

# Modernization of B-2 Data, Video, and Control Systems Infrastructure

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## ABSTRACT

The National Aeronautics and Space Administration (NASA) Glenn Research Center (GRC) Plum Brook Station (PBS) Spacecraft Propulsion Research Facility, commonly referred to as B-2, is NASA's third largest thermal-vacuum facility with propellant systems capability.

B-2 has completed a modernization effort of its facility legacy data, video and control systems infrastructure to accommodate modern integrated testing and Information Technology (IT) Security requirements. Integrated systems tests have been conducted to demonstrate the new data, video and control systems functionality and capability. Discrete analog signal conditioners have been replaced by new programmable, signal processing hardware that is integrated with the data system. This integration supports automated calibration and verification of the analog subsystem. Modern measurement systems analysis (MSA) tools are being developed to help verify system health and measurement integrity. Legacy hard wired digital data systems have been replaced by distributed Fibre Channel (FC) network connected digitizers where high speed sampling rates have increased to 256, 000 samples per second. Several analog video cameras have been replaced by digital image and storage systems. Hard-wired analog control systems have been replaced by Programmable Logic Controllers (PLC), fiber optic networks (FON) infrastructure and human machine interface (HMI) operator screens. New modern IT Security procedures and schemes have been employed to control data access and process control flows. Due to the nature of testing possible at B-2, flexibility and configurability of systems has been central to the architecture during modernization.



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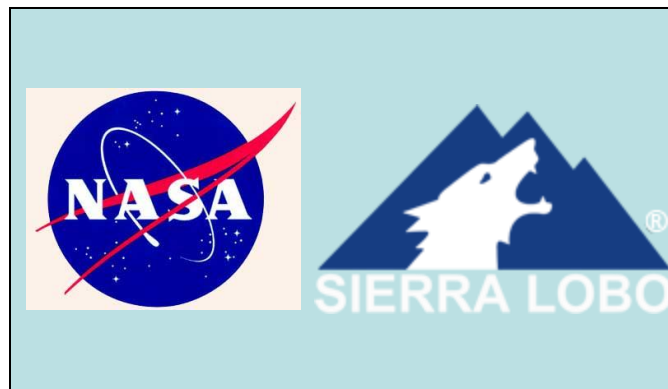
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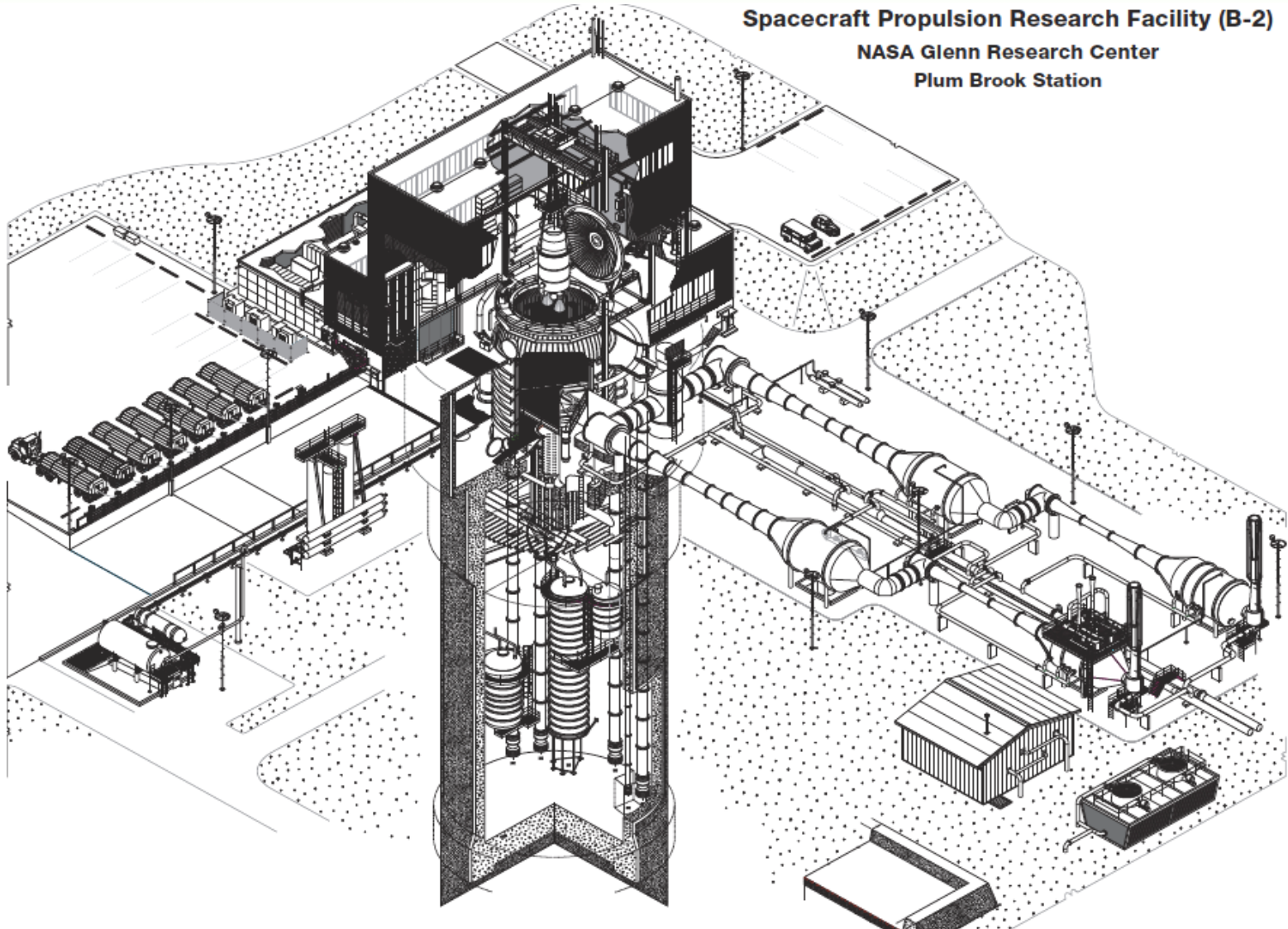


- The Space Propulsion Research Facility, commonly referred to as B-2, is designed simulate space conditions required to hot fire upper stage rocket engines or launch vehicles
- Supports 120,000 ft or higher altitude pressure conditions
- Supports Low Earth Orbit Solar light and dark deep space temperature conditions
- Supports developmental testing of large light weight space vehicles, cryogenic fluid systems and components
- Accommodates modern integrated testing requirements
- NASA's third largest thermal vacuum chamber

# Introduction

## Spacecraft Propulsion Research Facility (B-2)

NASA Glenn Research Center  
Plum Brook Station



- Original Infrastructure was installed in the 1960s to support Upper Stage Centaur Vehicle Testing
- Control devices, transducers, feedback sensors, and overall instrumentation was hardwired from the facility back to the control room on operator panels with relay logic
- Central Data System with sampling rates of 8 and 25 samples per second, reel to reel tape data storage and strip charts used to record vibration data
- Transitioned in 1990s to minicomputer based Data System with CRT display capability, increased channel counts, history file playback
- Replacement of sequencer and abort system with personal computer based programmable logic controller system
- Used Phototube and CCD camera technology with VHS recorders



- Original B-Control Room



- Deterioration of buried cables from weather and outdoor thermal cycles
- Damaged transducers and instrumentation from induced voltages and lightning strikes in hardwired systems
- Original Equipment Manufacturer no longer exist or support legacy data, control or video systems
- Floating Electrical Ground Grid potentials between facility and control room requiring isolation amplifiers
- Very limited flexibility and system re-configurability due to hardwired infrastructure
- Light bulb replacement on operator panels



- Implement programmable man machine operator screens in lieu of hardwired push button panels
- Install fiber optic backbone to accommodate higher throughput rates for data, control and video systems
- Maintain better control of calibrated hardware through eliminating hard wired backbone
- Meet new access and permission security requirements for facility systems
- Update data, control and video with equipment that is supported by manufacturers
- Minimize lightning induced instrumentation damage

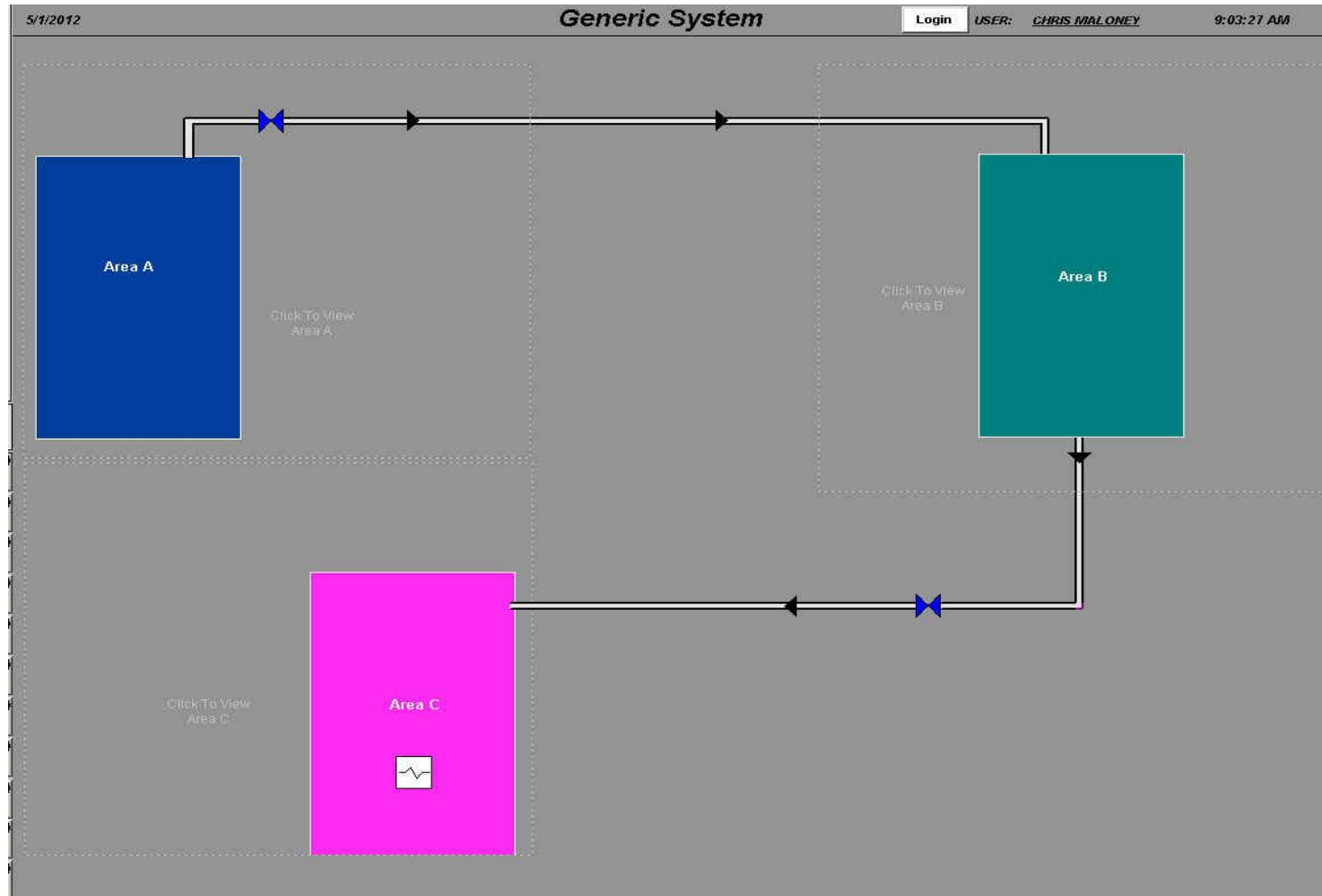
# New Requirements

- New B-control Room



- Distributed client server system based architecture
- Programmable Logic Controllers (PLC) and Graphical User Interfaces (GUI) with remote input/output drops
- New Control System controls, monitors and logs data inputs, alarms, and events from feedback instrumentation & devices
- Redundancy and flexibility in configuring Control System to meet testing requirements
- Two step decision process for valve operation to eliminate inadvertent valve actions
- Display instrumentation parameters on operator screens rather than hardwired meters with human factors considerations
- Event Notification System is available and configurable

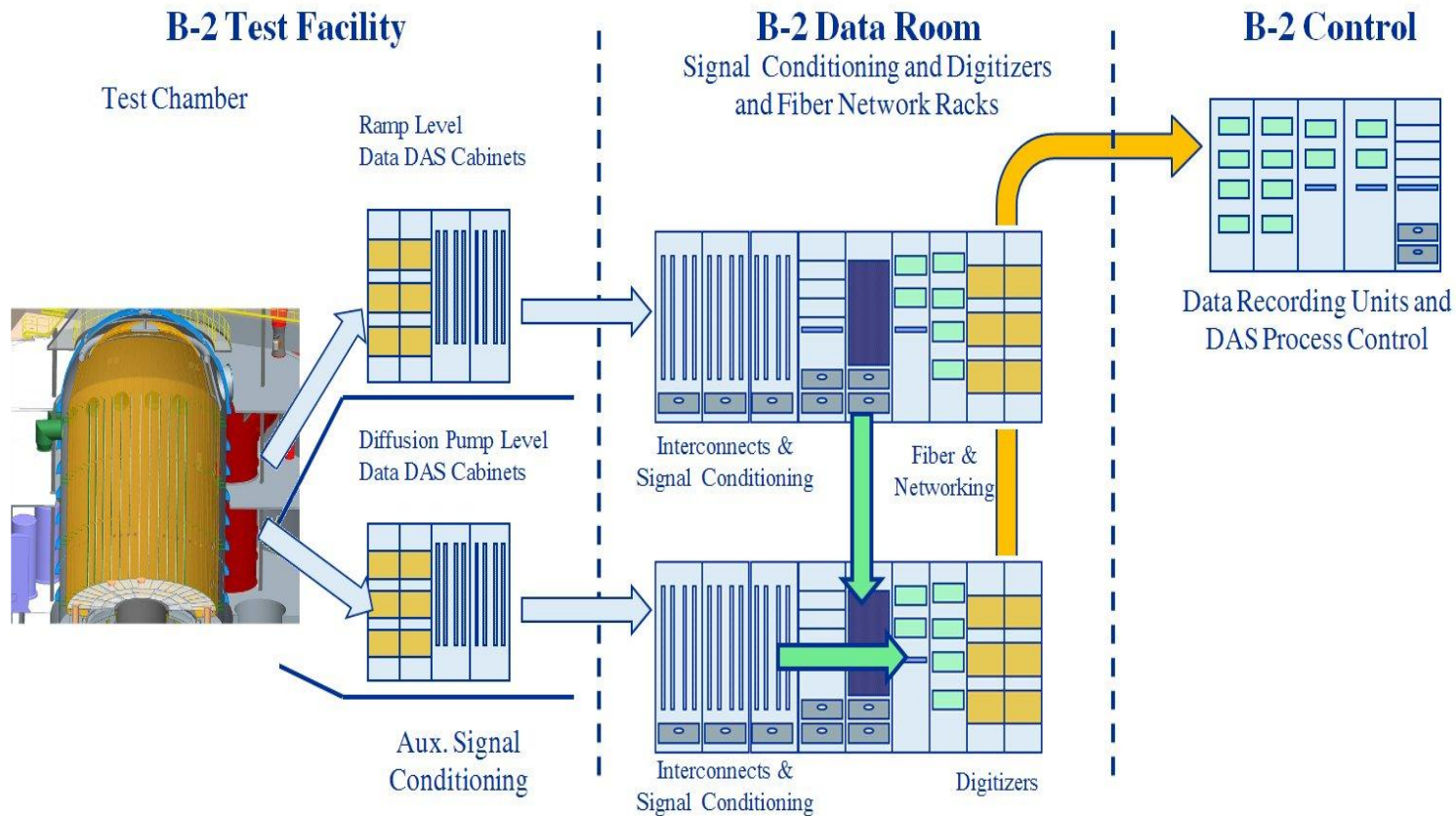
- Generic Control Systems GUI



- Distributed architecture designed to meet unique test requirements and minimize potential loss of data
- Meets NEC safety requirements for Class 1, Div II Group B
- Fiber Optic Communication and 4<sup>th</sup> generation storage area network using RAID arrays
- Commercially available off the shelf software and hardware
- Higher sampling rates up to 256K samples per second
- Programmable filters and analog signal conditioners
- 640 channel capability using IRIG-B time stamped channels in either Low speed or High speed Dynamic channel configurations
- Uses RAID storage drives and magnetic tape library
- Configurable Development, Control, and Monitor Workstations

# Data Acquisition System

- New Data Acquisition Signal Flow



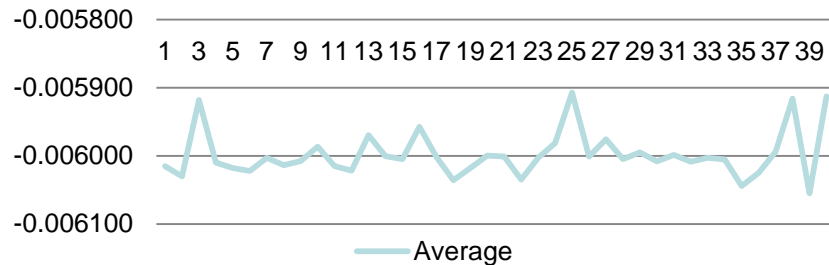


- New NASA guidelines on following ANSI/NCSL Z540.3
- Challenge to develop measurement system model, system inputs and outputs, and identify sources of error
- System model consists of performing an overall system calibration check with signal conditioners in series with the data system channel inputs through the analog to digital converter to a data file
- Used measurement analysis software tools to calculate the Mean, Mode, Standard Deviation, Skewness, and Kurtosis
- Generated Histogram, Time series data, and other graphs to validate normality of acquired data
- Refer to charts

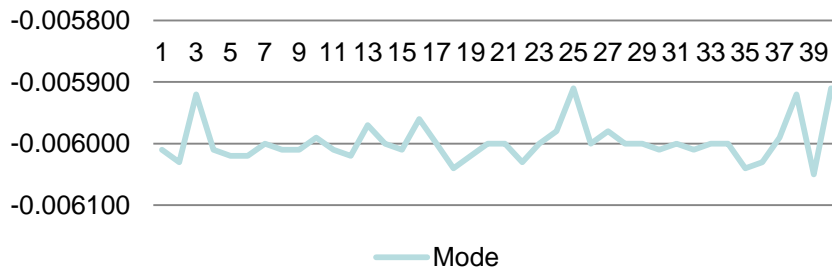
# MSA Report for 40 Low Speed Data Acquisition Channels



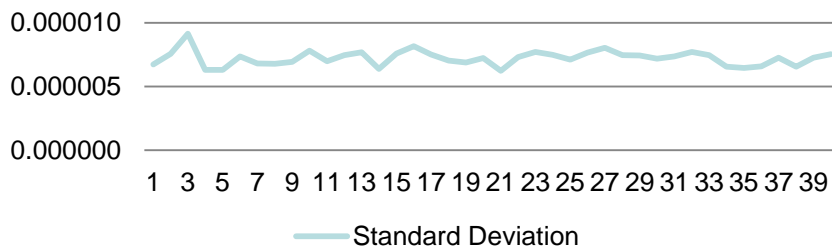
## Channel Average - Volts



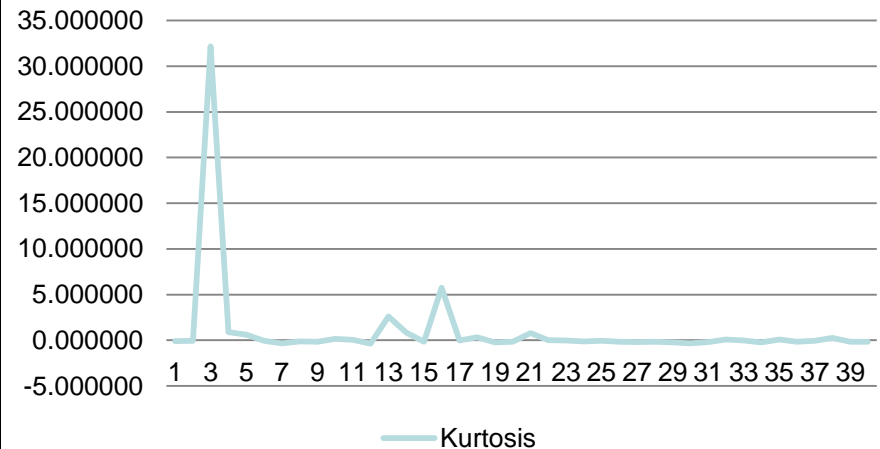
## Channel Mode - Volts



## Channel Standard Deviation - Volts



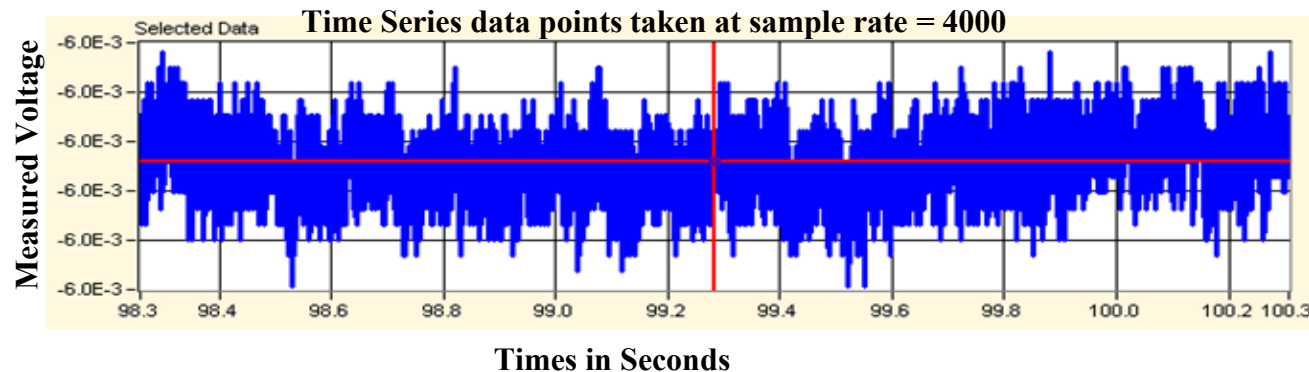
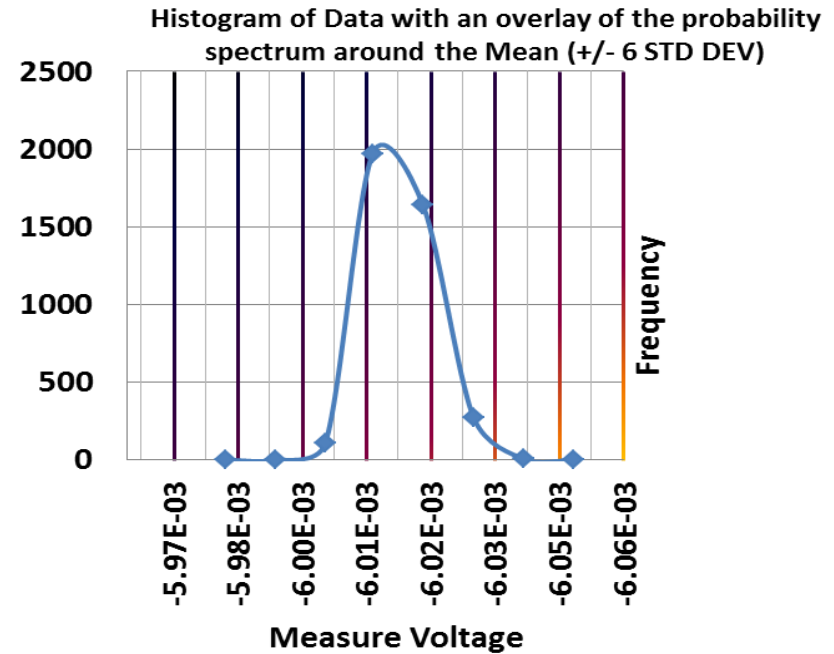
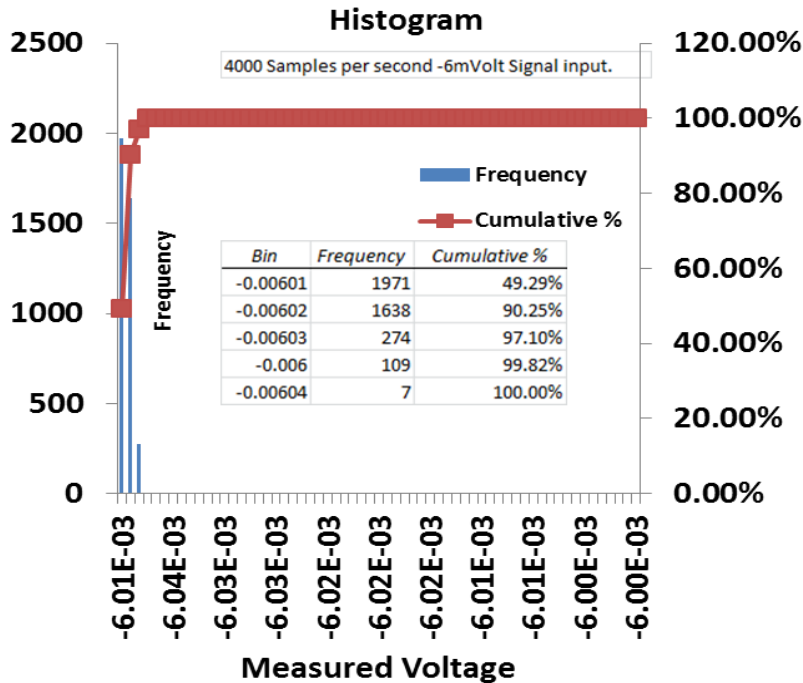
## Channel Kurtosis



## Channel Skewness



# MSA Report for an Individual Channel indicating a Normal Distribution



- Replace legacy camera systems with new modern distributed digital cameras and storage systems
- Fiber Optic backbone is key to this camera implementation
- Remote control of cameras via joystick control
- Recording and play back is configurable from several minutes to several days to several weeks as required.
- Potential of sending live video feeds to customers

- B-2 test facility has been modernized with new infrastructure that meets current technology standards and testing requirements
- B-2 Modern Data, Control and Video provide configurability and flexibility to meet testing requirements
- Modernization eliminates legacy maintenance issues that were labor intensive and costly
- Employing MSA software tools will allow us to better identify problem channels and quantify errors
- Increased facility systems reliability and performance