STATISTICAL PROCESS CONTROL IN AN E3 TEST LABORATORY

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EMC '98 Roma - 9/17/98

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IEEE

EMC SOCIETY

Introduction:

Measurement system variability in a test laboratory can be a source of discomfort for the test engineer.

Your development engineers, your product managers, and anyone doing repeat testing want to be sure your test system is “The Same” as the last time they tested.

Introduction (Cont.):

Simply connecting up the same equipment does not provide any '<u>measurable assurance</u>' of repeatability.

The use of Statistical Process Control (SPC) methods to gage, and track the variability of system measurements can provide confidence in the repeatability of the test system setup, and in the data it produces.

Dayton T. Brown Inc.

DAYTON T. BROWN INC.

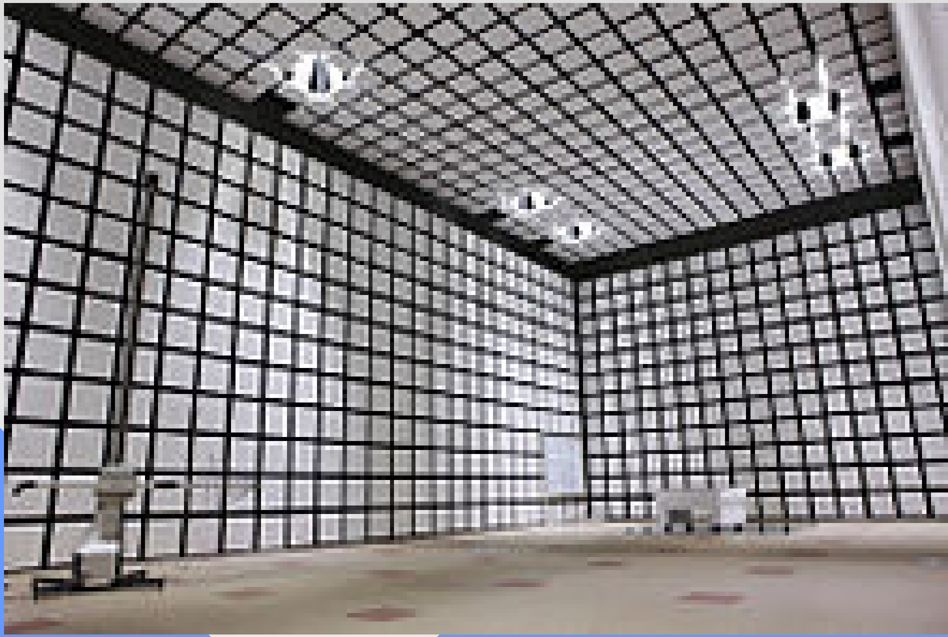
Founded 1950

Navy Missile: Duplicate Test

- Testing suggested a ‘new’ problem.
- Customer believed test missile to be unchanged in any way.
- Same physical equipment was verified.
- However, a photo of the original e-prom date code showed new software!

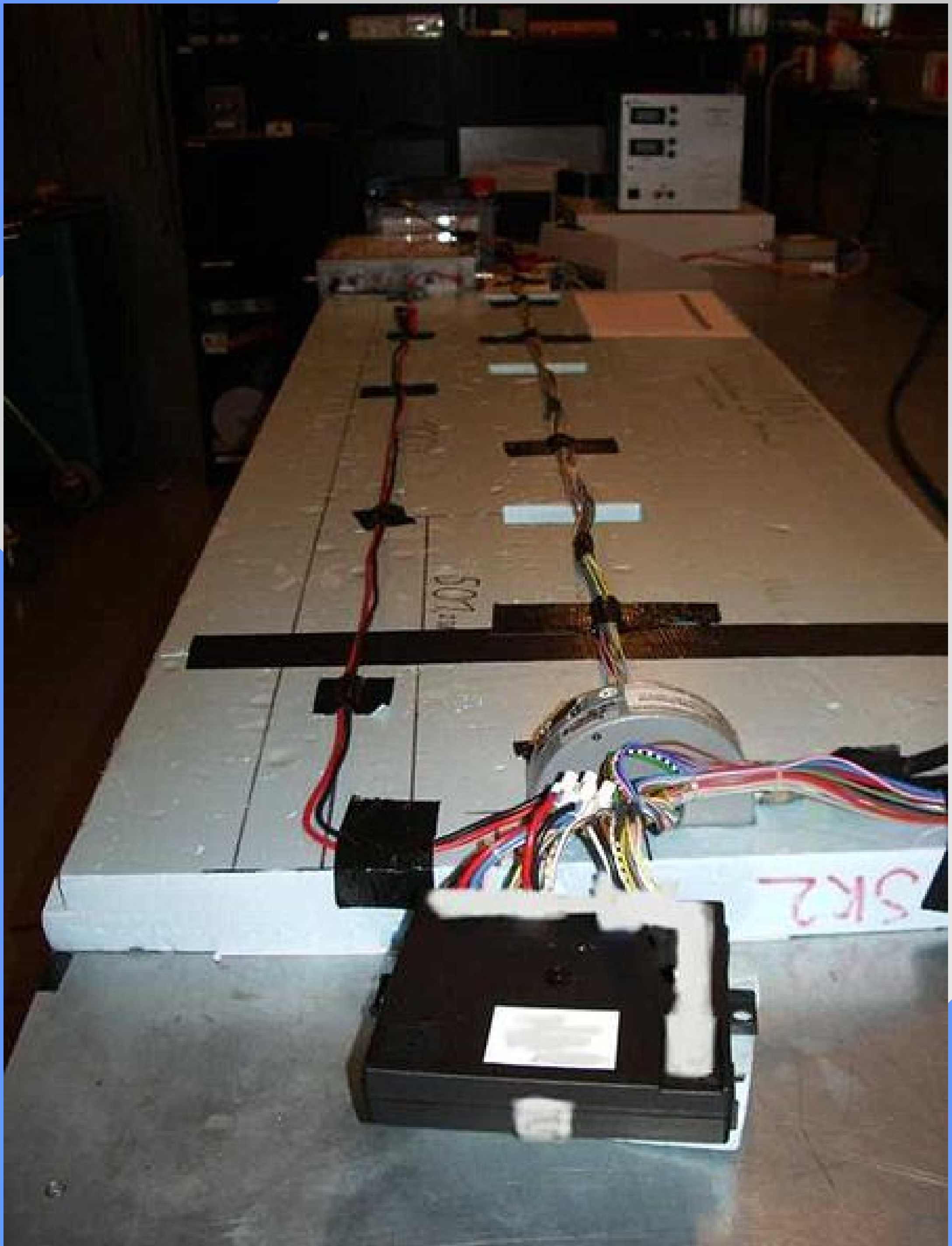
The Problem:

- New setup for each test, …each time.
  - Lack of equipment.
  - Lack of space.



The Problem:

- New setup for each test, …each time.
  - Lack of equipment.
  - Lack of space.
- No one has the room to have all tests set up, all the time.
- How to verify test setup repeatability?
- How to verify system integrity?

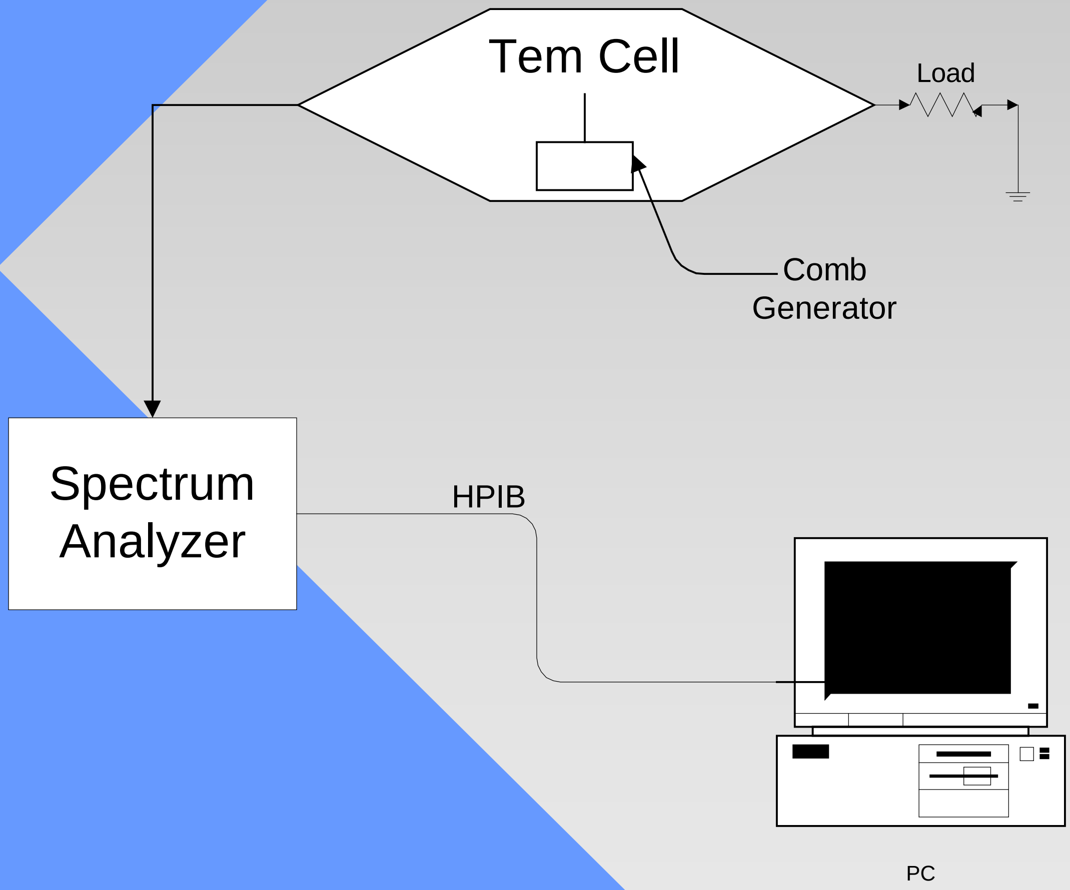


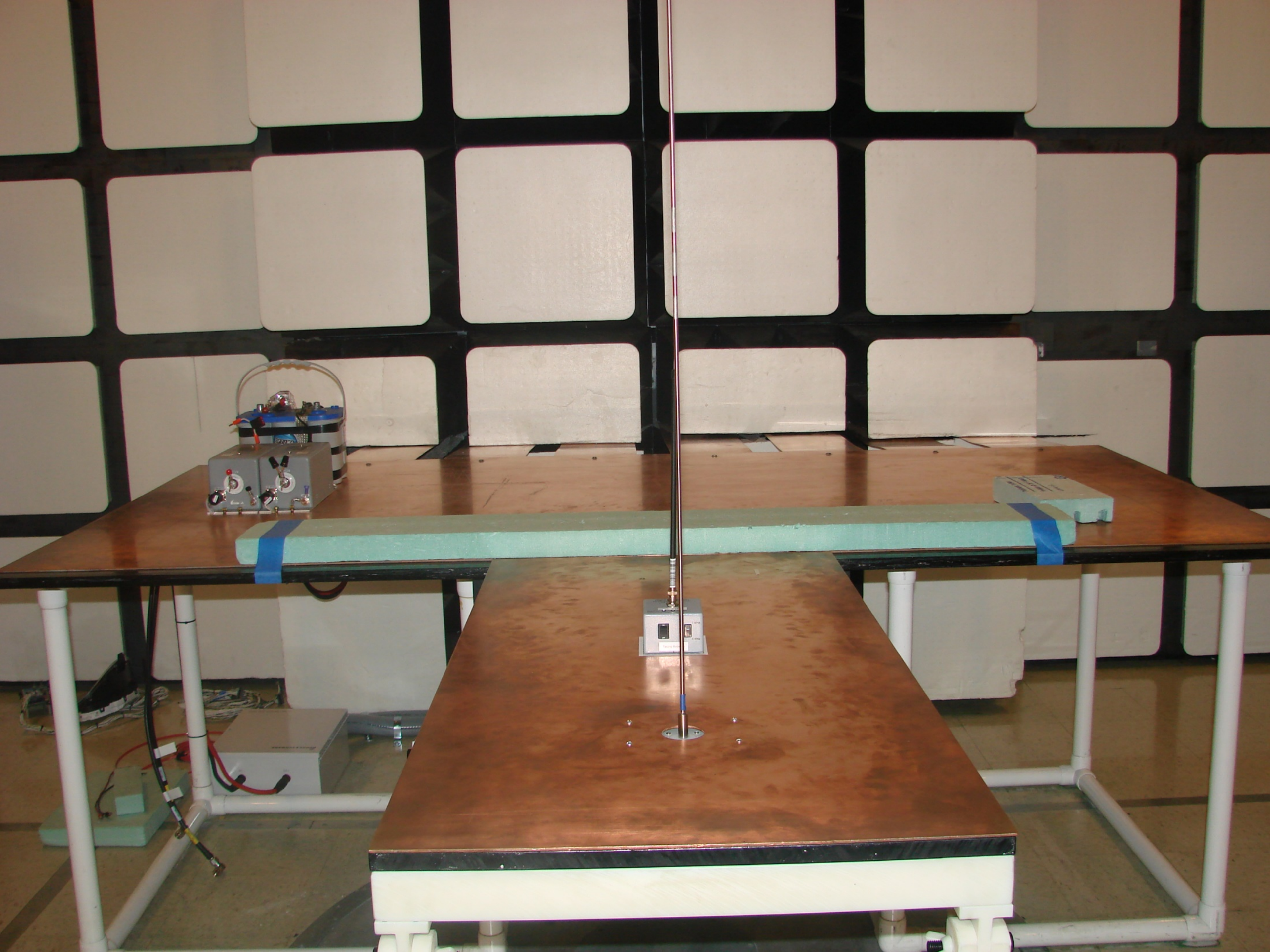
Meet Walter Shewhart

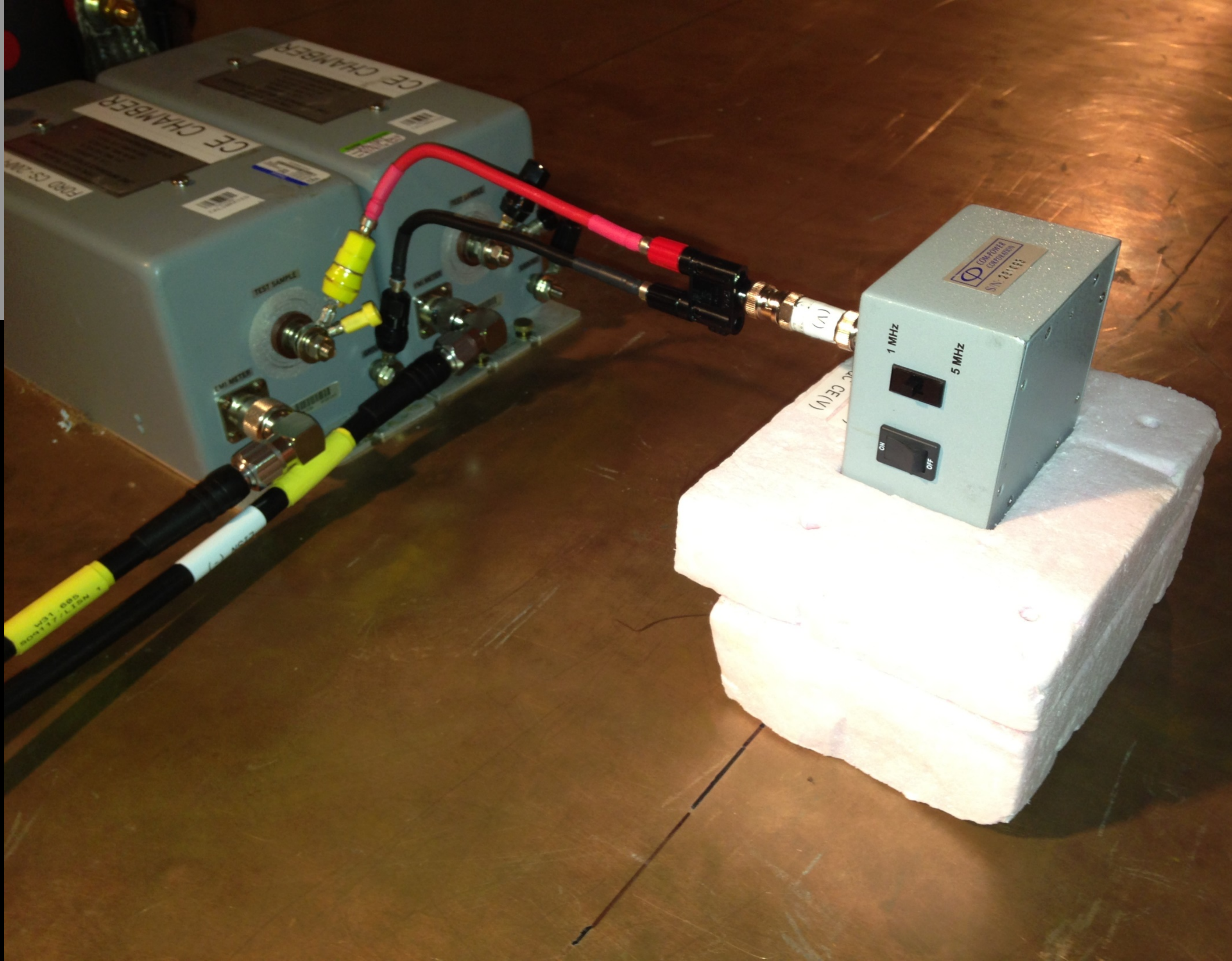
- Physicist / Engineer
- 1924 Challenge
- Statistics & Products
- Statistics & Processes
- SPC!
- .....Edward Deming.

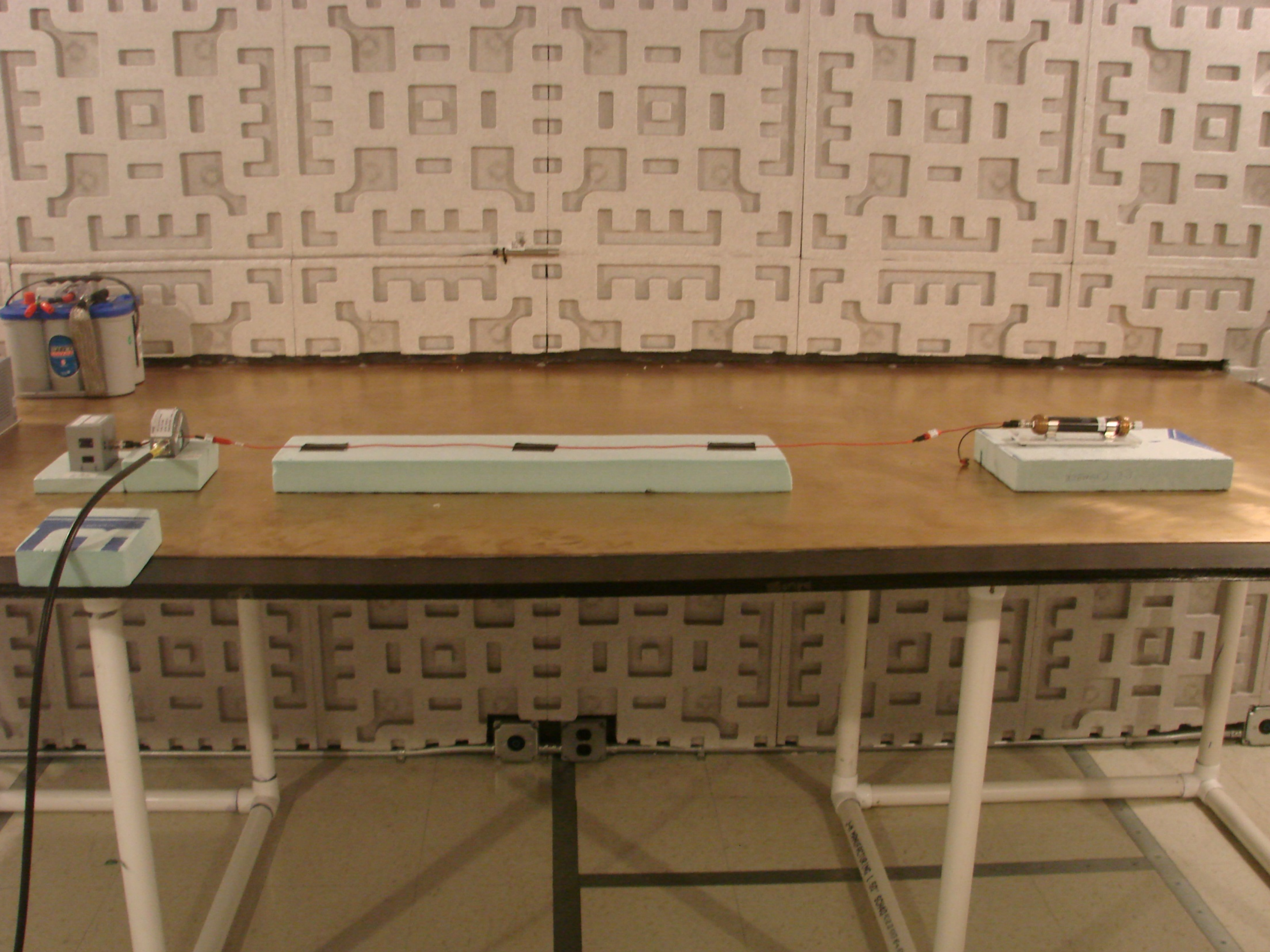
Monitor System Performance:

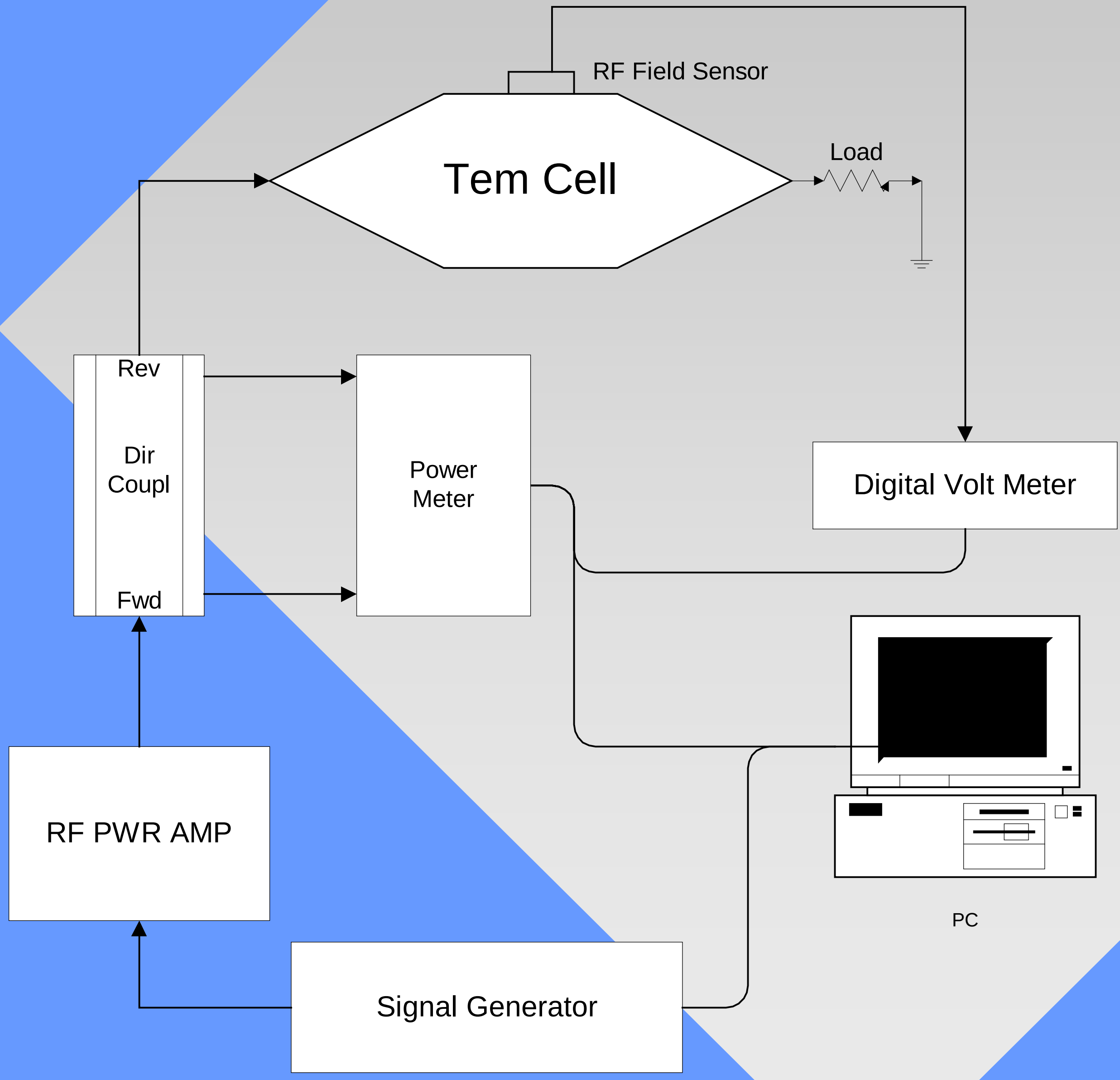
- Method to verify system performance.
- Independent of normal controls.
  - Ex: Comb generator in TEM for RE.
  - EX: Field Meter to check RI levels.

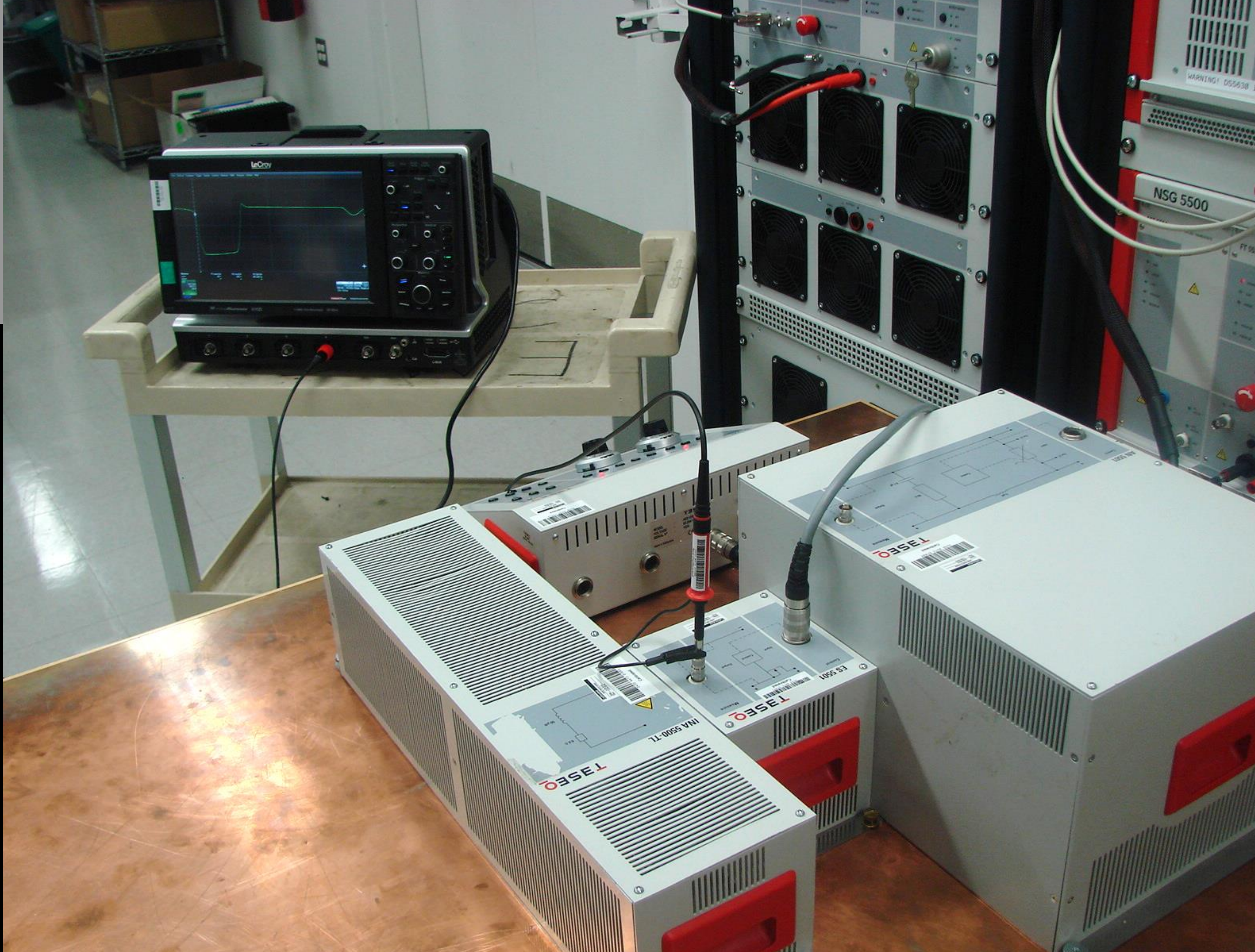

Tem Cell
Load
Comb Generator
Spectrum Analyzer
HPIB
PC




CE CHAMBER
CE CHAMBER
TEST SAMPLE
EMI METER
1 MHz
5 MHz
ON
OFF




RF Field Sensor
Tem Cell
Load
Rev
Dir
Coupl
Fwd
Power
Meter
Digital Volt Meter
PC
RF PWR AMP
Signal Generator


LeCroy
NSG 5500
INA 5500-TL
ES 5501

Approach

- Measurement that has no effect on normal test system behavior.
- Gather data representative of normal performance.
- Plot data on SPC historical charts.
- Track long term system behavior.

Verify Test System Integrity

- Verify physical test setup.
- Verify test system function.
- Document system repeatability.
- Capture as historical charts.

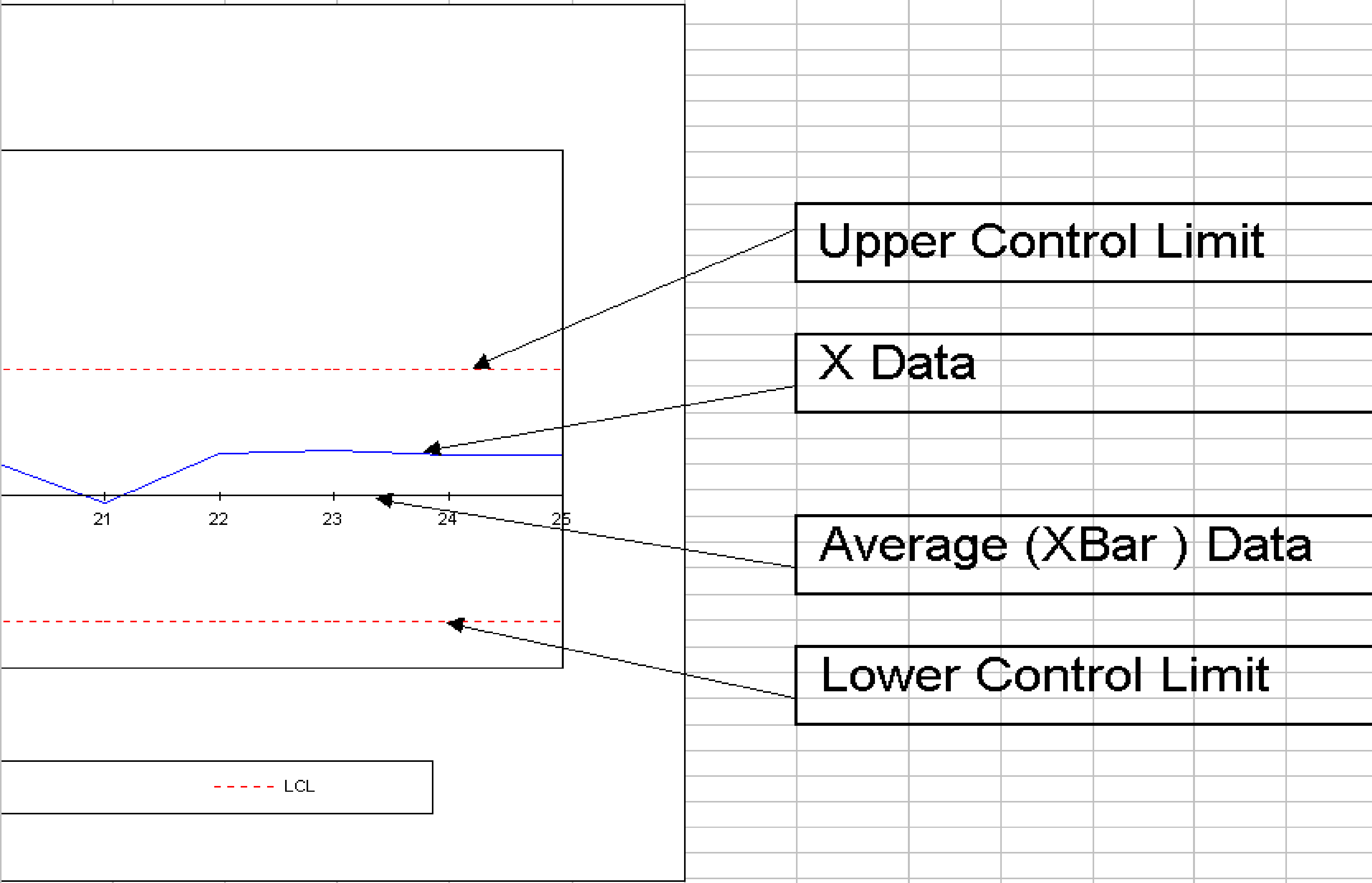
Statistical Process Control (SPC) Charts (Range):

- Walter Shewart's Control Chart - Range Equations.
- $MR = X_N - X_{N-1}$ (Delta Change)
- $MRBar = (\sum MR_N)/N$
- $UCL_R = MRBar * D4$
- $LCL_R = MRBar * D3 => 0$

Statistical Process Control (SPC) Charts: (Data)

- Walter Shewart's Control Chart - Data Equations.
- Let X_N = N data pts.
- $XBar = (\sum X_N)/N$
- $UCL_X = XBar + A * MRBar$
- $LCL_X = XBar - A * MRBar$

Set #	Set #	Set #	Set #	Set #
21	22	23	24	25
8.4071	8.7431	8.7663	8.7392	8.7392
15.9882	15.9889	15.9914	15.9916	15.9916



Patience!

- The method is ‘statistical’ in nature.
- The first few data points will NOT make sense.
- Results will begin to be reasonable after about 5 data points are in use.

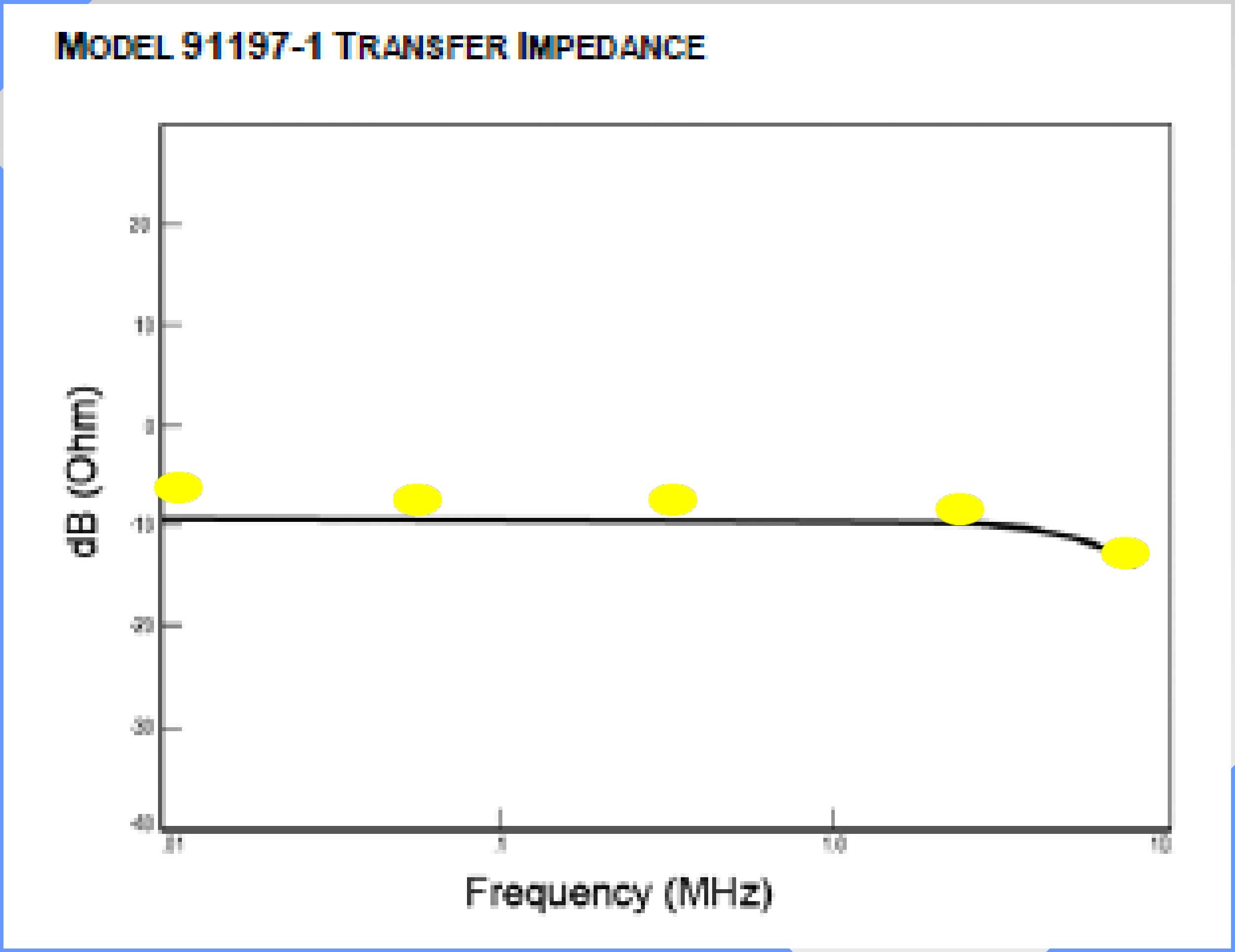
Caution:

- To avoid ‘Data Overload’ in the frequency domain, average multiple frequency readings together, and
- Limit the number of frequencies to a representative few.
- This avoids multiple XBar-R Charts for a single antenna.

Example:

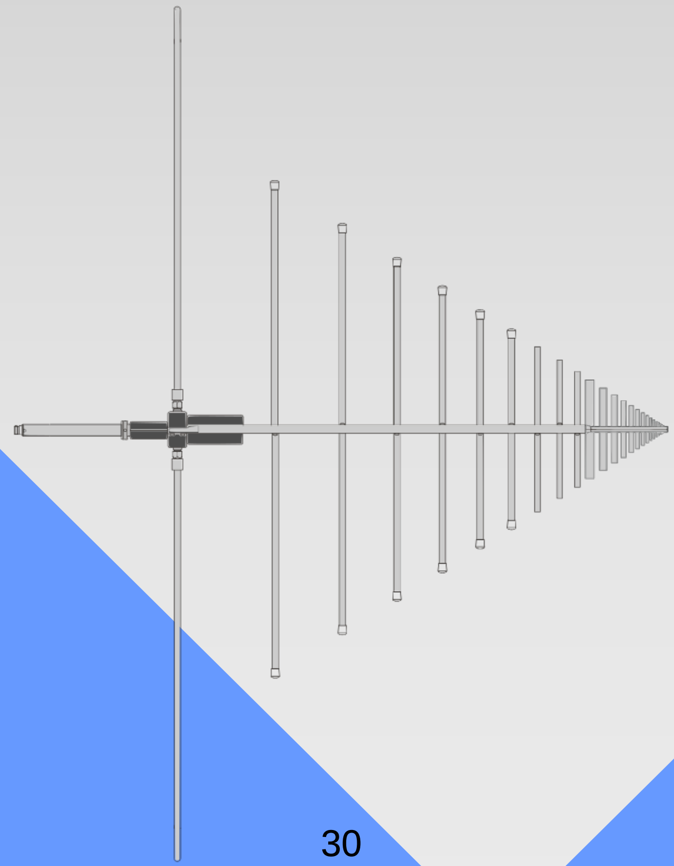
- For TEM or G-TEM use 15 frequencies to cover the cell’s range.
- Normally this would result in 15 Charts!
- By averaging all frequencies together, we arrive at single representative reading that describes the cell’s behavior.

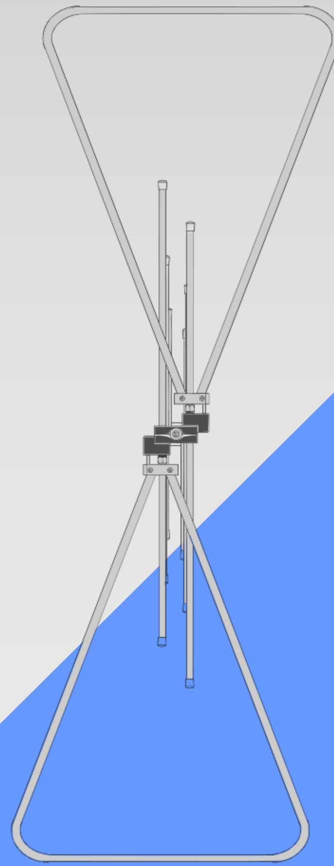
5 Point Spread



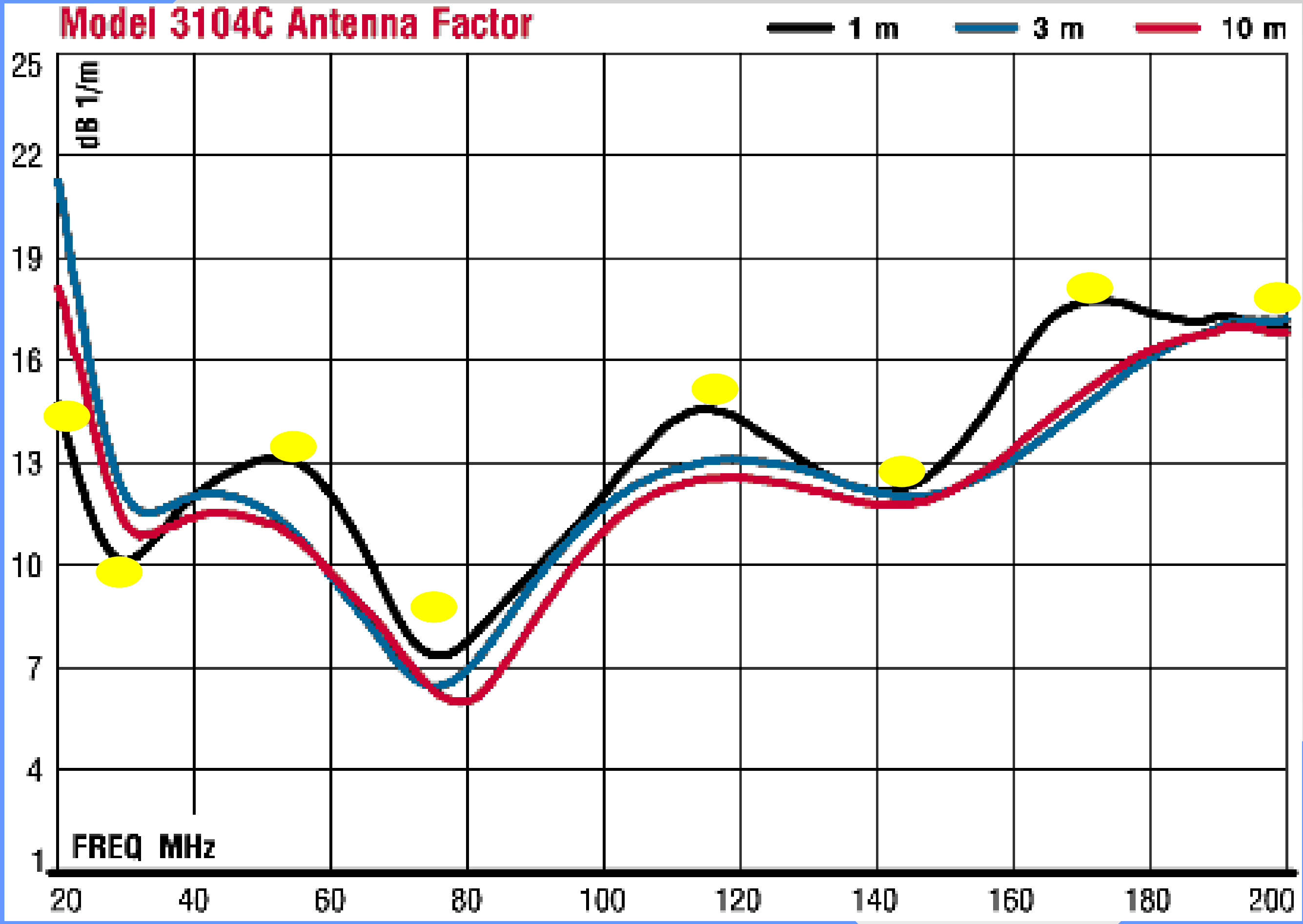
Ex: LP or BiCon Antenna

- 20 – 200 MHz
- 180 MHz Span
- 10 MHz/Point
- 18 Charts!





Points of 'interest'.



Example (Cont):

Experimentation has verified that the ‘averaged’ value still retains enough sensitivity to small changes in one measurement value to be a reliable indicator of potential problems.

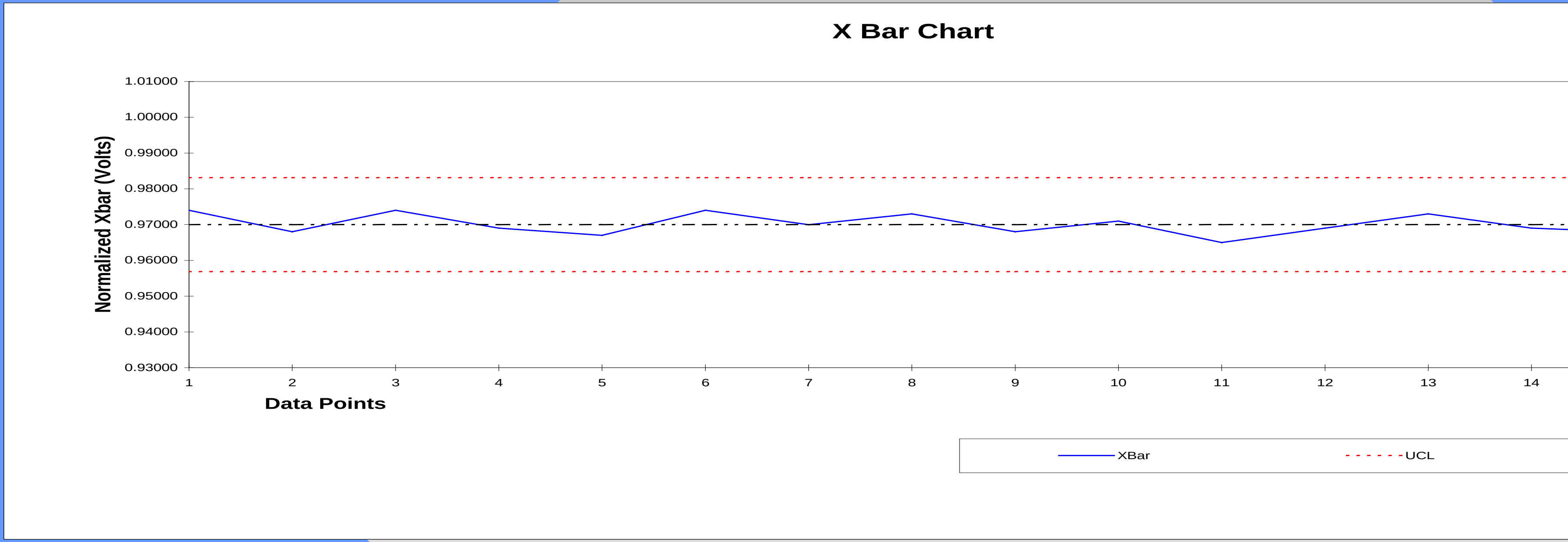
Caution:

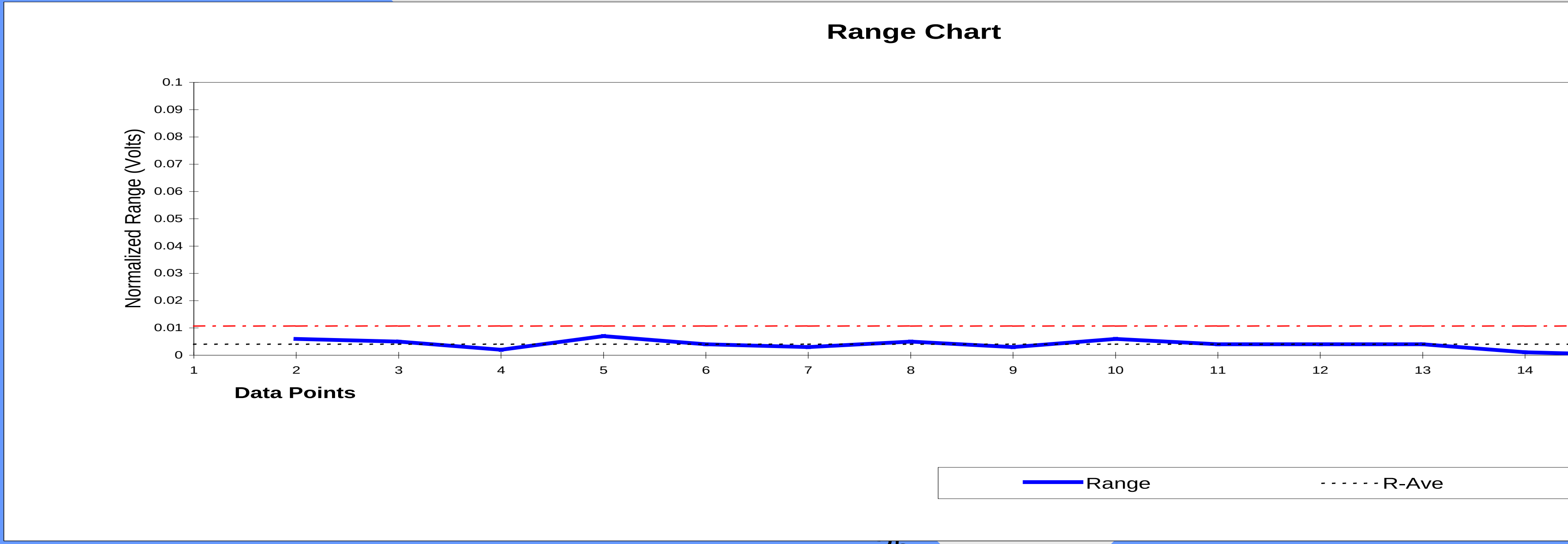
- When using measurements in Decibels (dB), convert the measured value to its representative Voltage, Current or Power, perform the appropriate mathematical operations, then convert back to dB for final display within the XBar & Range Charts.

Data Sets:

- Normal Data

Date	4/5/1999	4/12/1999	4/15/1999	6/9/1999	6/15/1999	6/24/1999	7/16/1999	7/30/1999	8/9/1999	8/17/1999	8/30/1999	9/9/1999	9/17/1999	10/9/1999	2/10
Current	0.974	0.968	0.974	0.969	0.967	0.974	0.97	0.973	0.968	0.971	0.965	0.969	0.973	0.969	0

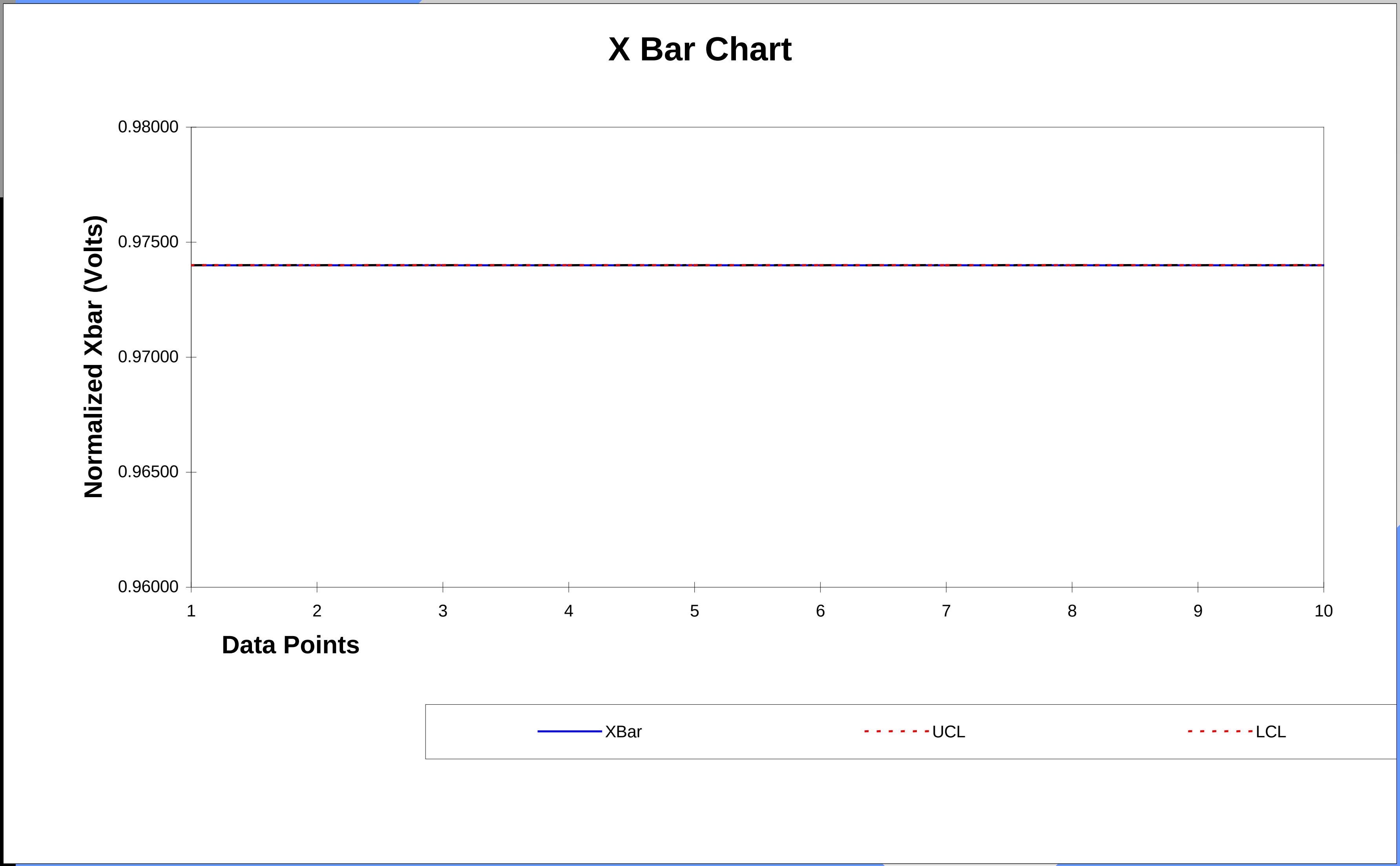




Data Sets:

- Normal Data
- Too Good to be True

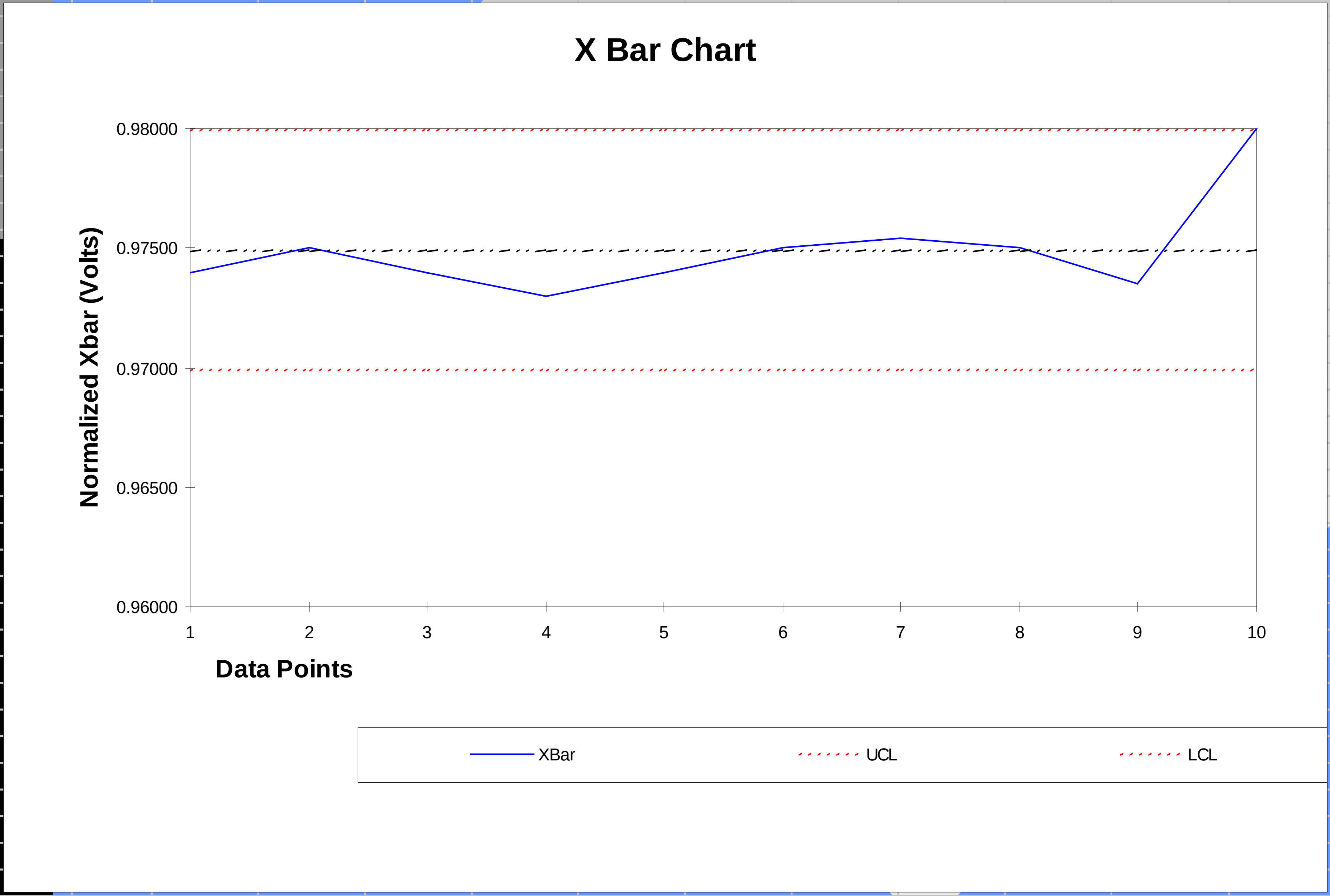
	1	2	3	4	5	6	7	8	9	16
Date	4/5/1999	4/12/1999	4/15/1999	6/9/1999	6/15/1999	6/24/1999	7/16/1999	7/30/1999	8/9/1999	2/24/2000
Current	0.974	0.974	0.974	0.974	0.974	0.974	0.974	0.974	0.974	0.974



Data Sets:

- Normal Data
- Too Good to be True
- Jump Data

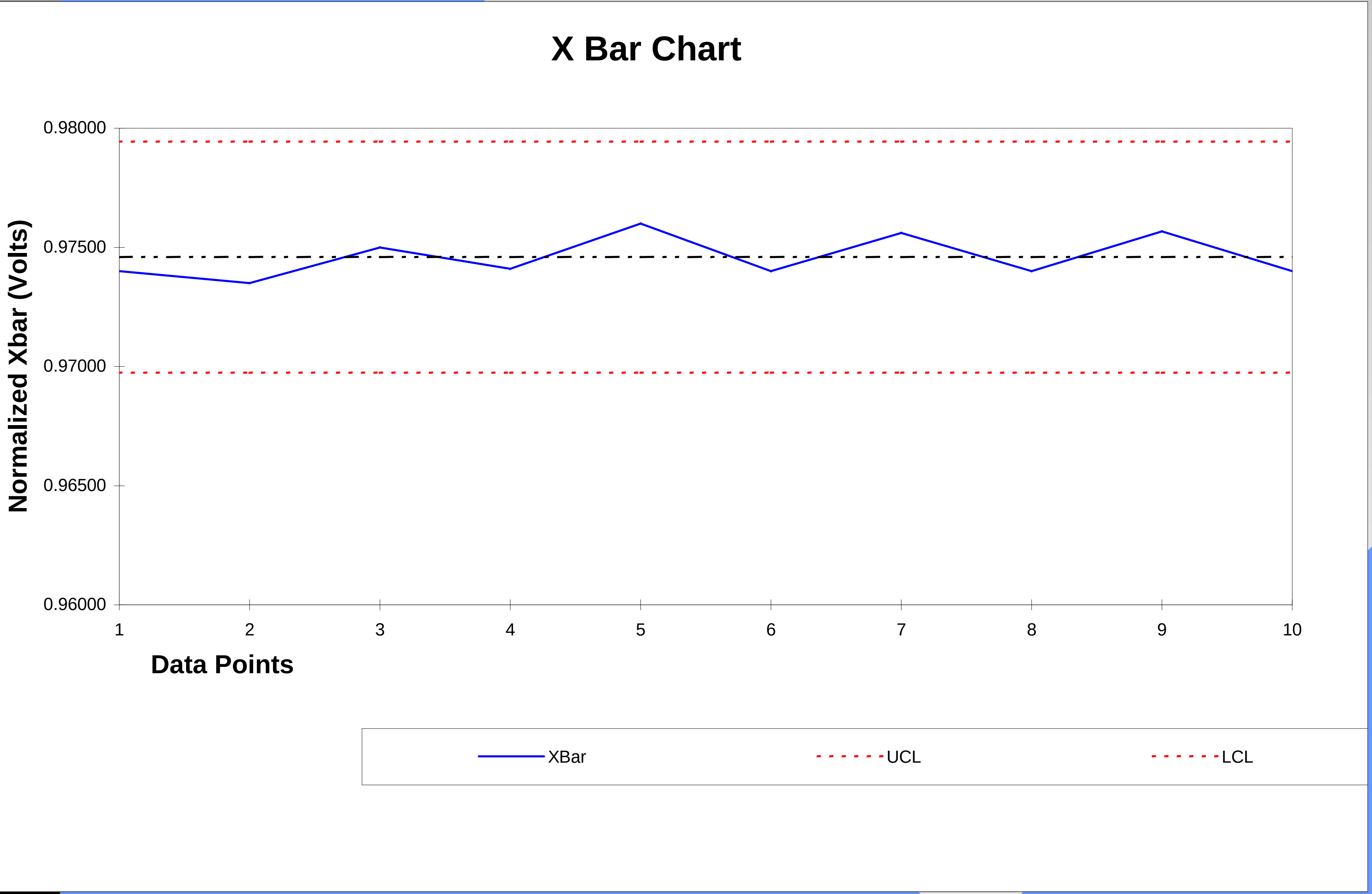
Date	4/5/1999	4/12/1999	4/15/1999	6/9/1999	6/15/1999	6/24/1999	7/16/1999	7/30/1999	8/9/1999	2/24/2000
Current	0.974	0.975	0.974	0.973	0.974	0.975	0.9754	0.975	0.9735	0.98



Data Sets:

- Normal Data
- Too Good to be True
- Jump Data
- Periodic Data

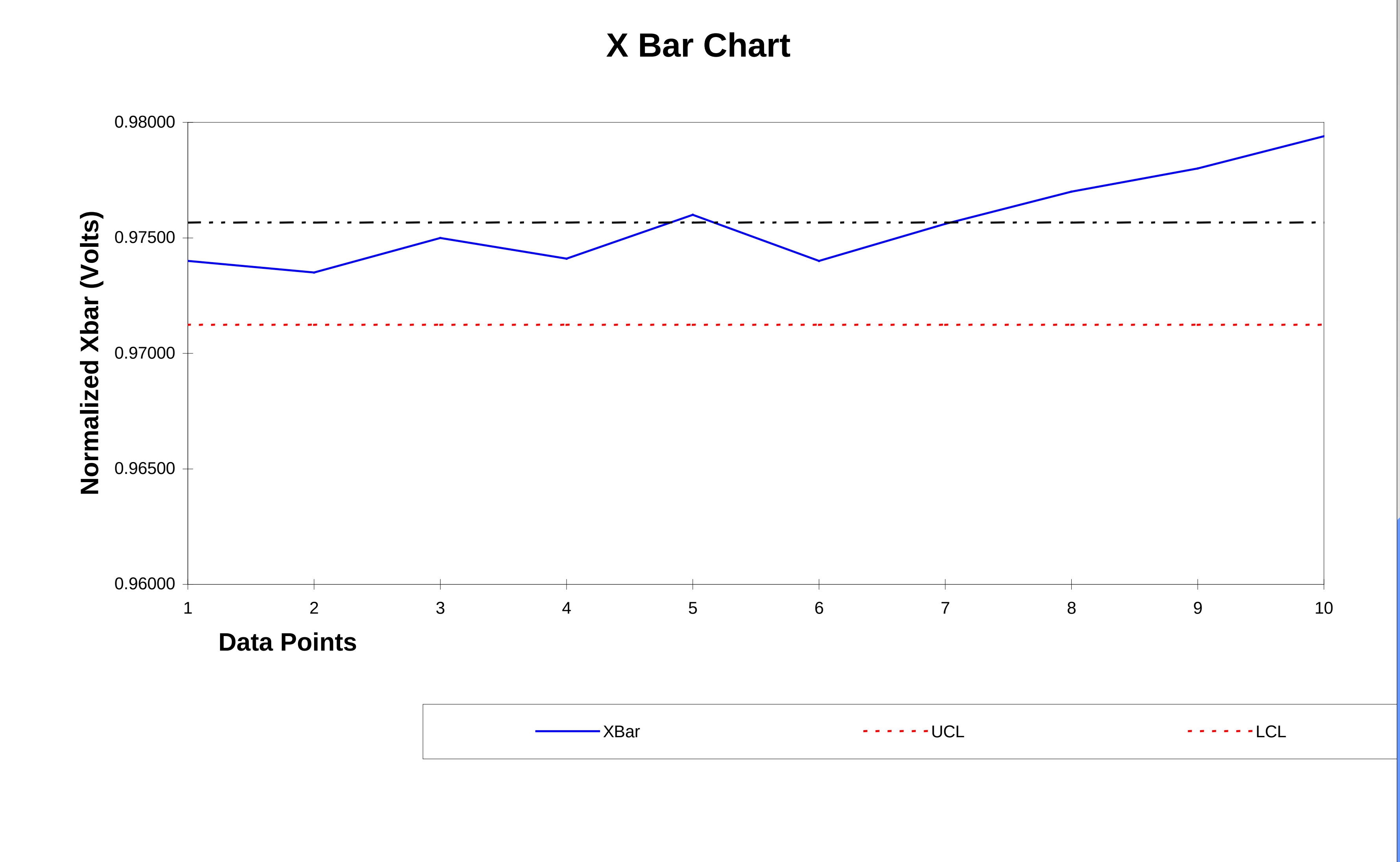
	1	2	3	4	5	6	7	8	9	16
Date	4/5/1999	4/12/1999	4/15/1999	6/9/1999	6/15/1999	6/24/1999	7/16/1999	7/30/1999	8/9/1999	2/24/2000
Current	0.974	0.9735	0.975	0.9741	0.976	0.974	0.9756	0.974	0.97567	0.974



Data Sets:

- Normal Data
- Too Good to be True
- Jump Data
- Periodic Data
- Ramp Data

	1	2	3	4	5	6	7	8	9	16
Date	4/5/1999	4/12/1999	4/15/1999	6/9/1999	6/15/1999	6/24/1999	7/16/1999	7/30/1999	8/9/1999	2/24/2000
Current	0.974	0.9735	0.975	0.9741	0.976	0.974	0.9756	0.977	0.978	0.9794



Other Test Methods

Test Method	Example SPC Method
RE	Standard Emission Generator (Comb)
RI	Field Monitor
CE	Broad Band Noise Source

Other Test Methods - Cont.

Test <u>Method</u>	**Example SPC <u>Method</u>**
BCI	'Loaded' Cal Fixture
CI	Coax Resistive Load + DVM
Trans I	Attenuator/Load+Scope Meas: Tr, Vpk, Area
Trans E	Same as above.

Test Setup Documentation:

- Create initial SPC for each system.
- Gather relevant data for each system component – separately.
- Later, if anything changes at the system level, you have all the individual component baseline data as reference.

Review:

- Problem - New setup for each test and the doubts about measurement data that results.
- Method to verify system performance.
  - test setup repeatability?
  - system data integrity?

Solution:

- Monitor system performance.
- Display information as SPC historical data charts.
- Retain SPC charts for system analysis and documentation.
- Adds very little time to test setup but, saves lots of discussions with customers.

Questions?

- Thank you for your attention.