Mu2e CD3c Review
WBS 9.1 & 9.2 Management & System Design and Test
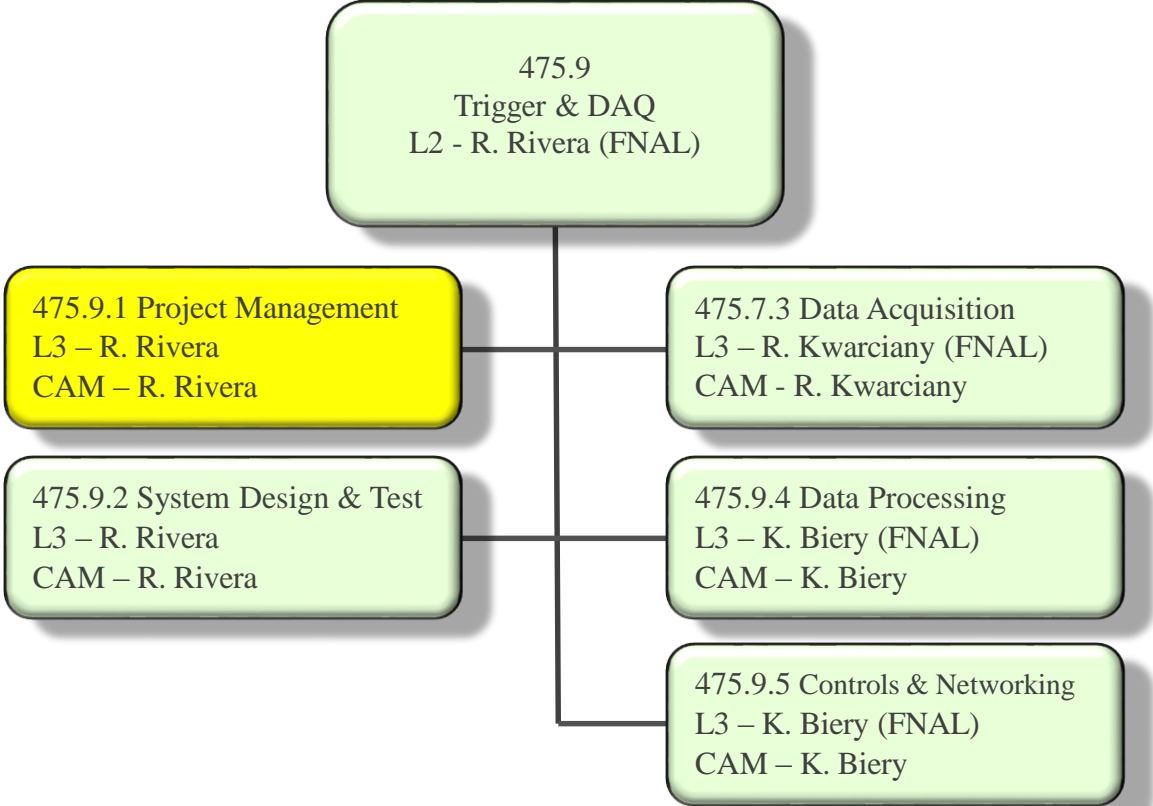
R. Rivera

Mu2e TDAQ L2 Manager

4/20/16

TDAQ Management Team

- Ryan Rivera – L2 Manager, L3 Manager (Project Management, System Design & Test)
  - Group Leader - Real-time Systems Engineering, Detector Electronics Group
  - 13 years experience

- Kurt Biery – L3 Manager (Data Processing, Control & Networking),
  - Department Head - Scientific Computing Division, Real-time Systems Engineering Department
  - 18 years experience

- Rick Kwarciany – L3 Manager (Data Acquisition)
  - Electrical Engineer – Real-time Systems Engineering
  - 33 years experience

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TDAQ Team

- Fermilab
  - Management, Hardware, Firmware, and Software
  - R. Rechenmacher, G. Deuerling, E. Flumerfelt, M. Bowden

- Kansas State University
  - Detector Control System
  - G. Horton-Smith

- Caltech
  - Communication Protocol, Online Filter
  - T. Miyashita

- Institutions funded through annual SOWs

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TDAQ Organization

475.9
Trigger & DAQ
L2 - R. Rivera (FNAL)

475.9.1 Project Management
L3 – R. Rivera
CAM – R. Rivera

475.7.3 Data Acquisition
L3 – R. Kwarciany (FNAL)
CAM - R. Kwarciany

475.9.2 System Design & Test
L3 – R. Rivera
CAM – R. Rivera

475.9.4 Data Processing
L3 – K. Biery (FNAL)
CAM – K. Biery

475.9.5 Controls & Networking
L3 – K. Biery (FNAL)
CAM – K. Biery

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Scope

WBS 475.9.1
Project Management
R. Rivera / Fermilab

475.9.1.3 **Implementation & Close-out**
Management activities following CD-3. Includes status reports, change requests, project closeout activities.

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TDAQ Requirements

- Requirements for TDAQ are described in mu2e-docdb 1150.

- Collect and assemble data from the Tracker (~18 GBytes/sec) and Calorimeter (~8 GBytes/sec) for online filtering.

- Facilitate online filtering to reduce Tracker & Calorimeter data volume by ≥ 99%.

- Combine with data from CRV, Extinction Monitor, and Stopping Target Monitor for transfer to offline storage.

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TDAQ Requirements

- Provide global timing synchronization

- Provide mechanism for detector partitioning and calibration

- Provide fast and slow control networks

- Provide connections to offline storage and site networking

- Provide control room operator interfaces

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TDAQ Design
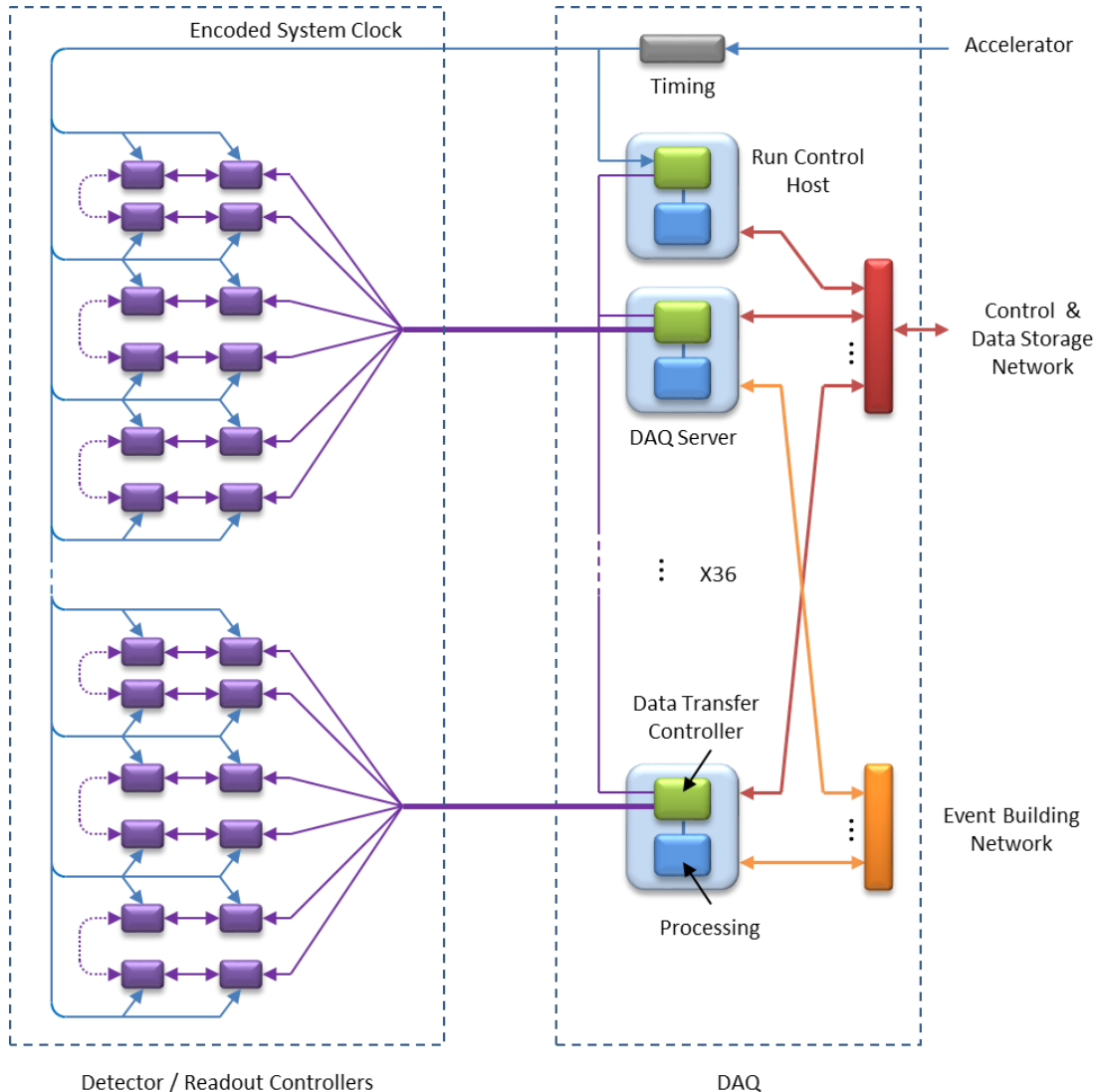
- architecture supports both streaming (Tracker, Calorimeter) and triggered (CRV) readout

- DAQ Servers handle data readout, event building and processing

- large front-end buffers for uniform data transfer

- scalable architecture... 1 GByte/sec per DAQ server

- expected 39 GB/s in with 68 GB/s available and 7 PB/yr offline storage

Design – Commercial Hardware

- DAQ Server
  - 3U rack-mount computer
  - integrated DAQ and online processing
- Data Transfer Controller (DTC)
  - PCIe card with FPGA, memory, and 8-port SFP+ optical interface (links at 3.125 Gbps)
  - 1 GByte/sec readout bandwidth
  - Firmware development
- Event Building network
  - 48 port 10G Ethernet switch

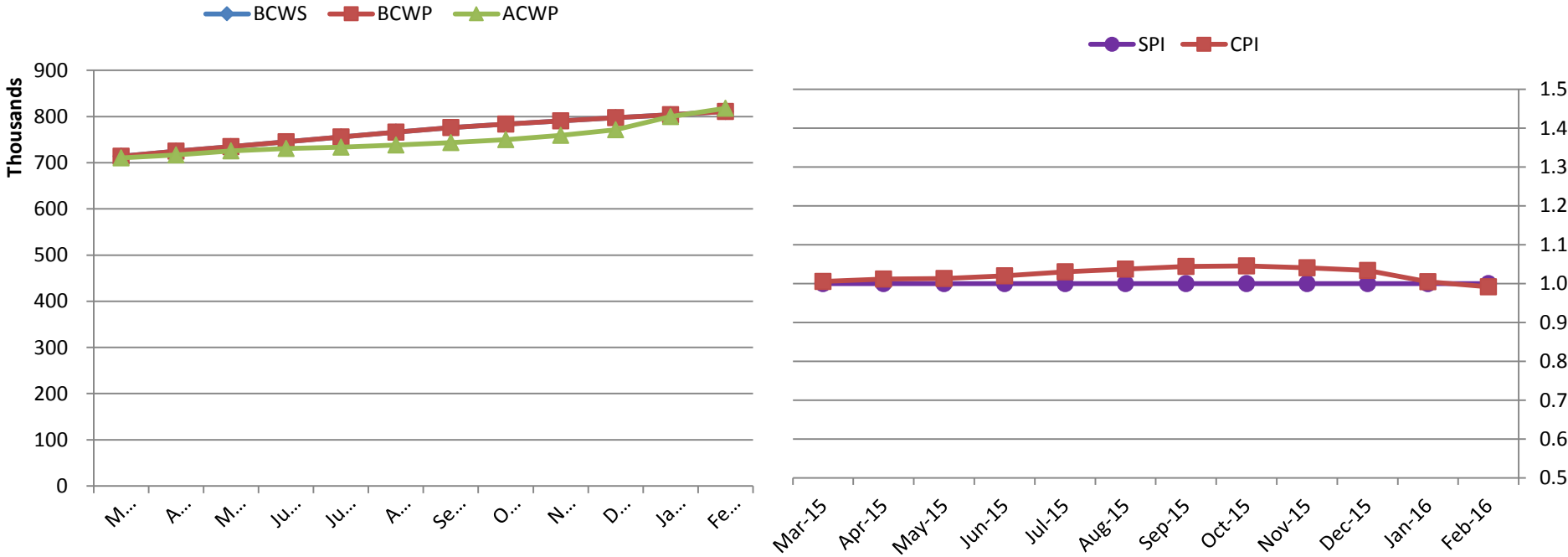Fermilab
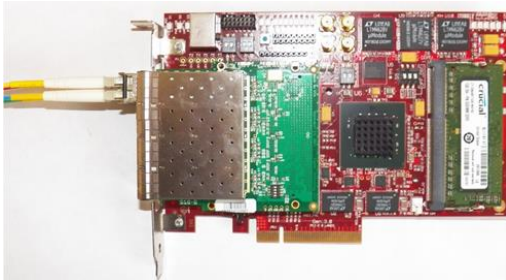
DAQ Design Review and Status

- A DAQ Design Review was held on Jan 26, 2016
  - John T. Anderson (ANL – Chair)
  - Jon Paley (FNAL)
  - Jamieson Olsen (FNAL)
  - Mark Paterno (FNAL)
  - Alan Prosser (FNAL)
- Committee answered yes to all charge questions
- Design is 90% complete.
- Primary risk to DAQ is an underestimation of detector rates
  - DAQ has been designed to be flexible, scalable and with significant headroom to mitigate this risk.
- Final report is in mu2e-docdb 6377

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Design Maturity and Path to Completion

- Design is mature:
  - Hardware selected
  - Firmware and software block diagrams
  - Pilot system functional
- Remaining 10%:
  - Connector/format choices
  - Bit level definition of packet protocol fields
  - DCS channels to monitor
- Low risk associated with the remaining design work
- Primary work remaining is implementing the design

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Cost and Schedule Performance

475.09.01 TDAQ Project Management

- No significant variances.

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Performance

Mu2e Project

February 29, 2016

Currency in: $K

Control Account, Work Package.CTC	Current Period							Cumulative to Date						
	Budget	Earned	Actuals	SV ($)	SV (%)	CV ($)	CV (%)	Budget	Earned	Actuals	SV ($)	SV (%)	CV ($)	CV (%)
475.09.01 TDAQ Project Management	7	7	18	0	0%	(11)	-147%	811	811	818	0	0%	(7)	-1%
475.481 475.09.01.01 Project Management Conceptual Design (OPC)	0	0	0	0	0%	0	0%	321	321	321	0	0%	(0)	0%
475.482 475.09.01.02 Project Management: Engineering Phase (PED)	0	0	0	0	0%	0	0%	393	393	393	0	0%	1	0%
475.484 475.09.01.04 Project Management: Implementation & Close-out Ph	7	7	18	0	0%	(11)	-147%	97	97	104	0	0%	(7)	-8%

Control Account, Work Package.CTC	At Complete				
	BAC	EAC	VAC	% Spent	% Complete
475.09.01 TDAQ Project Management	1,222	1,230	(8)	66%	66%
475.481 475.09.01.01 Project Management Conceptual Design (OPC)	321	321	(0)	100%	100%
475.482 475.09.01.02 Project Management: Engineering Phase (PED)	393	393	1	100%	100%
475.484 475.09.01.04 Project Management: Implementation & Close-out	508	517	(9)	20%	19%

- No significant variances.

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Change Control

Control Account	CR #	CR Description	Prior Start	Revised Start	Prior Finish	Values Revised Finish	BAC Before	BAC After	Cost Increase / (Decrease)
475.09.01	2	Establish internal baseline and incorporate recommendations from Director's Review.	-	-			855,597.23	853,368.54	(2,228.69)
	6	Corrections made to CR002	-	-			853,368.54	1,170,715.74	317,347.20
	3	New rate adjustments for labor fringe and overhead.	-	-			1,170,715.74	1,165,478.89	(5,236.85)
	4	Cost leveling; new CD-3c strategy	-	-			1,165,478.89	1,165,468.36	(10.53)
	8	FY15 Rate changes	-	-			1,165,468.36	1,206,488.38	41,020.02
	12	Solenoids PS and DS Contract terms and Accelerator design reviews	11/25/2009	11/25/2009	10/9/2020	11/3/2020 11/25/202	1,206,488.38	1,210,540.54	4,052.16
	13	Implement DOE Follow-Up CD-2/3b Recommendation (BAC=EAC)	11/25/2009	11/25/2009	11/3/2020	0	1,210,540.54	1,214,017.82	3,477.29
	15	Establish CD-2 Baseline	11/25/2009	11/25/2009	11/25/2020	1/13/2021	1,214,017.82	1,206,924.24	(7,093.59)
	17	PS/DS Vendor Pay Milestones; Remote Handling Design	11/25/2009	11/25/2009	1/13/2021	1/14/2021	1,206,924.24	1,207,141.57	217.33
	19	Reduced Constr oversight, FFP ECPs, and TS Module fab delay	11/25/2009	11/25/2009	1/14/2021	4/8/2021	1,207,141.57	1,219,964.05	12,822.49
	22	Detector Bldg. changes; Award TS Module fab; Test Cryostat mods and move	11/25/2009	11/25/2009	4/8/2021	1/13/2021	1,219,964.05	1,206,924.24	(13,039.82)
	24	FY16 Rate Update	11/25/2009	11/25/2009	1/13/2021	1/13/2021	1,206,924.24	1,222,034.94	15,110.70
475.09.01 Total									366,437.71

- There have been no changes in the TDAQ Management plan.

- The changes listed above have been a consequence of changes in schedules and labor rates outside of TDAQ.
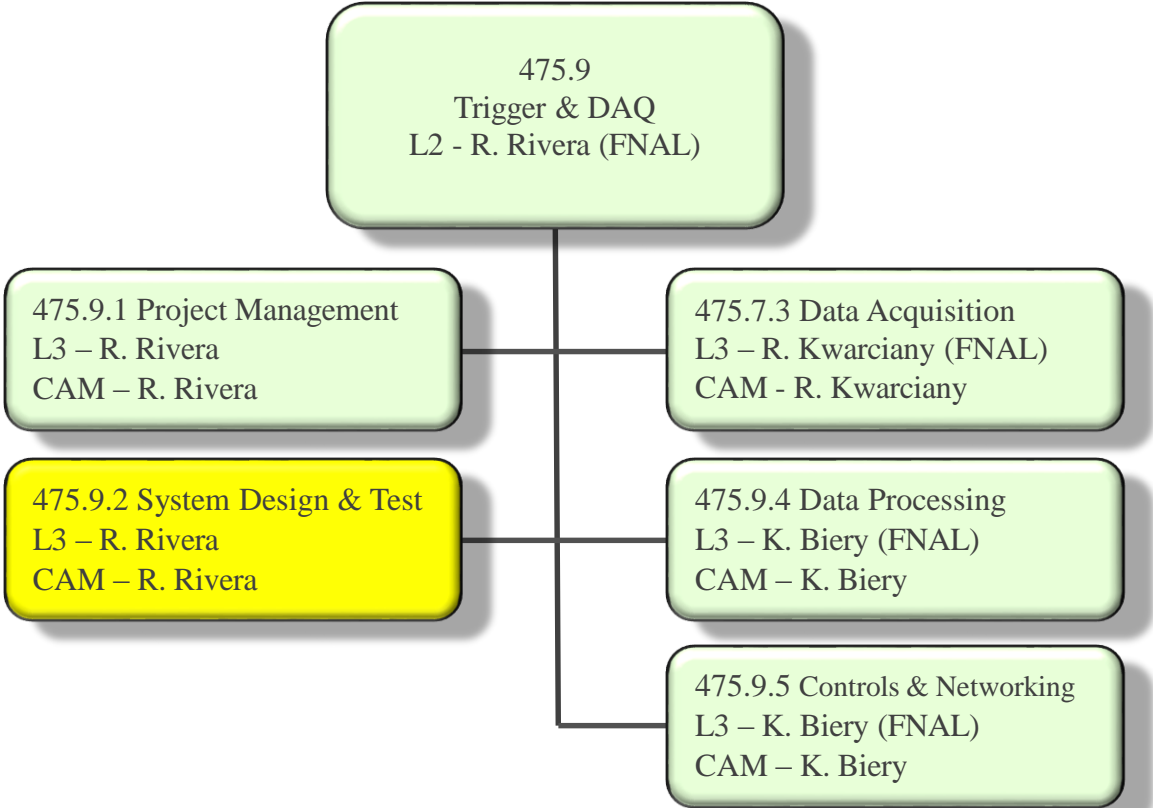
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TDAQ Interfaces

- Internal and external interfaces identified and described in DAQ Interface document (docdb #1520).

- DAQ has external interfaces to Conventional Construction (space, power, cooling, cable paths), Muon Beamline, Tracker, Calorimeter, and CRV (monitoring, control/timing, data), Accelerator (monitoring, timing), Solenoids (monitoring), and site networking.

- Internal interfaces between servers, timing system and general-purpose networking.

- Participation in Electronics and Detector integration meetings.

- Participation in Software and Simulations meetings.

- Maintain web notebook: http://www-ese.fnal.gov/mu2e/notebook

Interfaces are understood and under control

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TDAQ Risks

- 6 TDAQ risks in Risk Register
  - 3 Threats
    - 0 High
    - 3 Moderate
  - 3 Opportunities
- Detailed mitigation plans for all risks, documented in risk forms on docdb and linked from Risk Register (docdb 4320)
  - TRIG-128, Threat, Insufficient manpower for DAQ software.
  - TRIG-130, Threat, Insufficient DAQ online processing.
  - TRIG-131, Threat, Higher than expected data rates to the DAQ.

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TDAQ Organization

475.9
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Scope

WBS 475.9.2
System Design & Test
R. Rivera / Fermilab

475.9.2.4 Production System
Perform system level integration and operational tests. Perform production system failure modes effects analysis. Revisions to system design as needed. Integration testing of DAQ and DCS with detector and beamline, cosmic ray system test.

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Quality

- TDAQ Quality plans included in Mu2e Quality Planning Document
  - Developed in conjunction with the QA manager
 - Available on web page (docdb 6005)

Sub-Project	Deliverable	QA or QC Step?	QA or QC Process Documentation (DocDB #)	Inspection or Acceptance Criteria/Plan	Verification	Records (DocDB# or Database Reference)
TDAQ L2	System Software/Firmware	Version Control	FNAL Engineering Manual	NA	All software/firmware development	NA
TDAQ L2	System Software/Firmware	Code Verification/Profiling	FNAL Engineering Manual	NA	All software/firmware development	NA
TDAQ L2	System Software Databases	Integrity Checks	FNAL Engineering Manual	NA	All software/firmware development	NA
System Design & Test	System	Design Reviews	Mu2e Design Review DocDB #5061	DAQ Requirements DocDB #1150	Independent review of requirements, data rate assumptions	Design Review Docs (Final Design Review DocDB #6377)
System Design & Test	Readout Controller Integration Tests (Tracker, Calorimeter, CRV)	Verify external detector interfaces	Final Design Report Chapter DocDB #6377	Trigger and DAQ Interfaces DocDB #1520	Sub-detector interface tests	Test Results
System Design & Test	Cosmic Ray Readout Test (full system test)	Verify internal and external interfaces, timing synchronization, data rates, end-to-end data transfer, Data acquisition and Data Processing software, Controls and Networking	Final Design Report Chapter DocDB #6377	NA	Full system test at maximum throughput using simulated data	Test Results & sign-off

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Quality Assurance / Quality Control

- Full system test at maximum throughput using simulated data
- 72 hour continuous burn-in test for hardware
- Incremental release testing
- Error and status registers built into firmware

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Cost and Schedule Performance

475.09.02 TDAQ System Design and Test
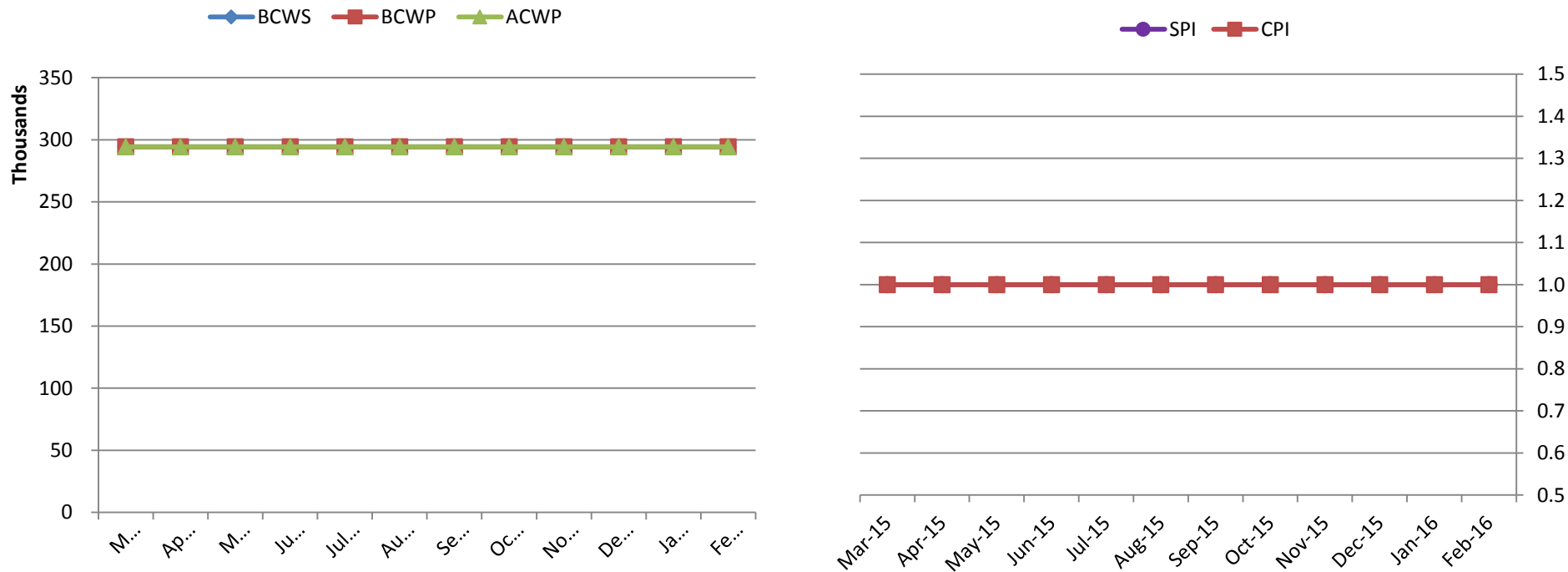
- No activity until the end of the Pilot phase.

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Performance

Mu2e Project
February 29, 2016
Currency in: $K

Control Account, Work Package.CTC	Current Period							Cumulative to Date						
	Budget	Earned	Actuals	SV ($)	SV (%)	CV ($)	CV (%)	Budget	Earned	Actuals	SV ($)	SV (%)	CV ($)	CV (%)
475.09.02 TDAQ System Design and Test	0	0	0	0	0%	0	0%	294	294	294	0	0%	0	0%
475.485 475.09.02.01 System Design and Test Conceptual Design (OPC)	0	0	0	0	0%	0	0%	203	203	203	0	0%	0	0%
475.486 475.09.02.02 System Design & Development Infrastructure Protot	0	0	0	0	0%	0	0%	91	91	91	0	0%	0	0%
475.487 475.09.02.03 System Design & Development Infrastructure Pilot	0	0	0	0	0%	0	0%	0	0	0	0	0%	0	0%
475.488 475.09.02.04 System Design & Development Infrastructure Produc	0	0	0	0	0%	0	0%	0	0	0	0	0%	0	0%

Control Account, Work Package.CTC	At Complete			% Spent	% Complete
	BAC	EAC	VAC		
475.09.02 TDAQ System Design and Test	368	368	(0)	80%	80%
475.485 475.09.02.01 System Design and Test Conceptual Design (OPC)	203	203	0	100%	100%
475.486 475.09.02.02 System Design & Development Infrastructure Protot	91	91	0	100%	100%
475.487 475.09.02.03 System Design & Development Infrastructure Pilot	45	45	(0)	0%	0%
475.488 475.09.02.04 System Design & Development Infrastructure Produc	29	29	(0)	0%	0%

- No variances.
- Pilot phase activity ramped up in March.

Change Control

Control Account	CR #	CR Description	Prior Start	Revised Start	Prior Finish	Values Revised Finish	BAC Before	BAC After	Cost Increase / (Decrease)
475.09.02	2	Establish internal baseline and incorporate recommendations from Director's Review.	-	-			678,952.14	679,036.46	84.32
	6	Corrections made to CR002	-	-			679,036.46	361,679.39	(317,357.07)
	3	New rate adjustments for labor fringe and overhead.	-	-			361,679.39	361,010.67	(668.72)
	4	Cost leveling; new CD-3c strategy	-	-			361,010.67	361,451.35	440.68
	8	FY15 Rate changes	-	-			361,451.35	366,500.57	5,049.22
	12	Solenoids PS and DS Contract terms and Accelerator design reviews	11/25/2009	11/25/2009	8/21/2020	9/16/2020	366,500.57	366,747.49	246.92
	15	Establish CD-2 Baseline	11/25/2009	11/25/2009	9/16/2020	10/30/202 0	366,747.49	367,537.65	790.16
	19	Reduced Constr oversight, FFP ECPs, and TS Module fab delay	11/25/2009	11/25/2009	10/30/2020	11/4/2020	367,537.65	367,550.58	12.94
	22	Detector Bldg. changes; Award TS Module fab; Test Cryostat mods and move	11/25/2009	11/25/2009	11/4/2020	11/9/2020	367,550.58	367,563.52	12.94
	24	FY16 Rate Update	11/25/2009	11/25/2009	11/9/2020	11/9/2020	367,563.52	367,909.65	346.13
	28	Increase Project Office Support, Constr Rev 13, Racks & Rack Monitor	11/25/2009	11/25/2009	11/18/2020	11/18/202 0	367,909.65	367,940.19	30.55
475.09.02 Total									**(311,011.95)**

- There have been no changes in the TDAQ System Design & Test plan.

- The changes listed above have been a consequence of changes in schedules and labor rates outside of TDAQ.

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Environmental, Safety, & Health

- ESH is integrated into all phases of the Project
  - Design, Construction, Installation
- ESH requirements are clearly defined within the Project
  - FESHM, FRCM
- TDAQ hazards & mitigations are captured in the Project HAR and are standard:
  - High voltage (208 VAC, no exposed connections)
  - Electronic racks
  - Class 1 lasers (eye safe)
- Design & installation review process includes an ESH component
- Utilize Fermilab's work planning requirements & processes
  - Hazard analysis

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Summary

- TDAQ design is 90% complete. The risks associated with the remaining design are understood and small. Clear path to a final design.
  - Recommendations from design review addressed
  - Interfaces, risks, ES&H issues identified and under control
  - QA/QC plans in place
  - Procurement plans in place
- TDAQ cost and schedule remain consistent with the baseline schedule approved in March 2015.
- Construction Readiness Review scheduled for August 2016
- TDAQ is ready for CD-3 approval

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