Distribution Asset Management
The P^2 and AA Problems

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Agenda

- Some common asset management fallacies
- Problems to be solved
- History of research: 1996 - 2003
- Overview of P2
- Overview of AA

A Few Asset Management Fallacies

- Problems can be solved by organizational change and asset management teams
- "Cost Benefit analysis, the "tried and true" method for ranking projects is perfectly reasonable way to select projects to fund."
- The first important step is to gather data
- All projects can be valued using the same aggregate measures (i.e. $)
- Projects are risky because of uncertain financial consequences
- Beta is an appropriate way to measure project risk
- An important objective is near-term profitability

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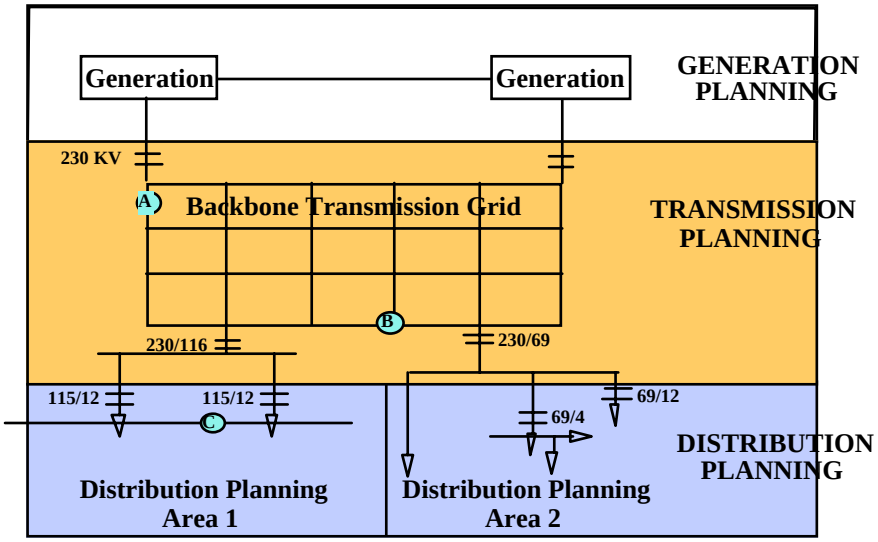
Distribution Asset Management is Mostly About Solving Investment Problems

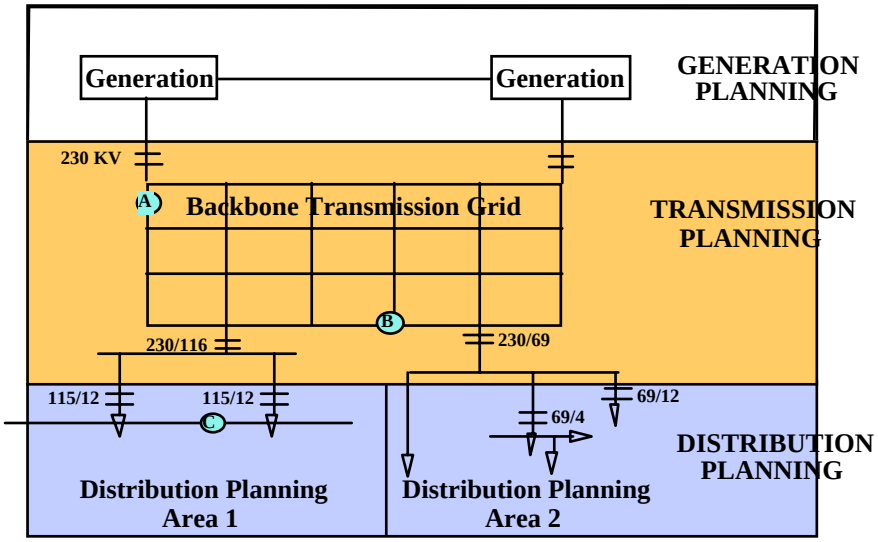
- 40% to 50% of electric utility net investment
- Business issues
  - Minimizing investment costs
  - Having "right" infrastructure to meet customer needs
  - Making money
- Key strategic needs
  - Managing assets
  - Linking investment decisions to customer needs



Net Invest.
Gen. = $8.7B
Tran. = $4.5B
Dist. = $13.5B
Total = $26.7B

Distribution Asset Management

- Two driving facts
  - Very low revenue to asset ratio
  - Large embedded asset base
- Substantial care and feeding is required
  - Repair / Replace
  - Expand / Prepare for future



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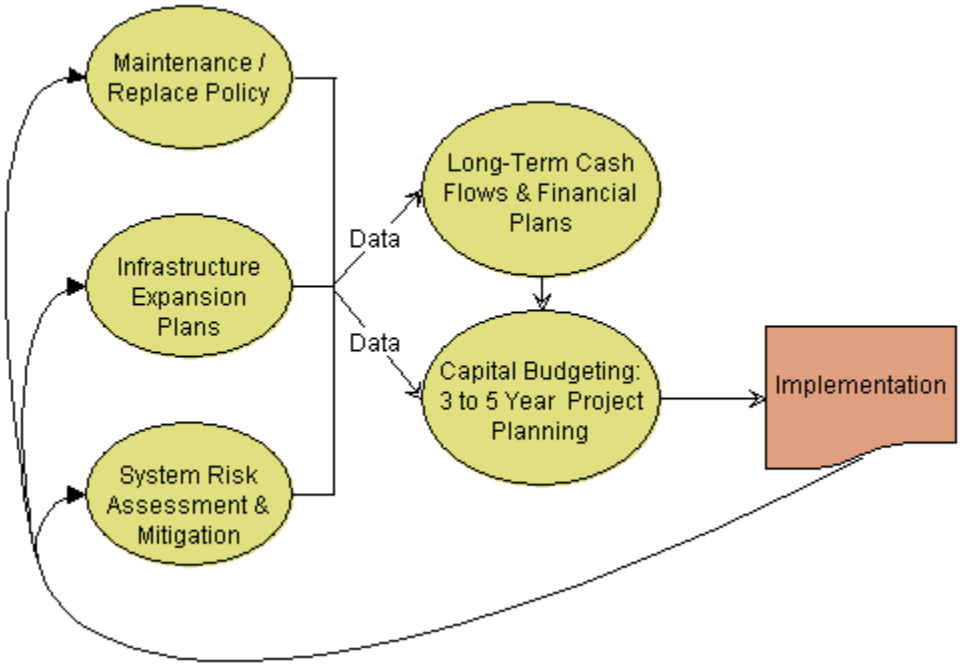
Distribution Asset Management – the problems to be solved

- Fundamental engineering economic problems
  - Maintenance / Repair / Replace
  - Capacity expansion
  - System Risk Assessment & Mitigation
- Financial planning problems
  - 3 to 5 year Capital Budgeting / Project Planning
  - Long-Term Financial Planning



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Planning Work 1997 – 2002

- December 1996 Chicago Focus Group
- 1997 - 1998
  - Create the portfolio - projects in Distribution Systems Target
  - Produce V1.0 Area Investment Planning Tools
- 1999
  - Start work on Customer Needs & Reliability projects
  - V1.5 Strategy Model & V2.0 LoadDynamics
  - Methodology design for Project Prioritization (AEP)

Planning Work 1997 – 2002 cont.

- 2000
  - Aging Assets - Started
  - Project Prioritization – method & software designed
  - Customer Needs & Reliability – EPRI white papers
  - Area Investment Planning – tech transfer
- 2001: Focus on Aging Assets and Project Prioritization
- 2002:
  - Continued focus on Aging Assets and Project Prioritization
  - Some work on Measuring & Valuing Reliability
- 2003 New EPRI program with two parts
  - Tools to support Asset Planning Decisions – continuation of planning work
  - Asset Management Practices

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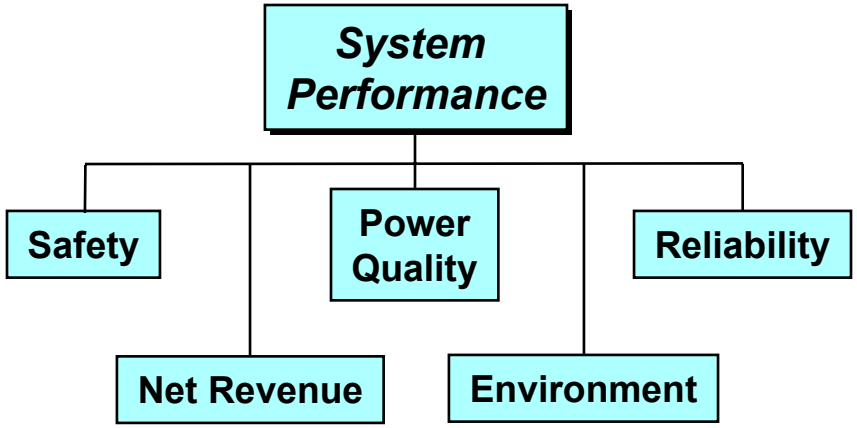
- Problems to be solved
- History of research: 1996 - 2003
- Overview of P^2
  - Problem
  - Objective
  - Scope
  - Method
- Overview of AA

Problem Definition

- The company does not currently *quantitatively* evaluate and compare all distribution projects. (A formal, repeatable, and uniform approach for valuing projects does not currently exist.)
- The value of doing a particular project is not compared with the values of competing projects.
- For the projects that are evaluated, the company is not satisfied with the current procedures.

Project Objective

- System for valuing & prioritizing distribution projects
  - Multi-year
  - Multi-attribute
  - Value driven
- For picking the "best" portfolio of projects given the project attributes, budget levels, and company objectives
- Three key dimensions
  - Objectives of the project portfolio
    - » minimizing or maximizing important, measurable aspects of system performance
  - Values
    - » capture relative importance of competing objectives.
  - Project attributes
    - » describe how each project contributes to attainment of objectives



Scope of Project Prioritization Problem

- Large number of projects
- Multiple performance measures
- Projects done for different reasons
- Analysis of uncertainty
- Risk of deferral
- Respond to budget signals

Required I/O + Transformations

INPUTS

- Corporate budgets
- Projects + Alternatives
- Objectives
- Values
- Attributes

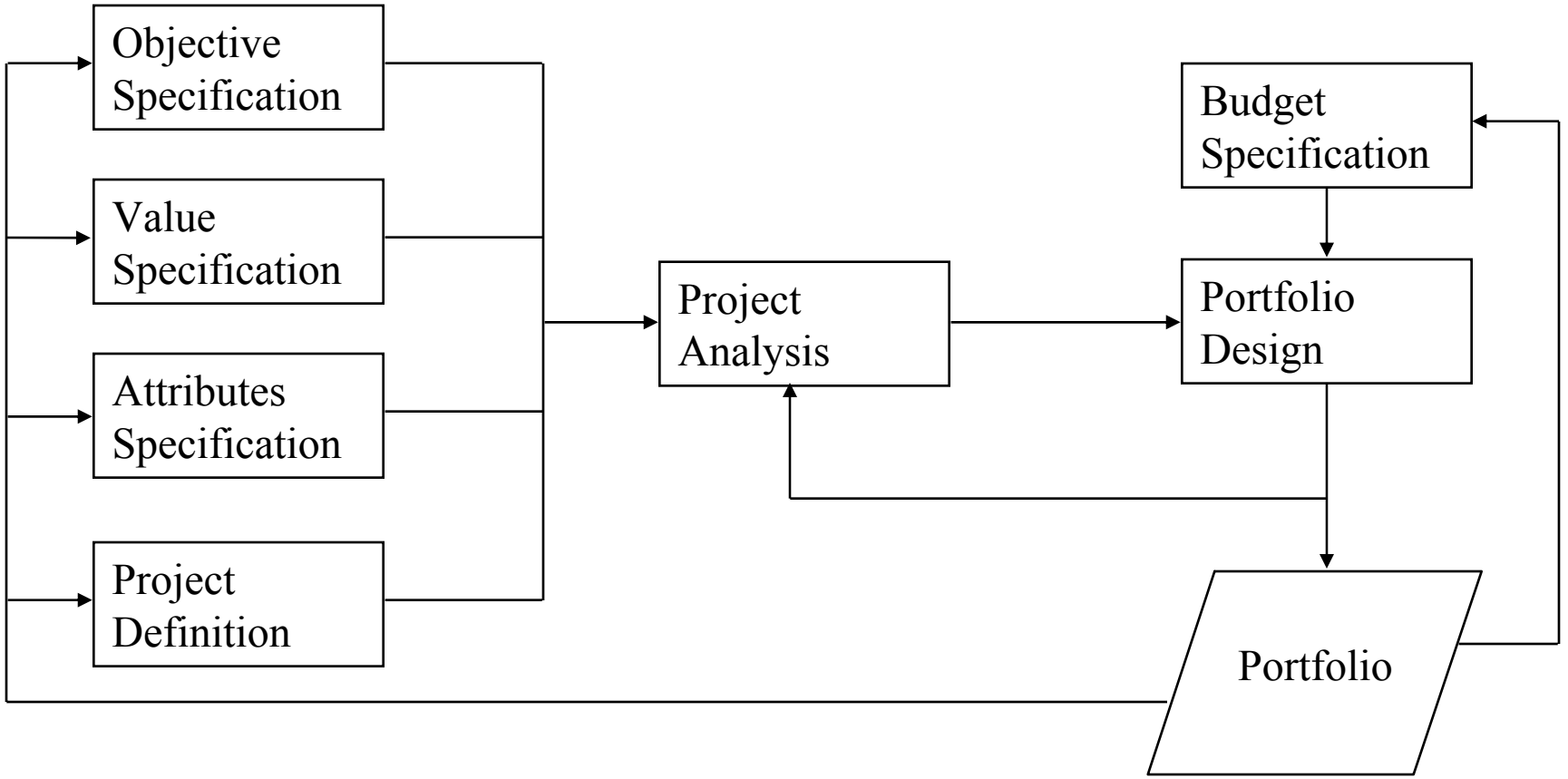
OUTPUTS

- Project Rankings
- Portfolio of projects
- Timing of projects
- Value of additional budget
- Value
- Risks
- Costs

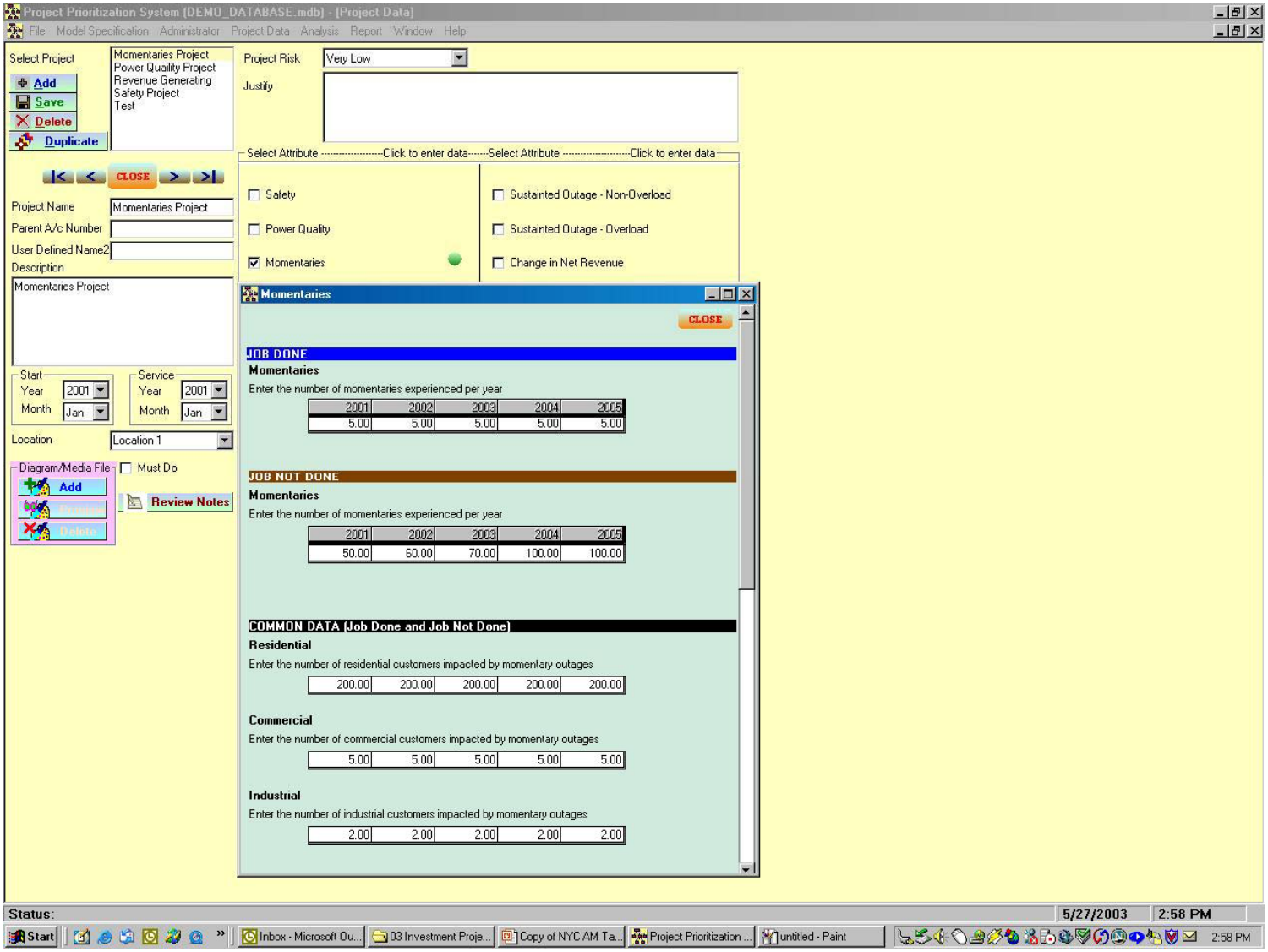
TRANSFORMATION PROCESS

- Attribute + values + objectives → Benefits
- Projects + Alternatives → Budget requirements
- Benefits + budget req'ts → Portfolio
- Δ Budgets → Δ Portfolio

Overview of System Structure



We Have Software



We Are Learning From Implementations

- BGE, TXU, Exelon, HECO, NES / TVA, Southern Co., CPS-SA
- Projects are done for many reasons
- Relatively few high-level attributes:
  - Reliability
  - Capacity
  - Safety
  - Revenue
  - Quality and Customer Values
- Details matter
- Clarity follows from attribute structure
- Uncertainty matters

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  - The Aging Asset Problem
  - Data & Model
  - Example Results

The Aging Asset Problem

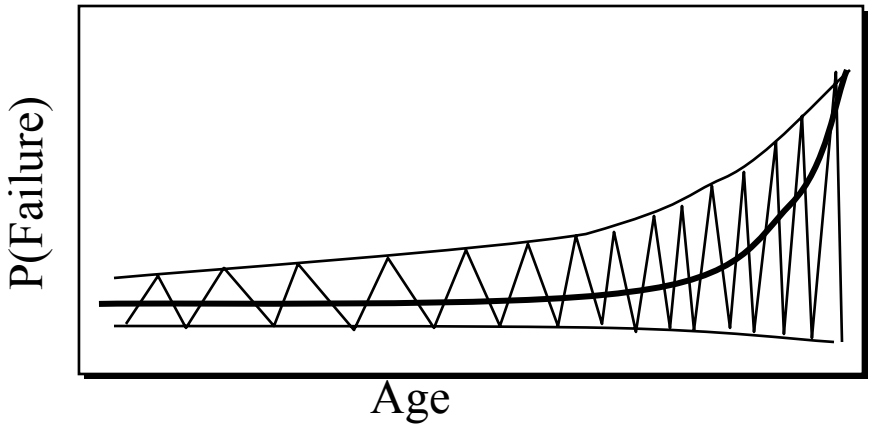
- Given
  - An asset type (e.g., transformers, cables, poles, etc.)
  - A set of asset characteristics
    - Age
    - Condition
    - Failure modes
    - Uncertainties in future performance
    - Observables and Unobservables
    - Costs
  - A set of alternatives
    - Repair
    - Replace
    - Rebuild
    - Refurbish
    - Test
    - Maintain
- What should we do, when, and under what conditions?

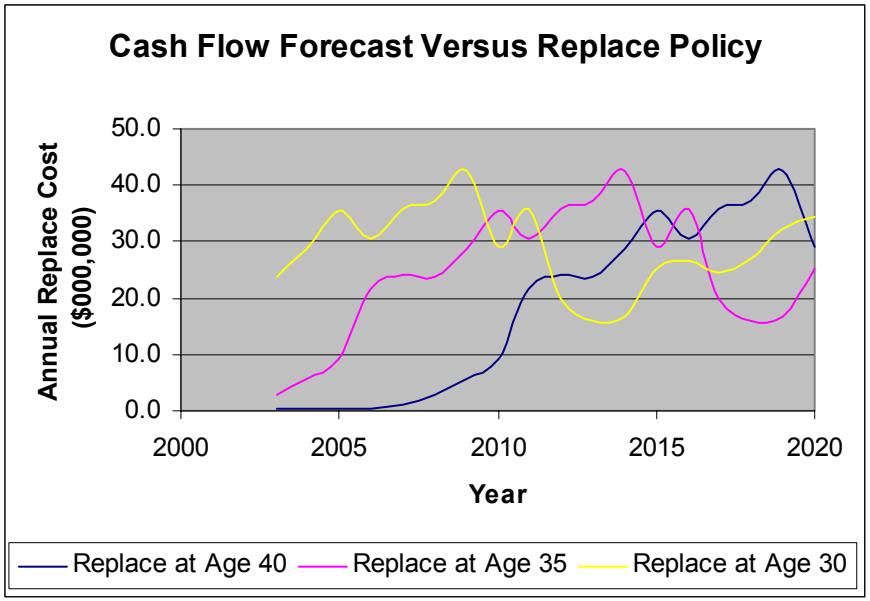
Aspects of the Aging Asset Problem

- Optimal management of a single asset
- Optimal policy for entire asset population
- Cash flows for repair/replace for entire asset population
- Role of diagnostic tests

Two Fundamental Problems

- Optimal maintenance and replacement policy
  - Varies by asset class
  - Based on age, performance, and condition information for individual assets
- Cash flow planning
  - Least cost replacement of infrastructure inventory
  - Long term financial planning
  - Policy based on maintenance and replacement policy for individual assets





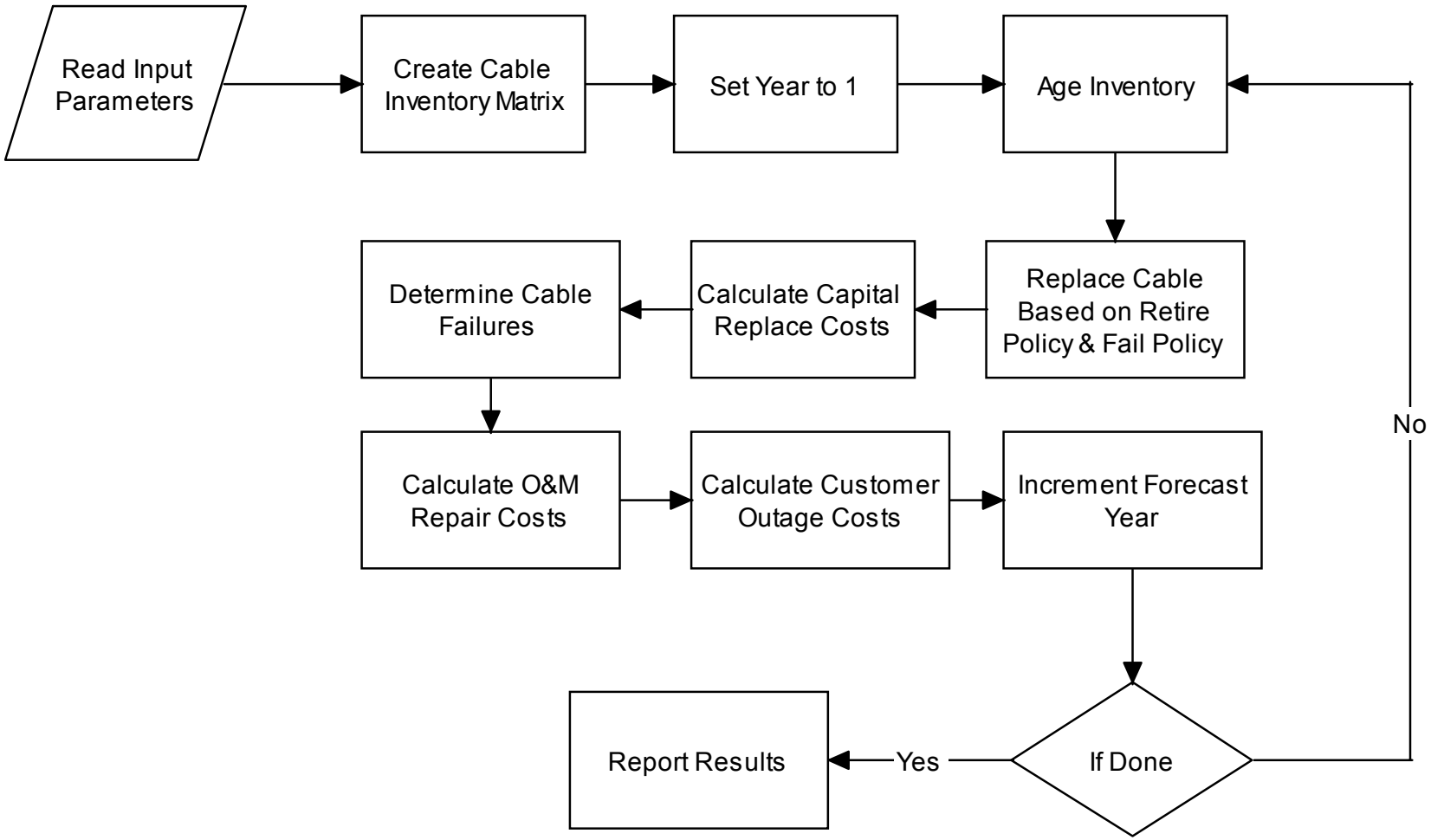
Cable Problem Statement

- The current system contains approximately 6,000 circuit miles of aging cable of several types
- Company is not satisfied with its current replacement policy
- Objective:
  - Develop a least-cost strategy for repair/replacement of all cable assets
  - Forecast the cash flows associated with this strategy

Data

- Failure Rates
- Cable Inventory (type & age)
- Costs
  - Customer outage costs
  - Repair costs
  - Replace costs

Model Logic

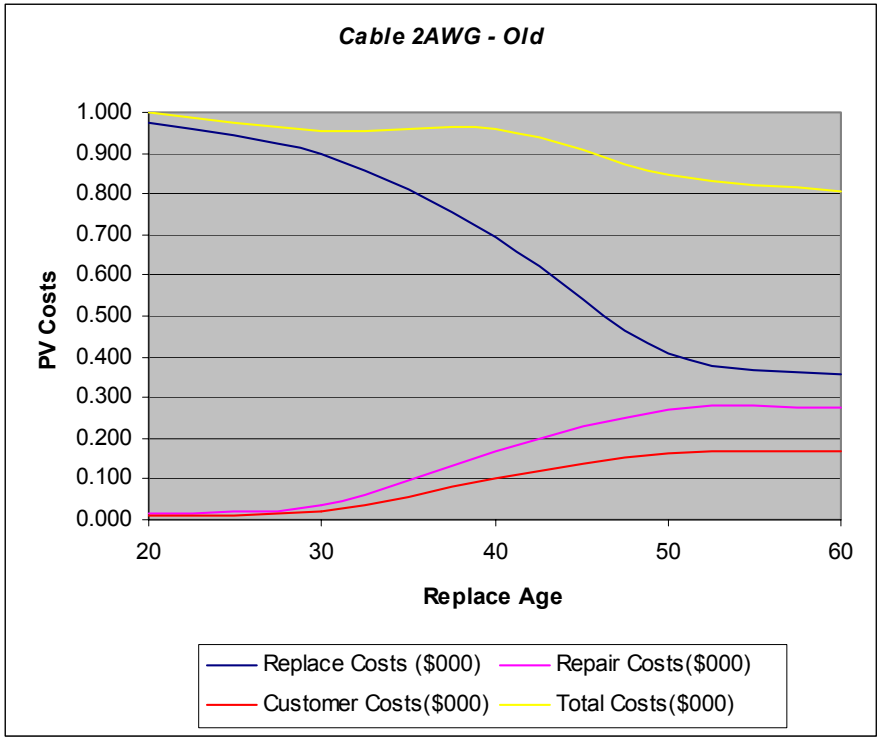

Read Input Parameters
Create Cable Inventory Matrix
Set Year to 1
Age Inventory
Replace Cable Based on Retire Policy & Fail Policy
Calculate Capital Replace Costs
Determine Cable Failures
Calculate O&M Repair Costs
Calculate Customer Outage Costs
Increment Forecast Year
If Done
No
Yes
Report Results

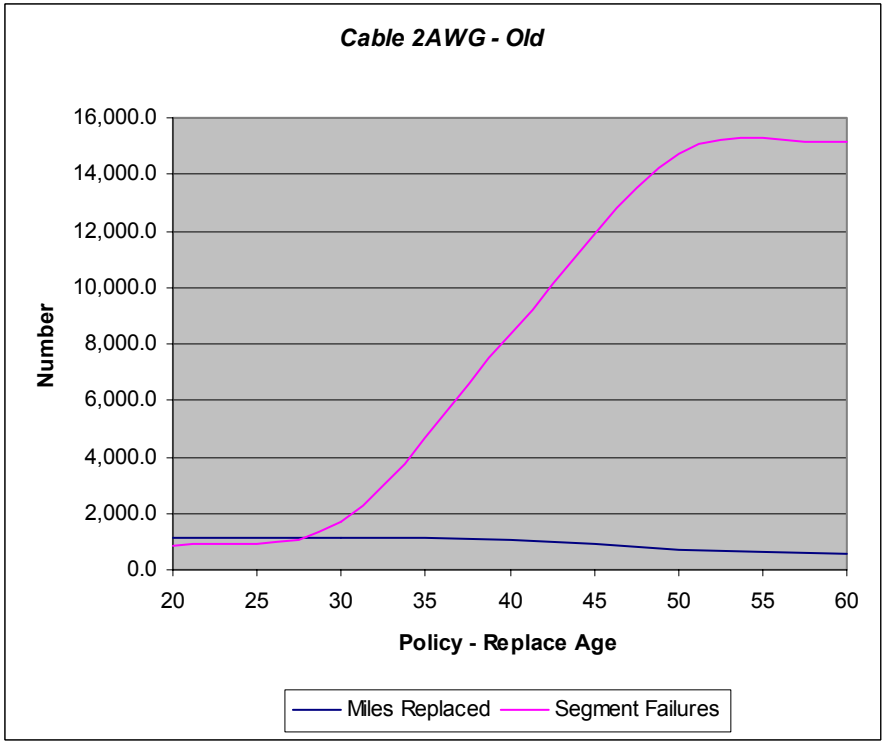
Results Summary – Optimal Management of Cable Inventory

Cable Type	Optimal Policy	PV Costs
2AWG Old	2 Failures then replace	1.000
2AWG New	3 Failures then replace	0.028

Example Results

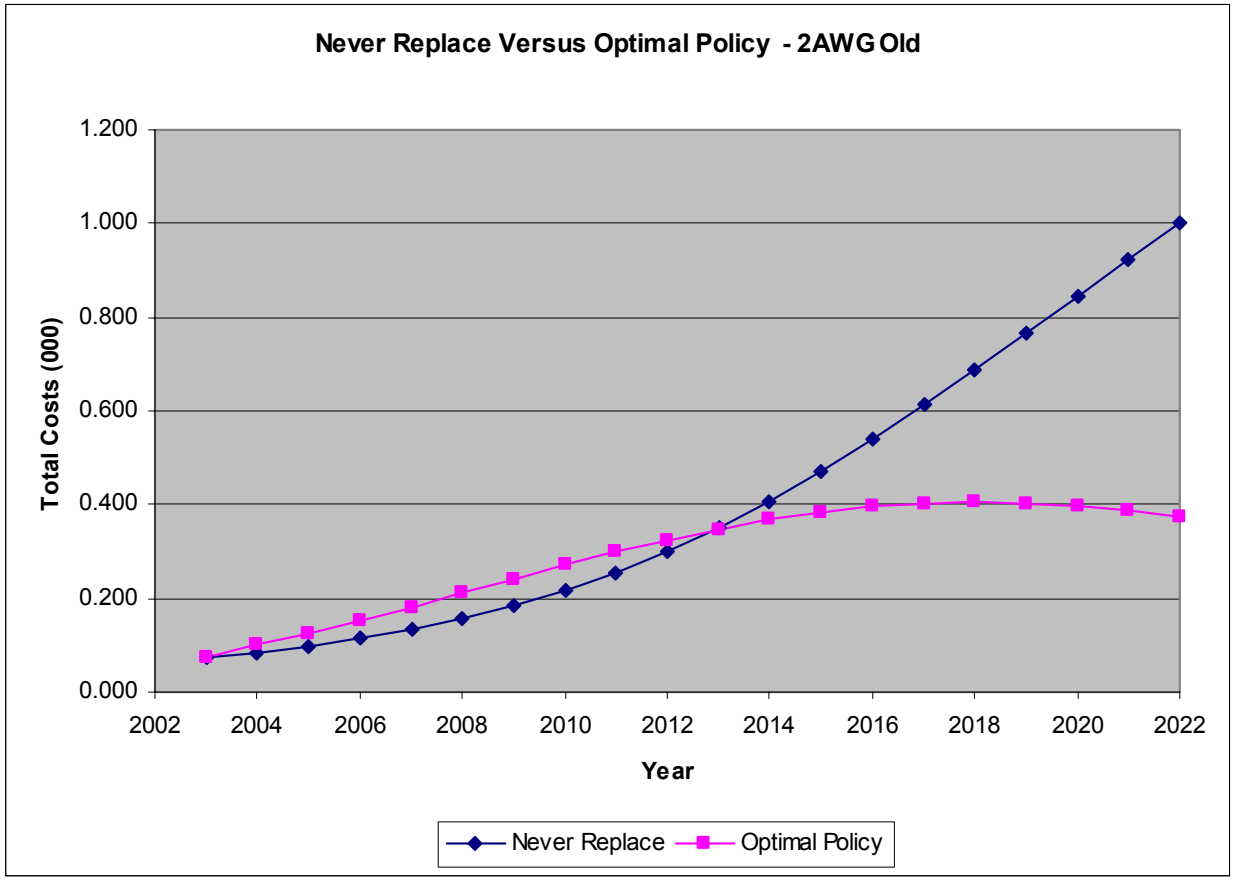
2AWG Cable Results - Old





Example Results

Total Costs - Continued Repair & Optimal Replace – 2AWG Old



Example Results

Revisiting the Fallacies

- Methodology: Problems can be solved by organizational change & asset management teams
  - Process vs. rigorous analysis
  - Debate outcomes vs. debate assumptions and logic
  - Cost benefit analysis vs. multi-year value optimization
- Procedural: The first important step is to gather data
  - Data first vs. problem formulation first
- Value Measurement: All projects can be valued using the same aggregate measures (i.e. $)
  - Single vs. multi-attributes
- Risk Measurement: Projects are risky because of uncertain financial consequences (Beta appropriate way to measure project risk)
  - Financial risk vs. uncertainty in system performance
- Decision Objective: An important objective is near-term profitability
  - Project financial return vs. project system contribution
  - Corporate values vs. project specific system performance
  - Profitability vs. service
  - Short term planning vs. long lived assets
  - Reduced costs vs. appropriately guided investments
  - Asset management is a way to become more efficient and thus more profitable

And In Closing

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