Upgrading Relays? – Be Prepared

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Upgrading Relays Discussion

Old electromechanical and solid-state relays

First-generation numeric relays

Second-generation numeric relays

Relay life expectancy

Counting the cost

Upgrade plan

Step-by-step implementation

Old (Somewhat) Faithful Electromechanical Relays

- Swiss-watch precision
- One function per relay
- Requires frequent testing
- No relay trouble alarm
- Increasingly unreliable with age

Solid-State Relays

- Analog processing
- Some have rudimentary microprocessors
- Require frequent calibration
- Power supply trouble alarm– no process watchdog
- Capacitor shelf-life aging

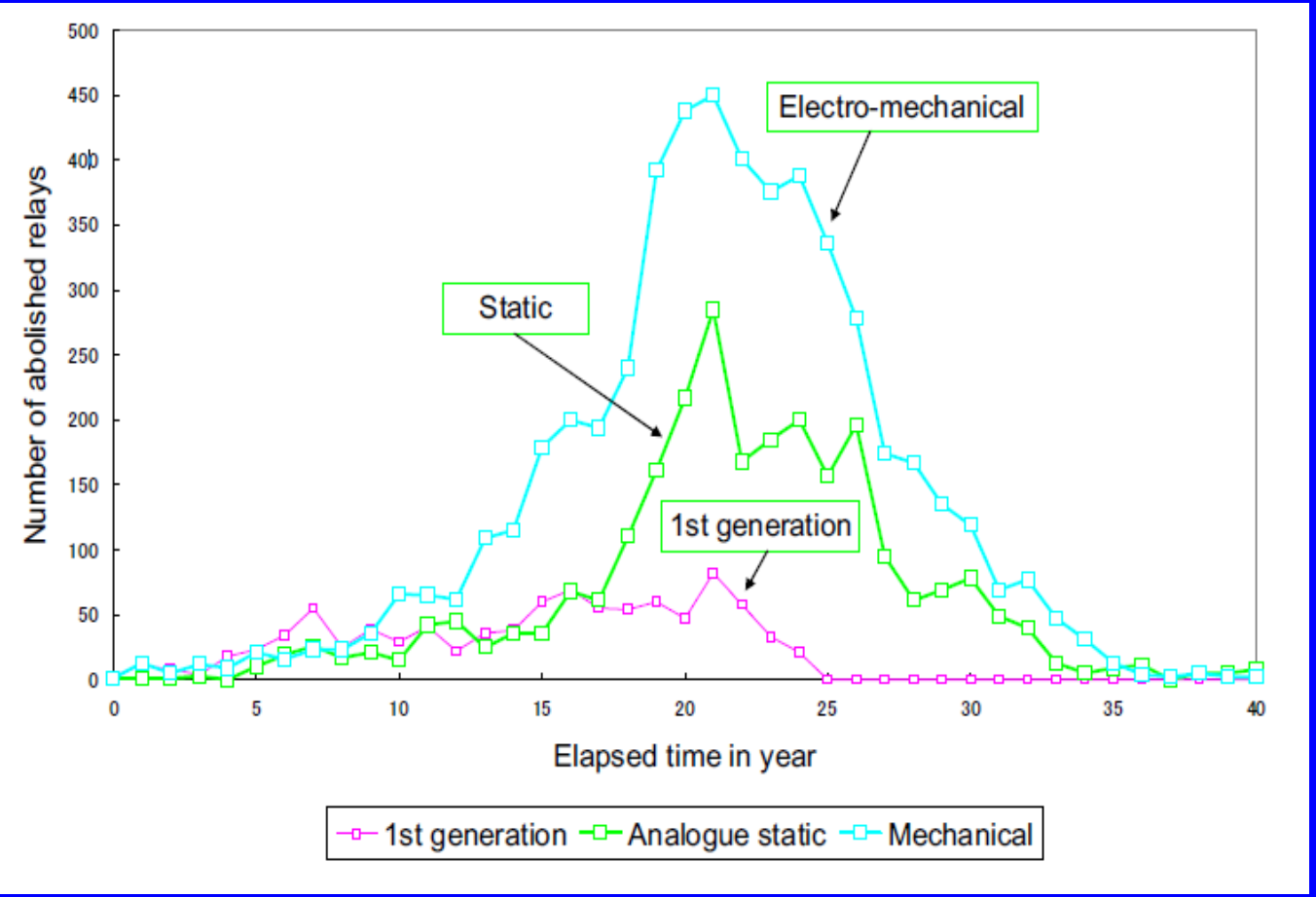
First-Generation Numeric Relays

- Digital sampling
- Rudimentary algorithms
- Poor security
- Lower-reliability components
- First true operation watchdog alarm

Second-Generation Numeric Relays

- Advanced digital sampling
- Concise, fast algorithms
- Improved security, logging
- Watchdog alarm for hardware and software
- Expanded com protocols and Ethernet
- USB serial

Crucial Upgrade Timing



Track relay failures—know when to replace

Costs As a Function of Time

Least Unit Life-Cycle Cost

$$C(t) = \frac{C_L(t)}{\tau}$$

$$C_L(t) = C_d + C_x \int_0^t \rho(t)\,dt + C_t \frac{MTTR}{MTTF} \int_0^t \rho(t)\,dt$$

- $C_L(t)$ – unit life-cycle cost
- C_d – relay cost
- C_x – maintenance cost
- C_t – out-of-service cost

Mean Time To …

- MTBF
  - Mean Time Between Failure
  - For repaired and reinstated relays
  - Keep large
- MTTF
  - Mean Time To Failure
  - Better measurement if no repair
  - Keep large
- MTTR
  - Mean Time To Repair
  - Keep small

Protection Costs

C_d

- C_d – relay and installation

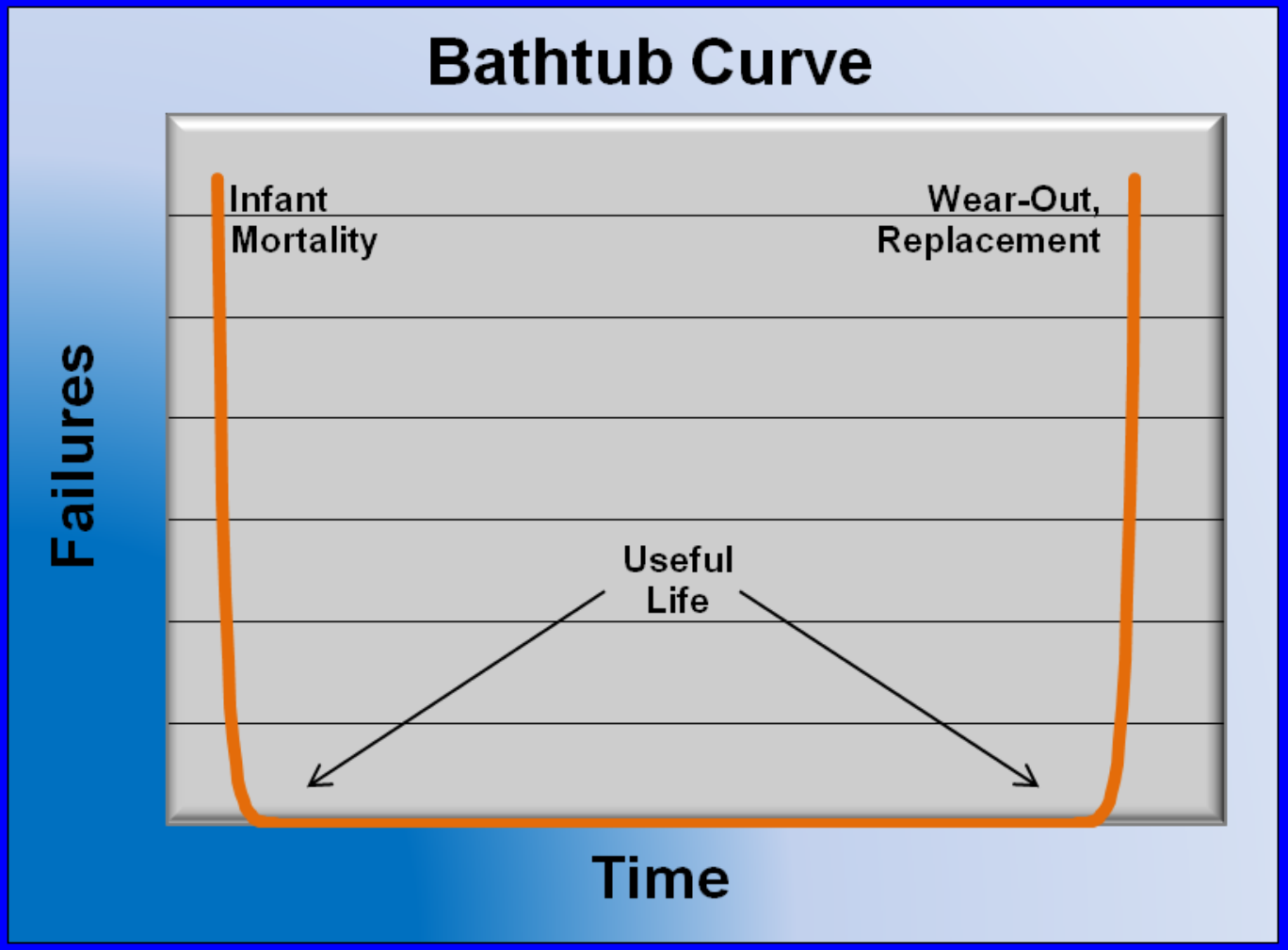
$C_x \int_0^t \rho(t)\,dt$

- C_x – maintenance

$C_t \frac{MTTR}{MTTF} \int_0^t \rho(t)\,dt$

- C_d – downtime

Relay Failures Over Time



Mean Time To Failure

λ Constant During Useful Life

$$MTTF = \int_0^\infty R(t)dt = \int_0^\infty e^{-\lambda t}dt = \frac{1}{\lambda}$$

- $R(t)$ – reliability at time ‘t’
- λ – failure rate
- $e^{-\lambda t}$ – natural log of failure rate (reliability)

Availability

System Operates Properly During Useful Life

$$A = \frac{MTTF}{MTTR} \qquad (MTTF > MTTR)$$

Increase availability

- Maximize MTTF
- Minimize MTTR
- Have on-shelf spares

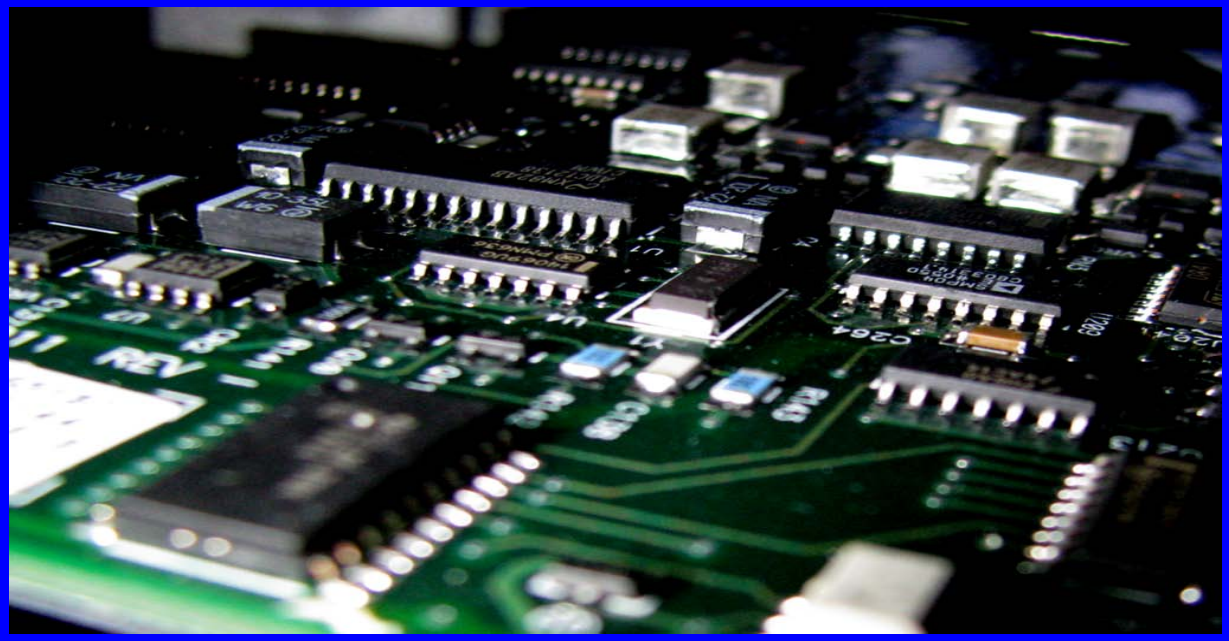
Treat On-Shelf Spares Well

Apply power to spare relays yearly

- 30 minutes
- Keep electrolytic capacitors fresh
- Increases system availability
- Great Intern job

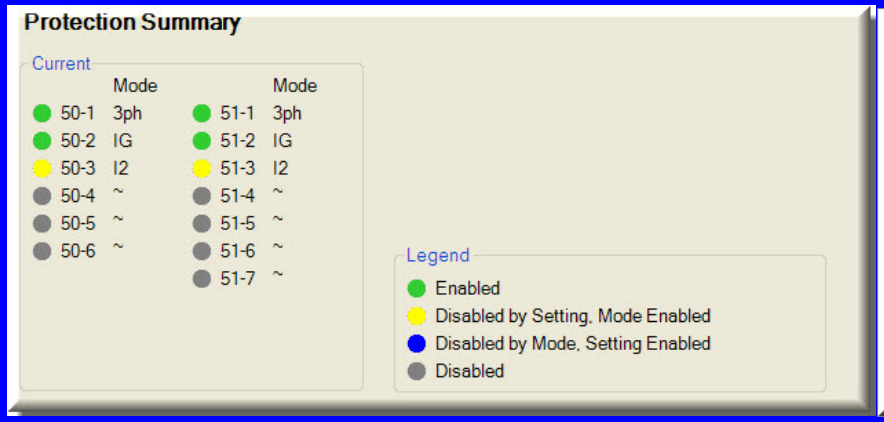
Upgrade to 2nd-Generation Relays

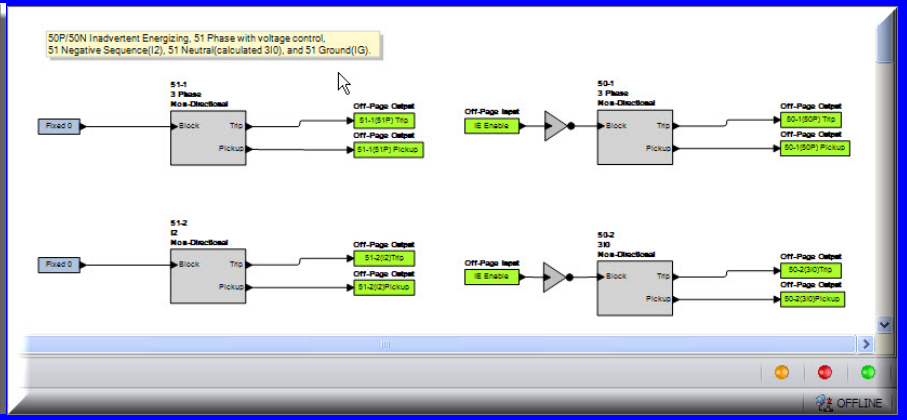
- Hardware advances
  - Faster and better processors
  - Surface-mount component reliability
  - Plug-out more reliable than drawout



Computers Are Here to Help Us!

- Firmware and software advances
  - Number and type of elements
  - Increased recording and reporting
  - Improved internal diagnoses
- Enhanced relay security
- Smart software for simplicity and settings check

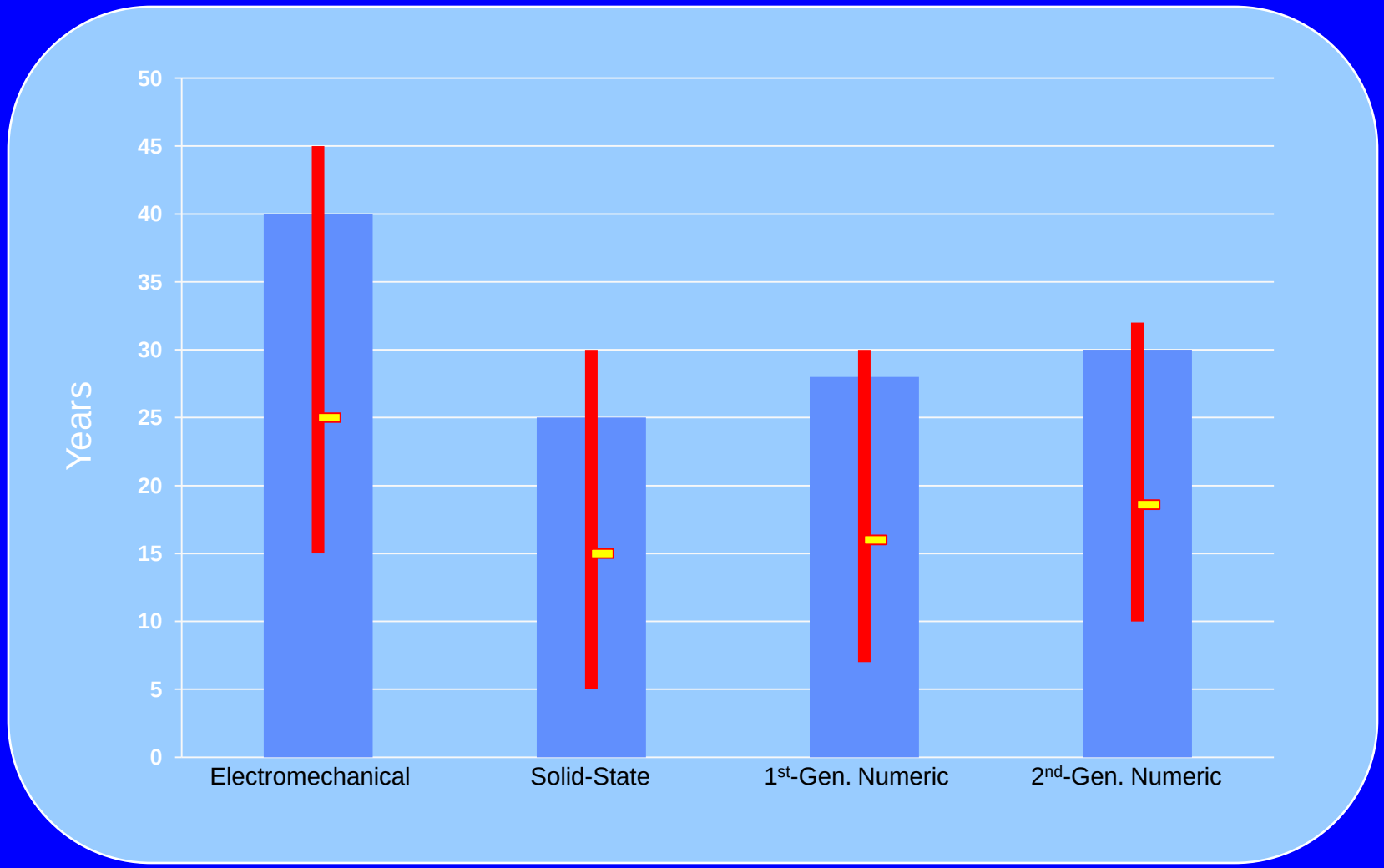




Main and Backup

- Different vendors is better design
  - Avoid mutual failures
  - Overcome hardware weaknesses
  - Catch faults using dissimilar algorithms

Relay Longevity by Type



↑Protection, ↓Cost, ↓Space

Old

New

- …and adds communication
- Space for backup relay or other devices

Making No Change

- Are you OK with costs of downtime and equipment repairs?
- Are you OK with lead time on motor rewinds?
- Have you backup stock for transformers?
- Be informed: identify high-risk portions of power system!

Upgrading Costs to Consider

- Drawing changes
- Mounting
- Communication
- Battery size
- Labor
- Downtime
- Maintenance

Upgrading Relays

- Obtain management approval and team acceptance
- Update drawings for new relays / panels
- Order all required materials, tools, and labor
- Develop an outage plan
- Do the installation
- Complete documentation with as-is data
- Responsibly dispose of old equipment
- Report outcome to management

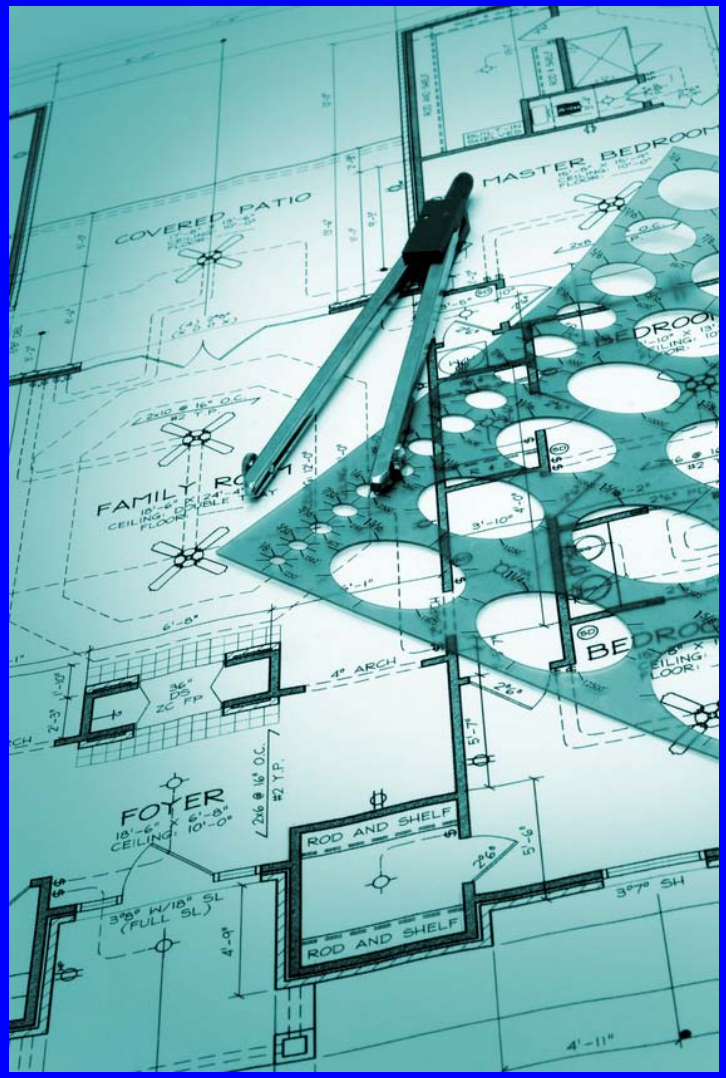
Management and Team Approval

- Make sure your boss knows …and approves project
- Have good pre-planning
  - Develop costs and benefits lists
  - Account for unexpected

- Communicate with colleagues and staff

Update Drawings

- Examine existing documentation
  - Drawings
  - Protection philosophy
- Consult manufacturers' websites
- Develop step-by-step procedures



Develop Outage Plan

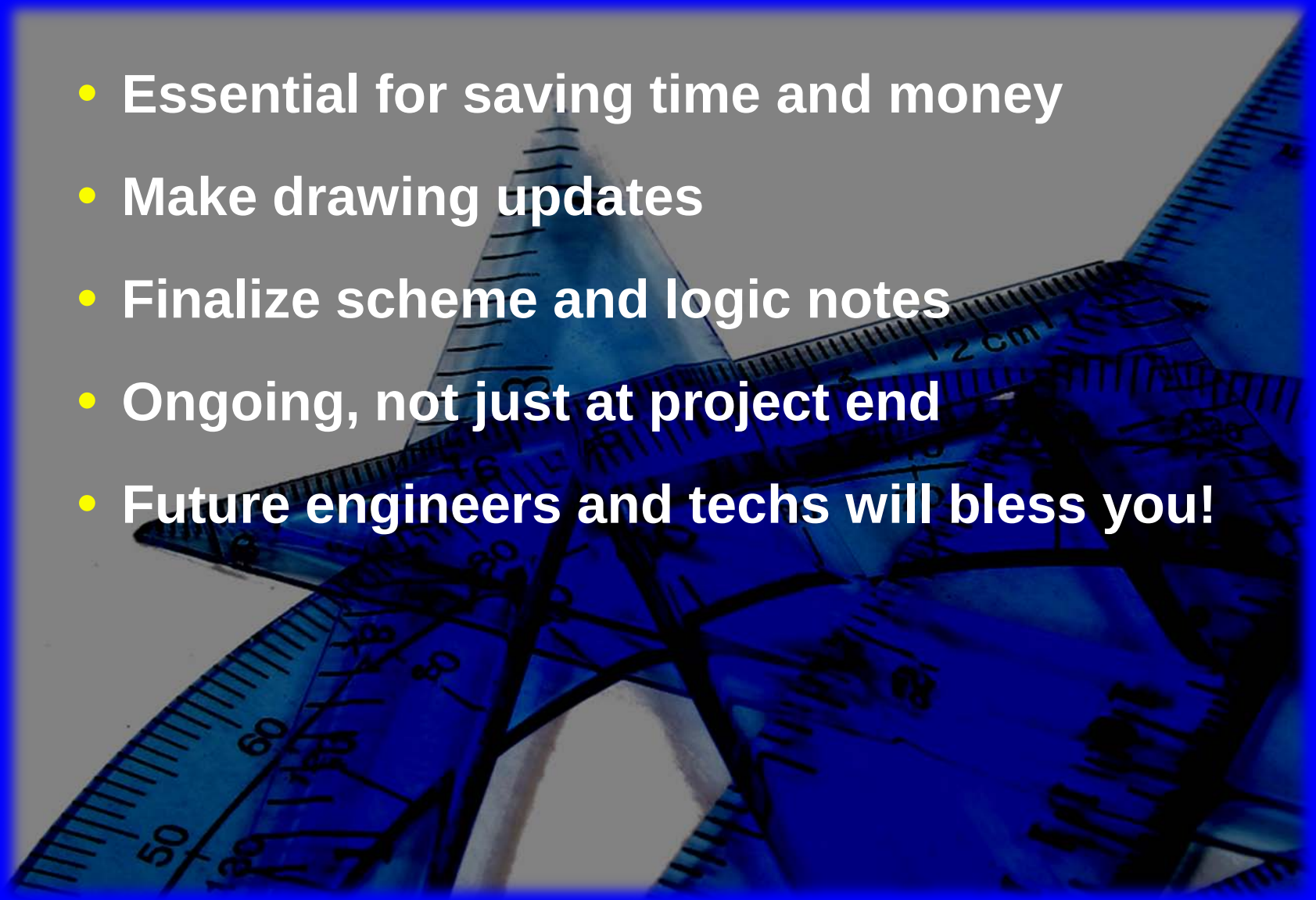
- Safety first!
- Examine hazards
- De-energize if possible
- “Walk through” upcoming work
- Avoid outage cost increases and project delays

- Simplify inspections and commissioning
- Increase personnel productivity

Order Labor, Material, Tools

- Order relays, test blocks, panels, special tools …
- Determine terminal designators
- Consider mechanics
- Coordinate labor – buy-in makes job go better

Complete As-Is Documentation



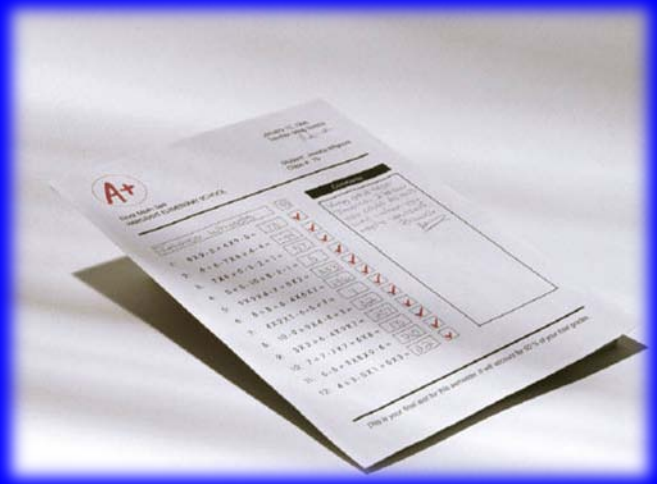
- Essential for saving time and money
- Make drawing updates
- Finalize scheme and logic notes
- Ongoing, not just at project end
- Future engineers and techs will bless you!

Dispose of Old Equipment

- Keep lead, cadmium, mercury, and other dangerous chemicals out of refuse landfills
- Donate old equipment to universities and tech schools
- Enhance community goodwill

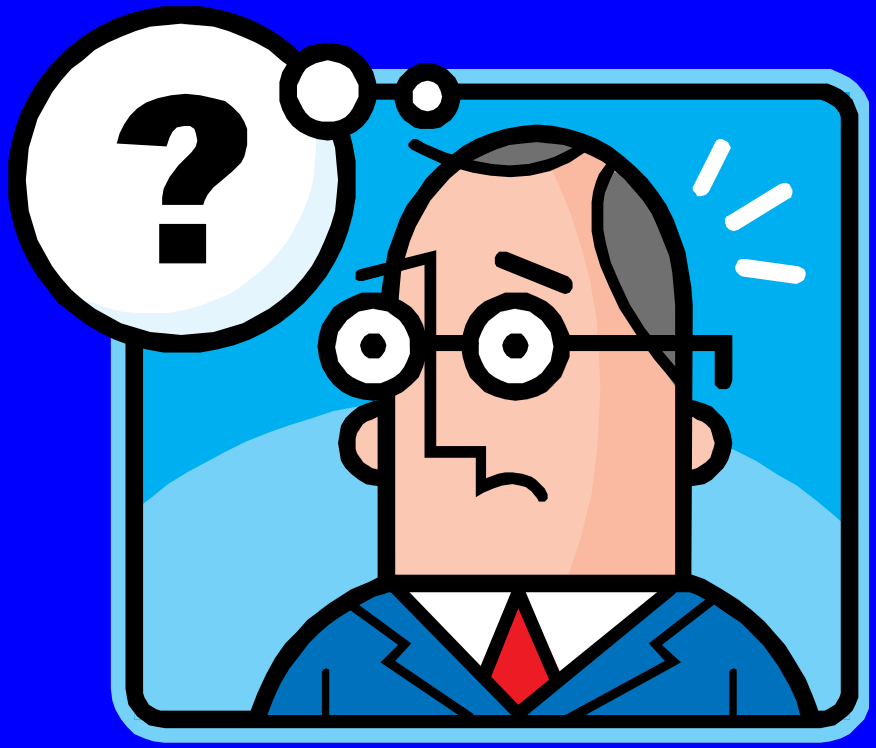
Report to Management

- Make a formal presentation
  - Confirms project goals
  - Increases management support of next project
- Recognize colleagues' and staffs' achievements
- Write a "lessons learned"



Application Questions?

- Problems during design and installation?
- Don’t struggle!
- CALL!
- Application Engineers want to help you



Conclusions

- Upgrading gives opportunity for increased protection and cost reduction
- Eliminate failures – replace at end of useful life
- 2nd-generation, multi-function relays
  - Better hardware and software
  - More reliable
- Plan work well
  - Document
  - Communicate w/ labor and management

Thank you!

Questions?