

Technology Paper

Exceeding Capacity, Speed and Performance Expectations

Seagate® AcuTrac™ Technology
Defines New Standards

In their *2011 Digital Storage for Media and Entertainment Report*, Coughlin Associates made the following forecast about the future of storage capacity demands: “Between 2011 and 2016 we expect the media and entertainment industry will see about a 7.7× increase in the required digital storage capacity and about a 5.6× growth in storage capacity shipments per year (from 11,248PB to 62,736PB).”¹

Furthermore, University of Southern California researchers Martin Hilbert and Priscila Lopez estimated that global digital storage capacity totaled 295 trillion megabytes in 2007. According to Hilbert, if a grain of sand were used to represent a single megabyte, we would need 315 times the amount of sand than is available on the world’s beaches.²

As storage capacity demand continues to increase at over 50% every year,³ the need for fast, high-density and reliable storage solutions is clear. But can the hard drive industry keep up?

Storage Capacities vs. Market Demands

To meet the constantly growing storage demands of the consumer electronics and PC market segments, hard drive manufacturers have faced the challenge of maintaining data integrity with magnetic coating technology that utilizes extremely small particles. In recent history, hard drive technology has been focused on increasing the areal density of storage media. *Areal density* is a measure of how closely individual bits of digital data (recorded on magnetic particles) fit together on a hard drive. The tighter the grouping of these bits, the higher the areal density.

¹ *2011 Digital Storage for Media and Entertainment Report*, Coughlin Associates, 2011.

² “World’s shift from analog to digital is nearly complete,” Andrea Leontiou, MSNBC.com, February 10, 2011.

³ “Changing Digital Storage Requirements for Clouds and Mobile Devices,” Tom Coughlin, Forbes.com, June 17, 2011.



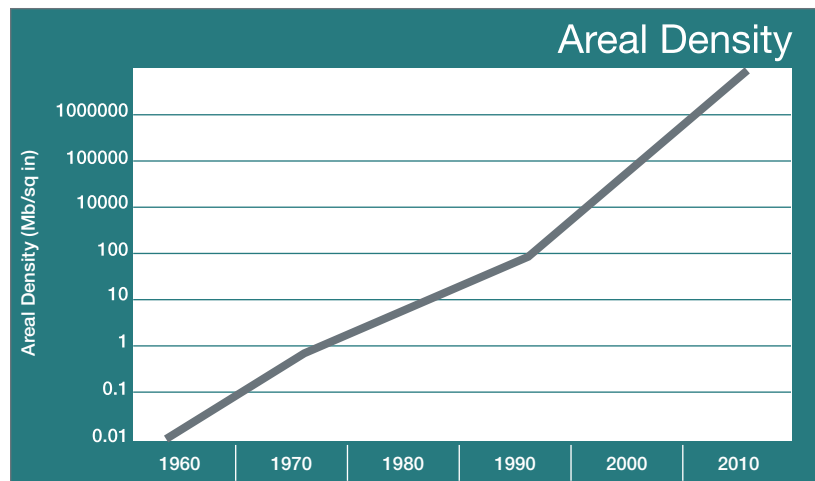
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One measure of areal density is bits per inch (BPI); higher BPI on a storage device allows capacity levels to grow. Utilizing magnetic particles that stand perpendicular to the media surface, rather than laying flat upon it, perpendicular recording technology has allowed experts to dramatically boost BPI. While this technology has been the primary enabler of increased storage capacities over the last five years, perpendicular recording has nearly reached maximum densities, and is expected to peak at approximately 1 to 1.5 terabits (Tb) per square inch.⁴

A second factor influencing storage capacities is *track density*, commonly measured by tracks per inch (TPI). Hard drives store data in concentric circles (tracks) on the hard drive's platters; the more tightly these tracks are packed together, the more TPI and disk capacity grow. Increases in TPI have proven to be a key opportunity for the next generation of capacity improvements.

As shown in the chart below, areal density has experienced outstanding growth over the past 55 years. In fact, since the first magnetic storage drive was introduced in 1956, areal density of magnetic storage has increased more than 200 million fold.⁵



Although areal density has increased tremendously over the past 50 years, it is struggling to keep up with the continuous demand for high-capacity storage. It is becoming very difficult to downsize technology while continuing to distinguish one bit from another. In other words, striking a balance of creating ever-smaller magnetic particles while maintaining data integrity has presented new problems for the hard drive industry.

With the introduction of Seagate® AcuTrac™ technology, however, Seagate is helping to close the gap between capacity and demand in today's storage marketplace. While both BPI and TPI were essential factors for the improvements found in the newest generation of the popular Seagate Barracuda® series of hard drives, AcuTrac technology enables significant increases in TPI. The result: a reliable combination of enterprise-level capacity, speed and performance for the everyday consumer.

The Unique Challenges Behind AcuTrac Technology

In the Seagate Barracuda hard drive series, TPI levels have gone from 250,000 in the previous generation to 340,000 today. These numbers represent a remarkable 36% increase in TPI and, consequently, a vast improvement in storage capacity. With such a high quantity of tracks on a mere 3.5-inch disk, each track is only *75 nanometers wide*—smaller than some viruses.

The drive components required to achieve these results are even more microscopic. When it came to positioning the head over each track, engineers needed to design a control system capable of increments only 10% (or less) of track width for enhanced accuracy. In Barracuda drives, the head is controlled down to seven nanometers of resolution, comparable to the size of a cell membrane or three strands of DNA.

The challenges didn't stop at the infinitesimal track width and servo design. Seagate engineers were determined to build a drive that would deliver not only higher storage capacity, but also superior 7200-RPM performance. When the head moves over a 3.5-inch drive at 7200 RPM, it is traveling at 80 mph. In short, the Barracuda drive's development team faced the additional difficulty of positioning the head to microscopic levels and designing it to function under—effectively—hurricane-force winds.

To further enhance the features of the Barracuda drive, Seagate sought to offer a product that would operate over a very large temperature range. As the drive is primarily composed of aluminum, a material that expands and contracts at about 300 nanometers per degree Fahrenheit, this created yet another daunting challenge for the drive's developers. Any slight change in temperature had the potential to alter the position of the head by 300 to 400 times the track width.

With AcuTrac technology, Seagate was able to meet every one of these challenges, creating a drive with groundbreaking capacity, track accuracy and speed. With AcuTrac technology, the Barracuda drive offers unprecedented features to mainstream consumers at street prices that start at under US\$100.

⁴ "Future Storage Technology: How to Store the Entire U.S. Library of Congress on a Coin," Seagate Technology, December 2010.

⁵ "Capacity Measurements, Areal Density, And PMR," Bestofmedia Group, August 31, 2011.

www.tomshardware.com/reviews/hard-drive-magnetic-storage-hdd,3005-7.html#

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Superior Solutions at Microscopic Scales

The fundamental component of AcuTrac technology is what Seagate calls the nano-actuator. Most hard drives have a single actuator to help position the head along the drive's surface. In such previous-generation hard drives, a motor turns a single actuator at a pivot point. This actuator controls the suspension arm as one body, guiding the head to specific tracks on the disk. AcuTrac technology places a secondary actuator further down the suspension arm, bringing it closer to the head and therefore tightening control. The secondary nano-actuator fundamentally enables TPI improvement by directing the head more accurately to individual tracks, even at the nanometer scale.

Jason Won, senior director of servo production and corporate servo platform lead at Seagate Technology, uses the following analogy: "In 7200-RPM drives that don't utilize AcuTrac technology, positioning the head is like trying to ring a doorbell with a ten-foot stick in 80mph winds; with AcuTrac technology, the control mechanism is 80% closer to the head, so the ten-foot stick becomes a two-foot stick. The stick also becomes much more rigid and more easily controlled for better tracking accuracy."

A technology exclusive to Seagate, AcuTrac technology distinguishes itself from competing technologies by utilizing two actuator elements rather than one, providing larger stroke and range of motion for the actuator. Throughout the development of AcuTrac technology, Seagate also leveraged algorithm development and advanced control theory used in high-tech military and aerospace applications to perfect the microscopic servo design.

In the past, a similar form of actuator technology has been implemented in the more expensive and sophisticated Seagate enterprise drives. AcuTrac technology represents a refined version of this technology that can be used in a lower-cost solution, therefore bringing what was once exclusive to the enterprise segment to the mainstream consumer market.

Outstanding Results for Today's Digital Landscape

The benefits of AcuTrac technology are so compelling that Seagate included this technology in every configuration of the newest Barracuda drive, from one- to three-platter configurations. Not only is TPI 36% higher, helping to increase storage capacity, but tracking accuracy has also improved in comparison to previous drives.

As a perfect example of how AcuTrac technology improves reliable performance, consider the growing popularity of all-in-one computers. All-in-one designs incorporate the hard drive within the monitor enclosure, along with integrated speaker systems. The large speakers on an increasing number of these computers can vibrate the hard drive and diminish overall performance. AcuTrac technology has improved TPI while also delivering a more robust drive that can withstand the vibration in these environments. The result? Better reliability with nano-scale tracks, even while your teenager blasts the music on the family's all-in-one computer. As stated by Jason Won, "AcuTrac technology is a *huge* leap in our ability to track accurately."

Because AcuTrac technology significantly boosts capacity, speed and performance, it makes Barracuda drives ideal for the modern digital world. With track density at 340,000 TPI, Barracuda drives deliver storage capacities up to 3TB—enough to store 120 high-definition movies, thousands of photos and countless hours of digital music. Seagate will also offer these newest Barracuda drives in capacities of 1TB, 1.5TB and 2TB beginning in November of 2011.

Thanks to AcuTrac technology, Barracuda drives offer 7200-RPM performance at every capacity point, from 250GB to 3TB, providing an unmatched lineup of cost-effective storage that delivers superior speed. Sacrificing performance for capacity is a thing of the past. Consumers now have choices beyond the previous generation's high-capacity drives, which offered only 5400-RPM options.

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Jason Won describes the clear benefit of the 7200-RPM performance in the latest generation of Barracuda drives: "If you want to get to the other side of the disk, or if you want to get from Sacramento to San Francisco, you want the car that can go 80mph (7200 RPM), not the one that can go 60mph (54000 RPM)."

Conclusion

The tremendous demand for digital storage continues to increase year after year, and forecasts show that demand will only continue to build over time. Technologies like Seagate AcuTrac technology are becoming an essential part of meeting such monumental storage demands.

By applying the innovative capabilities of AcuTrac technology, Seagate Barracuda hard drives give consumers the outstanding speed and rock-solid reliability they demand in today's storage solutions. And with an exceptional balance of capacity, speed and performance (including low power consumption), the Barracuda drive fits the needs of both organizations and consumers throughout the world who continue to amass huge amounts of digital content.

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