Fundamentals of Asset Management

Background: Optimized Investment Decision Making

A Hands-On Approach
View 6: AM plan 10-step process

1. Develop Asset Registry
2. Assess Condition, Failure Modes
3. Determine Residual Life
4. Determine Live Cycle & Replacement Costs
5. Set Target Levels of Service (LOS)
6. Determine Business Risk (“Criticality”)
7. Optimize O&M Investment
   - Root Cause; RCM; PdM; ORDM
8. Optimize Capital Investment
   - Confidence Level Rating; Strategic Validation; ORDM
9. Optimize O&M Investment
10. Optimize Capital Investment
   - Determine Funding Strategy
11. Build AM Plan

Investment Decision-Making
Three fundamental management decisions

1. What are my work crews doing, where are they doing it—*and why*?
2. *What* CIP projects should be done—*and when*?
3. When should I *repair*, when should I *rehab*, when should I *replace*?

These decisions typically account for *over 80%* of a utility’s annual expenditures.
Asset decision framework

*Big picture*
- Whole portfolio perspective
  - Trends
  - Macro forces
- Policy framework
- Budget arena

*Micro view*
- Event based
- Specific asset focus
- Case-by-case decision points

Repair? Refurbish? Replace? Augment?
Managing the “asset consumption” process

Advancing Asset Management
There exists for every asset, a theoretical “best” investment.
Bringing it all together

Repair-refurbish-replace decision

1. Fix when broken (run to failure)
2. End of prescriptive life
   - 12 years old
   - 3,000 run-time hours
   - 35,000 miles
3. Rule of thumb
   - 3 breaks per mile or in 24 hours
   - Poor condition (and worst first)
   - FCI > 6% (Facility condition index—O&M as a percentage of replacement cost)
4. Optimized renewal decision making (ORDM)
What is optimized decision making?

- **Systematic search for lowest-cost renewal investment**
- **Based on interaction of**
  - Cost trends (direct O&M, indirect)
  - Condition trends (decay/survivor curve)
  - Risk-consequence trends
- **Three major approaches**
  - Valued expert judgment
  - Lowest projected average life-cycle cost per year of residual life;
    - Operational costs
    - Risk-weighted, full economic costs
  - Intervention factors; condition, performance, reliability, Business Risk Exposure, etc.
Three levels of ORDM

- **Level 1** Decision tables/trees
  - Structured, often substantially qualitative, value judgment-based
  - Event-focused, scenario-based

- **Level 2** Lowest average PV life cycle cost scenario analysis
  - Specific decision event-focused
  - Spreadsheet-driven
  - Can be used to refine decision tables/trees

- **Level 3** Integrated intervention and full economic life cycle cost optimization
  - Sophisticated modeling
  - Objective function-driven
  - Both portfolio- and event-driven
So, what to we mean by…

Minimum life cycle cost strategies

- Fundamental asset management options available to the management team are
  - Do nothing (zero-based strategy)
  - Status quo
  - Operate differently
  - Maintain differently—run to failure, preventive-based, predictive-based (condition, usage)
  - Repair
  - Refurbish/rehabilitate
  - Replace
  - Decommission
  - Non asset-based
- Which strategy for each asset?
- Combinations over life cycle

It’s *all* investment!
What do we mean by “alternative treatment options”?

- **Maintain and Repair**
  - Option 1
  - Option 2

- **Refurbish**
  - Option 1
  - Option 2

- **Replace**
  - Option 1
  - Option 2
  - Option 3

- **Non-asset Options**
  - Option 1
Our “decision rule”

Estimated total costs for the effective life of the solution (capital, operations, & maintenance)

Look for “alternative treatment” with lowest *average annual* (present value) cost (average annual cost = total annual cost/year)

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Say, a 40-year solution
ORDM decision rules

- **Which** strategies?
  Lowest average annual cost (PV) is used to determine which strategies to use

- **When** to change strategies?
  - Lowest marginal cost is used to determine when to transition to the next strategy, or
  - When intervention point is triggered by interaction of trend lines

PV is present value
ORDM future costs

![Graph showing ORDM future costs over Age of Assets]

- **Future total maintenance costs**
- **Unplanned maintenance**
- **Planned maintenance**

*Note: The graph illustrates how future maintenance costs change with the age of assets, distinguishing between planned and unplanned maintenance costs.*
ORDM—where do the savings come from?

- Future total maintenance and operations before renewal
- Future total maintenance and operations after renewal
- Renewal work completed
- Potential savings
- Estimated future unplanned costs
- Estimated future planned maintenance cost

Total Maintenance Costs

Age of Assets

Decreasing

Increasing
ORDM—timing the renewal

- Optimizing the savings
- Trial: Several renewal dates

ORDM is optimized renewal decision-making, LTD is life to date
Setting up the basic analysis: lowest annual life cycle cost

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| 14 | Replace | | | | | | | | | | |
| 15 | Capital | $61,000.00 | | | | | | | | | |
| 16 | Operations | $10,853.56 | $200.00 | $203.00 | $206.05 | $209.14 | $212.27 | $215.46 | $218.69 | $221.97 | $225.25 |
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| 18 | Total Costs | $64,097.25 | $2,102 | | | | | | | | |
| 19 | PV Total Costs | $69,240.55 | | | | | | | | | |

Advancing Asset Management 18
Adding uncertainty: a decision tree approach — Tom’s pump

A Decision Point

Pump Options

A Chance Point

Repair

Min Failure: (50%) ($70,000)
Max Failure: (90%) ($70,000)

Replace

Min Failure: (150%) ($17,000)
Max Failure: (300%) ($17,000)

Refurbish

Min Failure: (100%) ($6,000)
Max Failure: (800%) ($6,000)

An option

Weighted Average

$78,000/2 $39,000
$76,500/2 $38,250
$98,000/2 $49,000

An outcome

Probability of Outcome

Cost of Outcome

(Assume 40 year life)
Adding non-financial decision elements: weighted decision tables

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* Scored 1 (low) to 10 (high)
Facility condition indices

Facility Condition Index (FCI) = $\frac{\text{Cost of deferred maintenance/renewal}}{\text{Current replacement cost of asset}} = X \%$

- **Poor**: > 10%
- **Fair**: 5 - 10%
- **Good**: < 5%

Typically applied to buildings and related facilities
TeamPlan main screen
Management strategy groups

- Grouping of assets with similar renewal and behavioral patterns
- Purpose
  - Allocate defaults to assets (missing data)
  - Assign asset lives and decay curves
  - Calculate current replacement costs
  - Calculate business risk
    - Consequence of failure
    - Probability of failure
  - *Determine appropriate investment intervention*
- Example
  Gravity pipes, RCP, built <1950, high H$_2$S
Creating management strategies
TeamPlan decision logic
Advanced level ORDM example: asset operations

- Operate?
- Average operations costs?
- Which curve?
- Curve shape factor?

![Graph showing Unit Maintenance % of RV and Condition Rating with various curves and conditions](image-url)
Advanced level ORDM example: asset maintenance

- Maintain?
  - Managed (CMMS)?
  - Non-managed (CMMS)?
  - Run to failure (CMMS)?
- Average maintenance costs?
  - Use CMMS as base
- Which curve?
- Curve shape factor?
Advanced level ORDM example: asset rehabilitation

- Rehabilitate?
  - Non-managed (CMMS)?
  - Run to failure (CMMS)?
- Effective life?
  % maximum potential life
- Installation factor?
- Cost curve?
- Cost shape factor?
- Condition curve shape factor?
Advanced level ORDM example: asset replacement

- Is asset type valued by size?
- What is the default size and unit code of the asset?
- Should asset type strategy vary by size?
- Does the length and depth of the asset type effect value?
- What is the maximum potential of this asset type?
- What is the unit cost of the asset (per unit)?
- What is the installation/difficulty factor?
- Which curve represents the decay curve of the asset type?
Random life statistical model

- Assets are allocated a random life centered around the allocated average life
- Utilizes the normal distribution bell-curve
- Reflects real life asset failure uncertainty
Reporting and scenarios
Drilling into assets
Asset renewal decision model
Overall projected (optimized) expenditures
Key points from this session

How do I optimize O&M and capital investment?

Key Points:

- Follow a logical best practice process – Optimized Decision Making or Life Cycle Costing Analysis.
- Get the best information and data you have, consider all feasible alternatives, and generate your best strategy.
- Consider non-asset solutions!

Associated Techniques:

- Optimized renewal decision-making
- Life-cycle costing (including projections)
- Decision-tree analysis
- Weighted decision tables