

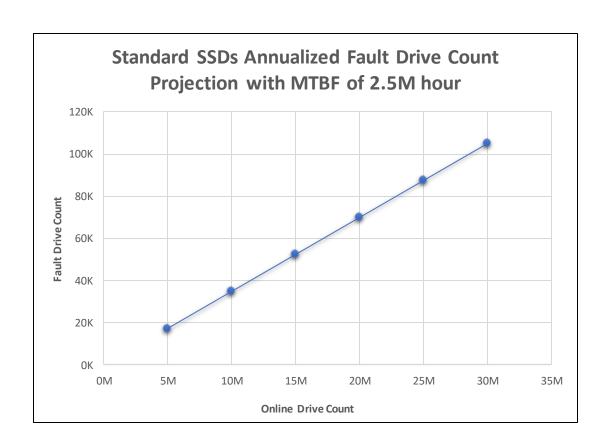
# Vertically Integrated High Resilience SSDs Designed for Cloud Computing

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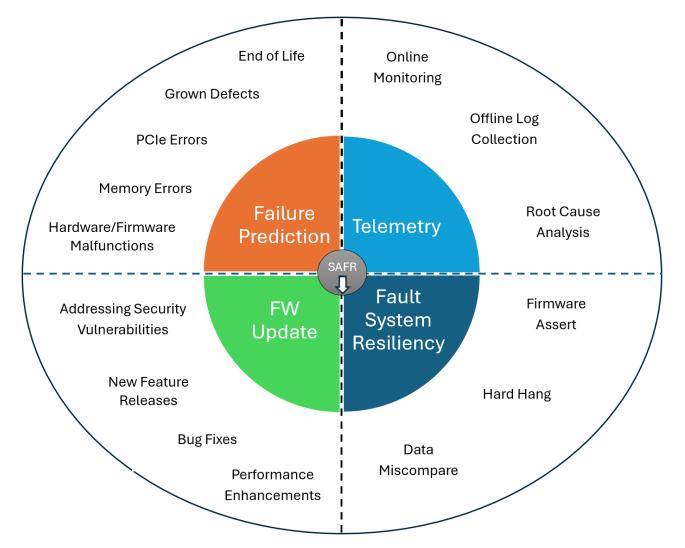
### Objective

- There exist tens of millions of Solid-State Drives (SSDs) within the Cloud infrastructure.
- Given the standardized SSD Mean Time Between Failures (MTBF) of 2.5M hour or Annualized Failure Rate (AFR) of 0.35% prevalent in the industry, a significant number of storage devices, in the hundreds daily or tens of thousands yearly, encounter failures.
- To address this challenge, Microsoft is proactively engaged in enhancing the quality of storage devices, minimizing capacity impact, and improving customer experience through vertically integrated high resilience (VIHR) SSDs as specified in OCP v2.5 and above.
- VIHR reduces overall system annualized failure rate (SAFR) significantly.







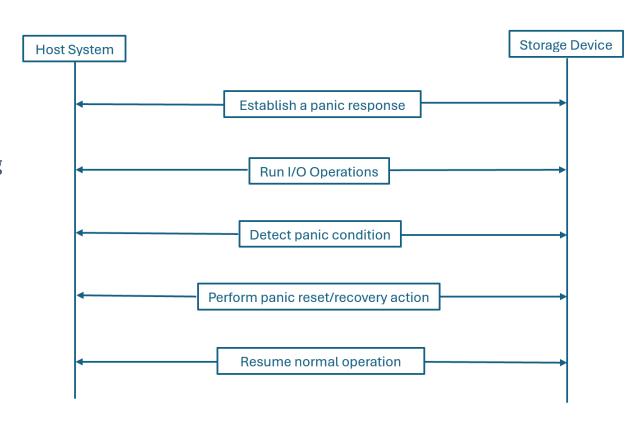


Facilitating these four essential capabilities effectively mitigates the system-level impact of SSD failures.

# Fault System Resiliency



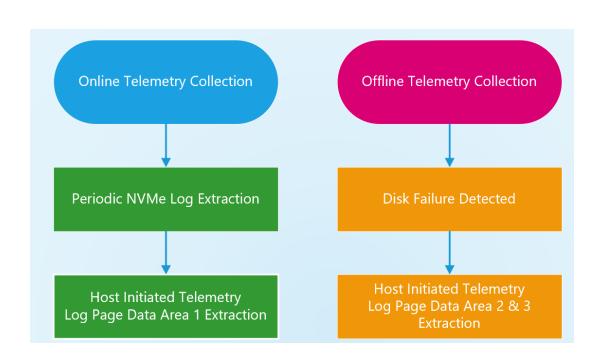
- Panic is a firmware assert, crash or hard hang.
- This Fault System Resiliency (FSR) capability detects and recovers from a panic on a storage device.
- A panic response is established through 0xC1 Error Recovery Log Page and Asynchronous Event Request (AER).
- A panic condition is identified through CSTS.CFS bit or AEN.
- Storage device performs one or more non-invasive corrective actions to recover from a detected panic condition to facilitate a normal operational state between a host system and the storage system.
- Systems with panic drives are moved to offline gracefully without impacting workload for further inspection and repair.





## **Telemetry Collection**

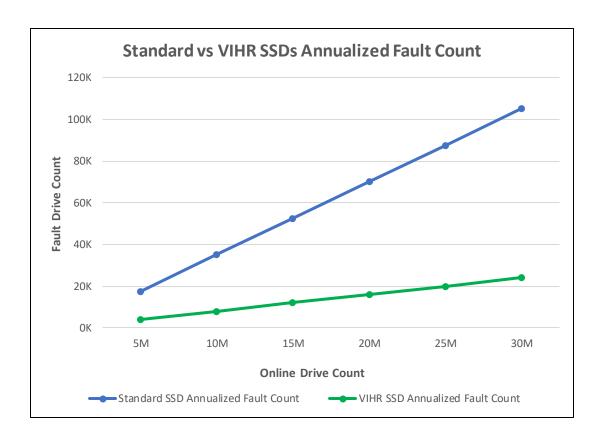
- Standardized host and controller-initiated telemetry log page including vendor specific debug data section.
- NVMe Logs including Telemetry Log Page Data Area 1 are collected regularly from online drives to monitor devices health and predict failures.
- Vendor specific debug data including Data Area 2 & 3 of Telemetry Log Page is collected at the time of failures for root cause analysis.
- Telemetry attributes are specified to root cause all intermittent failures including, data miscompare, IO timeout and IO errors or latency spikes along with persistent failures.





### Results

- Vertically Integrated High Resilience (VIHR) SSDs with 4 key capabilities of Telemetry, FW Update, Failure Prediction and Fault System Resiliency have resulted in a reduction of:
  - The system-level annualized failure rate of SSDs to 0.09%
  - Concurrently elevating the Mean Time
     Between Failures (MTBF) to 10 million hours
- The benefits of system failure savings increase as the fleet grows.



### Conclusion

- The utilization of Vertically Integrated High Resilience (VIHR) SSDs presents a cost-effective strategy for constructing fault-tolerant systems.
- Continuous improvements to achieve North Star goal of 100% system resiliency:
  - Increasing the fault system resiliency coverage will detect and handle more fatal failures gracefully.
  - Enhanced telemetry with new critical drive attributes will root cause more failures and improve failure prediction further.

