A New Approach to Qualification Testing

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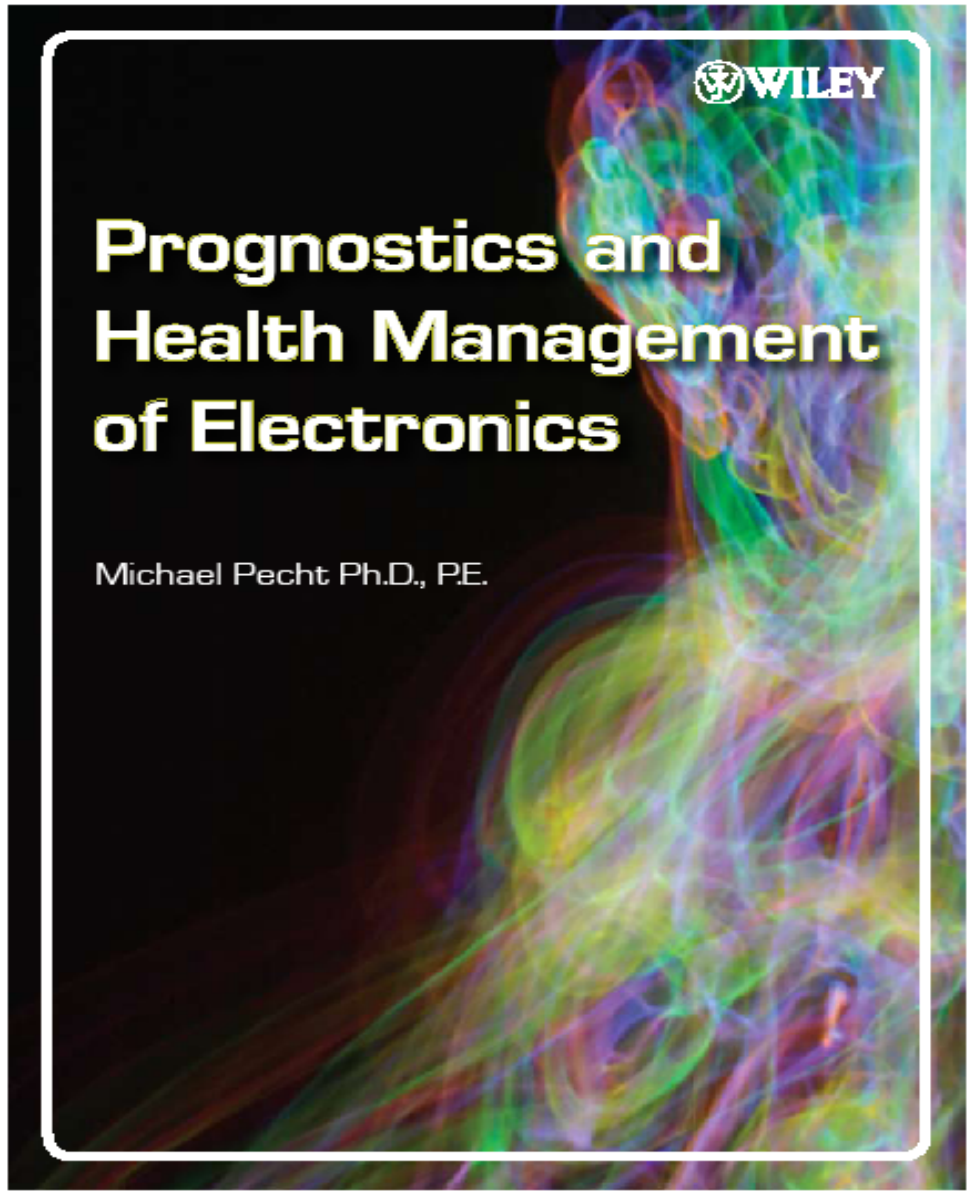
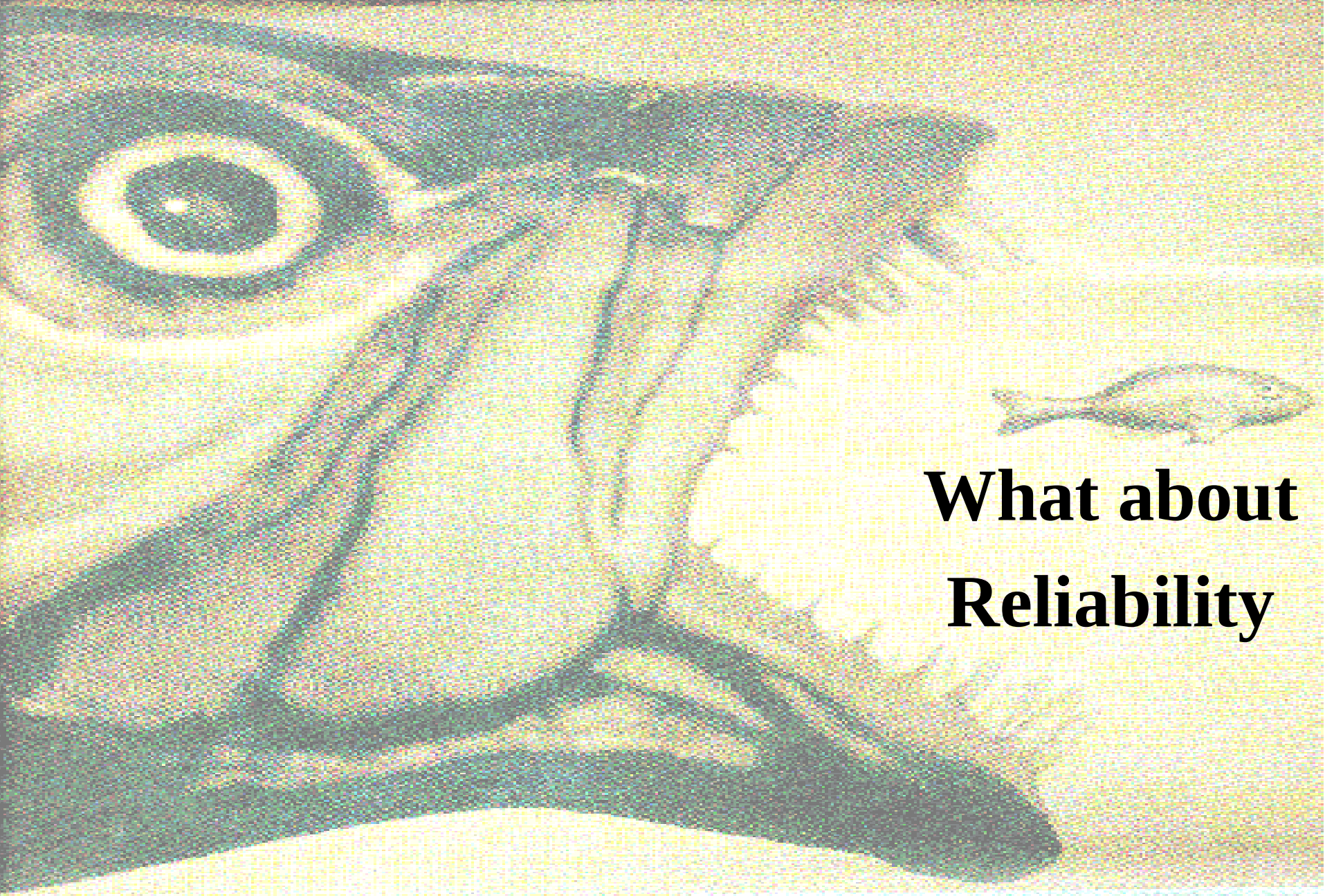


The Electronics Marketplace

- Products are changing very rapidly
- Customers have more choices
- Supply-chains are extremely complex and tremendous price pressure exists on suppliers
- Time to profit is the driving force of company success



What about Reliability

Concerns about Reliability

- Reliability practices slow down schedules
- Testing takes too much time
- View that many of the standards are not working

What's Needed

- Reliability capability assessment of supply chain
- Overhauled parts selection and management processes
- Improved qualification methods
- Improved approaches for fault assessment (NFF, intermittent failures)
- Better industry awareness of new failure mechanisms of changing and new technologies

U. S. Military View of Reliability Handbook Methods

"… Mil-Hdbk-217, Reliability Prediction of Electronic Equipment, **and progeny**, is not to be used as it has been shown to be unreliable and its use can lead to erroneous and misleading reliability predictions."

October 1994

Decker, Assistant Secretary of the Army (Research, Development, and Acquisition), Memorandum for Commander, U.S. Army Material Command, Program Executive Officers, and Program Managers

Qualification Tests

- Qualification is the process of demonstrating that a **product** is capable of meeting or exceeding **specified requirements**
- For example, before the launch of a semiconductor product, qualification tests (e.g. JESD-22) must be "passed"
  - HAST
  - THB
  - Pressure cooker
  - etc.

Costly Field Failures

- Ford ignition modules
- GM windshield wiper electronics
- Sony batteries
- Microsoft X-Box
- HP laptop computers

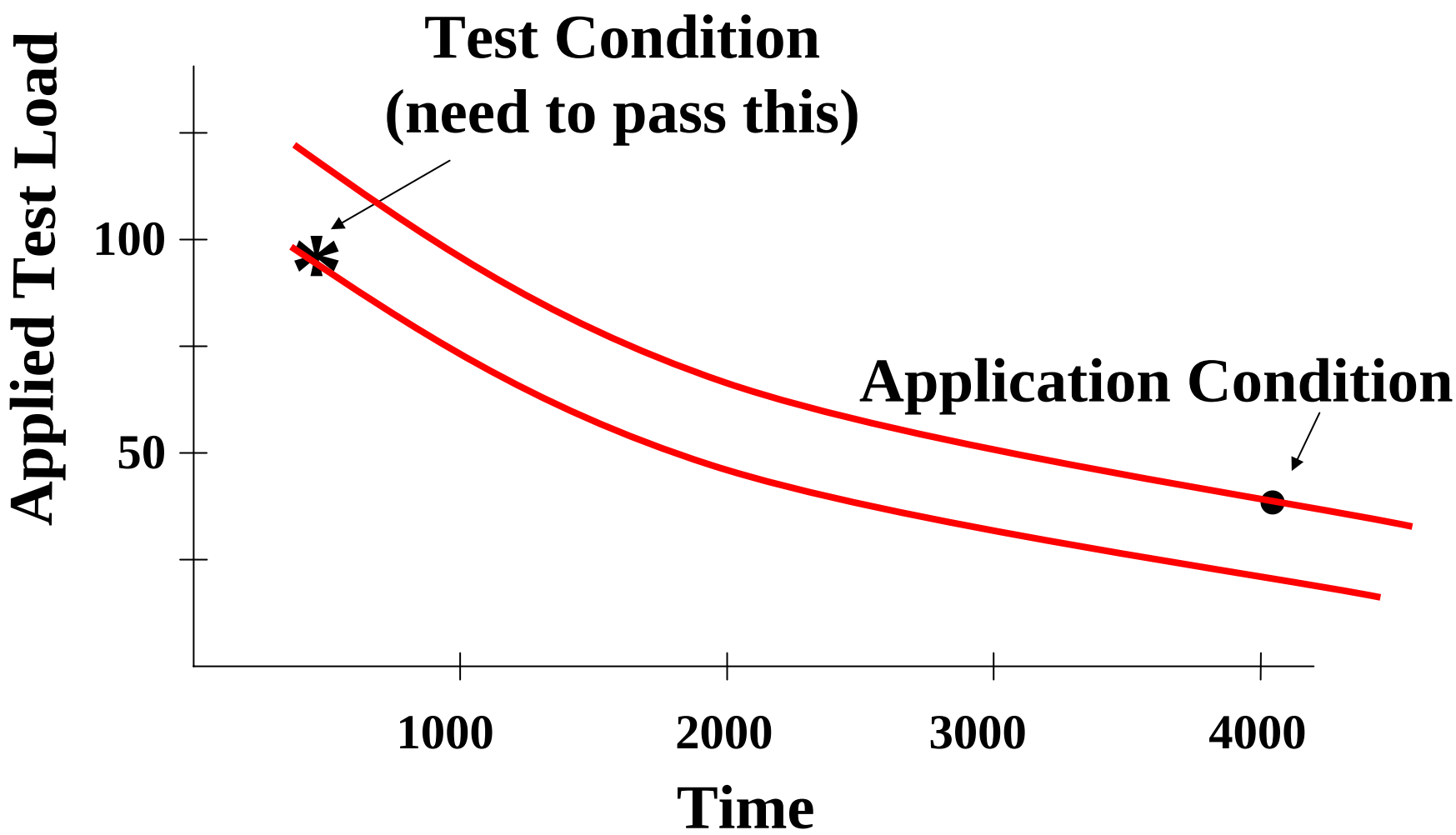
What Went Wrong!

U.S. Legal Liabilities
Breach of Duty of Care

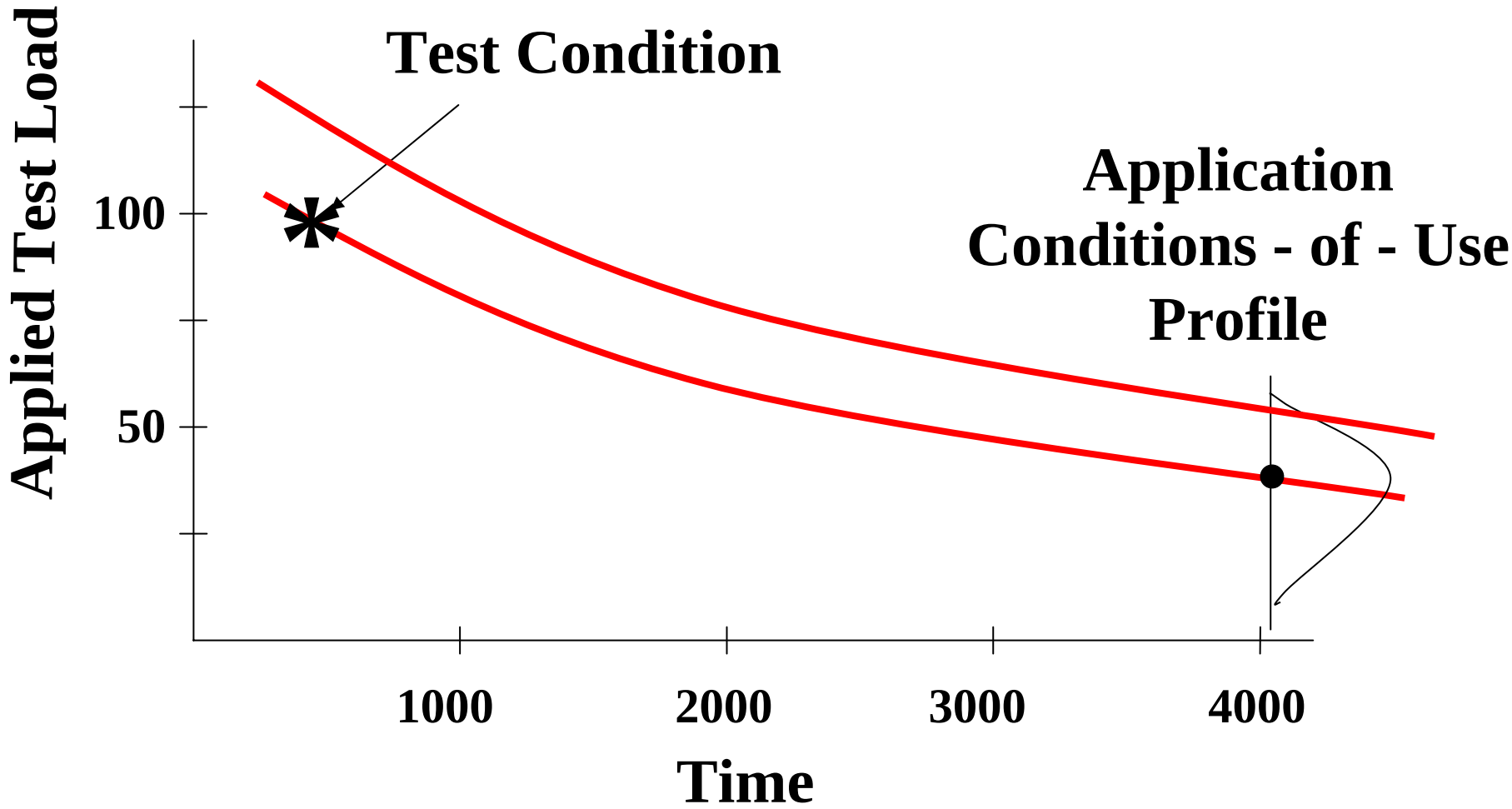
The USA generally operates on the theory of strict liability. A company is liable for damages resulting from a defect for no reason other than that one exists, and a plaintiff does not need to prove any form of negligence to win their case.

Thus, we need to know as much about "how things fail" as we know about "how things work."

Qualification Tests



Qualification Tests



What Else could be Wrong

- The types of loads, load combinations and load profiles in the field may not have been properly anticipated

- Component interactions might have caused failures at some “higher” assembly level, that were not evaluated in the qualification test

2003: IEEE 1413 and IEEE 1413.1

IEEE Std 1413-1998

IEEE Standard Methodology for Reliability Prediction and Assessment for Electronic Systems and Equipment

Sponsor

Standards and Definitions Committee
of the
IEEE Reliability Society

Approved 8 December 1998

IEEE-SA Standards Board

Abstract: The framework for the reliability prediction process for electronic systems and equipment, including hardware and software predictions at all levels, is covered.
Keywords: hardware prediction, reliability, reliability prediction, software prediction

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

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PDF: ISBN 0-7381-1552-5 SS94714

IEEE Std 1413.1™-2002

IEEE Guide for Selecting and Using Reliability Predictions Based on IEEE 1413™

Sponsor

IEEE Standards Coordinating Committee 37
on
Reliability Prediction

Approved 12 September 2002

IEEE-SA Standards Board

Abstract: A framework for reliability prediction procedures for electronic equipment at all levels is provided in this guide.
Keywords: baseline, classic reliability, constant failure rate, estimation, failure, goal, item, operating environment, reliability prediction, requirement, system life cycle

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IEEE 1413 and 1413.1

- Shows that there is very little value in the use of Mil-Hdbk-217, 217-Plus, PRISM, FIDES, and progeny prediction methods

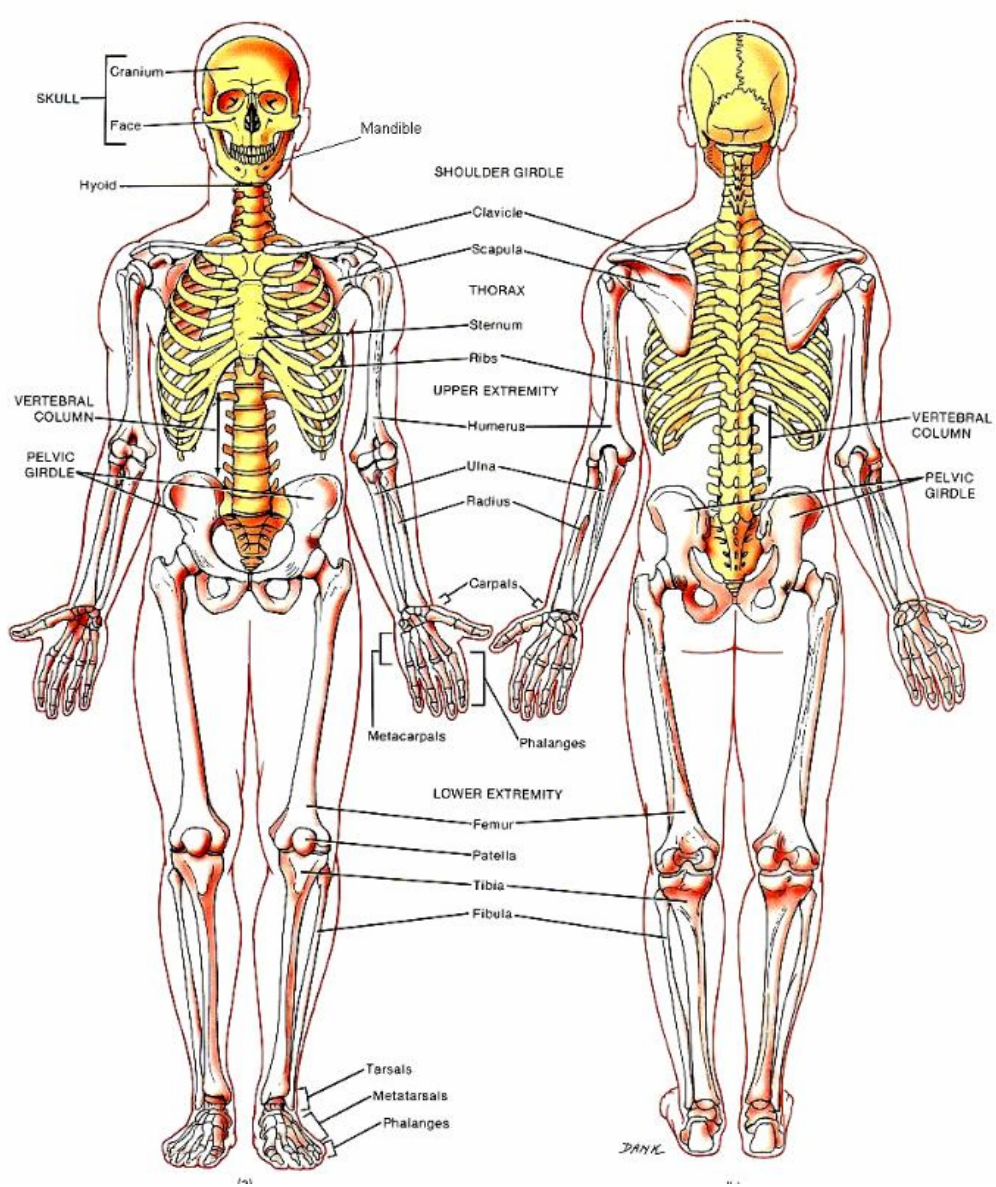
- Physics-of-failure methods (models) of failure mechanisms are necessary for good reliability assessment (qualification) and prediction

….. BUT one also needs a good assessment of the "conditions of use in the application"

2004: JEDEC-STD-148
Reliability Qualification of Semiconductor Devices Based on Physics of Failure
Risk and Opportunity Assessment

- Transition to a qualification approach based on an understanding of failure mechanisms (physics-of-failure) and the end user conditions

Health is the extent of deviation or degradation from an expected normal condition.

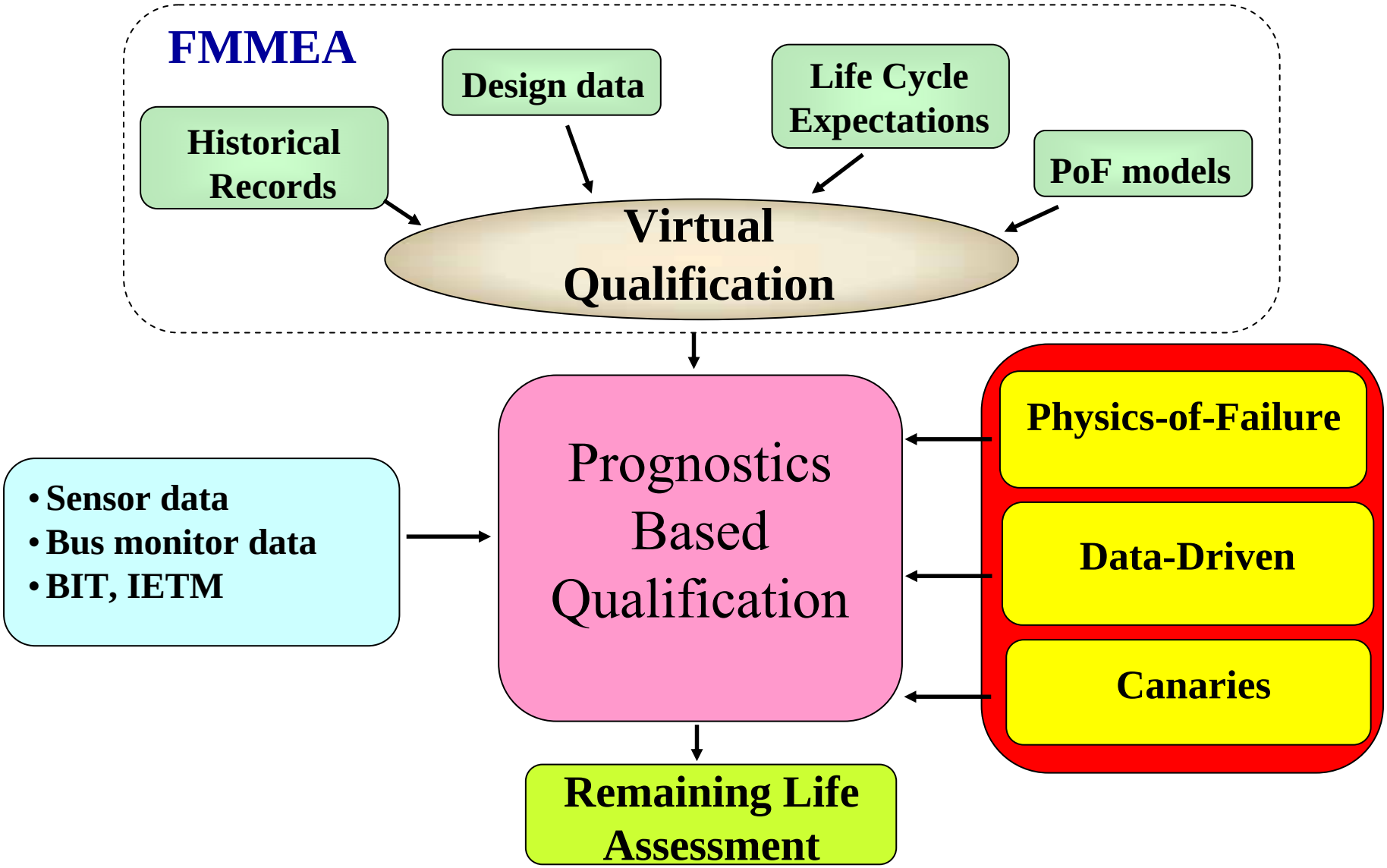


Prognostics

Techniques utilized to trend health as a means to determine the remaining life

2003: US Military Requires Prognostics to be Included in All New Weapon Systems

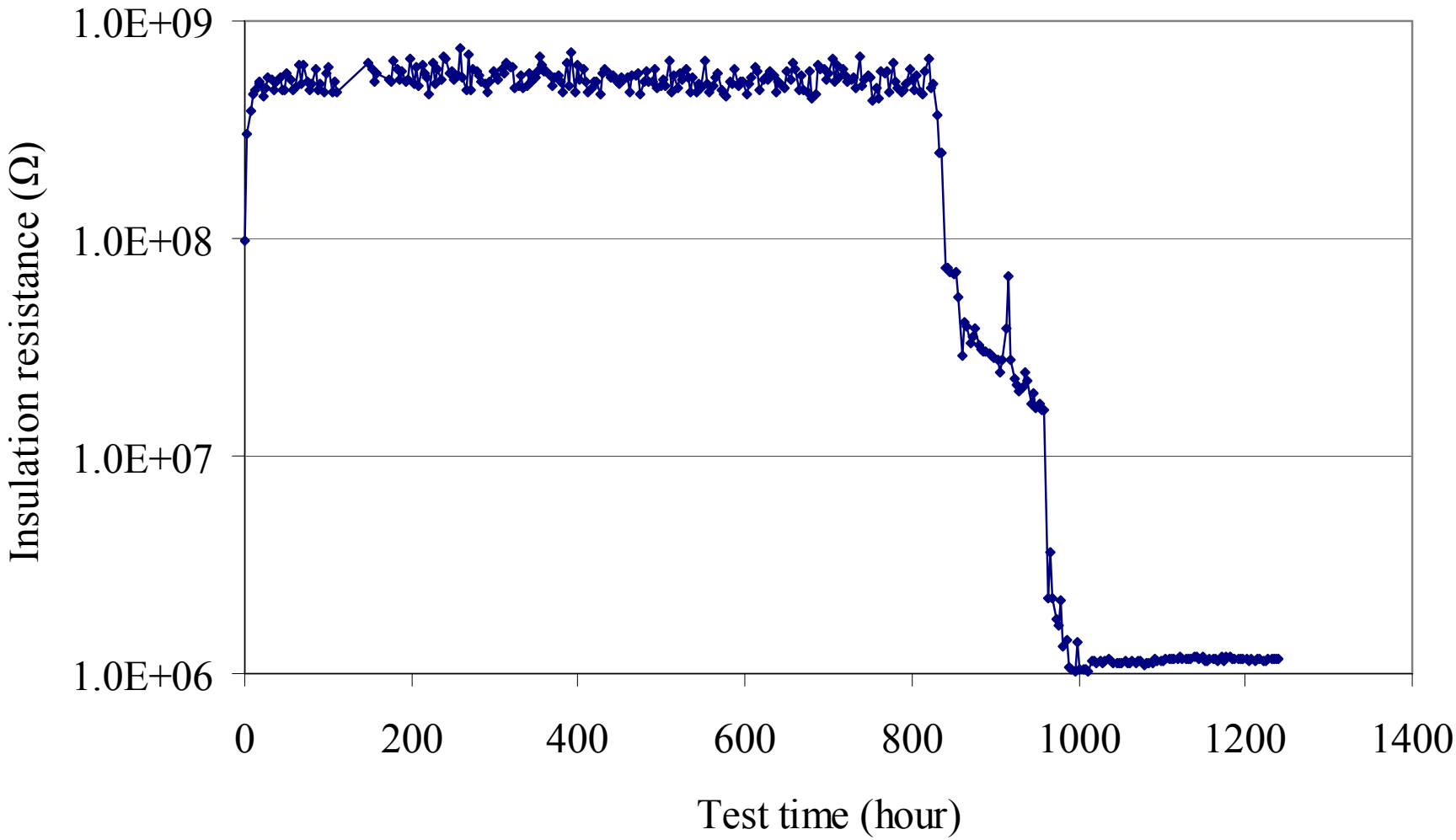
Prognostics Based Qualification Methodology



Simple Component Example

- Capacitors, such as multilayer ceramic capacitors (MLCCs), often suffer parametric drift and intermittents, when exposed to stress
- Using prognostics, it is possible to uncover intermittent anomalies and qualify capacitors in a shortened period of time

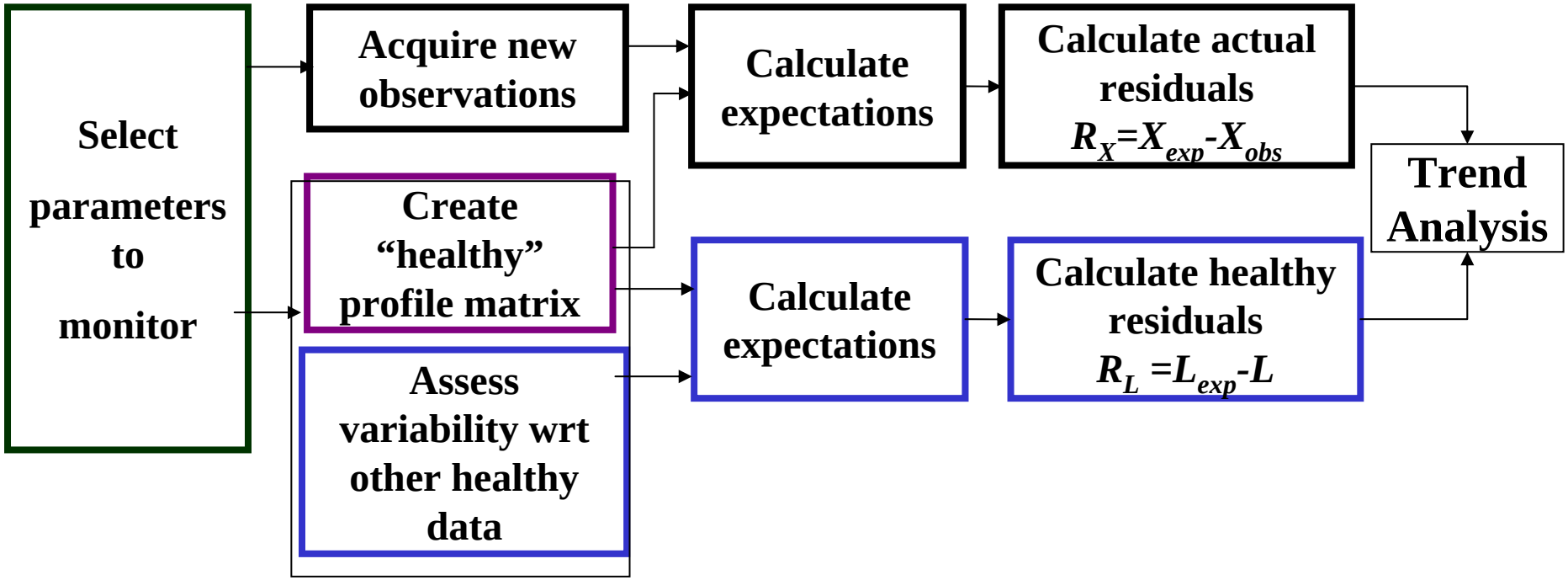
IR for Capacitor



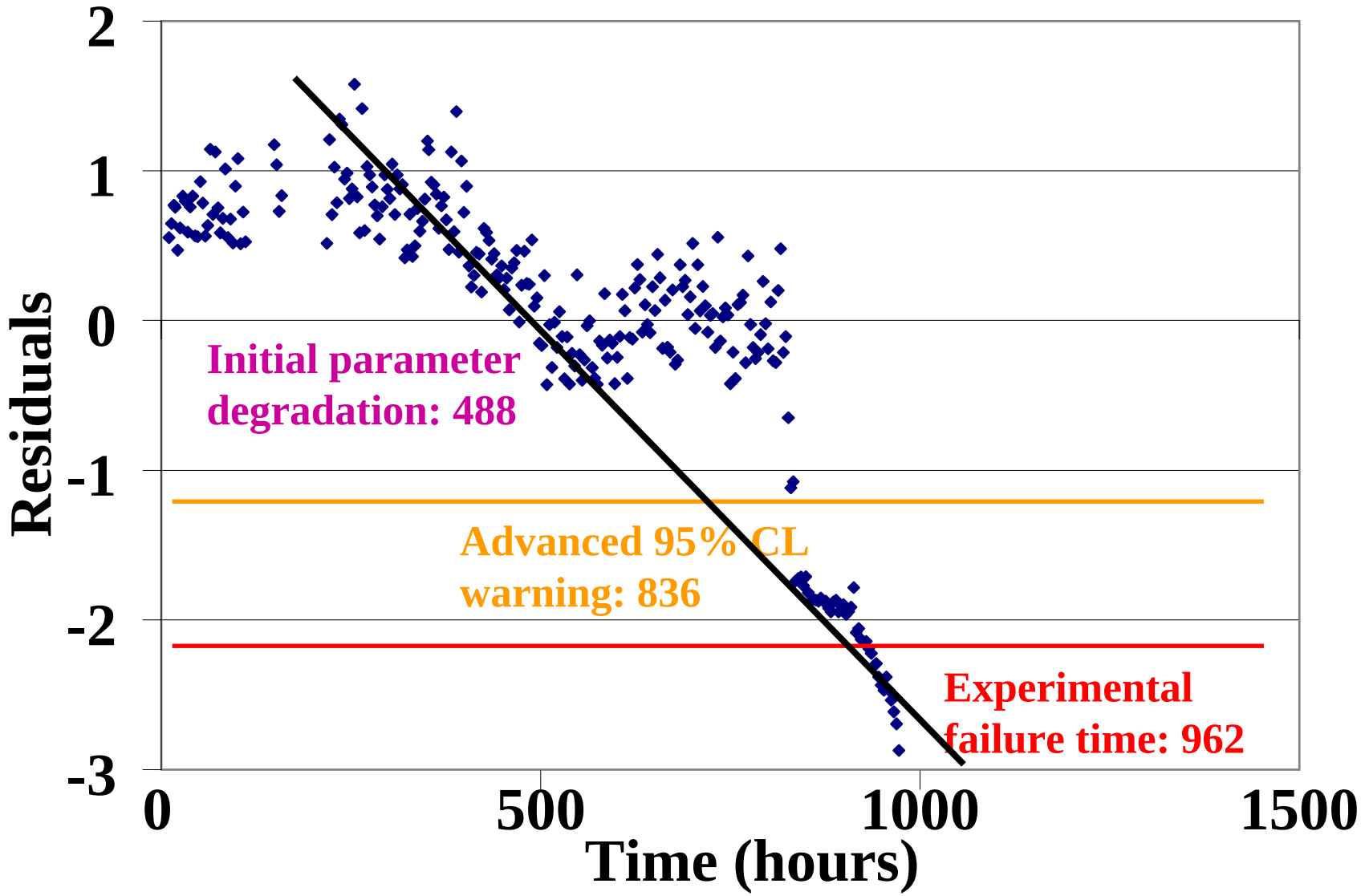
MLCCs Test Conditions

- Accelerated test conditions (THB) conditions
  - 85°C, 85% RH, 50V
- In-situ monitored 3 parameters: capacitance (C), dissipation factor (DF), insulation resistance (IR)
- 10 capacitors used to define a standardized and correlated “healthy” baseline
- Other capacitors were then qualified with respect to deviations from this baseline

Data Driven Prognostics Analysis



Residuals with Respect to Baseline



Categories of Parameters Monitored in Qualification

- Performance parameters (Memory, CPU)
- Device information (e.g. IC, battery charge, fan speed, LCD brightness)
- Thermal (e.g. CPU, board, graphics), humidity, vibration, other load information
- Mechanical usage information (e.g. keystrokes, battery insertions)
- System hardware information

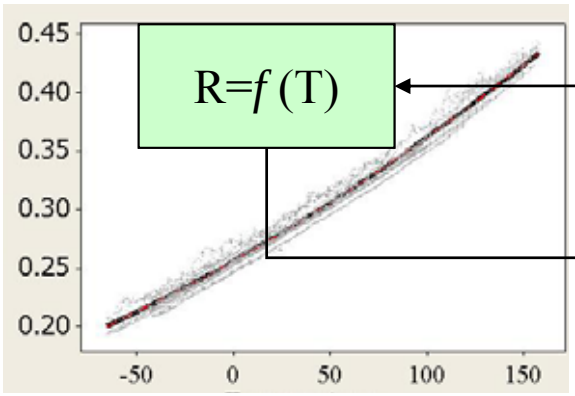
Snapshot of Qualification Data

	A	B	C	D	E	F	G	H	I	J	K	L
8	Battery	Sampling	Rate:	60000ms								
9	Fan	Sampling	Rate:	30000ms								
10	LCD	Sampling	Rate:	60000ms								
11	Thermistor	Sampling	Rate:	30000ms								
12	Power	Management	Sampling	Rate:	5000ms							
13												
14												
15	**System_Time**	**Reason_Code**	**RSOC**	**Current**	**Voltage**	**RSOC**	**Current**	**Voltage**	**Fan0**	**Fan1**	**Brightness**	**Therm0(CPU)**
16	060710.14:58:00:218	T:PM	96	0	12321	79	3040	12616	2387	N/A	0	40
17	060710.14:58:05:171	T:PM	96	0	12321	79	3040	12616	2387	N/A	0	40
18	060710.14:58:10:671	T:PM	96	0	12321	79	3040	12616	2387	N/A	0	40
19	060710.14:58:15:203	T:PM	96	0	12321	79	3040	12616	2387	N/A	0	40
20	060710.14:58:20:203	T:PM	96	0	12321	79	3040	12616	2387	N/A	0	40
21	060710.14:58:23:031	T:Therm	96	0	12321	79	3040	12616	2387	N/A	0	39
22	060710.14:58:23:031	T:Fan	96	0	12321	79	3040	12616	2434	N/A	0	39
23	060710.14:58:25:218	T:PM	96	0	12321	79	3040	12616	2434	N/A	0	39
24	060710.14:58:30:203	T:PM	96	0	12321	79	3040	12616	2434	N/A	0	39
25	060710.14:58:35:203	T:PM	96	0	12321	79	3040	12616	2434	N/A	0	39
26	060710.14:58:40:187	T:PM	96	0	12321	79	3040	12616	2434	N/A	0	39
27	060710.14:58:45:203	T:PM	96	0	12321	79	3040	12616	2434	N/A	0	39
28	060710.14:58:50:203	T:PM	96	0	12321	79	3040	12616	2434	N/A	0	39
29	060710.14:58:53:031	T:LCD	96	0	12321	79	3040	12616	2434	N/A	0	39
30	060710.14:58:53:093	T:Batt	96	0	12321	81	3316	12708	2434	N/A	0	39
31	060710.14:58:53:109	T:Therm	96	0	12321	81	3316	12708	2434	N/A	0	39

Frequency of data collection

Date/Time Stamp

Prognsotics Analysis



R=*f* (T)

In-situ Monitoring

Temperature (T)

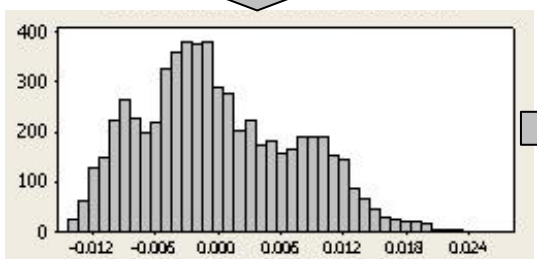
Charge, fan resistance

Parameter Estimate

Parameter Drift

Parameter Drift Distribution

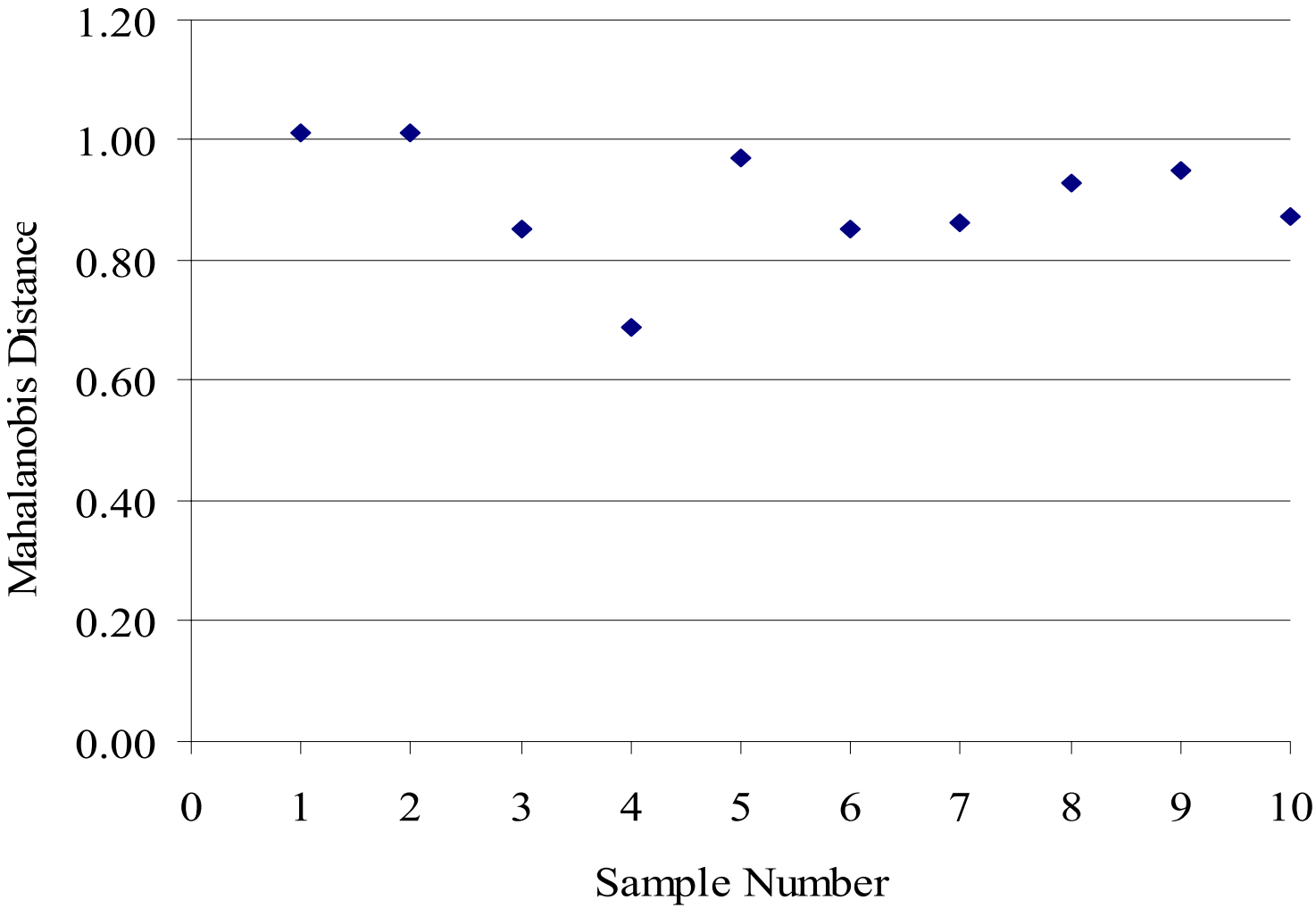
Identify failure progression



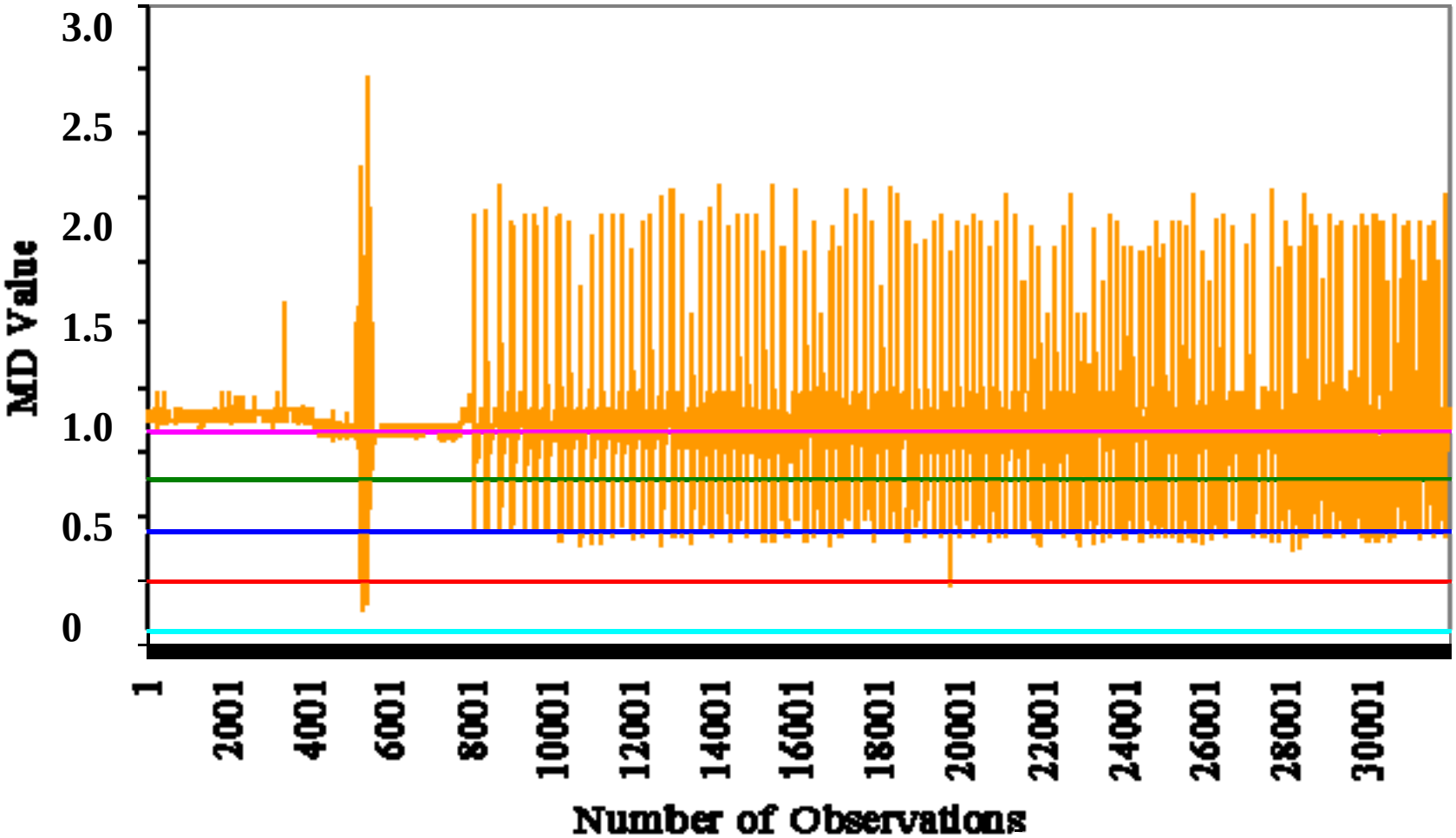
Features Investigated

- **Mean drift values**
- **Mean peaks**
- **Standard deviation**
- **95% cumulative distribution values**
- **95% cumulative peaks**
- **Skewness**
- **Kurtosis**
- **others**

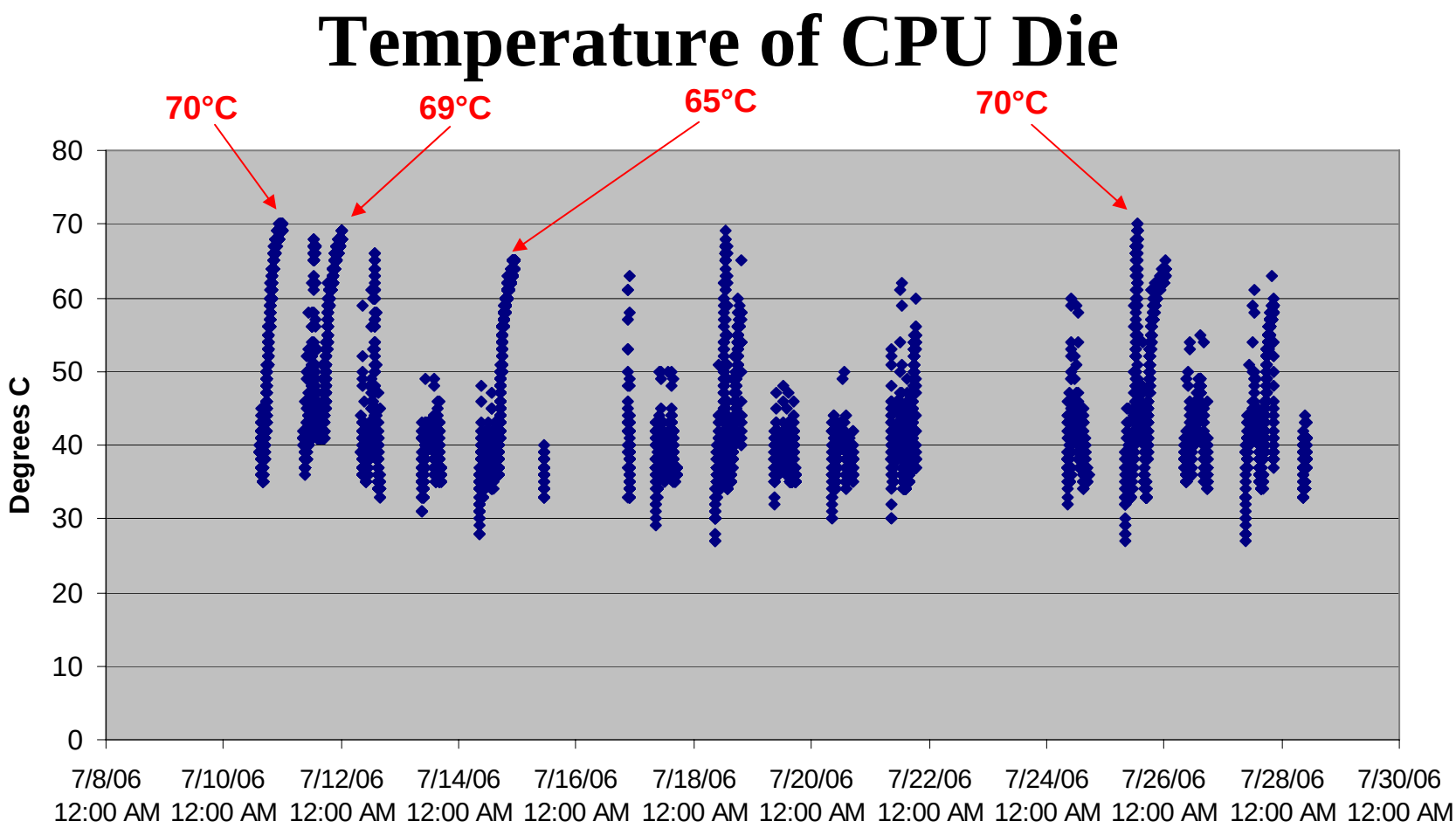
MD Values Plot for Healthy System



Qualification Analysis

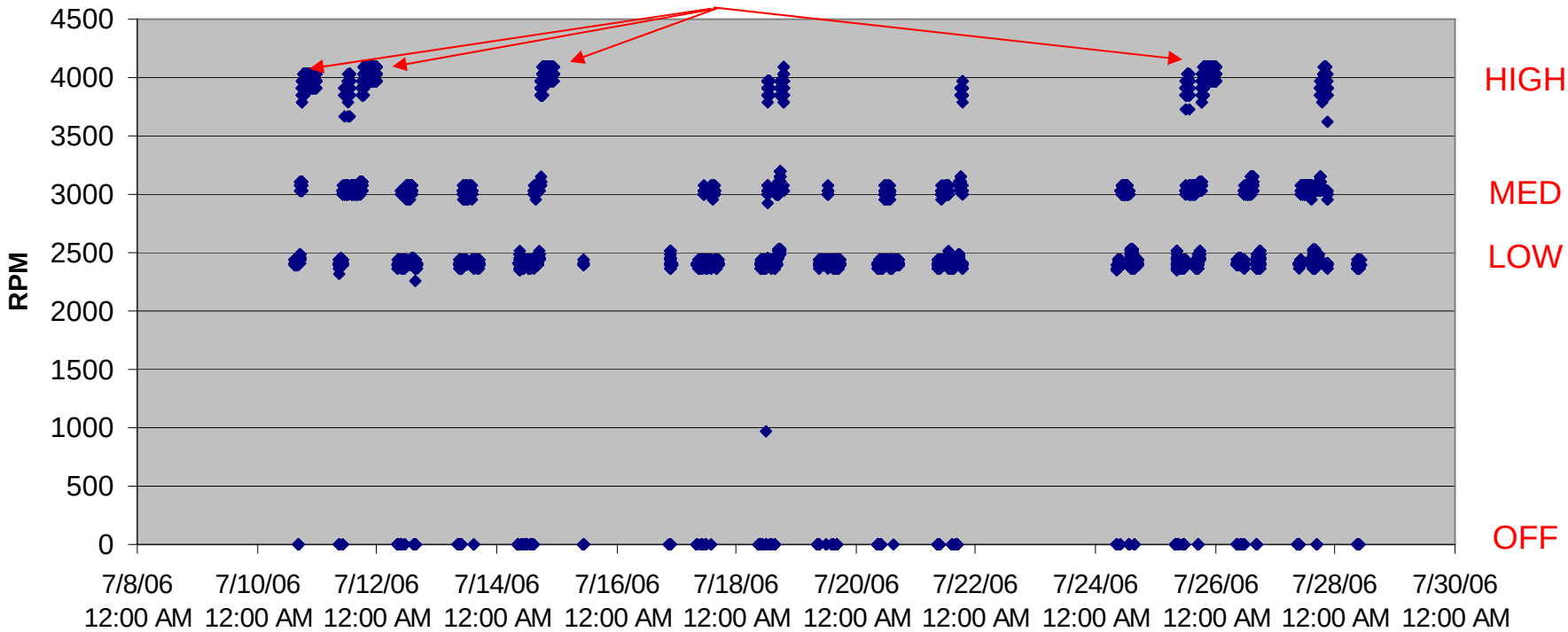


Interesting Results



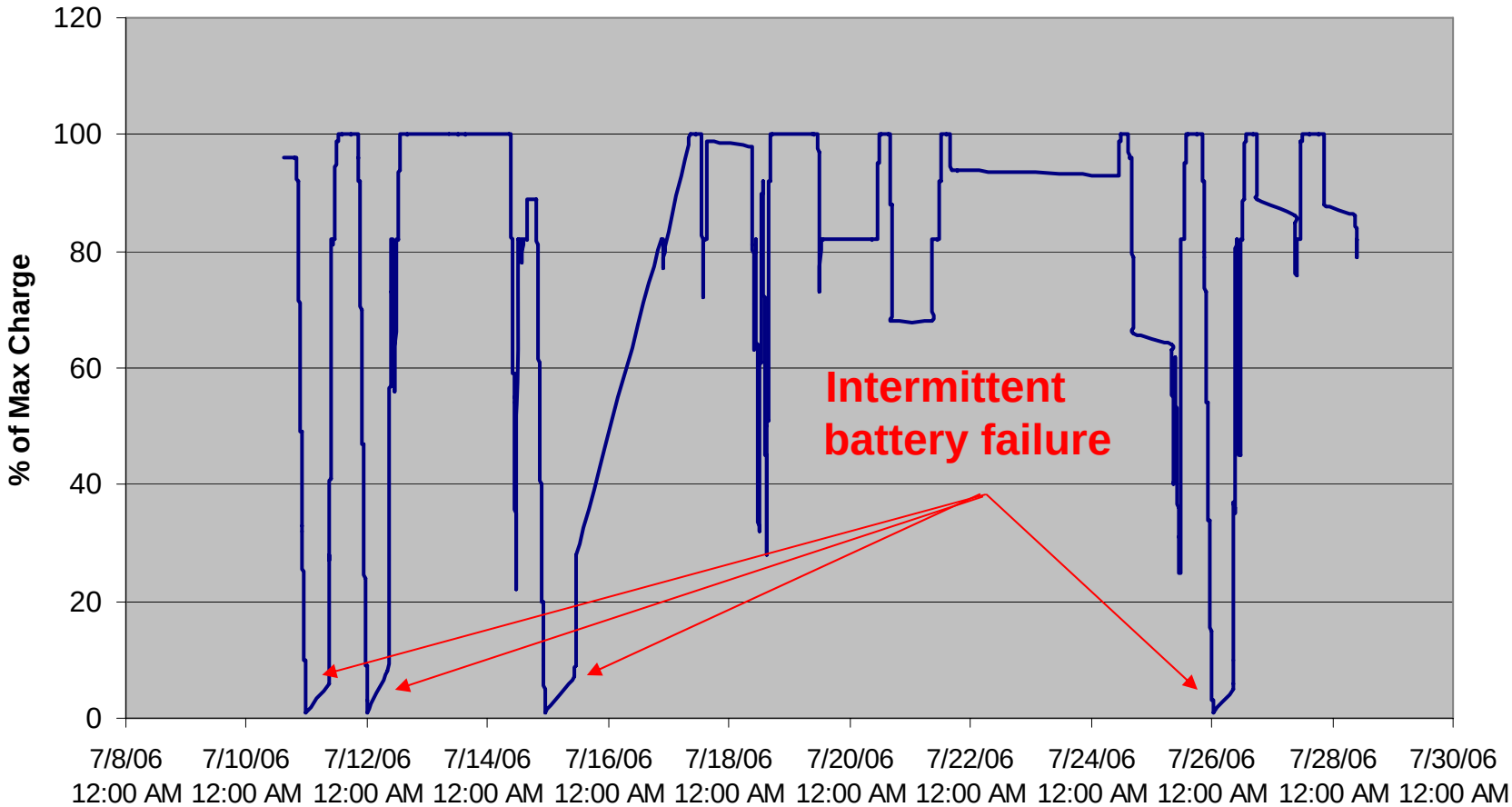
Interesting Results

System Fan Speed Anomalies

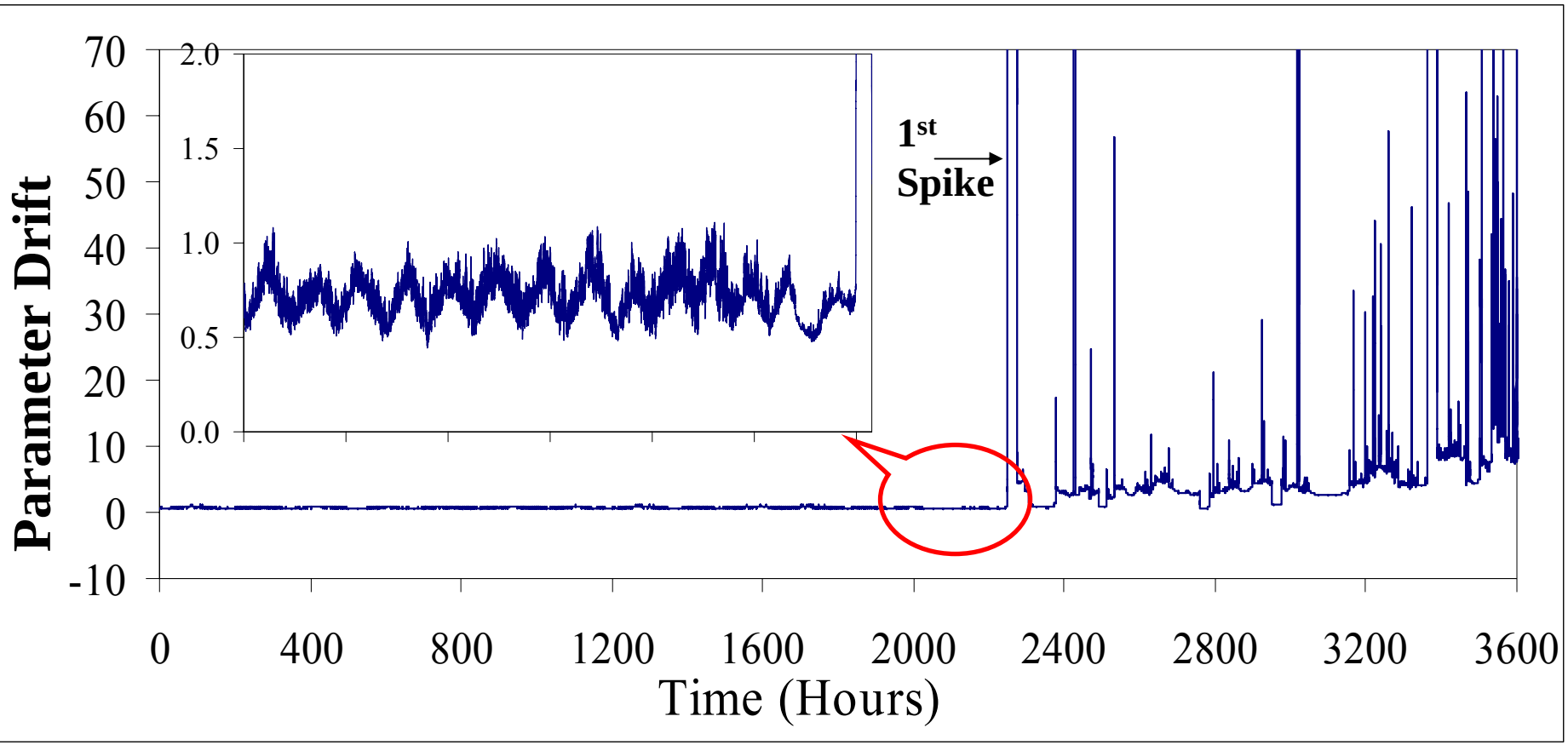


Interesting Results

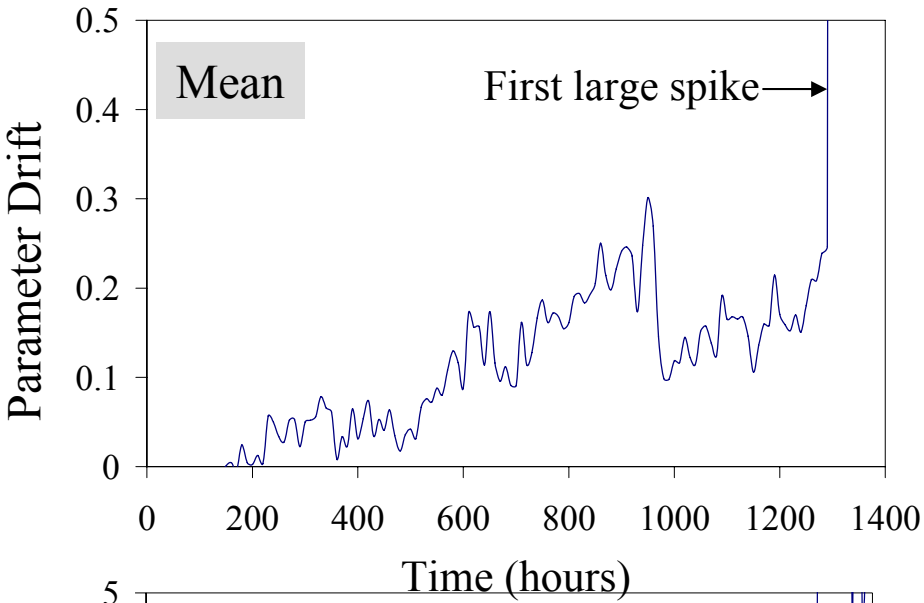
Relative State of Charge of Battery

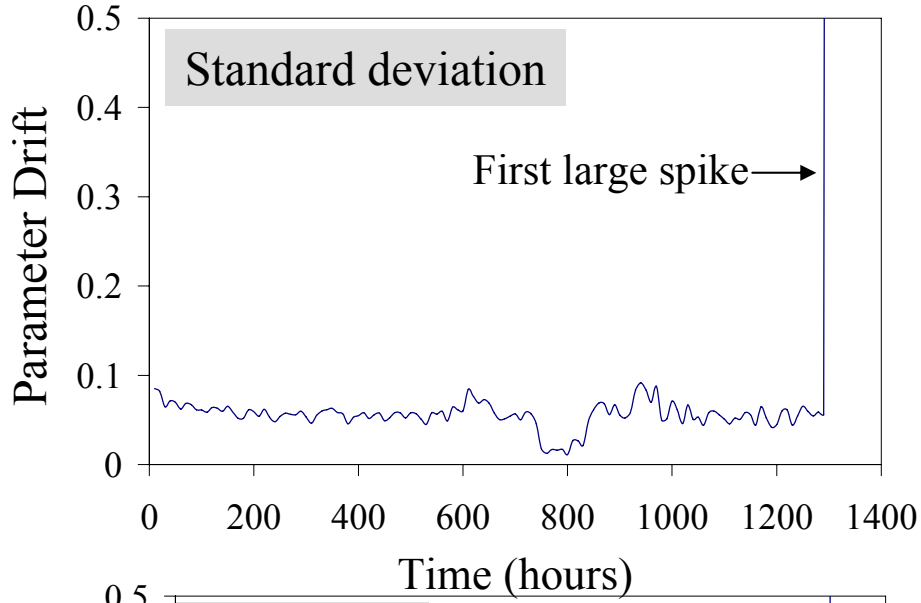


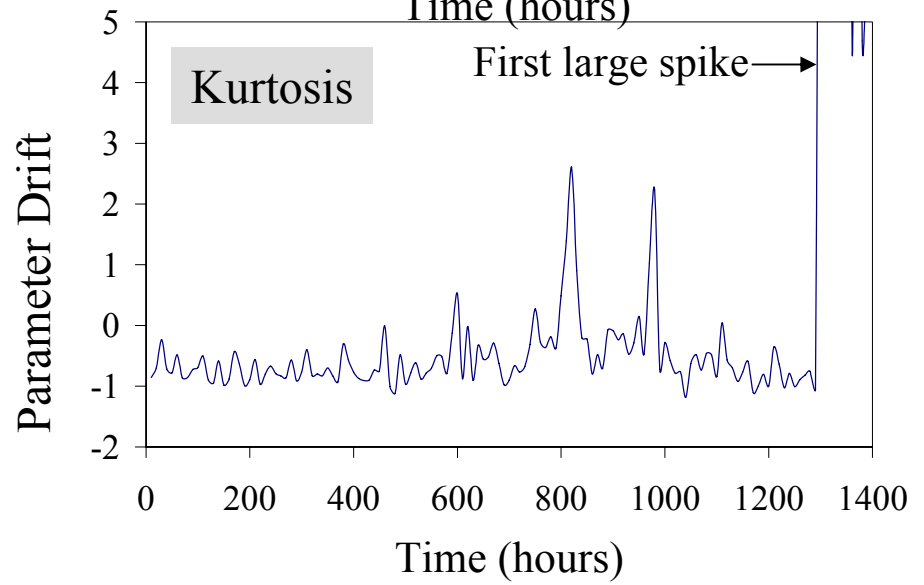
Data Trending Prognostic

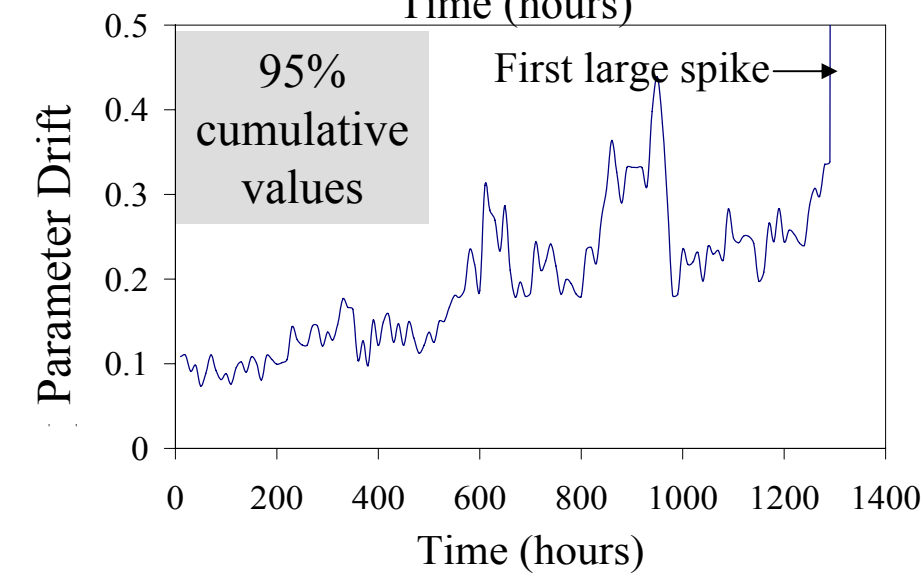


Trending Features

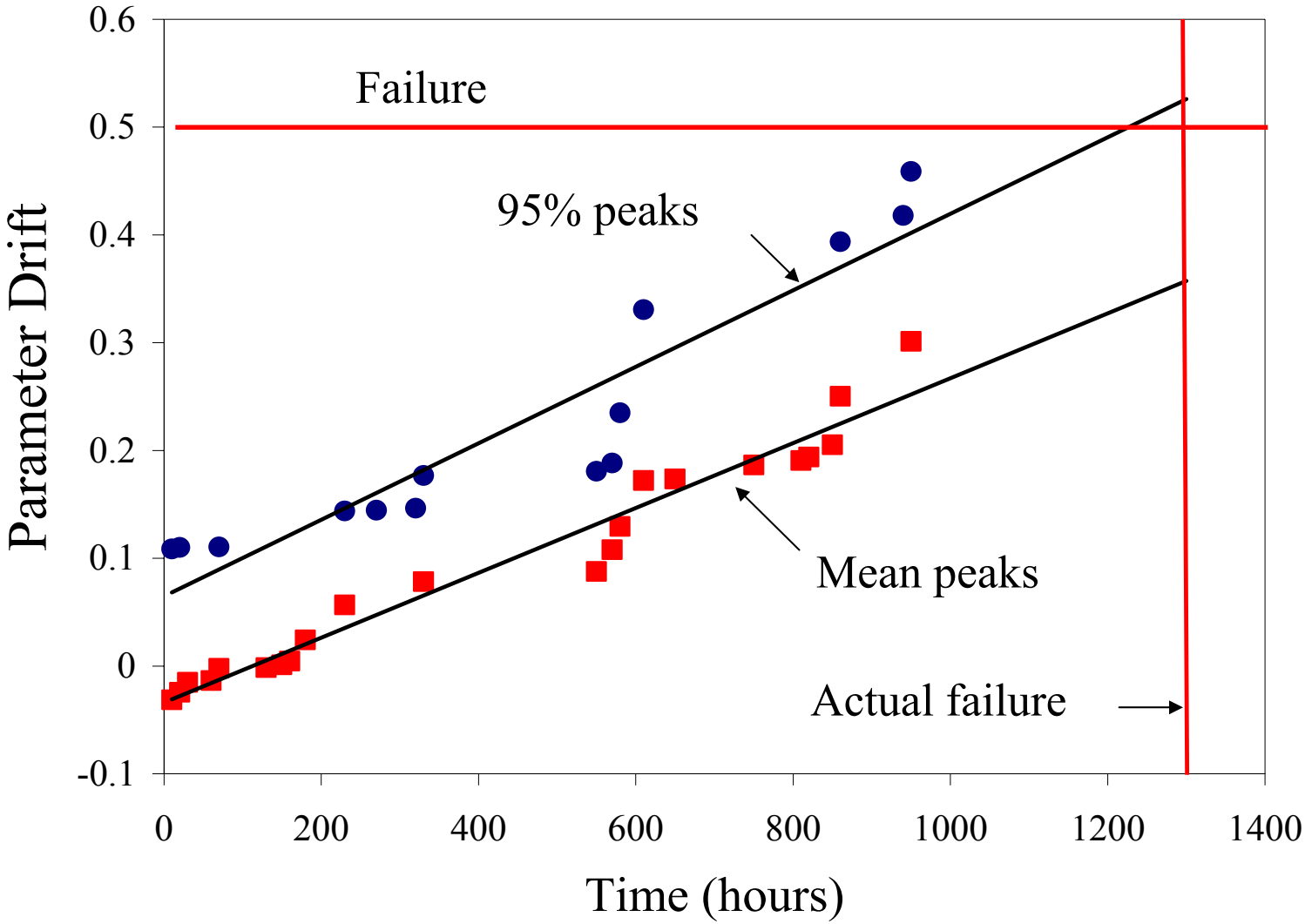








Qualification Life Prediction



Summary :
Prognostics Based Qualification

- Can significantly reduce the test time
- Can pick up intermittent anomalies because it is sensitive to correlated parameter changes (parameter interactions)
- Can better incorporate the types and combinations of loads and load profiles of the target applications
- Can be incorporated into products for other prognostics and health management purposes

The Future

- **Prognostics will be incorporated into all electronics**
- **Prognostics will not only be used for product qualification, but also for screening, in-situ health monitoring, and continuous remaining life assessment**