Creating a Sustainable Protective Relay Asset Strategy

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Creating a Sustainable Protective Relay Asset Strategy

- Introduction
- Characteristics of Relay Generations
- Protection System Asset Management Challenges
- Triage of Existing Installations of Aging Relays
- Impact of Misoperations and Human Errors
- Design of new P&C standards, panels and buildings for rapid future change
- Asset and fleet management strategies
- Conclusions

From Then to Now - Introduction

Protection systems have evolved from:

- Assemblies of electromechanical single function devices
- Through multiple generations of analog solid state systems
- To advanced microprocessor based protection systems

Many utilities now face a complex tangle of challenges

- Managing the performance and reliability of multiple generations of relays in service

We will explore the challenges of creating a sustainable relay upgrade and replacement program

Characteristics of Relay Generations

- Electro-mechanical (EM) relays
  - last as long as the primary power apparatus they protect and installations designed around this longevity
  - Require regular maintenance and subject to drift
  - Simple with limited functionality
- Solid State (SS) relays
  - Analog Solid State relays are a lost generation
  - Failure rates high due to electronic component failures
  - Being phased out at most utilities
- Microprocessor (MP) relays
  - Shorter service life than EM relays (maybe ½)
  - Can self monitor and extend maintenance cycles indefinitely
  - Complex multi-functional and integrated

Sustainable New P&C Designs

- What new installation design principles apply when we are using MP relays?

Topics:

- Design standards
- Drop-in buildings
- Reusing existing buildings
- Process bus prospects
- Panel design features

Design Standards

Features *of effective, highly structured standards (1):*

- Specific, limited options for different uses
- Uses the same relay(s) in all places, even if a cheaper one would work in some of the places
- Peer review to filter exceptions
- Periodically review new approaches and equipment, collecting changes and new designs to introduce all in one revision (e.g., every 3 years)
- Standardize relay/product hardware and firmware versions

Design Standards

Features of effective, highly structured standards (2):

- Standardize setting templates for logic and system settings – limit variations to application settings
- Create a standard panel laboratory and keep it according to the standard!
  - Misoperation replication and analysis
  - Test bed for emergency analysis and fixes
  - Training facility for engineers and technicians
  - Trial location for next generation standard development
- Keep centralized accessible records of field experiences, suggestions, ideas, fixes, and problems to resolve next time

Design Standards

***Benefits** of highly structured standards:*

- Efficiency and reduced human error
- Fast & accurate engineering & installation
- Fast & accurate troubleshooting
- Clear & effective data gathering/asset management
- Easier configuration & settings management
- Much easier to create & document condition based maintenance (CBM) program per NERC PRC-005-2
- Easier spares and field repairs
- Faster, lower cost, error-free equipment purchasing

Using Drop-in Control Buildings

When to use:

- Plan to replace all old P&C at once
- Old building crowded
- No room to cut over
- Decayed yard wiring
- Room in switchyard for a drop-in building

If using:

- Tie to new design standards
- The drop-in building will outlast the P&C inside
  - See panel design advice (coming here) so newer P&C standards can be easily installed.

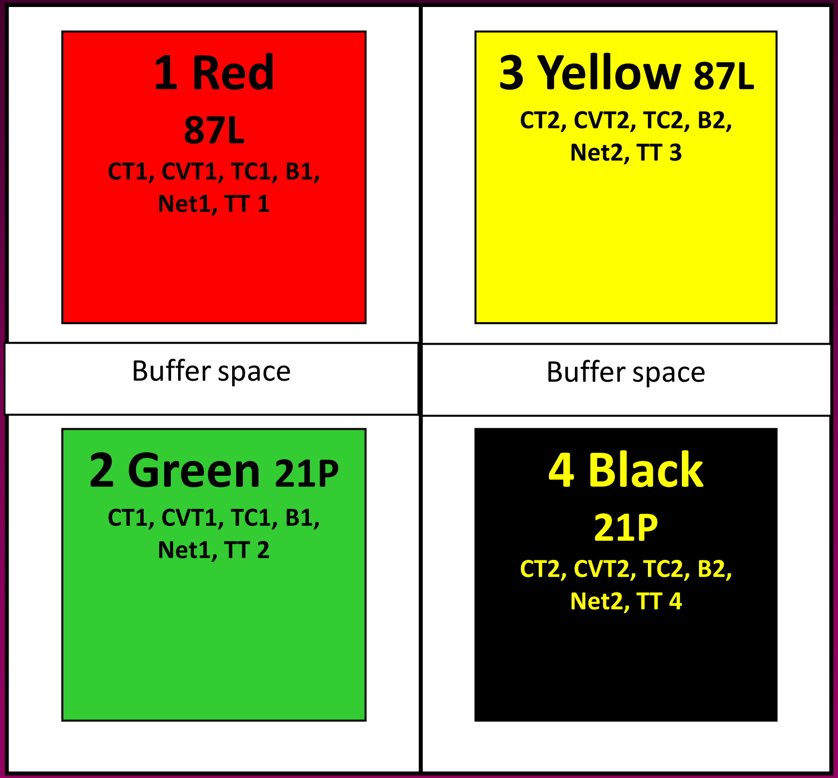
Reusing Existing P&C Building

A fine old building can be better than a new drop-in building when it offers:

- Good condition
- Lots of room for replacement work
- Good switchyard wiring, or
- Good access for wiring replacement & rerouting

Improving MP Panel Designs

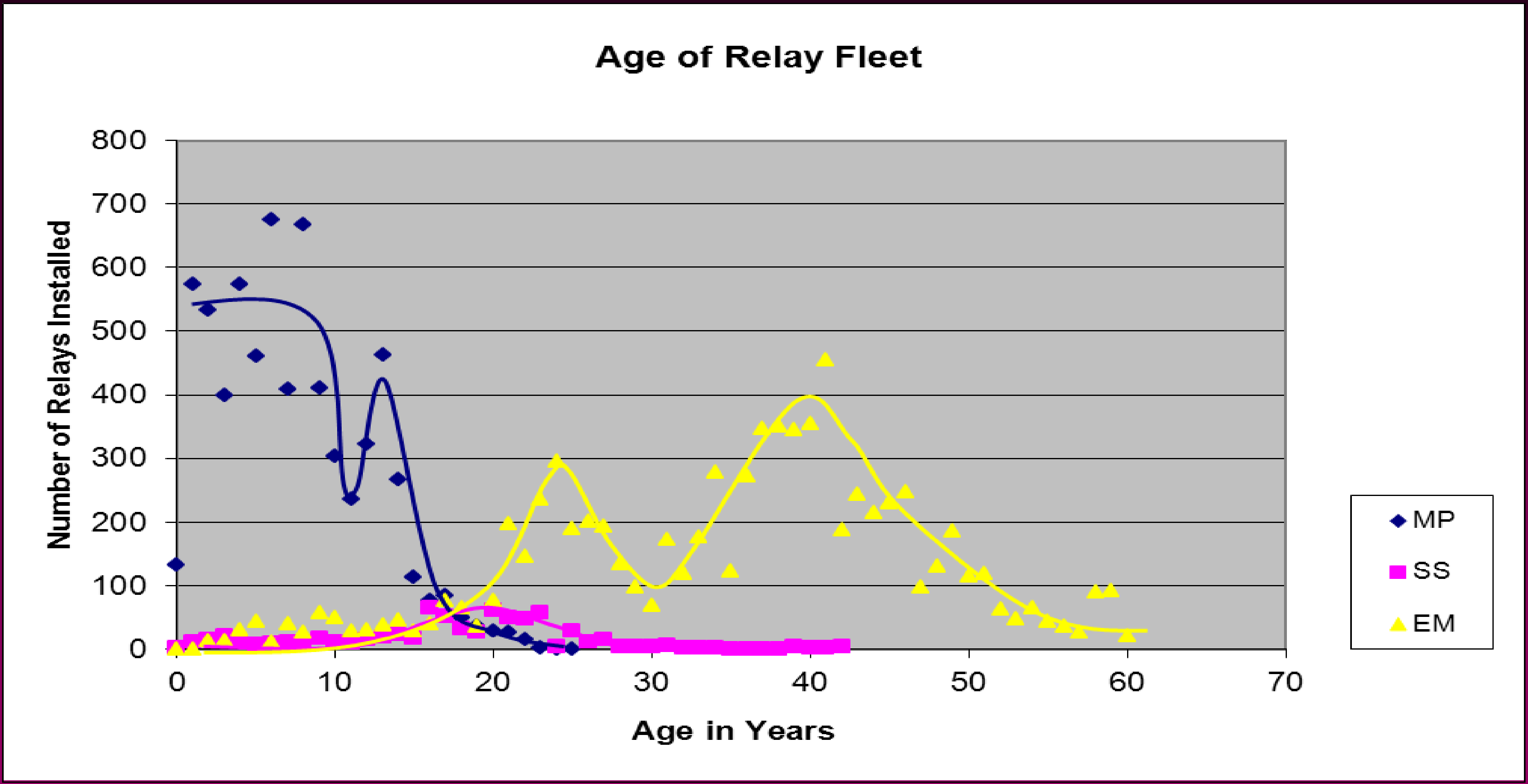
- Each zone of protection is a physical unit - easy to remove & replace whole unit (redundant units are separate)
- Buffer spaces and barriers (permanent or easy-to-insert) for safe work on one system – no dropped-tool false trips
- Clearly distinguished markings & color coding for each unit , connections, & remote associations
- Grouped wiring/connection bundles, all to one edge
- Terminations on one edge designed for live disconnection – in addition to panel test switches
- Safe and easy life changeout - can't get outages in the future



More Questions about Relay Generations

- What tools does the organization need to manage a mixed fleet of new and old installations?
- What principles can we apply to decide about repairing and sustaining EM or SS relays versus replacing them with new MP relays?
- What new organizational approaches are needed to support MP relays?

Protection System Asset Management Challenges



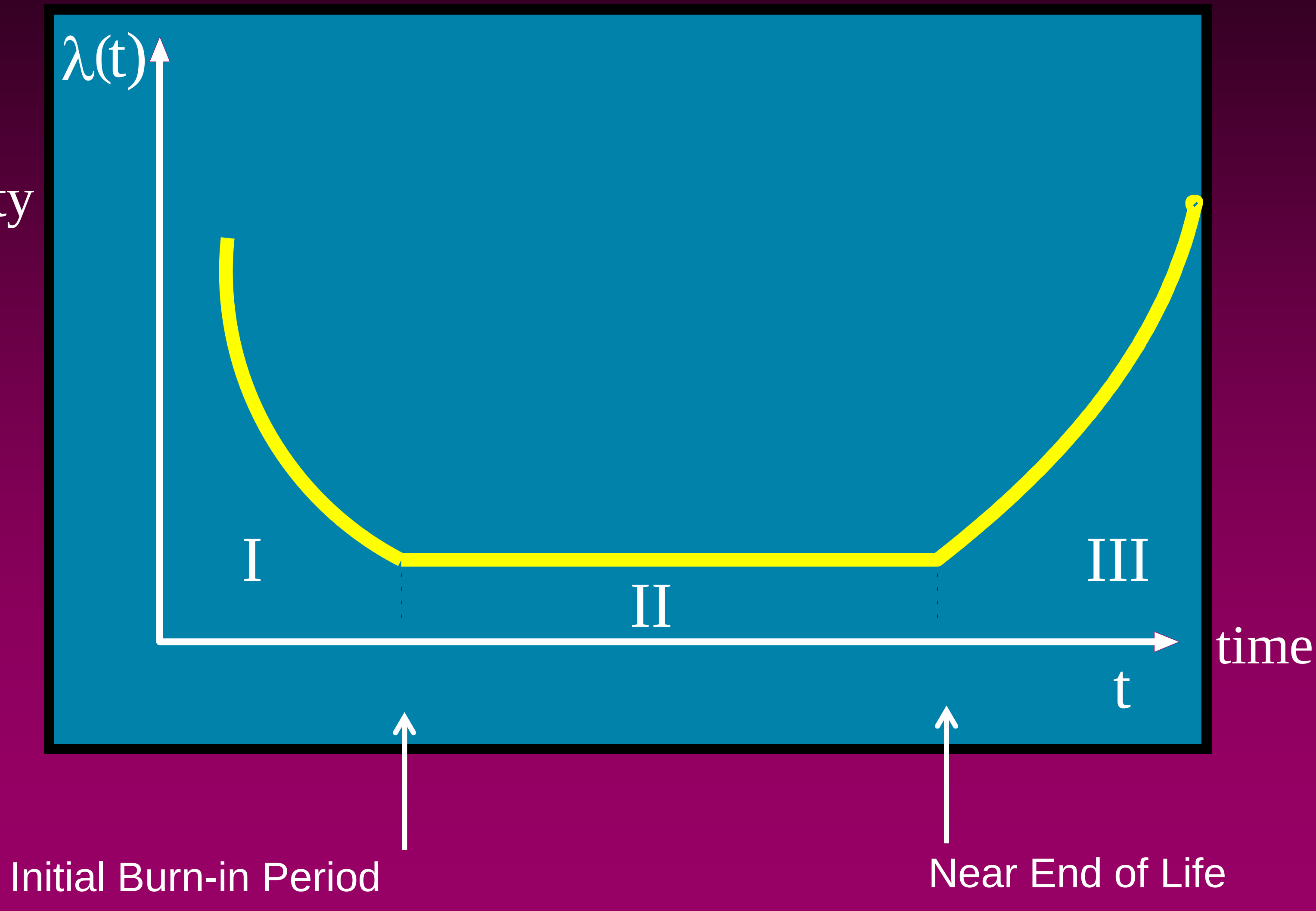
- Relay fleet is migrating from electromechanical (EM) to microprocessor (MP) based relays.
- Microprocessor relays and Solid State Relays have a shorter life expectancy.
- First generation microprocessor relays will be approaching end of life.

Triage of Existing Installations of Aging Relays

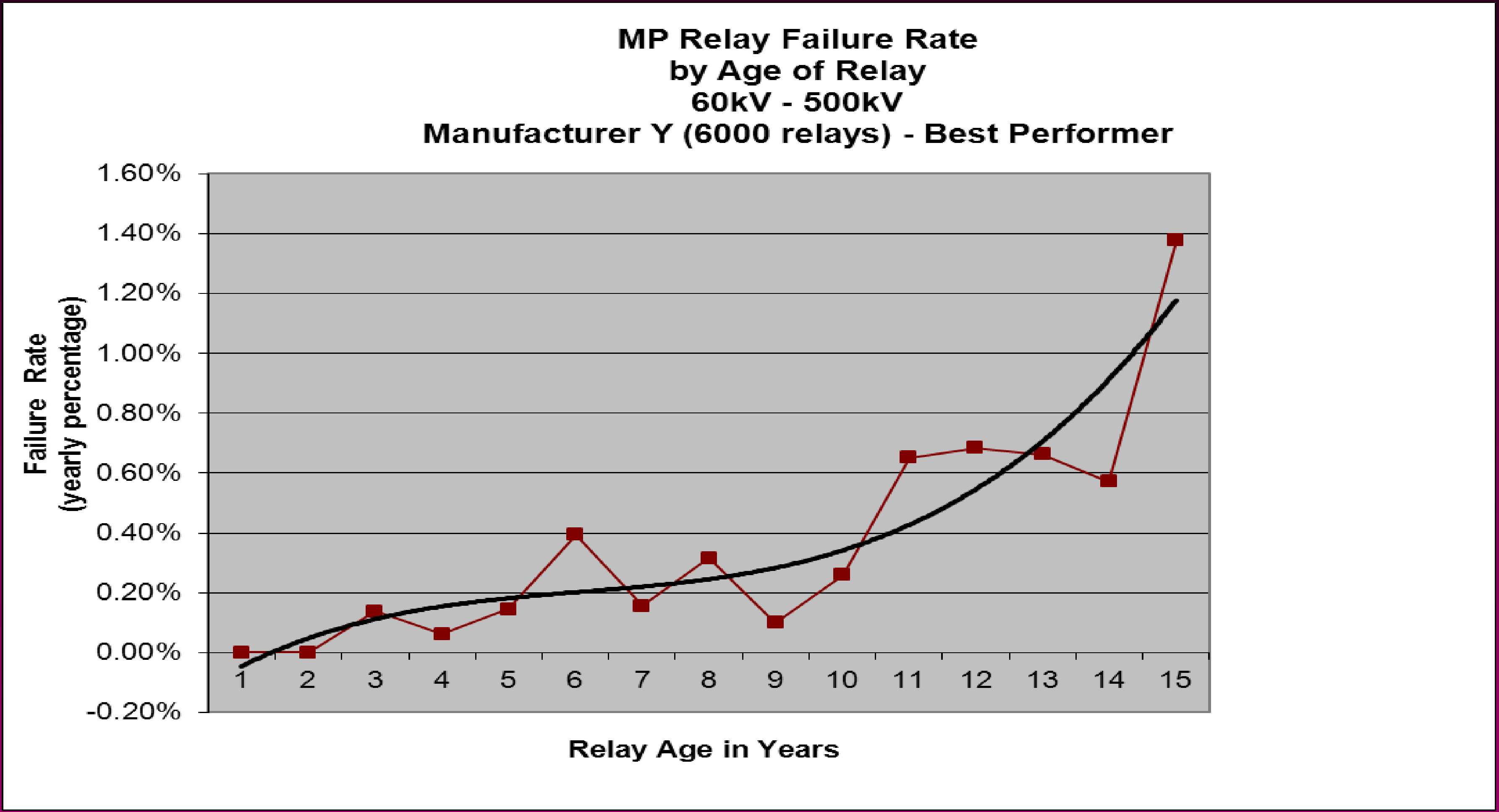
- Need to know how existing installations are performing
  - Relay Identification Information
  - Failure Date
  - Date Relay Installed
  - Date Relay Manufactured
  - Relay Manufacturer and Model
  - Relay S/N
  - Firmware Version
  - Description of relay failure
    - Component Failed (e.g., power supply)
  - Did relay trip (misoperate) when failure occurred?
  - How relay failure was identified

Triage of Existing Installations of Aging Relays
Probability of Failure "Bathtub" Curve

Probability
Of
Failure



Triage of Existing Installations of Aging Relays
Relay Failure Rates



Triage of Existing Installations of Aging Relays
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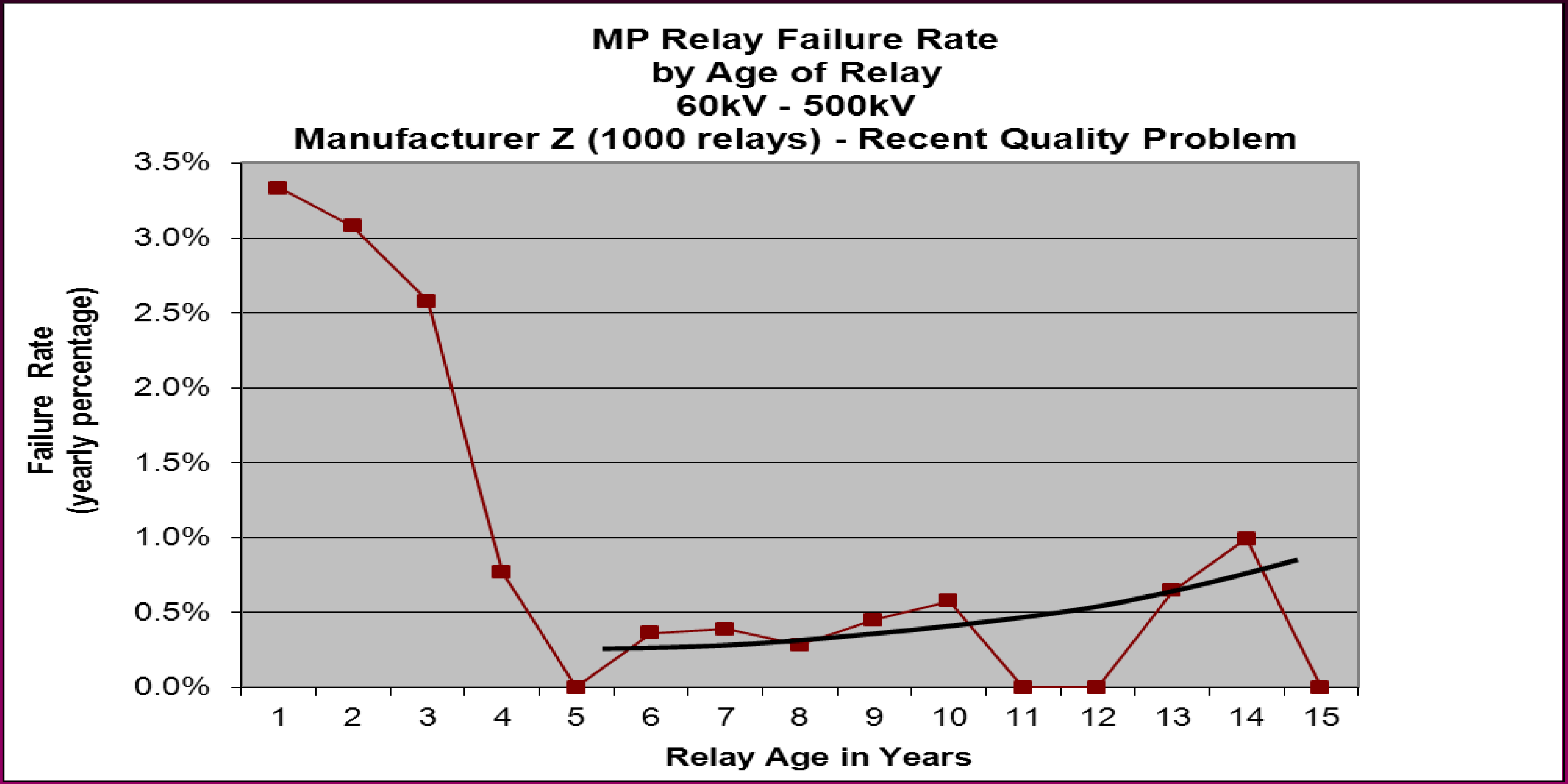
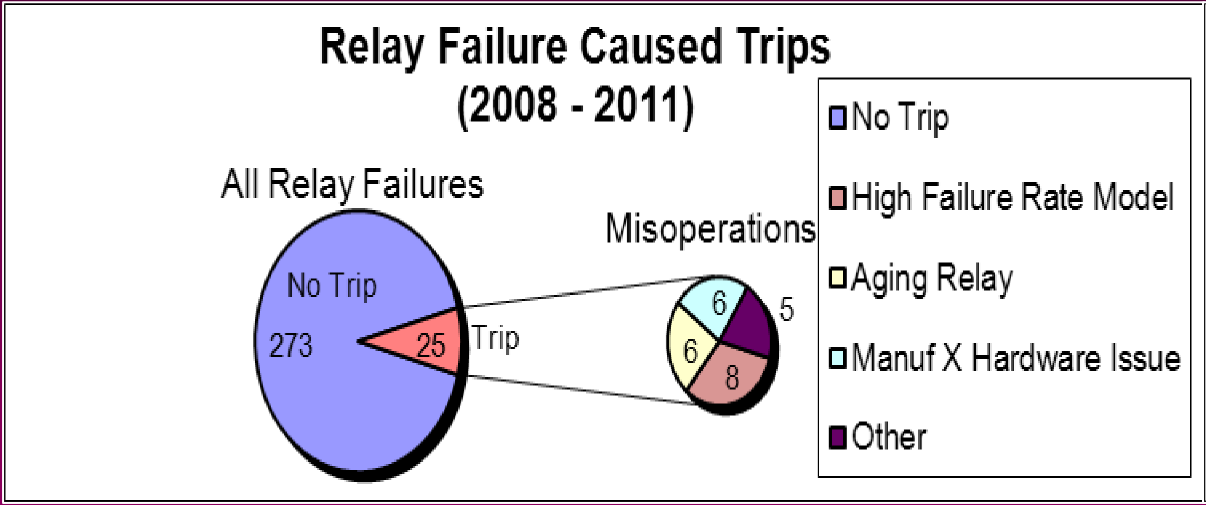
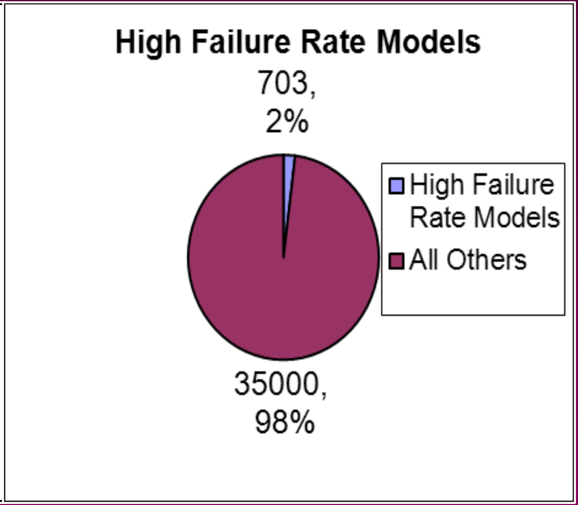


Protection System Asset Management Challenges

MTBF is a measure of how reliable a relay is but not a prediction of the relay's practical life.





- How do failures impact reliability (loss of grid or customers)?
- When failures do occur what is needed to replace the MP relay?

Asset and Fleet Management Strategies

Relay Replacement Prioritization Chart

Rating 1-5	Age in years (A)	Protection Gap (G)	Product Performance (P)	Design/Maintenance Prob. (M)
1	• EM < 10 • MP or SS < 5	• None	• None	• None
2	• EM 10 to < 20 • MP or SS 5 to < 10	• Lack of Operational Flexibility	• Lack of desired features • Lack of optimal functions and settings	• Lack of maintenance flexibility • Obsolete Design
3	• EM 20 to < 30 • MP or SS 10 to < 15	• Possible over Trip no loss of customers. • Compliance issue for emerging standards	• History of failures with no loss of customers • No longer meets company standards • MF does not support but no problems	• Restoration Problems • Consistently out of tolerance • No long meets company standard
4	• EM 30 to < 40 • MP or SS 15 to < 20	• Over trip with loss of customers for N-2 • Under trip for N-2 • Possible Compliance violation	• History of failures with loss of customers for N-2 • Not compatible with company equipment	• Cannot be tested without isolating element. • MF does not support this product • Unique skills are needed for testing
5	• EM > 40 • MP or SS > 20	• Over trip with loss of customers for N-1 • Under trip for N-1 • Compliance violation	• History of failures with loss of customers • Not compatible with company equipment • MF does not support but significant problems	• Cannot be tested without dropping customers. • MF has recall on this product • Skills are no longer available • Limited spares
SCORE = A * G * P *M				

Asset and Fleet Management Strategies
Maintenance Program

Testing impacts to consider in MP scheme design:

- Time to test - Both commissioning and routine maintenance
  - EM and simple MP relay schemes take roughly the same amount of time to test
  - Complex integrated MP schemes much longer – More time to test and more trouble shooting.
- Isolation Points
  - MP Relays may not have visual isolation - Difficult to know if fully isolated (hidden traps).
- Test Methodology and Expertise Required
  - Complex schemes require detailed step by step test document to prove all logic.
  - Technicians may not understand the procedures and are just executing the steps. Loss of expertise.

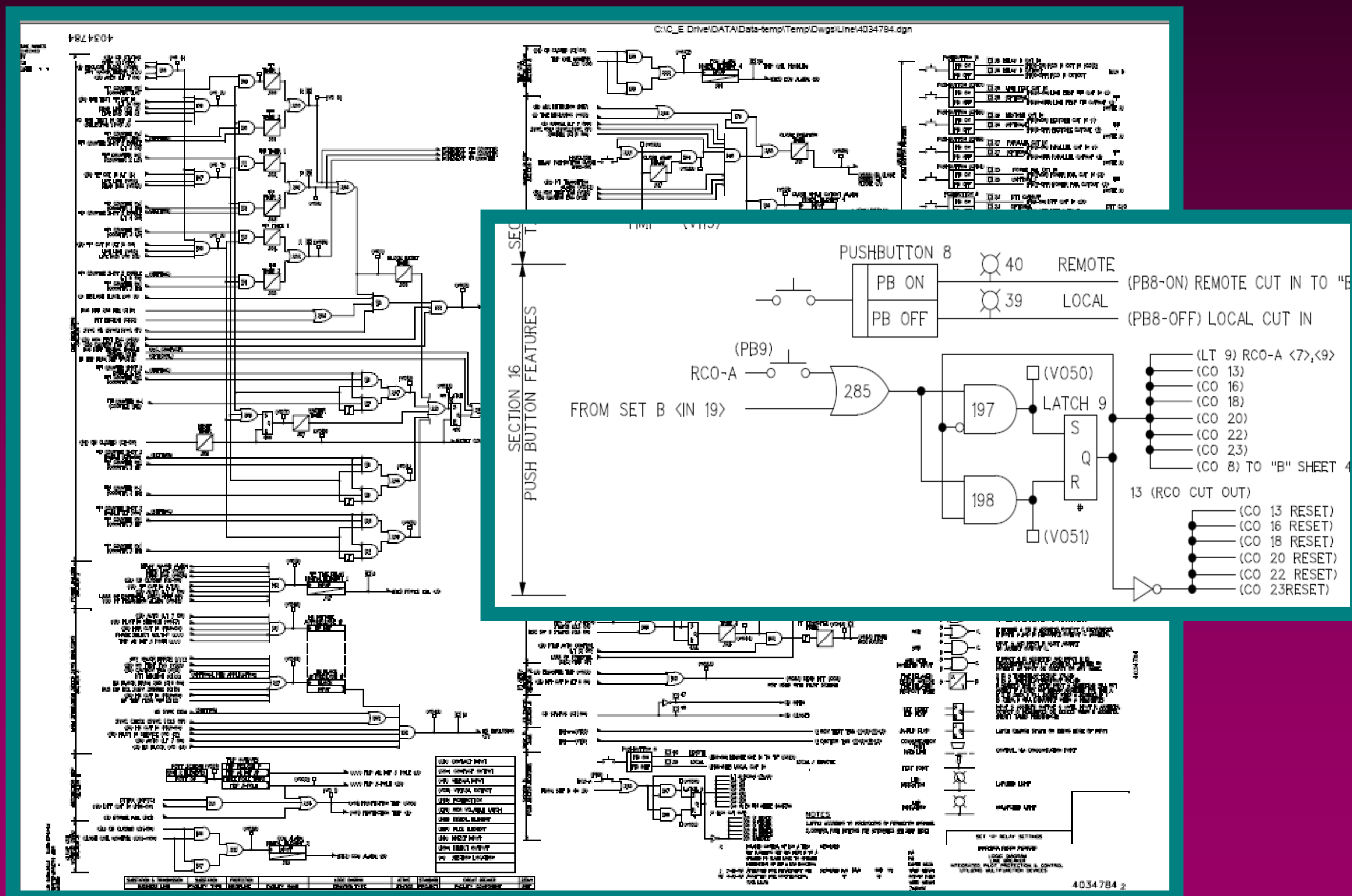
Asset and Fleet Management Strategies
Training and Tools

Additional tools for complex MP relay schemes include:

- Relay logic diagram
- Relay Resource Spreadsheets - Overview of the applied relay functions (e.g. SCADA points, digital I/O)
- Relay to relay configuration (IEC-61850) software and summary output reports.
- Diagnostic software for trouble shooting relay logic. View real time state of relay elements on logic diagram.

Asset and Fleet Management Strategies
Training and Tools

Relay logic diagram



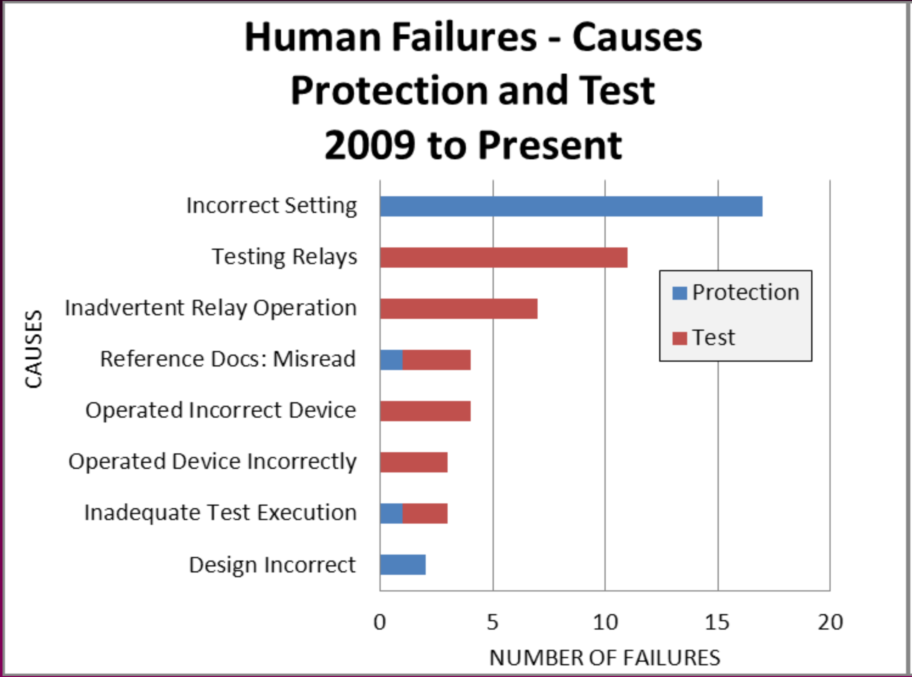
Asset and Fleet Management Strategies Training and Tools

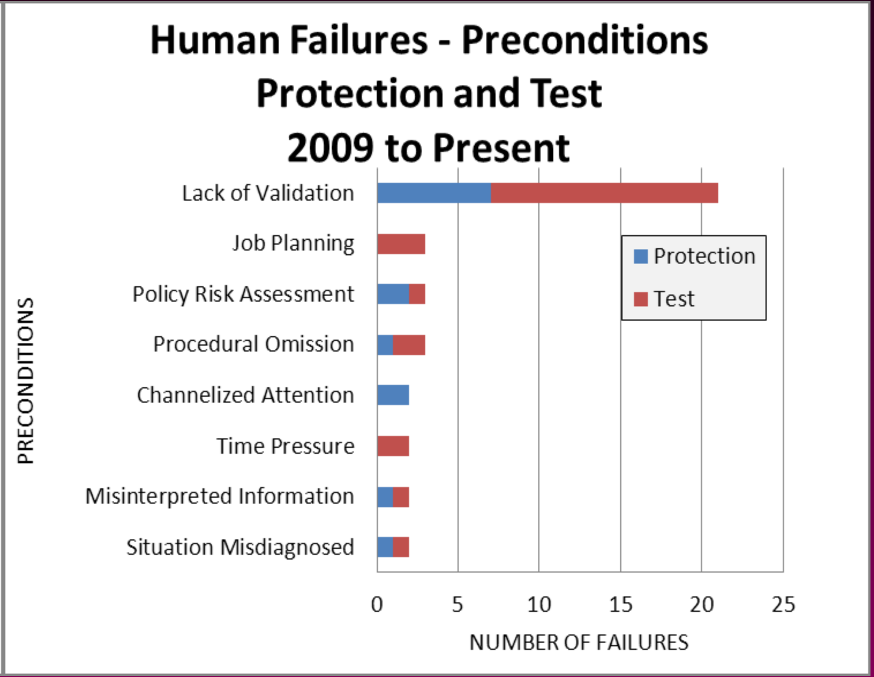
Relay Resource Spreadsheet (Job Aid)

	A	B	C	D	E	F	G
1							
2	*Location:*				**Substation: Design Standard Bay: Line Distance CB, Double Bus**		
3	*Scheme Type Code:*				**XYZ - Set "B"**		
4	*Relay Type Code:*				**SEL-311C, 0311 C01H2425421**		
5	*Relay Name:*				**CB xxx**		
6	*Direct I/O Device No:*				**SEL 2505**		
7							
8					*Relay Configuration*		
9	***Remote Bit #***		***ID (12 characters)***	***LD#***	***Function Description***	***Source***	***SelfReset Latched***
10							
11	**1**	**RB1**			MANUAL		
12	**2**	**RB2**			AUTO		
13	**3**	**RB3**			RCO B Cut-out		
14	**4**	**RB4**			RCO B Cut-In		
15	**5**	**RB5**			DTT C/O to A (CXR C/O TO A)		
16	**6**	**RB6**			DTT C/I to A (CXR C/I TO A)		
17	**7**	**RB7**					
18	**8**	**RB8**					
19	**9**	**RB9**					
20	**10**	**RB10**			HS RECLOSE CUTOUT		
21	**11**	**RB11**			HS RECLOSE CUTIN		
22	**12**	**RB12**			SETTING GROUP CHANGE TO A		
23	**13**	**RB13**			RCO A C/O to A (out 210)		
24	**14**	**RB14**			RCO A C/I to A		
25	**15**	**RB15**					
26	**16**	**RB16**					
27		OC			SCADA OPEN		
28		CC			SCADA CLOSE		

Contact Inputs | Contact Outputs | **Remote Bits** | SEL Variables | Local Bits | Non-Volatile Latches | Display Points

Asset and Fleet Management Strategies
Tracking Misoperations





Protection System Guiding Principles

- **User Friendly** - Install infrastructure that is user and human performance friendly and flexible to accommodate changes at the same time maintain public and employee safety, customer satisfaction, reliability, work efficiency and overall human performance.

- **Reliability** - Incorporate reliability in designs so that no single points of failure in the protection systems cause the elements to be removed from service and insure there is no interdependency between systems and equipment. These designs must meet regulatory standards for reliability of protection systems.

- **Simplicity** - Incorporate simplicity in designs so that engineers and technicians working with this equipment for testing and programming need only a Journey level of knowledge and experience. The deployment of new technology must be studied to understand how this technology will impact long term strategies (i.e. workforce skills).

- **Sustainability** - Incorporate sustainability in designs so that changes in equipment or firmware can occur without major redesign or lengthy outages to equipment. Designs should not be manufacture dependent.

? QUESTIONS ?

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