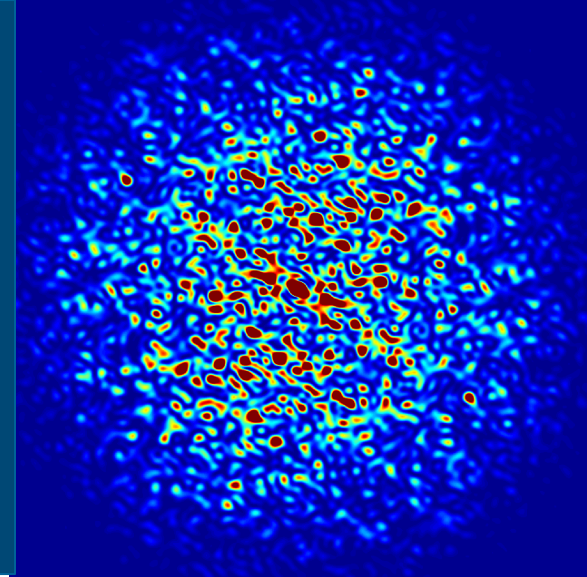# EPICS Upgrade Path for AWA

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AWA Upgrades Mini Workshop
March 25, 2021

Outline

- Existing AWA Controls System Overview

- System Upgrade Assumptions

- AWA Controls System Upgrade Design

- Implementation Consideration, Approaches, and Priorities

- Further Consideration

- Current Status

- Summary

Existing AWA Controls System Overview

- Existing system upgraded from a CAMAC based system over years
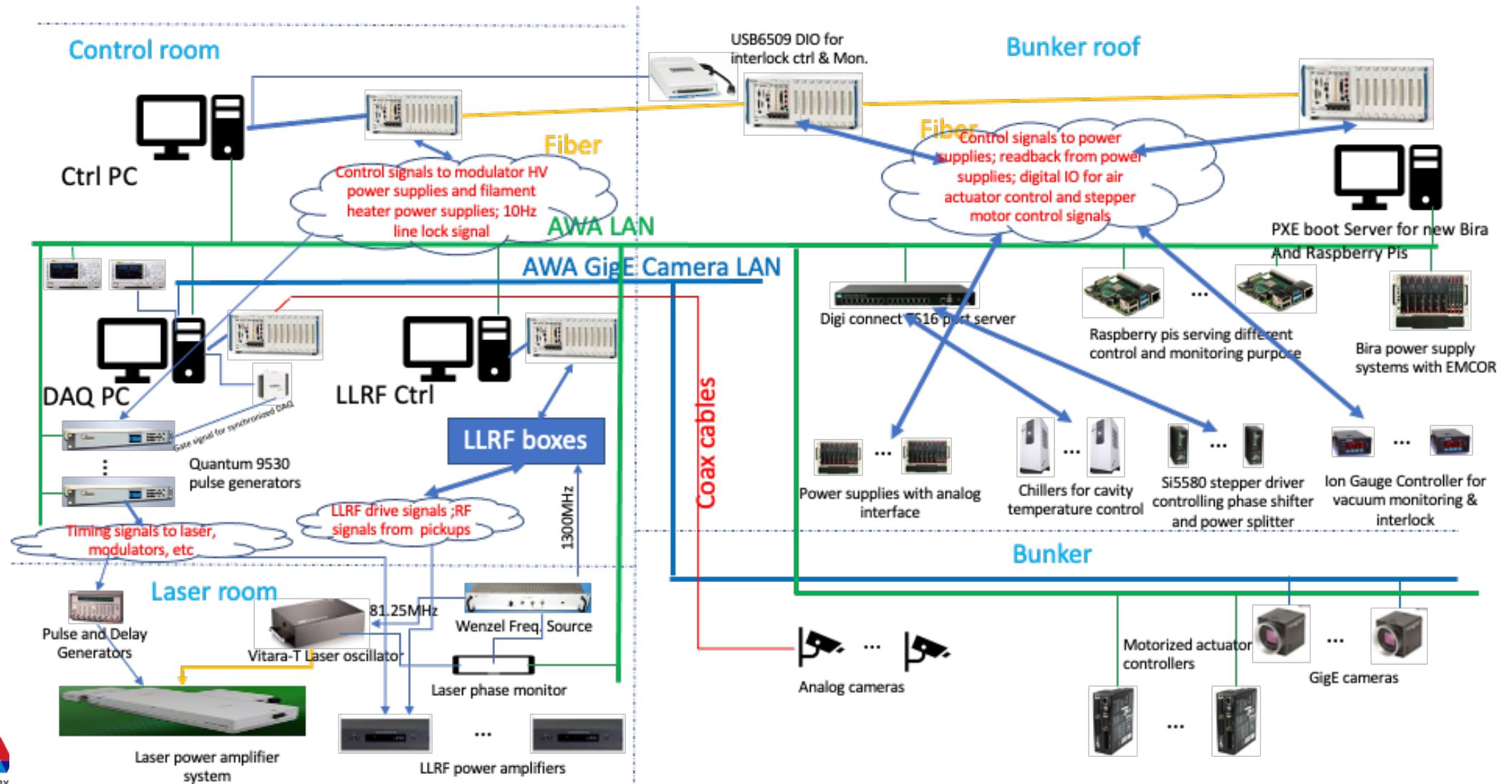
Existing AWA Controls System Overview

- A centralized system with two (2) computers working independently.
  - One is responsible for control and the other one is responsible for data acquisition

Controls Computer

DAQ Computer
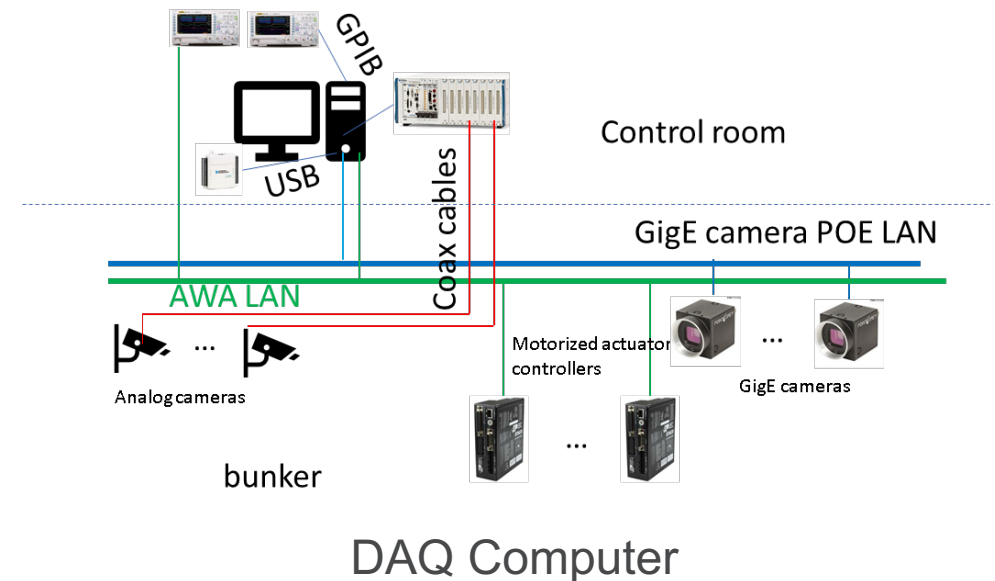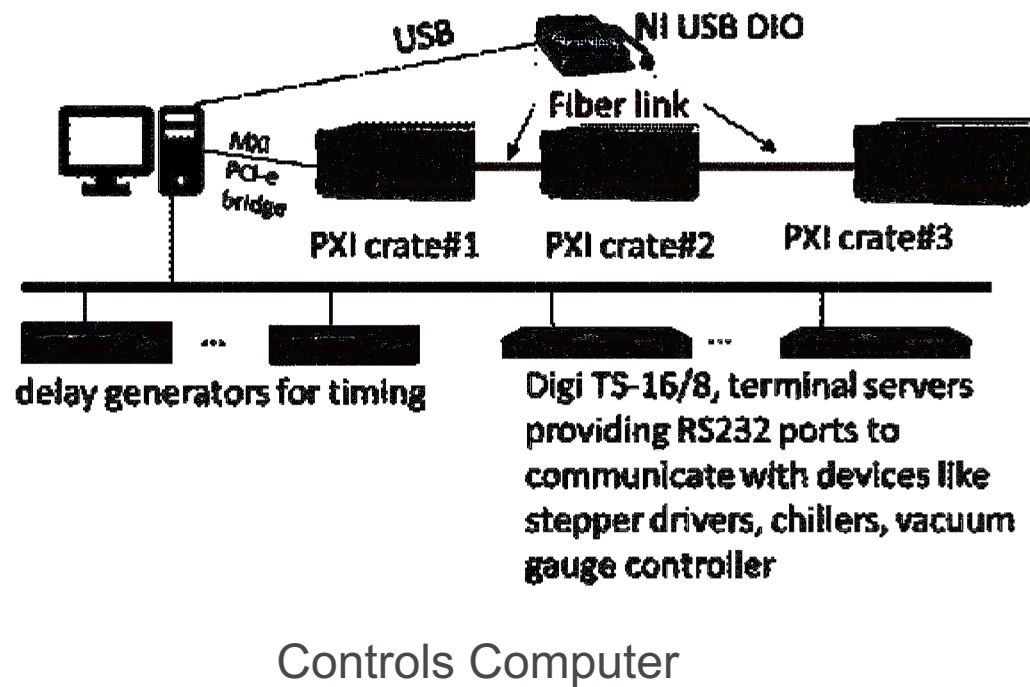
System Upgrade Assumptions

- Control system upgrade shall minimize the impact to AWA operation
- Controls for existing components will continue to be maintained in operations
- Control architecture will be built on existing infrastructure and gradually transit to new infrastructure
- Control hardware will be built as an evolutionary development from existing designs
- Provide EPICS support on top of existing control system and gradually transit to a full EPICS based control system
- Progress compliant with the constrains of both budget and man-power

AWA Controls System Upgrade

- ## Hardware Architecture Consideration
    - Adopt a standard 3-tier distributed structure

Tier-3: Operator Interface
OS:
Unix/Linux
Windows

Tier-2: I/O Controllers (IOC)
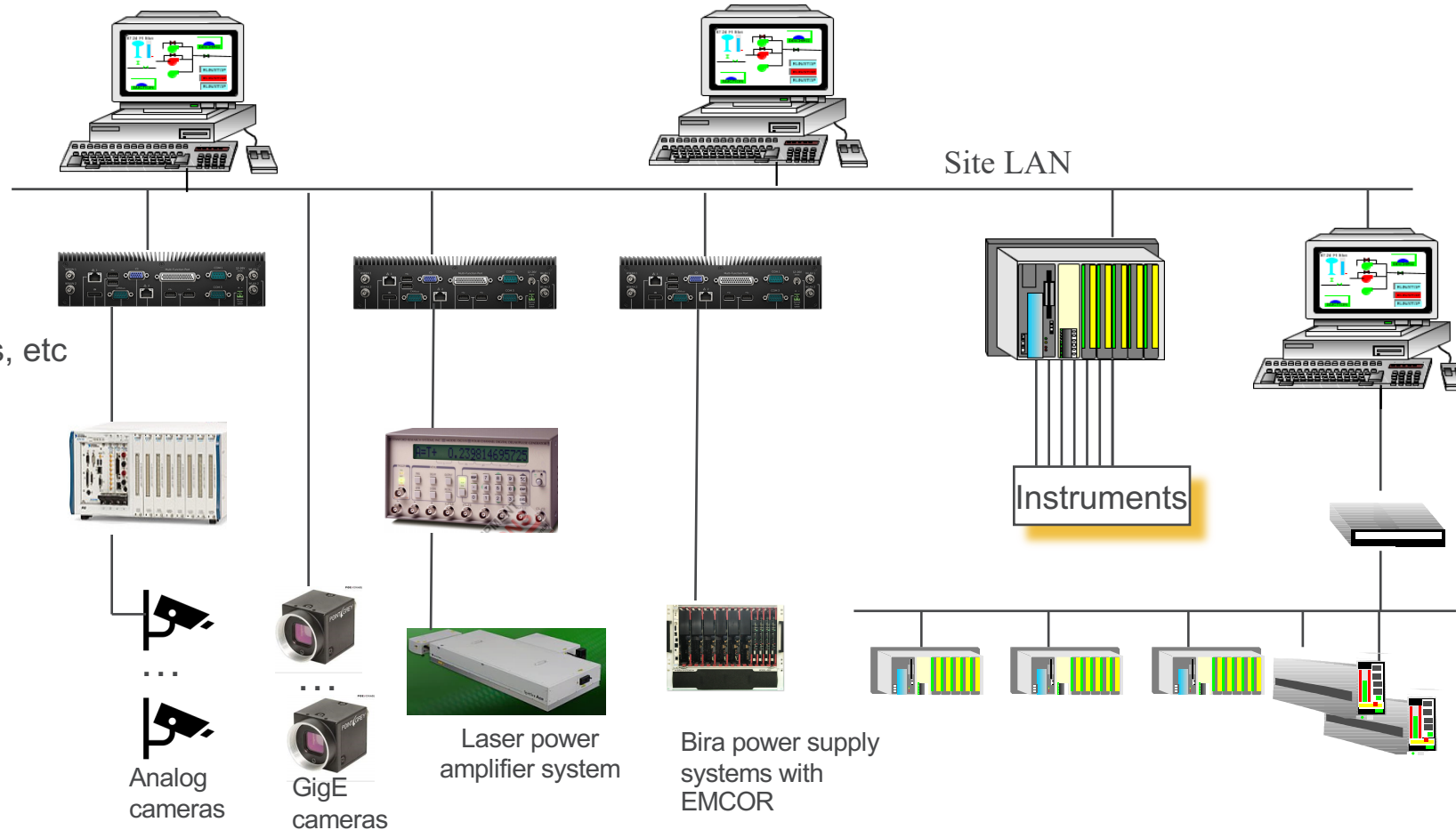VME, uTCA, PCI/PCIe, PLC, FPGAs
OS:
Linux, RTLinux**,** vxWorks, RTEMS, Windows, etc

Tier-1: Remote and Local I/O

Buses:
Ethernet, VME/VXI, GPIB,
Serial, Modbus, Ethernet/IP, ….

Site LAN

Instruments

Analog cameras

GigE cameras

Laser power amplifier system
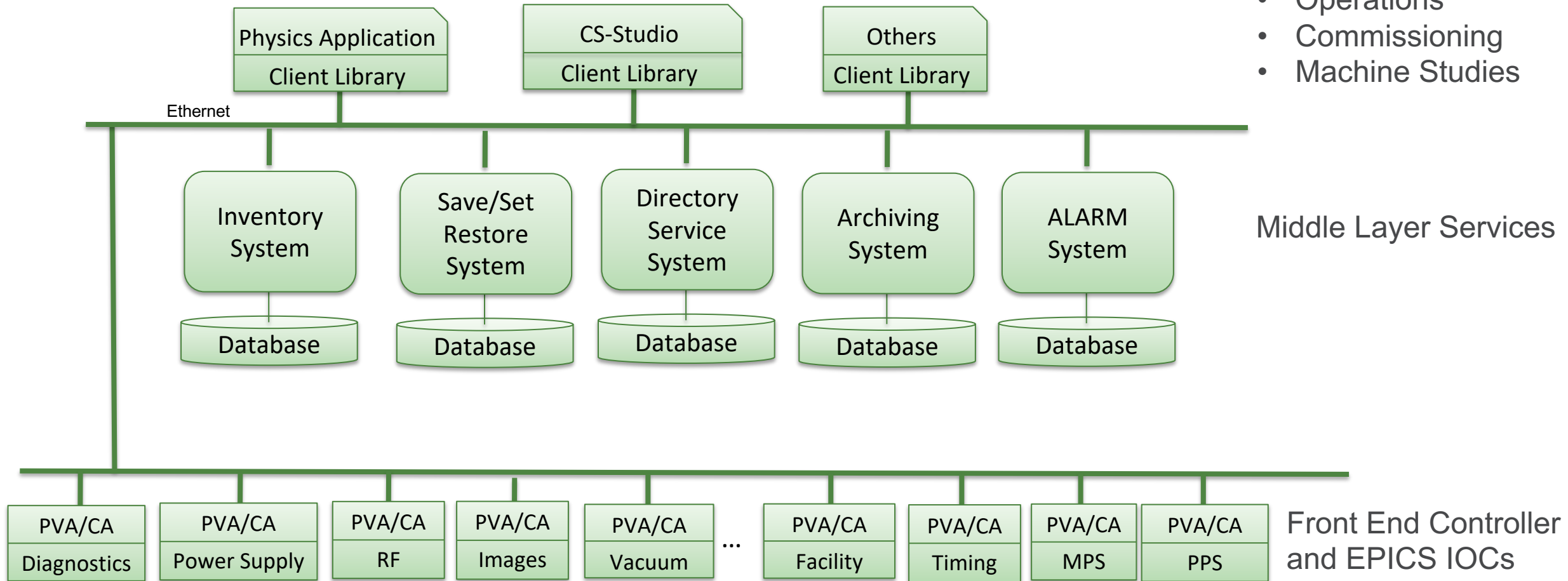
Bira power supply systems with EMCOR

AWA Controls System Upgrade

- ## Software Architecture Consideration
  - Adopt EPICS base software framework

High Level Clients:
- Operations
- Commissioning
- Machine Studies

Physics Application		CS-Studio		Others	
Client Library		Client Library		Client Library	

Ethernet

Middle Layer Services

Inventory System	Save/Set Restore System	Directory Service System	Archiving System	ALARM System
Database	Database	Database	Database	Database

PVA/CA	PVA/CA	PVA/CA	PVA/CA	PVA/CA	...	PVA/CA	PVA/CA	PVA/CA	PVA/CA
Diagnostics	Power Supply	RF	Images	Vacuum		Facility	Timing	MPS	PPS

Front End Controller and EPICS IOCs
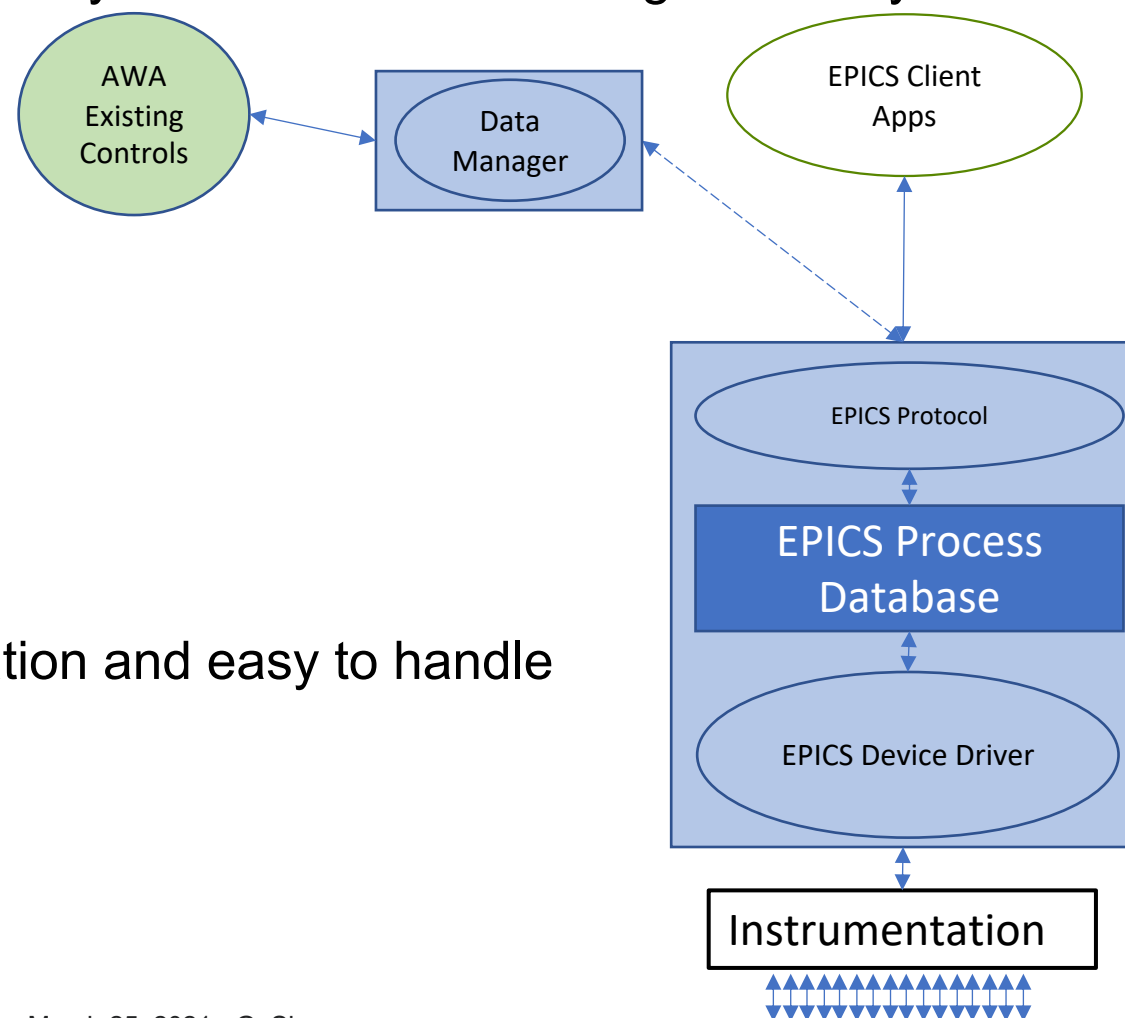
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Implementation Consideration

- Prioritize the development
  - Simple hardware with minimum impact to operation
  - Bridge the existing system
  - Address obsolete hardware and software
  - Reduce some serious failure risks
- Staging approach with different phases distributed over years
  - Allow the AWA team to take advantage of modern hardware and software technologies
  - Position the AWA team to exploit future emerging technologies
  - Gain experience, and smooth the transition from existing controls system to EPICS base controls system
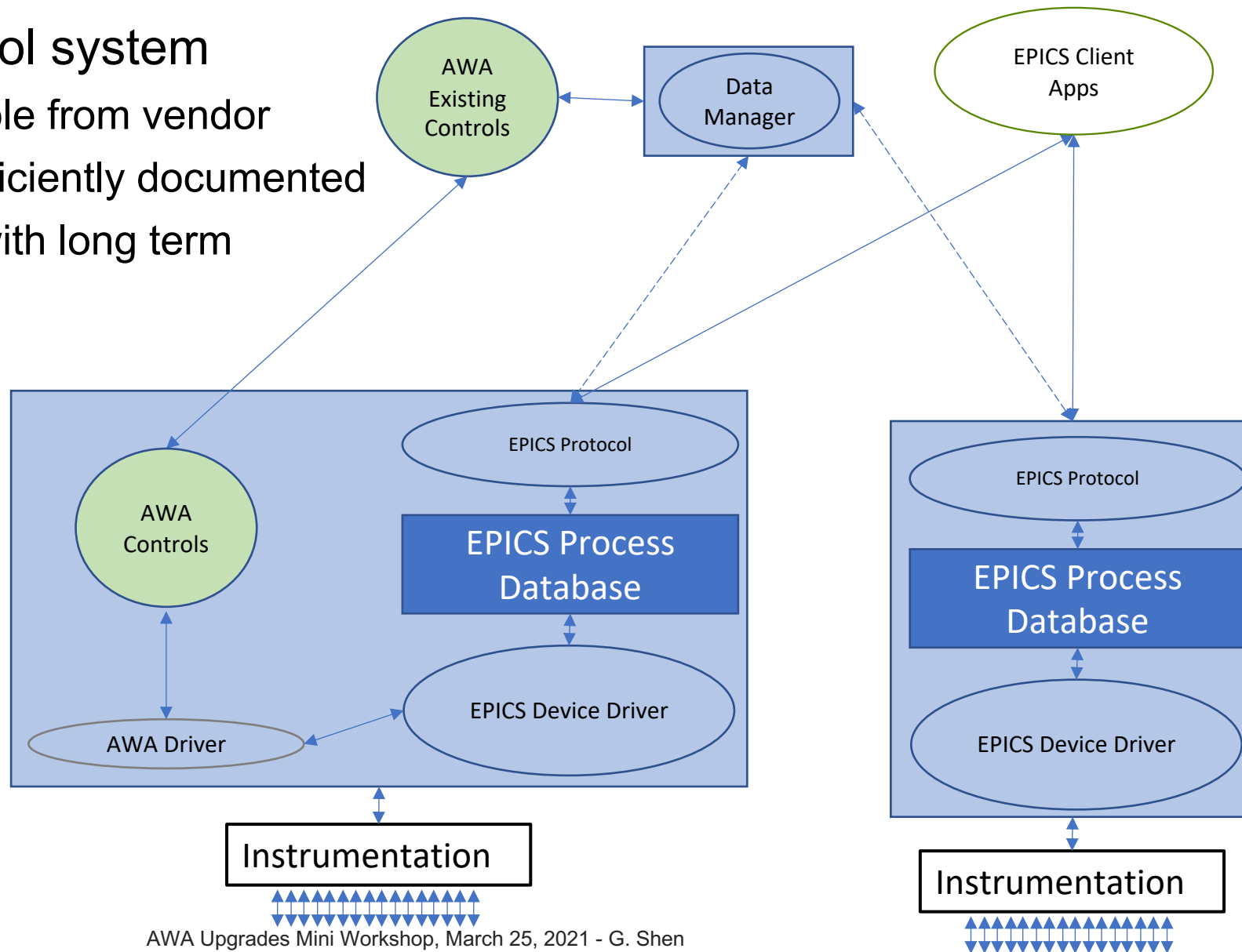
Implementation Approach

- Solution for some system requires minimum effort
  - EPICS driver existed in, and developed by, community which could be leveraged directly
    - Digital camera for example
  - EPICS driver framework existed in, and developed by, community which could be adopted with minimum effort
    - Asyn driver
    - Stream device support
    - Typical hardware
      - Serial-based devices
      - Ethernet based devices
  - Hardware with minimum impact to machine operation and easy to handle

AWA Existing Controls

Data Manager

EPICS Client Apps

EPICS Protocol

EPICS Process Database

EPICS Device Driver

Instrumentation

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Implementation Approach

- **Bridge the existing control system**
  - Driver source code available from vendor
  - Driver library with API, sufficiently documented
  - Most recent devices and with long term maintenance plan
    - Embedded CPU (ARM)
    - Raspberry Pi

Implementation Approach
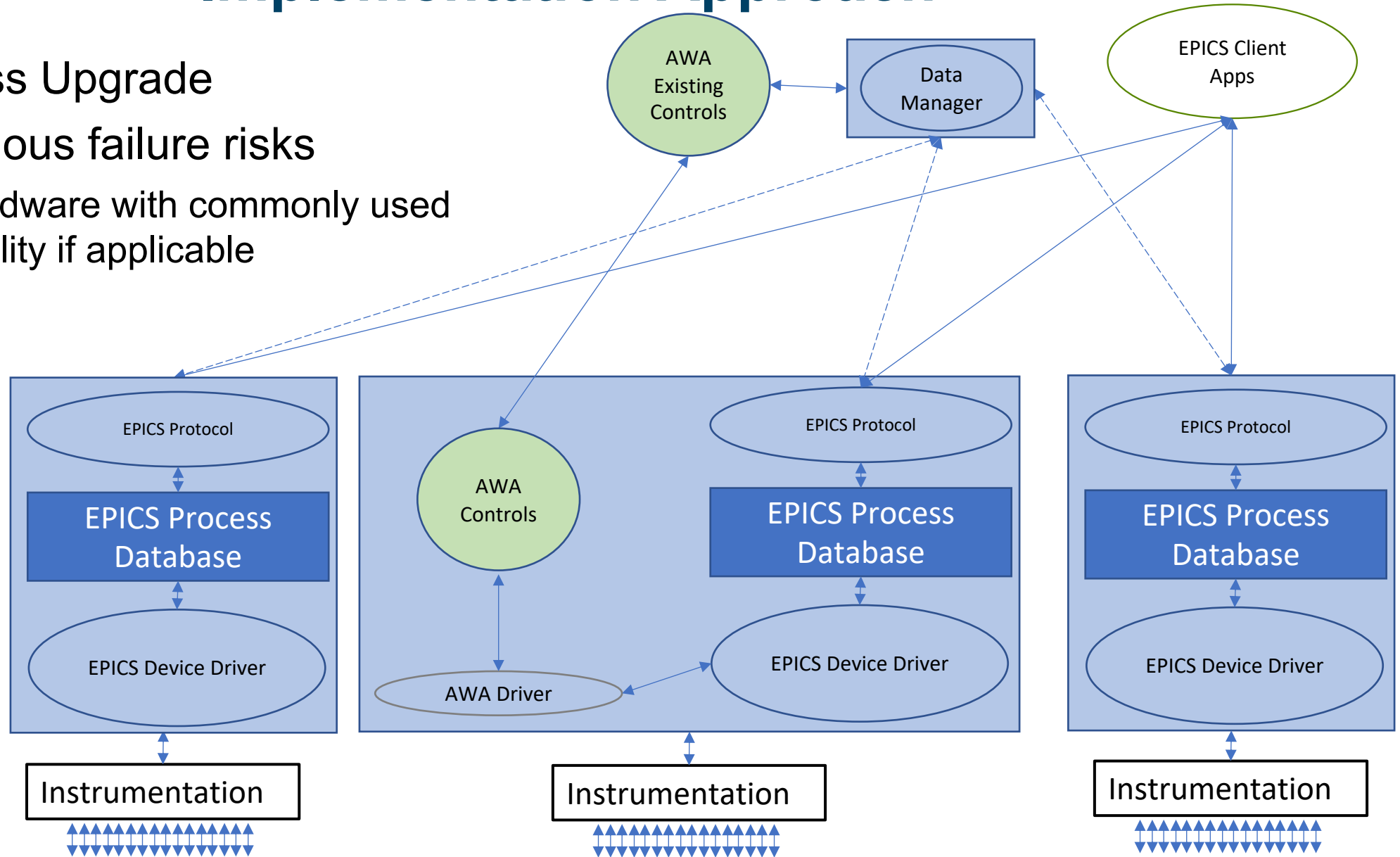
- **Address obsoleteness**
  - Hardware
  - Software
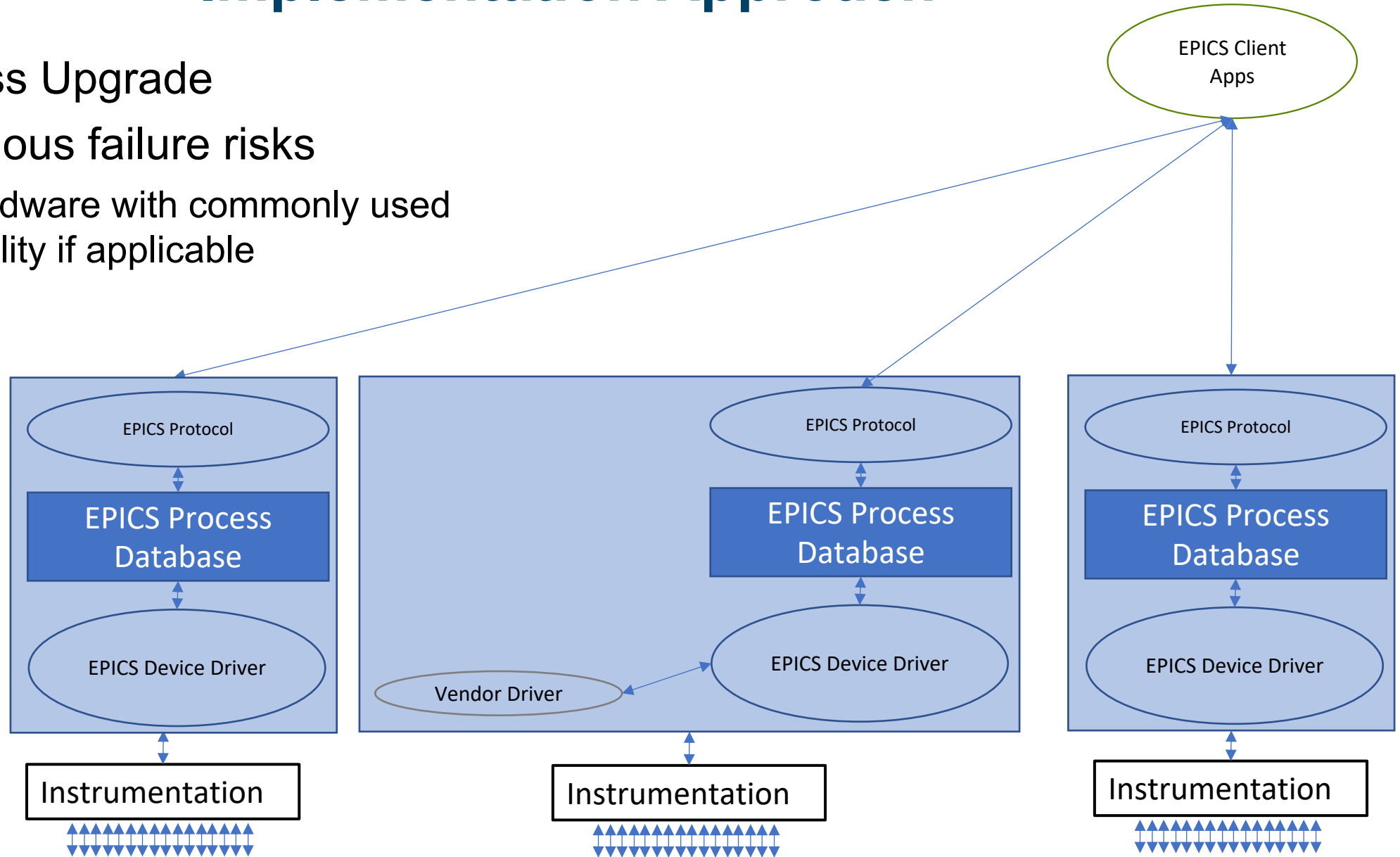- **Replace them gradually**
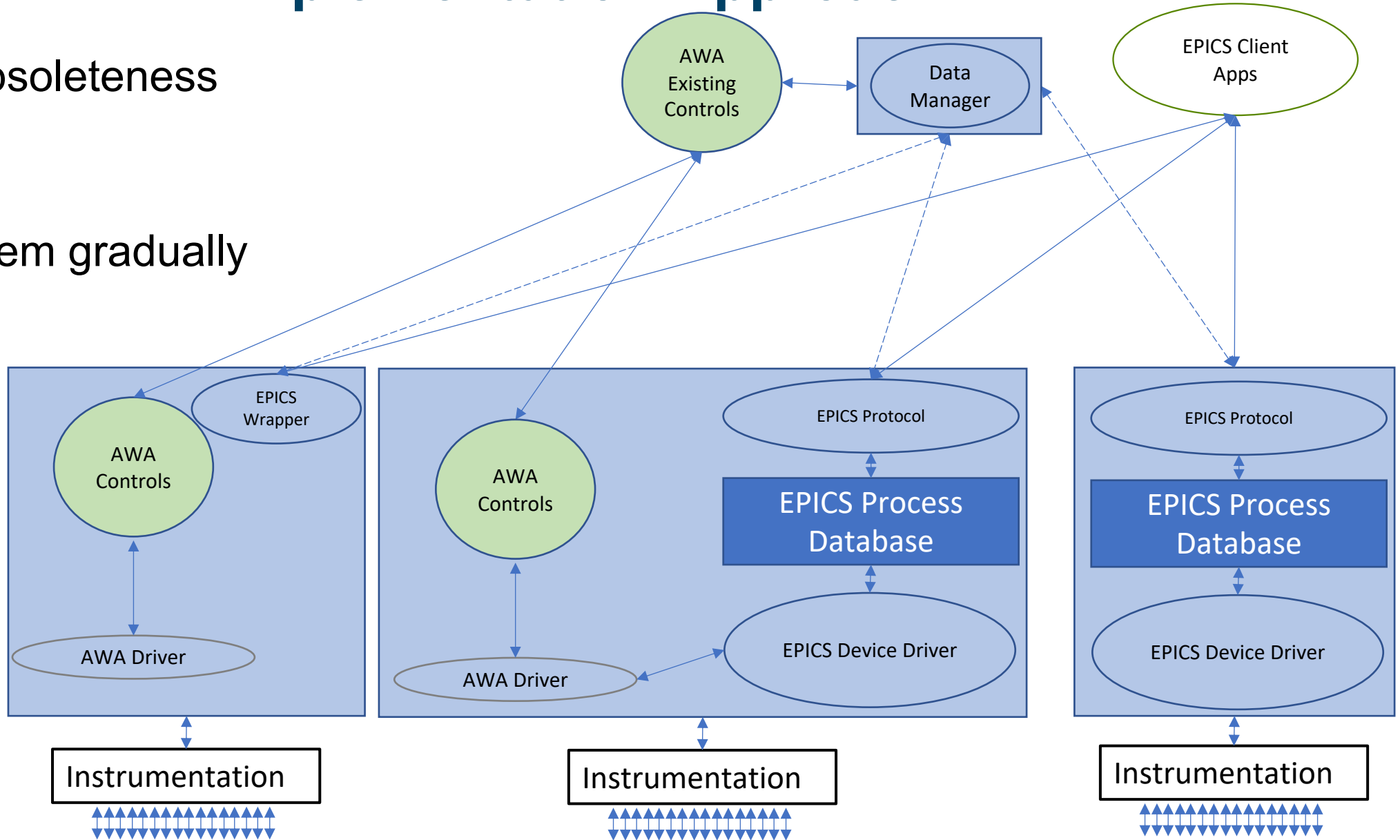
Implementation Approach

- Obsoleteness Upgrade
- Address serious failure risks
  - Replace hardware with commonly used by other facility if applicable

Implementation Approach

- Obsoleteness Upgrade
- Address serious failure risks
  - Replace hardware with commonly used by other facility if applicable

Further Consideration

- Global Systems
  - High Precision Timing
  - Network
  - MPS
  - PPS
  - Facility integration

Industrial I/O Controller

I/O Controller
Data Acquisition Computer

Console Server

Ethernet for EPICS Channel Access or pvAssess

Ethernet instrumentation bus

Ethernet pvAccess for DAQ
Mitigation Node

Signal

PLC

Deterministic Communication Network

Deterministic Timing Distribution Network

Master Timing
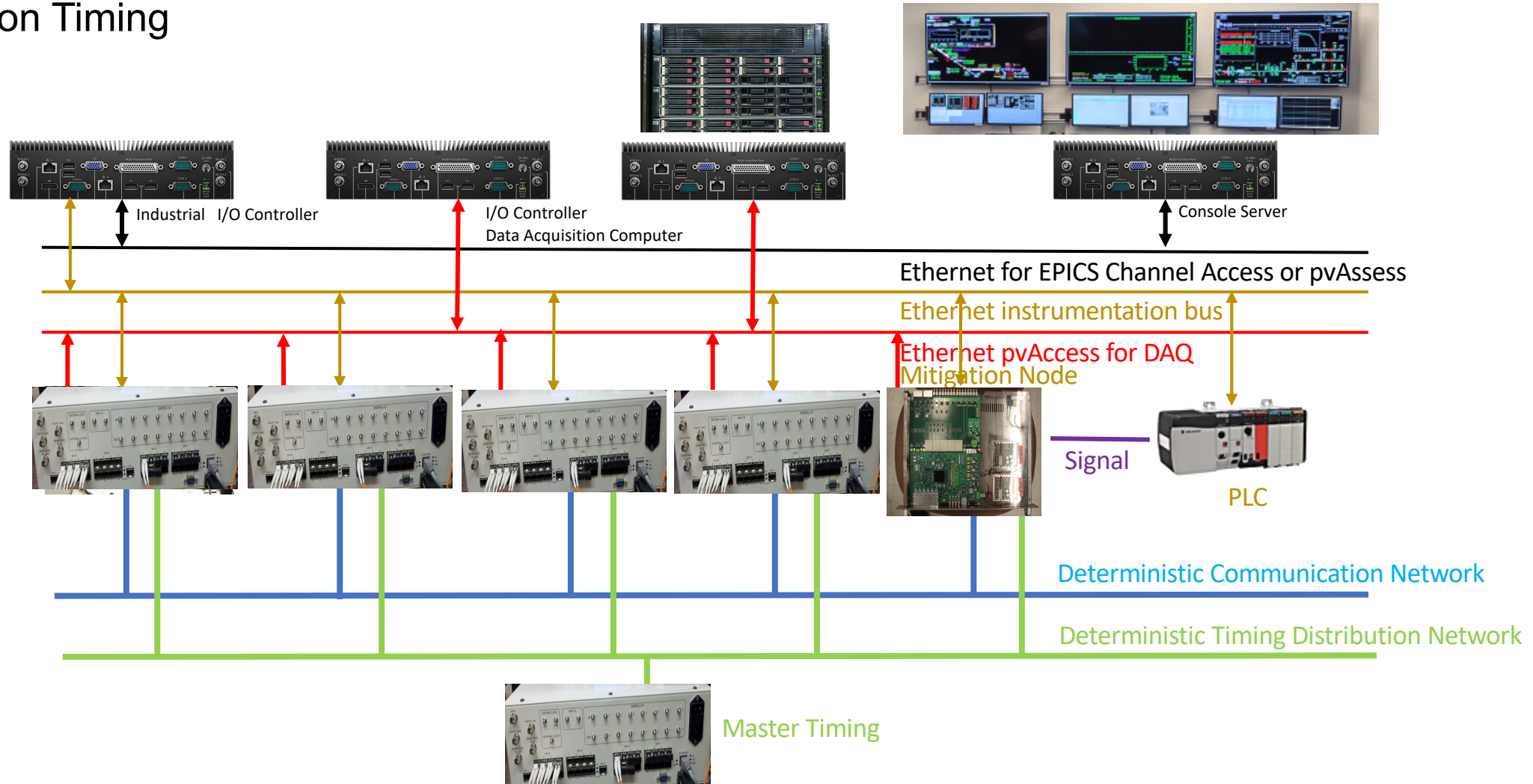
AWA Controls System After Upgrade

Operator stations: Displays

Archiving, Alarm Management,
Strip charts, Save/Restore Utility

Fiber Network for High Performance System (Timing, etc)

Data Acquisition

Ethernet – EPICS Channel Access, PTP/NTP Timing

I O C	Serial Comm	PLC (DI, DO, Temp, Interlock)

Vacuum Controller (Pump, Gauge, Valve, …)

Vacuum Control

C P U	E V G

High Precision Timing

IOC	PLC (Temperature, Interlock)

Power Supply
Magnet

Power Supply Control

LLRF IOC	HVRF IOC

LLRF	RF Amp

RF Control

IOC (AI, AO)	PLC (DI, DO, Temp, Interlock)

Digitizer	Motor Controller
Analog Front End	Motor

Diagnostic Control

I O C	Motor Controller	DAQ

Motion Control

Experimental System

Current Status

- AWA team has practiced and finished the following
  - EPICS base on Windows 10 Platform
  - EPICS base for Raspberry Pi
  - EPICS base for PXE server
  - Asyn driver on windows 10
  - Stream device support module on windows 10
- EPICS IOC development with Asyn & Stream device
  - About 90% IOC for beamline controls
  - About 30% IOC coverage for over all facility

NOTE: All above progress made by Wanming Liu @ AWA Team

Summary

- Current AWA controls is a centralized system with two (2) computers working independently, which was upgraded from a CAMAC based system over years
- The control system new design adopts a distributed system with standard 3-tier hardware and software architecture
- EPICS software has been decided for next generation of AWA control system
- The design has taken into consideration to minimize the impact to facility operation
- Staging approach with different phases proposed
- Development has been prioritized
- Some good progress have been made already by AWA team