In Search of a Better Tape Library?  
IBM Announces the TS4500 R3

Analyst: Mike Kahn

Management Summary

Recently, my wife and I bought a new car, mostly for her to use on her long commute. While vehicle type, price range, and vendor were important considerations, high-end safety features were more important. Did we consider buying a “previously owned” vehicle? No, we didn’t, because many of the desired safety features were only to be found on the most recent models. Sometimes, you just have to pay more to get what you want. New features often drive us to replace what we now have with something new and decidedly better. Why did you acquire your latest smartphone? To keep up with the Joneses or to gain new functionality and capabilities? The same need to “buy the latest” is true for information technology.

This paper focuses on large tape libraries — the ones capable of housing thousands or tens of thousands of tape cartridges. These enterprise-class tape libraries often will last, with maintenance support, a decade or more. So why would you want to replace a 10-15-year-old tape library with a new one (instead of maintaining it for another year or two or three)? There are three quick answers:

- **You are spending so much to maintain your existing library** that you can save money by replacing it and getting an included multi-year warranty.
- **You are about to run out of space and capacity**, either in the maximum slot or tape drive capacity of the library or in the data center space housing your tape library.
- **You need new or improved functionality** that only is available on a recently announced model.

Often, all three are involved. If you are driven to buy a large-scale tape library for the first time, all of the above may be involved, except that you likely are comparing the tape library to higher cost disk-based solutions.1 Each of these three reasons will be discussed.

This paper’s title gives you a sense of where this paper is going. Today, IBM announced the latest release of its **TS4500 Tape Library**, called **R3**. There is more here than meets the eye, along the line of the three quick answers given above. Please read on to better understand your requirements and how the **TS4500 R3** (as it will be called in this paper) meets and probably exceeds your requirements.

---

1 Let’s be clear here. This will be true if you already have decided that tape will provide the best solution for your requirements. How to reach this conclusion is not a subject that will be discussed in this paper. For more about making that tape decision, see Continuing the Search for the Right Mix of Long-Term Storage Infrastructure - A TCO Analysis of Disk and Tape Solutions in The Clipper Group Calculator dated July 15, 2015, which is available at [http://www.clipper.com/research/TCG2015006.pdf](http://www.clipper.com/research/TCG2015006.pdf), and a supplement to thid – The Impact of LTO-7 on the TCO of Long-Term Storage in The Clipper Group Calculator dated September 15, 2015, and available at [http://www.clipper.com/research/TCG2015008.pdf](http://www.clipper.com/research/TCG2015008.pdf). Also see Enterprise Tape for Archival Storage? — Why This Just Might Make Sense (Updated) in the September 12, 2013, issue of The Clipper Group Calculator, available at [http://www.clipper.com/research/TCG2013018.pdf](http://www.clipper.com/research/TCG2013018.pdf). See also LTO-7 Tape Introduced with Higher Capacity and Throughput in the September 14, 2015, issue of The Clipper Group Navigator, which is available at [http://www.clipper.com/research/TCG2015007.pdf](http://www.clipper.com/research/TCG2015007.pdf).
Reasons to Procure a New Large-Scale Tape Library

As introduced above, there are three primary reasons for procuring a new tape library capable of holding tens of thousands of cartridges.

(1) The Cost of Maintaining an Older Library

Tape libraries and tape drives are electromechanical devices. The mechanical components are more likely to fail (over time and with heavy use) than the electrical and electronic components. Given that most libraries are retained for a long time (often 10 years or more), especially when compared to disk solutions, data centers usually continue to maintain service contracts on their library and tape drives after the warranty expires. This is part of a carefully constructed enterprise ROI model, one that makes sense—well—until it no longer makes sense, usually when the next generation library model becomes available and a good reputation has been established.

Product life-cycle economics are well understood across all of the components typically found in a data center, such as servers, storage, and networks. However, in comparison to tape library solutions, energy and floor space are much greater part of the total cost of ownership (TCO) equation for disk-based solutions. Because of improvements in the capacity of disk drives, often it is less expensive to buy a new disk-based solution than to maintain a three- or four-year-old outdated disk-based solution (with less-dense hard drives).

The same logic applies to tape libraries, although the average life (time in service) usually is three-to-five times the average life of a disk-based solution. This is due to the maintenance cost being reasonable (e.g., non-punitive after the warranty expires) and the ability to update the library as new, denser tape cartridges and tape drives are announced after the tape library’s initial procurement. Additionally, there may be improvements in frames that house the cartridges (both capacity per frame and the number of frames allowed) and the maximum number of tape drives allowed. Nonetheless, almost always, there comes a point in time when the cost of maintaining an older library is greater than the cost of getting a new one with a multi-year warranty.

(2) Running Out of Space and Capacity

Demands for tape storage capacity are exploding in this era of big data repositories and business analytics. The library that you have may be reaching its scalability limit (the maximum number of slots or tape drives in a library) or, sometimes, the incremental cost of making your current library even bigger becomes prohibitive. If you’re reading this paper, you probably have an overwhelming need to store a lot of data on tape.

However, there is another space-related dimension. Sometimes, you are running out of adjacent space in your data center in which to expand your current library. Knocking down data center walls rarely is a feasible option. While you could move the entire library to another location, you probably don’t want to move your existing (older) library. Instead, you are more likely will want to buy a new, better, and more functional library, either for your existing location or for that new location. Key to this is the almost certainty that you can store a lot more data per cubic foot of data center space with a new library than what you now are doing with your existing library, even if you keep your existing drives and install them in the new library. However, this is because tape library storage frames have become much denser in recent years, i.e., they can store many more cartridges per rack and, thus, more cartridges per cubic foot or cubic meter. Thus, you almost certainly can expand significantly within the space of your existing tape library or, if you are comparing this to disk solutions, in less space than all but the most current (recently acquired) disk solutions.

(3) New or Improved Functionality is Needed

This may be the biggest reason to move to a new tape library. It if has been 5-to-10 years since you last bought a new library, the principal uses of your library very likely have changed. A decade ago, tape was used primarily as a backup target and for mainframe data processing, often for report generation (e.g., annual, monthly, weekly reports that used to be printed and

2 Often these are called “high density” or “HD” frames.
3 Disk solutions use a lot more electricity and cooling than tape drives. In our 2014 study cited in the first footnote, the amount of energy used by the tape library solution was less than 1% of what was required for the disk-based solution. With high-energy consuming and heat-generating disk solutions, additional electrical and cooling capacity to the data center may be limited or unavailable. This is another kind of “space” that can be reduced handsomely by using a tape library.
physically distributed regularly). While tape still has a use in backup, today your tape library probably is being used primarily as an active repository of files and objects — and now is being used heavily for analytics and decision-making. This is driven by the much lower TCO for storing a given amount of data on tape than when using a disk solution. **However, to get the most out of the latest cost-reducing tape-library efficiencies, you need to be using the densest tape cartridges with the latest generation of tape drives in the highest density frames, etc.** Certainly, these physical characteristics are a big part of the latest generation’s advantages.

However, there is another side to the “new features” story. This has to do with automation and high-availability, and management functionality and ease of use.

**High Availability and Automation**

If you are using your tape library for support of important, near real-time business activities (typically measured in seconds and not in small fractions of a second), then you need to be prepared for a mechanical failure. Tape drives will fail (albeit rarely). You typically protect against this by having a few extra tape drives in your library. A maintenance contract for repair or replacement is important (in the long run) but having an extra drive or two (beyond what you think you will need maximally) will give you immediate protection.

The devices that pick, transport, and insert the needed tape cartridge into the targeted tape drive (and then returns the cartridge to its storage location when done) often are called “accessors” or “robots”. If you only have one accessor and it fails (also rarely), then you will need to have one or more humans to do these tasks while you wait for the accessor to be repaired. For many of today’s near real-time uses, this is unacceptable. Thus, you need a second accessor. Having two not only gives you access to all of your library-based cartridges when one of them fails, it also may give you two accessors that can work simultaneously (in an active/active mode), thus reducing the time needed to fetch and mount the needed cartridge.⁴

There are other library features that might be classified as automation or, alternately, operational efficiencies. These tend to be related to the feeding of cartridges into and out of the tape library and care of the cartridges once they are there. This includes the vehicles (such as magazines or trays) for getting many cartridges into or out of the library and devices for automatically maintaining the quality of the tape drives (by cleaning them when this is needed, either by prediction or warning) or by verifying the veracity of what is stored on each cartridge (which some applications require to be done regularly). Assisting and automating these processes reduces or removes the need for staff to attend to these needs individually and limits the amount of manual involvement, at least until a significant problem is detected.

**Management Functionality**

When all is said and done, storing and retrieving data on tape cartridges in a tape library is inexpensive. Data center support staff are quite the opposite. The more that the staff can be replaced by automation; the better it is for the enterprise. There are more important tasks for humans to do and also fewer opportunities for human mistakes to be made. However, when staff attention and involvement is required, the simpler and easier those tasks are to execute, the better it is. The name of the game hasn’t been “keep the data center staff busy” for a long time. Making these folks more productive is an important goal. Improvements in software and new features often pay for themselves in short order. Many of these capabilities are bundled into the basic functionality of a new tape library.

**The New IBM TS4500 R3**

First, a little history of IBM’s tape libraries. The *IBM TS3500* tape library, the generation before the current one, was introduced in 2000 as the *IBM Tape Library 3584*. It has been adopted widely. The latest generation *IBM TS4500* tape library was introduced in 2014.⁵ (Subsequently, this was labeled *R1.*). *R2* was introduced last year and was a rounding out of the initial R1 offering. *R3*, announced today and available in early June, has some significant new capabilities and sets the baseline for what no doubt will be added in later releases.

Let’s look at the TS4500 R3 offering using the “Reasons to Acquire a New Tape Library”

---

⁴ This often is achieved by spitting the frames into two zones, typically left and right halves, and having each accessor work only in their half, unless one of them fails and has to work on both halves.

laid out in the previous section, while comparing it to the older TS3500, when appropriate, since upgrading from a previous generation likely will be the most common procurement scenario.\(^6\) (See Exhibit 1, above for a list of the most significant capabilities of the TS4500 R3.)

**The Cost of Maintaining an Older Library**

The latest tape libraries contain many technological improvements introduced after the TS3500 was introduced in 2000. The same can be said of many of the other large-scale tape libraries whose origins can be traced back more than a decade. Of course, there have been improvements and upgrades along the way (such as new drives and higher-capacity cartridges and, for some of the vendors, improvements in frames and automation), but any architecture more-than-a-decade-old is, in fact, getting old. A lot has been learned along the way and, more importantly, a lot of needs and uses for tape-based solutions have changed.

Many of the latest improvements focus on significantly lowering the cost a storing a gigabyte/terabyte/petabyte on tape in a library. The cost of storing a petabyte per year tends to be the most important driving factor in the decision to procure a new tape library (whether as a replacement or a first-time purchase). Thus, you need to do a cost analysis based on your own data volumes, data growth, data access requirements, etc.

Doing a cost analysis is straightforward but can become complicated because of the number of significant factors involved.\(^7\) Determine what you think it will cost to maintain and grow what you have over the next three years (to handle your projected requirements) and compare that to what it will cost to get a new tape library with a three-year warranty (or compare it to the cost of storing this data on hard disks)\(^8\). Any tape library sales rep would be glad to help you with

---

6 This same approach can be done with another vendor’s large-scale tape library, whether you have the latest generation or something older.

7 See The Clipper Group papers cited in the first footnote on page 1.

8 Do not lose sight of the fact that you may need to procure multiple generations of disk-based solutions to meet the life of your tape library procurement. If that is 10 years (for example only), then you may need three generations of disk-based solutions to equal a new library’s expected useful life.
You should consider more than these costs, however. Most importantly, you should consider the amount of data center staff time that now is required to manage your tape library (or disk-based solution) and how that will change with a new library. Don’t forget to consider the space and capacity issues that are discussed next.

Running Out of Space and Capacity

If you are running out of data center floor space to expand your current tape library, that almost certainly will improve, probably by saving 30% to 70%, depending on whether you now have HD frames and what percentage of your cartridges are in HD frames. When comparing the TS4500 to the TS3500, here are some key facts. (See also Exhibit 2, above.)

- The leftmost frame of the TS4500 contains 2.8 to 3.5 times more cartridge slots than the leftmost TS3500 frame. \(^{10}\)
- Subsequent (middle) frames of the TS4500 contain 1.8 to 2.4 times more cartridge slots than on the TS3500 equivalent. This is done with the HD2 frame that was announced with the TS4500 (details are in the chart above). This range depends on whether your middle frames have tape drives installed (and how many) and what kind of cartridges are stored in the frame. \(^{11}\)
- Subsequent (middle) frames of the TS4500 are only available in HD configurations. The improvements in this HD frame make it unnecessary to have higher-performing, but more costly per terabyte “standard” frames, as was typical in the TS3500.
- Subsequent (middle) frames of the TS4500 can have up to 16 drives in each (instead of 12 on the TS3500), up to a new limit of 128. \(^{12}\) This is less than the current TS3500 maximum of 192 drives. If you need that many drives, then you may have to transition from the TS3500 in stages or set up two separate TS4500 libraries. \(^{13}\)

\(^{9}\) You should also consider the staff time required and the cost of the effort to transition to the new library.  

\(^{10}\) The same is true of the rightmost frame in dual accessor configurations, as will be discussed later in this report.

\(^{11}\) Generally, when you install one or more tape drives in a frame, you reduce the number of cartridges that can reside in the frame. IBM’s frame models are either drive-capable or storage only, with different models for LTO and TS11x0 cartridges, as shown in Exhibit 2.

\(^{12}\) It was 60 in TS4500 R2. These can be TS1150, TS1140 or LTO-5, 6, or 7 drives.

\(^{13}\) We do expect that future releases of the TS4500 will allow more drives (by one of several possible means) and larger libraries (with more cartridges), but there is no commitment from IBM at this time. However, with the current and next generations of tape drives and cartridges (expected in the next few years and, hopefully, with improvements in

### Exhibit 2 – IBM’s TS4500 HD Frames

**Up to 3.5X Slot Density, Up to 1.3X Drive Density**

<table>
<thead>
<tr>
<th>TS3500 Leftmost Frame</th>
<th>TS4500 Leftmost HD Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lx3</td>
<td>Lx5 or Dx5</td>
</tr>
<tr>
<td>12 Drives</td>
<td>12 Drives</td>
</tr>
<tr>
<td>0 or 32 I/O</td>
<td>0 or 32 I/O - LTO</td>
</tr>
<tr>
<td>LTO</td>
<td>Storage only</td>
</tr>
<tr>
<td>3592</td>
<td></td>
</tr>
<tr>
<td>219</td>
<td>774 or 730</td>
</tr>
<tr>
<td>199</td>
<td>1054</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TS3500 Frame #2+</th>
<th>TS4500 HD Frame #2+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dx3</td>
<td>Dx4</td>
</tr>
<tr>
<td>12 Drives</td>
<td>16 Drives</td>
</tr>
<tr>
<td>0 I/O</td>
<td>0 or 32 I/O - LTO</td>
</tr>
<tr>
<td>LTO</td>
<td>Storage only</td>
</tr>
<tr>
<td>3592</td>
<td>Storage only</td>
</tr>
<tr>
<td>396</td>
<td>970 or 882</td>
</tr>
<tr>
<td>360</td>
<td>1320</td>
</tr>
</tbody>
</table>

Source: IBM
• TS4500 R3 can expand either to the left or to the right. There must be a leftmost base frame. A second base frame can be added at the right end, providing high availability and potentially faster mount times. This provides flexibility regarding how to expand the library and how to deal with unrelated floorplan changes within the data center. The TS3500 only can expand in one direction (to the right).

With the detailed configuration information in hand (both for the existing and newly proposed library), you can determine how much less floor space you will need. If you are running out of floor space, this alone may justify moving to the TS4500.

If you mostly are on an n-l or earlier generation of cartridges, you will get a significant savings in the number of cartridges that you will need to replace what you now have (whether you do this now or in the future). Almost certainly, you should be writing all new data to the latest generation of cartridges. If you project this through just three years, you will see how much less floor space and how many fewer frames you will need by using the latest generation of drives and cartridges (whether LTO-7 or TS1150). You might even need fewer drives to write your incoming data.

Do recognize that during the next three years there no doubt will be another generation of tape drives and cartridges announced, presumably with a significant increase in capacity. When you consider this, you may need even fewer frames, drives, and cartridges for your current and incoming data than you may have calculated based on the most current tape technology. If you are transitioning from a disk-based solution, to a current-generation tape-library solution, then you will also have to compare the energy (electricity and cooling) costs of your disk-based solution to the energy-stingy TS4500. The savings likely will be sizeable.

Worth mentioning, the TS4500 has an integrated accessor service bay in its first and last frames (when dual accessors are used; to be discussed shortly). With the TS3500, you need a separate frame, essentially a parking space for the accessor when it is idled intentionally or because it has failed and the second accessor needs to access the whole string of frames. In the TS4500, you can store cartridges in the slots behind the parking space, but do recognize that these can be blocked when the accessor is parked. Managing this situation requires some special intelligence and planning. IBM handles this with Transparent Capacity on Demand, because it will use this space intelligently to minimize the impact of any blockage.

Most important to larger libraries, typically with six or more frames, is high-availability for automatic access to the cartridges in the library; this often is called “automation”. If you only have one accessor to pick and move your cartridges, then you have a single point of failure, which is unacceptable for most larger libraries, especially those containing actively-used archived data. The TS3500 supports two accessors. The TS4500 R1 and R2 only allowed one. Now, with TS4500 R3, two accessors are allowed. As with the TS3500, the TS4500 accessors require a special frame in the leftmost and rightmost positions. The second accessor in the TS4500 R3 may be the most important (and most desired) improvement of the R3 announcement.

There is one more kind of capacity, not mentioned previously – networking capacity. The TS4500 can connect to 16Gb Fibre Channel (FC) switches, while the TS3500 is capped at

---

17 Transitioning from an older generation of tape drives and cartridges to a newer one generally is an automated process, but does not happen overnight. You need to plan for this transition and, likely, procure additional drives to make it happen. That is why such generational transitions tend to be done every two-to-four generations and not with each new generation. In the end, this requires both an economic and operational analysis.

18 There are several strategies for utilizing these potentially restricted slots, including putting the oldest or least-used cartridges there. This, of course, depends on the application and information availability requirements.
8Gb FC networks. The faster network is a requirement for connecting the *IBM TS7760T* virtual tape library. If you want to do that, you will need the TS4500 R2 or R3. Regardless, if you have a lot of data to transport to and from your tape library, 16Gb FC may be an operating requirement.

All things considered, the economics of scaling (both space and capacity) and high availability may alone justify the transition to the TS4500 R3 from the TS3500 or earlier models of the TS4500. The same may be true if you have another vendor’s tape library or if you are moving data from a disk-based solution.

**New or Improved Functionality is Needed**

New functionality almost always is better than what it supplants or replaces. (See Exhibit 3, above, for a list of what’s new in the TS4500 R3.) The older your tape library, the more noticeable the improvements. Many of the TS4500 R3 hardware-based features discussed in the previous sections might be “new technology” when compared to what you have installed today. Others may be software or administrative methodology improvements, over the R1 and R2. Some features, like the TS4500’s magazine for loading and removing cartridges from the library, are a combination of both. It all depends to what you are comparing the TS4500 R3.

Some of the TS4500 R3 administration improvements will be no-additional-charge software upgrades available to those data centers with existing R1 and R2 models. If you currently have a TS3500 or other older library, you most certainly will be pleased with the improved ease of use offered by the TS4500 R3’s latest administrative software. With R3, the views are faster (quicker to get to the desired data) and often fewer steps are required to request what you want to see. No longer is there a need to download the data into a database and open that separately for inspection.

**Transparent media verification**, announced last December for the TS4500, allows for verification of media on request (for a specific cartridge) or automatically (regularly testing in the background the quality of all of the cartridges in a dynamic partition). This no-charge feature requires dedicated tape drives. If the cartridge being validated is requested for use, the validation will cease and the accessor will move the cartridge to a drive for accessing the data, as it would with any other cartridge request. By doing this, the temporary location (in a verification tape drive) is transparent to the application or user requesting the cartridge, because the car-
tridge is mounted directly. This is just one example of increasing application agnosticism in the operation of the TS4500.\footnote{This means that application developers, including ISVs, do not have to “know” that they are interacting with a specific tape library from a specific vendor. Administrative functions, like media verification and transparent capacity on demand, happen transparently in the background, unknown to the application or user.}

Worth noting, dynamic partitioning (tightly coupling specified library slots and drives for a specific use) is required with TS4500 R3, i.e., all slots and drives must be allocated to a partition. This good practice now is mandatory. Previously, it was optional. This is another example of application agnosticism.

Larger enterprises sometimes have many systems employed and tape libraries often need to work with more than one of them. In the R1 and R2 releases of TS4500, no more than two encryption key managers could access a logical tape library. In R3, this has been raised to four Library Managed Encryption (LME) key paths per logical library.

Of course, you want your new library to be easy to use and ready to go when it is delivered. The TS4500 R3 is mainframe ready. What this means is that R3 is ready to connect to and integrate with IBM TS7700 backend switches and to attach to TS7700 TSSC for centralized service, and that the administrative GUI is ready to work with the preset TS7700 and z Systems mainframes.

Sometimes, compliance with a standard is a base requirement. So can be requirements regarding the sourcing of components. For the U.S. government, the latter is an important concern. The Committee on Foreign Investment in the United States (CFIUS) mandates the requirements for government agencies procuring technology, in order to ensure that foreign persons are not able to control or interfere with its systems. With R3, the TS4500 meets CFIUS requirements.\footnote{What this means is that there are no foreign-manufactured control systems (i.e., servers or other systems that potentially could be controlled by foreigners). For the TS4500, this refers to the Integrated Management Console (IMC).}

Finally, the R3 has many enhancements to the administrative GUI, including:

- Additional support for uploading key-tap for Kerberos
- Additional support for uploading encrypted certificates for LDAP
- Additional service options

**Conclusion**

Whether you already have a TS4500 R1 or R2, a TS3500, another vendor’s older library, or are considering a tape library for the first time, the TS4500 has a lot to offer to meet your large-scale information storage needs. Most likely, it also will give you a lot more storage and productive functionality for each Dollar, Euro, Pound, or other currency that you invest. By all means, check out the IBM TS4500 R3!
About The Clipper Group, Inc.
The Clipper Group, Inc., now in its twenty-fourth year, is an independent publishing and consulting firm specializing in acquisition decisions and strategic advice regarding complex, enterprise-class information technologies. Our team of industry professionals averages more than 45 years of real-world experience. A team of staff consultants augments our capabilities, with significant experience across a broad spectrum of applications and environments.

The Clipper Group can be reached at 781-235-0085 and found on the web at www.clipper.com.

About the Author
Mike Kahn is Managing Director and a co-founder of The Clipper Group. Mr. Kahn is a veteran of the computer industry, having spent more than four decades working on information technology, spending the last 23 years at Clipper. For the vendor community, Mr. Kahn specializes on strategic marketing issues, especially for new and costly technologies and services, competitive analysis, and sales support. For the end-user community, he focuses on mission-critical information management decisions. Prior positions held by Mr. Kahn include: at International Data Corporation – Director of the Competitive Resource Center, Director of Consulting for the Software Research Group, and Director of the Systems Integration Program; at Power Factor Corporation, a Boston-based electronics start-up – President; at Honeywell Bull – Director of International Marketing and Support; at Honeywell Information Systems – Director of Marketing and Director of Strategy, Technology and Research; at Arthur D. Little, Inc. – a consultant specializing in database management systems and information resource management; and at Intel Corporation – Mr. Kahn served in a variety of field and home office marketing management positions. Earlier, he founded and managed PRISM Associates of Ann Arbor, Michigan, a systems consulting firm specializing in data management products and applications. Mr. Kahn also managed a relational DBMS development group at The University of Michigan, where he earned B.S.E. and M.S.E. degrees in industrial engineering.

Reach Mike Kahn via e-mail at Mike.Kahn@clipper.com or via phone at (781) 235-0085 Ext. 121. (Please dial “121” when you hear the automated attendant.)

Regarding Trademarks and Service Marks

Disclosures
Officers and/or employees of The Clipper Group may own as individuals, directly or indirectly, shares in one or more companies discussed in this bulletin. Company policy prohibits any officer or employee from holding more than one percent of the outstanding shares of any company covered by The Clipper Group. The Clipper Group, Inc., has no such equity holdings.

After publication of a bulletin on clipper.com, The Clipper Group offers all vendors and users the opportunity to license its publications for a fee, since linking to Clipper’s web pages, posting of Clipper documents on other’s websites, and printing of hard-copy reprints is not allowed without payment of related fee(s). Less than half of our publications are licensed in this way. In addition, analysts regularly receive briefings from many vendors. Occasionally, Clipper analysts’ travel and/or lodging expenses and/or conference fees have been subsidized by a vendor, in order to participate in briefings. The Clipper Group does not charge any professional fees to participate in these information-gathering events. In addition, some vendors sometime provide binders, USB drives containing presentations, and other conference-related paraphernalia to Clipper’s analysts.

Regarding the Information in this Issue
The Clipper Group believes the information included in this report to be accurate. Data has been received from a variety of sources, which we believe to be reliable, including manufacturers, distributors, or users of the products discussed herein. The Clipper Group, Inc., cannot be held responsible for any consequential damages resulting from the application of information or opinions contained in this report.