Welcome to Hardware Differences – VMAX All Flash Family Q3 2016.
This course describes new hardware support for VMAX3 and VMAX All Flash arrays with the Q3 2016 Service Release of HYPERMAX OS 5977.
Module 1: VMAX 250F Hardware

Upon completion of this module, you should be able to:

- Recognize VMAX 250F Hardware
- Discuss VMAX 250F racking and configuration options
- List VMAX 250F upgrade options

This module focuses on the VMAX 250F Hardware.
The Q3 2016 Service Release of HYPERMAX OS 5977 includes support for the VMAX 250F. This new model expands the VMAX All Flash portfolio from the high-end enterprise market segment down to the upper midrange market segment. It fits between the all-flash UNITY 600F and the all-flash VMAX 450F and offers six 9s availability (99.9999% availability) and all of the VMAX Data Services in a 10U form factor.
The VMAX 250F can scale up to 1 petabyte of effective capacity and up to 1 million IOPS with sub-millisecond response times using an 8KB Random Read Hit (RRH) I/O workload. The effective capacity assumes a 2:1 compression ratio.

The 250F scales out by leveraging EMC's V-Brick architecture. Each 250F V-Brick includes 1 engine and a minimum 11TB of usable SSD capacity. As shown here, the system supports up to 2 V-Bricks and can scale out with VMAX 250F Flash Capacity Packs; each providing 11TB of usable capacity.

A fully configured VMAX 250F provides up to 64 host ports and is incredibly space efficient. Each VMAX 250F V-Brick requires just 10U of rack space and a fully configured dual V-Brick system requires just 20U of space.

The array leverages a 25-drive DAE which supports a 12Gb SAS backend interface.

All data services for open systems such as inline compression, SRDF, D@RE, and eNAS are available on the VMAX 250F. There is no support for Mainframe connectivity for the VMAX 250F. Mainframe connectivity remains available on the VMAX 450F and 850F arrays.
Shown here is a comparison of the three VMAX All Flash arrays. Note that the VMAX 250F can include engines with different cache configurations (mixed cache support). There are more details on this later. The VMAX 250F is also unique in that it supports 7.68 and 15.36TB SSDs. Note that TBu refers to the usable storage capacity in the absence of compression. TBe refers to the effective storage capacity with compression assuming a 2:1 compression ratio.
Shown here are the components that make up a single engine VMAX 250F. The maximum number of drives for this configuration is 50. Note that there are no Ethernet switches or KVM included. The VMAX 250F system also supports flexible stacking of rack-mounted equipment. This will allow users to share the rack with third party equipment and support installation of the VMAX 250F system into a third party rack. For a single engine system, you should leave 10U of empty rack space above the DAEs for expansion into a dual engine system. This would leave 20U for non-EMC equipment. Non-EMC equipment should be racked from the top down while the VMAX components should be racked from the bottom up. Note that you can rack 3rd party equipment between VMAX 250F systems, but not between VMAX 250F system components. All non-EMC equipment installed in the rack will require a separate PDU.
Shown here are the components of a dual engine VMAX 250F. The maximum number of drives in this system is 100. Note that there are no InfiniBand switches. The 56Gb/s inter-director links are all direct connect.

- Four 25 Drive DAEs
- No InfiniBand switches required
Shown here is the stacking order for a dual engine system in a single rack as well as a rack with two dual engine systems. As seen here a dual engine VMAX 250F requires 20U of rack space. A standard Titan 40U rack can house two dual engine systems in a single cabinet. The components use the standard vertical PDP/PDUs. The power options are 3-phase delta, 3-phase wye, or single-phase. The components can be shipped installed in the rack or field installed.
Shown here are some possible rack layouts with mixed engine configurations. Note that a VMAX 250F always includes one engine and two DAEs or two engines and four DAEs. A single engine system can be upgraded to a dual engine system by adding an engine, its SPSs, and two DAEs. The components come installed in a mini-rack with adjustable rails included. The upgrade procedure is performed via a script driven installation process.
Shown here is the front view of the VMAX 250F Engine. It is a 4U enclosure that supports two director boards, each with its own redundant power and cooling modules. The cooling fan modules have a higher RPM setting than the ones in the previous hardware release to provide better cooling. Each director contains two Intel Broadwell 12 core 2.2GHz CPUs with 256GB, 512GB, or 1TB cache, and can support up to 16 frontend ports.
Shown here is the VMAX 250F engine I/O Module layout. Each VMAX 250F director supports a management module and eleven I/O Module slots. The I/O Module slots are numbered 0-10 from left to right. The I/O Module ports are numbered 0-3 from the bottom to the top. I/O modules with just two ports are numbered 0 and 1 from the bottom to the top.

A VMAX 250F director supports up to three Vault to Flash I/O Modules in slots 0, 1, and 6. The Vault to Flash I/O Module population order is slot 0 first, slot 6 second, and slot 1 third. Note that all Vault to Flash I/O Modules in the engine need to be the same capacity.

There are up to four frontend I/O Modules in slots 2, 3, 8, and 9. Frontend I/O Modules are always added in pairs across directors.

Slot 4 is used for the backend connections to the disk drives in the DAEs. Slot 5 is empty and slot 7 is used for the hardware compression I/O Module. Finally, slot 10 is used for the directly connected 56Gb/s inter-director links.
Shown here are the options available for frontend I/O Modules in slots 2, 3, 8, and 9. As mentioned earlier, the frontend I/O Modules are always added in pairs across directors.

<table>
<thead>
<tr>
<th>Use</th>
<th>Interface</th>
<th>Ports</th>
<th>Gb/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC/SRDF</td>
<td>FC, SRDF</td>
<td>4</td>
<td>2/4/8</td>
</tr>
<tr>
<td></td>
<td>FC, SRDF</td>
<td>4</td>
<td>4/8/16</td>
</tr>
<tr>
<td>SRDF</td>
<td>GigE SRDF</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>GigE SRDF</td>
<td>2/2</td>
<td>1</td>
</tr>
<tr>
<td>iSCSI</td>
<td>GigE/iSCSI</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>eNAS</td>
<td>GigE</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>GigE (Copper)</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Tape backup</td>
<td>4</td>
<td>2/4/8</td>
</tr>
</tbody>
</table>
Memory and Vault to Flash Considerations

- Engine mixed memory sizes can only be one size apart
  - 512GB and 1TB or 1TB and 2TB
- Must use largest memory engine’s Vault to Flash capacity and count
- Field upgraded second engines must have the same Vault to Flash capacity and count as the original engine
- Field upgraded systems that require higher memory size and Vault to Flash capacity and count must upgrade original engine first

As mentioned earlier, the VMAX 250F engines can have mixed memory sizes, but the differences can only be one capacity size apart.

For systems that have different engine memory sizes, both engines must use the largest memory engine’s Vault to Flash I/O Module capacity and count.

For field upgraded systems that are upgraded from single engine systems to a second engine with like memory size, the second engine must have the same Flash capacity and I/O Module count as the original engine.

For field upgraded systems that require a larger memory size and Flash I/O Module configuration for a second engine, the original engine must be upgraded first with I/O Modules to have the same size Vault to Flash and I/O Module count that the second engine will have when it is installed. After upgrading the original engine, the second engine can then be installed.
Shown here is the front view of the 25 drive DAE. It includes dual power supplies and dual Link Control Cards (LCC) that are accessible from the rear. The LCCs are connected to the engine via the backend I/O Modules in slot four of the engines.
Shown here are the currently supported SSDs in the VMAX 250F storage system.

<table>
<thead>
<tr>
<th>Raw Capacity</th>
<th>Formatted Capacity</th>
<th>RAID 5 (3+1)</th>
<th>RAID 6 (6+2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>960 GB</td>
<td>939GB</td>
<td>2.8TB</td>
<td>5.6TB</td>
</tr>
<tr>
<td>1.92TB</td>
<td>1.88TB</td>
<td>5.6TB</td>
<td>11.3TB</td>
</tr>
<tr>
<td>3.84TB</td>
<td>3.76TB</td>
<td>11.3TB</td>
<td>22.6TB</td>
</tr>
<tr>
<td>7.68TB</td>
<td>7.52TB</td>
<td>22.6TB</td>
<td>45.1TB</td>
</tr>
<tr>
<td>15.36TB</td>
<td>15.04TB</td>
<td>45.1TB</td>
<td>90.3TB</td>
</tr>
</tbody>
</table>
Since there is no KVM included with a VMAX 250F storage system, you will need to connect to the Management Module Control Station (MMCS) using a service laptop connected to the red service cable. The service laptop IP configuration must be set with the IP, Subnet Mask, and Default Gateway shown. The service laptop IP configuration can be changed to the required parameters automatically using the IP Switcher Tool shown on the right. The tool is available for download on support.emc.com. This tool will work as long as the user hasn’t changed the internal MMCS subnets on the VMAX system using the EMC VMAX Subnet Override Customer Service Procedure. Note that the IP Switcher Tool just configures the laptop IP settings, it does not actually connect to the MMCS.

Once you have configured the laptop, then you can connect via RemotelyAnywhere to the primary or secondary MMCS on the 172.16 subnet. Note that the 172.17 subnet is not available through the red service cables. If the user has changed the internal MMCS subnets then you can either set the service laptop IP parameters manually, or use an onsite KVM.
The VMAX 250F software offers the same F and FX software packages as the existing VMAX All Flash arrays except for Mainframe support. The rules for the a la carte options are also the same as the current VMAX 450F and 850F.
Module Summary

Key points covered in this module:

- The VMAX 250F fits between the all-flash UNITY 600F and the all-flash VMAX 450F and offers six 9s availability and all of the VMAX Data Services in a 10U form factor.
- The VMAX 250F system supports flexible stacking of rack-mounted equipment.

This module covered the VMAX 250F hardware.
Module: Hardware Compression

Upon completion of this module, you should be able to:

- Discuss hardware compression requirements
- Monitor compression statistics

This module focuses on Hardware Compression.
The Q3 2016 Service Release of HYPERMAX OS 5977 includes inline compression, which maximizes the VMAX All Flash value proposition by providing the best space savings. VMAX All Flash inline compression delivers higher space efficiency, reducing the overall cost per usable TB.

VMAX All Flash delivers no compromise compression and works with all VMAX trusted data services. VMAX All Flash can encrypt compressed data in real-time which is unique.

VMAX All Flash compression operates granularly at the Storage Group (Application) level so customers can target those workloads that benefit the most. Compression can also be applied to existing data that was written prior to the availability of this HYPERMAX release.

In VMAX data compression, data is compressed as it moves from the system cache to the back end drives using a compression I/O Module on each director. Software-based compression is used if the hardware compression I/O Module fails.

VMAX All Flash compression is performance optimized and smart enough to make sure the most active data is not compressed. This allows the system to deliver maximum throughput leveraging cache and SSD technology and ensures that system resources are balanced and always available when required.
Shown here are some typical compression ratios for various applications. Generally you should expect a compression ratio of about 2:1, which is the default, although compression rates vary depending on the applications and environments and are not guaranteed. Supported compression ratios range from 1.3:1 to 3.0:1.

### Compression on VMAX

<table>
<thead>
<tr>
<th>Application</th>
<th>Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Services</td>
<td>50%</td>
</tr>
<tr>
<td>Virtualization</td>
<td>55%</td>
</tr>
<tr>
<td>Oracle OLTP</td>
<td>65%</td>
</tr>
<tr>
<td>Oracle DW</td>
<td>70%</td>
</tr>
<tr>
<td>Exchange 2007</td>
<td>35%</td>
</tr>
<tr>
<td>Exchange 2010</td>
<td>35%</td>
</tr>
<tr>
<td>Software Dev</td>
<td>55%</td>
</tr>
<tr>
<td>Geoseismic</td>
<td>40%</td>
</tr>
</tbody>
</table>

Source: EMC Competitive Intelligence

**VMAX Compression:**
- Ratios vary by application
- Great fit for VMAX as a consolidation platform
- Expect 2:1 compression ratio on average
- Supported ratios range from 1.3:1 to 3.0:1.
For host level compression analysis use the Mitrend tool to help determine the best compressibility factor for the scenario. Compression analysis via Mitrend will be available with the Q3 2016 Service Release of HYPERMAX OS 5977.
Compression is supported for Fixed Block Architecture (FBA) devices on all VMAX All Flash arrays. VMAX All Flash models that ship with the Q3 2016 Service Release of HYPERMAX OS 5977 will have compression enabled by default, although it is not required. Existing VMAX 450F and 850F systems can take advantage of this capability by upgrading to this latest HYPERMAX release. Existing VMAX All Flash systems shipped with the required hardware compression I/O Module already installed in anticipation of this software release.

Before enabling compression on upgraded arrays, a system validation is required. This will be performed using the VMAX Sizer tool.

Next, a compression conversion is performed. Compression conversion prepares the system for compression and builds an IMPL file with a target compression ratio.

Note that the existing Storage Groups will not be automatically enabled. The user needs to enable compression on any existing Storage Groups. Compression will be enabled by default when creating new Storage Groups.

One thing to keep in mind is that there are no rollbacks to the prior software release allowed once compression is enabled on an upgraded system. You may be able to roll back with an RPQ approval but only prior to compression enablement.
As mentioned in the previous slide, the configuration needs to be verified that it is sufficient for the target compression ratio prior to enabling compression on upgraded systems. Use the VMAX Sizer tool to validate the system cache size and SSD capacity. The system cache size and SSD count may need to be adjusted according to the anticipated compression ratio and performance requirements of the system. Note that the VMAX Sizer tool will support compression sizing for new configurations in the October release but the compression evaluation option for existing systems will come in a future release.
Q3 2016 SR Compression Restrictions

- Compression not supported on VMAX3 Hybrid arrays
- Fixed Block Architecture only
  - No mixed FBA/CKD storage groups
- SG must be FAST managed
- Changes requires StorageAdmin rights
- No external array support
  - No FAST.X support
  - CloudArray can run on array with compression

Shown here are some of the restrictions on VMAX compression. Compression is only supported on the VMAX All Flash arrays.

Compression is supported on Fixed Block Architecture (FBA) devices only. Compression is not supported with Mainframe (CKD) including mixed FBA/CKD storage groups.

Any Storage Groups with compression enabled must be FAST managed storage groups. Any changes to compression settings require StorageAdmin rights.

Compression is not supported with SRPs with external Flash, therefore FAST.X is not supported. However, CloudArray is supported on a VMAX with compression as long as a different SRP is used.
Key Compression Components

<table>
<thead>
<tr>
<th>Compression Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Hot Data</td>
<td>Tags hottest data per SRP to skip compression. Determined by FAST - same mechanism used for FAST promotions in hybrid arrays. Ensures optimal response time of hot data. Simultaneously decreases the compression load.</td>
</tr>
<tr>
<td>4x32k Mode</td>
<td>Each 128K front end track is compressed in four 32K pieces. Each piece can be compressed by an independent compression I/O module channel. Allows for read/modify/compress/write on less than 128KB.</td>
</tr>
<tr>
<td>FACT(CPR)</td>
<td>Fully autonomous compression tiering/compression pool ratio. Automated process that converts TDATs from one compression ratio to another. Approximately 5-20% of allocated capacity per day initially. Over time approximately 0-2% converted per day.</td>
</tr>
<tr>
<td>Zero Reclaim</td>
<td>Performed automatically during compression. Compression action includes a check for zeros. If found to be all zeros it will be deallocated rather than compressed. Hint bit for each 32K unit (4x32 mode) - allows for partial track read without accessing or decompressing a 32K unit of all zeros.</td>
</tr>
</tbody>
</table>

Shown here are some of the key components of the compression feature that run in the background.
In Unisphere for VMAX, Navigate to Storage > Storage Group Dashboard to view the Overall Efficiency for the Storage Resource Group. Here we see that the Overall Efficiency for SRP_1 is 5.3:1. Note that you can view the compression ratio of a particular storage group or volume by navigating to their respective details pages. You can also modify the storage group or volume to enable or disable compression. Note that disabling compression on an SG stops compression of new data, but previously written data will stay compressed unless it is accessed.

The Overall Efficiency ratio is the ratio of the sum of all TDEVs and Snapshot sizes (calculated based on the 128K track size) and the Physical Used Storage (calculated based on the compressed pool track size).

The Virtual Provisioning Ratio is the ratio of the TDEV configured storage and the TDEV Logical Backend Storage (calculated based on TDEV allocated tracks without shared unowned).

The Snapshot Ratio is the ratio of the sum of all Snapshot sizes and the RDP Logical Backend Storage.

The Compression Ratio is the ratio of the sum of all TDEVs and RDP Logical Backend Storage (calculated based on the 128K track size) and the TDEVs and RDP Physical Used Storage (calculated based on the compressed pool track size).

Click on the Overall Efficiency link to view the SRP Efficiency Report.
Show here is the Storage Resource Pool (SRP) Efficiency Report. The SRP Efficiency Report displays the following additional information:

The Virtual Provisioning % Saved is the percentage savings of the TDEV configured storage presented to the hosts and the TDEV Allocated Storage.

The Shared Ratio is the ratio of the TDEV allocated storage and the TDEV Logical Backend Storage. Backend Storage is the sum of TDEV allocated tracks without counting the TDEV shared unowned tracks.

The Snapshot % Saved is the percentage savings of the sum of all TDEV Snapshot sizes (at the time of Snapshot creation) and the TDEV Snapshot Allocated Storage.

The Snapshot Shared Ratio is the ratio of the Snapshot Allocated Storage and the RDP Logical Backend Storage.

The Compression Virtual Provisioning Ratio is the ratio of the TDEV Logical Backend Storage (calculated based on the 128K track size) and the TDEV Physical Used Storage (calculated based on the compressed pool track size).

The Compression Snapshot Ratio is the ratio of the RDP Logical Backend Storage (calculated based on the 128K track size) and the RDP Physical Used Storage of the RDP space (calculated based on the compressed pool track size).

Note that all these details can be seen in the Unisphere for VMAX Online Help pages.
# Data Services Considerations

<table>
<thead>
<tr>
<th>Data Service</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Replication Nocopy Sessions</td>
<td>Track owner determines compression</td>
</tr>
<tr>
<td>(SnapVX, VP Snap)</td>
<td>Compressed source track remains compressed after it becomes a snapshot delta</td>
</tr>
<tr>
<td></td>
<td>Uncompressed source track remains uncompressed but may be compressed later if it becomes cold data</td>
</tr>
<tr>
<td></td>
<td>Compression setting of linked targets does not effect snapshot deltas</td>
</tr>
<tr>
<td></td>
<td>Read activity to snapshot deltas through a linked target may cause the data to become hot (RHD) which could prevent it from being compressed or to be decompressed</td>
</tr>
<tr>
<td>Local Replication Copy Sessions</td>
<td>Compression setting of the target Storage groups taken into account during copy</td>
</tr>
<tr>
<td>(SnapVX Full copy linked targets,</td>
<td>Compressed source track may remain compressed to a target with compression enabled</td>
</tr>
<tr>
<td>clone, mirror)</td>
<td>Full copy may copy slower due to compression setting on the target (May want to set compression enabled on the target after the initial copy is complete)</td>
</tr>
<tr>
<td>Remote Replication SRDF S/A SRDF</td>
<td>Compression is supported however with RDF compression enabled data that will be sent across the link that has inline compression enabled will be uncompressed and recompressed by RDF compression to send across the link (Target may not be VMAX All Flash with the same inline compression)</td>
</tr>
<tr>
<td>Metro</td>
<td>D@RE</td>
</tr>
<tr>
<td></td>
<td>Encryption is applied to compressed data</td>
</tr>
</tbody>
</table>

Shown here are some data services considerations.
Solutions Enabler Compression Commands

- `symcfg show -srp <srp_name> -sid xxx |more`
  - Displays SRP compression ratio
- `symmsg -sid xxx show <sg_name>`
  - Displays storage group compression ratio
- `symmsg -sid xxx -sg <sg_name> set -compression`
  - Enables compression on the selected storage group
- `symmsg -sid xxx create <sg_name> -compression -srp <srp_name> -sl <service level_name>`
  - Creates new storage group with compression enabled

Shown here are some Solutions Enabler commands used to monitor and manage compression.
Module Summary

Key points covered in this module:

- VMAX All Flash inline compression delivers higher space efficiency, reducing the overall cost per usable TB.
- Data is compressed as it moves from the system cache to the back end drives using a I/O Module on each director.
- Compression can be monitored and managed with Unisphere for VMAX and with Solutions Enabler.

This module covered VMAX All Flash hardware compression.
This course covered the hardware support for VMAX3 and VMAX All Flash arrays with the Q3 2016 Service Release of HYPERMAX OS 5977. This concludes the training. Proceed to the course assessment on the next slide.