmental and Data Retention Testing determines the capability of embedded flash devices to retain data for a targeted duration when powered off, particularly in end-of-life conditions and harsh extremes.

For the testing of data retention, we precondition flash devices to your specifications using high-speed aging workloads. Environmental conditions and temperature profiles are defined together with you, and using established algorithms, we accelerate data retention testing using a thermal chamber.

#### Environmental and Data Retention Testing in a nutshell:

- Testing end-of-life reliability under harsh conditions
  - Extreme heat
  - Temperature changes
  - Voltage events
- Accelerated testing using standardized techniques
- Pre-conditioning using high-speed workloads
- Validating for extended time periods

#### Environmental and Data Retention Testing answers questions such as:

1. Is my data safe for extended periods?
2. How long can the storage device hold data without power?
3. How much data can be corrupted?
4. Do extreme temperature changes affect my data?

## We're with you every step of the way

Tuxera brings decades of experience in storage development and close cooperation with all the major operating system developers, flash memory vendors, and chipset makers. Each year, our technology is deployed in millions of cars and other devices in need of reliable storage.

We help you every step of the way to bring next-generation products quickly to market. Our experts have solved everything from showstopper memory corruption issues to getting the maximum life out of their devices and systems.

Let's find the best hardware-software combinations and performance for your storage stack.

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## About Tuxera

Tuxera is the leading provider of quality-assured embedded storage management software and networking technologies. Helping people and businesses store and do more with their data, our software is at the core of phones, tablets, cars, TV sets, cameras, drones, external storage, routers, spacecraft, IoT devices, and more. We help you store your data reliably, while making file transfers fast and

content easily accessible. Tuxera is also an active member of multiple industry organizations, including JEDEC, SNIA, AGL, SD Association, The Linux Foundation, and many others. Founded in 2008, Tuxera's headquarters are located in Finland, with regional offices in China, Germany, Hungary, South Korea, Japan, Taiwan, and the US. Learn more about us at <http://www.tuxera.com/>.