Hitachi AMS 2000 Family ShadowImage In-system Replication User Guide
Export authorization is required for the AMS 2000 Data At Rest Encryption

- Import/Use regulations may restrict export of the AMS2000 SED to certain countries
- China – AMS2000 is eligible for import but the License Key and SED may not be sent to China
- France – Import pending completion of registration formalities
- Hong Kong – Import pending completion of registration formalities
- Israel – Import pending completion of registration formalities
- Russia – Import pending completion of notification formalities
- Distribution Centers – IDC, EDC and ADC cleared for exports
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Preface

This document provides instructions on assessing your ShadowImage requirements, designing an implementation to meet those requirements, and implementing and operating ShadowImage software using the Storage Navigator 2 graphical user interface.

This preface includes the following information:

- Intended audience
- Product version
- Release notes and readme
- Document revision level
- Changes in this revision
- Document organization
- Document conventions
- Convention for storage capacity values
- Related documentation
- Getting help
**Intended audience**

This document is intended for system administrators, Hitachi Data Systems representatives, and Authorized Service Providers who install, configure, and operate Hitachi Adaptable Modular System (AMS) 2000 family storage systems.

**Product version**

This document applies to Hitachi AMS 2000 Family firmware version 08C3/R or later.

**Release notes and readme**

Read the release notes and readme file before installing and using this product. They may contain requirements or restrictions that are not fully described in this document and/or updates or corrections to this document.

**Product Abbreviations**

<table>
<thead>
<tr>
<th>Product Abbreviation</th>
<th>Product Full Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ShadowImage</td>
<td>ShadowImage In-system Replication</td>
</tr>
<tr>
<td>Snapshot</td>
<td>Copy-on-Write Snapshot</td>
</tr>
<tr>
<td>TrueCopy Remote</td>
<td>TrueCopy Remote Replication</td>
</tr>
<tr>
<td>TCE</td>
<td>TrueCopy Extended Distance</td>
</tr>
<tr>
<td>TCMD</td>
<td>TrueCopy Modular Distributed</td>
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### Document revision level

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<td>Initial Release</td>
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<td>December 2008</td>
<td>Revision 2, supersedes and replaces revision MK-97DF8129-01</td>
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<td>March 2009</td>
<td>Revision 3, supersedes and replaces revision MK-97DF8129-02</td>
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<td>June 2009</td>
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<td>August 2014</td>
<td>Revision 24, supersedes and replaces revision MK-97DF8129-23</td>
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Changes in this revision

- Medium Error and Aborted Command errors now generated to the host in Change Response for Replication Mode on page 2-19.
- Note indicating if a DMLU is in the same RAID group of the expansion target, it cannot be expanded in Differential Management LUs (DMLU) on page 1-12.

Document organization

Thumbnail descriptions of the chapters are provided in the following table. Click the chapter title in the first column to go to that chapter. The first page of every chapter or appendix contains links to the contents.

<table>
<thead>
<tr>
<th>Chapter/Appendix Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1, Overview</td>
<td>Provides descriptions of ShadowImage components and how they work together.</td>
</tr>
<tr>
<td>Chapter 2, Planning and design</td>
<td>Provides detailed planning and design information.</td>
</tr>
<tr>
<td>Chapter 3, Requirements</td>
<td>Provides ShadowImage requirements.</td>
</tr>
<tr>
<td>Chapter 4, Install and enable</td>
<td>Provides instructions for enabling ShadowImage.</td>
</tr>
<tr>
<td>Chapter 5, Configuration</td>
<td>Provides configuration information.</td>
</tr>
<tr>
<td>Chapter 6, Using ShadowImage</td>
<td>Provides information and procedures for using ShadowImage.</td>
</tr>
<tr>
<td>Chapter 7, Monitoring and troubleshooting</td>
<td>Provides monitoring and maintenance information.</td>
</tr>
<tr>
<td>Appendix A, ShadowImage specifications</td>
<td>Provides ShadowImage specifications.</td>
</tr>
<tr>
<td>Appendix C, Operations using CCI</td>
<td>Provides detailed Command Control Interface instructions for configuring and using ShadowImage.</td>
</tr>
<tr>
<td>Appendix D, I/O switching mode feature</td>
<td>Host access remains continuous despite drive failure with this feature.</td>
</tr>
<tr>
<td>Glossary</td>
<td>Provides definitions for terms and acronyms found in this document.</td>
</tr>
<tr>
<td>Index</td>
<td>Provides locations to specific information in this document.</td>
</tr>
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</table>
Document conventions

This document uses the following symbols to draw attention to important safety and operational information.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Tip</td>
<td>Tips provide helpful information, guidelines, or suggestions for performing tasks more effectively.</td>
<td></td>
</tr>
<tr>
<td>Note</td>
<td>Notes emphasize or supplement important points of the main text.</td>
<td></td>
</tr>
<tr>
<td>Caution</td>
<td>Cautions indicate that failure to take a specified action could result in damage to the software or hardware.</td>
<td></td>
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</tbody>
</table>

The following typographic conventions are used in this document.

<table>
<thead>
<tr>
<th>Convention</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bold</strong></td>
<td>Indicates text on a window, other than the window title, including menus, menu options, buttons, fields, and labels. Example: Click <strong>OK</strong>.</td>
</tr>
<tr>
<td><em>Italic</em></td>
<td>Indicates a variable, which is a placeholder for actual text provided by the user or system. Example: <em>copy source-file target-file</em> Angled brackets (&lt; &gt;) are also used to indicate variables.</td>
</tr>
<tr>
<td>screen/code</td>
<td>Indicates text that is displayed on screen or entered by the user. Example: <code># pairdisplay -g oradb</code></td>
</tr>
<tr>
<td>&lt; &gt; angled brackets</td>
<td>Indicates a variable, which is a placeholder for actual text provided by the user or system. Example: <code># pairdisplay -g &lt;group&gt;</code> Italic font is also used to indicate variables.</td>
</tr>
<tr>
<td>[ ] square brackets</td>
<td>Indicates optional values. Example: `[ a</td>
</tr>
<tr>
<td>{ } braces</td>
<td>Indicates required or expected values. Example: `{ a</td>
</tr>
<tr>
<td></td>
<td>Indicates that you have a choice between two or more options or arguments. Examples: `[ a</td>
</tr>
<tr>
<td>underline</td>
<td>Indicates the default value. Example: `[ a</td>
</tr>
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</table>
Convention for storage capacity values

Physical storage capacity values (e.g., disk drive capacity) are calculated based on the following values:

<table>
<thead>
<tr>
<th>Physical capacity unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 KB</td>
<td>1,000 bytes</td>
</tr>
<tr>
<td>1 MB</td>
<td>1,000 KB or 1,000^2 bytes</td>
</tr>
<tr>
<td>1 GB</td>
<td>1,000 MB or 1,000^3 bytes</td>
</tr>
<tr>
<td>1 TB</td>
<td>1,000 GB or 1,000^4 bytes</td>
</tr>
<tr>
<td>1 PB</td>
<td>1,000 TB or 1,000^5 bytes</td>
</tr>
<tr>
<td>1 EB</td>
<td>1,000 PB or 1,000^6 bytes</td>
</tr>
</tbody>
</table>

Logical storage capacity values (e.g., logical device capacity) are calculated based on the following values:

<table>
<thead>
<tr>
<th>Logical capacity unit</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>1 block</td>
<td>512 bytes</td>
</tr>
<tr>
<td>1 KB</td>
<td>1,024 (2^10) bytes</td>
</tr>
<tr>
<td>1 MB</td>
<td>1,024 KB or 1024^2 bytes</td>
</tr>
<tr>
<td>1 GB</td>
<td>1,024 MB or 1024^3 bytes</td>
</tr>
<tr>
<td>1 TB</td>
<td>1,024 GB or 1024^4 bytes</td>
</tr>
<tr>
<td>1 PB</td>
<td>1,024 TB or 1024^5 bytes</td>
</tr>
<tr>
<td>1 EB</td>
<td>1,024 PB or 1024^6 bytes</td>
</tr>
</tbody>
</table>

Related documentation

The AMS 2000 Family user documentation is available on the Hitachi Data Systems Portal: [https://portal.hds.com](https://portal.hds.com). Please check this site for the most current documentation, including important updates that may have been made after the release of the product.

This documentation set consists of the following documents.

**Release notes**
- Adaptable Modular Storage System Release Notes
- Storage Navigator Modular 2 Release Notes

⚠️ Please read the release notes before installing and/or using this product. They may contain requirements and/or restrictions not fully described in this document, along with updates and/or corrections to this document.
Installation and getting started

The following documents provide instructions for installing an AMS 2000 Family storage system. They include rack information, safety information, site-preparation instructions, getting-started guides for experienced users, and host connectivity information. The symbol identifies documents that contain initial configuration information about Hitachi AMS 2000 Family storage systems.

AMS2100/2300 Getting Started Guide, MK-98DF8152
Provides quick-start instructions for getting an AMS 2100 or AMS 2300 storage system up and running as quickly as possible.

AMS2500 Getting Started Guide, MK-97DF8032
Provides quick-start instructions for getting an AMS 2500 storage system up and running as quickly as possible.

AMS 2000 Family Site Preparation Guide, MK-98DF8149
Contains site planning and pre-installation information for AMS 2000 Family storage systems, expansion units, and high-density expansion units. This document also covers safety precautions, rack information, and product specifications.

AMS 2000 Family Fibre Channel Host Installation Guide, MK-08DF8189
Describes how to prepare Hitachi AMS 2000 Family Fibre Channel storage systems for use with host servers running supported operating systems.

AMS 2000 Family iSCSI Host Installation Guide, MK-08DF8188
Describes how to prepare Hitachi AMS 2000 Family iSCSI storage systems for use with host servers running supported operating systems.

Storage and replication features

The following documents describe how to use Storage Navigator Modular 2 (Navigator 2) to perform storage and replication activities.

Storage Navigator 2 Advanced Settings User’s Guide, MK-97DF8039
Contains advanced information about launching and using Navigator 2 in various operating systems, IP addresses and port numbers, server certificates and private keys, boot and restore options, outputting configuration information to a file, and collecting diagnostic information.
**Storage Navigator Modular 2 User's Guide**, MK-99DF8208

Describes how to use Navigator 2 to configure and manage storage on an AMS 2000 Family storage system.

**AMS 2000 Family Dynamic Provisioning Configuration Guide**, MK-09DF8201

Describes how to use virtual storage capabilities to simplify storage additions and administration.

**Storage Navigator 2 Storage Features Reference Guide for AMS**, MK-97DF8148

Contains concepts, preparation, and specifications for Account Authentication, Audit Logging, Cache Partition Manager, Cache Residency Manager, Data Retention Utility, LUN Manager, Performance Monitor, SNMP Agent, and Modular Volume Migration.

**AMS 2000 Family Copy-on-write SnapShot User Guide**, MK-97DF8124

Describes how to create point-in-time copies of data volumes in AMS 2100, AMS 2300, and AMS 2500 storage systems, without impacting host service and performance levels. Snapshot copies are fully read/write compatible with other hosts and can be used for rapid data restores, application testing and development, data mining and warehousing, and nondisruptive backup and maintenance procedures.


Describes how to perform high-speed nondisruptive local mirroring to create a copy of mission-critical data in AMS 2100, AMS 2300, and AMS 2500 storage systems. ShadowImage keeps data RAID-protected and fully recoverable, without affecting service or performance levels. Replicated data volumes can be split from host applications and used for system backups, application testing, and data mining applications while business continues to operate at full capacity.


Describes how to create and maintain multiple duplicate copies of user data across multiple AMS 2000 Family storage systems to enhance your disaster recovery strategy.

**AMS 2000 Family TrueCopy Extended Distance User Guide**, MK-97DF8054

Describes how to perform bi-directional remote data protection that copies data over any distance without interrupting applications, and provides failover and recovery capabilities.
Describes how to lock disk volumes as read-only for a certain period of time to ensure authorized-only access and facilitate immutable, tamper-proof record retention for storage-compliant environments. After data is written, it can be retrieved and read only by authorized applications or users, and cannot be changed or deleted during the specified retention period.

Storage Navigator Modular 2 online help
Provides topic and context-sensitive help information accessed through the Navigator 2 software.

Hardware maintenance and operation
The following documents describe how to operate, maintain, and administer an AMS 2000 Family storage system. They also provide a wide range of technical information and specifications for the AMS 2000 Family storage systems. The symbol identifies documents that contain initial configuration information about Hitachi AMS 2000 Family storage systems.

AMS 2100/2300 Storage System Hardware Guide, MK-97DF8010
Provides detailed information about installing, configuring, and maintaining an AMS 2100/2300 storage system.

AMS 2500 Storage System Hardware Guide, MK-97DF8007
Provides detailed information about installing, configuring, and maintaining an AMS 2500 storage system.

Contains specifications and technical information about power cables, system parameters, interfaces, logical blocks, RAID levels and configurations, and regulatory information about AMS 2100, AMS 2300, and AMS 2500 storage systems. This document also contains remote adapter specifications and regulatory information.

Provides information about servicing and upgrading AMS 2100, AMS 2300, and AMS 2500 storage systems.

Describes how to spin down volumes in selected RAID groups when they are not being accessed by business applications to decrease energy consumption and significantly reduce the cost of storing and delivering information.
Command and Control (CCI)
The following documents describe how to install the Hitachi AMS 2000 Family Command Control Interface (CCI) and use it to perform TrueCopy and ShadowImage operations.

AMS 2000 Family Command Control Interface (CCI) Installation Guide, MK-97DF8122
Describes how to install CCI software on open-system hosts.

Contains reference, troubleshooting, and maintenance information related to CCI operations on AMS 2100, AMS 2300, and AMS 2500 storage systems.

Describes how to use CCI to perform TrueCopy and ShadowImage operations on AMS 2100, AMS 2300, and AMS 2500 storage systems.

Command Line Interface (CLI)
The following documents describe how to use Hitachi Storage Navigator Modular 2 to perform management and replication activities from a command line.

Storage Navigator Modular 2 Command Line Interface (CLI) Unified Reference Guide, MK-97DF8089
Describes how to interact with all Navigator 2 bundled and optional software modules by typing commands at a command line.

Storage Navigator 2 Command Line Interface Replication Reference Guide for AMS, MK-97DF8153
Describes how to interact with Navigator 2 to perform replication activities by typing commands at a command line.
**Dynamic Replicator documentation**

The following documents describe how to install, configure, and use Hitachi Dynamic Replicator to provide AMS Family storage systems with continuous data protection, remote replication, and application failover in a single, easy-to-deploy and manage platform.

**Hitachi Dynamic Replicator - Scout Release Notes**, RN-99DF8211

**Hitachi Dynamic Replicator - Scout Host Upgrade Guide**, MK-99DF8267

**Hitachi Dynamic Replicator - Scout Host User Guide**, MK-99DF8266

**Hitachi Dynamic Replicator - Scout Installation and Configuration Guide**, MK-98DF8213

**Hitachi Dynamic Replicator - Scout Quick Install/Upgrade Guide**, MK-98DF8222

**Getting help**

If you need to contact the Hitachi Data Systems support center, please provide as much information about the problem as possible, including:

- The circumstances surrounding the error or failure.
- The exact content of any messages displayed on the host systems.
- The exact content of any messages displayed on Storage Navigator Modular 2.
- The Storage Navigator Modular 2 configuration information. This information is used by service personnel for troubleshooting purposes.

The Hitachi Data Systems customer support staff is available 24 hours a day, seven days a week. If you need technical support, please log on to the Hitachi Data Systems Portal for contact information: [https://portal.hds.com](https://portal.hds.com)

**Comments**

Please send us your comments on this document: [doc.comments@hds.com](mailto:doc.comments@hds.com). Include the document title, number, and revision, and refer to specific sections and paragraphs whenever possible.

*Thank you!* (All comments become the property of Hitachi Data Systems.)
Overview

ShadowImage™ In-System Replication Software uses local mirroring technology to create a copy of any volume in the AMS array. During copying, host applications can continue to read/write to and from the primary production volume. Replicated data volumes can be split as soon as they are created for use with other applications.

This guide provides instructions for planning and design, configuring, using, and monitoring ShadowImage. In this chapter, the following are discussed:

- ShadowImage in-system replication software
- Hardware and software configuration
- How ShadowImage works
- Interfaces for performing ShadowImage operations
- Cascade connection of ShadowImage with TrueCopy
- Cascade connection of ShadowImage with SnapShot
ShadowImage in-system replication software

Hitachi’s ShadowImage uses local mirroring technology to create full-volume copies within the AMS array. In a ShadowImage pair operation, all data blocks in the original data volume are sequentially copied onto the secondary volume.

The original and secondary data volumes remain synchronized until they are split. While synchronized, updates to the original data volume are continually mirrored to the secondary volume. When the secondary volume is split from the original volume, it contains a mirror image of the original volume at that point in time.

After the pair is split, the secondary volume can be used for offline testing or analytical purposes since there is no common data sharing with the original volume. Since there are no dependencies between the original and secondary volumes, each can be written to by separate hosts. Changes to both volumes are tracked so they can be re-synchronized.

Hardware and software configuration

The typical configuration includes a Hitachi AMS array, a host connected to the array, and software to configure and operate ShadowImage (management software). The host is connected to the array using fibre channel or iSCSI connections. The management software is connected to arrays via a management LAN.

ShadowImage employs a primary volume, a secondary volume or volumes, and the Hitachi Storage Navigator Modular2 (Navigator 2) graphical user interface (GUI). Additional user functionality is made available through Navigator 2 Command-Line Interface (CLI) or Hitachi Command Control Interface (CCI).

Figure 1-1 shows a typical ShadowImage environment.
The following sections describe how these components work together.

**How ShadowImage works**

ShadowImage creates a duplicate volume of another volume. This volume “pair” is created when you:

- Select a volume that you want to replicate
- Identify another volume that will contain the copy
- Associate the primary and secondary volumes
- Copy all primary volume data to the secondary volume

When the initial copy is made, all data on the P-VOL is copied to the S-VOL. The P-VOL remains available for read/write I/O during the operation. Write operations performed on the P-VOL are always duplicated to the S-VOL.

When the pair is split, the primary volume continues being updated, but data in the secondary volume remains as it was at the time of the split. At this time:

- The secondary volume becomes available for read/write access by secondary host applications.
- Changes to primary and secondary volumes are tracked by differential bitmaps.
- The pair can be made identical again by re-synchronizing changes from primary-to-secondary or secondary-to-primary.
Volume pairs (P-VOLs and S-VOLs)

Each ShadowImage pair can consist of up to 8 secondary volumes (S-VOL). The primary and secondary volumes are located in the same array.

The S-VOL only becomes accessible to a host after the pair is split. When a pair is split, the pair status becomes Split. While a pair is split, the array keeps track of changes to the P-VOL and S-VOL in differential bitmaps.

When the pair is re-synchronized, differential (changed) data in the P-VOL is copied to the S-VOL; then the S-VOL is again identical to the P-VOL. A reverse-resync can also be performed when you want to update the P-VOL with the S-VOL data. In a reverse resync, the differential data in the S-VOL is copied to the P-VOL.

Figure 1-2 illustrates basic operations. Figure 1-3 illustrates pair operations using Storage Navigator Modular 2 GUI.
Figure 1-2: Basic ShadowImage Operations
Creating pairs

The ShadowImage creating pairs operation establishes the newly specified ShadowImage pairs. The volumes, which will become the P-VOL and S-VOL, must both be in the Simplex state before becoming a ShadowImage pair. Also, when the P-VOL to be an operation target configures a ShadowImage pair in any of the following status with another S-VOL, a pair cannot be newly created using the Create button:

- Paired
- Paired Internally Synchronizing
- Synchronizing
- Reverse Synchronizing
- Split Pending
- Failure (Restore)
Initial copy operation

The ShadowImage initial copy operation takes place when you create a new ShadowImage pair, as shown in Figure 1-4. The ShadowImage initial copy operation copies all data on the P-VOL to the associated S-VOL. The P-VOL remains available to all hosts for read and write I/Os throughout the initial copy operation. Write operations performed on the P-VOL during the initial copy operation will always be duplicated to the S-VOL. The status of the pair is Synchronizing while the initial copy operation is in progress. The pair status changes to Paired when the initial copy is complete.

When creating pairs, you can select the pace for the initial copy operations: Slow, Medium, and Fast. The default setting is Medium.

Automatically split the pair following pair creation

When creating a new ShadowImage pair, you can execute an initial copy in the background and perform pair creation and pair split continuously by specifying Quick Mode. If you execute the command, you will be able to make Read/Write access for the S-VOL immediately and the S-VOL data accessed by the host becomes the same as the P-VOL data at the time of command execution. The pair status under the initial copy is Split Pending. The pair status changes to Split when the initial copy is completed.

Splitting pairs

The ShadowImage splitting pairs operation splits the paired P-VOL and S-VOL, and changes the pair state of the P-VOL and S-VOL to Split.

When splitting pairs is performed the S-VOL becomes identical to the P-VOL and then provides full Read/Write access to the S-VOL.
You can split the pair whose status is Synchronizing or Paired Internally Synchronizing by executing the split operation in Quick Mode. To perform the split operation in Quick Mode for the pair whose status is Synchronizing, specify the option at the time of command execution. Moreover, the split operation for the pair whose status is Paired Internally Synchronizing is executed in Quick Mode regardless of the Quick Mode specification option. In the split operation in Quick Mode, if you execute the command, you will be able to make Read/Write access for the S-VOL immediately, and the S-VOL data accessed by the host becomes the same as the P-VOL data at the time of command execution. The data to make the S-VOL data same as the P-VOL data at the time of command execution is copied in the background, and the status becomes Split Pending until the copy is completed. The status changes to Split when the copy is completed.

This feature provides point-in-time backup of your data, and also facilitates real data testing by making the ShadowImage copies (S-VOLs) available for host access.

When the split operation is complete, the pair status changes to Split or Split Pending, and you have full Read/Write access to the split S-VOL. While the pair is split, the array establishes a track map for the split P-VOL and S-VOL and records all updates to both volumes. The P-VOL remains fully accessible during splitting pairs operation. Splitting pairs operations cannot be performed on suspended (Failure) pairs. Also, when the P-VOL that will be an operation target configures a ShadowImage pair in the Split Pending status with another S-VOL, the split operation in the Quick Mode cannot be executed.

Re-synchronizing pairs operations

The ShadowImage re-synchronizing pairs operation resynchronizes the split pairs (Split or Split Pending) or the suspended on error pairs (Failure). When re-synchronizing pairs operation starts, the pair status changes to Synchronizing, Reverse Synchronizing, or Paired Internally Synchronizing. The pair status changes to Paired when re-synchronizing pairs copy operations are completed.

ShadowImage allows you to perform two types of re-synchronizing pairs operations:

Normal

The normal re-synchronizing pairs operation (see Figure 1-5 on page 1-9) resynchronizes the S-VOL with the P-VOL. The copy direction for a normal re-synchronizing pairs operation is P-VOL to S-VOL. The pair status during a normal re-synchronizing copy operation is Synchronizing. The S-VOL becomes inaccessible to all hosts for write operation, and the P-VOL remains accessible to all hosts for both read and write operations during a normal re-synchronizing pairs. The normal re-synchronizing pairs operation can be executed for pairs with a status of Split, Split Pending, and Failure. However, when the P-VOL that will be an operation target configures a
ShadowImage pair in the Reverse Synchronizing status or the Failure (Restore) status with another S-VOL, re-synchronizing pairs operation cannot be executed.

When the firmware of the array is 0897/A or more, the P-VOL to be the operation target configures another S-VOL, two pairs which are in the Paired status, Paired Internally Synchronizing status, Synchronizing status, or Split Pending status, re-synchronizing pairs operation cannot be executed. Or, if one of two pairs is in the Split Pending status and the other pair status is any of the Paired status, Paired Internally Synchronizing status, or Synchronizing status, re-synchronizing pairs operation cannot be executed.

When the firmware of the array is less than 0897/A, the P-VOL that will be an operation target configures a ShadowImage pair in the Paired status, the Paired Internally Synchronizing status, the Synchronizing status, and the Split.

Moreover, if you specify Quick Mode when executing the re-synchronizing operation, the pair status becomes Paired Internally Synchronizing. Although the P-VOL data is copied to the S-VOL just like the pair in the Synchronizing status, you can execute the split operation without specifying Quick Mode option for the pair in the Paired Internally Synchronizing status.

When re-synchronizing pairs operation is executed for a pair in the Failure (S-VOL Switch) status, the restore (reverse resynchronization) operation is performed. When operating restore, you cannot specify Quick Mode.

**Figure 1-5: Normal Re-synchronizing Pairs Operation**

**Reverse**

Restore pairs operation (see Figure 1-6) synchronizes the P-VOL with the S-VOL. However, when the P-VOL that will be an operation target configures a ShadowImage pair in the Paired status, the Paired Internally Synchronizing status, the Synchronizing status, the Reverse Synchronizing status, the Split Pending status or the Failure (Restore) status with another S-VOL, the restore operation cannot be executed. The copy direction for a restore pairs operation is S-VOL to P-VOL. The pair status during a restore operation...
operation is Reverse Synchronizing, and the S-VOL becomes inaccessible to all hosts for write operations during a restore pairs operation. The P-VOL remains accessible for both read and write operations, and the write operation on P-VOL will always be reflected to S-VOL (see Figure 1-7). When operating restore, you cannot specify Quick Mode.

Figure 1-6: Reverse Re-synchronizing Pairs Operation

Figure 1-7: Reflecting Write Data to S-VOL during Reverse Re-synchronizing Pairs Operation (Restore)

ShadowImage allows you to perform re-synchronizing operations on split, Split Pending, and Failure pairs.

Re-synchronizing for split or split pending pair

When a re-synchronizing pairs operation is performed on a split pair or split pending (status = Split or Split Pending), the array merges the S-VOL differential track map into the P-VOL track differential map and copies all flagged data from the P-VOL to the S-VOL. When a reverse re-synchronizing pairs operation is performed on a split pair, the array merges the P-VOL differential track map into the S-VOL differential track map and then copies all flagged tracks from the S-VOL to the P-VOL. This ensures that the P-VOL and S-VOL are properly resynchronized in the desired direction, and also greatly reduces the time needed to resynchronize the pair.
Re-synchronizing for suspended pair

When a re-synchronizing pairs operation is performed on a suspended pair (status = Failure), the array copies all data on the P-VOL to the S-VOL, since all P-VOL tracks were flagged as difference data when the pair was suspended. It takes the same time as the initial copy of ShadowImage until the copy for resynchronization is completed and the status changes to Paired.

Suspending pairs operation

The ShadowImage suspending pairs operation (split pair with Suspend operation in progress and force the pair in failure state) immediately suspends the ShadowImage copy operations to the S-VOL of the pair. The user can suspend a ShadowImage pair at any time. When a ShadowImage pair is suspended on error (status = Failure), the array stops performing ShadowImage copy operations to the S-VOL, continues accepting write I/O operations to the P-VOL, and marks the entire P-VOL track map as difference data. When a re-synchronizing pairs operation is performed on a suspended pair, the entire P-VOL is copied to the S-VOL (when a restore operation is performed, the entire S-VOL is copied to the P-VOL). While re-synchronizing pairs operation for a split or split pending ShadowImage pair greatly reduces the time needed to resynchronize the pair, re-synchronizing pairs operation for a suspended on error pair will take as long as the initial copy operation.

The array will automatically suspend a ShadowImage pair when copy operation cannot be continued or cannot keep the pair mirrored for any reason. When the array suspends a pair, a file is output to the system log or event log to notify the host (CCI only). The array will automatically suspend a pair under the following conditions:

- When the ShadowImage volume pair has been suspended or deleted from the UNIX®/PC host using the CCI.
- When the array detects an error condition related to an initial copy operation. When a volume pair with Synchronizing status is suspended on error, the array aborts the initial copy operation, changes the status of the P-VOL and S-VOL to Failure and accepts all subsequent write I/Os to the P-VOL.

Releasing pairs operation

The ShadowImage releasing pairs operation stops the ShadowImage copy operations to the S-VOL of the pair and releases the volume in paired status. The user can release a ShadowImage pair at any time except when the volumes are already in Simplex or Split Pending status. In both ShadowImage volumes, the status will change to Simplex.
**Differential Management LUs (DMLU)**

The DMLU is an exclusive volume used for storing ShadowImage information when the array is powered down. The DMLU is treated the same as other volumes in the storage array, but is hidden from a host. See *Setting up the DMLU on page 5-2* to configure.

If the DMLU is in the RAID group of the expansion target, you cannot expand the RAID group. Remove the DMLU, then expand the RAID group.

**Cascade configuration of SnapShot and ShadowImage**

When the firmware version of the array is 08B0/A or more, SnapShot and ShadowImage can be cascaded. When SnapShot pair status is *Split*, and the ShadowImage pair status is any of *Paired*, *Paired Internally Synchronizing*, *Synchronizing*, and *Split Pending*, the host I/O performance for the P-VOL deteriorates. Use ShadowImage in the *Split* status and, if needed, resynchronize the ShadowImage pair and acquire the backup. When cascading TrueCopy, SnapShot, and ShadowImage, if TrueCopy pair status is *Paired*, the host I/O performance of the P-VOL may deteriorate. Operate TrueCopy in the *Split* pair status, and if needed, resynchronize the TrueCopy pair and acquire the backup.

The I/O switching function operates even in the configuration in which ShadowImage and SnapShot are cascaded. However, when cascading TrueCopy, if the I/O switching target pair and TrueCopy are cascaded, the I/O switching function does not operate.

**Consistency group (CTG)**

Application data often spans more than one volume. With ShadowImage, it is possible to manage operations spanning multiple volumes as a single group. In a “consistency group” (CTG), all primary logical volumes are treated as a single entity.

Managing ShadowImage primary volumes as a consistency group allows multiple operations to be performed on grouped volumes concurrently. Write order is guaranteed across application logical volumes, since pairs can be split at the same time.

Splitting the group without specifying the quick mode option is possible only when the pairs of Paired and Paired Internally Synchronizing are included in the group. Moreover, splitting the group by specifying the quick mode option is possible only when the pairs of Paired, Paired Internally Synchronizing, and Synchronizing are included in the group.

**Quick mode**

If you use the Quick Mode for creating or updating the copying volume (S-VOL) by ShadowImage, the Read/Write access for the S-VOL becomes available immediately. Since the S-VOL data accessed from the host...
becomes the same as the P-VOL data at the time when the command was executed, you can start the backup from the S-VOL without waiting for the completion of the data copy.

**Table 1-1: Quick Mode Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With Quick Mode</strong></td>
<td>Access from the host to the S-VOL becomes possible without waiting for data copy completion while creating or updating the copying volume.</td>
<td>Since the P-VOL data is used when accessing the S-VOL, the load for the S-VOL affects the I/O performance of the P-VOL. The I/O performance of the S-VOL is affected by the load of the P-VOL and is more deteriorated than the case where Quick Mode is not used.</td>
</tr>
<tr>
<td><strong>Without Quick Mode</strong></td>
<td>Since access from the host to the S-VOL is independent of the P-VOL, the I/O performance is less affected.</td>
<td>Access to the S-VOL cannot begin unless the data copy is completed while creating or updating the copying volume. Therefore, wait for data copy completion before accessing the S-VOL.</td>
</tr>
<tr>
<td><strong>HP</strong></td>
<td>HP-UX 11i V1.0 (PA-RISC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V2.0 (PA-RISC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V3.0 (PA-RISC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V2.0 (IPF)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V3.0 (IPF)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tru64 UNIX 5.1</td>
<td></td>
</tr>
<tr>
<td><strong>IBM®</strong></td>
<td>AIX 5.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AIX 5.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AIX 5.3</td>
<td></td>
</tr>
<tr>
<td><strong>SGI</strong></td>
<td>IRIX 6.5.x</td>
<td></td>
</tr>
</tbody>
</table>
ShadowImage pair status

The ShadowImage displays the pair status of all ShadowImage volumes (LUs). Figure 1-8 shows the ShadowImage pair status transitions and the relationship between the pair status and the ShadowImage operations.

Table 1-2 lists and describes the ShadowImage pair status conditions. If a volume is not assigned to a ShadowImage pair, its status is Simplex.

When you create a ShadowImage pair not specifying Quick Mode, the status of the P-VOL and S-VOL changes to Synchronizing. When the initial copy operation is complete, the pair status becomes Paired. When specifying Quick Mode, if the ShadowImage pair creation starts in the pair creation operation, the pair status becomes Split Pending. In this status, the initial copy is in progress in the background. When the initial copy operation is completed, the pair status changes to Split.
If the array cannot maintain the data copy for any reason or if you suspend the pair, the pair status changes to Failure. When you split a pair, the pair status changes to Synchronizing.

When splitting pairs operation is complete, the pair status changes to Split or Split Pending to enable you to access the split S-VOL. When you start a re-synchronizing pairs operation, the pair status changes to Synchronizing or Paired Internally Synchronizing. When you specify reverse mode for a re-synchronizing pairs operation (restore), the pair status changes to Reverse Synchronizing (data is copied in the reverse direction from the S-VOL to the P-VOL). When re-synchronizing pairs operation is complete, the pair status changes to Paired. When you release a pair, the pair status changes to Simplex.

### Table 1-2: ShadowImage Pair Status

<table>
<thead>
<tr>
<th>Pair Status</th>
<th>Description</th>
<th>S-VOL Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplex</td>
<td>The volume is not assigned to a ShadowImage pair. The array accepts read and write I/Os for all Simplex volumes.</td>
<td>N/A (There is no S-VOL yet).</td>
</tr>
<tr>
<td>Synchronizing</td>
<td>Creating a pair or re-synchronizing a pair, the copy operation is in progress. The array continues to accept read and write operations for the P-VOL but does not accept write operations for the S-VOL. When a split pair is resynchronized in normal mode, the array copies only the P-VOL differential data to the S-VOL. When creating a pair or a Failure pair is resynchronized, the array copies the entire P-VOL to the S-VOL.</td>
<td>Read only.</td>
</tr>
<tr>
<td>Paired Internally Synchronizing</td>
<td>The copy operation is in progress as same as Synchronizing. The P-VOL and the S-VOL are not yet the same. The pair split in the Paired Internally Synchronizing status operates in the Quick Mode even without specifying the option and changes to Split Pending.</td>
<td>Read only.</td>
</tr>
<tr>
<td>Paired</td>
<td>The copy operation is complete, and the array starts copying the write operation taken to the P-VOL data onto the S-VOL. The P-VOL and S-VOL of a duplex pair (Paired status) is identical. The array rejects all write I/Os for S-VOLs with the status Paired.</td>
<td>Read only.</td>
</tr>
<tr>
<td>Split</td>
<td>The array starts accepting write I/Os for Split S-VOLs. The array keeps track of all updates to the split P-VOL and S-VOL so that the pair can be resynchronized quickly.</td>
<td>Read and write. the S-VOL can be mounted.</td>
</tr>
<tr>
<td>Split Pending</td>
<td>Although the array starts accepting the I/O operation of Write for the S-VOL in the Split Pending status, the data copy from the P-VOL to the S-VOL is in progress in the background. The array records the positions of all updates to the split P-VOL and S-VOL. You cannot delete the pair in the Split Pending status.</td>
<td>Read and write. the S-VOL can be mounted.</td>
</tr>
<tr>
<td>Reverse Synchronizing</td>
<td>The array does not accept write I/Os for Reverse Synchronizing S-VOLs. When a split pair is resynchronized in reverse mode, the array copies only the S-VOL differential data to the P-VOL.</td>
<td>Read only.</td>
</tr>
<tr>
<td>Failure</td>
<td>The array continues accepting read and write I/Os for a Failure (suspended under error) P-VOL (however, if the status transits from Reverse Synchronizing, all access to P-VOL is disabled). The array marks the entire P-VOL track map as difference data, so that the entire P-VOL is copied to the S-VOL when the Failure pair is resumed. Use re-synchronizing pairs operation to resume a Failure pair.</td>
<td>Read only. (If the status transits from Reverse Synchronizing, all access to S-VOL is disabled.)</td>
</tr>
</tbody>
</table>
Interfaces for performing ShadowImage operations

ShadowImage can be operated using the following interfaces:

- The GUI (Hitachi Storage Navigator Modular 2 Graphical User Interface) is a browser-based interface from which ShadowImage can be setup, operated, and monitored. The GUI provides the simplest method for performing operations, requiring no previous experience. Scripting is not available.

- CLI (Hitachi Storage Navigator Modular 2 Command Line Interface), from which ShadowImage can be setup and all basic pair operations can be performed—create, split, resynchronize, restore, swap, and delete. The GUI also provides these functionalities. CLI also has scripting capability.

- CCI (Hitachi Command Control Interface), used to display volume information and perform all copying and pair-managing operations. CCI provides a full scripting capability which can be used to automate replication operations. CCI requires more experience than the GUI or CLI. CCI is required on Windows 2000 Server for performing mount/unmount operations.

HDS recommends using the GUI to begin operations for new users with no experience with CLI or CCI. Users who are new to replication software but have CLI experience in managing arrays may want to continue using CLI, though the GUI is an option. The same recommendation applies to CCI users.

---

NOTE: Hitachi Replication Manager can be used to manage and integrate ShadowImage. It provides a GUI representation of the ShadowImage system, with monitoring, scheduling, and alert functions. For more information, visit the Hitachi Data Systems website.

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CAUTION! Storage Navigator 2 CLI is provided for users with significant storage management expertise. Improper use of this CLI could void your Hitachi warranty. Please consult with your reseller before using CLI.
Cascade connection of ShadowImage with TrueCopy

ShadowImage volumes can be cascaded with those of TrueCopy, as shown in the Figure 1-9 through Figure 1-13. ShadowImage P-VOL volumes can be cascaded with those of TrueCopy in the Split Pending or Paired Internally Synchronizing status. ShadowImage S-VOL volumes cannot be cascaded with those of TrueCopy in the Split Pending or Paired Internally Synchronizing status.

NOTE: When cascading ShadowImage with TrueCopy:

- ShadowImage cannot be cascaded with ShadowImage or SnapShot.
- When the firmware of the array is less than 08B0/A, ShadowImage cannot be cascaded with SnapShot.
- ShadowImage concurrent use with TCE however cannot be cascaded with TCE.

Volumes of ShadowImage can be cascaded with those of TrueCopy as shown in the following figures.
- Cascade with a P-VOL of ShadowImage

```
Host  
Read /Write
  
P-VOL
  
Cascade Connection
  
S-VOL
  
P-VOL
  
ShadowImage
  
S-VOL
  
Local array
  
Remote array

- Cascade with an S-VOL of ShadowImage

```

```
Host  
Read /Write
  
P-VOL
  
TrueCopy
  
S-VOL
  
P-VOL
  
ShadowImage
  
S-VOL
  
Local array
  
Remote array

```

Figure 1-9: Cascade Connection of ShadowImage with TrueCopy (P-VOL: S-VOL=1:1)
- Cascade with a P-VOL and an S-VOL of ShadowImage

Figure 1-10: Simultaneous Cascade Connection of ShadowImage with TrueCopy (P-VOL: S-VOL=1:1)
Cascade with a P-VOL of ShadowImage

**Figure 1-11: Cascade Connection of ShadowImage with TrueCopy (P-VOL: S-VOL=1:3)**
Cascade with an S-VOL of ShadowImage

**Figure 1-12: Cascade Connection of ShadowImage with S-VOL**
Cascade with a P-VOL and an S-VOL of ShadowImage

Figure 1-13: Simultaneous Cascade Connection of ShadowImage with TrueCopy (P-VOL: S-VOL=1:3)
Cascade restrictions with ShadowImage P-VOL

If by using TrueCopy, the P-VOL on ShadowImage is cascaded, there is a possibility that the data of P-VOL on the local side does not equal the data of P-VOL on the remote side due to restore being executed using ShadowImage. To counteract this, the restriction that enables restores using ShadowImage to be executed in the Split status only is provided on TrueCopy. When restores using ShadowImage are executed, TrueCopy must be in the Split status. If restore using ShadowImage is executed in the Synchronizing status or Paired status of TrueCopy, the data in the LUs for P-VOL that are cascaded using TrueCopy on the local side and the remote side cannot be assured of being equal.

LU shared with P-VOL on ShadowImage and P-VOL on TrueCopy

Table 1-3 shows whether or not a read/write from/to a P-VOL of ShadowImage on the local side is possible in the case where a P-VOL of ShadowImage and a P-VOL of TrueCopy are the same LU.

### Table 1-3: Read/Write Instruction to a ShadowImage P-VOL on the Local Side

<table>
<thead>
<tr>
<th>TrueCopy P-VOL</th>
<th>ShadowImage P-VOL</th>
<th>Paired (Including Paired Internally Synchronizing)</th>
<th>Synchronizing (Including Split Pending)</th>
<th>Split (Including Split Pending)</th>
<th>Failure</th>
<th>Failure (Restore)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Synchronizing R/W W</td>
<td>Synchronizing R/W W</td>
<td>Synchronizing R/W W</td>
<td>+, R/W</td>
<td>+, R/W</td>
</tr>
<tr>
<td>Paired</td>
<td>+, R/W</td>
<td>+, R/W</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Synchronizing</td>
<td>+, R/W</td>
<td>+, R/W</td>
<td>-</td>
<td>-</td>
<td>+, R/W</td>
<td>+, R/W</td>
</tr>
<tr>
<td>Split</td>
<td>R/W</td>
<td>+, R/W</td>
<td>+, R/W</td>
<td>+, W</td>
<td>+, R/W</td>
<td>Δ, R/W</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>+, R/W</td>
<td>+, R/W</td>
<td>+, W</td>
<td>+, R/W</td>
<td>Δ, R/W</td>
</tr>
<tr>
<td>Failure</td>
<td>R/W</td>
<td>+, R/W</td>
<td>Δ, R/W</td>
<td>Δ, W</td>
<td>+, R/W</td>
<td>Δ, R/W</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>+, R/W</td>
<td>+, W</td>
<td>+, R/W</td>
<td>Δ, R</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>R/W</td>
<td>+, R/W</td>
<td>-</td>
<td>-</td>
<td>+, R/W</td>
<td>Δ, R/W</td>
</tr>
</tbody>
</table>

+ indicates a possible case, – indicates an impossible case
Δ indicates a case where a pair operation causes an error (a case that can occur as a result of a change of the pair status to Failure)
R/W: Read/Write by a host is possible.
R: Read by a host is possible but write is impossible.
W: Write by a host is possible but read is impossible.
R/W: Read/Write by a host is impossible.

---

**NOTE:** Failure in this table excludes any condition where LU access is not possible (for example, LU blockage).
When one P-VOL configures a pair with one or more S-VOLs, decide which item is applied as the pair status of the P-VOL of the above-mentioned ShadowImage with the following procedure.

1. If all the pairs that the P-VOL concerned configures are in the Split status, the item of Split is applied.

2. If all the pairs that the P-VOL concerned configures are in the Split status or the Failure status, the item of Split is applied. However, when including the pair that became Failure during restore, the items of Failure (Restore) are applied.

3. If a pair in the Paired status, the Synchronizing status, or the Reverse Synchronizing status is included in the pair that the P-VOL concerned configures, the item of Paired, Synchronizing, and Reverse Synchronizing is applied, respectively.

4. When multiple Paired statuses and Synchronizing status exist in the pairs that the relevant P-VOL configures, if the respective statuses are all Readable, they are Readable. If the respective statuses are all Writable, they are Writable.

**One LU used for P-VOL on ShadowImage and S-VOL on TrueCopy**

Table 1-4 shows whether a read/write from/to a P-VOL of ShadowImage on the remote side is possible or not in the case where a P-VOL of ShadowImage and an S-VOL of TrueCopy are the same LU.

**Table 1-4: Read/Write Instruction to a ShadowImage P-VOL on the Remote Side**

<table>
<thead>
<tr>
<th>TrueCopy P-VOL</th>
<th>ShadowImage P-VOL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired (Including Paired Internally Synchronizing)</td>
</tr>
<tr>
<td>Paired</td>
<td>+, R</td>
</tr>
<tr>
<td>Synchronizing</td>
<td>+, R</td>
</tr>
<tr>
<td>Split</td>
<td>R/W</td>
</tr>
<tr>
<td>Failure</td>
<td>+, R</td>
</tr>
</tbody>
</table>

+ indicates a possible case, – indicates an impossible case.
Δ indicates a case where a pair operation causes an error (a case that can occur as a result of a change of the pair status to Failure).
R/W: Read/Write by a host is possible.
R: Read by a host is possible but write is impossible.
W: Write by a host is possible but read is impossible.
Δ: Read/Write by a host is impossible.
When one P-VOL configures a pair with one or more S-VOLs, decide which item is applied as the pair status of the P-VOL of the above-mentioned ShadowImage with the following procedure.

1. If all the pairs that the P-VOL concerned configures are in the Split status, the item of Split is applied.

2. If all the pairs that the P-VOL concerned configures are in the Split status or the Failure status, the item of Split is applied. However, when including the pair that became Failure during restore, the items of Failure (Restore) are applied.

3. If a pair is in the Paired status, the Synchronizing status, or the Reverse Synchronizing status is included in the pair that the P-VOL concerned configures, the item of Paired, Synchronizing, and Reverse Synchronizing is applied, respectively.

4. When multiple Paired statuses and Synchronizing status exist in the pairs that the relevant P-VOL configures, if the respective statuses are all Readable, they are Readable. If the respective statuses are all Writable, they are Writable.

**Cascade restrictions with S-VOL of ShadowImage**

Cascade of a TrueCopy LU with a ShadowImage S-VOL is supported only when the ShadowImage S-VOL and TrueCopy P-VOL are the same LU. Also, the operations of the ShadowImage and TrueCopy pairs are restricted depending on the status of the pairs.

Create a ShadowImage pair first when cascading TrueCopy volumes with an S-VOL of the ShadowImage. When a TrueCopy pair is created earlier, split the TrueCopy pair once and create a pair using ShadowImage.

When changing the status of a ShadowImage pair, the status of a TrueCopy pair must be Split or Failure. When changing the status of a TrueCopy pair, the status of a ShadowImage pair must be Split.

Table 1-5 shows whether a read/write to/from a ShadowImage S-VOL on the local side is possible in the case where a ShadowImage S-VOL and a TrueCopy P-VOL are the same LU.
Simultaneous cascading restrictions with ShadowImage P-VOL and S-VOL

When operating a ShadowImage pair where both ShadowImage P-VOL and S-VOL are cascaded with TrueCopy volumes, restrictions are placed on the operation if any restrictions are applied to cascade either ShadowImage P-VOL or S-VOL. To operate the TrueCopy pair, restrictions on the respective cascade configuration are applied depending on which ShadowImage P-VOL and S-VOL is the cascaded volume.

When creating a TrueCopy pair that is to be cascaded with the ShadowImage S-VOL, create the ShadowImage pair first. When changing the status of the TrueCopy pair that is cascaded with the ShadowImage S-VOL, it is required that the ShadowImage pair status is Split.

When changing the status of the ShadowImage pair it is required that the status of the TrueCopy pair, which is cascaded with the ShadowImage S-VOL, is Split or Failure. Furthermore, when executing the restore of ShadowImage, the TrueCopy pair cascaded with the ShadowImage P-VOL in the Split status must change.

NOTE: Failure in this table excludes any condition where LU access is not possible (for example, LU blockage).
Cascade restrictions with data pool of SnapShot

A ShadowImage pair cannot be created using a data pool.

Cascade connection of ShadowImage with SnapShot

When the firmware version of the array is 08B0/A or more, volumes of SnapShot can be cascaded with those of ShadowImage as shown in Figure 1-14. However, the ShadowImage P-VOL and the SnapShot V-VOL cannot be cascaded. Also, the ShadowImage S-VOL and the SnapShot V-VOL cannot be cascaded.

![Cascade connection of ShadowImage with SnapShot](Image)

- LU Ownership

When cascading SnapShot and ShadowImage, the LU Ownership is the same as the owner controller which contains the data pool for SnapShot. If pairs are placed disproportionately in the controllers whose ownership is the same, the load is concentrated and the performance may deteriorate. Specify the ownership so that the load can be diversified.

Also, the load balancing feature does not apply to a ShadowImage pair that is cascaded with a SnapShot pair.
Cascade connection with P-VOL of SnapShot

Cascade of an LU of SnapShot with a P-VOL of ShadowImage, it is supported only when the P-VOL of ShadowImage and a P-VOL of SnapShot are the same LU. Besides, operations of the ShadowImage and SnapShot pairs are restricted depending on statuses of the pairs.

Restriction when performing restoration

When performing restoration, the pair status of the pairs must be made different than those which make restoration Split. While the ShadowImage pair is executing restoration, the V-VOLs of the cascaded SnapShot cannot be Read/Write. When the restoration is completed, Read/Write from/to all the V-VOLs will be possible again.
Figure 1-16: While restoring ShadowImage, the SnapShot V-VOL cannot be Read/Write

Performance when cascading the P-VOL of ShadowImage with SnapShot

In the configuration in which the P-VOL of ShadowImage and the P-VOL of SnapShot are cascaded, when ShadowImage pair status is any of Paired, Paired Internally Synchronizing, Synchronizing, and Split Pending, and at the same time, SnapShot pair status is Split, the host I/O performance for the P-VOL deteriorates. Use ShadowImage in the Split status and, if needed, resynchronize the ShadowImage pair and acquire the backup.

Table 1-6 on page 1-30 shows whether a read/write from/to a P-VOL of ShadowImage is possible or not in the case where a P-VOL of SnapShot and a P-VOL of ShadowImage are the same LU.
Table 1-6: A Read/Write Instruction to a P-VOL of ShadowImage

<table>
<thead>
<tr>
<th>SnapShot P_VOL</th>
<th>ShadowImage P_VOL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired (Including Paired Internally Synchronizing)</td>
</tr>
<tr>
<td>Paired</td>
<td>R/W</td>
</tr>
<tr>
<td>Reverse Synchro</td>
<td>x</td>
</tr>
<tr>
<td>Split</td>
<td>R/W</td>
</tr>
<tr>
<td>Failure</td>
<td>R/W</td>
</tr>
<tr>
<td>Failure (Restore)</td>
<td>x</td>
</tr>
</tbody>
</table>

? indicates a possible case, x indicates an impossible case
? indicates a case where a pair operation causes an error (a case that can occur as a result of a change of the pair status to Failure)
R/W: Read/Write by a host is possible.
R: Read by a host is possible but write is impossible.
W: Write by a host is possible but read is impossible.
R/W: Read/Write by a host is impossible.
Cascade restrictions with P-VOL of ShadowImage

Cascade of an LU of SnapShot with an S-VOL of ShadowImage, is supported only when the S-VOL of ShadowImage and a P-VOL of SnapShot are the same LU. Also, operations of the ShadowImage and SnapShot pairs are restricted depending on statuses of the pairs.

- **Restriction of pair creation order.** When cascading a P-VOL of SnapShot with an S-VOL of ShadowImage, create a ShadowImage pair first. When a SnapShot pair is created earlier, delete the SnapShot pair once and create a pair using ShadowImage.

- **Restriction of Split Pending.** When the ShadowImage pair status is Split Pending, the SnapShot pair cannot be changed to the Split status. Execute it again after changing the ShadowImage pair status to other than Split Pending.

- **Changing the SnapShot pair to Split while copying ShadowImage.** When the SnapShot pair is changed to the Split status while the ShadowImage pair status is Synchronizing or Paired Internally Synchronizing, the V-VOL data of SnapShot cannot be guaranteed. This is because the status where the background copy of ShadowImage is operating is determined as the V-VOL data of SnapShot.

- **Performing pair re-synchronization when the ShadowImage pair status is Failure.** If a pair is re synchronized when the ShadowImage pair status is Failure, all data is copied from the P-VOL to the S-VOL of ShadowImage. When the SnapShot pair status is Split, all data of the P-VOL of SnapShot is saved to the V-VOL. Be careful of the free capacity of the data pool used by the V-VOL.

- **Performance at the time of cascading the S-VOL of SnapShot and ShadowImage.** In the configuration in which the S-VOL of ShadowImage and the P-VOL of SnapShot are cascaded, when ShadowImage pair status is any of Paired, Paired Internally...
Synchronizing, Synchronizing, and Split Pending, and at the same time, SnapShot pair status is Split, the host I/O performance for the P-VOL of ShadowImage deteriorates. Use ShadowImage in the Split status and, if needed, resynchronize the ShadowImage pair and acquire the backup.

Table 1-7 shows whether a read/write from/to an S-VOL of ShadowImage is possible when a P-VOL of SnapShot and an S-VOL of ShadowImage are the same LU.

**Table 1-7: A Read/Write Instruction to a S-VOL of ShadowImage**

<table>
<thead>
<tr>
<th>SnapShot P_VOL</th>
<th>Paired (Including Paired Internally Synchronizing)</th>
<th>Synchronizing</th>
<th>Reverse Synchronizing</th>
<th>Split</th>
<th>Split Pending</th>
<th>Failure</th>
<th>Failure (Restore)</th>
<th>Failure (S_VOL Switch)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>○ R</td>
<td>○ R</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
</tr>
<tr>
<td></td>
<td>Reverse Synchronizing</td>
<td>○ R</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
</tr>
<tr>
<td></td>
<td>Split</td>
<td>○ R</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
</tr>
<tr>
<td></td>
<td>Failure</td>
<td>○ R</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
<td>○ R</td>
<td>○ R/W</td>
<td>△ R/W</td>
</tr>
<tr>
<td></td>
<td>Failure (Restore)</td>
<td>○ R</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
<td>○ R</td>
<td>○ R/W</td>
<td>△ R/W</td>
</tr>
<tr>
<td></td>
<td>○ R</td>
<td>○ R</td>
<td>○ R</td>
<td>○ R/W</td>
<td>○ R/W</td>
<td>○ R</td>
<td>○ R/W</td>
<td>△ R/W</td>
</tr>
</tbody>
</table>

○ indicates a possible case, × indicates an impossible case
△ indicates a case where a pair operation causes an error (a case that can occur as a result of a change of the pair status to Failure)
R/W: Read/Write by a host is possible.
R: Read by a host is possible but write is impossible.
W: Write by a host is possible but read is impossible.
R/W: Read/Write by a host is impossible.
NOTE: When using SnapShot with ShadowImage

- **Failure** in this table excludes a condition in which access of an LU is not possible (for example, LU blockage).
- When one P-VOL configures a pair with one or more S-VOLs, decide which item is applied as the pair status of the P-VOL of the above-mentioned ShadowImage with the following procedure:
  - If all the pairs that the P-VOL concerned configures are in the **Split** status, the item of **Split** is applied.
  - If all the pairs that the P-VOL concerned configures are in the **Split** status or the **Failure** status, the item of **Split** is applied. However, when including the pair that became **Failure** during restore, the items of **Failure (Restore)** are applied.
  - If a pair in the **Paired** status, the **Synchronizing** status, or the **Reverse Synchronizing** status is included in the pair that the P-VOL concerned configures, the item of **Paired, Synchronizing**, and **Reverse Synchronizing** is applied, respectively.

---

### Pair Operation Restrictions when Cascading SnapShot with ShadowImage

Table 1-8 to Table 1-11 on page 1-35 shows pair status and operation when cascading SnapShot with ShadowImage. The shaded areas in the tables indicate unworkable combinations.

**Table 1-8: ShadowImage pair operation when LU shared with P-VOL on ShadowImage and P-VOL on SnapShot (1)**

<table>
<thead>
<tr>
<th>ShadowImage Operation</th>
<th>SnapShot Pair Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired</td>
</tr>
<tr>
<td>Creating pairs</td>
<td>☒</td>
</tr>
<tr>
<td>Splitting pairs</td>
<td>☒</td>
</tr>
<tr>
<td>Re-synchronizing pairs</td>
<td>☒</td>
</tr>
<tr>
<td>Restoring pairs</td>
<td>☒</td>
</tr>
<tr>
<td>Deleting pairs</td>
<td>☒</td>
</tr>
</tbody>
</table>
Table 1-9: SnapShot pair operation when LU shared with P-VOL on ShadowImage and P-VOL on SnapShot (2)

<table>
<thead>
<tr>
<th>SnapShot Operation</th>
<th>ShadowImage Pair Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired (Including Paired Internal Synchronizing)</td>
</tr>
<tr>
<td>Creating pairs</td>
<td>o o x o o x x</td>
</tr>
<tr>
<td>Splitting pairs</td>
<td>o o</td>
</tr>
<tr>
<td>Re-synchronizing pairs</td>
<td>o o x o o</td>
</tr>
<tr>
<td>Restoring pairs</td>
<td>x x x o x</td>
</tr>
<tr>
<td>Deleting pairs</td>
<td>o o o o o x</td>
</tr>
</tbody>
</table>

Table 1-10: ShadowImage pair operation when LU shared with S-VOL on ShadowImage and P-VOL on SnapShot

<table>
<thead>
<tr>
<th>ShadowImage Operation</th>
<th>SnapShot Pair Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired</td>
</tr>
<tr>
<td>Creating pairs</td>
<td>x x</td>
</tr>
<tr>
<td>Splitting pairs</td>
<td>o</td>
</tr>
<tr>
<td>Re-synchronizing pairs</td>
<td>o x</td>
</tr>
<tr>
<td>Restoring pairs</td>
<td>o x</td>
</tr>
<tr>
<td>Deleting pairs</td>
<td>o o</td>
</tr>
</tbody>
</table>
### Table 1-11: SnapShot Pair Operation when LU Shared with S-VOL on ShadowImage and P-VOL on SnapShot (2)

<table>
<thead>
<tr>
<th>ShadowImage Operation</th>
<th>SnapShot Pair Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paired (Including Paired Internally Synchronizing)</td>
</tr>
<tr>
<td>Creating pairs</td>
<td>✓</td>
</tr>
<tr>
<td>Splitting pairs</td>
<td>✓</td>
</tr>
<tr>
<td>Re-synchronizing pairs</td>
<td>✓</td>
</tr>
<tr>
<td>Restoring pairs</td>
<td>x</td>
</tr>
<tr>
<td>Deleting pairs</td>
<td>✓</td>
</tr>
</tbody>
</table>
Simultaneous Cascading Restrictions with ShadowImage P-VOL and S-VOL

When the firmware version of the array is 08B0/A or more, the P-VOL and the S-VOL of ShadowImage can cascade SnapShot at the same time as shown in Figure 1-17. However, when operating ShadowImage in the status of Paired, Paired Internally Synchronizing, Synchronizing, or Split Pending and operating SnapShot in the Split status as is, the performance deteriorates significantly. Start the operation after advance verification.

Figure 1-17: Simultaneous Cascading Restrictions with ShadowImage P-VOL and S-VOL

- **LU Ownership.** When cascading the P-VOL and the S-VOL of ShadowImage and SnapShot at the same time, if the owner controllers which the data pool for SnapShot specified at the time of SnapShot pair creation belongs are different, the pair creation is guarded. Execute the pair operation again by changing the ownership of the specified data pool for SnapShot or specifying the other data pool for SnapShot.
- Be careful when changing the LU ownership in the configuration in which the P-VOL and the S-VOL of ShadowImage and SnapShot are cascaded at the same time. Since the LU ownership change processing operates for all LUs in the cascaded configuration and all other SnapShot pairs using the data pool for SnapShot in the relevant pair configuration, the performance deterioration occurs at the time of execution. To change the ownership, perform it when the load of the array is low.
LU ownership of P-VOLs and S-VOLs

The load balancing feature applies to a ShadowImage pair. When the load balancing feature is activated for a ShadowImage pair, the ownership of the P-VOL and S-VOL changes to the same controller. When the pair state is Synchronizing or Reverse Synchronizing, the ownership of the pair will change across the cores but not across the controllers.

The ownership of the LU specified in the S-VOL of the ShadowImage pair is the same as the ownership of the LU specified in the P-VOL. This ownership change operates regardless of the setting status of load balancing.

For example, if creating a ShadowImage pair by specifying the LU whose ownership is controller 0 as a P-VOL and specifying the LU whose ownership is controller 1 as an S-VOL, the ownership of the LU specified in the S-VOL is changed to controller 0.

When the same controller has the P-VOL ownerships of two or more ShadowImage pairs, the ownerships of all the pairs are biased toward the same controller and the load is concentrated. To diversify the load, specify the ownership to be equal when creating a ShadowImage pair.

If the ownership of a volume has been changed at pair creation, the ownership is not changed at pair deletion. After deleting a pair, set ownership again considering load balance.
Cascade Restrictions of TrueCopy with ShadowImage and SnapShot

When the firmware version of the array is 08B0/A or more, SnapShot can cascade ShadowImage and TrueCopy at the same time. However, since the performance may deteriorate, start the operation after advance verification.

- **Cascade restrictions of TrueCopy S-VOL with SnapShot V-VOL.** In the configuration in which the P-VOL of ShadowImage and the P-VOL of SnapShot are cascaded as shown in **Figure 1-20 on page 1-38**, and at the same time, in the configuration in which the V-VOL of SnapShot and the S-VOL of TrueCopy are cascaded, when the TrueCopy pair status is **Paired** or **Synchronizing**, ShadowImage cannot be restored. Change the TrueCopy pair status to **Split**, and then execute it again.

**Figure 1-19: LU ownership**

**Figure 1-20: Cascade restrictions of TrueCopy S-VOL with SnapShot V-VOL**
Planning and design

With ShadowImage you create copies of your production data so that it can be used to restore the P-VOL or used for tape backup, development, data warehousing, and so on.

This chapter guides you in planning a design that meets your organizational business requirements.

- Plan and design workflow
- Copy frequency
- Copy lifespan
- Establishing the number of copies
- Requirements and recommendations for Logical Units
- Cascading ShadowImage with TrueCopy
- Calculating maximum capacity
Plan and design workflow

A ShadowImage system can only be successful when your business needs are assessed. Business needs determine your ShadowImage copy frequency, lifespan, and number of copies.

- Copy frequency means how often a P-VOL is copied.
- Copy lifespan means how long the copy is held before it is updated.
- Knowing the frequency and lifespan help you determine the number of copies that are required.

These objectives are addressed in detail in this chapter. Three additional tasks are required before your design can be implemented, which are also addressed in this chapter.

- The primary and secondary logical volumes must be set up. Recommendations and supported configurations are provided.
- The ShadowImage maximum capacity must be calculated and compared to the array maximum supported capacity. This has to do with how the array manages storage segments.
- Equally important in the planning process are the ways that various host operating systems interact with ShadowImage. Make sure to review the information at the end of the chapter.

Copy frequency

How often copies are made is determined by how much data could be lost in a disaster before business is significantly impacted.

Ideally, a business desires no data loss. In the real world, disasters occur and data is lost. You or your organization’s decision makers must decide the number of business transactions that could be lost, the number of hours required to key in lost data, and so on to decide how often copies must be made.

For example, if losing 4 hours of business transaction could be tolerated, but not more, then copies should be planned for every 4 hours. If 24 hours of business transaction could be lost, copies should be planned every 24 hours.

Figure 2-1 illustrates copy frequency.
Copy lifespan

Copy lifespan is the length of time a copy (S-VOL) is held, before a new backup is made to the volume. Lifespan is determined by two factors:

- Your organization’s data retention policy for holding onto backup copies
- Secondary business uses of the backup data

Lifespan based on backup requirements

- If the copy is to be used for tape backups, the minimum lifespan must be \( \geq \) the copy time from S-VOL to tape. For example:
  
  Hours to copy an S-VOL to tape = 4
  
  Therefore, S-VOL lifespan = 4 hours

- If the copy is to be used as a disk-based backup available for online recovery, you can determine the lifespan by multiplying the number of copies you will require to keep online times the copy frequency. For example:
  
  Copies held = 4
  
  Copy frequency = 4 hours
  
  \[ 4 \times 4 = 16 \text{ hours} \]
  
  S-VOL lifespan = 16 hours

Lifespan based on business uses

- If copy data is used for testing an application, the testing requirements determine the amount of time a copy is held.
- If copy data is used for development purposes, development requirements determine the time the copy is held.
- If copy data is used for business reports, the reporting requirements determine the backup’s lifespan.

Figure 2-2 illustrates copy lifespan.
Establishing the number of copies

Data retention and business-use requirements for the secondary volume determine a copy’s lifespan. They also determine the number of S-VOLs needed per P-VOL.

For example: If your data must be backed up every 12 hours, and business-use of secondary volume data requires holding it 36 hours, then your ShadowImage system requires 3 S-VOLs. This is illustrated in Figure 2-3.
Best practice

Hitachi recommends setting up at least two S-VOLs per P-VOL. When an S-VOL is re-synchronizing with the P-VOL, it is in an inconsistent state and therefore not usable. Thus, if at least two S-VOLs exist, one is always available for restoring the P-VOL in an emergency.

A workaround when employing one S-VOL only is to backup the S-VOL to tape. However, this operation can be lengthy, and recovery time from tape is more time-consuming than from an S-VOL. Also, if a failure occurs during the updating of the copy, both the P-VOL and the single S-VOL are invalid.

Requirements and recommendations for Logical Units

This section relates mostly to primary and secondary volumes. However, recommendations for the DMLU and command device are also included.

Please review the following key requirements and recommendations.

Also, review the information on setting up LUs for ShadowImage volumes, DMLUs, and command devices in:

- Chapter 3, Requirements
- Appendix A, ShadowImage specifications

When preparing for ShadowImage, please observe the following regarding the P-VOL and S-VOL:

- They must be the same in size, with identical block counts. You can verify block size. In the Navigator 2 GUI, navigate to Groups/RAID Groups/Logical Units tab. Click the desired LUN. On the popup window that appears, review the Capacity field. This shows block size.
- They must be assigned to the same controller.
- Use SAS drives, SAS7.2K drives, SSD drives, or SAS (SED) drives to increase performance. Performance is lower when SATA drives are used.
- Assign four or more disks to the data disks.
- Volumes used for other purposes should not be assigned as a primary volume. If such a volume must be assigned, move as much of the existing write workload to non-ShadowImage volumes as possible.
- When locating multiple P-VOLs in the same parity group, performance is best when the status of their pairs are the same (Split, Paired, Resync, and so on).
RAID configuration for ShadowImage LUs

Please observe the following regarding RAID levels when setting up ShadowImage pairs and Differential Management LUs.

- Volumes should be assigned to different RAID groups on the array to reduce I/O impact.
- If assigned to the same RAID group, limit the number of pairs in the group to reduce impact on performance.
- Avoid locating P-VOLs and S-VOLs within the same ECC group of the same RAID group for the following reasons:
  - A single drive failure causes status degeneration in the P-VOL and S-VOL.
  - Initial copy, coupling, and resync processes incurs a drive bottleneck which decreases performance.
- A RAID level with redundancy is recommended for both P-VOLs and S-VOLs.
- Redundancy for the P-VOL should be the same as the redundancy for the S-VOL.
- The recommended RAID configuration for P-VOLs and S-VOLs is RAID 5 (4D+1)/RAID 5 (4D+1).
- When two or more DMLUs or command devices (when using CCI) are set within the one AMS array, assign them to the respective RAID groups for redundancy.
Operating system considerations and restrictions

This section describes the system considerations and restrictions that apply to ShadowImage volumes.

Identifying P-VOL and S-VOL in Windows

In Navigator 2, the P-VOL and S-VOL are identified by their LU number. In Windows, LUs are identified by HLUN. To map LUN to HLUN on Windows, proceed as follows. These instructions provide procedures for the fibre channel and iSCSI interfaces.

1. Identify the HLUN of your Windows disk.
   b. Right-click the disk whose HLUN you want to know, then select Properties. The number displayed to the right of “LUN” in the dialog window is the HLUN.

2. Identify HLUN-to-LUN Mapping for the iSCSI interface as follows. (If using Fibre Channel, skip to Step 3.)
   a. In the Navigator 2 GUI, select the desired array.
   b. In the array tree that displays, click the Group icon, then click the iSCSI Targets icon in the Groups tree.
   c. On the iSCSI Target screen, select an iSCSI target.
   d. On the target screen, select the Logical Units tab. Find the identified HLUN. The LUN displays in the next column.
   e. If the HLUN is not present on a target screen, on the iSCSI Target screen, select another iSCSI target and repeat Step d.

3. Identify HLUN-to-LUN Mapping for the Fibre Channel interface, as follows:
   a. In the Navigator 2 GUI, select the desired array.
   b. In the array tree, click the Group icon, then click Host Groups.
   c. Click the host group that the volume is mapped to.
   d. On the screen for the host group, click the Logical Units tab. The volumes mapped to the Host Group display. You can confirm the LUN is mapped to the H-LUN.

WARNING! Your host group changes will be applied to multiple ports. This change will delete existing host group mappings and corresponding Host Group IDs, corrupting or removing data associated with the host groups. To keep specified host groups you do not want to remove, please cancel this operation and make changes to only one host group at a time.
LU mapping with CCI

You cannot pair a P-VOL and S-VOL when their mapping information has not been defined in the configuration definition file. To prevent a host from recognizing a P-VOL or S-VOL, use LUN Manager to either map them to a port that is not connected to the host or map them to a host group that does not have a registered host. If you use Storage Navigator instead of LUN Manager, you need only perform this task with either the P-VOL or S-VOL.

AIX

To ensure that the same host recognizes both a P-VOL and an S-VOL, version 04-00-/B or later of HDLM (JP1/HiCommand Dynamic Link Manager) is required.

Microsoft Cluster Server (MSCS)

To make an S-VOL recognized by a host, observe the following:

- Use the CCI mount command. Do not use Disk Administrator.
- Do not place the MSCS Quorum Disk in CCI.
- Map the S-VOL to different host than the P-VOL’s host. A host cannot recognize a P-VOL and its S-VOL at the same time.
- The command device cannot be shared between the different hosts in the cluster.
- Assign the exclusive command device to each host.

Veritas Volume Manager (VxVM)

A host cannot recognize both a P-VOL and its S-VOL at the same time. Map the P-VOL and S-VOL to separate hosts.

Windows 2000

- A host cannot recognize both a P-VOL and its S-VOL at the same time. Map the P-VOL and S-VOL to separate hosts.
- When mounting a volume, you must use the CCI mount command, even if you are operating the pairs using Navigator 2 GUI or CLI. Do not use the Windows mountvol command because the data residing in server memory is not flushed. The CCI mount command flushes data in server memory, which is necessary for ShadowImage operations. For more information, see the Hitachi Adaptable Modular Storage Command Control Interface (CCI) Reference Guide.
Windows Server and ShadowImage configuration

**Volume mount:**
- In order to make a consistent backup using a storage-based replication such as ShadowImage, you must have a way to flush the data residing on the server memory to the array, so that the source volume of the replication has the complete data. You can flush the date on the server memory using the umount command of CCI to un-mount the volume. When using the umount command of CCI for un-mount, use the mount command of CCI for mount. For more detail about mount/unmount command, see the *Hitachi Adaptable Modular Storage Command Control Interface (CCI) Reference Guide*.
- If you are using Windows Server 2003, mountvol /P to flush data on the server memory when un-mounting the volume is supported. Please understand the specification of the command and run sufficient test before you use it for your operation.
- In Windows Server 2008, use the umount command of CCI to flush the data on the memory of the server at the time of the unmount. Do not use the mountvol command of Windows standard. Refer to the *Hitachi Adaptable Modular Storage Command Control Interface (CCI) Reference Guide* for the detail of the restrictions of Windows Server 2008 when using the mount/unmount command.
- Windows may write for the un-mounted volume. If a pair is resynchronized while remaining the data to the S-VOL on the memory of the server, the compatible backup cannot be collected. Therefore, execute the sync command of CCI immediately before re-synchronizing the pair for the un-mounted S-VOL.

**Volumes recognized by the host:**
- If you recognize the P-VOL and S-VOL on Windows Server 2008 at the same time, it may cause an error because the P-VOL and S-VOL have the same disk signature. When the-VOL and S-VOL have the same data, split the pair and then rewrite the disk signature so that they can retain different disk signatures. You can use the uniqueld command to rewrite a disk signature. See the *Hitachi Adaptable Modular Storage Command Control Interface (CCI) Reference Guide* for the detail.

**Command devices**
- When a path detachment, which is caused by a controller detachment or interface failure, continues for longer than one minute, the command device may be unable to be recognized at the time when recovery from the path detachment is made. To make the recovery, execute the "re-scanning of the disks" of Windows. When Windows cannot access the command device although CCI is able to recognize the command device, restart CCI.
Linux and LVM configuration

A host cannot recognize both a P-VOL and its S-VOL at the same time. Map the P-VOL and S-VOL to separate hosts.

Concurrent use with Volume Migration

The maximum number of pairs and copying operations are limited when ShadowImage is used with Volume Migration, as follows:

- Number of ShadowImage and Volume Migration pairs:
  - AMS2500/AMS2300: 2,047
  - AMS2100: 1,023
- The number of copying operations that can be performed at the same time in the background is called *copying multiplicity*. Volume Migration and ShadowImage share copying multiplicity, which is limited to four per controller for AMS2300/2100, and eight per controller for AMS2500.

AMS executes copying operations for ShadowImage and Volume Migration in sequential order. There may be times when copying is not started immediately when previously issued copy operations are being performed.

Concurrent use with Cache Partition Manager

ShadowImage can be used with Cache Partition Manager. See the section on restrictions in the *Hitachi Storage Navigator Modular 2 Storage Features Reference Guide* for more information.

Concurrent use with Dynamic Provisioning

This section describes things to keep in mind when using ShadowImage and Dynamic Provisioning together. Refer to the Hitachi Adaptable Modular Storage Dynamic Provisioning User's Guide for detailed information regarding Dynamic Provisioning. The LU created in the RAID group is called a normal LU and the LU created in the DP pool created by Dynamic Provisioning is called a DP-VOL.

- When using a DP-VOL as a DMLU
  Check that the free capacity (formatted) of the DP pool to which the DP-VOL belongs is 10 GB or more, and then set the DP-VOL as a DMLU. If the free capacity of the DP pool is less than 10 GB, the DP-VOL cannot be set as a DMLU.

- LU type that can be set for a P-VOL or an S-VOL of ShadowImage
  The DP-VOL created by Dynamic Provisioning can be used for a P-VOL or an S-VOL of ShadowImage. *Table 2-1* shows a combination of a DP-VOL and a normal LU that can be used for a P-VOL or an S-VOL of ShadowImage. When using the DP-VOL, which is already used as an S-VOL at the time of the ShadowImage pair creation, a pair can be created by using the used DP-VOL. In that case, however, the initial copy time may be long. Therefore, create a pair after initializing the DP-VOL.
• LU type that can be set for a DMLU.
The DP-VOL created by Dynamic Provisioning can be set for a DMLU. Set the normal LU for the DMLU.

• LU type that can be set for a command device
The DP-VOL created by Dynamic Provisioning can be set for a command device. Set the normal LU for a command device.

• Assigning the controlled processor core of a P-VOL or an S-VOL that uses the DP-VOL
When the controlled processor core of the DP-VOL used for a ShadowImage P-VOL or S-VOL differs from the normal LU, switch the S-VOL controlled processor core assignment to the P-VOL controlled processor core automatically, and create a pair. This applies to AMS2500.

• DP pool designation of a P-VOL or S-VOL which uses the DP-VOL
When using the DP-VOL created by Dynamic Provisioning for a ShadowImage P-VOL or S-VOL, using the DP-VOL designated in a separate DP pool of a P-VOL or S-VOL is recommended considering the performance implications.

• Pair status at the time of DP pool capacity depletion
When the DP pool is depleted after operating the ShadowImage pair which uses the DP-VOL created by Dynamic Provisioning, the pair status of the pair concerned may be a Failure. Table 2-2 shows the pair statuses before and after the DP pool capacity depletion. When the pair status becomes a Failure caused by the DP pool capacity depletion, add the DP pool capacity whose capacity is depleted, and execute the pair operation again.

---

**Table 2-1: Combination of a DP-VOL and a Normal LU**

<table>
<thead>
<tr>
<th>ShadowImage P-VOL</th>
<th>ShadowImage S-VOL</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP-VOL</td>
<td>DP-VOL</td>
<td>Available. When both the P-VOL and the S-VOL use DP-VOLs, a pair cannot be created by combining the DP-VOLs which have different setting of Enabled/Disabled for Full Capacity Mode.</td>
</tr>
<tr>
<td>DP-VOL</td>
<td>Normal LU</td>
<td>Available. When executing the restore, the DP pool of the same capacity as the normal LU (S-VOL) is used.</td>
</tr>
<tr>
<td>Normal LU</td>
<td>DP-VOL</td>
<td>Available. In this combination, the DP pool of the same capacity as the normal LU (P-VOL) is used. Therefore, this combination is not recommended.</td>
</tr>
</tbody>
</table>
*When write is performed to the P-VOL to which the capacity depletion DP pool belongs, the copy cannot be continued and the pair status changes to Failure.*

<table>
<thead>
<tr>
<th>Pair Statuses before the DP Pool Capacity Depletion</th>
<th>Pair Statuses after the DP Pool Capacity Depletion belonging to P-VOL</th>
<th>Pair Statuses after the DP Pool Capacity Depletion belonging to S-VOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplex</td>
<td>Simplex</td>
<td>Simplex</td>
</tr>
<tr>
<td>Synchronizing</td>
<td>Synchronizing</td>
<td>Failure</td>
</tr>
<tr>
<td></td>
<td>Failure*</td>
<td></td>
</tr>
<tr>
<td>Reverse Synchronizing</td>
<td>Failure</td>
<td>Reverse Synchronizing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Failure*</td>
</tr>
<tr>
<td>Paired</td>
<td>Paired</td>
<td>Failure</td>
</tr>
<tr>
<td></td>
<td>Failure*</td>
<td></td>
</tr>
<tr>
<td>Paired Internally Synchronizing</td>
<td>Paired Internally Synchronizing</td>
<td>Failure</td>
</tr>
<tr>
<td></td>
<td>Failure*</td>
<td></td>
</tr>
<tr>
<td>Split</td>
<td>Split</td>
<td>Split</td>
</tr>
<tr>
<td>Split Pending</td>
<td>Split Pending</td>
<td>Failure</td>
</tr>
<tr>
<td></td>
<td>Failure*</td>
<td></td>
</tr>
<tr>
<td>Failure</td>
<td>Failure</td>
<td>Failure</td>
</tr>
</tbody>
</table>
• DP pool status and availability of pair operation

When using the DP-VOL created by Dynamic Provisioning for a P-VOL or S-VOL of the ShadowImage pair, the pair operation may not be executed depending on the status of the DP pool to which the DP-VOL belongs. Table 2-3 shows the DP pool status and availability of the ShadowImage pair operation. When the pair operation fails due to the DP pool status, correct the DP pool status and execute the pair operation again.

**Table 2-3: DP Pool Statuses and availability of ShadowImage Pair Operation**

<table>
<thead>
<tr>
<th>Pair Operation</th>
<th>DP Pool, DP Pool Capacity, and DP Pool Optimization Statuses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
</tr>
<tr>
<td>Create pair</td>
<td>+*</td>
</tr>
<tr>
<td>Create pair (split option)</td>
<td>+</td>
</tr>
<tr>
<td>Split pair</td>
<td>+</td>
</tr>
<tr>
<td>Resync pair</td>
<td>+*</td>
</tr>
<tr>
<td>Restore pair</td>
<td>+**</td>
</tr>
<tr>
<td>Delete pair</td>
<td>+</td>
</tr>
</tbody>
</table>

+ indicates a possible case, – indicates an impossible case

* Refer to the status of the DP pool to which the DP-VOL of the S-VOL belongs. If the status exceeds the DP pool capacity belonging to the S-VOL by the pair operation, the pair operation cannot be executed.

** Refer to the status of the DP pool to which the DP-VOL of the P-VOL belongs. If the status exceeds the DP pool capacity belonging to the P-VOL by the pair operation, the pair operation cannot be executed.

**NOTE:** When the DP pool was created or the capacity was increased, the DP pool underwent formatting. If pair creation, pair resynchronization, or restoration is performed during formatting, depletion of usable capacity may occur. Since the formatting progress is displayed when checking the DP pool status, check if sufficient usable capacity is secured according to the formatting progress, and then start the operation.

• Operation of the DP-VOL while using ShadowImage

When using the DP-VOL created by Dynamic Provisioning for a ShadowImage P-VOL or S-VOL, any of the operations among the capacity growing, capacity shrinking, and LU deletion of the DP-VOL in use cannot be executed. To execute the operation, delete the ShadowImage pair of which the DP-VOL to be operated is in use, and then execute it again. The attribute edit and capacity addition of the DP pool can be executed regardless of the ShadowImage pair.
• ShadowImage I/O Switching function
  When the DP-VOLs created by Dynamic Provisioning are used for a ShadowImage P-VOL or S-VOL, ShadowImage I/O Switching function cannot operate.

• Volume write during Split Pending
  When using the DP-VOL created by Dynamic Provisioning for a ShadowImage P-VOL or S-VOL, if writing to a P-VOL or an S-VOL when the pair status is Split Pending, the capacity of the DP pool to which both volumes belong may be consumed.

• Cascade connection
  When the firmware array version is 0893/A or more, using the DP-VOL created by Dynamic Provisioning for a ShadowImage P-VOL or an S-VOL, for the pair including the normal LU, the cascade connection with TrueCopy can be executed.
  However, when the firmware version of the array is less than 0893/A, see the following restrictions:
  When using the DP-VOL for a ShadowImage P-VOL or S-VOL, for the pair including the normal LU, the cascade connection with TrueCopy, TCE, and SnapShot, cannot be executed. The cascade connection between ShadowImage also cannot be executed. Figure 2-4 shows an example of the configuration that cannot execute the cascade connection. For example, in each cascade configuration, the cascade connection is executed with the TrueCopy volume for the normal LU. However, when the normal LU and DP-VOL executing the cascade connection are in the ShadowImage pair relation, the cascade connection also cannot be executed for the normal LU.
- Cascade with a P-VOL (normal LU) of ShadowImage

**Figure 2-4: Example of a non-supported Cascade Connection of ShadowImage with TrueCopy (P-VOL: S-VOL=1:1)**
Windows Server and Dynamic Disk

Observe the following when using Windows Server 2000/ Windows Server and dynamic disk:

- A P-VOL and S-VOL can be made into a dynamic disk on Windows Server 2003; they cannot be made into a dynamic disk on Windows Server 2000 and Windows Server 2008.
- When using an S-VOL with a secondary host, ensure that the pair status is Split or Split Pending after the pair is created.
- A host cannot recognize both a P-VOL and its S-VOL at the same time. Map the P-VOL and S-VOL to separate hosts.
- An LU in which two or more dynamic disk volumes co-exist cannot be copied.
- Do not use a dynamic disk function for volumes other than a S-VOL on the secondary host side.

When copying, hide all the dynamic disks that exist on the primary side using the CCI raidvchkset –vg idb command. No restriction is placed on the primary side. Hide all the dynamic disk volumes to be restored on the primary side at the time of restoration.

If any one of the dynamic disks is left un-hidden, a **Missing** drive occurs. When this occurs, delete it manually using the `diskpart delete` command.
Figure 2-5: Supported, un-Supported Dynamic Disk Configurations
• Copy dynamic disk volumes that consist of two or more LUs only after hiding all LUs from a host. When the copy is completed, you can have them recognized by the host.

Figure 2-6: Supported Copying for Dynamic Disk Volumes

• A dynamic disk cannot be used with a cluster (MSCS, VCS, etc.) or VxVM and HDLM.

Limitations of Dirty Data Flush Number

This setting determines the number of times processing is executed for flushing the dirty data in the cache to the drive at the same time. This setting is effective when ShadowImage is enabled. When all the LUs in the array are created in the RAID group of RAID 1 or RAID 1+0, the SAS drives or the SAS (SED) drives are configured and in the DP pool. If this setting is enabled, the dirty data flush number is limited even though ShadowImage is enabled. When the dirty data flush number is limited, the response time in I/O, which has a low load and high Read rate, shortens. Note that, when TrueCopy or TCE is unlocked at the same time, this setting is not effective.

See Setting the System Tuning Parameter or for CLI Setting the System Tuning Parameter for the setting method about the Duty Data Flush Number Limit.
**Formatting the DMLU in the Event of a Drive Failure**

When the DMLU is in a RAID group or DP pool with RAID5 or RAID6 and a drive failure occurs on the RAID group or DP pool with no redundancy, the data in the DMLU will be incomplete and unusable.

At that time, for the firmware version of 08C3/F and later, the DMLU will automatically become unformatted, so make sure to format the DMLU.

For less than 08C3/F, even though the DMLU will not automatically become unformatted, make sure to format the DMLU.

It is possible to format a DMLU without having to release the DMLU.

**Change Response for Replication Mode**

When write commands execute on the P-VOL or S-VOL in the Split Pending state and the background copy process times out, the array generates a Medium Error (03) error indication to the host. Some hosts receiving this error may determine the P-VOL or S-VOL to be inaccessible and stop accessing it.

In these instances, enabling the Change Response for Replication Mode makes the array generate an Aborted Command (08) error indication to the host. When the host receives this error, it attempts to run the command on the P-VOL or S-VOL again, and the operation continues.

**VMWare and ShadowImage configuration**

When creating a backup of the virtual disk in the vmfs format using ShadowImage, shutdown the virtual machine that accesses the virtual disk, and then split the pair.

If one LU is shared by multiple virtual machines, it is required to shutdown all the virtual machines that share the LU when creating a backup. Therefore, it is not recommended to share one volume by multiple virtual machines in the configuration that creates a backup using ShadowImage.

The VMWare ESX has a function to clone the virtual machine. Although the ESX clone function and ShadowImage can be linked, cautions are required for the performance at the time of execution.

When the LU which becomes the ESX clone destination is a ShadowImage P-VOL pair whose pair status is Paired, Synchronizing, Paired Internally Synchronizing, Reverse Synchronizing or Split Pending, the data may be written to the S-VOL for writing to the P-VOL. And when the LU which becomes the ESX clone destination is a ShadowImage P-VOL pair whose pair status is Synchronizing, Paired Internally Synchronizing, Reverse Synchronizing or Split Pending, since background copy is executed for re-synchronizing the P-VOL and S-VOL, the load on the drive becomes heavy. Therefore, the time required for a clone may become longer and the clone may be terminated abnormally in some cases.
To avoid this, we recommend the operation to make the ShadowImage pair status Split or Simplex and to resynchronize or create the pair after executing the ESX clone. Also, if you execute the ESX clone while ShadowImage is in a pair state such as Synchronizing where background copy is being executed, we recommend to set the copy pace to Slow. It is the same for executing the functions such as migration the virtual machine, deploying from the template, inflating the virtual disk and Space Reclamation.

![Figure 2-7: VMWare ESX](image)

When using the volume in the following status, disable (0) the VMFS3.HardwareAcceleratedLocking setting.

- The P-VOL which configures pairs with multiple S-VOLs and where multiple pairs in the Paired, Synchronizing, Paired Internally Synchronizing, or Split Pending status exist.
- The P-VOL which configures pairs with multiple S-VOLs and where the S-VOL switching has occurred.
- The P-VOL or the S-VOL of the pairs which configures the cascade of ShadowImage and SnapShot.

When VMFS3.HardwareAcceleratedLocking is enabled (1) in the above-mentioned status, the volume may not be recognized. If the volume cannot be recognized, recover it by using this procedure:

1. Set VMFS3.HardwareAcceleratedLocking to disabled (0).
2. Rescan the storage.

When the virtual OS was created on the volume which could not be recognized, the virtual OS may not recover even after the volume is re-realized. In that case, do the following:

1. Delete the virtual OS once, and re-register the virtual OS in the data store of the volume which was re-realized.
2. At that time, when "Alarms" or "Permissions" is set to the virtual OS, set it again after the re-registration.

3. Also, since the object ID of the virtual OS changes after the re-registration when the middleware is used, review the setting.

Creating Multiple Pairs in Same P-VOL

Consider the following when creating multiple pairs in the same P-VOL:

- Copy operation order when creating multiple pair configurations in the same P-VOL
  In the configuration where multiple pairs are created in the same P-VOL, only one physical copy (background copy) operates in the configuration. When the firmware of the array is 0897/A or more, it can be changed to the status that the background copy operates in the maximum of two pairs at the same time for the same P-VOL. Therefore, when the background copy of either pair is operating, the other pair is waiting for the background copy. When the background copy of either pair is completed, the other pair that was waiting for the background copy starts the operation.

- Performance when creating multiple pairs in the same P-VOL
  Among the ShadowImage pairs in the Paired, Synchronizing, Paired Internally Synchronizing or Split Pending status, the data copy processing is operating from the P-VOL to the S-VOL (differential copy or background copy). When the firmware of the array is 0897/A or more, the pairs that the data copy processing operates up to two pairs at the same time can be created in the same P-VOL. Therefore, the host I/O performance for the P-VOL, compared with the pair configuration of P-VOL:S-VOL=1:1, deteriorates at the maximum of 40% in the pair configuration of P-VOL:S-VOL=1:2.
Cascading ShadowImage with TrueCopy

The ShadowImage volumes can be cascaded (shared) with TrueCopy volumes, as shown in Figure 2-8. Several other cascade configurations are supported using TrueCopy and ShadowImage P-VOLs and S-VOLs on both the local and remote arrays.

- Cascade with a P-VOL of ShadowImage

- Cascade with an S-VOL of ShadowImage

Figure 2-8: Basic ShadowImage Cascade Examples with TCE

Read/write and pair operations are limited when a ShadowImage pair is cascaded with TrueCopy. Please see the chapter on cascading in the Hitachi AMS 2000 Family TrueCopy Remote Replication User Guide (MK-DF978052) for complete information.
Calculating maximum capacity

AMS manages capacity in segments of 15.75 GB for P-VOLs. Because of this it is necessary to calculate your ShadowImage system’s managed capacity and compare it to the maximum supported capacity.

To calculate ShadowImage capacity
1. Add the sizes of all ShadowImage S-VOLs.

The value must be less than the maximum supported capacity for your array/memory capacity, as shown in Table 2-4.

### Table 2-4: Maximum Supported Capacity per Controller

<table>
<thead>
<tr>
<th>Array</th>
<th>Mounted Memory Capacity (GB/CTL)</th>
<th>Maximum Supported Capacity (TB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMS 2100</td>
<td>1</td>
<td>261</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>748</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>897</td>
</tr>
<tr>
<td>AMS 2300</td>
<td>1</td>
<td>Not supported</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>673</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1,870</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>3,740</td>
</tr>
<tr>
<td>AMS 2500</td>
<td>2</td>
<td>486</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1,870</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2,618</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>3,366</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>4,488</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>5,610</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>6,733</td>
</tr>
</tbody>
</table>

**NOTE:** Maximum supported capacity is also limited by the size of the array.

If SnapShot, TrueCopy, or TCE are used on same array as ShadowImage
1. If SnapShot, TrueCopy, and/or TCE are used on the same array as ShadowImage, calculate the maximum supported capacity using the following formula:

   Maximum ShadowImage Capacity
   => Max. Supported Capacity
   - (17 x Total SnapShot P-VOL size)
   - (Total TrueCopy P-VOL and S-VOL size)
   - (51 x Total TCE P-VOL and S-VOL size)
   / 2
In the following example, the array/memory capacity is AMS2100/2 GB; therefore, maximum supported capacity is 748 TB.

a. List ShadowImage Capacity: 5 TB
b. List total SnapShot P-VOL size: 10 TB (if present)
c. List total TrueCopy P-VOL and S-VOL size: 20 TB (if present)
d. List total TCE P-VOL and S-VOL size: 15 TB (if present)
e. Then:

\[ 5 \text{ TB} \Rightarrow 748 \text{ TB} - (17 \times 10 \text{ TB} = 170 \text{ TB}) = 578 \text{ TB} - 20 \text{ TB} = 558 \text{ TB} - (51 \times 15 \text{ TB} = 765 \text{ TB}) = -187 \text{ TB} \]

In this example, maximum supported capacity is exceeded.

\[ = 748 \text{ TB} - 170 \text{ TB} = 578 \text{ TB} \]

578 TB is available for the ShadowImage system. If:

- ShadowImage S-VOL 1 = 15000 GB = 15 TB
- ShadowImage S-VOL 2 = 2500 GB = 2.5 TB
- Total ShadowImage S-VOL size = 17.5 TB

Then in this example, the total ShadowImage S-VOL size of 17.5 TB is well below the available capacity of 578 TB.

If your calculated capacity value exceeds the maximum allowable capacity, you can do one or more of the following:

- Reduce the number of P-VOLs
- Change P-VOL sizes
- Reduce the lifespan of the S-VOL
- Reduce ShadowImage P-VOL size
This chapter describes minimum operational requirements.

- System requirements
- Supported platforms
System requirements

Table 3-1 shows the minimum requirements for ShadowImage. See Appendix A, ShadowImage specifications for additional information.

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firmware</td>
<td>Version 0832/B or later is required for an AMS 2100 or 2300 array when the hardware Rev. is 0100.</td>
</tr>
<tr>
<td></td>
<td>Version 0840/A or later is required for an AMS2500 array when the hardware Rev. is 0100. When executing the pair operation in Quick Mode, version 0861/A or more is required for an AMS array when the hardware Rev. is 0100.</td>
</tr>
<tr>
<td></td>
<td>Version 0890/A or later is required for an AMS 2100, 2300, and 2500 when the hardware Rev. is 0200.</td>
</tr>
<tr>
<td>Storage Navigator 2</td>
<td>Version 3.21 or later is required for the management PC for an AMS 2100 or 2300 array when the hardware Rev. is 0100.</td>
</tr>
<tr>
<td></td>
<td>Version 4.00 or later is required for the management PC for an AMS 2500 array when the hardware Rev. is 0100. When executing the pair operation in Quick Mode, version 6.10 or more is required for the management PC.</td>
</tr>
<tr>
<td></td>
<td>Version 9.00 or later is required for the management PC for an AMS 2100, 2300, or 2500 when the hardware Rev. is 0200.</td>
</tr>
<tr>
<td>CCI</td>
<td>Version 01-21-03/06 or later is required for the host when CCI is used for the ShadowImage operation.</td>
</tr>
<tr>
<td>License key</td>
<td>Required for ShadowImage</td>
</tr>
<tr>
<td>Number of controllers</td>
<td>2 (dual configuration). Primary and secondary volumes must be on the same controller.</td>
</tr>
<tr>
<td>Command devices</td>
<td>Maximum of 128. The command device is required only when CCI is used for ShadowImage operations. CCI is provided for advanced users only. The command device volume size must be greater than or equal to 33 MB.</td>
</tr>
<tr>
<td>DMLUs</td>
<td>Maximum of 2.</td>
</tr>
<tr>
<td></td>
<td>The Differential Management LU size must be greater than or equal to 10 GB. Two per array recommended in different RAID groups.</td>
</tr>
<tr>
<td>LU size</td>
<td>The S-VOL block count must be equal to the P-VOL block count.</td>
</tr>
</tbody>
</table>
Displaying the hardware revision number

The hardware revision (Rev.) number can be displayed when an individual array is selected from the Arrays list using Navigator 2, version 9.00 or later.
**Supported platforms**

Table 3-2 shows the supported platforms and operating system versions required for ShadowImage.

### Table 3-2: Supported Platforms

<table>
<thead>
<tr>
<th>Platforms</th>
<th>Operating System Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUN</td>
<td>Solaris 8 (SPARC)</td>
</tr>
<tr>
<td></td>
<td>Solaris 9 (SPARC)</td>
</tr>
<tr>
<td></td>
<td>Solaris 10 (SPARC)</td>
</tr>
<tr>
<td></td>
<td>Solaris 10 (x86)</td>
</tr>
<tr>
<td></td>
<td>Solaris 10 (x64)</td>
</tr>
<tr>
<td>PC Server (Microsoft)</td>
<td>Windows 2000</td>
</tr>
<tr>
<td></td>
<td>Windows Server 2003 (IA32)</td>
</tr>
<tr>
<td></td>
<td>Windows Server 2008 (IA32)</td>
</tr>
<tr>
<td></td>
<td>Windows Server 2003 (x64)</td>
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<tr>
<td></td>
<td>Windows Server 2008 (x64)</td>
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<tr>
<td></td>
<td>Windows Server 2003 (IA64)</td>
</tr>
<tr>
<td></td>
<td>Windows Server 2008 (IA64)</td>
</tr>
<tr>
<td>Red Hat</td>
<td>Red Hat Linux AS2.1 (IA32)</td>
</tr>
<tr>
<td></td>
<td>Red Hat Linux AS/ES 3.0 (IA32)</td>
</tr>
<tr>
<td></td>
<td>Red Hat Linux AS/ES 4.0 (IA32)</td>
</tr>
<tr>
<td></td>
<td>Red Hat Linux AS/ES 3.0 (AMD64/EM64T)</td>
</tr>
<tr>
<td></td>
<td>Red Hat Linux AS/ES 4.0 (AMD64/EM64T)</td>
</tr>
<tr>
<td></td>
<td>Red Hat Linux AS/ES 3.0 (IA64)</td>
</tr>
<tr>
<td></td>
<td>Red Hat Linux AS/ES 4.0 (IA64)</td>
</tr>
<tr>
<td>HP</td>
<td>HP-UX 11i V1.0 (PA-RISC)</td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V2.0 (PA-RISC)</td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V3.0 (PA-RISC)</td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V2.0 (IPF)</td>
</tr>
<tr>
<td></td>
<td>HP-UX 11i V3.0 (IPF)</td>
</tr>
<tr>
<td></td>
<td>Tru64 UNIX 5.1</td>
</tr>
<tr>
<td>IBM®</td>
<td>AIX 5.1</td>
</tr>
<tr>
<td></td>
<td>AIX 5.2</td>
</tr>
<tr>
<td></td>
<td>AIX 5.3</td>
</tr>
<tr>
<td>SGI</td>
<td>IRIX 6.5.x</td>
</tr>
</tbody>
</table>
Install and enable

This chapter provides instructions for installing and enabling ShadowImage.

- Installing ShadowImage
- Enabling/disabling ShadowImage
- Uninstalling ShadowImage
Installing ShadowImage

If ShadowImage was purchased at the same time as the order for AMS was placed, then ShadowImage is bundled with the array and no installation is necessary. Proceed to Enabling/disabling ShadowImage on page 4-3.

If ShadowImage was purchased on an order separate from Adaptable, it must be installed before enabling.

NOTE: A key code or key file is required to install or uninstall. If you do not have the key file or code, you can obtain it from the download page on the HDS Support Portal, http://support.hds.com

For CLI instructions, see Installing and uninstalling ShadowImage on page B-2 (advanced users only).

Before installing or uninstalling ShadowImage, verify that the array is operating in a normal state. Installation/un-installation cannot be performed if a failure has occurred.

To install ShadowImage
1. Start Navigator 2.
2. Log in as a registered user.
3. In the Navigator 2 GUI, click the check box for the array where you want to install ShadowImage.
4. Click Show & Configure Array. The tree view appears.
5. Select the Install Licenses icon in the Common Array Task.

6. The Install License screen appears.
7. Select the **Key File** or **Key Code** radio button, then enter the file name or key code. You may browse for the Key File.

8. Click **OK**.

9. Click **Confirm** on the screen requesting confirmation to install ShadowImage.

10. Click **Close** on the confirmation screen.

---

**Enabling/disabling ShadowImage**

Enable or disable ShadowImage using the following procedure.

---

**NOTE:** Before disabling, ShadowImage pairs must be deleted.

---

**To enable or disable ShadowImage**

1. Start Navigator 2.
2. Log in as a registered user to Navigator 2.
3. Select the array where you want to enable or disable ShadowImage.
4. Click the **Show & Configure Array** button.
5. Click **Settings** in the tree view, then click **Licenses**.
6. Select **SHADOWIMAGE** in theLicenses list.
7. Click **Change Status**. The Change License screen appears.
8. To enable, click the **Enable: Yes** check box.
   To disable, clear the **Enable: Yes** check box.

9. Click **OK**.

10. A message appears confirming that ShadowImage is enabled or disabled. Click **Close**.
Uninstalling ShadowImage

ShadowImage pairs must be released and their status returned to Simplex before uninstalling.

To uninstall ShadowImage
1. Start Navigator 2.
2. Log in as a registered user to Navigator 2.
3. In the Navigator 2 GUI, click the check box for the array where you want to uninstall ShadowImage.
4. Click the Show & Configure Array button.
5. In the tree view, click Settings, then click Licenses.

The Licenses list is displays.
6. Click De-Install License.

The De-Install License screen appears.
7. On the De-Install License screen, enter the code in the Key Code box, and then click OK.
8. On the confirmation screen, click Close to confirm.
This chapter provides required information for setting up your system for ShadowImage.

- Configuration
- Setting up primary, secondary volumes
- Setting up the DMLU
- Setting the ShadowImage I/O switching mode
- Setting the System Tuning Parameter
Configuration

Setup for ShadowImage consists of making certain that primary and secondary volumes are set up correctly.

- Setting up the DMLU.

Setting up primary, secondary volumes

The primary and secondary volumes must be set up prior to making ShadowImage copies. When doing so, adhere to the following:

- The P-VOL and S-VOL must have identical block counts.
- Verify block size in the Navigator 2 GUI by navigating to Groups/Groups/Logical Units tab.
- Click the LUN whose block size you want to check.
- On the popup window that appears, review the Capacity field. This shows block size.
- The P-VOL and S-VOL must be assigned to the same controller.

Refer to Appendix A, ShadowImage specifications for all key requirements and recommendations.

Setting up the DMLU

The DMLU is an exclusive volume used for storing ShadowImage information when the array is powered down. You must set up the DMLU before using ShadowImage.

Prerequisites

- LUs for the DMLU must be set up and formatted. Minimum size: 10 GB.
- Though only one DMLU is needed, two are recommended, with the second used as a backup.
- For RAID considerations, see the information on DMLU in RAID configuration for ShadowImage LUs on page 2-6.
- Also see DMLU items in Appendix A, ShadowImage specifications.

To set up a DMLU

1. In the navigation tree, select Settings, then DMLU. The Differential Management Logical Units screen displays.
2. Click Add DMLU. The Add DMLU screen displays.
3. Select the **LUNs** that you want to assign as DMLUs, and click **OK**. A confirmation message displays.

4. Select the **Yes, I have read ...** check box, then click **Confirm**. When the success message displays, click **Close**.

### Setting the ShadowImage I/O switching mode

**To set the ShadowImage I/O Switching Mode:**

1. Start Navigator 2.
2. Log in as registered user to Navigator 2.
3. Select the array in which you will set ShadowImage.
4. Click **Show & Configure Array**.
5. Select the **System Parameters** icon in the **Settings** tree view.

6. Click **Edit System Parameters**.
   The **Edit System Parameters** screen appears.

   ![](Image)

7. Select the **ShadowImage I/O Switch Mode** in the **Options** and click **OK**.

8. A message displays. Click **Close**.
Setting the System Tuning Parameter

This setting determines whether to limit the number of times processing is executed for flushing the dirty data in the cache to the drive at the same time.

To set the Dirty Data Flush Number Limit of a system tuning parameters:

1. Select the System Tuning icon in the Tuning Parameter of the Performance tree view.
   The System Tuning screen appears.

2. Click Edit System Tuning Parameters.
   The Edit System Tuning Parameters screen appears.

**NOTE:** When turning off the ShadowImage I/O Switching mode, it is required to make pair statuses of all ShadowImage pairs to those other than Split (S-VOL Switch) and Synchronizing (S-VOL Switch).
3. Select the **Enable** radio button of the **Dirty Data Flush Number Limit**.
4. Click **OK**.
5. A message appears. Click **Confirm**.

6. A message appears. Click **Close**.
Using ShadowImage

This chapter describes ShadowImage operations.

- ShadowImage workflow
- Check pair status
- Create the pair
- Split the pair
- Resync the pair
- Delete a pair
- Edit a pair
- Restore the P-VOL
- Use the S-VOL for tape backup, testing, reports, etc.
ShadowImage workflow

A typical ShadowImage workflow consists of the following:
- Check pair status. Each operation requires a pair to have a specific status.
- Create the pair, in which the S-VOL becomes a duplicate of the P-VOL.
- Split the pair, which separates the primary and secondary volumes and allows use of the data in the S-VOL by secondary applications.
- Re-synchronize the pair, in which the S-VOL again mirrors the on-going, current data in the P-VOL.
- Restore the P-VOL from the S-VOL.
- Delete a pair.
- Edit pair information.

(For an illustration of basic ShadowImage operations, see Figure 1-2 on page 1-5.)

Check pair status

When you want to perform a specific ShadowImage operation the pair must be in a state that allows the operation. For instructions on checking pair status plus status definitions, see Monitor pair status on page 7-2.

Create the pair

Please review the following before creating a pair.
- When the primary volume is not part of another ShadowImage pair, both primary and secondary volumes must be in the SMPL (simplex) state.
- When the primary volume is part of another ShadowImage pair or pairs, the pair status of those pairs must be Split.
- The primary and secondary volumes must have identical block counts and must be assigned to the same controller.
- Because pair creation affects the performance on the host, observe the following:
  - Create a pair when I/O load is light.
  - Limit the number of pairs that you create simultaneously.
- During the Create Pair operation, the following takes place:
  - All data in the P-VOL is copied to the S-VOL.
  - The P-VOL remains available to the host for read/write throughout the copy operation.
  - Writes to the P-VOL during pair creation are copied to the S-VOL.
  - Pair status is Synchronizing while the initial copy operation is in progress.
- Status changes to Paired when the initial copy is complete.
- New writes to the P-VOL continue to be copied to the S-VOL in the Paired status.

**Copy pace**

Copy pace is the speed at which a pair is created or re-synchronized. You select the copy pace when you create or resynchronize a pair (if using CLI, you enter a copy pace parameter).

Copy pace impacts host I/O performance. A slow copy pace has less impact than a medium or fast pace. The pace is divided on a scale of 1 to 15, as follows:

- **Slow** — between 1-5. The process takes longer when host I/O activity is heavy. The amount of time to complete an initial copy or resync cannot be guaranteed.
- **Medium** — between 6-10. (Recommended) The process is performed continuously, but the amount of time to complete the initial copy or resync cannot be guaranteed. Actual pace varies according on host I/O activity.
- **Fast** — between 11-15. The copy/resync process is performed continuously and takes priority. Host I/O performance is restricted. The amount of time to complete an initial copy or resync is guaranteed.

<table>
<thead>
<tr>
<th>Resynchronization Pace</th>
<th>Resynchronization Process</th>
<th>Host's I/O Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow</td>
<td>Single copy unit (stripe size) is processed per copy every 200 ms. The process is</td>
<td>Read: Executing approximately 90% of host</td>
</tr>
<tr>
<td></td>
<td>performed in longer intervals if the I/O performance from the host is heavy. The time</td>
<td>limitation is possible.</td>
</tr>
<tr>
<td></td>
<td>of re-synchronizing completion cannot be guaranteed because the pace differs depending</td>
<td>Write: Executing approximately 90% of host</td>
</tr>
<tr>
<td></td>
<td>on the I/O performance from the host.</td>
<td>limitation is possible.</td>
</tr>
<tr>
<td>Medium</td>
<td>The re-synchronizing process is performed continuously, but the time of re-synchronizing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>completion cannot be guaranteed. The pace differs depending on the I/O performance from</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the host.</td>
<td></td>
</tr>
</tbody>
</table>
Table 6-1: Relationship between Copy Pace Parameters and Resynchronization Process

<table>
<thead>
<tr>
<th>Resynchronization Pace</th>
<th>Resynchronization Process</th>
<th>Host's I/O Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast (Note)</td>
<td>The re-synchronizing process is performed continuously and takes prior. Therefore, the I/O performance from the host is restricted. The time of re-synchronizing completion is guaranteed.</td>
<td></td>
</tr>
</tbody>
</table>

Note: When the pair status is Split Pending or Paired Internally Synchronizing, even if copy pace is specified as "Fast", the internal operation becomes the same as the case that "Medium" is specified. To operate the data copy by pair synchronization with "Fast", execute it without specifying Quick Mode.
Create a ShadowImage pair

To create a ShadowImage pair:

To use CLI, see Creating ShadowImage pairs on page B-6.)

1. In Navigator 2 GUI, select the desired array, then click the **Show & Configure Array** button.

2. From the Replication tree, select the **Local Replication** icon. The **Pairs** screen displays.

3. Click the **Create Pair** button at the bottom of the screen. View further instructions by clicking the Help button.

4. After making selections on the **Basic** tab, further customize the pair by clicking the **Advanced** tab.
5. From the **Copy Pace** dropdown list, select the speed at which copies will be made. Select Slow, Medium, or Fast. (See **Copy pace**, above, for more information.)

6. In the **Group Assignment** area, you have the option of assigning the new pair to a consistency group. (For a description, see **Consistency group (CTG) on page 1-12.**) Do one of the following:
   - If you do not want to assign the pair to a consistency group, leave the **Ungrouped** button selected.
   - To create a group and assign the new pair to it, click the **New or existing Group Number** button and enter a new number for the group in the box.
   - To assign the pair to an existing group, enter its number in the **Group Number** box, or enter the group name in the **Existing Group Name** box.

   **NOTE:** You can also add a Group Name for a consistency group as follows:
   a. After completing the create pair procedure, on the **Pairs** screen, check the box for the pair belonging to the group.
   b. Click the **Edit Pair** button.
   c. On the Edit Pair screen, enter the **Group Name** then click **OK**.

7. In the **Do initial copy from the primary volume**... field, leave **Yes** checked to copy the primary to the secondary volume. Leave the check box to create a pair without copying the P-VOL at this time, and thus reduce the time it takes to create the pair. The system treats the two volumes as a pair.
8. In the **Allow read access to the secondary volume after the pair is created** field, leave **Yes** checked to allow access to the secondary volume after the pair is created. Clear the check box to prevent read/write access to the S-VOL from a host after the pair is created. This option (un-checking) insures that the S-VOL is protected and can be used as a backup.

9. Add a check mark to the box **Automatically split the pair immediately after they are created** when you want to automatically split the pair after creation.

10. Click **OK**.

11. A confirmation message displays. Check the **Yes, I have read the above warning and want to create the pair** check box, and click **Confirm**.

12. A confirmation message displays. Click **Close**.

### Split the pair

When a primary and secondary volume are in Pair status, all data that is written to the primary volume is copied to the secondary volume. This continues until the pair is split.

When it is split, updates continue to be written to the primary volume, but not to the secondary volume. Data in the S-VOL is frozen at the time of the split. After the Split Pair operation:

- The secondary volume becomes available for read/write access by secondary host applications.
- Separate track tables record updates to the P-VOL and to the S-VOL.
- The pair can be made identical again by re-synchronizing from primary-to-secondary or secondary-to-primary.
To split the pair

To use CLI, see Splitting ShadowImage pairs on page B-8.)

1. In Navigator 2 GUI, select the desired array, then click the Show & Configure Array button.
2. From the Replication tree, select the Local Replication icon. The Pairs screen displays.
3. Select the pair you want to split.
4. Click the Split Pair button at the bottom of the screen. View further instructions by clicking the Help button, as needed.

**SplitPair - SI_LU1000_LU1001**

<table>
<thead>
<tr>
<th>Local Pair Split Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select the option of the split operation.</td>
</tr>
<tr>
<td>Option 1: Suspend operation in progress and force the pair into a failure state: Yes</td>
</tr>
<tr>
<td>Attach description to identify the pair upon split:</td>
</tr>
<tr>
<td>Quick Mode: Yes</td>
</tr>
</tbody>
</table>

5. Mark the check box of the Suspend operation in progress and force the pair in failure state if necessary.
6. Enter a character strings to the Attach description to identify the pair upon split if necessary.
7. When you want to split Quick Mode, add a check mark to Quick Mode.
8. Click OK.
9. A confirmation message displays. Click Close.

Resync the pair

Re-synchronizing a pair that has been split updates the S-VOL so that it is again identical with the P-VOL. A reverse resync updates the P-VOL so that it is identical with the S-VOL.

- The pair must be in Split status.
- Pair status during a normal re-synchronizing is Synchronizing.
- Status changes to Paired when the resync is complete.
- When the pair is re-synchronized, it can then be split for tape backup or other uses of the updated S-VOL.
To resync the pair

To use CLI, see Re-synchronizing ShadowImage pairs on page B-9.)

1. In Navigator 2 GUI, select the desired array, then click the Show & Configure Array button.
2. From the Replication tree, select the Local Replication icon. The Pairs screen displays.
3. Select the pair you want to resync.
4. Click the Resync Pair button. The Resync Pair screen appears as shown below. View further instructions by clicking the Help button, as needed.

```
Resync Pair - SI_LU1000_LU1001
```

```
Option of Re-synchronize Local Pair

Select the option of the re-sync operation.

Quick Mode: [ ] Yes
```

5. When you want to re-synchronize Quick Mode, place a check mark in the Yes box for Quick Mode.
6. Click OK.

A confirmation message displays.

```
Resync Pair - SI_LU1000_LU1001
```

```
After re-synchronizing the pair, you cannot use existing data in the secondary volume. Are you sure you want to re-synchronize the pair?

YOU CANNOT UNDO THIS OPERATION.
```

```
[ ] Yes, I have read the above warning and want to re-synchronize selected pairs.
```

7. For Yes, I have read the above warning and want to re-synchronize selected pairs. Place a check in the box, and click Confirm.
8. A confirmation message displays. Click Close.
Delete a pair

You can delete a pair when you no longer need it. When you delete a pair, the primary and secondary volumes return to their SIMPLEX state. Both are available for use in another pair.

To delete a ShadowImage pair

To use CLI, see Releasing ShadowImage pairs on page B-10.)
1. In Navigator 2 GUI, select the desired array, then click the Show & Configure Array button.
2. From the Replication tree, select the Local Replication icon. The Pairs screen displays.
3. Select the pair you want to delete.
4. Click Delete Pair.

Edit a pair

You can edit the name, group name, and copy pace for a pair.

To edit pairs

To use CLI, refer to Storage Navigator Modular 2 Command Line Interface (CLI) Reference Guide (for Replication).
1. In Navigator 2 GUI, select the desired array, then click the Show & Configure Array button.
2. From the Replication tree, select the Local Replication icon. The Pairs screen displays.
3. Select the pair that you want to edit.
4. Click the Edit Pair button. View instructions by clicking the Help button.

Restore the P-VOL

ShadowImage enables you to restore your P-VOL to a previous point in time. You can restore from any S-VOL paired with the P-VOL.

The amount of time it takes to restore your data is dependent on the size of the P-VOL and the amount of data that has changed.

To restore the P-VOL from the S-VOL
1. Shut down the host application.
2. Un-mount the P-VOL from the production server.
3. In the Storage Navigator 2 GUI, select the Local Replication icon in the Replication tree view.
   Advanced users using the Navigator 2 CLI, please refer to Restoring the P-VOL on page B-9.
4. In the GUI, select the pair to be restored in the Pairs list.
5. Click **Restore Pair**. View further instructions by clicking the Help button as needed.

6. Mount the P-VOL.

7. Re-start the application.

**Use the S-VOL for tape backup, testing, reports, etc.**

Your ShadowImage copies can be used on a secondary server to fulfill a number of data management tasks. These might include backing up production data to tape, using the data to develop or test an application, generating reports, populating a data warehouse, and so on.

Whatever the task, the process for preparing and making your data available is the same. The following process can be performed using the Navigator 2 GUI or CLI, in combination with an operating system scheduler. The process should be performed during non-peak hours for the host application.

**To use the S-VOL for secondary functions**

1. Un-mount the S-VOL if it is being used by a host.

2. Resync the pair before stopping or quiescing the host application. This is done to minimize the down time of the production application.
   - Navigator 2 GUI users, please see **Resync the pair on page 6-8**.
   - Advanced users using CLI, please see **Re-synchronizing ShadowImage pairs on page B-9**.

3. When pair status becomes Paired, shut down or quiece (quiet) the production application, if possible.

4. Split the pair. Doing this insures that the backup will contain the latest mirror image of the P-VOL.
   - GUI users please see **Split the pair on page 6-7**.
   - Advanced users using CLI, please see **Splitting ShadowImage pairs on page B-8**.

5. Un-quiesce or start up the production application so that it is back in normal operation mode.

6. Mount the S-VOL on the server, if needed.

7. Run the backup program using the S-VOL.
This chapter provides information and instructions for monitoring and troubleshooting the ShadowImage system.

- Monitor pair status
- Troubleshooting
Monitor pair status

Monitoring pair status insures the following:

- A pair is in the correct status for the ShadowImage operation you wish to perform.
- Pairs are operating correctly and status is changing to the appropriate state during and after an operation.
- Data is being updated from P-VOL to S-VOL in a pair resync, and from S-VOL to P-VOL in a pair reverse resync.
- Differential data management is being performed in the Split status. The Status column on the Pairs screen shows the percentage of synchronization. This can be used to estimate the amount of time a resync will take.

To check pair status

To use CLI, see Confirming pairs status on page B-6.)

1. In Navigator 2 GUI, select the desired array, then click the Show & Configure Array button.
2. From the Replication tree, select the Local Replication icon.

3. The Pairs screen displays.
4. Locate the pair and review the Status field.

NOTE: The pair status and pair identical rate are displayed.
Table 7-1 shows Navigator2 GUI status and descriptions. For CCI statuses see Confirming pair status on page C-9.

### Table 7-1: Pair Statuses

<table>
<thead>
<tr>
<th>GUI Pair Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplex</td>
<td>Status when the volume has not have been paired or when the pair has been deleted. The volume does not have a ShadowImage association with another volume.</td>
</tr>
<tr>
<td>Paired</td>
<td>S-VOL is a duplicate of the P-VOL. Updates to the P-VOL are copied to the S-VOL.</td>
</tr>
<tr>
<td>Paired Internally</td>
<td>Re-synchronizing pairs specifying the Quick Mode.</td>
</tr>
<tr>
<td>Synchronizing</td>
<td>Initial or re-synchronization copy is in progress. The array continues to accept read and write operations for the P-VOL but does not accept write operations for the S-VOL. When a split pair is resynchronized in normal mode, the array copies only the P-VOL differential data to the S-VOL. When creating a pair or when a Failure pair is resynchronized, the array copies the entire P-VOL to the S-VOL.</td>
</tr>
<tr>
<td>Split</td>
<td>Updates stop from P-VOL to S-VOL. The S-VOL remains a copy of the P-VOL at the time of the split. P-VOL continues being updated by the host application.</td>
</tr>
<tr>
<td>Split Pending</td>
<td>A pair split specifying the Quick Mode.</td>
</tr>
<tr>
<td>Resynchronizing</td>
<td>The S-VOL is updated from the P-VOL. When this operation is completed, the status changes to Paired.</td>
</tr>
<tr>
<td>Reverse Synchronizing</td>
<td>P-VOL restoration from S-VOL is in progress.</td>
</tr>
<tr>
<td>Failure</td>
<td>Copying is suspended due to a failure occurrence. The array marks the entire P-VOL as differential data; thus, it must be copied in its entirety to the S-VOL when a Resync is performed.</td>
</tr>
</tbody>
</table>

**NOTE:** The identical rate displayed with the pair status shows the identical ratio of the P-VOL and S-VOL data that can be accessed from the host. When the pair status is Split Pending, even though the background copy is performed, if the P-VOL and S-VOL data viewed from the host is matched, the identical rate becomes 100%. The ratio that the background copy is completed is indicated by the Progress. You can check the Progress by the detail information of each pair.
Troubleshooting

Pair failure

A pair failure occurs when one of the following takes place:

- A hardware failure occurs.
- Forcible release is performed by the user. This occurs when you halt a Pair Split operation. The array places the pair in Failure status.

If the pair was not forcibly suspended, the cause is hardware failure.

To restore pairs after a hardware failure

1. If the volumes were re-created after the failure, the pairs must be re-created.
2. If the volumes were recovered and it is possible to resync the pair, then do so. If resync is not possible, delete then re-create the pairs.
3. If a P-VOL restore was in progress during a hardware failure, delete the pair, restore the P-VOL if possible, and create a new pair.

To restore pairs after forcible release operation

Create or re-synchronize the pair. When an existing pair is re-synchronized, the entire P-VOL is re-copied to the S-VOL.

Path failure

When using CCI, and a path fails for more than one minute, the command device may not be recognized when the path is recovered. Execute Windows’ “re-scan the disks” to recovery. Restart CCI if Windows cannot access the command device even, if CCI is able to recognize Windows.
ShadowImage specifications

This appendix provides specifications for ShadowImage.

- General specifications
## General specifications

Table A-1 lists and describes the external specifications for ShadowImage.

### Table A-1: Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptable Modular Storage model</td>
<td>AMS2500&lt;br&gt;AMS2300&lt;br&gt;AMS2100&lt;br&gt;(For dual configuration only.)</td>
</tr>
<tr>
<td>Host interface</td>
<td>Fibre channel or iSCSI.</td>
</tr>
<tr>
<td>Number of pairs</td>
<td>• AMS2500, AMS2300: maximum of 2047 pairs&lt;br&gt;• AMS2100: maximum of 1023 pairs&lt;br&gt;&lt;strong&gt;Note&lt;/strong&gt;: When a P-VOL is paired with eight S-VOLs, the number of pairs is eight.</td>
</tr>
<tr>
<td>Command devices</td>
<td>Required for CCI.&lt;br&gt;• Maximum: 128 per array&lt;br&gt;• Volume size: 33MB or greater</td>
</tr>
<tr>
<td>Unit of pair management</td>
<td>Volumes are the target of ShadowImage pairs, and are managed per logical unit.</td>
</tr>
<tr>
<td>Pair structure (number of S-VOLs per P-VOL)</td>
<td>1 P-VOL: 8 S-VOLs</td>
</tr>
<tr>
<td>Differential Management LU (DMLU)</td>
<td>• Minimum size: 10 GB&lt;br&gt;• One DMLU is required, two (maximum) are recommended. When using two, each must be:&lt;br&gt;  - In different RAID groups than the other&lt;br&gt;  - Under different controller than the other&lt;br&gt;• The DP-VOL created by Dynamic Provisioning can be set for DMLU.</td>
</tr>
<tr>
<td>RAID level</td>
<td>• P-VOL: RAID 0 (2D to 16D), RAID 1+0 (2D+2D to 8D+8D), RAID 5 (2D+1P to 15D+1P), RAID 6 (2D+2P to 28D+2P), RAID 1 (1D+1D) (&quot;with redundancy&quot; recommended)&lt;br&gt;• S-VOL: RAID 0 (2D to 16D), RAID 1+0 (2D+2D to 8D+8D), RAID 5 (2D+1P to 15D+1P), RAID 6 (2D+2P to 28D+2P), RAID 1 (1D+1D) (&quot;with redundancy&quot; recommended)&lt;br&gt;• RAID 0 cannot be set for the SATA disk drive.</td>
</tr>
<tr>
<td>Combination of RAID groups</td>
<td>P-VOL and S-VOL should be paired on different RAID groups. The number of data disks does not have to be the same.</td>
</tr>
<tr>
<td>Size of P-VOL and S-VOL</td>
<td>P-VOL = S-VOL (block count must be equal). The max LU size is 128 TB.</td>
</tr>
</tbody>
</table>
Types of drive for the P-VOL and S-VOL

If the drive types are supported by the array, they can be set for the P-VOL and S-VOL. However, assign an LU consisting of SAS drives, SAS7.2K drives, SSD drives, or SAS (SED) drives to a P-VOL. When creating the LUs configured in the SATA drive, the use conditions of the SATA drive may be different.

### Table A-1: Specifications

<table>
<thead>
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</tr>
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</table>
| Consistency Group (CTG) number            | CTG per array: Max 256 Pairs per group:  
• AMS2500/2300: Max 2047  
• AMS2100: Max 1023 |
| Concurrent use with TrueCopy              | Yes. When the firmware of the array is less than 0893/A, the cascade connection cannot be executed with the ShadowImage pair including the DP-VOL created by Dynamic Provisioning. See Cascading ShadowImage with TrueCopy on page 2-22 for more information. |
| Concurrent use of TCE                     | ShadowImage and TCE can be used on the same array; however, a cascaded system between ShadowImage and TCE is not supported. |
| Concurrent use of Dynamic Provisioning    | The DP-VOL created by Dynamic Provisioning can be used as a ShadowImage P-VOL or S-VOL. For more details, see Concurrent use with Dynamic Provisioning on page 2-10. |
| load balancing feature                   | The load balancing feature applies to a ShadowImage pair. When the load balancing feature is activated for a ShadowImage pair, the ownership of the P-VOL and S-VOL changes to the same controller. When the pair state is Synchronizing or Reverse Synchronizing, the ownership of the pair will change across the cores but not across the controllers. Also, the load balancing feature does not apply to a ShadowImage pair that is cascaded with a SnapShot pair. |
| Concurrent use of SnapShot                | SnapShot and ShadowImage can be used together at the same time, but when the firmware of the array is less than 08B0/A SnapShot volumes cannot be paired with ShadowImage volumes. When using SnapShot and ShadowImage together, the maximum number of CTGs is 256. |
| Formatting, growing/shrinking, deleting during Coupling (RAID group, P-VOL, S-VOL) | Not available. However, when pair status is failure (S-VOL Switch), a P-VOL can be formatted. When pair status is Simplex, you can grow or shrink LUs. |
### Concurrent use of Volume Migration
Yes, however a P-VOL, an S-VOL, and a reserved LU of Volume Migration cannot be specified as a ShadowImage P-VOL. The maximum number of the pairs and the number of pairs whose data can be copied in the background is limited when ShadowImage is used together with Volume Migration.

### Concurrent use of Cache Residency Manager
Yes, however the LU specified for Cache Residency (LU cache residence) cannot be used as a P-VOL, S-VOL.

### Concurrent use of Cache Partition Manager
Yes

### Concurrent use of SNMP Agent
Yes. Traps are sent following when occurs. Pair status changes to Failure.

### Concurrent use of Data Retention Utility
Yes. However, when S-VOL Disable is set for an LU, the LU cannot be used in a ShadowImage pair. When S-VOL Disable is set for an LU that is already a S-VOL, no suppression of the pair takes place, unless the pair status is split.

### Concurrent use of Power Saving
Yes. However, when a P-VOL or S-VOL is included in a RAID group in which Power Saving is enabled, the only ShadowImage pair operation that can be performed are pair split and the pair release.

### Concurrent use of unified LU
Yes.

### Concurrent use of LUN Manager
Yes.

### Concurrent use of Password Protection
Yes.

### ShadowImage I/O switching function
Yes. DP-VOLs created by Dynamic Provisioning can be used for a P-VOL or an S-VOL of ShadowImage. For details, see Appendix D, I/O switching mode feature.

### Maximum supported capacity value of S-VOL (TB)
See Calculating maximum capacity on page 2-23 for details.

### License
ShadowImage must be installed using the key code.

### Management of LUs while using ShadowImage
Formatting and deleting LUs are not available. When formatting and deleting LUs, split ShadowImage pairs using the pairsplit command.

### Restriction for formatting the volumes
Do not execute ShadowImage operations while formatting the volume. Formatting takes priority and the ShadowImage operations will be suspended.

---

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<tr>
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</tr>
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</tr>
<tr>
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<td>Yes.</td>
</tr>
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<td>Yes. DP-VOLs created by Dynamic Provisioning can be used for a P-VOL or an S-VOL of ShadowImage. For details, see Appendix D, I/O switching mode feature.</td>
</tr>
<tr>
<td>Maximum supported capacity value of S-VOL (TB)</td>
<td>See Calculating maximum capacity on page 2-23 for details.</td>
</tr>
<tr>
<td>License</td>
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</tr>
<tr>
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</thead>
<tbody>
<tr>
<td>Restriction during RAID group expansion</td>
<td>A RAID group with a ShadowImage P-VOL or S-VOL can be expanded only when the pair status is Simplex or Split.</td>
</tr>
<tr>
<td>Failures</td>
<td>When a failure of the copy operation from P-VOL to S-VOL occurs, ShadowImage will suspend the pair and the status changes to failure. If a volume failure occurs, ShadowImage suspends the pair. If a drive failure occurs, the ShadowImage pair status is not affected because of the RAID architecture.</td>
</tr>
<tr>
<td>Reduction of memory</td>
<td>The memory cannot be reduced when ShadowImage, SnapShot, or TrueCopy are enabled. Reduce memory after disabling the functions.</td>
</tr>
</tbody>
</table>
Operations using CLI

This chapter describes basic Navigator 2 CLI procedures for performing ShadowImage operations.

☐ Installing and uninstalling ShadowImage

☐ ShadowImage operations

☐ Creating ShadowImage pairs that belong to a group

☐ Sample back up script for Windows

**NOTE:** For additional information on the commands and options used in this appendix, see the *Navigator 2 Command Line Interface (CLI) Reference Guide for Replication.*
Installing and uninstalling ShadowImage

If ShadowImage was purchased when the order for AMS was placed, then ShadowImage came bundled with the system and no installation is necessary. Proceed to Enabling or disabling ShadowImage on page B-3.

If you purchased ShadowImage on an order separate from your AMS, it must be installed before enabling. A key code or key file is required

NOTE: Before installing/uninstalling ShadowImage, verify that the array is operating in a normal state. If a failure such as a controller blockade has occurred, installation/un-installation cannot be performed.

Installing ShadowImage

To install ShadowImage, the key code or key file provided with the optional feature is required. You can obtain it from the download page on the HDS Support Portal, http://support.hds.com.

To install ShadowImage

1. From the command prompt, register the array in which the ShadowImage is to be installed, then connect to the array.
2. Execute the auopt command to install ShadowImage. For example:

   ```
   % auopt -unit subsystem-name -lock off -licensefile license-file-path\license-file-name
   No.  Option Name
   1  ShadowImage in-system replication
   Please specify the number of the option to unlock.
   When you unlock two or more options, partition the numbers given in the list with space(s). When you unlock all options, input 'all'. Input 'q', then break.
   The number of the option to unlock. (number/all/q [all]): 1
   Are you sure you want to unlock the option?
   (y/n [n]): y
   
   Option Name                                               Result
   ShadowImage in-system replication                    Unlock
   
   The process was completed.
   %
   
   3. Execute the auopt command to confirm whether ShadowImage has been installed.

   ```

   ```
   % auopt -unit array-name -refer
   Option Name     Type    Term     Status
   Reconfigure Memory Status
   SHADOWIMAGE     Permanent  ---    Enable
   N/A
   %
   ```

   ShadowImage is installed and the status is “Enable”. Installation of ShadowImage is now complete.
Uninstalling ShadowImage

To uninstall ShadowImage, the key code provided with the optional feature is required. Once uninstalled, ShadowImage cannot be used again until it is installed using the key code or key file.

To uninstall ShadowImage:

1. All ShadowImage pairs must be released (the status of all LUs are Simplex) before uninstalling ShadowImage.
2. From the command prompt, register the array in which the ShadowImage is to be uninstalled, then connect to the array.
3. Execute the `auopt` command to uninstall ShadowImage. For example:

   ```
   % auopt -unit subsystem-name -lock on -keycode downloaded-48 characters-key code
   Are you sure you want to lock the option? (y/n [n]): y
   The option is locked.
   %
   ```

4. Execute the `auopt` command to confirm whether ShadowImage has been uninstalled. For example:

   ```
   % auopt -unit subsystem-name -refer
   DMEC002015: No information displayed.
   %
   ```

Uninstalling ShadowImage is now complete.

Enabling or disabling ShadowImage

Once ShadowImage is installed, it can be enabled or disabled.

The following describes the enabling/disabling procedure.

1. If you are disabling ShadowImage, all pairs must be released (the status of all LUs are Simplex).
2. From the command prompt, register the array in which the status of the feature is to be changed, then connect to the array.
3. Execute the `auopt` command to change the status (enable or disable). The following is an example of changing the status from enable to disable. If you want to change the status from disable to enable, enter `enable` after the `-st` option, as shown in the example below.

   ```
   % auopt -unit subsystem-name -option SHADOWIMAGE -st disable
   Are you sure you want to disable the option? (y/n [n]): y
   The option has been set successfully.
   %
   ```

4. Execute the `auopt` command to confirm whether the status has been changed. For example:
Enabling or disabling ShadowImage is now complete.

**Setting the DMLU**

The DMLU is an exclusive volume used for storing ShadowImage information when the array is powered down. You must set up the DMLU before using ShadowImage.

**Prerequisites**

- LUs for the DMLUs must be set up and formatted.
- DMLU size must be at least 10 GB.
- One DMLU is needed but two are recommended, with the second used as a backup.
- For RAID considerations, see the bullet on DMLU in Cascading ShadowImage with TrueCopy on page 2-22.
- Also see Appendix B, Operations using CLI.

**To set up DMLU**

1. From the command prompt, register the array on which you want to create the DMLU and connect to that array.

2. Execute the `auDM-LU` command to create a DMLU. This command first displays LUs that can be assigned as DMLUs and later creates a DMLU. For example:

   ```
   % auopt -unit array-name -refer
   Option Name   Type     Term      Status
   Reconfigure Memory Status
   SHADOWIMAGE   Permanent ---    Disable
   N/A
   %
   
   % auDM-LU -unit array-name -availablelist
   Available Logical Units
   LUN Capacity    RAID Group DP Pool  RAID Level Type  Status
   0    10.0 GB    0    N/A   5( 4D+1P) SAS  Normal
   %
   
   % auDM-LU -unit array-name -set -lu 0
   Are you sure you want to set the DM-LU? (y/n [n]): y
   The DM-LU has been set successfully.
   %
   
   % auDM-LU -unit array-name -rm -lu 0
   Are you sure you want to release the DM-LU? (y/n [n]): y
   The DM-LU has been released successfully.
   %
   ```

   ```
Setting the ShadowImage I/O switching mode

The following procedure explains how to set the ShadowImage I/O switching mode to ON. For more information, see Appendix D, I/O switching mode feature.

To set the ShadowImage I/O Switching Mode

1. From the command prompt, register the array on which you want to set the ShadowImage I/O Switching Mode. Connect to the array.

2. Execute the ausystemparam command.

   When you want to reset the ShadowImage I/O Switching Mode, enter disable following the -set -ShadowImageIOSwitch option. For example:

   ```
   % ausystemparam -unit array-name -set -ShadowImageIOSwitch enable
   Are you sure you want to set the system parameter? (y/n [n]): y
   The system parameter has been set successfully.
   %
   ```

3. Execute the ausystemparam command to verify that the ShadowImage I/O Switching Mode has been set. For example:

   ```
   % ausystemparam -unit array-name –refer
   Options
   : Turbo LU Warning = OFF
   : ShadowImage I/O Switch Mode = ON
   : Operation if the Processor failures Occurs = Reset a Fault
   %
   ```

**NOTE:** When turning off the I/O Switching Mode, pair status must be other than Split (S-VOL Switch) and Synchronizing (S-VOL Switch).

Setting the System Tuning Parameter

This setting limits the number of times processing is executed for flushing the dirty data in the cache to the drive at the same time.

To set the Dirty Data Flush Number Limit of a system tuning parameters:

1. From the command prompt, register the array on which you want to set a system tuning parameters and connect to that array.

2. Execute the ausystuning command to set the system tuning parameters.
Example:

```bash
% aureplicationlocal -unit subsystem-name -refer -si
Pair Name                            LUN  Pair LUN  Status
Copy Type    Group                    LUN  LUN  Status
SI_LU1020_LU1021                    1020      1021  Paired(0%)                 ShadowImage  ---:Ungrouped
```

**ShadowImage operations**

The `aureplicationlocal` command operates ShadowImage pair. To refer the `aureplicationlocal` command and its options, type in `aureplicationlocal -help` at the command prompt.

**Confirming pairs status**

To confirm the ShadowImage pairs, use the `aureplicationlocal -refer` command.

1. From the command prompt, register the array on which you want to confirm the ShadowImage pairs. Connect to the array.
2. Execute the `aureplicationlocal` command to confirm the ShadowImage pairs, as shown in the example below.

```text
% aureplicationlocal -unit subsystem-name -refer -si
Pair Name                            LUN  Pair LUN  Status
Copy Type    Group                    LUN  LUN  Status
SI_LU1020_LU1021                    1020      1021  Paired(0%)                 ShadowImage  ---:Ungrouped
```

**Creating ShadowImage pairs**

The following procedure explains how to create on pair. To create pairs in a group, refer to Creating ShadowImage pairs that belong to a group on page B-11.

To create the ShadowImage pairs, use the `aureplicationlocal -create` command.

1. From the command prompt, register the array on which you want to create the ShadowImage pairs. Connect to the array.
2. Execute the `aureplicationlocal` command to create the ShadowImage pairs.

When you want to automatically split the pair immediately after creation is completed, create the pair specifying the `-compsplit` option. In this case, the pair status immediately after pair creation becomes Split Pending.
In the following example, the P-VOL LUN is 1020 and the S-VOL LUN is 1021.

```shell
% aureplicationlocal -unit subsystem-name -create -si -pvol 1020 -svol 1021
Are you sure you want to create pairs "SI_LU1020_LU1021"?
(y/n [n]): y
The pair has been created successfully.
%
```

3. Verify the pair status, as shown in the example below.

```shell
% aureplicationlocal -unit subsystem-name -refer -si
Pair Name                  LUN  Pair LUN  Status       Copy Type   Group
SI_LU1020_LU1021           1020      1021  Synchronizing(40%) ShadowImage ---:Ungrouped
%
```

The ShadowImage pair is created.
Splitting ShadowImage pairs

To split the ShadowImage pairs, use the `aureplicationlocal -split` command.

1. From the command prompt, register the array on which you want to split the ShadowImage pairs. Connect to the array.

2. Execute the `aureplicationlocal` command to split the ShadowImage pairs.

   When you want to split Quick Mode, split the pair specifying the `-quick` option. In this case, the pair status immediately after pair splitting becomes Split Pending.

   In the following example, the P-VOL LUN is 1020 and the S-VOL LUN is 1021.

```
% aureplicationlocal -unit subsystem-name -split -si -pvol 1020 -svol 1021
Are you sure you want to split pairs?
(y/n [n]): y
The pair has been split successfully.
%
```

3. Verify the pair status as shown in the example below.

```
% aureplicationlocal -unit subsystem-name -refer -si
Pair Name                            LUN  Pair LUN  Status
  Copy Type   Group
SI_LU1020_LU1021                    1020      1021  Split(100%)
  ShadowImage  ---:Ungrouped
%
```

The ShadowImage pair is split.
Re-synchronizing ShadowImage pairs

To re-synchronize the ShadowImage pairs, use the `aureplicationlocal -resync` command.

1. From the command prompt, register the array on which you want to re-synchronize the ShadowImage pairs. Connect to the array.

2. Execute the `aureplicationlocal` command to re-synchronize the ShadowImage pairs.

   When you want to re-synchronize Quick Mode, re-synchronize the pair specifying the `-quick` option. In this case, the pair status immediately after pair re-synchronizing becomes Paired Internally Synchronizing.

   In the following example, the P-VOL LUN is 1020 and the S-VOL LUN is 1021.

   ```
   % aureplicationlocal -unit subsystem-name -resync -si -pvol 1020 -svol 1021
   Are you sure you want to re-synchronize pairs?
   (y/n [n]): y
   The pair has been re-synchronized successfully.
   
   %
   ```

3. Verify the pair status as shown in the example below.

   ```
   % aureplicationlocal -unit subsystem-name -refer -si
   Pair Name    LUN  Pair LUN  Status               Copy Type   Group
   SI_LU1020_LU1021  1020      1021  Synchronizing(40%) ShadowImage ---:Ungrouped
   
   %
   ```

   The ShadowImage pair is resynchronized.

Restoring the P-VOL

To restore the ShadowImage pairs, use the `aureplicationlocal -restore` command.

1. From the command prompt, register the array on which you want to restore the ShadowImage pairs. Connect to the array.

2. Execute the `aureplicationlocal` command to restore the ShadowImage pairs.

   In the following example, the P-VOL LUN is 1020 and the S-VOL LUN is 1021.

   ```
   % aureplicationlocal -unit subsystem-name -restore -si -pvol 1020 -svol 1021
   Are you sure you want to restore pairs?
   (y/n [n]): y
   The pair has been restored successfully.
   
   %
   ```

3. Verify the pair status as shown in the example below.
The ShadowImage pair is restored.

**Releasing ShadowImage pairs**

To release the ShadowImage pairs, use the `aureplicationlocal -simplex` command.

1. From the command prompt, register the array on which you want to release the ShadowImage pairs. Connect to the array.
2. Execute the `aureplicationlocal` command to release the ShadowImage pairs.
   
   In the following example, the P-VOL LUN is 1020 and the S-VOL LUN is 1021.

   ```
   % aureplicationlocal –unit subsystem-name -simplex –si –pvol 1020 –svol 1021
   Are you sure you want to release pairs?
   (y/n [n]): y
   The pair has been released successfully.
   %
   ```

3. Verify the pair status as shown in the example below.

   ```
   % aureplicationlocal –unit subsystem-name -refer -si
   DMCEC002015: No information displayed.
   %
   ```

The ShadowImage pair is released.

**Editing pair information**

You can change the pair name, group name, and/or copy pace.

To change the pair information:

1. From the command prompt, register the array on which you want to change the ShadowImage pair information. Connect to the array.
2. Execute the `aureplicationlocal` command to change the ShadowImage pair information.
In the following example, the P-VOL LUN is 1020 and the S-VOL LUN is 1021.

% aureplicationlocal -unit subsystem-name -chg -si -pace slow -pvol 1020 -svol 1021
Are you sure you want to change pair information?
(y/n [n]): y
The pair information has been changed successfully.
%

The ShadowImage pair information is changed.

Creating ShadowImage pairs that belong to a group

To create multiple ShadowImage pairs that belong to a group:

1. Create the first pair that belongs to a group specifying an unused group number for the new group with the –gno option. The new group has been created and in this group, the new pair has been created too.

   % aureplicationlocal -unit array-name -create -si -pvol 1020 -svol 1021 -gno 20
   Are you sure you want to create pairs "SI_LU1020_LU1021"?
   (y/n [n]): y
   The pair has been created successfully.
   %

2. Add the name to the group if necessary using command to change the pair information.

   % aureplicationlocal -unit array-name -chg -si -gno 20 -newgname group-name
   Are you sure you want to change pair information?
   (y/n [n]): y
   The pair information has been changed successfully.
   %

3. Create the next pair that belongs to the created group specifying the number of the created group with –gno option.

4. By repeating the step 3, the multiple pairs that belong to the same group can be created.

   NOTE: You cannot use the options of the group number specification and automatic split after pair creation at the same time. To create two or more pairs that utilize the group by using Quick Mode, create all pairs belonging to the group, specify the quick option, and execute the split by group unit.
## Splitting ShadowImage pairs that belong to a group

To split two or more ShadowImage pairs that belong to a group:

1. Execute the `aureplicationlocal` command to split the ShadowImage pairs. Display the status of the pairs belonging to the group to be the target, and split the pairs after checking that all pairs are in the split-able status.

   ```
   % aureplicationlocal -unit array-name -refer -si
   Pair Name                          LUN  Pair LUN  Status
   Copy Type    Group
   SI_LU1000_LU1003                  1000      1003  Paired(100%)
   ShadowImage  0:
   SI_LU1001_LU1004                  1001      1004  Paired(100%)
   ShadowImage  0:
   SI_LU1002_LU1005                  1002      1005  Paired(100%)
   ShadowImage  0:
   %
   ```

   When using Quick Mode:
   - Paired
   - Paired Internally Synchronizing
   - Synchronizing

   When not using the Quick Mode:
   - Paired
   - Paired Internally Synchronizing

2. Verify the pair status executing the `aureplicationlocal` command.

   ```
   % aureplicationlocal -unit array-name -si -split -gno 0
   Are you sure you want to split pair? (y/n [n]): y
   The pair has been split successfully.
   %
   ```

### NOTE:
If a pair that cannot be split is mixed in the specified group, the pair split in the group unit does not operate. When this occurs, an error as a response to the pair split operation may or may not be displayed. Also, the pair split-able status differs depending on whether Quick Mode is used or not. Therefore, check that all the pairs belonging to the group to be the pair split target are in the following statuses according to each case.

   ```
   % aureplicationlocal -unit array-name -refer -si
   Pair Name                          LUN  Pair LUN  Status
   Copy Type    Group
   SI_LU1000_LU1003                  1000      1003  Split(100%)
   ShadowImage  0:
   SI_LU1001_LU1004                  1001      1004  Split(100%)
   ShadowImage  0:
   SI_LU1002_LU1005                  1002      1005  Split(100%)
   ShadowImage  0:
   %
   ```

The ShadowImage pair is split.
Sample back up script for Windows

This section provides sample script for backing a volume on Windows.

```bash
echo off
REM Specify the registered name of the arrays
set UNITNAME=Array1
REM Specify the group name (Specify “Ungroup” if the pair doesn’t belong to any group)
set G_NAME=Ungrouped
REM Specify the pair name
set P_NAME=SI_LU0001_LU0002
REM Specify the directory path that is mount point of P-VOL and S-VOL
set MAINDIR=C:\main
set BACKUPDIR=C:\backup
REM Specify GUID of P-VOL and S-VOL
PVOL_GUID=xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx
SVOL_GUID=yyyyyyyy-yyyy-yyyy-yyyy-yyyy-yyyy-yyyy-yyyy
REM Unmounting the S-VOL
pairdisplay -x umount %BACKUPDIR% REM Re-synchronizing pair (Updating the backup data)
aureplicationlocal -unit %UNITNAME% -si -resync -pairname %P_NAME% -gname %G_NAME%
aureplicationmon -unit %UNITNAME% -evwait -si -pairname %P_NAME% -gname %G_NAME% -st paired -pvol
REM Unmounting the P-VOL
pairdisplay -x umount %MAINDIR%
REM Splitting pair (Determine the backup data)
aureplicationlocal -unit %UNITNAME% -si -split -pairname %P_NAME% -gname %G_NAME%
aureplicationmon -unit %UNITNAME% -evwait -si -pairname %P_NAME% -gname %G_NAME% -st split -pvol
REM Mounting the P-VOL
pairdisplay -x mount %MAINDIR% Volume{%PVOL_GUID%}
REM Mounting the S-VOL
pairdisplay -x mount %BACKUPDIR% Volume{%SVOL_GUID%}
< The procedure of data copy from C:\backup to backup appliance>
```

**NOTE:** For Windows 2000 or Windows Server 2003/2008 environments, the CCI mount/unmount commands must be used when mounting/unmounting a volume.
Operations using CCI

This chapter describes basic CCI procedures for setting up and performing ShadowImage operations.

- Setting up CCI
- ShadowImage operations using CCI
- Pair, group name differences in CCI and Navigator 2
Setting up CCI

The following sub-sections describe necessary set up procedures for CCI for ShadowImage.

Setting the command device

The command devices and LU mapping setting is used Navigator 2.

To designate command devices

1. From the command prompt, register the array to which you want to set the command device. Connect to the array.
2. Execute the `aucmddev` command to set a command device. First, display LUs to be assignable command device, and later set a command device. When you want to use the protection function of CCI, enter `enable` following the `-dev` option.

The following example specifies LU 2 for command device 1.

```
% aucmddev -unit array-name -availablelist
Available Logical Units
  LUN  Capacity  RAID Group  DP Pool  RAID Level  Type Status
  2    35.0 MB   0           N/A      6( 9D+2P)  SAS  Normal
  3    35.0 MB   0           N/A      6( 9D+2P)  SAS  Normal
%
% aucmddev -unit array-name -set -dev 1 2
Are you sure you want to set the command devices?
(y/n [n]): y
The command devices have been set successfully.
%
```

3. Execute the `aucmddev` command to verify that the command device has been set. For example:

```
% aucmddev -unit array-name -refer
Command Device LUN  RAID Manager Protect
  1                2 Disable
%
```

**NOTE:** To set the alternate command device function or to avoid data loss and array downtime, designate two or more command devices. For details on alternate Command Device function, refer to the *Hitachi Adaptable Modular Storage Command Control Interface (CCI) User’s Guide*. 
4. The following example releases a command device:

```
% aucmddev -unit array-name -rm -dev 1
Are you sure you want to release the command devices?
(y/n [n]): y
This operation may cause CCI, which is accessing this command device, to freeze.
Stop the CCI, which is accessing this command device, before performing this operation.
Are you sure you want to release the command devices? (y/n [n]): y
The specified command device will be released.
Are you sure you want to execute? (y/n [n]): y
The command devices have been released successfully.
```

5. To change an already set command device, release the command device, then change the LU number. The following example specifies LU 3 for command device 1.

```
% aucmddev -unit array-name -set -dev 1 3
Are you sure you want to set the command devices?
(y/n [n]): y
The command devices have been set successfully.
```

**Setting LU mapping**

If using iSCSI, use the autargetmap command instead of the auhgmap command used with fibre channel.

**To set up LU Mapping**

1. From the command prompt, register the array to which you want to set the LU Mapping, then connect to the array.

2. Execute the auhgmap command to set the LU Mapping. The following is an example of setting LU 0 in the array to be recognized as 6 by the host. The port is connected via target group 0 of port 0A on controller 0.

```
% auhgmap -unit array-name -add 0 A 0 6 0
Are you sure you want to add the mapping information?
(y/n [n]): y
The mapping information has been set successfully.
```

3. Execute the auhgmap command to verify that the LU Mapping is set. For example:

```
% auhgmap -unit array-name -refer
Mapping mode = ON
Port  Group  H-LUN    LUN
0A      0      6      0
```

Defining the configuration definition file

The configuration definition file describes the system configuration. It is required to make CCI operational. The configuration definition file is a text file created and/or edited using any standard text editor. It can be defined from the PC where CCI software is installed.

A sample configuration definition file, HORCM_CONF, is included with the CCI software. It should be used as the basis for creating your configuration definition files. The system administrator should copy the sample file, set the necessary parameters in the copied file, and place the copied file in the proper directory. For details on configuration definition file, refer to the Hitachi Adaptable Modular Storage Command Control Interface (CCI) User’s Guide.

The configuration definition file can be automatically created using the mkconf command tool. For details on the mkconf command, refer to the Hitachi Adaptable Modular Storage Command Control Interface (CCI) Reference Guide. However, the parameters, such as poll(10ms) must be set manually (see step 4 below).

To define the configuration definition file

The following is an example that manually defines the configuration definition file. The system is configured with two instances within the same Windows host.

1. On the host where CCI is installed, verify that CCI is not running. If CCI is running, shut it down using the horcmshutdown command.

2. In the command prompt, make two copies of the sample file (horcm.conf). For example:

   ```
c:\HORCM\etc> copy \HORCM\etc\horcm.conf \WINDOWS\horcm0.conf
   c:\HORCM\etc> copy \HORCM\etc\horcm.conf \WINDOWS\horcm1.conf
   ```

3. Open horcm0.conf using the text editor.

4. In the HORCM_MON section, set the necessary parameters.

   **Important:** A value more than or equal to 6000 must be set for poll(10ms). Specifying the value incorrectly may cause resource contention in the internal process, resulting the process temporarily suspending and pausing the internal processing of the array.

5. In the HORCM_CMD section, specify the physical drive (command device) on the array. Figure C-1 and Figure C-2 show examples of the horcm0.conf file in which the ShadowImage P-VOL-to-S-VOL ratio is 1:1 and 1:3, respectively.
6. Save the configuration definition file and use the `horcmstart` command to start CCI.
7. Execute the `raidscan` command and write down the target ID displayed in the execution result.

8. Shut down CCI and then open the configuration definition file again.

9. In the **HORCM_DEV** section, set the necessary parameters. For the target ID, set the ID of the `raidscan` result you wrote down. Also, the item MU# must be added after the LU#.

10. In the **HORCM_INST** section, set the necessary parameters, and then save (overwrite) the file.

11. Repeat Steps 3 to 10, using Figure C-4 and Figure C-5 for examples.

---

**Figure C-4**: Horcm1.conf Example 3 (P-VOL: S-VOL=1: 1)

**Figure C-5**: Horcm1.conf Example 4 (P-VOL: S-VOL=1: 3)
### Figure C-6: Horcm1.conf Example (Cascading ShadowImage S-VOL with SnapShot P-VOL)

```
[Horcm.cnf]

Horcm_PMDN
#p_address service pull(T) timeout(T)  
\\\physicaldrive1

Horcm_CMD
#dev_name dev_name

\\\physicaldrive1

Horcm_DEV
#dev_group dev_name port# TargetID LU# M#  
VSD\1 oraudl2\1 oraudl2\1 oraudl2\1 oraudl2\1
VSD\2 oraudl2\2 oraudl2\2 oraudl2\2 oraudl2\2

Horcm_INST
#dev_group ip_address service

\\\physicaldrive1

VSD\1 oraudl2\1 oraudl2\1 oraudl2\1 oraudl2\1
VSD\2 oraudl2\2 oraudl2\2 oraudl2\2 oraudl2\2
```
12. Enter the following example lines in the command prompt to verify the connection between CCI and the array:

```
C:\>cd horcm\etc
C:\HORCM\etc>echo hd1-3 | .\inqraid
  Harddisk 1 -> [ST] CL1-A Ser =85000174 LDEV =  0 [HITACHI ]
  [DF600F-CM ]
  Harddisk 2 -> [ST] CL1-A Ser =85000174 LDEV =  1 [HITACHI ]
  [DF600F ]
   HORC = SMPL  HOMRCF[MU#0 = SMPL MU#1 = NONE MU#2 = NONE]
   RAID6[Group  1-0] SSID = 0x0000
  Harddisk 3 -> [ST] CL1-A Ser =85000174 LDEV =  2 [HITACHI ]
  [DF600F ]
   HORC = SMPL  HOMRCF[MU#0 = SMPL MU#1 = NONE MU#2 = NONE]
   RAID6[Group  2-0] SSID = 0x0000
C:\HORCM\etc>
```n
### Setting the environment variable

To perform ShadowImage operations, you must set the environment variable for the execution environment. The following describes an example in which two instances are configured within the same Windows host.

1. Set the environment variable for each instance. Enter the following from the command prompt:

```
C:\HORCM\etc>set HORCMINST=0
```

2. To enable ShadowImage, the environment variable must be set as follows:

```
C:\HORCM\etc>set HORCC_MRCF=1
```

3. Execute the `horcmstart` script, and then execute the `pairdisplay` command to verify the configuration, as shown in the following example:

```
C:\HORCM\etc>horcmstart 0 1
starting HORCM inst 0
HORCM inst 0 starts successfully.
starting HORCM inst 1
HORCM inst 1 starts successfully.
C:\HORCM\etc>pairdisplay -g VG01
  group   PairVOL(L/R) (Port#,TID, LU-M) ,Seq#,LDEV#.P/S,Status,
  Seq#,P-LDEV#  M
  VG01   oradb1(L)  (CL1-A , 1,  1-0 )85000174     1.SMPL ----- 
       ,----- ----- 
  VG01   oradb1(R)  (CL1-A , 1,  2-0 )85000174     2.SMPL ----- 
       ,----- ----- 
```

CCI setup for performing ShadowImage operations is now complete.
ShadowImage operations using CCI

Pair operation using CCI are shown in Figure C-7.

Figure C-7: ShadowImage Pair Status Transitions

Confirming pair status

Table C-1 shows the related CCI and Navigator 2 GUI pair status.

Table C-1: CCI/Navigator 2 GUI Pair Status

<table>
<thead>
<tr>
<th>Description</th>
<th>CCI</th>
<th>Navigator 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status where a pair is not created.</td>
<td>SMPL</td>
<td>Simplex</td>
</tr>
<tr>
<td>Initial copy or resynchronization copy is in execution.</td>
<td>COPY</td>
<td>Synchronizing</td>
</tr>
<tr>
<td>Status that the copying is completed and the contents written to the P-VOL is reflected in the S-VOL.</td>
<td>PAIR</td>
<td>Paired</td>
</tr>
<tr>
<td>Status that the written contents are managed as difference data by split.</td>
<td>PSUS/SSUS</td>
<td>Split</td>
</tr>
<tr>
<td>Status that the difference data is copied from the S-VOL to the P-VOL for restoration.</td>
<td>RCPY</td>
<td>Reverse Synchronizing</td>
</tr>
<tr>
<td>Status that suspends copying forcibly when a failure occurs.</td>
<td>PSUE</td>
<td>Failure</td>
</tr>
</tbody>
</table>
To confirm ShadowImage pairs

For the example below, the group name in the configuration definition file is VG01.

1. Execute the pairdisplay command to verify the pair status and the configuration. For example:

```
C:\HORCM\etc>pairdisplay -g VG01
Group   PairVol(L/R) (Port#,TID, LU-M) ,Seq#,LDEV#.P/S,Status, Seq#,P-LDEV# M
VG01   oradb1(L)    (CL1-A , 1,  1-0 )85000174    1.P-VOL PAIR,85000174     2  -
VG01   oradb1(R)    (CL1-A , 1,  2-0 )85000174    2.S-VOL PAIR,-----        1  -
```

The pair status is displayed. For details on the pairdisplay command and its options, refer to Hitachi AMS Command Control Interface (CCI) Reference Guide.

Creating pairs (paircreate)

To create ShadowImage pairs

1. Execute the pairdisplay command to verify that the status of the ShadowImage volumes is SMPL. The following example specifies the group name in the configuration definition file as VG01.

```
C:\HORCM\etc>pairdisplay -g VG01
Group   PairVol(L/R) (Port#,TID, LU-M) ,Seq#,LDEV#.P/S,Status, Seq#,P-LDEV# M
VG01    oradb1(L)    (CL1-A , 1,  1-0 )85000174     1.SMPL -----,-----   ----  -
VG01    oradb1(R)    (CL1-A , 1,  2-0 )85000174     2.SMPL -----,-----   ----  -
```

2. Execute the paircreate command, then execute the pairevtwait command to verify that the status of each volume is PAIR. When using the paircreate command, the -c option is copying pace, which can vary between 1-15. 6-10 (medium) is recommended. 1-5 is a slow pace, which is used when I/O performance must be prioritized. 11-15 is a fast pace, which is used when copying is prioritized. The following example shows the paircreate and pairevtwait commands.

```
C:\HORCM\etc>paircreate -g VG01 -vl -c 15
C:\HORCM\etc>pairevtwait -g VG01 -s pair -t 300 10
pairevtwait : Wait status done.
```

3. Execute the pairdisplay command to verify the pair status and the configuration. For example:

```
C:\HORCM\etc>pairdisplay -g VG01
Group   PairVol(L/R) (Port#,TID, LU-M) ,Seq#,LDEV#.P/S,Status, Seq#,P-LDEV# M
VG01    oradb1(L)    (CL1-A , 1,  1-0 )85000174     1.P-VOL PAIR,85000174     2  -
VG01    oradb1(R)    (CL1-A , 1,  2-0 )85000174     2.S-VOL PAIR,-----        1  -
```
Pair creation using a consistency group

A consistency group insures that the data in two or more S-VOLs included in a group are of the same time. For more information, see Consistency group (CTG) on page 1-12.

To create a pair using a consistency group

1. Execute the `pairdisplay` command to verify that the status of the ShadowImage volumes is SMPL. In the following example, the group name in the configuration definition file is VG01.

   ```
   C:\HORCM\etc>pairdisplay -g VG01
   Group   PairVol(L/R) (Port#,TID, LU-M) ,Seq#,LDEV# .P/S,Status, Seq#,P-LDEV# M
   VG01 oradb1(L)  (CL1-A , 1, 1-0 )85000174     1.SMPL -----,-----   ----  -
   VG01 oradb1(R)  (CL1-A , 1, 2-0 )85000174     2.SMPL -----,-----   ----  -
   VG01 oradb2(L)  (CL1-A , 1, 3-0 )85000174     3.SMPL -----,-----   ----  -
   VG01 oradb2(R)  (CL1-A , 1, 4-0 )85000174     4.SMPL -----,-----   ----  -
   VG01 oradb3(L)  (CL1-A , 1, 5-0 )85000174     5.SMPL -----,-----   ----  -
   VG01 oradb3(R)  (CL1-A , 1, 6-0 )85000174     6.SMPL -----,-----   ----  -
   
   To create a pair using a consistency group
   
   2. Execute the `paircreate -m grp` command, then execute the `pairevtwait` command to verify that the status of each volume is PAIR.

   ```
   C:\HORCM\etc>paircreate -g VG01 -vl -m grp
   C:\HORCM\etc>pairevtwait -g VG01 -s pair -t 300 10
   pairevtwait : Wait status done.
   ```

3. Execute the `pairdisplay` command to verify the pair status and the configuration. For example:

   ```
   C:\HORCM\etc>pairdisplay -g VG01
   Group   PairVol(L/R) (Port#,TID, LU-M) ,Seq#,LDEV# .P/S,Status, Seq#,P-LDEV# M
   VG01 oradb1(L)  (CL1-A , 1, 1-0 )85000174     1.P-VOL PAIR,85000174     2  -
   VG01 oradb1(R)  (CL1-A , 1, 2-0 )85000174     2.S-VOL PAIR,-----        1  -
   VG01 oradb2(L)  (CL1-A , 1, 3-0 )85000174     3.P-VOL PAIR,85000174     4  -
   VG01 oradb2(R)  (CL1-A , 1, 4-0 )85000174     4.S-VOL PAIR,-----        3  -
   VG01 oradb3(L)  (CL1-A , 1, 5-0 )85000174     5.P-VOL PAIR,85000174     6  -
   VG01 oradb3(R)  (CL1-A , 1, 6-0 )85000174     6.S-VOL PAIR,-----        5  -
   ```
Splitting pairs (pairsplit)

To split ShadowImage pairs

1. Execute the pairsplit command to split the ShadowImage pair in the PAIR status. In the following example, the group name in the configuration definition file is VG01.

   C:\HORCM\etc\pairsplit -g VG01

2. Execute the pairdisplay command to verify the pair status and the configuration.

   C:\HORCM\etc\pairdisplay -g VG01
   Group   PairVol(L/R) (Port#,TID,LU-M) ,Seq#,LDEV#.P/S,Status, Seq#,P-LDEV# M
   VG01    oradb1(L)    (CL1-A , 1,  1-0 )85000174     1.P-VOL PSUS,85000174     2  -
   VG01    oradb1(R)    (CL1-A , 1,  2-0 )85000174     2.S-VOL SSUS,-----        1  -

When it is required to split two or more S-VOLs included in a group at the same time and to assure that data of the same time are stored in the S-VOLs, use the CTG. In order to use the CTG, create a pair adding the -m grp option with the paircreate command.

Resynchronizing pairs (pairresync)

To resynchronize ShadowImage pairs

1. Execute the pairresync command to resynchronize the ShadowImage pair, then execute the pairevtwait command to verify that the status of each volume is PAIR. When using the -c option (copy pace), see the explanation in Creating pairs (paircreate) on page C-10. For the following example, the group name in the configuration definition file is VG01.

   C:\HORCM\etc\pairresync -g VG01 -c 15
   C:\HORCM\etc\pairevtwait -g VG01 -s pair -t 300 10
   pairevtwait : Wait status done.

2. Execute the pairdisplay command to verify the pair status and the configuration. For example:

   C:\HORCM\etc\pairdisplay -g VG01
   Group   PairVol(L/R) (Port#,TID,LU-M) ,Seq#,LDEV#.P/S,Status, Seq#,P-LDEV# M
   VG01    oradb1(L)    (CL1-A , 1,  1-0 )85000174     1.P-VOL PAIR,85000174     2  -
   VG01    oradb1(R)    (CL1-A , 1,  2-0 )85000174     2.S-VOL SSUS,-----        1  -
Releasing pairs (pairsplit –S)

To release the ShadowImage pair and change the status to SMPL

1. Execute the pairdisplay command to verify that the status of the ShadowImage pair is PAIR. In the following example, the group name in the configuration definition file is VG01.

2. Execute the pairsplit (pairsplit -S) command to release the ShadowImage pair.

3. Execute pairdisplay command to verify that the pair status changed to SMPL. For example:

Pair, group name differences in CCI and Navigator 2

Pairs and groups that were created using CCI will be displayed differently when status is confirmed in Navigator 2.

- Pairs created with CCI and defined in the configuration definition file display unnamed in Navigator 2.
- Groups defined in the configuration definition file are also different in Navigator 2.
- Pairs defined in a group on the configuration definition file using CCI are displayed in Navigator 2 as ungrouped.

For information about how to manage a group defined on the configuration definition file as a CTG, see the Hitachi Adaptable Modular Storage Command Control Interface (CCI) Reference Guide.
I/O switching mode feature

This appendix provides a description, specifications, and setup instructions for the I/O Switching Mode feature.

- I/O switching mode feature
- Specifications
- Recommendations
- Enabling I/O switching mode
- Recovery from a drive failure
**I/O switching mode feature**

When a P-VOL becomes inaccessible due to a drive failure, I/O Switching Mode automatically transfers input/output operations between the host and P-VOL to the host and S-VOL. I/O Switching Mode must be enabled.

This feature only operates under the following conditions:
- This function operates only when one P-VOL configures a pair with one S-VOL.
- The pair must be in Paired status.
- The pair configuration must be P-VOL:S-VOL=1:1. Also, an S-VOL cannot be created newly from the P-VOL whose I/O is switched to the S-VOL.
- In the ShadowImage I/O Switching function, DP-VOLs created by Dynamic Provisioning can be used for a P-VOL or an S-VOL of ShadowImage.

*Figure D-1* illustrates I/O Switching Mode.

![Diagram of I/O Switching Mode Function](image)

**Figure D-1: I/O Switching Mode Function**

The I/O Switching feature activates when a drive double failure (triple failures for RAID 6) occurs. At that time, the pair’s status is changed to “Failure (S-VOL Switch)”, and host read/write access is automatically transferred from a P-VOL to an S-VOL. When one P-VOL configures a pair with one or more S-VOLs, switch to the S-VOL that has the smallest logical unit number.

**NOTE:** When I/O Switching is activated, all LUs in the associated RAID group become unformatted, whether or not they are in a ShadowImage pair.
**Specifications**

Table D-1 shows specifications for the ShadowImage I/O Switching Mode function.

**Table D-1: I/O Switching Mode Specifications**

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
</table>
| Preconditions for operation        | • The ShadowImage I/O Switching mode must be turned on.  
• Pair status must be PAIR.  
• "The pair configuration needs to be P-VOL: S-VOL=1:1. |
| Scope of application               | All ShadowImage pairs that satisfy the preconditions for operation.  
In ShadowImage I/O Switching function, DP-VOLs created by Dynamic Provisioning can be used for a P-VOL or an S-VOL of ShadowImage. |
| Access to a P-VOL                  | Execution of host I/O continues after a drive failure because a report is sent to the host from the S-VOL as if from the P-VOL.              |
| Access to an S-VOL                 | An I/O instruction issued to an S-VOL results in an error.                                                                                  |
| Display of the status              | **In Navigator 2:** When host I/O is switched to an S-VOL, pair status is displayed as PSUE (S-VOL Switch). When the pairresync command is executed, pair status changes to COPY (S-VOL Switch).  
**In CCI** (pairdisplay command): Even when host I/O is switched to an S-VOL, the pair status is displayed as PSUE. However, when the pairmon -allsnd -nowait command is issued, the code (internal code of the pair status) is displayed as 0x08. When the pairresync command is executed for a pair in the PSUE (S-VOL Switch) status, the pair status is displayed as RCPY. |
| Formatting                         | Quick formatting can only be performed when the pair status is PSUE (S-VOL Switch).                                                           |
| Notes                              | • The pairsplit, pairresync -restore or pairsplit -s commands cannot be performed when the status is PSUE (S-VOL Switch) or copying PSUE (S-VOL Switch) to P-VOL. |
**Recommendations**

- Locate P-VOLs and S-VOLs in respective RAID groups. When both are located in the same RAID group, they can become unformatted in the event of a drive failure.

- When a pair is in the Paired status, as it must be for the I/O Switching Mode, performance is lower than when the pair is Split. Hitachi recommends assigning an LU that uses SAS/SSD drives to an S-VOL to assure best performance results.
Enabling I/O switching mode

To use CLI, see Setting the ShadowImage I/O switching mode on page B-5.

Use the following procedure to enable I/O switching mode which displays a Navigator 2 applet screen. If your system does not display the screen (it takes a minute or two to appear), see the GUI online Help for Advanced Settings.

To enable I/O Switching Mode

1. In Navigator 2, select the subsystem in which ShadowImage is to be operated, then click **Show & Configure Array**.
2. In the tree view, select the **Advanced Settings** icon.
3. Click **Open Advanced Settings**. The Array Unit screen displays, as shown in Figure D-2. This may take a few minutes.
   
   If you have problems with screen, see the following section.

![Figure D-2: Array Unit Screen](image)

4. Select **Configuration Settings**, then click **Set**. The Configuration Settings screen displays.
5. Click the **System Parameter** tab.
6. Click the **ShadowImage I/O Switch Mode** check box, then click **Apply**.
7. On the confirmation message, click **OK**.
8. Click **Close** on the **Configuration Settings** page.
9. Click **Close** on the subsequent message screen.

**NOTE:** When disabling I/O Switching Mode, pair statuses must be other than Failure (S-VOL Switch) and Synchronizing (S-VOL Switch).

**About the array unit screen**

This screen is an applet connected to the SNM2 Server. After 20 minutes elapses while displaying this applet screen, automatic logoff occurs. Therefore, when your operation is completed, close the screen.

If the applet screen does not display, the login to the SNM2 Server may have failed. In this case, the applet screen cannot be displayed again. The code: 0x000000000000b045 or "DMEG800003: The error occurred in connecting RMI server." is displayed on the applet screen. Take the following actions.

- Close the Web browser, stop the SNM2 Server, restart it, then navigate to the array.
- Close the Web browser; confirm the SNM2 Server is started. If it has stopped, start it and display the screen of the Array that you want to operate.
- Return to the Array screen after 20 minutes elapsed and display the screen of the Array you want to operate.

**Recovery from a drive failure**

When the I/O Switching Mode feature is used, recovery from a drive failure on which the P-VOL is located can be undertaken during the newly-established host read/write operations to the S-VOL. This section provides the basic procedure for recovery.

**To recover from a drive failure after I/O Switching Mode is activated**

1. After a drive double failure occurs (triple failure for RAID 6) in a P-VOL and I/O from the host is transferred via the I/O Switching Mode feature to the S-VOL, have the P-VOL drives replaced.
2. When one P-VOL configures a pair with one or more S-VOLs, delete the pairs other than the Paired in which the I/O switching to the S-VOL was operated.
3. When a drive double failure occurs (triple failures for RAID 6) in a P-VOL that is DP-VOL, reinitialize the DP pool.
4. When the drives have been replaced, perform quick formatting of the P-VOL.
5. Perform a reverse-resync of the pair, copying S-VOL data to the P-VOL. Performance is lowered during the reverse-resync, but host I/O can be continued. When resynchronization is completed, the pair status becomes Paired.
6. When one P-VOL configures a pair with one or more S-VOLs, create a pair in the original pair configuration.
Glossary

This glossary provides definitions for replication terms as well as terms related to the technology that supports your Hitachi modular array. Click the letter of the glossary section to display the related page.

A

array
A set of hard disks mounted in a single enclosure and grouped logically together to function as one contiguous storage space.

asynchronous
Asynchronous data communications operate between a computer and various devices. Data transfers occur intermittently rather than in a steady stream. Asynchronous replication does not depend on acknowledging the remote write, but it does write to a local log file. Synchronous replication depends on receiving an acknowledgement code (ACK) from the remote system and the remote system also keeps a log file.

B

background copy
A physical copy of all tracks from the source volume to the target volume.

bps
Bits per second, the standard measure of data transmission speeds.
C

cache
A temporary, high-speed storage mechanism. It is a reserved section of main memory or an independent high-speed storage device. Two types of caching are found in computers: memory caching and disk caching. Memory caches are built into the architecture of microprocessors and often computers have external cache memory. Disk caching works like memory caching; however, it uses slower, conventional main memory that on some devices is called a memory buffer.

capacity
The amount of information (usually expressed in megabytes) that can be stored on a disk drive. It is the measure of the potential contents of a device; the volume it can contain or hold. In communications, capacity refers to the maximum possible data transfer rate of a communications channel under ideal conditions.

CCI
See command control interface.

CLI
See command line interface.

cluster
A group of disk sectors. The operating system assigns a unique number to each cluster and then keeps track of files according to which clusters they use.

cluster capacity
The total amount of disk space in a cluster, excluding the space required for system overhead and the operating system. Cluster capacity is the amount of space available for all archive data, including original file data, metadata, and redundant data.

command control interface (CCI)
Hitachi’s Command Control Interface software provides command line control of Hitachi array and software operations through the use of commands issued from a system host. Hitachi’s CCI also provides a scripting function for defining multiple operations.

command devices
Dedicated logical volumes that are used only by management software such as CCI, to interface with the arrays. Command devices are not used by ordinary applications. Command devices can be shared between several hosts.
command line interface (CLI)
A method of interacting with an operating system or software using a command line interpreter. With Hitachi’s Storage Navigator Modular Command Line Interface, CLI is used to interact with and manage Hitachi storage and replication systems.

concurrency of S-VOL
Occurs when an S-VOL is synchronized by simultaneously updating an S-VOL with P-VOL data AND data cached in the primary host memory. Discrepancies in S-VOL data may occur if data is cached in the primary host memory between two write operations. This data, which is not available on the P-VOL, is not reflected on to the S-VOL. To ensure concurrency of the S-VOL, cached data is written onto the P-VOL before subsequent remote copy operations take place.

concurrent copy
A management solution that creates data dumps, or copies, while other applications are updating that data. This allows end-user processing to continue. Concurrent copy allows you to update the data in the files being copied, however, the copy or dump of the data it secures does not contain any of the intervening updates.

configuration definition file
The configuration definition file describes the system configuration for making CCI operational in a TrueCopy Extended Distance Software environment. The configuration definition file is a text file created and/ or edited using any standard text editor, and can be defined from the PC where the CCI software is installed. The configuration definition file describes configuration of new TrueCopy Extended Distance pairs on the primary or remote array.

consistency group (CTG)
A group of two or more logical units in a file system or a logical volume. When a file system or a logical volume which stores application data, is configured from two or more logical units, these multiple logical units are managed as a consistency group (CTG) and treated as a single entity. A set of volume pairs can also be managed and operated as a consistency group.

consistency of S-VOL
A state in which a reliable copy of S-VOL data from a previous update cycle is available at all times on the remote array. A consistent copy of S-VOL data is internally pre-determined during each update cycle and maintained in the remote data pool. When remote takeover operations are performed, this reliable copy is restored to the S-VOL, eliminating any data discrepancies. Data consistency at the remote site enables quicker restart of operations upon disaster recovery.
CRC
Cyclical Redundancy Checking. A scheme for checking the correctness of data that has been transmitted or stored and retrieved. A CRC consists of a fixed number of bits computed as a function of the data to be protected, and appended to the data. When the data is read or received, the function is recomputed, and the result is compared to that appended to the data.

CTG
See Consistency Group.

cycle time
A user specified time interval used to execute recurring data updates for remote copying. Cycle time updates are set for each array and are calculated based on the number of consistency groups CTG.

cycle update
Involves periodically transferring differential data updates from the P-VOL to the S-VOL. TrueCopy Extended Distance Software remote replication processes are implemented as recurring cycle update operations executed in specific time periods (cycles).

D

data pool
One or more disk volumes designated to temporarily store untransferred differential data (in the local array or snapshots of backup data in the remote array). The saved snapshots are useful for accurate data restoration (of the P-VOL) and faster remote takeover processing (using the S-VOL).

data volume
A volume that stores database information. Other files, such as index files and data dictionaries, store administrative information (metadata).

differential data control
The process of continuously monitoring the differences between the data on two volumes and determining when to synchronize them.

differential data copy
The process of copying the updated data from the primary volume to the secondary volume. The data is updated from the differential data control status (the pair volume is under the suspended status) to the primary volume.
**Differential Management Logical Unit (DMLU)**

The volumes are used to manage differential data in a array. In a TrueCopy Extended Distance system, there may be up to two DM logical units configured per array. For Copy-on-Write and ShadowImage, the DMLU is an exclusive volume used for storing data when the array system is powered down.

**differential-data**

The original data blocks replaced by writes to the primary volume. In Copy-on-Write, differential data is stored in the data pool to preserve the copy made of the P-VOL to the time of the snapshot.

**disaster recovery**

A set of procedures to recover critical application data and processing after a disaster or other failure. Disaster recovery processes include failover and failback procedures.

**disk array**

An enterprise storage system containing multiple disk drives. Also referred to as “disk array device” or “disk storage system.”

**DMLU**

See Differential Management-Logical Unit.

**dual copy**

The process of simultaneously updating a P-VOL and S-VOL while using a single write operation.

**duplex**

The transmission of data in either one or two directions. Duplex modes are full-duplex and half-duplex. Full-duplex is the simultaneous transmission of data in two direction. For example, a telephone is a full-duplex device, because both parties can talk at once. In contrast, a walkie-talkie is a half-duplex device because only one party can transmit at a time.

**E**

**entire copy**

Copies all data in the primary volume to the secondary volume to make sure that both volumes are identical.

**extent**

A contiguous area of storage in a computer file system that is reserved for writing or storing a file.
F

failover
The automatic substitution of a functionally equivalent system component for a failed one. The term failover is most often applied to intelligent controllers connected to the same storage devices and host computers. If one of the controllers fails, failover occurs, and the survivor takes over its I/O load.

fallback
Refers to the process of restarting business operations at a local site using the P-VOL. It takes place after the arrays have been recovered.

Fault tolerance
A system with the ability to continue operating, possibly at a reduced level, rather than failing completely, when some part of the system fails.

FC
See Fibre channel.

Fibre channel
A gigabit-speed network technology primarily used for storage networking.

table of contents

firmware
Software embedded into a storage device. It may also be referred to as Microcode.

full duplex
The concurrent transmission and the reception of data on a single link.

G

Gbps
Gigabits per second.

granularity of differential data
Refers to the size or amount of data transferred to the S-VOL during an update cycle. Since only the differential data in the P-VOL is transferred to the S-VOL, the size of data sent to S-VOL is often the same as that of data written to the P-VOL. The amount of differential data that can be managed per write command is limited by the difference between the number of incoming host write operations (inflow) and outgoing data transfers (outflow).
GUI
    Graphical user interface.

I

I/O
    Input/output.

initial copy
    An initial copy operation involves copying all data in the primary volume to the secondary volume prior to any update processing. Initial copy is performed when a volume pair is created.

initiator ports
    A port-type used for main control unit port of Fibre Remote Copy function.

IOPS
    I/O per second.

iSCSI

iSNS

L

LAN
    Local Area Network. A computer network that spans a relatively small area, such as a single building or group of buildings.

load
    In UNIX computing, the system load is a measure of the amount of work that a computer system is doing.

logical
    Describes a user’s view of the way data or systems are organized. The opposite of logical is physical, which refers to the real organization of a system. A logical description of a file is that it is a quantity of data collected together in one place. The file appears this way to users. Physically, the elements of the file could live in segments across a disk.
logical unit
See logical unit number.

**logical unit number (LUN)**
An address for an individual disk drive, and by extension, the disk device itself. Used in the SCSI protocol as a way to differentiate individual disk drives within a common SCSI target device, like a disk array. LUNs are normally not entire disk drives but virtual partitions (or volumes) of a RAID set.

**LU**
Logical unit.

**LUN**
See logical unit number.

**LUN Manager**
This storage feature is operated through Storage Navigator Modular 2 software and manages access paths among host and logical units for each port in your array.

**M**

**metadata**
In sophisticated data systems, the metadata -- the contextual information surrounding the data -- will also be very sophisticated, capable of answering many questions that help understand the data.

**microcode**
The lowest-level instructions directly controlling a microprocessor. Microcode is generally hardwired and cannot be modified. It is also referred to as firmware embedded in a storage array.

**Microsoft Cluster Server**
Microsoft Cluster Server is a clustering technology that supports clustering of two NT servers to provide a single fault-tolerant server.

**mount**
To mount a device or a system means to make a storage device available to a host or platform.

**mount point**
The location in your system where you mount your file systems or devices. For a volume that is attached to an empty folder on an NTFS
file system volume, the empty folder is a mount point. In some systems a mount point is simply a directory.

P

pair

Refers to two logical volumes that are associated with each other for data management purposes (e.g., replication, migration). A pair is usually composed of a primary or source volume and a secondary or target volume as defined by the user.

pair splitting

The operation that splits a pair. When a pair is “Paired,” all data written to the primary volume is also copied to the secondary volume. When the pair is “Split,” the primary volume continues being updated, but data in the secondary volume remains as it was at the time of the split, until the pair is re-synchronized.

pair status

Internal status assigned to a volume pair before or after pair operations. Pair status transitions occur when pair operations are performed or as a result of failures. Pair statuses are used to monitor copy operations and detect system failures.

paired volume

Two volumes that are paired in a disk array.

parity

The technique of checking whether data has been lost or corrupted when it’s transferred from one place to another, such as between storage units or between computers. It is an error detection scheme that uses an extra checking bit, called the parity bit, to allow the receiver to verify that the data is error free. Parity data in a RAID array is data stored on member disks that can be used for regenerating any user data that becomes inaccessible.

parity groups

RAID groups can contain single or multiple parity groups where the parity group acts as a partition of that container.

peer-to-peer remote copy (PPRC)

A hardware-based solution for mirroring logical volumes from a primary site (the application site) onto the volumes of a secondary site (the recovery site).
point-in-time logical copy
A logical copy or snapshot of a volume at a point in time. This enables a backup or mirroring application to run concurrently with the system.

pool volume
Used to store backup versions of files, archive copies of files, and files migrated from other storage.

primary or local site
The host computer where the primary volume of a remote copy pair (primary and secondary volume) resides. The term "primary site" is also used for host failover operations. In that case, the primary site is the host computer where the production applications are running, and the secondary site is where the backup applications run when the applications on the primary site fail, or where the primary site itself fails.

primary volume (P-VOL)
The storage volume in a volume pair. It is used as the source of a copy operation. In copy operations a copy source volume is called the P-VOL while the copy destination volume is called "S-VOL" (secondary volume).

P-VOL
See primary volume.

Q
quiesce
Used to describe pausing or altering the state of running processes on a computer, particularly those that might modify information stored on disk during a backup, in order to guarantee a consistent and usable backup. This generally requires flushing any outstanding writes.

R
RAID
Redundant Array of Independent Disks. A disk array in which part of the physical storage capacity is used to store redundant information about user data stored on the remainder of the storage capacity. The redundant information enables regeneration of user data in the event that one of the array's member disks or the access path to it fails.

Recovery Point Objective (RPO)
After a recovery operation, the RPO is the maximum desired time period, prior to a disaster, in which changes to data may be lost. This
measure determines up to what point in time data should be recovered. Data changes preceding the disaster are preserved by recovery.

**Recovery Time Objective (RTO)**

The maximum desired time period allowed to bring one or more applications, and associated data back to a correct operational state. It defines the time frame within which specific business operations or data must be restored to avoid any business disruption.

**remote or target site**

Maintains mirrored data from the primary site.

**remote path**

A route connecting identical ports on the local array and the remote array. Two remote paths must be set up for each array (one path for each of the two controllers built in the array).

**remote volume**

In TrueCopy operations, the remote volume (R-VOL) is a volume located in a different array from the primary host array.

**resynchronization**

Refers to the data copy operations performed between two volumes in a pair to bring the volumes back into synchronization. The volumes in a pair are synchronized when the data on the primary and secondary volumes is identical.

**RPO**

See Recovery Point Objective.

**RTO**

See Recovery Time Objective.

**S**

**SAS**

Serial Attached SCSI. An evolution of parallel SCSI into a point-to-point serial peripheral interface in which controllers are linked directly to disk drives. SAS delivers improved performance over traditional SCSI because SAS enables up to 128 devices of different sizes and types to be connected simultaneously.

**SATA**

Serial ATA is a computer bus technology primarily designed for the transfer of data to and from hard disks and optical drives. SATA is the
evolution of the legacy Advanced Technology Attachment (ATA) interface from a parallel bus to serial connection architecture.

**secondary volume (S VOL)**
A replica of the primary volume (P-VOL) at the time of a backup and is kept on a standby array. Recurring differential data updates are performed to keep the data in the S-VOL consistent with data in the P-VOL.

**SMPL**
Simplex.

**snapshot**
A term used to denote a copy of the data and data-file organization on a node in a disk file system. A snapshot is a replica of the data as it existed at a particular point in time.

**SNM2**
See Storage Navigator Modular 2.

**SSD**
Solid State Disk (drive). A data storage device that uses solid-state memory to store persistent data. An SSD emulates a hard disk drive interface, thus easily replacing it in most applications.

**Storage Navigator Modular 2**
A multi-featured scalable storage management application that is used to configure and manage the storage functions of Hitachi arrays. Also referred to as “Navigator 2.”

**suspended status**
Occurs when the update operation is suspended while maintaining the pair status. During suspended status, the differential data control for the updated data is performed in the primary volume.

**S-VOL**
See secondary volume.

**S-VOL determination**
Independent of update operations, S-VOL determination replicates the S-VOL on the remote array. This process occurs at the end of each update cycle and a pre-determined copy of S-VOL data, consistent with P-VOL data, is maintained on the remote site at all times.
**T**

**target copy**

A file, device, or any type of location to which data is moved or copied.

**TrueCopy**

Refers to the TrueCopy remote replication.

**V**

**virtual volume (V-VOL)**

In Copy-on-Write, a secondary volume in which a view of the primary volume (P-VOL) is maintained as it existed at the time of the last snapshot. The V-VOL contains no data but is composed of pointers to data in the P-VOL and the data pool. The V-VOL appears as a full volume copy to any secondary host.

**volume**

A disk array object that most closely resembles a physical disk from the operating environment's viewpoint. The basic unit of storage as seen from the host.

**volume copy**

Copies all data from the P-VOL to the S-VOL.

**volume pair**

Formed by pairing two logical data volumes. It typically consists of one primary volume (P-VOL) on the local array and one secondary volume (S-VOL) on the remote arrays.

**V-VOL**

See virtual volume.

**V-VOLTL**

Virtual Volume Tape Library.

**W**

**WMS**

Workgroup Modular Storage.

**write order guarantee**

Ensures that data is updated in an S-VOL, in the same order that it is updated in the P-VOL, particularly when there are multiple write
operations in one update cycle. This feature is critical to maintain data consistency in the remote S-VOL and is implemented by inserting sequence numbers in each update record. Update records are then sorted in the cache within the remote system, to assure write sequencing.

**write workload**

The amount of data written to a volume over a specified period of time.
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