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  Wed, August 11, 2021 @ 10am
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  Wed, August 25, 2021 @ 10am
- **Configuring Drives with CCW**
  Wed, September 15, 2021 @ 10am
- **ControlFlash Plus**
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Our Guest Panelists

Mike Masterson
Automation Specialist
The Reynolds Company

David Nute
Automation Specialist
The Reynolds Company

ControlLogix Redundancy Recommended Topologies & Guidelines

v20201009

Overview

- The purpose of the following slides is to help provide guidance to users that are designing high availability **Ethernet** networks that include 5560 / 5570 / 5580 ControlLogix redundancy.[1]

- The recommended high availability topologies provided in this document are either single-fault tolerant (e.g. DLR) or multiple-fault tolerant[2] (e.g. PRP) and have been tested in a lab environment.
- While other topologies and configurations may work, not following the guidance provided in this document will increase risk.
- Please refer to the notes section of each of the slides for additional notes, detailed guidance, and for sources and references.

Links – Literature Library

New! High Availability Systems Reference Manual, publication HIGHAV-RM002

New! ControlLogix 5580 Redundancy Controller User Manual, publication 1756-UM015 (focused on 5580)

- ControlLogix Redundancy User Manual, publication 1756-UM535 (focused on 5560/5570)
- Logix 5000 Controllers Design Considerations Reference Manual, publication 1756-RM094
- PlantPAx Selection Guide, publication PROCES-SG001
- EtherNet/IP Device Level Ring Application Technique, publication ENET-AT007
- Deploying Parallel Redundancy Protocol within a Converged Plantwide Ethernet Architecture, publication ENET-TD021
- FactoryTalk Linx Getting Results Guide, publication LNXENT-GR001
- Converged Plantwide Ethernet (CPwE) Design and Implementation Guide, publication ENET-TD001
- Deploying Device Level Ring within a Converged Plantwide Ethernet Architecture, publication ENET-TD015
- Deploying the Resilient Ethernet Protocol (REP) in a Converged Plantwide Ethernet System (CPwE) Design Guide, publication ENET-TD005

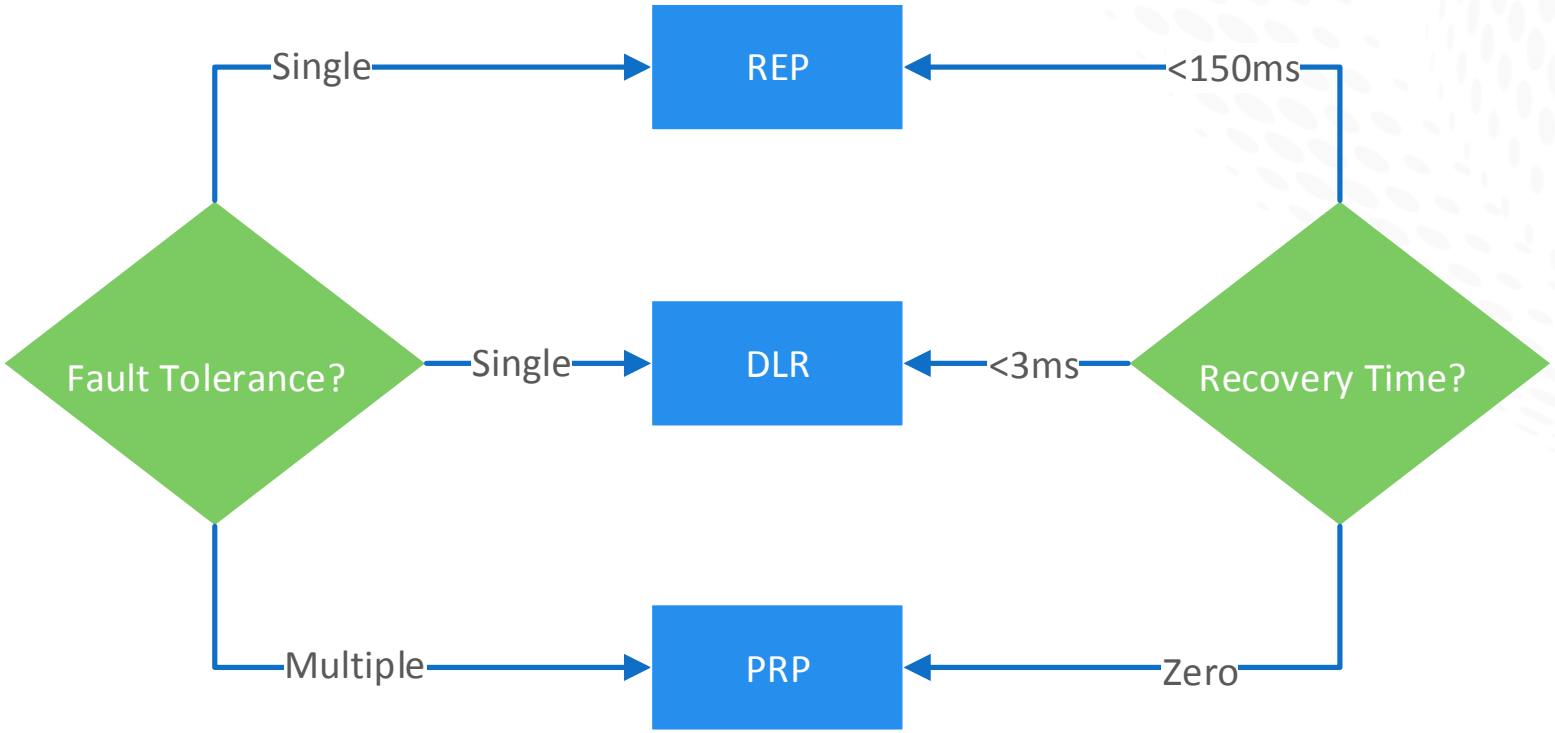
Links - Knowledgebase

- ControlLogix Redundancy Recommended Network Topologies
- ControlLogix Redundancy High Availability Ethernet System Testing
- ControlLogix Redundancy: Possible Cause of Switchover
- ControlLogix Redundancy System: the secondary chassis remains disqualified
- Optimizing a ControlLogix Redundancy System, Programming Guidelines and Case Study

Requirements → Design

Before designing a network that includes ControlLogix redundancy, you should always start with a set of documented requirements.

- Application requirements such as availability & performance drive the choice of resiliency technology and topologies[1].



Direct DLR Non-converged

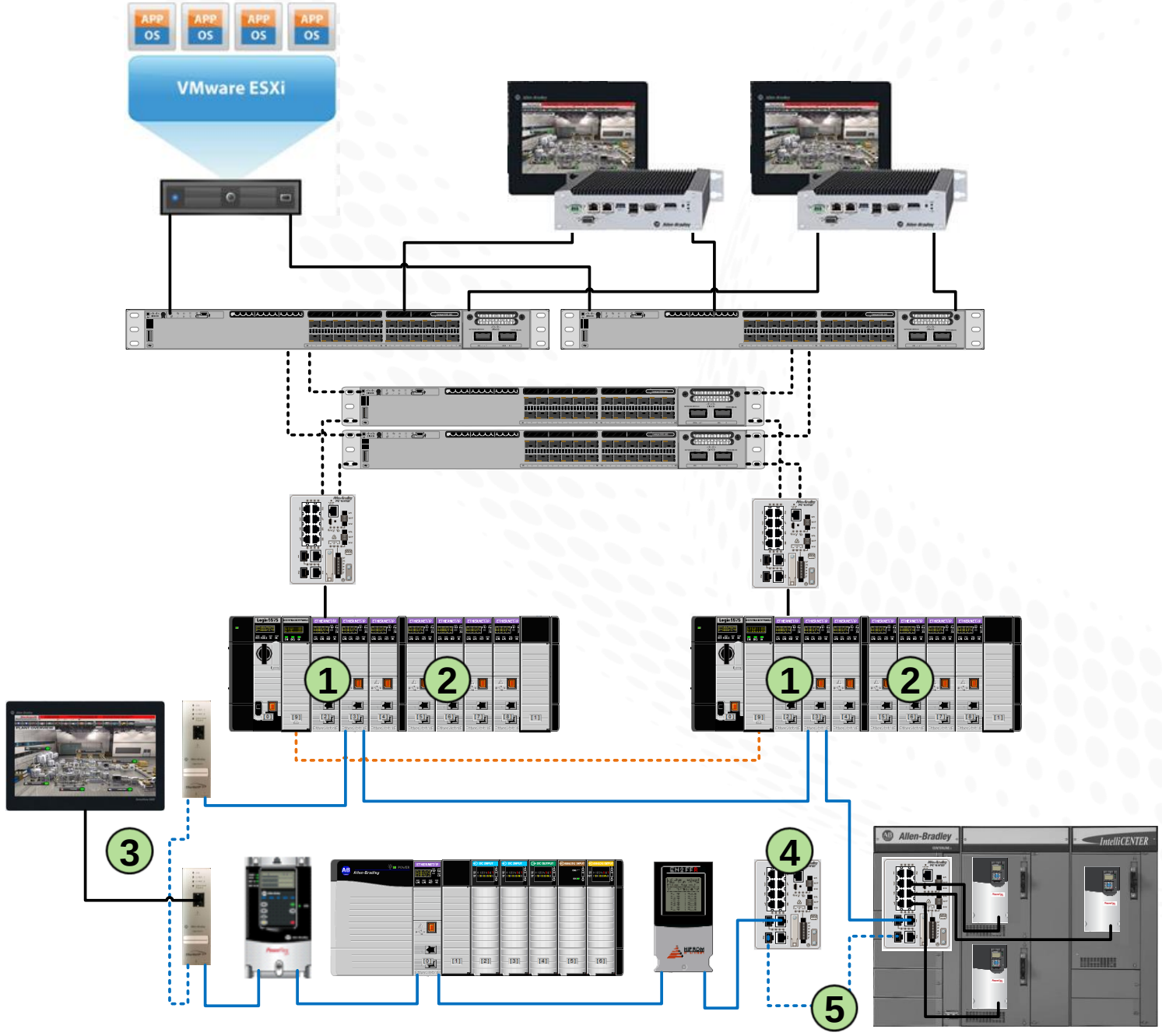
1. One Ethernet Module dedicated to upstream communications.

2. Up to six Ethernet Modules available for separate DLR I/O networks. 50 nodes max per DLR network, ∴ 50 nodes x 6 DLR networks = 300 DLR nodes possible. Please note that for switch-only rings other restrictions may apply.

3. 1783-ETAP*F modules allow for multimode fiber segments.

4. DLR capable Stratix switches can be included in the DLR ring, but they must not be connected to the upstream network.

5. DLR capable Stratix switches allow for multimode or single mode fiber segments.



Direct DLR Non-converged

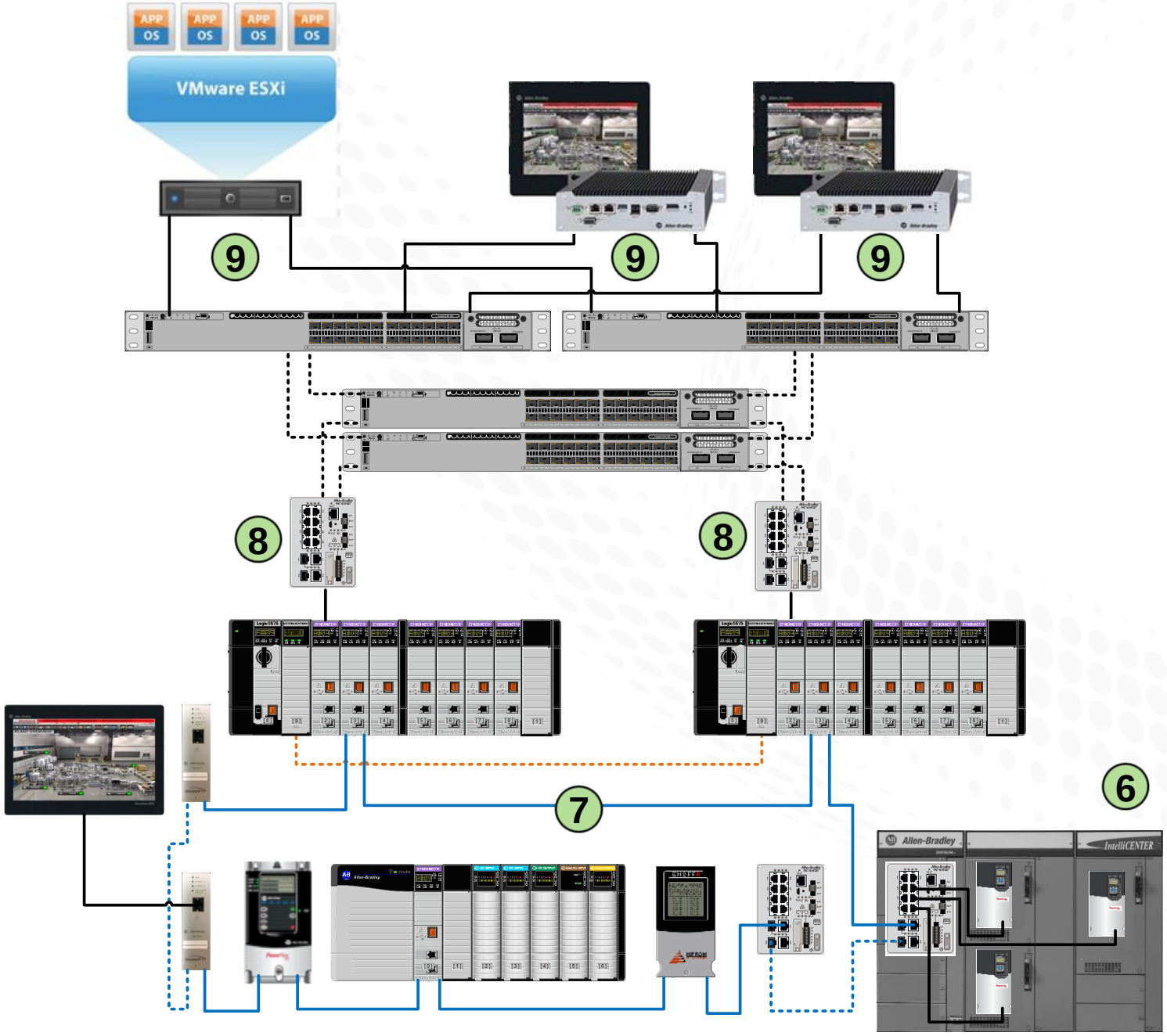
Continued…

6. Devices connected to non-DLR configured ports of a Stratix will be in a star topology, ∴ there exists single points of failure for those devices.

7. DLR I/O networks can be on the same or separate VLANs.

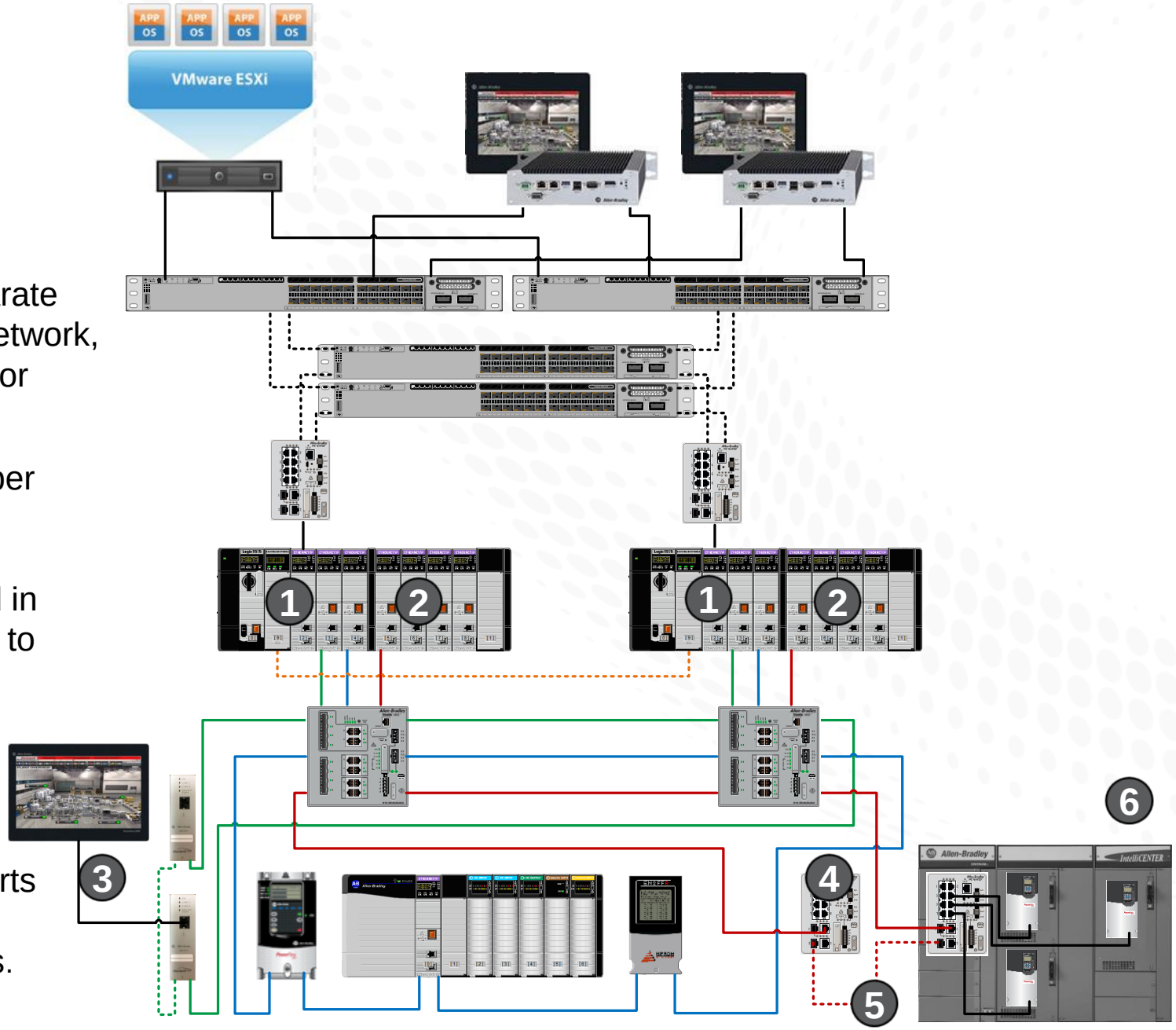
8. It is recommended that the PRI and SEC redundant controller racks connect to separate upstream switches. If the upstream switches are in a REP ring, please refer to the notes section of this slide.

9. NIC teaming on servers and clients for additional resiliency.



Indirect DLR Non-Converged

1. One Ethernet Module dedicated to upstream communications.
2. Up to six Ethernet Modules available for separate DLR I/O networks. 50 nodes max per DLR network, ∴ 300 DLR nodes possible. Please note that for switch-only rings other restrictions may apply.
3. 1783-ETAP*F modules allow for multimode fiber segments.
4. DLR capable Stratix switches can be included in the DLR ring, but they must not be connected to the upstream network.
5. DLR capable Stratix switches allow for multimode or single mode fiber segments.
6. Devices connected to non-DLR configured ports of a Stratix will be in a star topology, ∴ there exists single points of failure for those devices.



Indirect DLR Non-Converged

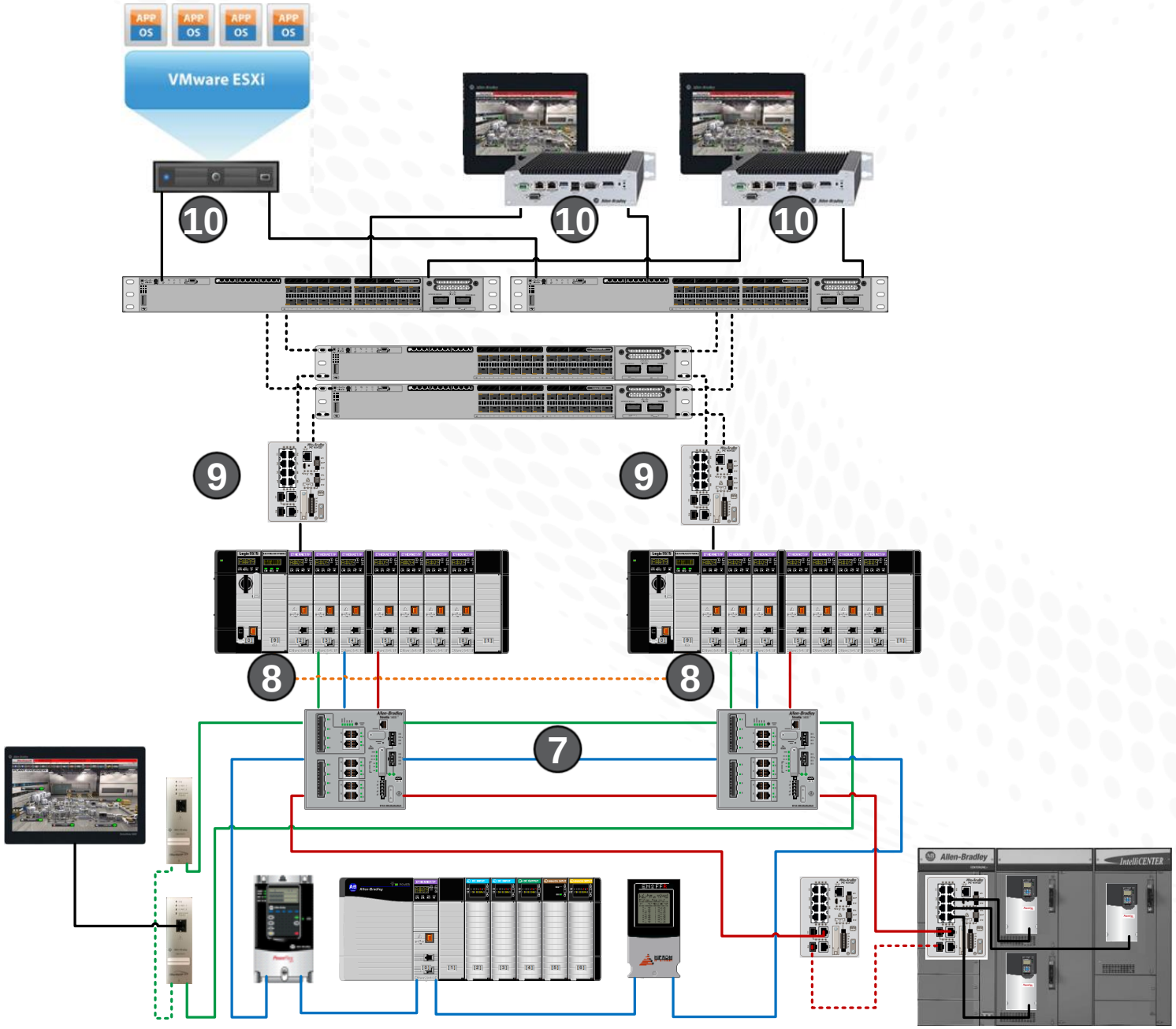
Continued…

7. DLR I/O networks must be on separate VLANs and all devices within the same ring must be at the same network speed.

8. No media converters or switches are allowed between an EN2* and DLR Switch. It MUST be direct link.

9. It is recommended that the PRI and SEC redundant controller racks connect to separate upstream switches. If the upstream switches are in a REP ring, please refer to the notes section of this slide.

10. NIC teaming on servers and clients for additional resiliency.



Direct DLR Converged

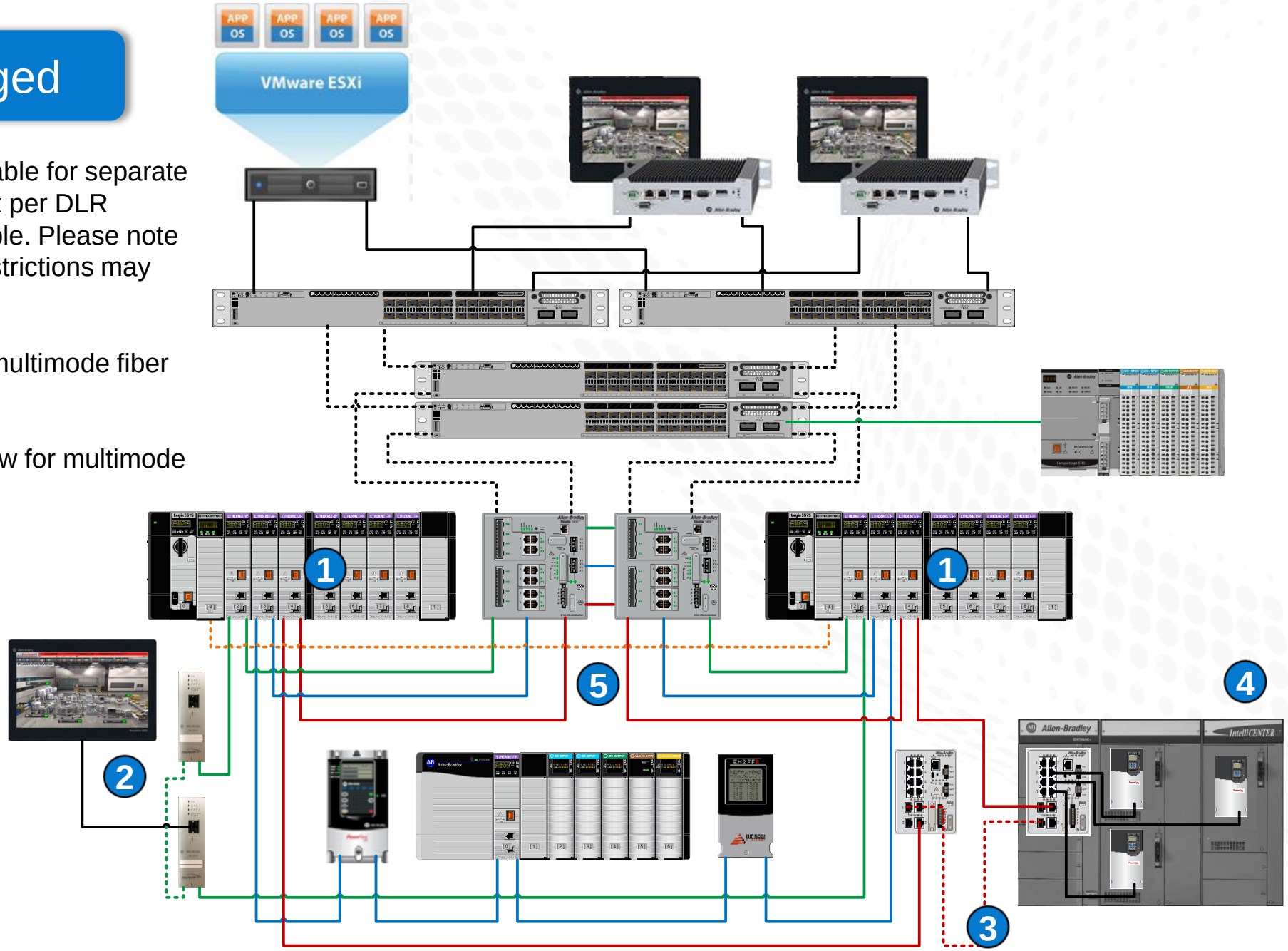
1. All seven Ethernet modules available for separate DLR I/O networks. 50 nodes max per DLR network, ∴ 350 DLR nodes possible. Please note that for switch-only rings other restrictions may apply.

2. 1783-ETAP*F modules allow for multimode fiber segments.

3. DLR capable Stratix switches allow for multimode or single mode fiber segments.

4. Devices connected to non-DLR configured ports of a Stratix will be in a star topology, ∴ there exists single points of failure for those devices.

5. DLR I/O networks can be on the same **or** separate VLANs and all devices within the same ring must be at the same network speed.



Direct DLR Converged

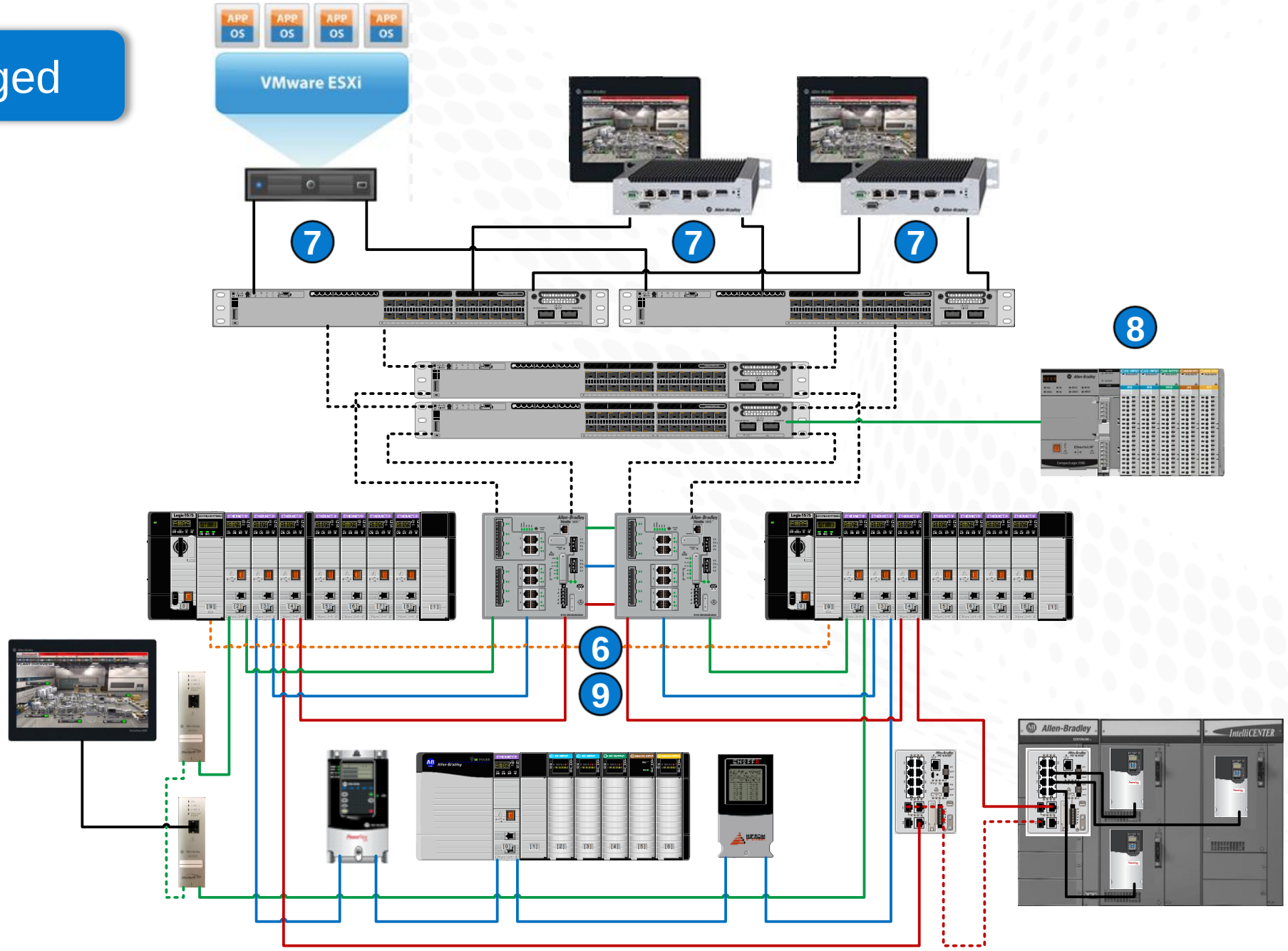
Continued…

6. The two Stratix switches used as DLR redundant gateways should be between the PRI and SEC redundant rack in each DLR I/O network. In addition, no other devices can be connected to these switches.

7. NIC teaming on servers and clients for additional resiliency.

8. When a DLR redundant gateway switchover event occurs, note that there is chance that traffic traversing the gateways will be interrupted during the gateway switchover and/or recovery phases.

9. Requires Stratix Firmware 15.2 (7)EA or higher due to anomaly in earlier versions.



PRP Non-Converged

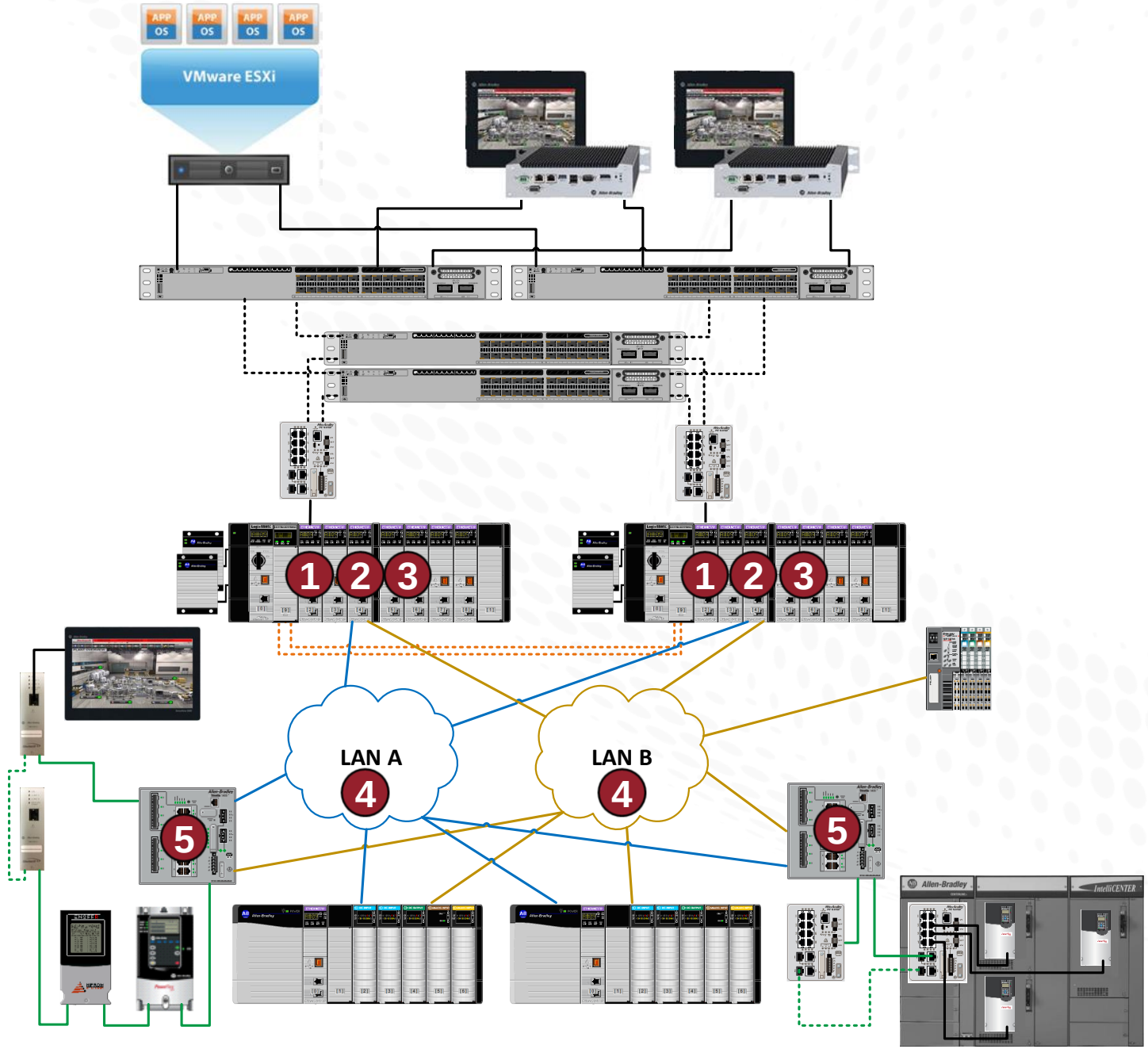
1. One Ethernet Module dedicated to upstream communications.

2. Connect the redundant Controller rack directly to the PRP network with PRP capable 1756-EN2TP modules.

3. Up to six other Ethernet Modules available for separate PRP or DLR networks. This drawing shows a single PRP network. Note: a pair of 1756-EN2TPs in the same chassis cannot be used as redundant adapters.

4. Infrastructure switches do NOT need PRP functionality built in; they only must support a baby jumbo frame size of 1506 bytes. It is recommended that all switches have unique IP addresses. LAN A and LAB B can have different topologies. See the notes section of this slide below regarding multi-fault tolerance guidelines.

5. A Redundancy Box (RedBox) can be used to connect non-PRP devices to the PRP networks.



PRP Non-Converged

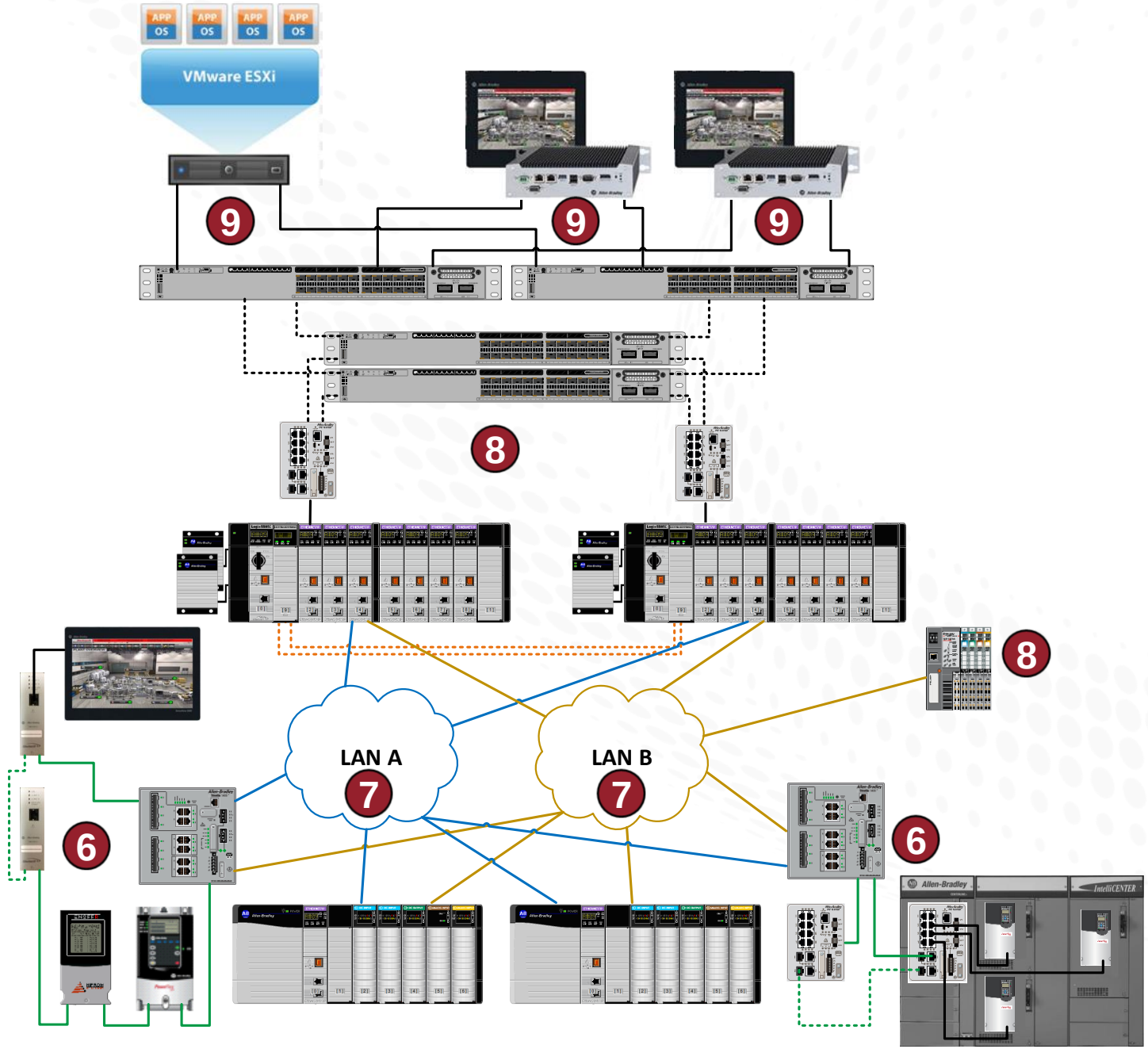
Continued…

6. By using a Stratix 5400 as a RedBox, you can configure as many as three DLR rings that can have redundancy through the RedBox.

7. Both PRP LANs must on the same subnet, same VLAN, and must be physically separate. VLAN and subnet should contain < 250 nodes to limit broadcasts.

8. Non-PRP devices can be added to either LAN A or LAB B, but not both. Only devices on that same LAN will be able to communicate with it.

9. NIC teaming on servers and clients for additional resiliency. Teamed NICs within the PRP network should only connect to Redboxes.



PRP Converged

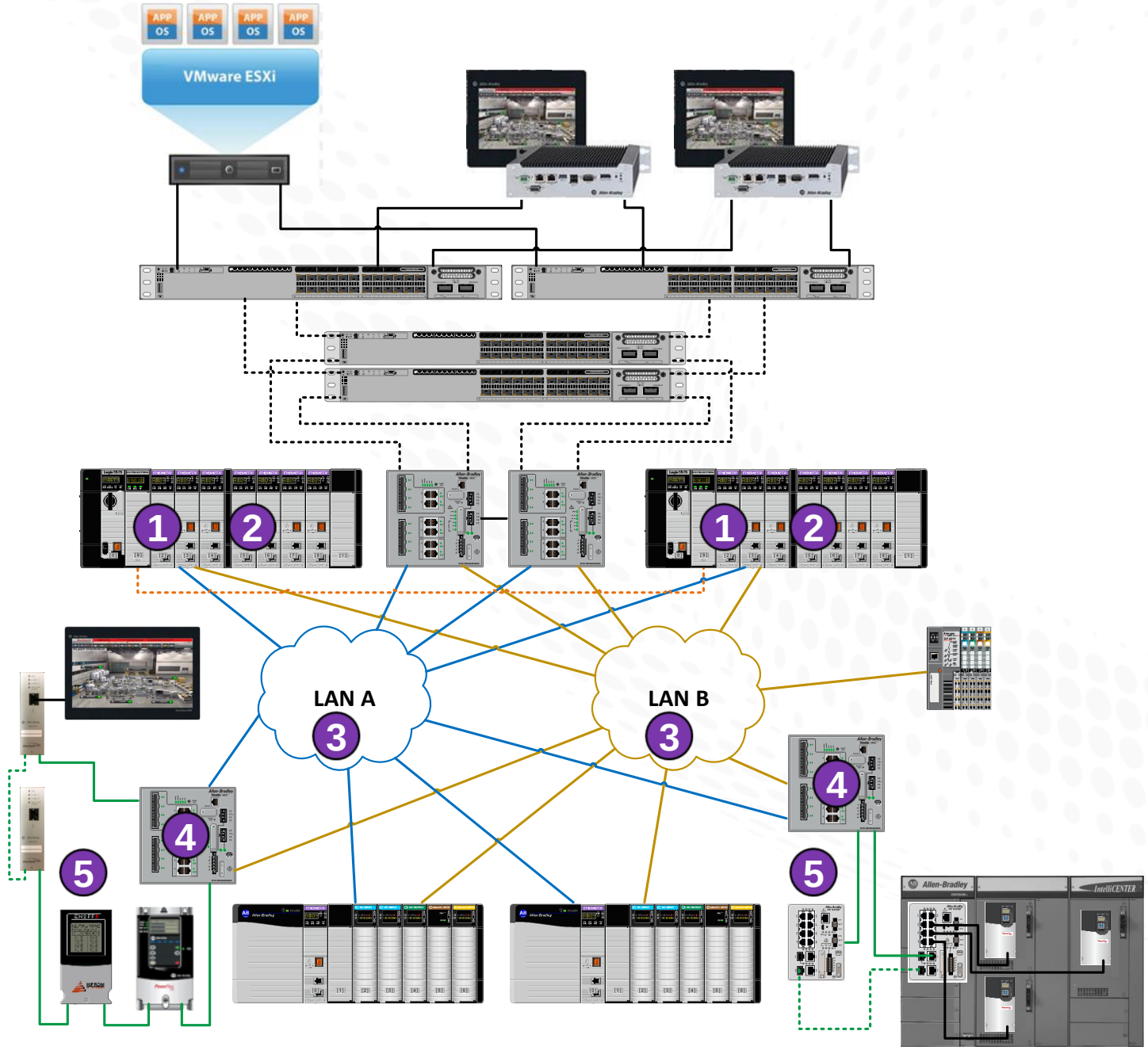
1. Connect the redundant Controller rack directly to the PRP network with PRP capable 1756-EN2TP modules.

2. Up to six Ethernet Modules available for separate PRP or DLR networks. This drawing shows a single PRP network. Note: a pair of 1756-EN2TPs in the same chassis cannot be used as redundant adapters.

3. Infrastructure switches do NOT need PRP functionality built in; they only must support a baby jumbo frame size of 1506 bytes. It is recommended that all switches have unique IP addresses. LAN A and LAB B can have different topologies. See the notes section of this slide below regarding multi-fault tolerance guidelines.

4. A Redundancy Box (RedBox) can be used to connect non-PRP devices to the PRP networks.

5. By using a Stratix 5400 as a RedBox, you can configure as many as three DLR rings that can have redundancy through the RedBox.



PRP Converged

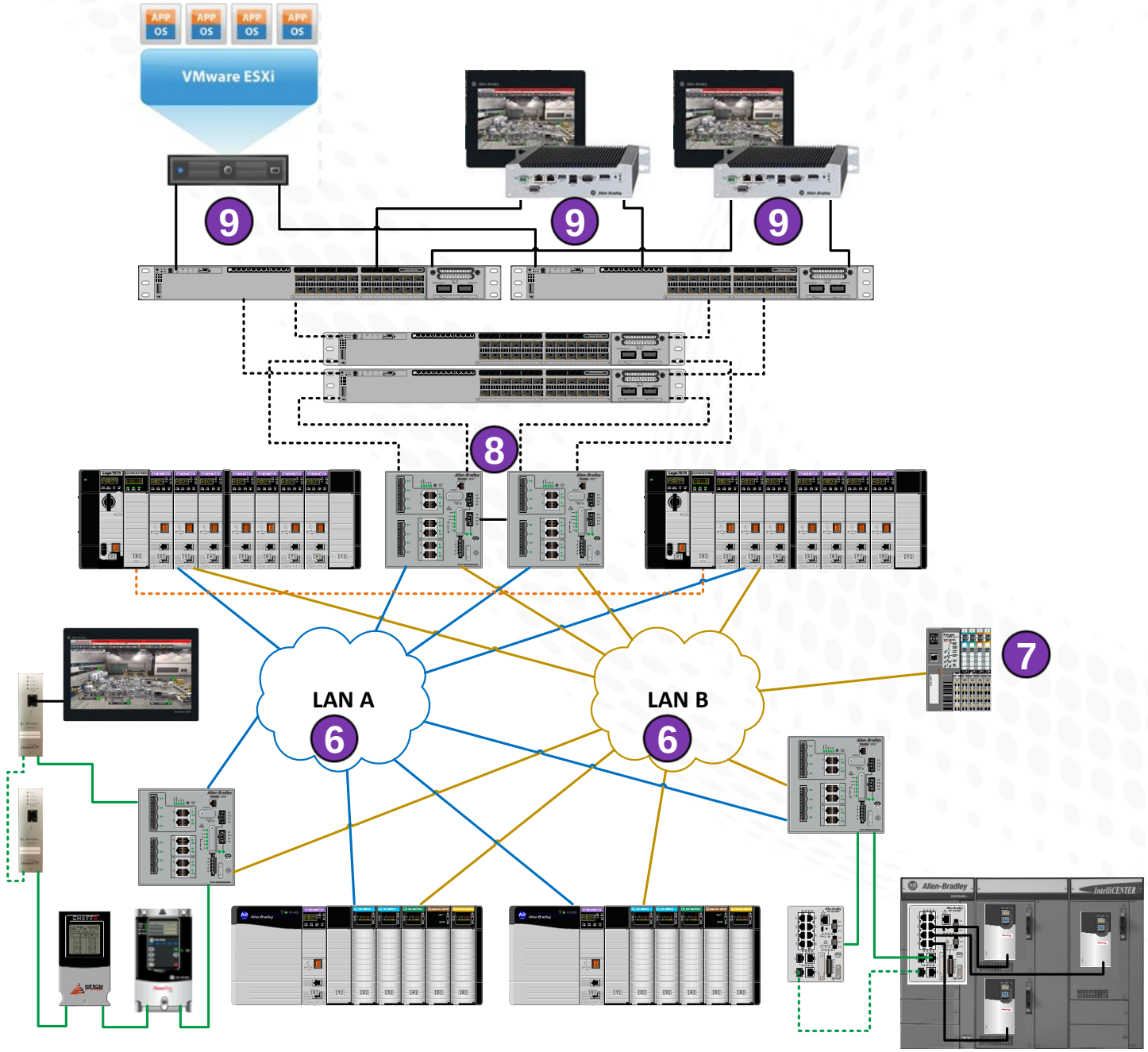
Continued…

6. Both PRP LANs must on the same subnet, same VLAN, and must be physically separate. VLAN and subnet should contain < 250 nodes to limit broadcasts.

7. Non-PRP devices can be added to either LAN A or LAB B, but not both. Only devices on that same LAN will be able to communicate with it.

8. Stratix 5400 RedBoxes can be used to connect PRP network to the supervisory network. Connections from Redboxes to infrastructure and between RedBoxes must be layer 3 routed connections. No additional layer 2 connections are allowed. Hot Standby Routing Protocol (HSRP) can be configured on redundant RedBoxes for Layer 3 redundancy in the PRP network.

9. NIC teaming on servers and clients for additional resiliency. Teamed NICs within the PRP network should only connect to Redboxes.



Other Notes & More Detailed Information

Controller Guidance – 5560 / 5570 / 5580 Redundancy

5580 Redundancy

- Place no more than one ControlLogix 5580 controller in each redundant chassis.
- When redundancy is enabled, the embedded Ethernet port is disabled; you cannot use it.

For more information, see:

ControlLogix 5580 Redundancy Controller User Manual,

publication 1756-UM015

5560 / 5570 Redundancy

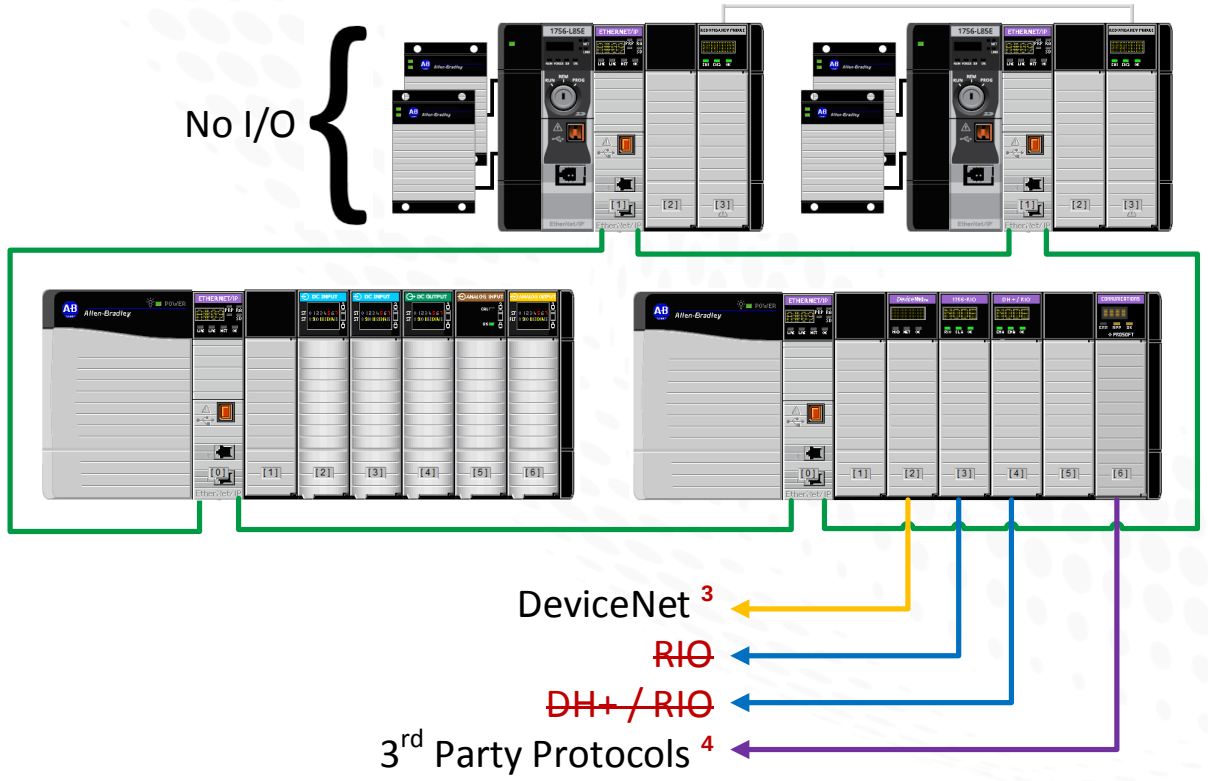
- Non-PlantPAx ControlLogix 5570 redundancy applications support as many as two controllers in each redundant chassis
- PlantPAx guidelines recommend only one controller per ControlLogix redundancy chassis

For more information, see:
ControlLogix Redundancy User Manual,
publication 1756-UM535

Important! Review the Redundancy User Manuals for a complete list of differences.

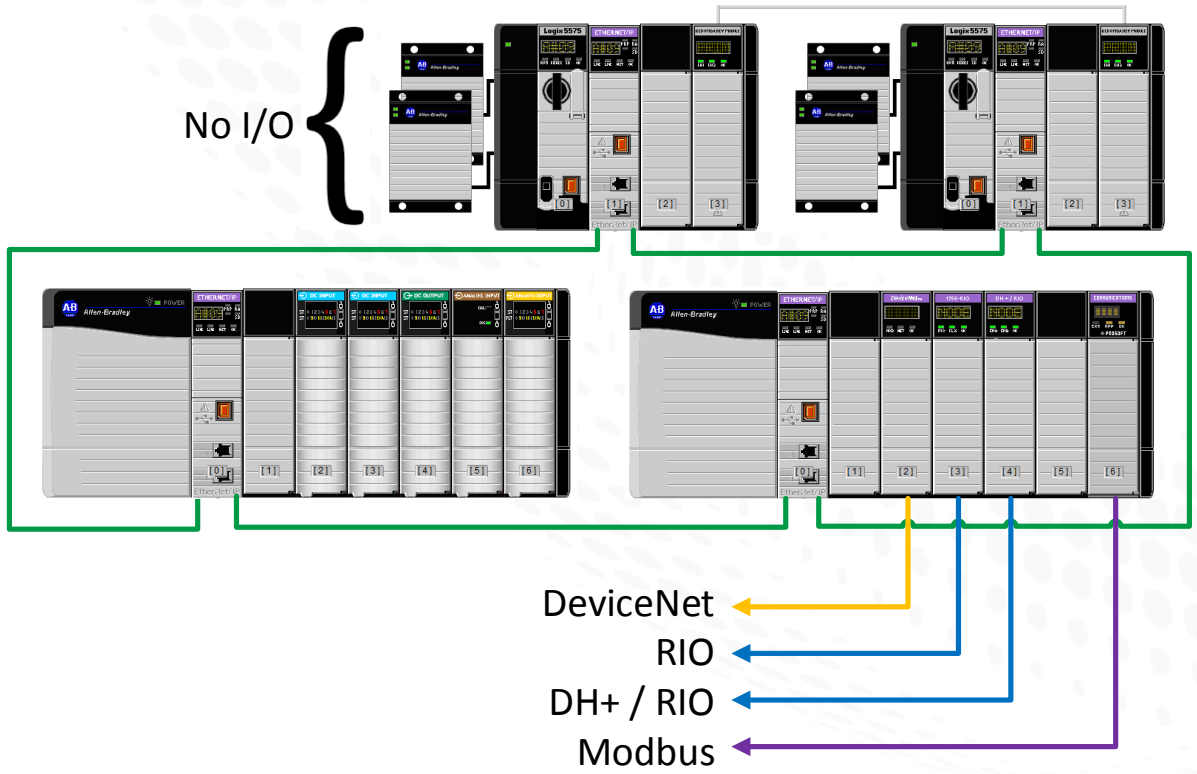
General Guidance – I/O & Legacy Networks for 5580 Redundancy

- **Do not** place I/O in a redundant chassis.
- I/O can be connected to the redundant chassis via EtherNet/IP, *without bridging*.[1]
- When implementing ControlLogix redundancy, all EtherNet/IP I/O and ***consumed*** tag connections **must** be multicast connections.
- ControlLogix 5580 redundancy does not support the following [2]:
  - ControlNet networks
  - Remote I/O (RIO) networks
  - DH+ networks
  - DeviceNet(1) network [3]
  - Explicit messaging to legacy PLC-2, PLC-5, or SLC controllers



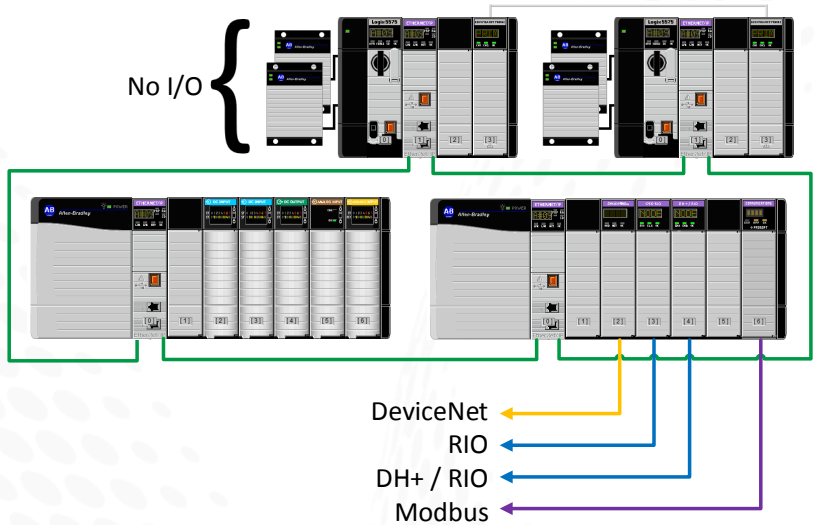
General Guidance – I/O Networks for 5560 / 5570 Redundancy

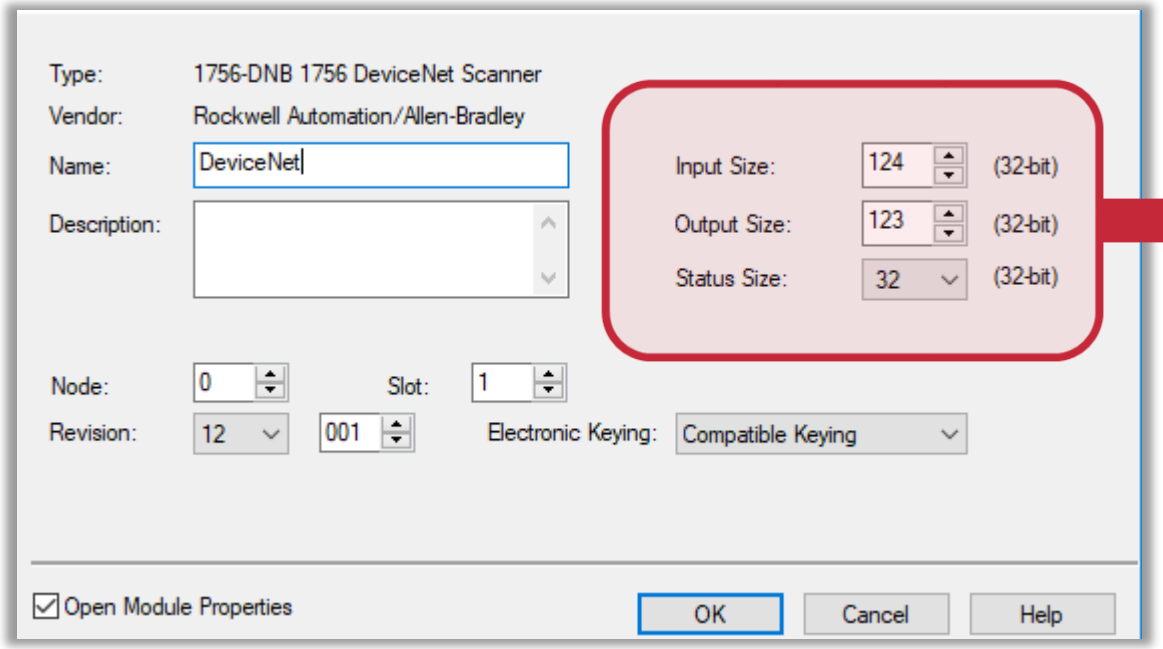
- **Do not** place I/O in a redundant chassis.
- I/O can be connected to the redundant chassis via EtherNet/IP or ControlNet, *without bridging*.[1]
- When implementing ControlLogix redundancy, all EtherNet/IP I/O and ***consumed*** tag connections **must** be multicast connections.
- For 5560 / 5570 You can bridge to these I/O networks via a remote chassis:
  - DeviceNet
  - Universal remote I/O
  - Data Highway Plus
  - 3rd Party

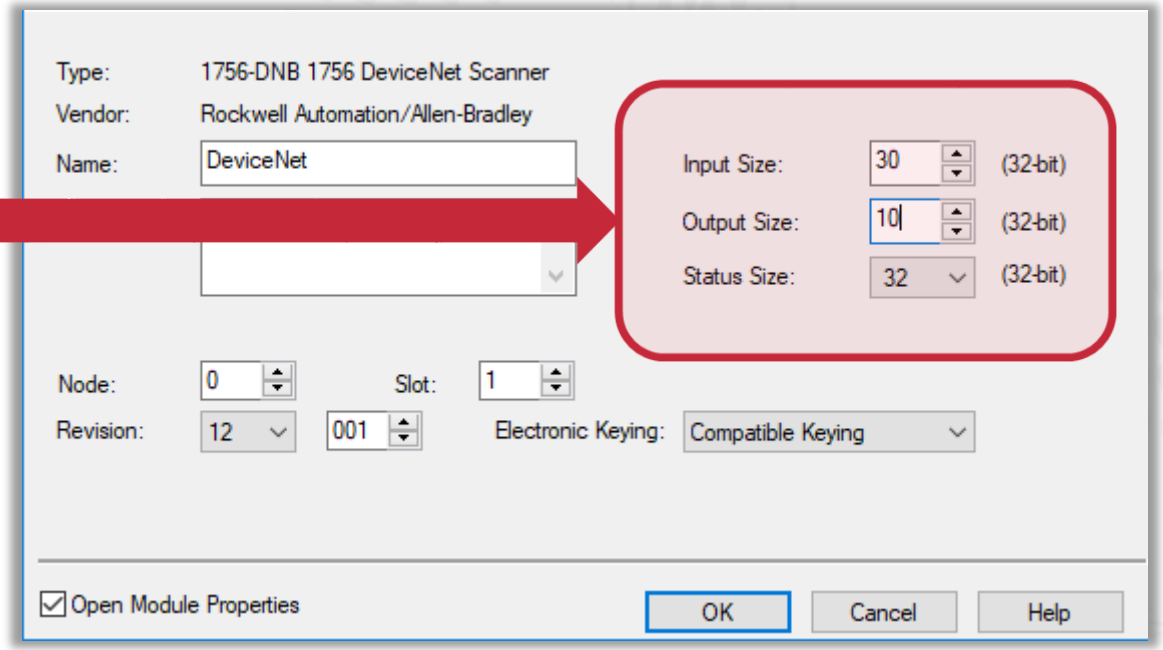


General Guidance – I/O Networks

- As a best practice, adjust the data table size for each network adapter used to bridge to other networks.



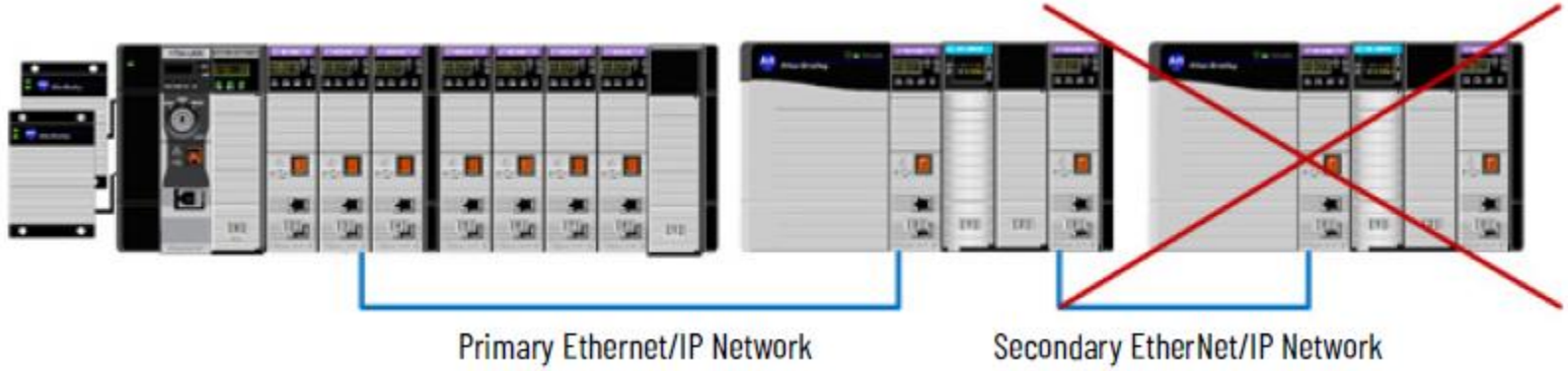




General Guidance – Unsupported Bridged I/O Configurations

- Do not use bridged Ethernet I/O racks.[1]

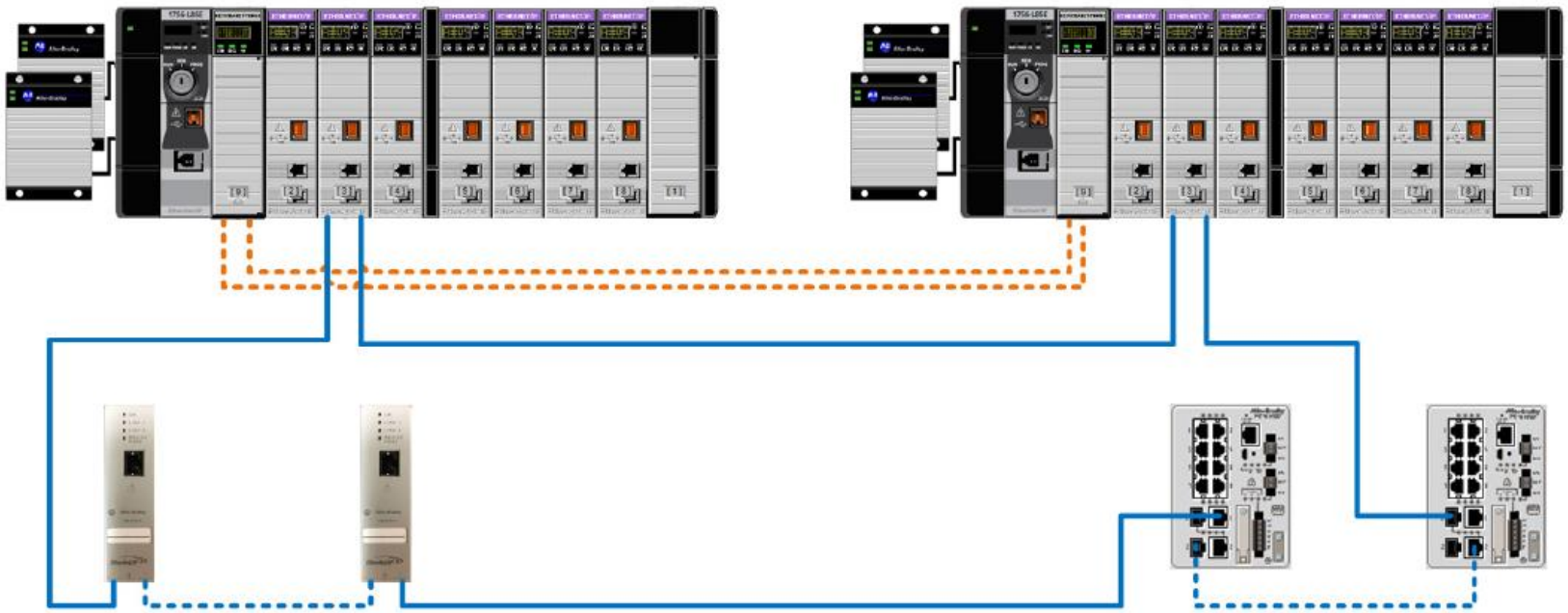
- See Knowledgebase article Logix Platform: Unsupported Bridged I/O Configurations for additional information.



Fiber Segments

- 1783-ETAP*F modules allow for **multimode** fiber segments.

Note that each ETAP counts as a DLR node[1]

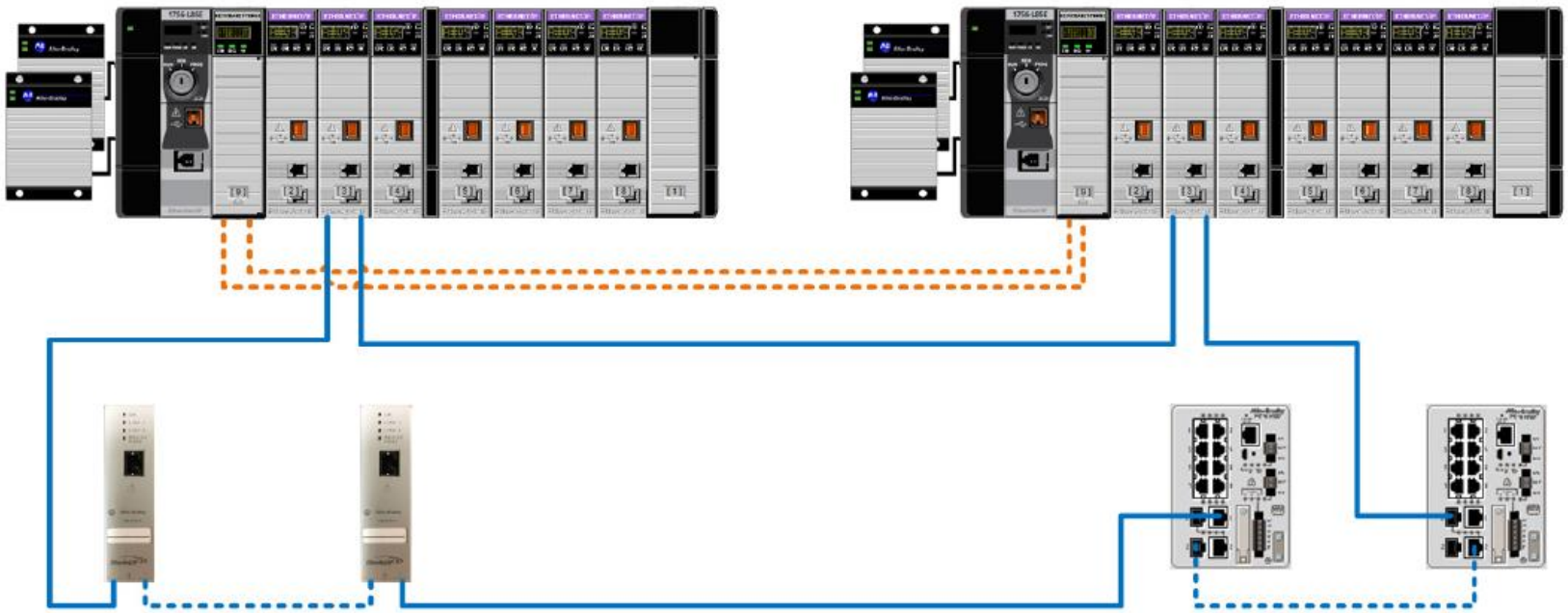


1783-ETAP1F and 1783-ETAP2F modules support only multimode fiber.

DLR-capable Stratix switches support both multimode and singlemode fiber.

Fiber Segments

- DLR capable Stratix switches allow for **multimode** or **single mode** fiber segments.
- Do not mix 100 Mbps and 1 Gbps on the same DLR network. A DLR should use the same speed throughout.

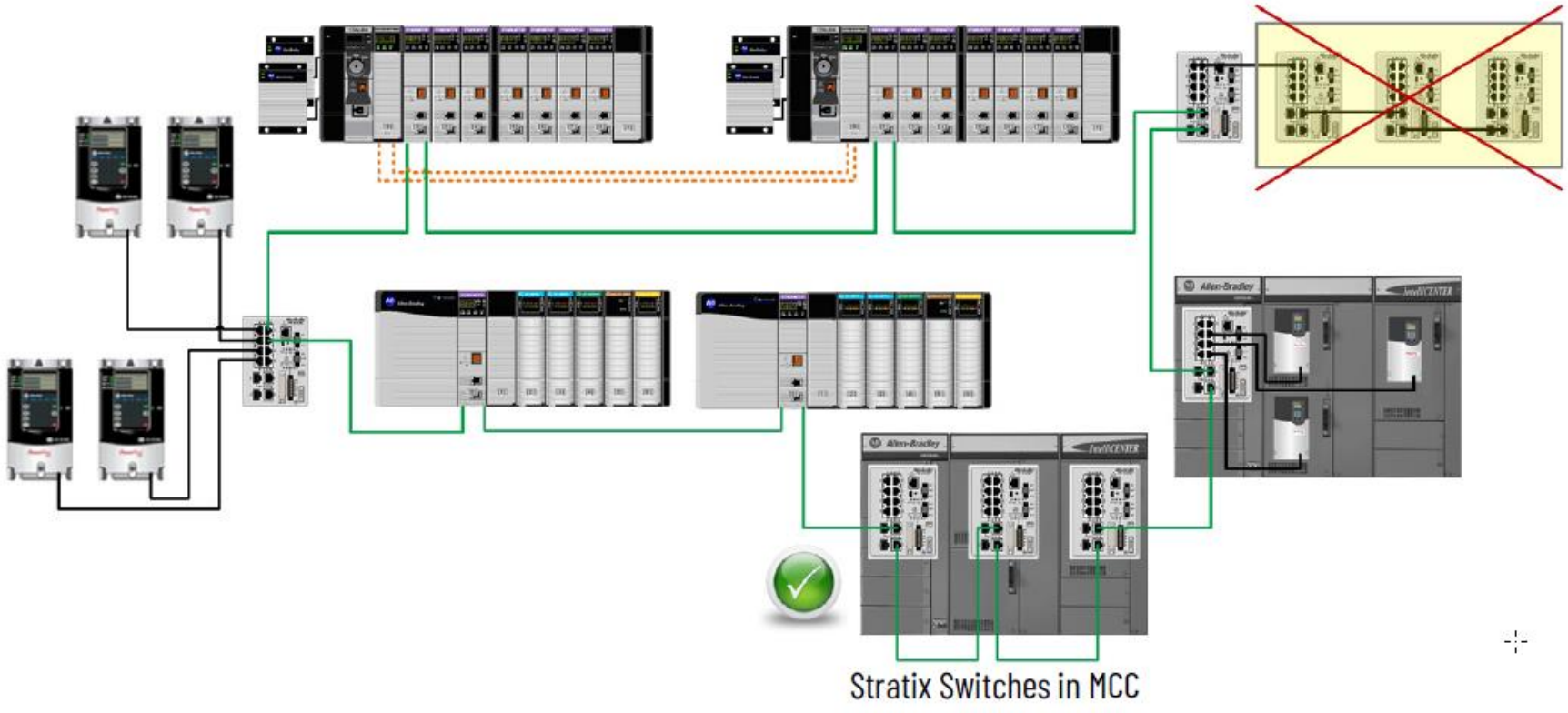


1783-ETAP1F and 1783-ETAP2F modules support only multimode fiber.

DLR-capable Stratix switches support both multimode and singlemode fiber.

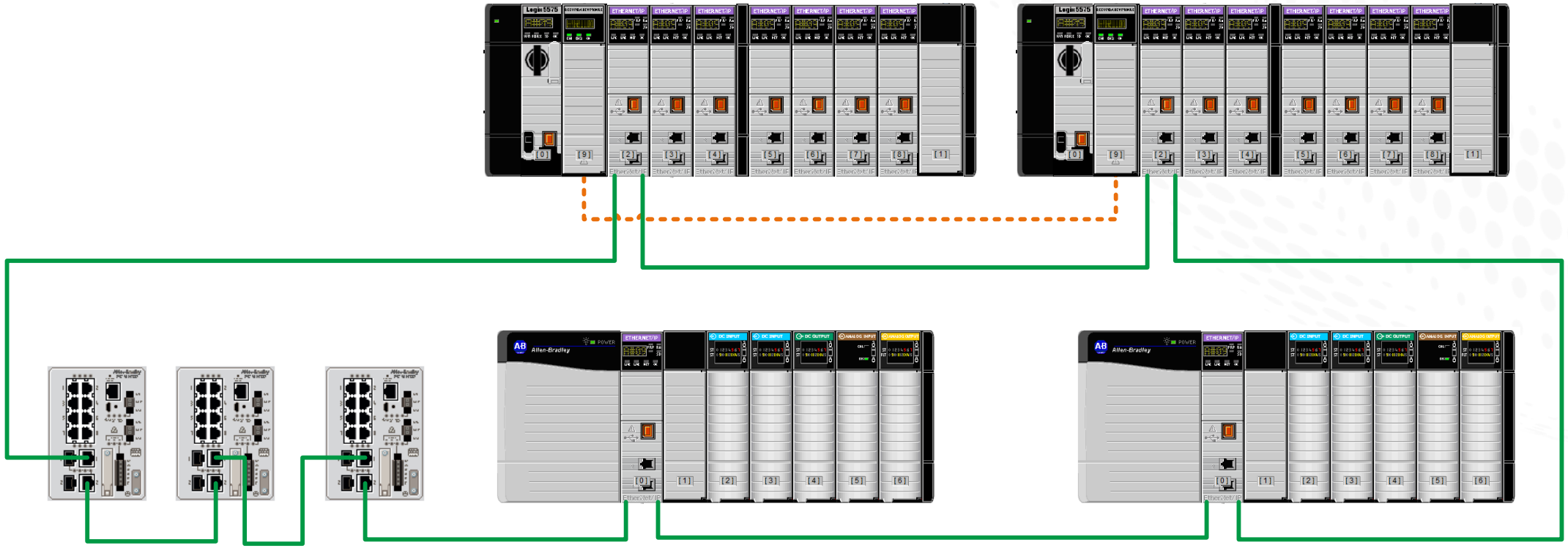
Adding Indirect Nodes

- Devices connected to **non-DLR** configured ports of a Stratix will be in a star topology.
- Devices connected in this way have multiple single points of failure (e.g. switch, cable, single device port on the device itself)
- MCC lineups can be connected in this way.



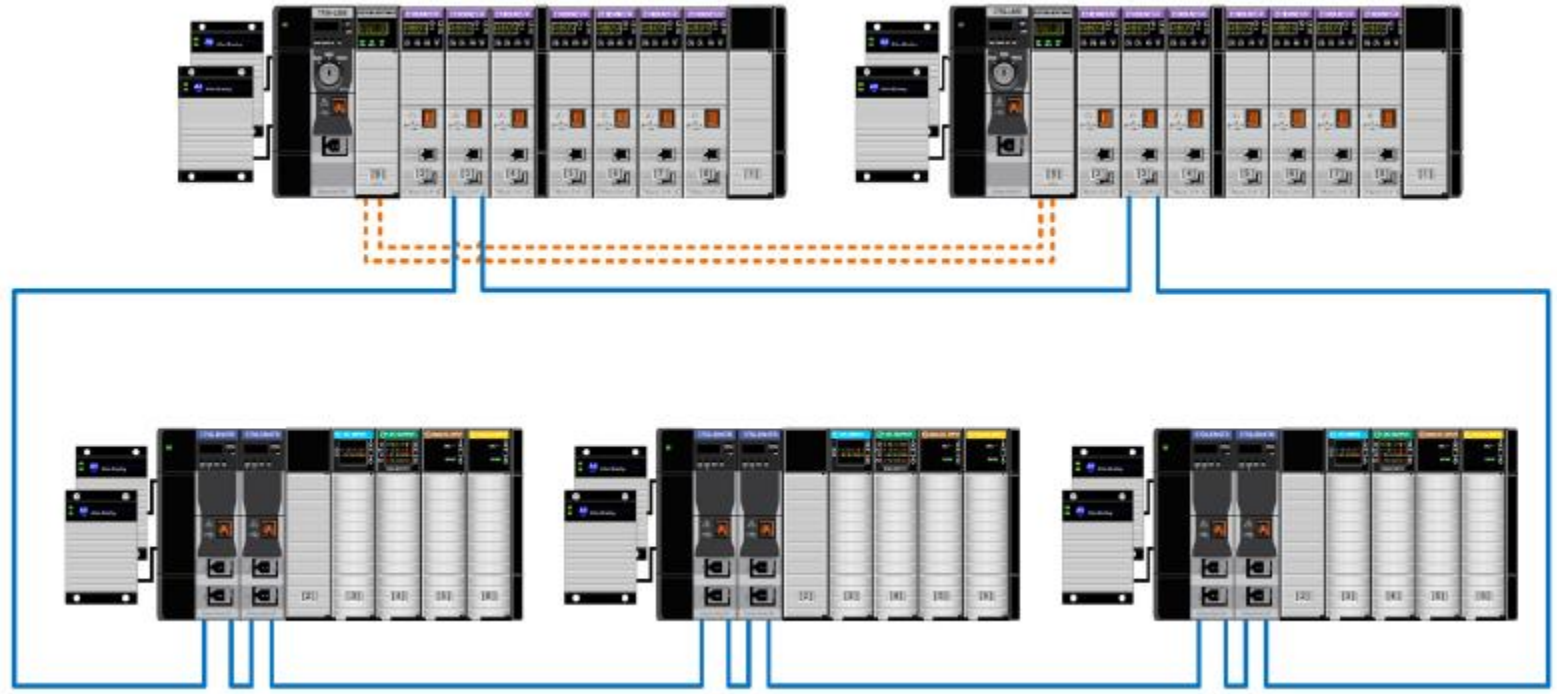
Stratix in DLR

- DLR capable Stratix switches can be included in a DLR ring, but they should not be connected to the upstream network in non-converged topologies.[1]



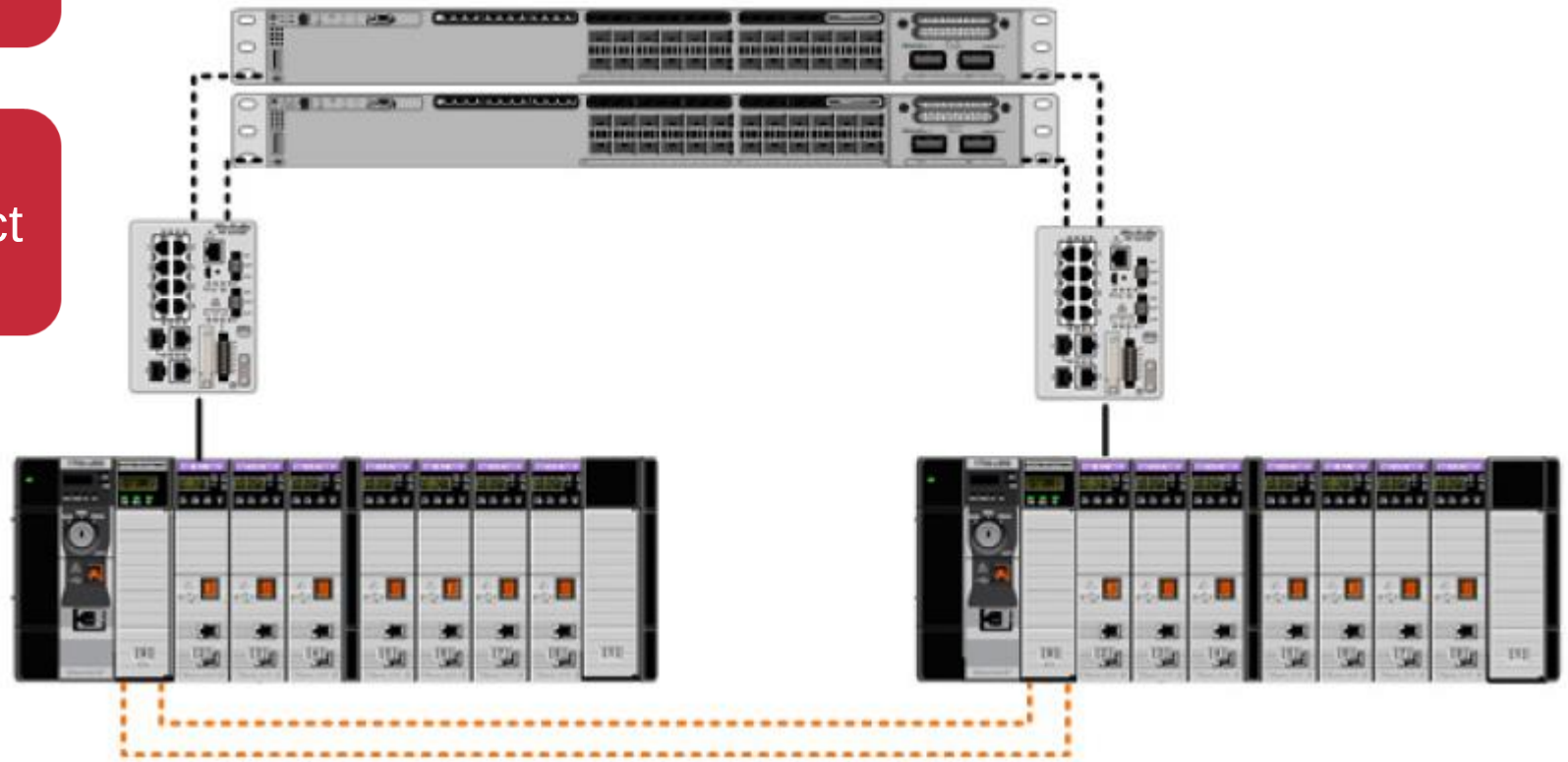
Redundant 1756-EN4TR EtherNet/IP Adapters in an I/O Chassis

- Redundant 1756-EN4TR adapters can be used for added resiliency at the adapter level. i.e. in a ControlLogix I/O chassis.[1,2]
- Redundant adapter functionality is available starting in revision 3.001 firmware.
- Note that each ControlLogix I/O chassis utilizing redundant EtherNet/IP adapters as counts as two DLR nodes.



Redundant Rack EtherNet/IP Modules

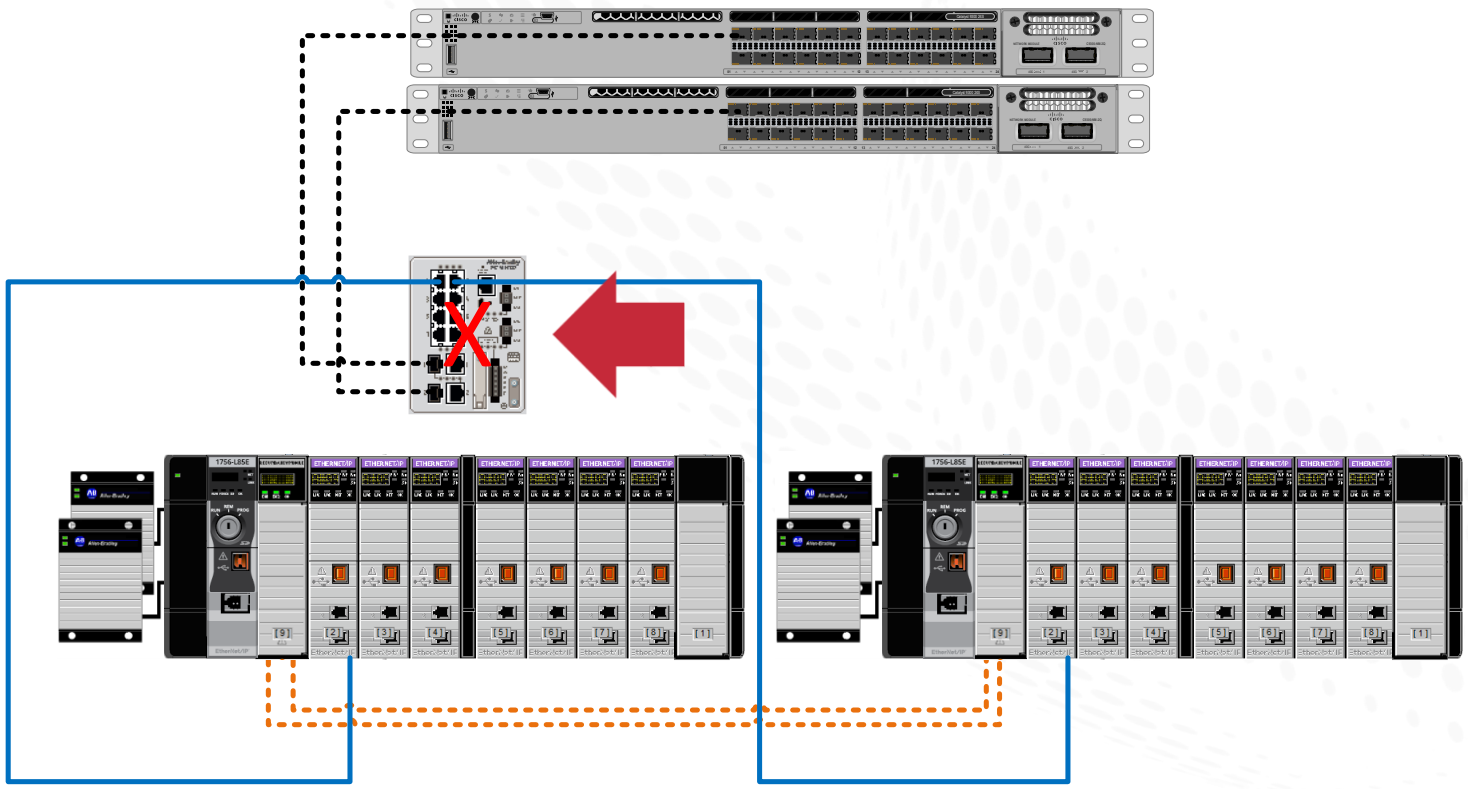
- One EtherNet/IP Module should be dedicated to upstream communications
- Up to six *other* EtherNet/IP modules can be used to connect to DLR or PRP networks.



Use Separate Upstream Switches

- The redundant controller racks should be connected to **separate** upstream switches.[1]

- Eliminates a single point of failure
- Avoids the switchover “race condition” scenario where both primary and secondary racks have a communication module in the lonely state at the same time.



Upstream Redundant Star vs. Ring

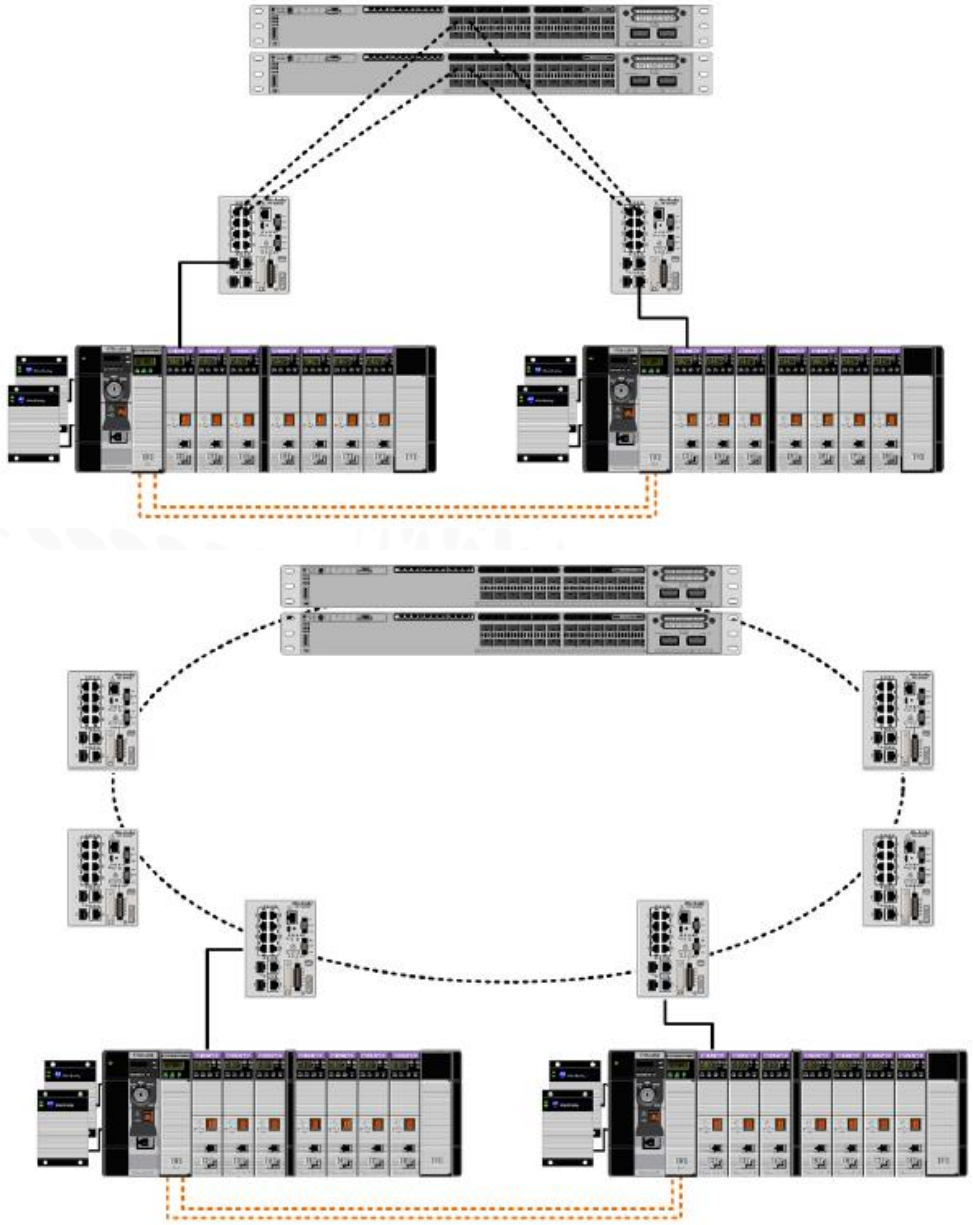
Redundant Star

- Resiliency from **multiple** connection failures.
- Faster convergence to connection loss
- **Consistent number of hops** (typically two in a flat design) provides predictable and consistent performance and real-time characteristics
- Fewer bottlenecks in the design reduces chances of segment over-subscription

Ring

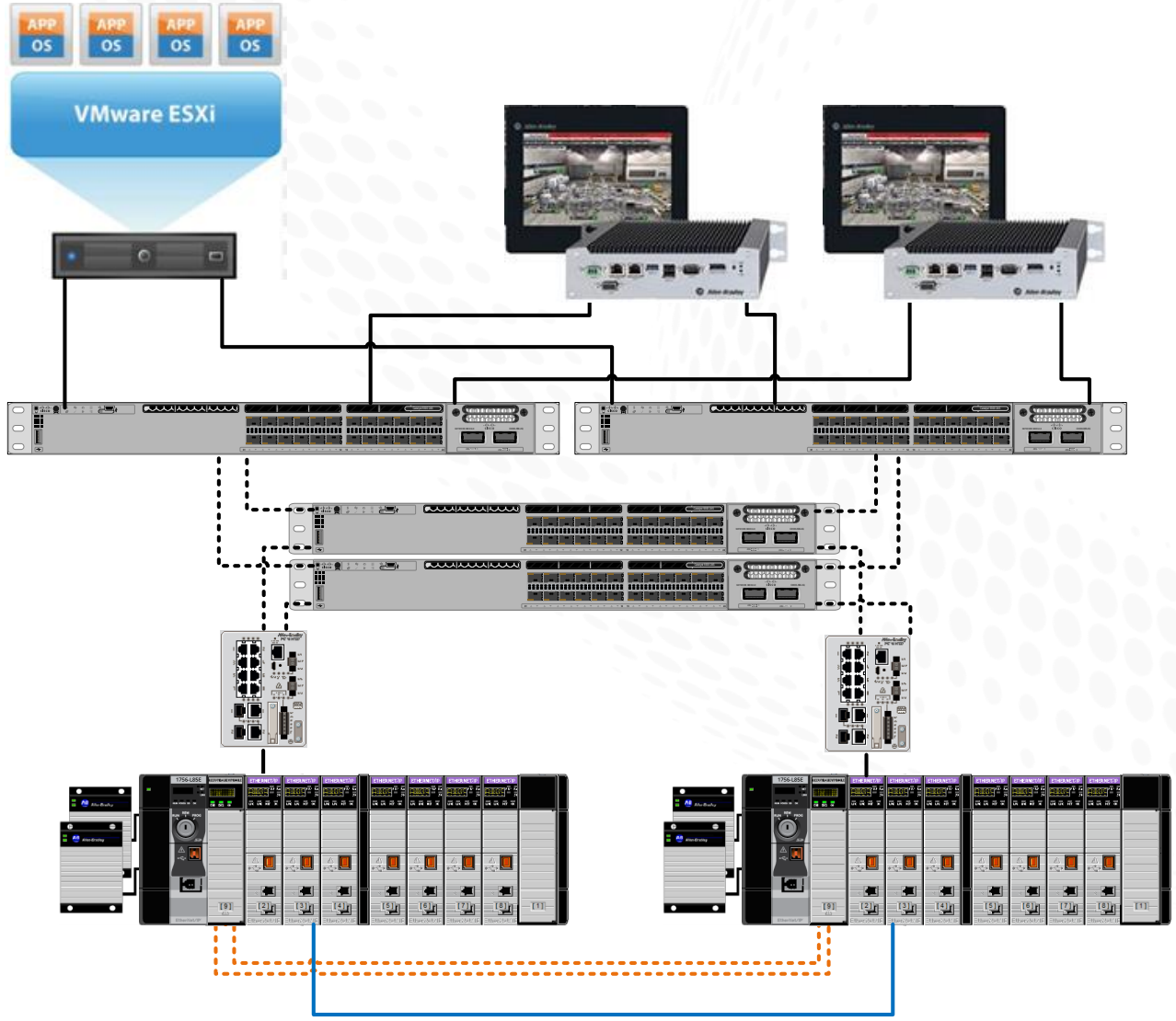
- Resiliency from loss of **one** network connection
- When using REP, convergence times range from 50 ms – 150 ms[1,2]
- **Variable number of hops** makes designing predictable performance more complex
- Less cabling complexity in certain plant floor layouts
- Multiple paths reduces potential for oversubscription and bottlenecks

Recommended Best Practice: redundant star



Reducing **Data Server Communications Recovery Time**

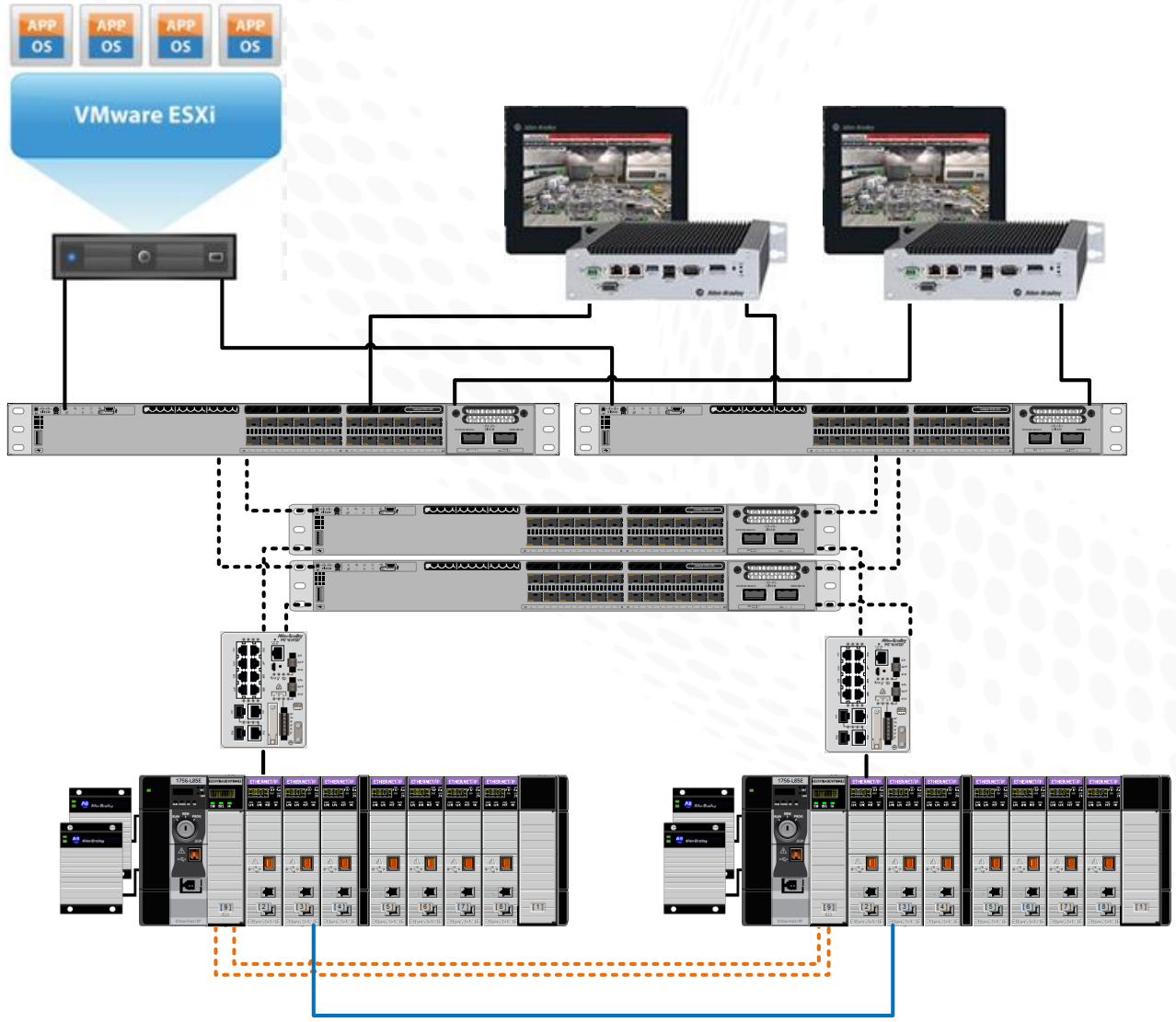
- **Data Server Communications Recovery Time** is the brief time during a switchover from primary to secondary, when tag data from the controller is unavailable for reading or writing.
- **Data Server Communications Recovery Time** is applicable to any software that uses tag data, such as HMI displays, data loggers, alarming systems, or historians.[1,2]
- As of revision 31.052, the communication delays over Ethernet during a switchover event have been reduced significantly.



Reducing Data Server Communications Recovery Time

Redundant Shortcut Paths

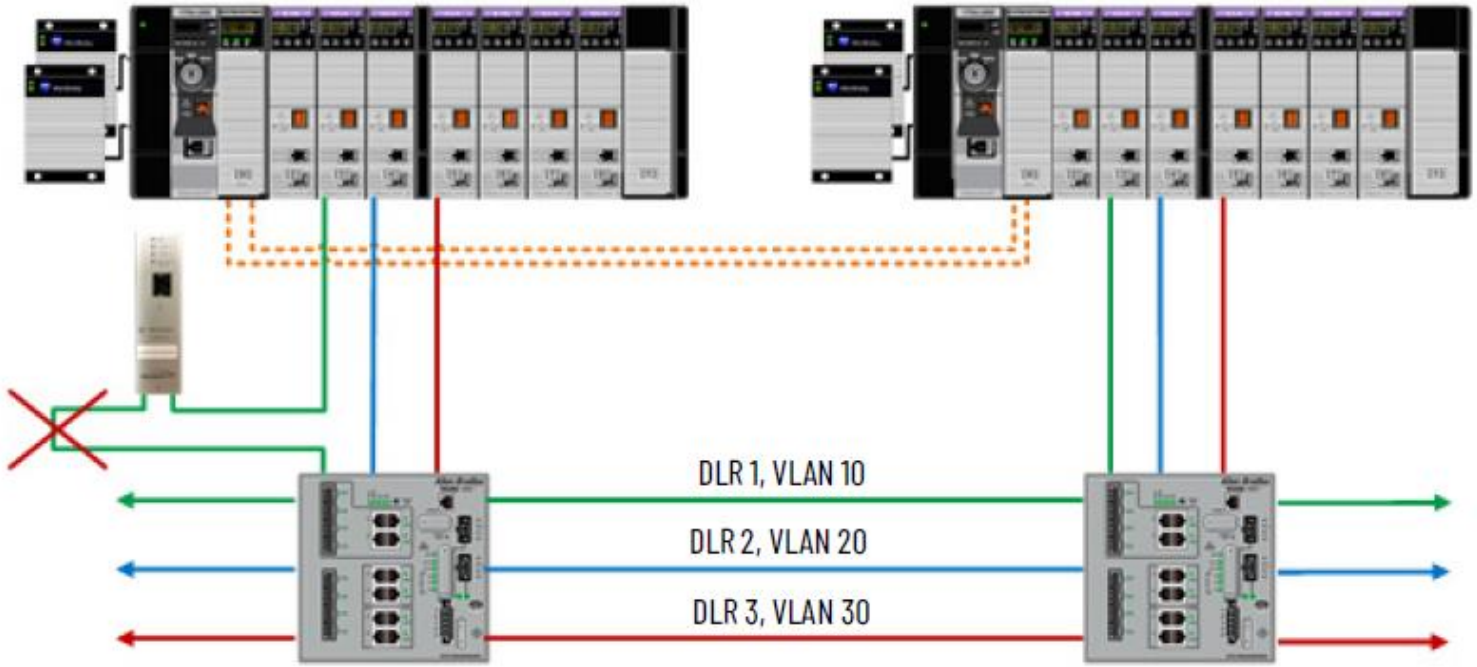
- These shortcut paths help to reduce data server communication recovery time during a redundancy switchover.
- Redundant controller shortcut paths are available starting with ControlLogix redundancy system, revision 31.5x and FactoryTalk Linx version 6.00.00.
- For details about how to implement this feature, see the FactoryTalk Linx Getting Results Guide, publication LNXENT-GR001



Media Convertor Restrictions for Indirect DLR

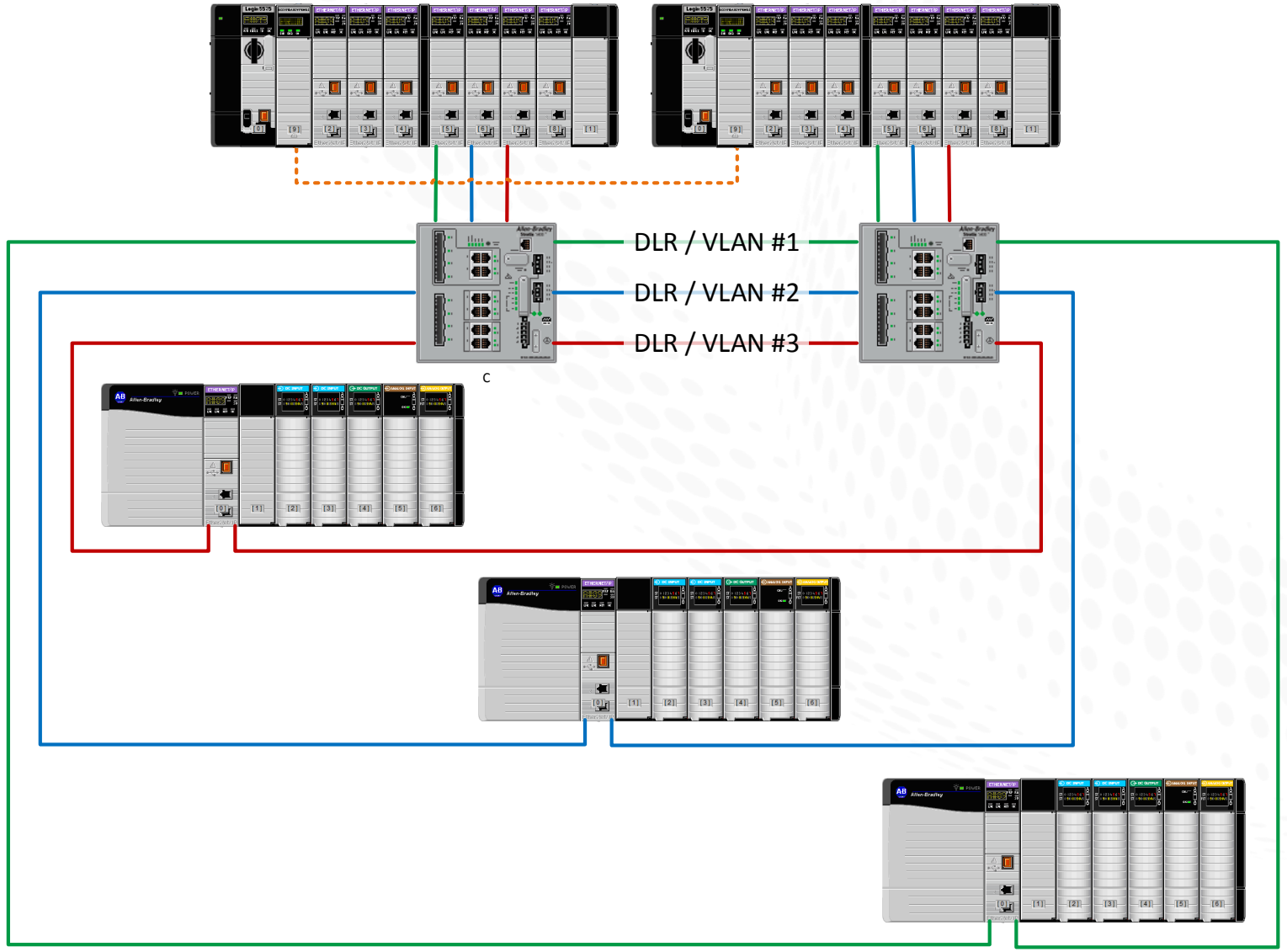
- When indirectly connecting the redundant racks to DLR networks, **no** media converters or switches are allowed between an EN2* and DLR Switch. It **must** be a direct link.[1]

- By following the guidance above, you can avoid the scenario where:
  1. The link between the media convertor and DLR Stratix switch fails.
  2. Since the EN2* link is still up, the primary **will not** switch over, even though it can't "see" the DLR network and the secondary can.



VLAN Restrictions for Indirect DLR

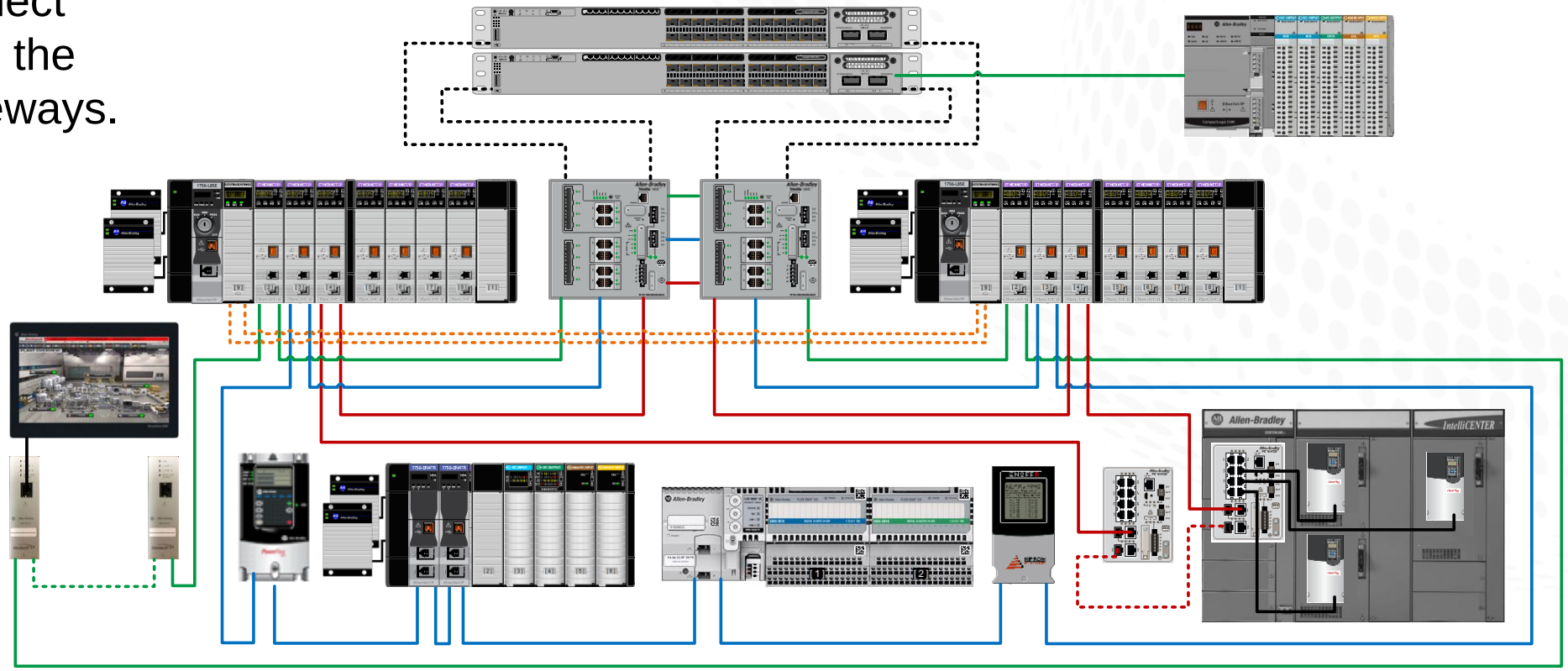
- DLR networks must be on separate VLANs and all devices within the same ring must be at the same network speed.



Placement of DLR Redundant Gateways

- The two DLR redundant gateways should be located between the two redundant controller racks just like it is shown in the diagram[1].

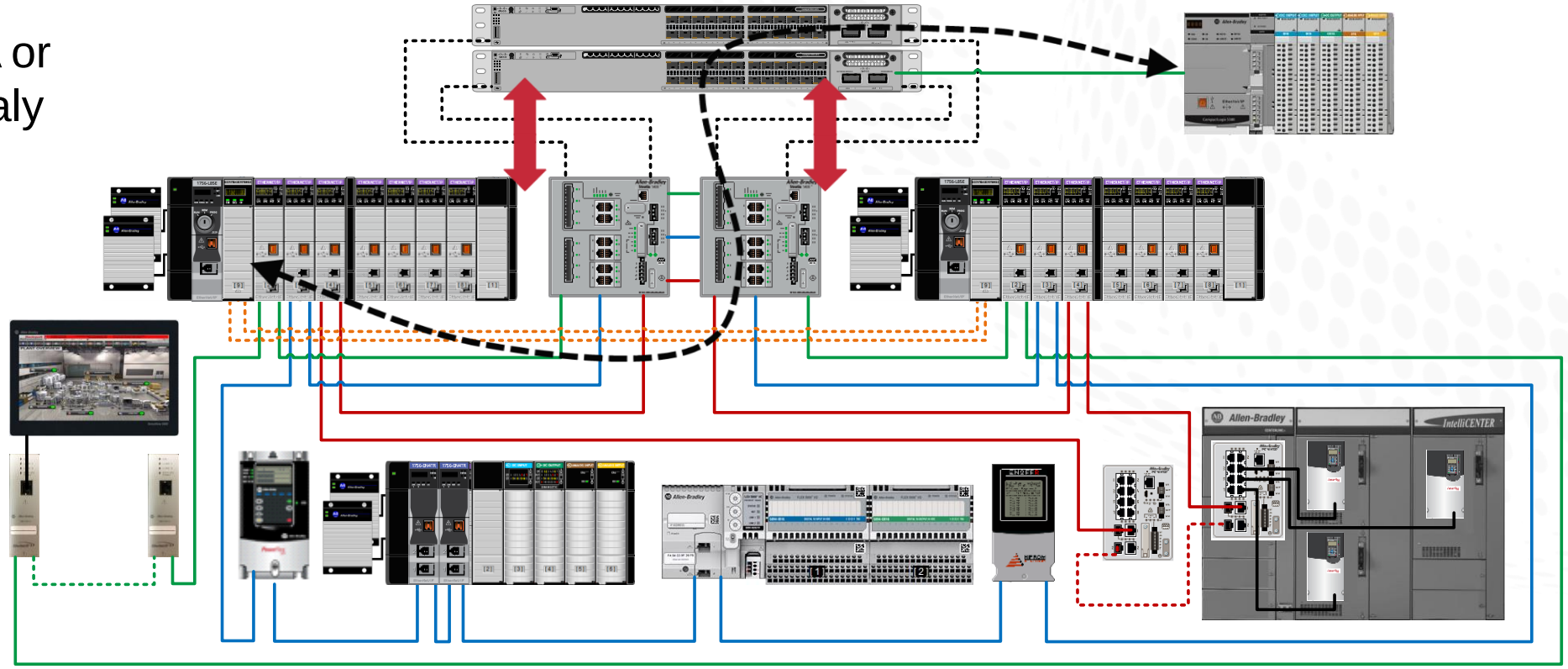
- You should not connect any other devices to the DLR redundant gateways.



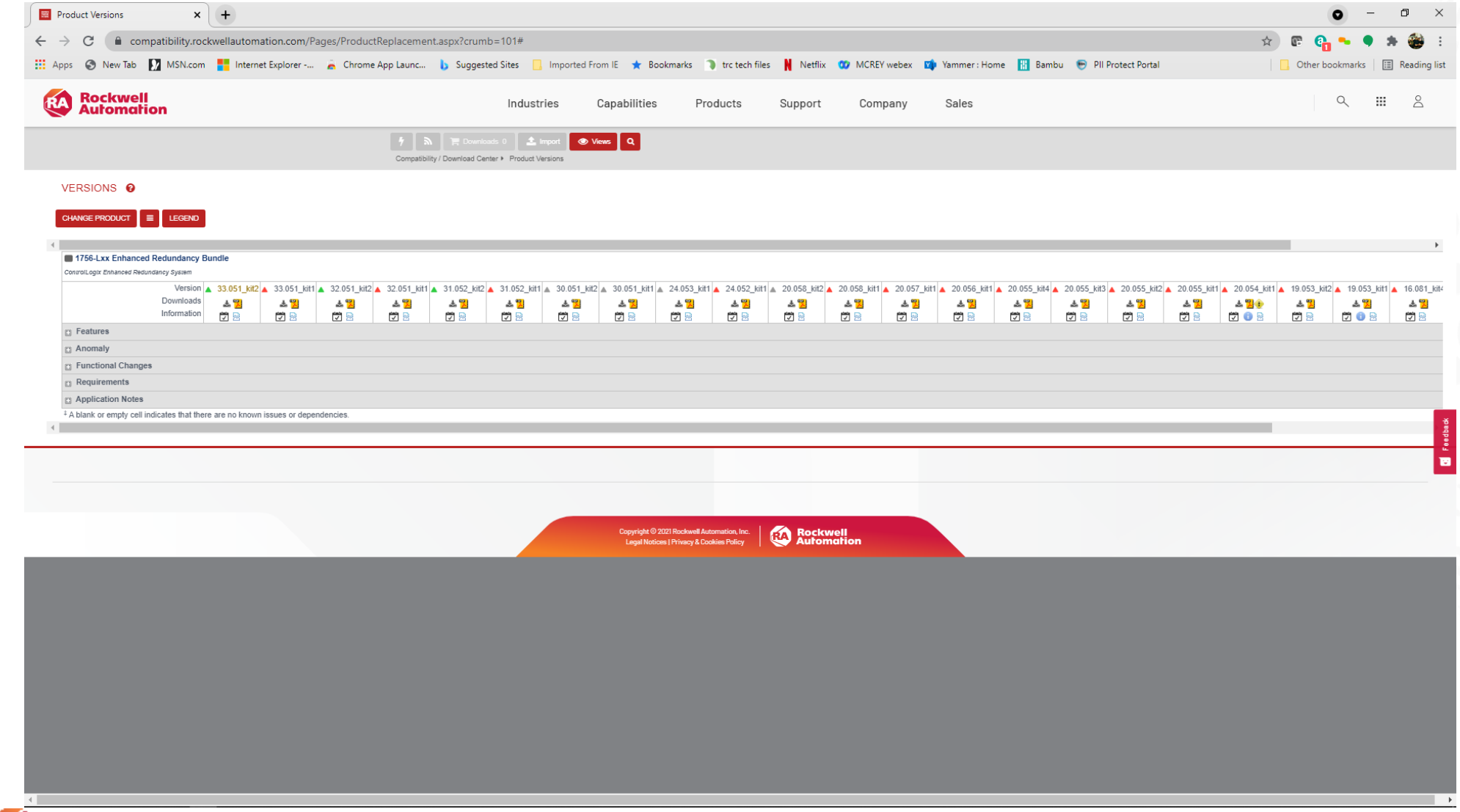
Traffic through DLR Redundant Gateways

- When a DLR redundant gateway switchover event occurs, there is chance that *traffic traversing the DLR gateways* will be interrupted during the gateway switchover and/or recovery phases.[1]

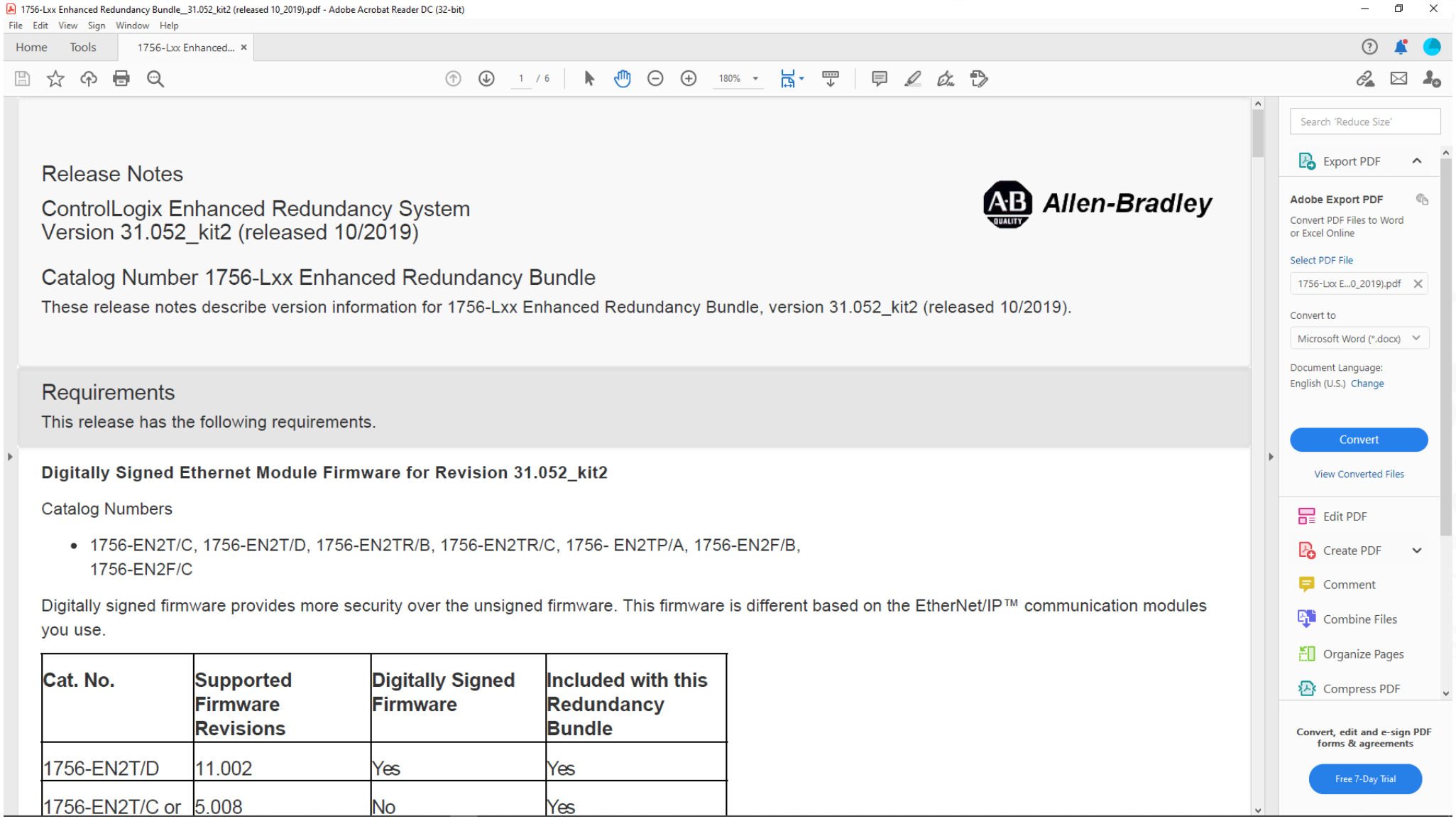
- Requires Stratix Firmware 15.2(7)EA or higher due to anomaly in earlier versions.[2]



Where to find release notes- PCDC



Release notes- PCDC



ControlLogix 5580 Redundancy Programming Best Practices

Rockwell Automation

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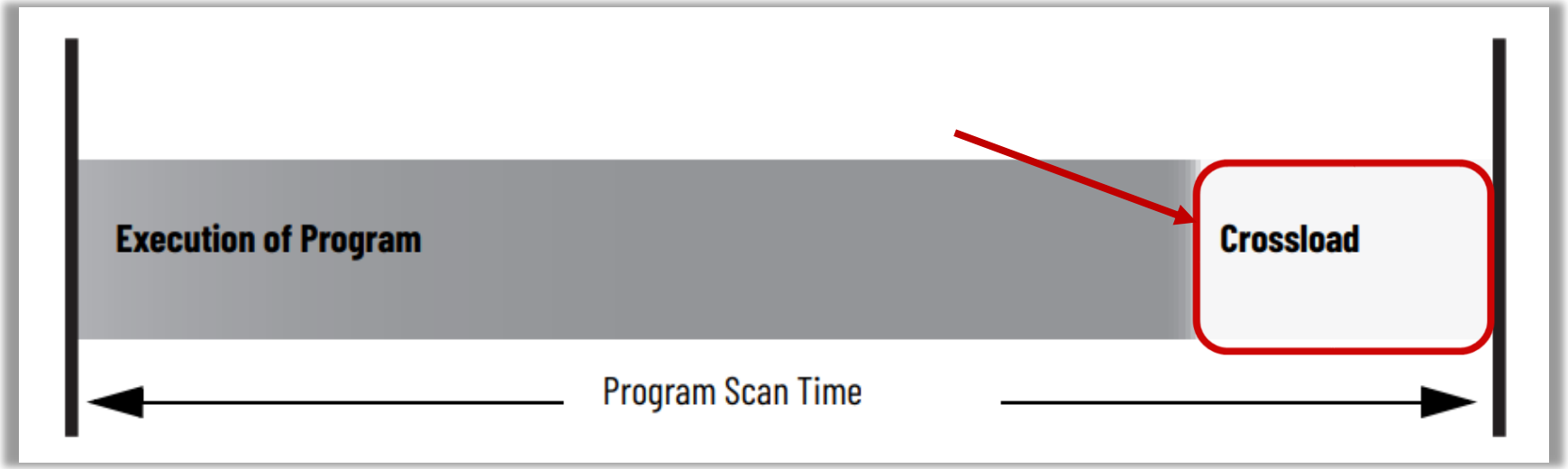
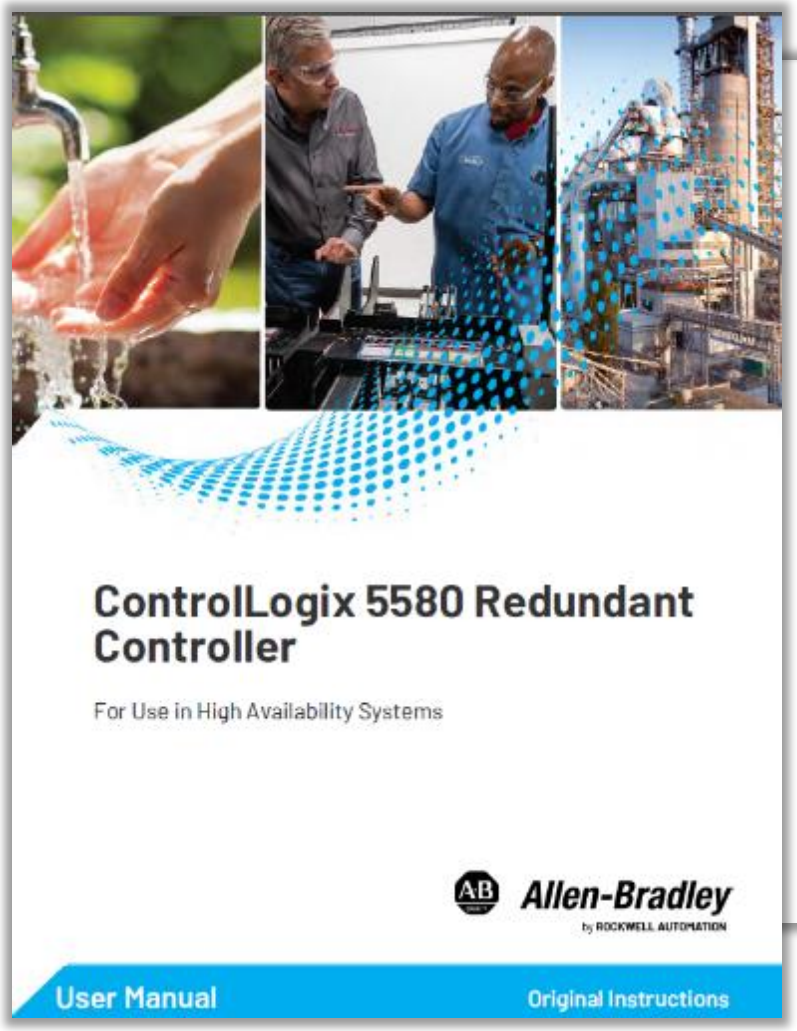
Simplex versus Redundancy Scan Time Performance

- **Question**: Why does the program scan time increase in a ControlLogix Redundancy System?
- **Answer**: Crossloading.
  - Crossloading is when a primary controller periodically pauses execution to synchronize data with the secondary controller.
  - Crossloading allows for bumpless transfer of outputs during a switchover event.
  - By **default**, crossloading occurs at the end of every program scan.



ControlLogix Redundancy Programming Best Practices

See Chapter 6 of ControlLogix 5580 Redundant Controller User Manual, publication 1756-UM015



Chapter 6

Programming Best Practices

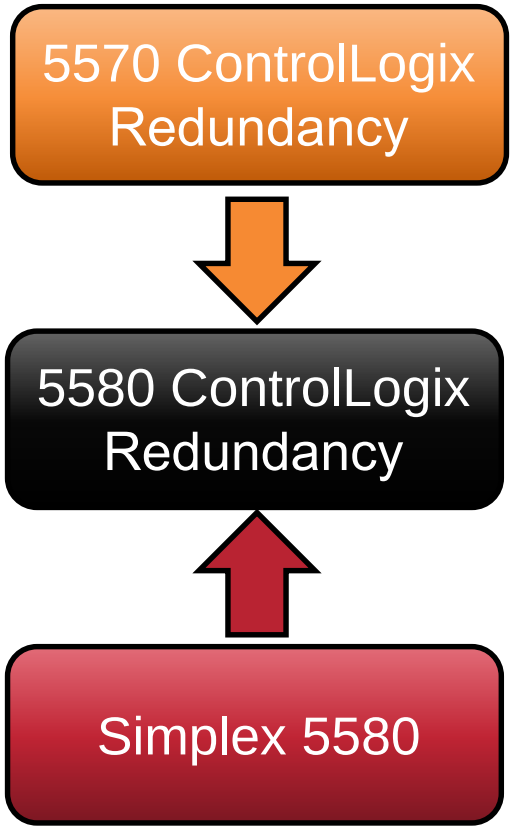
Optimizing a ControlLogix 5580 Redundancy Application

To optimize scan time performance in a ControlLogix Redundancy application:

- Utilize a Periodic Task over a Continuous Task.
- Minimize the number of programs.
- Optimize program execution.
- Consolidate code.
- Combine data into groups which are likely to change during the same program scan arrays or structures.
- Use arrays or structures instead of individual tags.
- Optimize the layout of User-defined Data Types (UDTs).
- Delete unused tags.

5580 ControlLogix Redundancy Migrations – Expected Performance

- **Question:** What performance difference can be expected when **migrating** to 5580 ControlLogix Redundancy?
- **Answer**: It depends. Achieved performance is **very** dependent on the implementation of the Programming Best Practices covered in Chapter 6 of the ControlLogix 5580 Redundant Controller User Manual, pub. 1756-um015



5570 Redundancy → 5580 Redundancy:

If programming best practices are followed, expect 1:1 performance.

Simplex 5580 → 5580 Redundancy:

Harder to predict performance.

If best practices are NOT followed:

Expect substantially degraded performance

5570 → 5580 ControlLogix Redundancy Migrations

- The 5570 ControlLogix Redundancy crossload boundary is **256** bytes.

256	256	256	256	256

- The 5580 ControlLogix Redundancy crossload boundary is **4096** bytes.

4096	4096	4096	4096	4096

Literature Library

Replacement Guidelines: Logix 5000 Controllers Reference Manual, publication 1756-rm100

5570 → 5580 ControlLogix Redundancy Migrations

This table shows how much data is transferred from the primary controller to the secondary controller, assuming each tag is a DINT.

Scenario	ControlLogix 5570 transfer size range (bytes)	ControlLogix 5580 transfer size range (bytes)
Change 1 tag	256	4,096
Change 2 adjacent tags	256	4,096
Change 2 non-adjacent tags	256…512	4,096…8,192
Change 10 adjacent tags	256…512	4,096…8,192
Change 10 non-adjacent tags	256…2,560	4,096…40,960
Change 16 non-adjacent tags	256…4,096	4,096…65,536
Change 1000 tags	4,096…256,000	4,096…4,096,000

The amount of data crossloaded for 5580s can be up to 16x greater than 5570s

Best Practice: To optimize performance, follow the Best Practices captured in Chapter 6 of the ControlLogix 5580 Redundant Controller User Manual, pub. 1756-um015.