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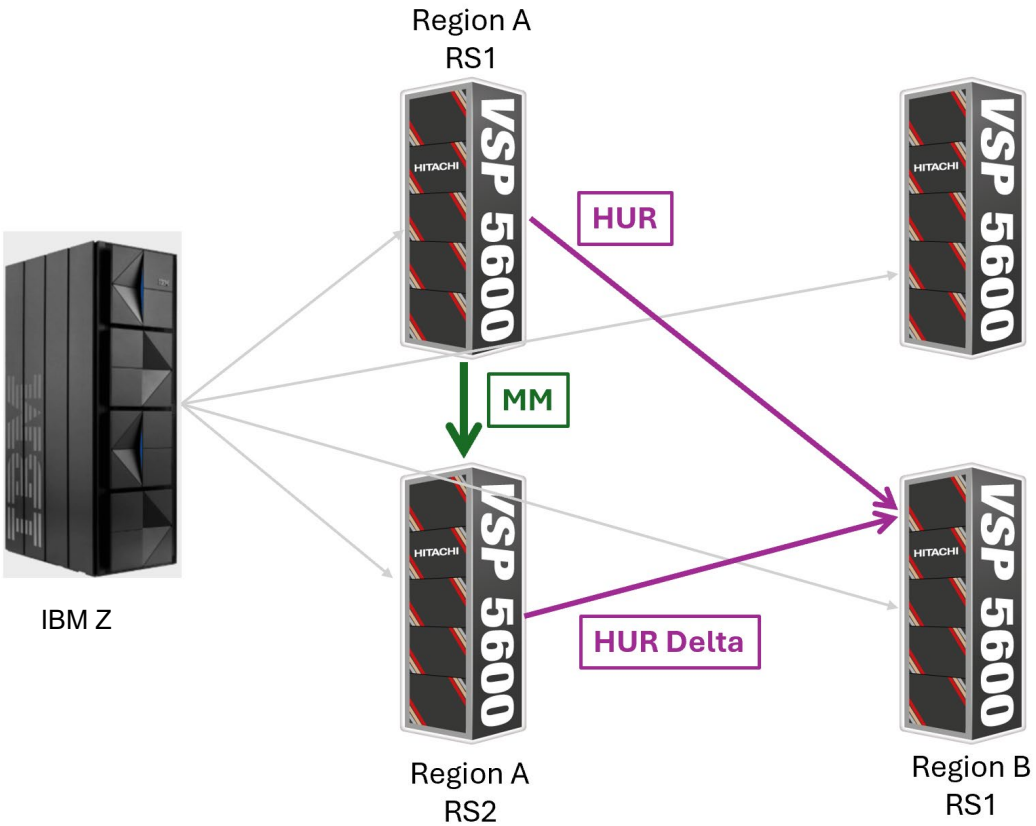
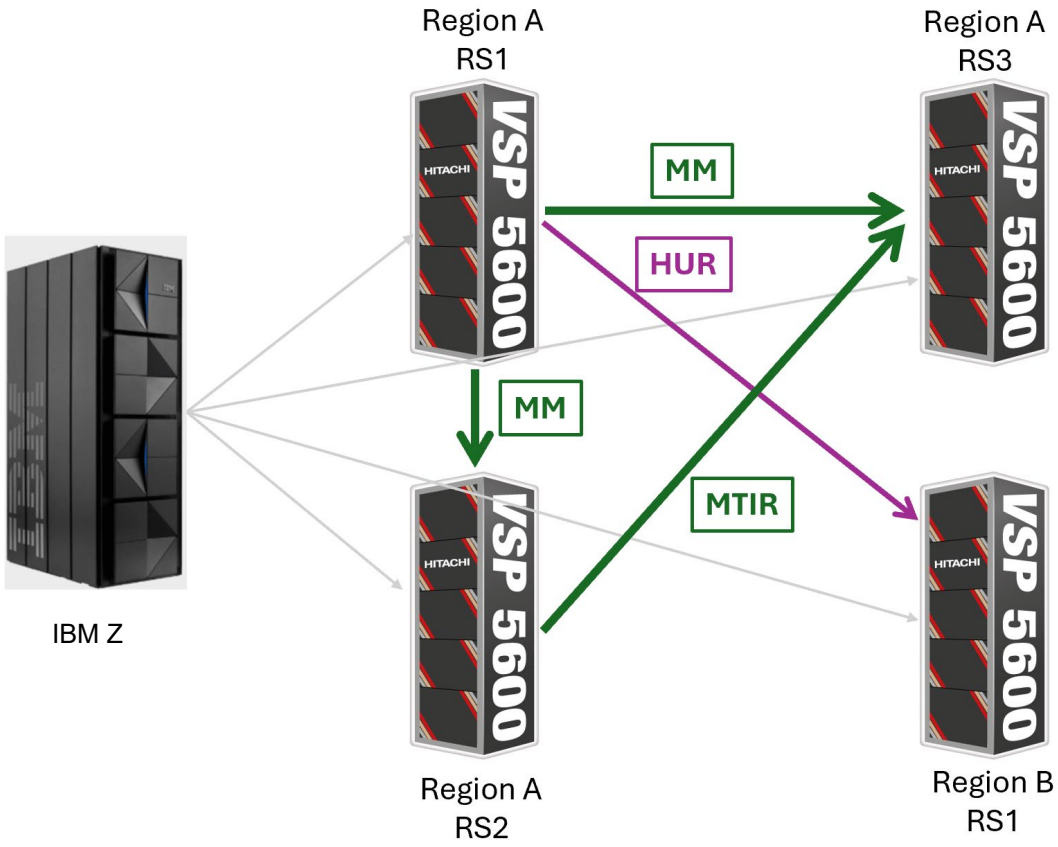
Report of Successful Completion of Qualification Testing

International Business Machines Corporation and Hitachi Vantara, Ltd. have successfully completed compatibility and interoperability testing Hitachi Virtual Storage Platform 5600™ at code level 90-09-26-00/70 in the following phases:

- Phase 1a – 3 Data Center configuration where GDPS® Metro manages Metro Mirror (MM) across RS1 & RS2 in Region A and BCM manages Hitachi Universal Replicator (HUR) across Region A & Region B



- Phase 1b – 4 Data Center configuration with GDPS Metro Dual Leg manages Multi-target Metro Mirror (MTMM) across RS1 & RS2 and RS1 & RS3 in Region A and BCM manages HUR across Region A & Region B



IBM and Hitachi hereby confirm that testing for the support of FICON® and FCP connectivity of the following has been successfully completed:

CPU	IBM z15® Driver level:41 Bundle level: S84a
	IBM z16® Driver level:51 Bundle level: S32
OS&GDPS®	z/OS® V3.1
	GDPS Metro V4.R7.M0
Functions	GDPS Metro HyperSwap® Manager • Freeze/run • Planned HyperSwap • Unplanned HyperSwap • HyperSwap Failover/Failback • Soft Fence
	GDPS Metro Single Leg (MM) & Dual Leg (MTMM) • Freeze/run • Planned HyperSwap • Unplanned HyperSwap • HyperSwap Failover/Failback • Soft Fence
Combined Functions	3 Data Center configuration with GDPS Metro (single leg) & HUR with “delta resync” controlled by BCM • Regression test • RS1 & RS2 in Region A and RS1 in Region B maintenance • RS1 & RS2 in Region A and RS1 in Region B failure • Link failure (MM & HUR)
	4 Data Center configuration with GDPS Metro (dual leg) & HUR with “delta resync” controlled by BCM • Regression test • MTIR • RS1, RS2, & RS3 in Region A and RS1 in Region B maintenance • RS1, RS2, & RS3 failure in Region A and RS1 in Region B Failure • Link failure (MM & HUR)
Storage Devices	Hitachi VSP 5600 • MM volumes were assigned to Hitachi Dynamic Provisioning pool

More detailed testing results are available from IBM or Hitachi on request.

No GDPS Metro FlashCopy® functions were tested, Additionally, no GDPS Metro priced features were tested (including z/OS Proxy, LCP Manager, KVM Proxy, and SSC Proxy) except the Dual Leg feature.

Limitations:
The following considerations and limitations apply to the tested configurations:

- The following features are not supported at the testing time (GDPS Metro):
  - Global Copy (aka PPRC XD) mode copy processing.
  - GDPS Health Check GDPS_CHECK_SPOF indicates a false failure for the MM links host adapters as being a single point of failure.
  - While Multi-target Metro Mirror (MTMM) is supported, Multi-Target Incremental Resynch (MTIR) is taking longer in certain conditions than what we observed with other disk vendors. Seek Hitachi advisory to calculate time needed for MTIR to be established and when MTIR resynch is being recycled.
  - Open LUN management
  - Taking non-disruptive state saves of disk subsystem
  - LCP phase 0 and phase 1 not supported
  - Easy Tier® / Heat Map Transfer not supported

IBM does not make any representations or warranties of any kind regarding the Hitachi products and is not liable for such products or any claims made regarding such products. The fact that the listed Hitachi products passed the enumerated IBM tests does not imply that the products will operate properly in any particular customer environment.

Hitachi retains sole responsibility for its products, the performance of such products and all claims relating to such products, including without limitation its products' compliance to product specifications, safety requirements, regulatory agencies requirements and industry standards.

David B Petersen
IBM Distinguished Engineer
IBM Z, IBM Infrastructure
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Attachment A -- Test Matrix

GDPS Metro (single leg)

Test Case Suite	Successfully Completed	Test Case Suite Description
• **Initial Tests**	✔	Basic remote copy operations using panels Basic Freeze tests (GO/STOP/COND)
• **Planned Actions**	✔	Remote copy operations using scripts (START/STOP SECONDARY, HyperSwap (Resync & Suspend), etc.) Simulate Site maintenance (RS1 & RS2)
• **Unplanned Actions**	✔	GDPS reacts to a failure, depending on the FREEZE option (GO / STOP / COND / SWAP&GO / SWAP & STOP) Failures were generated by MM links unplug, Chpid unplug, DASD control Unit power off and elongated I/O response times
• **Disruptive Testing (aka Config Testing)**	✔	GDPS reacts to a failure, depending on the FREEZE policy. Failures were generated by Control Unit Emergency power off and control unit internal failures
• **HyperSwap Stress test**	✔	Run a planned HyperSwap, with the application systems and the controlling system having CPU contention
• **Miscellaneous**	✔	HyperSwap extension (checking of secondary MM status – failure, Concurrent Copy, etc.) Reserve transferred PPRCSum

3 Data Center configuration: GDPS Metro Single Leg (SL) and HUR controlled by BCM

Test Case Suite	Successfully Completed	Test Case Suite Description
• **Regression test**	✔	Basic GDPS Metro testing to verify there are no unexpected impacts due to HUR.
• **RS1 in Region A maintenance**	✔	Simulation of a scheduled disruptive maintenance of RS1 by issuing a HyperSwap to RS2 in Region A without stopping application systems, and initiating delta-resync to maintain small D/R RPO. After this procedure, RS2 and RS1's roles are reversed, and the same procedure can be used again to restore service back to the original RS1 after the maintenance completes.
• **RS2 in Region A maintenance**	✔	Simulation of scheduled disruptive disk maintenance in RS2 by suspending the MM replica from RS1 to RS2 disks in Region A. There was no impact on the application systems running on RS1 disks in Region A and on the HUR replica from RS1 in Region A to RS1 disks in region B.

Attachment A -- Test Matrix

Test Case Suite	Successfully Completed	Test Case Suite Description
• **RS1 in Region B maintenance**	✔	Simulation of scheduled disruptive disk maintenance in RS1 in Region B by suspending the HUR replica from RS1 in Region A to RS1 in Region B disks (Suspend Flush). There was no impact on the application systems running on RS1 disks and on the MM replica from RS1 to RS2 disks in Region A.
• **RS1 in Region A failure**	✔	An unplanned HyperSwap moves the MM primary's from RS1 to RS2 in Region A, application systems continue running; delta resync the HUR from RS2 in region A to RS1 in Region B disks. The RS1 Maintenance procedure can be used in reverse to restore service to RS1 in Region A without stopping application systems.
• **RS2 in Region A failure**	✔	The MM replica from RS1 to RS2 in Region A disks is suspended. There was no impact on the application systems running on RS1 disks in Region A and on the HUR replica from RS1 in Region A to RS1 in Region B disks.
• **RS1 in Region B failure**	✔	The HUR continues writing to the RS1 in Region B journal until it fills up, then eventually goes in track mode. There was no impact on the application systems running on RS1 disks in Region A disks and on the MM replica from RS1 to RS2 in Region A disks.
• **Links failure**	✔	RS1 to RS2 in Region A, RS1 in Region A to RS1 in Region B, and RS2 in Region A to RS1 in Region B link failure testing. There was no impact on the application systems running on RS1 disks in Region A, MM or HUR replica. Eventually the links suspend and the data is incrementally resynchronized when the links operational.

4 Data Center configuration: GDPS Metro Dual Leg (DL) and HUR controlled by BCM

Test Case Suite	Successfully Completed	Test Case Suite Description
• **Regression test**	✔	Basic GDPS Metro testing to verify there are no unexpected impacts due to HUR.
• **RS1 in Region A maintenance**	✔	Simulation of a scheduled disruptive maintenance of RS1 by issuing a HyperSwap to RS2 in Region A without stopping application systems, and initiating delta-resync to maintain small D/R RPO. After this procedure, RS2 and RS1's roles are reversed, and the same procedure can be used again to restore service back to the original RS1 after the maintenance completes.
• **RS2 in Region A maintenance**	✔	Simulation of scheduled disruptive disk maintenance in RS2 by suspending the MM replica from RS1 to RS2 disks in Region A.

Attachment A -- Test Matrix

Test Case Suite	Successfully Completed	Test Case Suite Description
		There was no impact on the application systems running on RS1 disks in Region A and on the HUR replica from RS1 in Region A to RS1 disks in region B.
• **RS3 in Region A maintenance**	✔	Simulation of scheduled disruptive disk maintenance in RS3 by suspending the MM replica from RS1 to RS3 disks in Region A. There was no impact on the application systems running on RS1 disks in Region A and on the HUR replica from RS1 in Region A to RS1 disks in region B.
• **RS1 in Region B maintenance**	✔	Simulation of scheduled disruptive disk maintenance in RS1 in Region B by suspending the HUR replica from RS1 in Region A to RS1 in Region B disks (Suspend Flush). There was no impact on the application systems running on RS1 disks and on the MM replica from RS1 to RS2 disks in Region A.
• **RS1 in Region A failure**	✔	An unplanned HyperSwap moves the MM primary's from RS1 to RS2 in Region A, application systems continue running; delta resync the HUR from RS2 in region A to RS1 in Region B disks. The RS1 Maintenance procedure can be used in reverse to restore service to RS1 in Region A without stopping application systems.
• **RS2 in Region A failure**	✔	The MM replica from RS1 to RS2 in Region A disks is suspended. There was no impact on the application systems running on RS1 disks in Region A and on the HUR replica from RS1 in Region A to RS1 in Region B disks.
• **RS3 in Region A failure**	✔	The MM replica from RS1 to RS3 in Region A disks is suspended. There was no impact on the application systems running on RS1 disks in Region A and on the HUR replica from RS1 in Region A to RS1 in Region B disks.
• **RS1 in Region B failure**	✔	The HUR continues writing to the RS1 in Region B journal until it fills up, then eventually goes in track mode. There was no impact on the application systems running on RS1 disks in Region A disks and on the MM replica from RS1 to RS2 in Region A disks.
• **Links failure**	✔	RS1 to RS2 in Region A, RS1 to RS3 in Region A, RS1 in Region A to RS1 in Region B, and RS2 in Region A to RS1 in Region B link failure testing. There was no impact on the application systems running on RS1 disks in Region A, MM or HUR replica. Eventually the links suspend and the data is incrementally resynchronized when the links operational.
• **Miscellaneous**	✔	HyperSwap extension (checking of secondary MM status – failure, Concurrent Copy, etc.) Reserve transferred PPRCSum