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Driving quality everywhere

Many methods are used by Hitachi Global Storage Technologies to deliver industry-leading reliability in its hard drive products. Quality is a never-ending process that encompasses design and technology considerations, component selection, development test engineering, manufacturing test processes, as well as customer expectations, requirements, integration efforts and field experiences. Hitachi GST uses a holistic approach to quality and reliability, taking into consideration every aspect in the total quality equation that contributes to a successful product.

Drawing upon collaborative work involving multiple disciplines around the globe, quality and reliability at Hitachi GST is achieved by collective results orchestrated under defined and well-integrated processes. Contributions from 'small efforts and initiatives by large numbers of people' who are committed to the shared objective of superior quality and customer satisfaction make a fundamental difference when supported by a system which embraces the procedures, metrics, demonstration and maintenance methods necessary to determine acceptable quality standards and continuous improvement beyond those standards. This is the basis of the Total Quality Initiative that is employed within Hitachi GST.

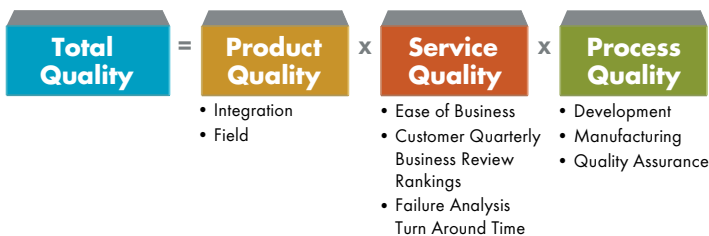


Figure 1. The Total Quality equation reflecting Hitachi GST's view of the elements that contribute to product quality and forms the base of the Total Quality Initiative.

High reliability by design

Unlike other hard disk drive performance parameters, reliability cannot be measured until quantitative data is available. Analysis of field failures is needed for accurate numbers. Hitachi GST addresses this limitation by understanding the environmental and operational influences on drives integrated in host systems, as well as various individual component factors that contribute to high quality and reliability.

The characteristic requirements of each drive type with its specific environmental and operational parameters are submitted to long-term quality and reliability calculations whose results are based on:

- Design and technology
- Component selection
- Development test process
- Manufacturing test process

Quality and reliability at Hitachi GST begins with the design process.

At the early stages of product development, reliability levels are set as a key design parameter along with fundamental drive specifications including capacity, spindle motor speeds, interface type, access times, data rates, shock and vibration tolerances, and other core attributes. Reliability issues and failure modes of previous generation products are assessed and root cause analyzed to design improvements into the architecture of the new product. Customer feedback is applied to understand drive requirements based on host system configurations, mechanical enclosures, integration concerns, usage environment and service life expectations.



Early in the drive development cycle, new technologies and manufacturing techniques are evaluated for performance, quality, yield, as well as the ability to enhance product reliability. Verification testing is conducted at the component, subassembly, or at the prototype drive level as applicable to the concept under evaluation. From there, the individual components targeted for usage in the final product design are identified.

Driving reliability through component selection, subassembly, and part suppliers is an integral part of the quality and reliability process. Hitachi GST employs a team of qualification specialists who conduct in-depth testing to collect the attributes which define best of breed components; this forms the basis of the supplier selection process. Every component and subassembly is tested and the factories audited to ensure all processes meet Hitachi's stringent requirements.

Hitachi GST is known for its well-established processes in incoming inspection, factory audits and documentation practices provide clearly defined criteria for component acceptance. Failure of any part is analyzed to root cause and driven back to the supplier for corrective action. Improvement measures are analyzed and certified before implementation approval is provided. Each vendor is actively engaged in collaborative work to ensure procurement specifications for



on-going process quality and component reliability are attained by specific milestones designated within the product life cycle.

Inherent in the disk drive design are other aspects of product reliability that are integral to the development phase including drive optimization functions to decrease heat dissipation and technologies such as on-the-fly error correction, Data Recovery Procedures, error logging processes, and features to ensure data integrity under a broad spectrum of field usage conditions. These technologies, mechanisms and techniques are defined early in the development cycle for testing and verification against critical drive parameters such as performance, data reliability, duty cycles and service life before being integrated into the final drive design.

High reliability from verification testing

Before a new Hitachi disk drive product is approved for release to manufacture, a series of performance and stress tests are conducted. Included in this battery of tests is acoustics, EMI, ESD, operating and non-operating environment, power, shock, vibration, temperature, shipping, storage and start/stop verification. Test parameters cover both in-specification usage as well as stress testing to the extremes of the product boundaries. Should issues arise, a cycle of testing and product improvement measures ensues until the new drive meets or exceeds the designated specification levels and Hitachi GST's rigorous reliability standards.

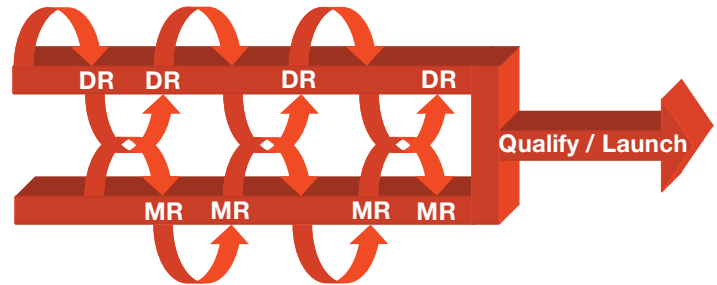


Figure 2. The Hitachi GST hard disk drive product delivery methodology employed during drive development utilizes an iterative process to interlock concurrent product and manufacturing development engineering efforts at designated points timed around a series of Design Reviews (DR) and Manufacturing Reviews (MR). The process drives learning and critical findings into the development process at multiple checkpoints before the product enters launch qualification.

Host system manufacturers contribute to the product verification process to define the verification sequences used in the evaluation of early drives that are tested in the customers' system enclosures by Hitachi GST quality assurance engineers. During this stage, Hitachi GST focuses on strength and weakness assessments which are used by development engineering to design margin into the base product. Quality assurance culminates in customer Reliability Demonstration Tests (RDT) that run for many hours to demonstrate the hard drive meets the reliability requirements of the host system manufacturer.

Each category of hard disk drive has its own environmental and operating parameters including temperature, power, operational vibration, duty cycle and operational hours. Hitachi GST drives undergo functionality testing where aggressive temperature and voltage cycling is applied, pushing the hardware beyond the thermal and power specifications of the drive. For Ultrastar™ server-class disk drives, reliability engineers develop dynamic stress tests to induce early life failures. Engineers also check error-logging integrity at the drive level where errors are forced, and any fault is detected and correctly reported. Smaller form factor drives such as the Travelstar™ 2.5- and 1.8-inch drives are subject to Temperature Voltage Stress Testing to verify the drives can support various combinations of temperature and voltage stress at sufficient margins to ensure durability in the final host application.

Only when all supplier, development and manufacturing engineering, and verification tests are successfully concluded is a new Hitachi GST hard drive deemed ready for release into volume manufacture. This marks the start of the continuous improvement process.

High reliability from audits and control procedures

Hitachi GST is fully ISO-9000 certified. Quality control audits are used to verify that processes and procedures are in place to react quickly to problems that may occur. Audits based on ISO standards are conducted at various stages of the product build process such as component material handling, manufacturing build and manufacturing test. In addition, Ongoing Reliability Tests (ORTs) are conducted to monitor initial quality as well as the mid- and long-term reliability of the products. Hitachi GST also conducts an end-of-line quality sampling test called the Outgoing Quality Audit (OQA) on selected products, to simulate usage of the drive in a stringent integration test. Together, these tests ensure repeatability of the processes required to consistently provide reliable and high quality disk drive products.

High reliability and customer partnerships

Once in the field, reliability of the same model disk drive can vary by customer. The design of the host system, including its hardware, software and diagnostics, the supporting service organization, and integration handling of the drive all contribute to determining drive reliability.

Hitachi GST employs worldwide teams of technical support specialists who assist system integrators in reviewing the host design for items particularly important to the service life of the drive. Areas such as drive mounting, grounding, shock, vibration, cooling, and power utilization are investigated. These partnerships help the system manufacturer derive the best possible reliability from Hitachi GST disk drives in their application. Technical support specialists also provide disk drive handling trainings to minimize the possibility of drive damage during the manufacture of the host system.

System level expertise is provided through several different centers located in Asia, the United States and Europe based on the type of support required by the customer application. Design Application Labs offer integration assistance for the usage of Hitachi GST hard drives in the more traditional information technology applications. Specialists in the design of Hitachi GST hard drives into

consumer and handheld applications are available through newly established support centers in five different world locations. Together, Hitachi GST offers a broad spectrum of services to help customers meet specific objectives for their end-user products, including operating system compatibility testing, performance benchmarking, emissions and regulatory certification testing, mechanical design analysis for reliability and maximum expected service life of the hard drive, and custom qualification programs to name a few.

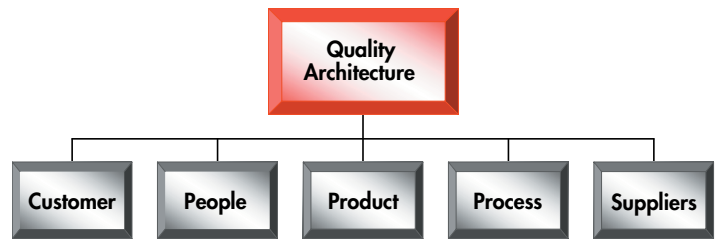


Figure 3. Key components under the Hitachi GST “Quality Architecture” umbrella which contribute to world-class quality in both product and services.

Summary

Hitachi GST believes that quality is not the result of a single, one-time event, but is a comprehensive system supported by processes, procedures, metrics, and disciplines that involve all areas of the corporation. Quality at Hitachi GST extends from the initial drive development effort through on-going, cooperative work with component and sub-assembly suppliers. It extends to customers in the form of highly reliable products and a support network of technical engineering specialists offering experience in host box design, drive integration and systems testing, as well as sales, marketing and financial teams versed in business practices oriented to the attainment of collaborative success. The Total Quality Initiative orchestrates the integration of a pervasive, systemic and dedicated approach to product and service quality that responds to market conditions and results in the consistent delivery of industry leading storage products as well as world-class business relationships.

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