
Secure PLC Programming
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Why Discuss This?

- Engineers are not taught good programming habits
- Security specialists do not know what the process does
- Good code leads to more rapid diagnostics
- Can determine and even help isolate hacks more rapidly
- Make working with protocol sensitive firewalls easier

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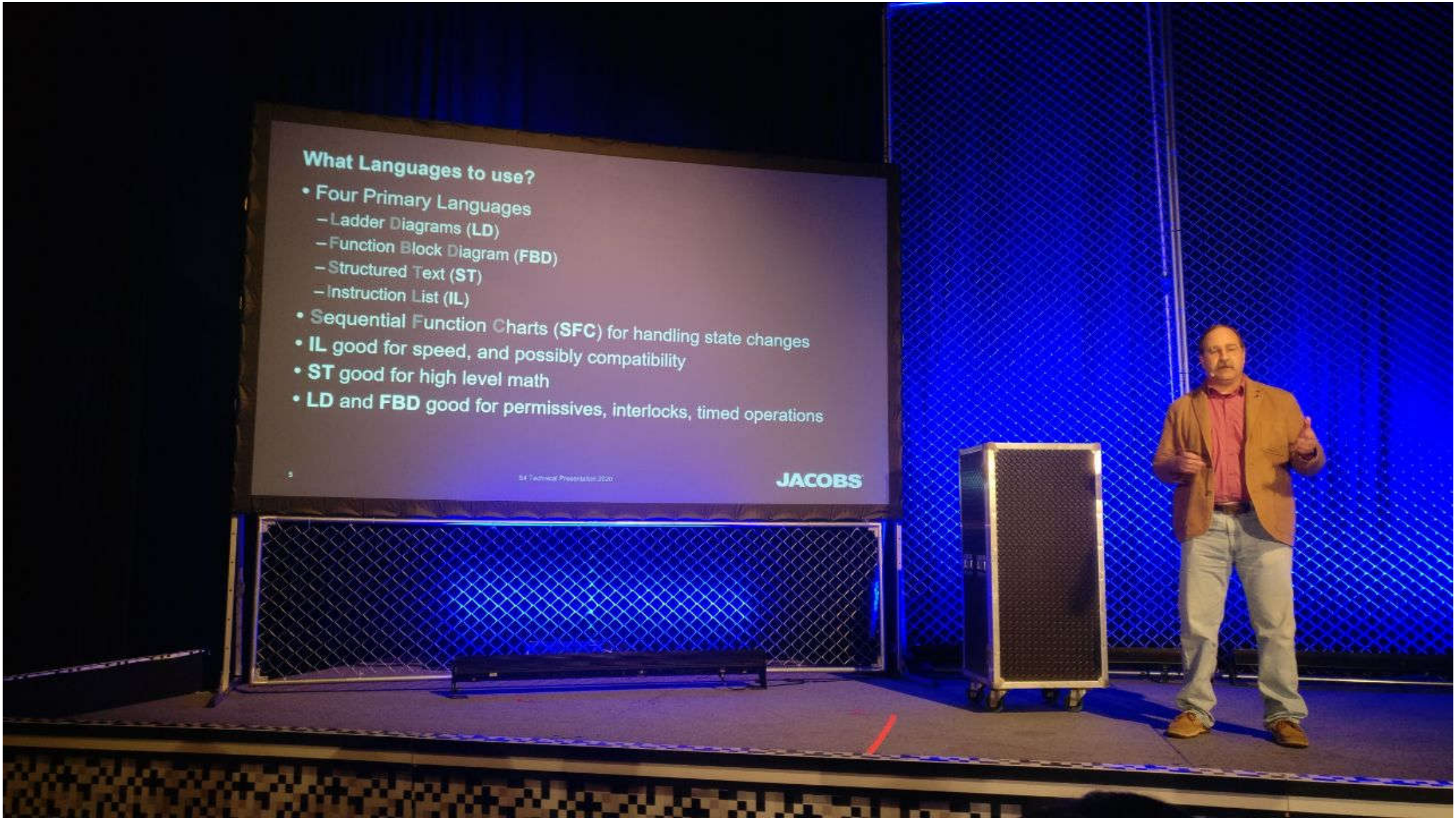
What Languages to use?
• Four Primary Languages
– Ladder Diagrams (LD)
– Function Block Diagram (FBD)
– Structured Text (ST)
– Instruction List (IL)
• Sequential Function Charts (SFC) for handling state changes
• IL good for speed, and possibly compatibility
• ST good for high level math
• LD and FBD good for permissives, interlocks, timed operations
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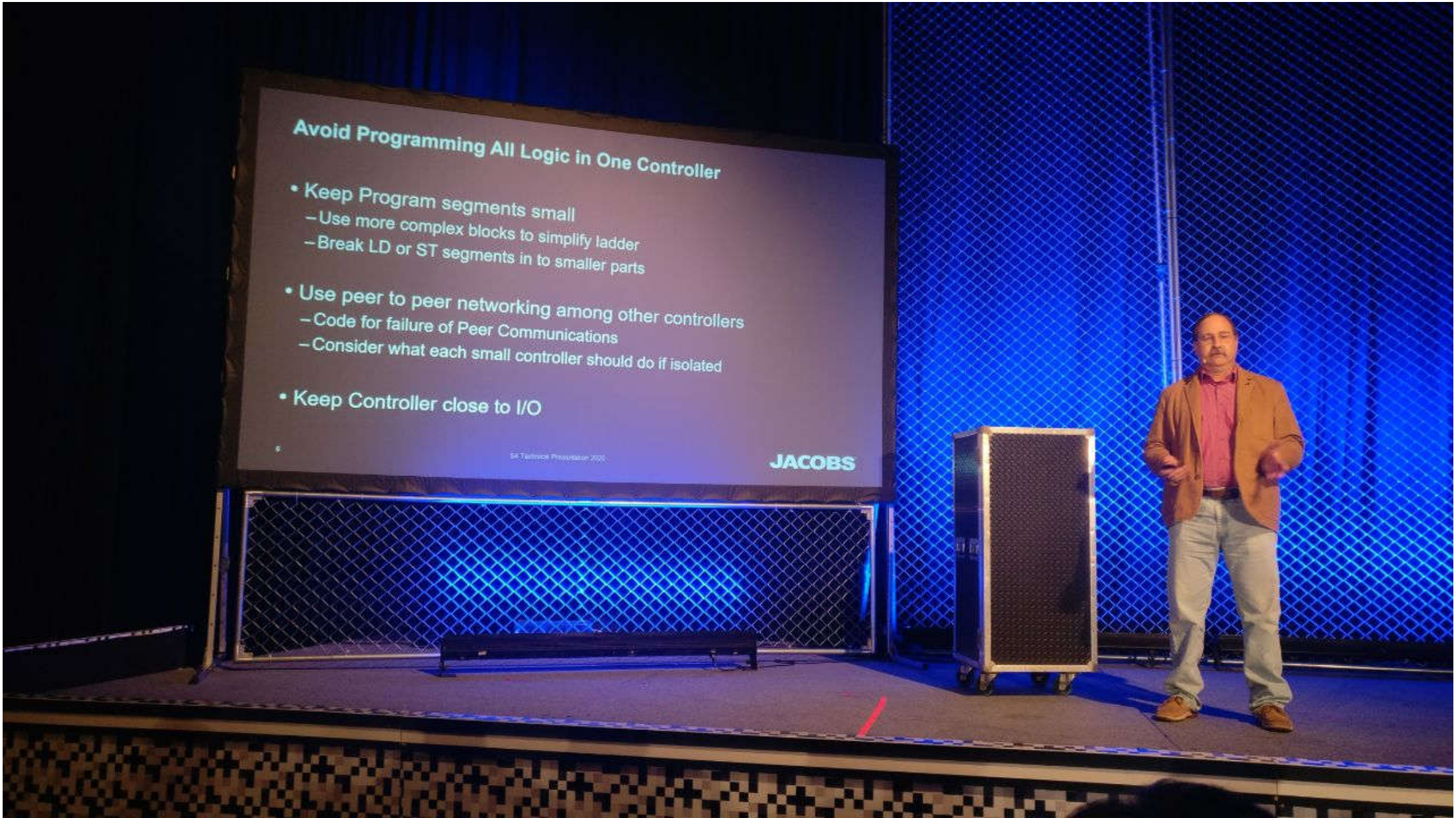
Avoid Programming All Logic in One Controller
• Keep Program segments small
– Use more complex blocks to simplify ladder
– Break LD or ST segments in to smaller parts
• Use peer to peer networking among other controllers
– Code for failure of Peer Communications
– Consider what each small controller should do if isolated
• Keep Controller close to I/O
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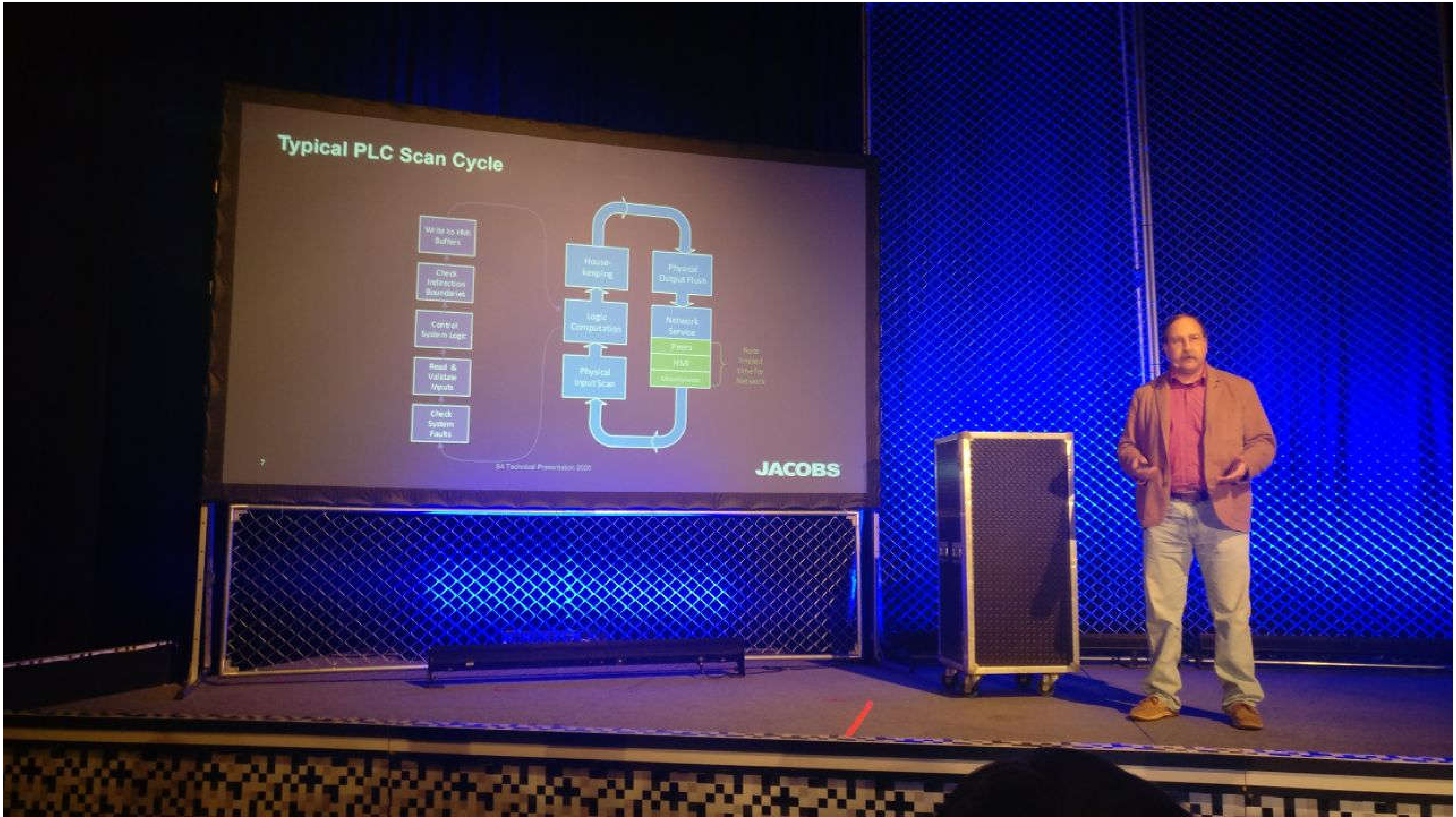
Typical PLC Scan Cycle
Write to HMI Buffers
Check Infraction Boundaries
Control System Logic
Read & Validate Inputs
Check System Faults
House-keeping
Logic Computation
Physical Input Scan
Physical Output Flush
Network Service
HMI
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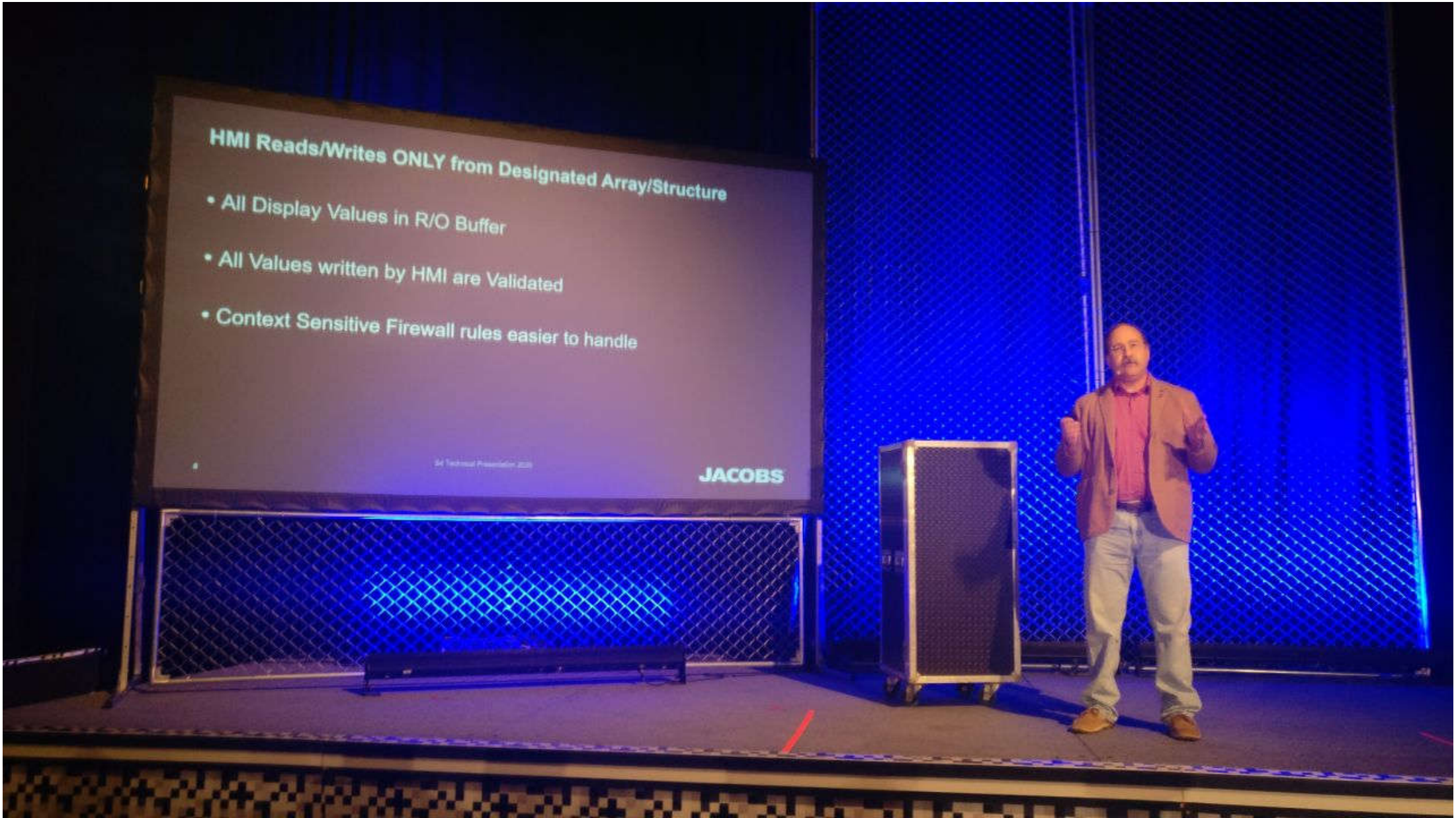
HMI Reads/Writes ONLY from Designated Array/Structure
• All Display Values in R/O Buffer
• All Values written by HMI are Validated
• Context Sensitive Firewall rules easier to handle
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How This Keeps Attackers At Bay
1. Attacker Writes to Buffer
2. Logic Recomputes
3. Overwrites Attack Data
4. Network Service Reports no change
I/O Buffer
Attacker is overwritten
House-keeping
Logic Computation
Physical Input Scan
Physical Output Flush
Network Service
Peers
JVM
Maintenance
Attacker Write
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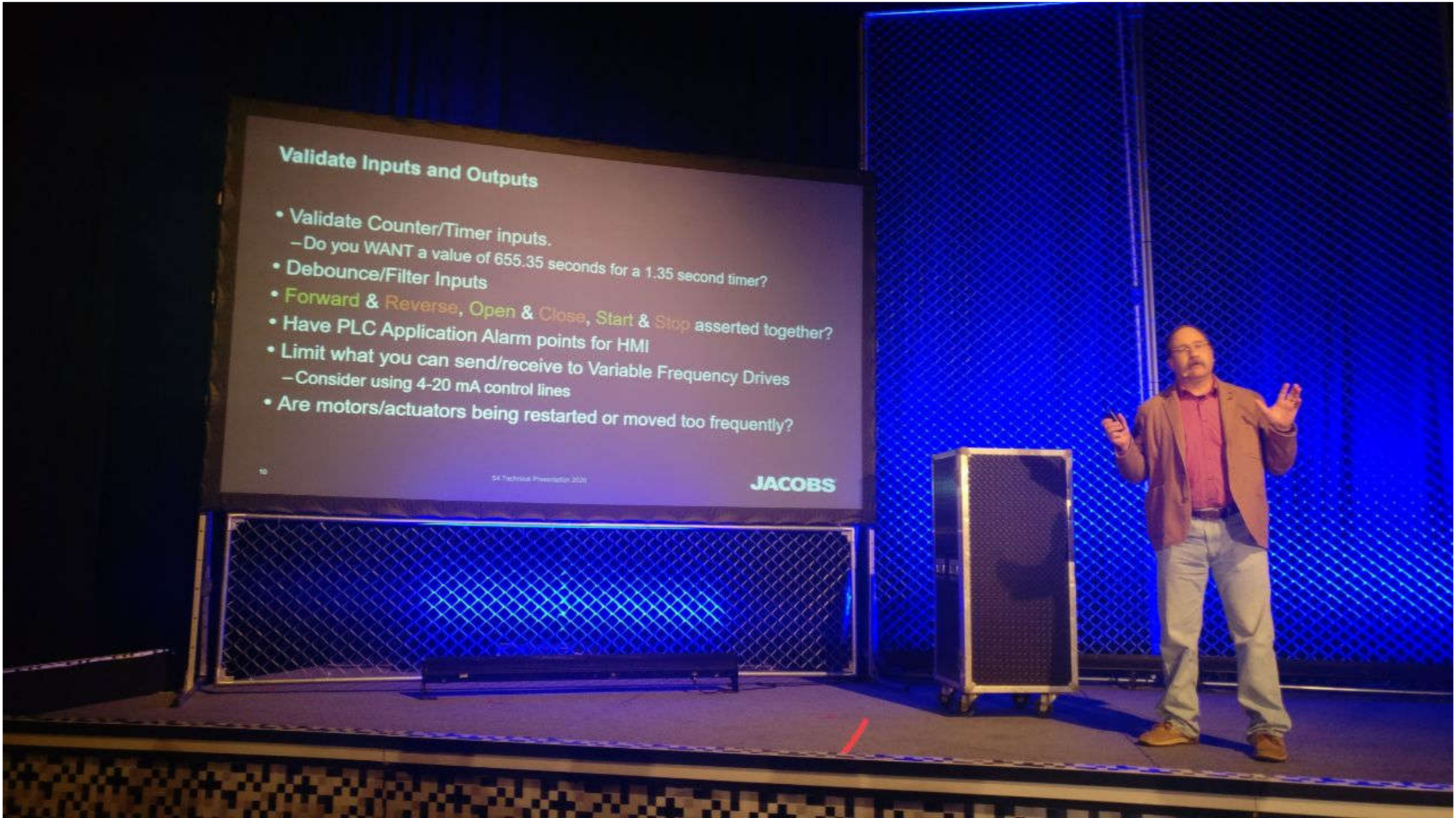
Validate Inputs and Outputs
• Validate Counter/Timer inputs.
– Do you WANT a value of 655.35 seconds for a 1.35 second timer?
• Debounce/Filter Inputs
• Forward & Reverse, Open & Close, Start & Stop asserted together?
• Have PLC Application Alarm points for HMI
• Limit what you can send/receive to Variable Frequency Drives
– Consider using 4-20 mA control lines
• Are motors/actuators being restarted or moved too frequently?
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Motor Restart Delay
Line
Neutral
Motor Running
Start Permissive Timer
Start Motor
Start Permissive
Stop Motor
Motor
Motor Running
Start Motor
Start Permissive
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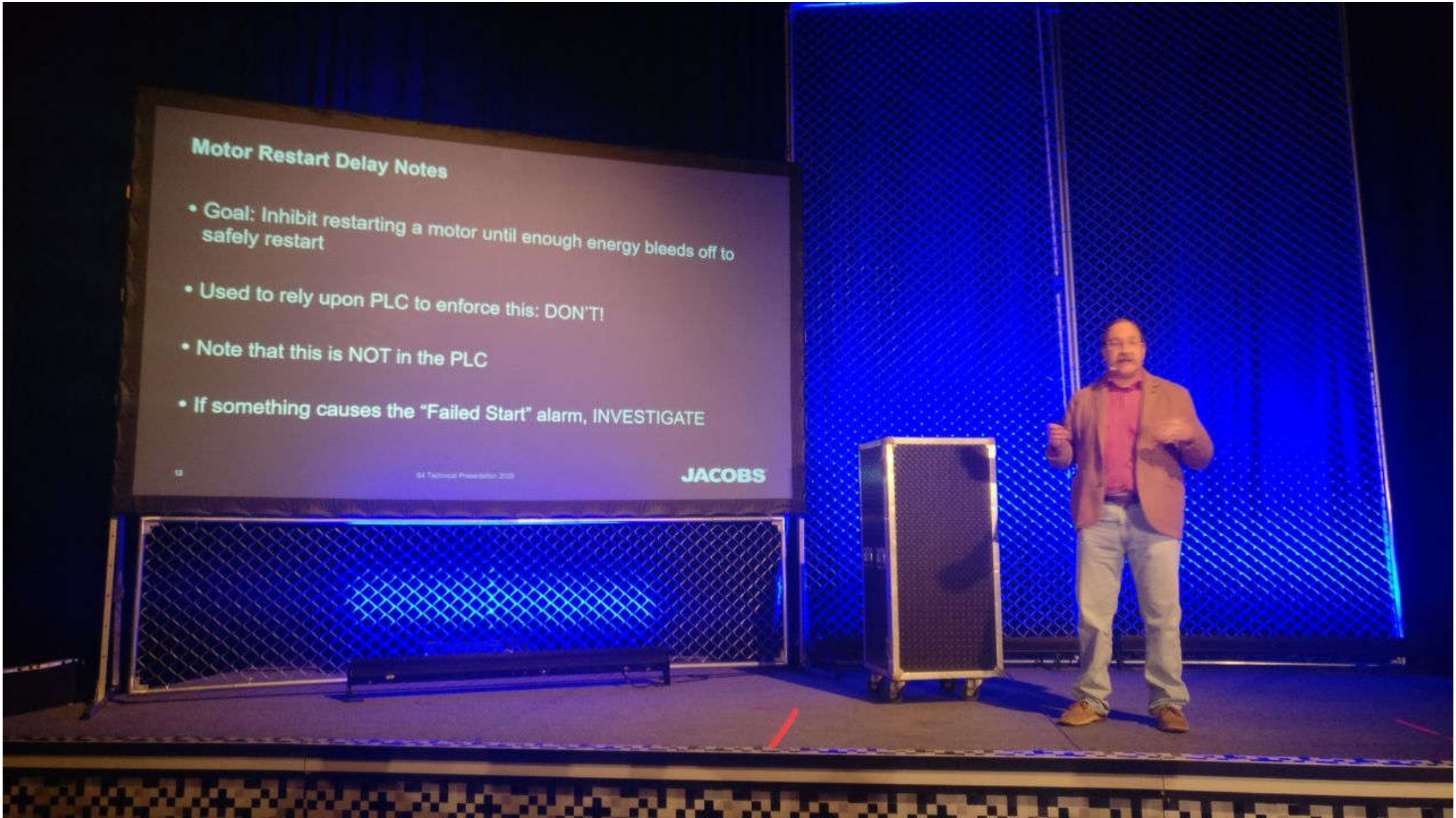
Motor Restart Delay Notes
• Goal: Inhibit restarting a motor until enough energy bleeds off to safely restart
• Used to rely upon PLC to enforce this: DON'T!
• Note that this is NOT in the PLC
• If something causes the "Failed Start" alarm, INVESTIGATE
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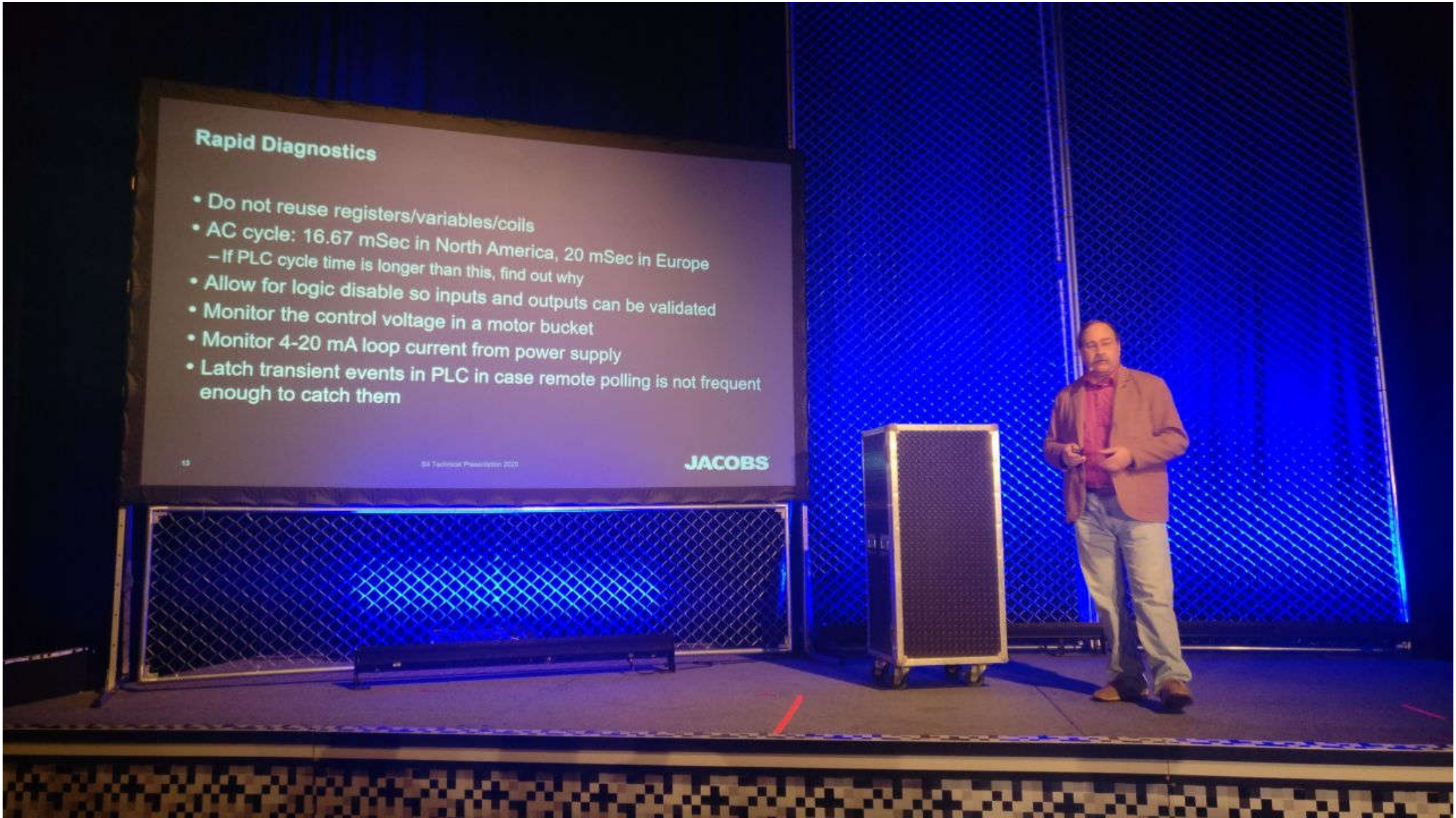
Rapid Diagnostics
• Do not reuse registers/variables/coils
• AC cycle: 16.67 mSec in North America, 20 mSec in Europe
– If PLC cycle time is longer than this, find out why
• Allow for logic disable so inputs and outputs can be validated
• Monitor the control voltage in a motor bucket
• Monitor 4-20 mA loop current from power supply
• Latch transient events in PLC in case remote polling is not frequent enough to catch them
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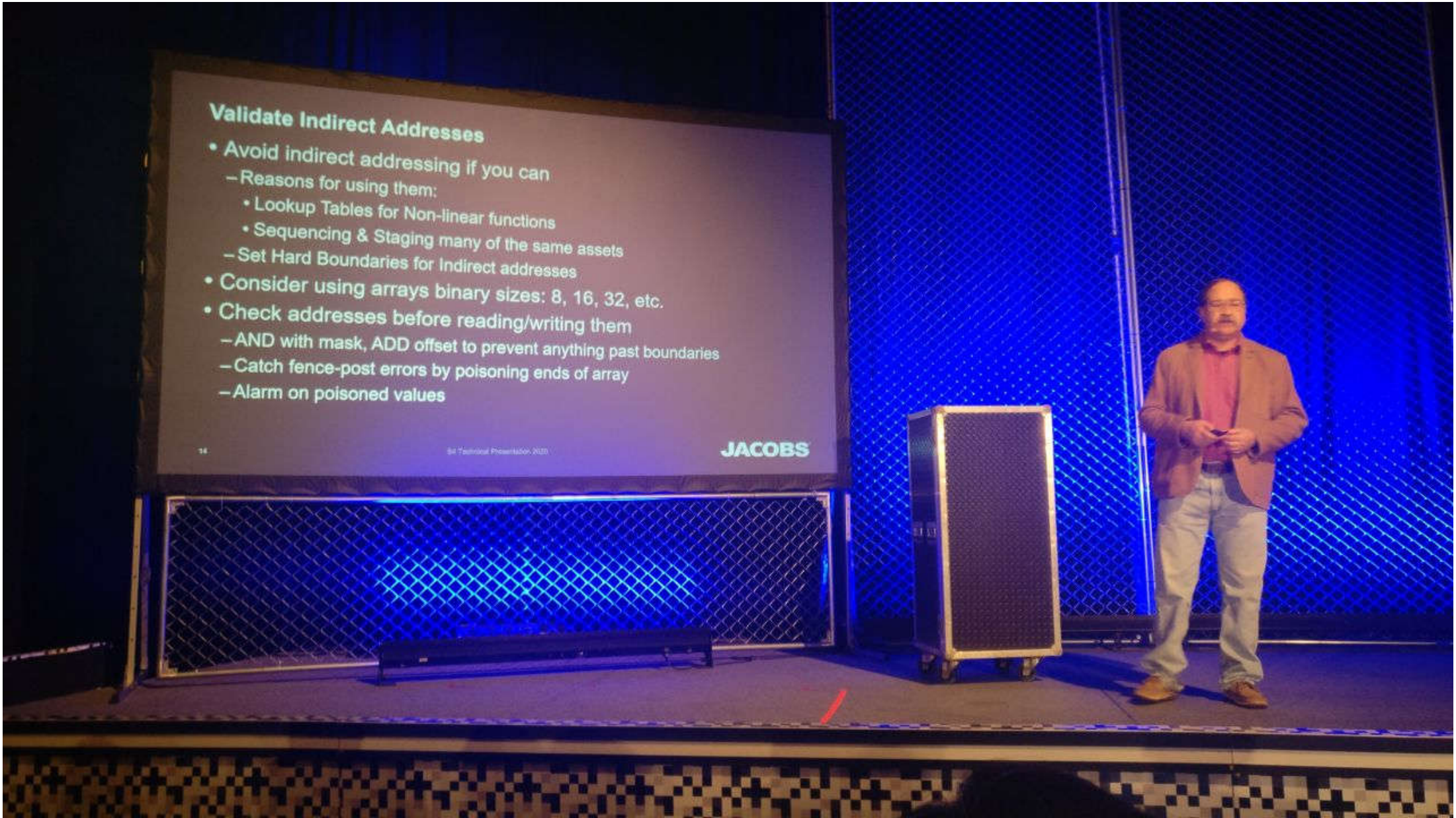
Validate Indirect Addresses
• Avoid indirect addressing if you can
– Reasons for using them:
• Lookup Tables for Non-linear functions
• Sequencing & Staging many of the same assets
– Set Hard Boundaries for Indirect addresses
• Consider using arrays binary sizes: 8, 16, 32, etc.
• Check addresses before reading/writing them
– AND with mask, ADD offset to prevent anything past boundaries
– Catch fence-post errors by poisoning ends of array
– Alarm on poisoned values
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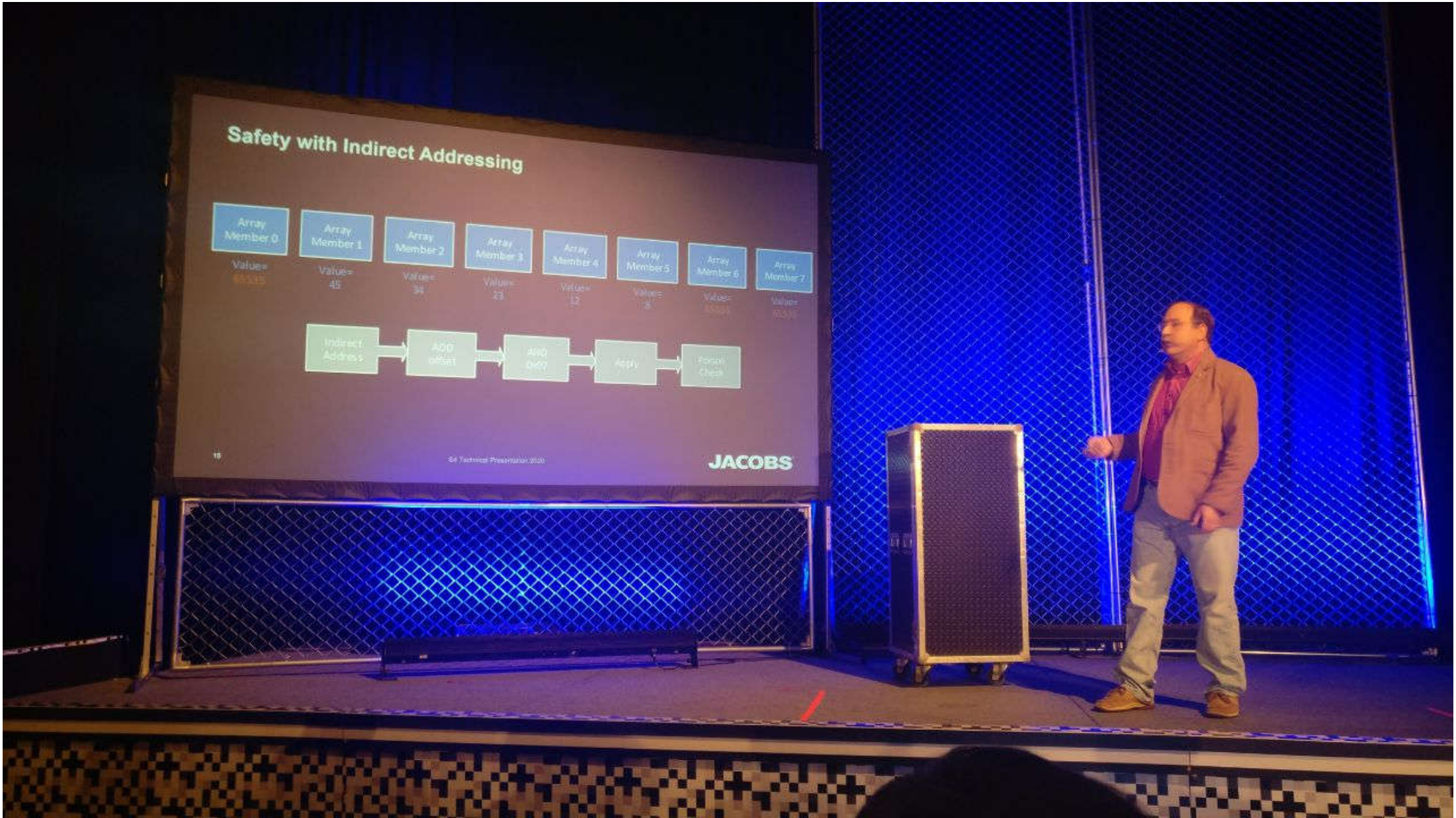
Safety with Indirect Addressing
Array Member 0
Array Member 1
Array Member 2
Array Member 3
Array Member 4
Array Member 5
Array Member 6
Array Member 7
Value= 45
Value= 34
Value= 23
Value= 12
Value= 8
Indirect Address
ADD offset
AND 0xFF
Array
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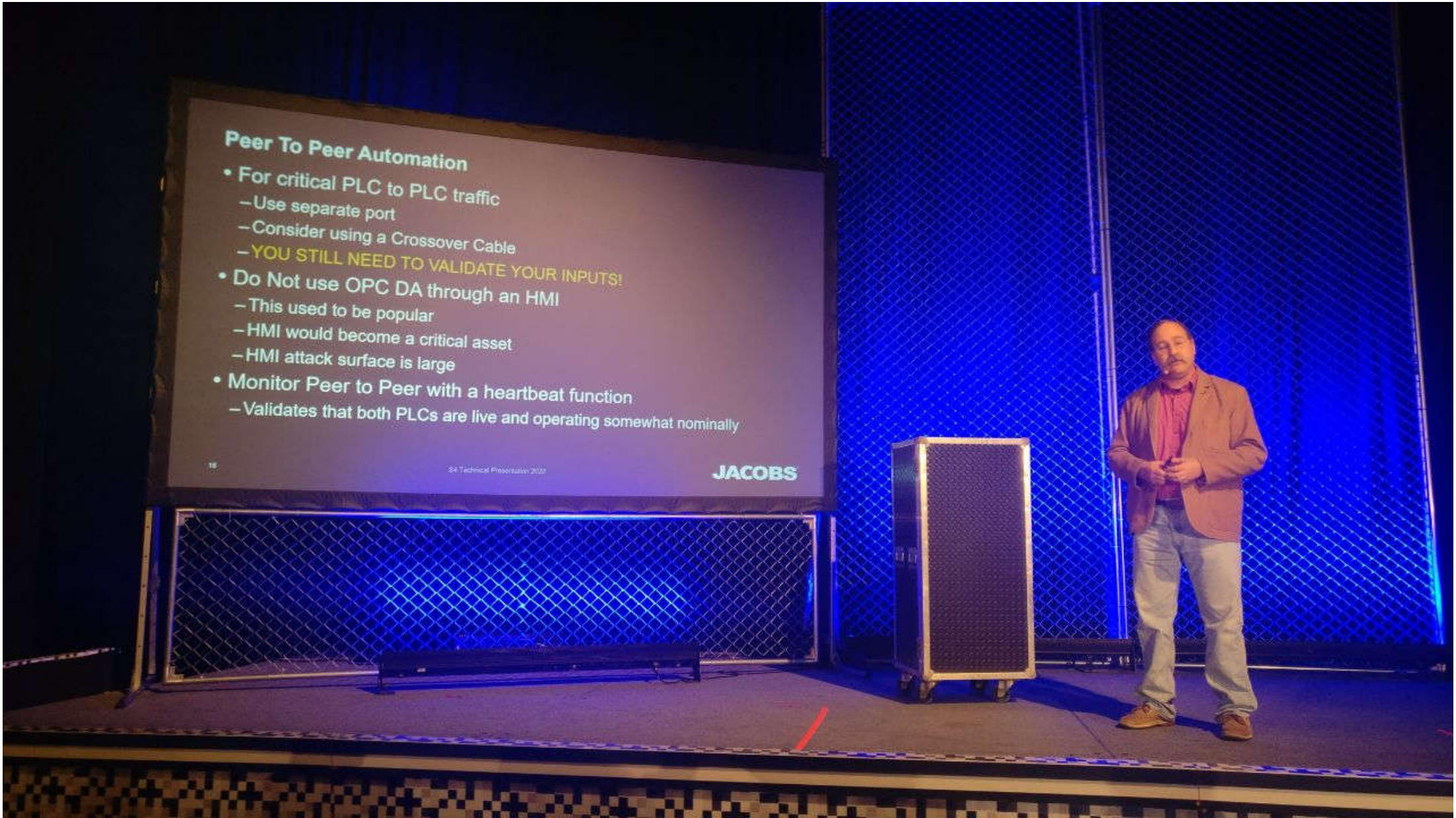
Peer To Peer Automation
• For critical PLC to PLC traffic
– Use separate port
– Consider using a Crossover Cable
– YOU STILL NEED TO VALIDATE YOUR INPUTS!
• Do Not use OPC DA through an HMI
– This used to be popular
– HMI would become a critical asset
– HMI attack surface is large
• Monitor Peer to Peer with a heartbeat function
– Validates that both PLCs are live and operating somewhat nominally
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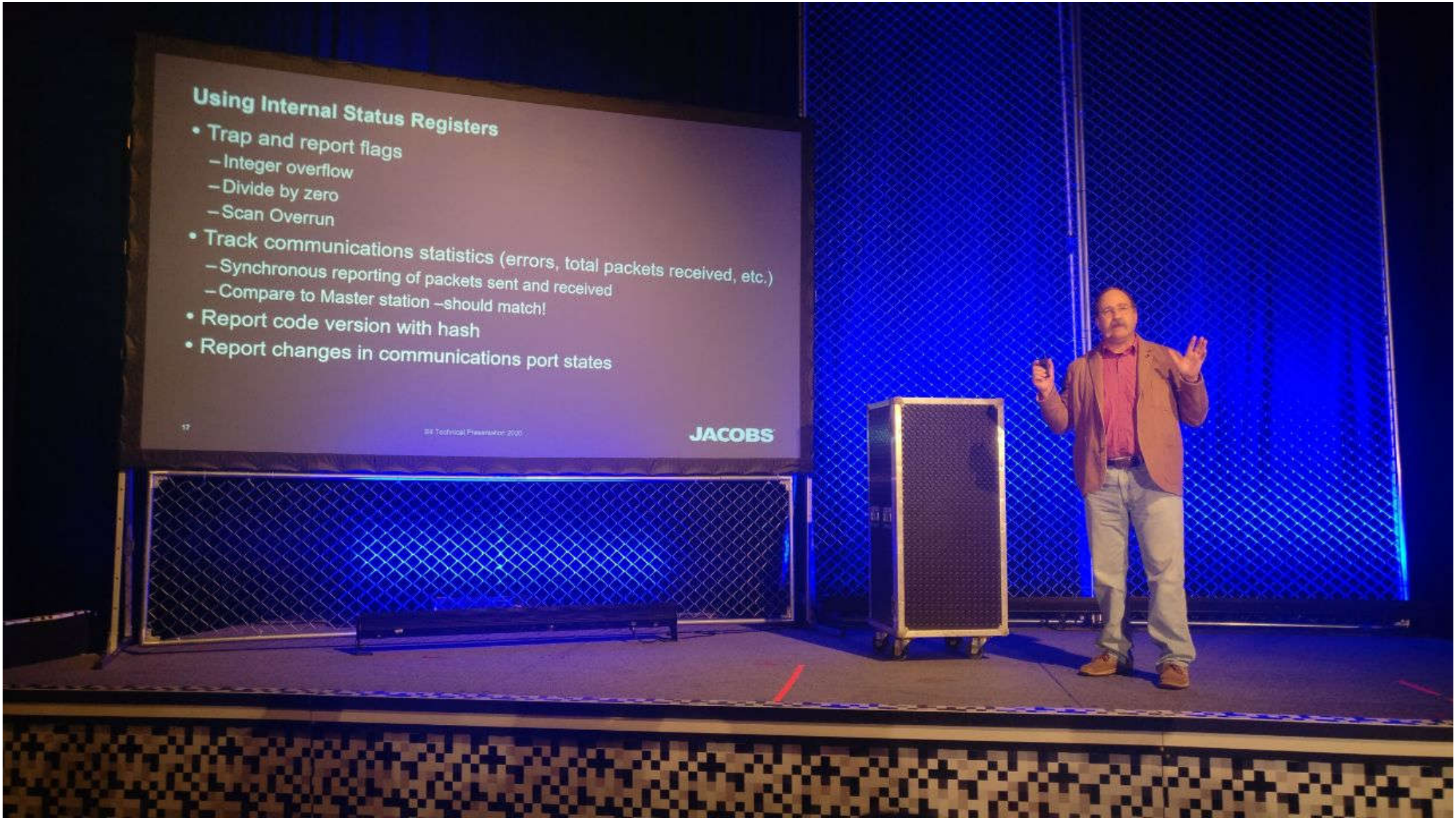
Using Internal Status Registers
• Trap and report flags
– Integer overflow
– Divide by zero
– Scan Overrun
• Track communications statistics (errors, total packets received, etc.)
– Synchronous reporting of packets sent and received
– Compare to Master station –should match!
• Report code version with hash
• Report changes in communications port states
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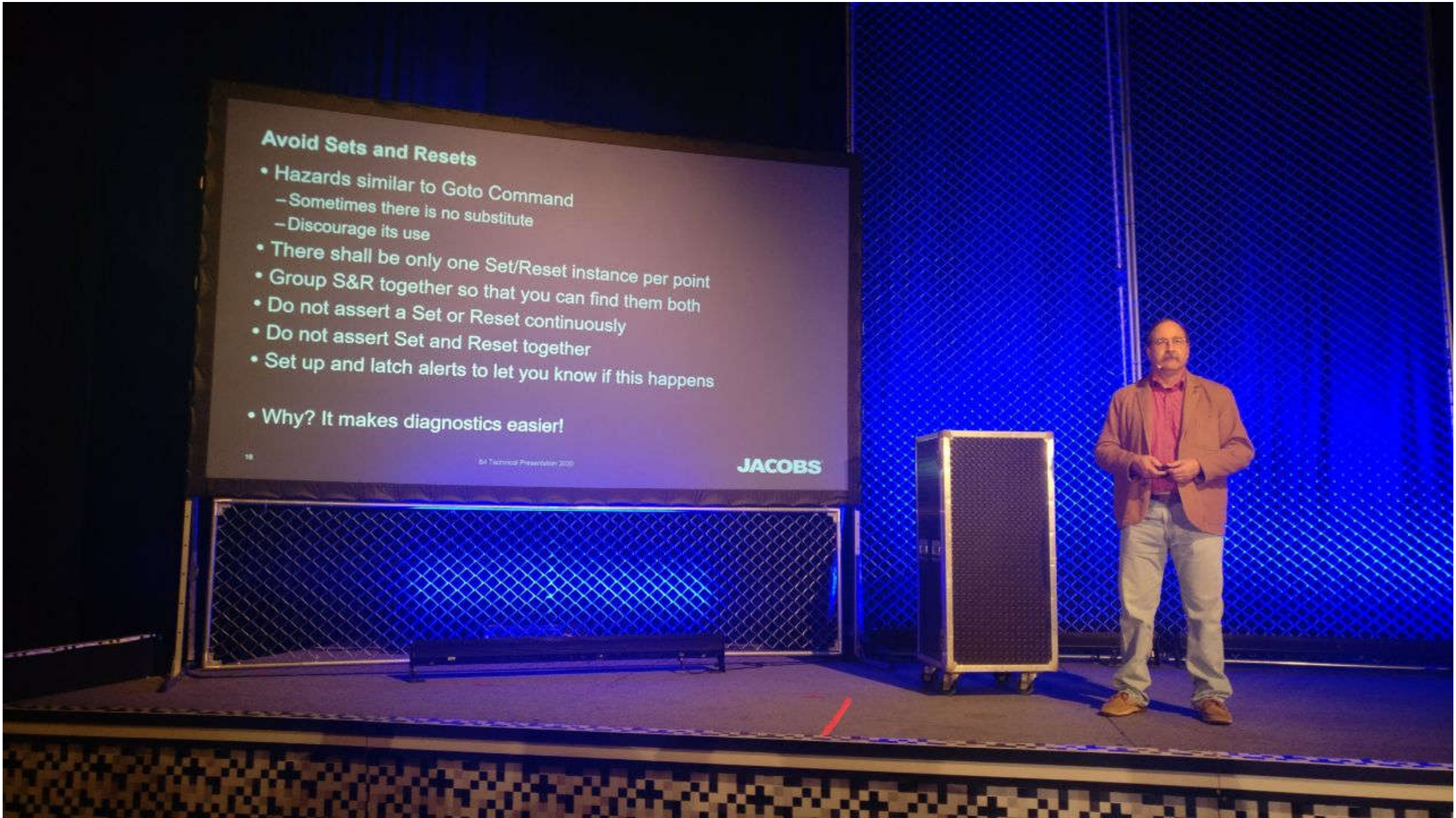
Avoid Sets and Resets
• Hazards similar to Goto Command
– Sometimes there is no substitute
– Discourage its use
• There shall be only one Set/Reset instance per point
• Group S&R together so that you can find them both
• Do not assert a Set or Reset continuously
• Do not assert Set and Reset together
• Set up and latch alerts to let you know if this happens
• Why? It makes diagnostics easier!
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