Lesson 20 – Replacement Analysis

Replacement Analysis

- Often the question is not *if* but *when* should an asset by replaced?
  - When should a new truck replace the existing truck?
  - When should a process/product be redesigned?
- The physical life of a product or piece of equipment will sometimes be well-defined, though in some cases we have to set an arbitrary limit on how long we're prepared to keep an obsolete asset in service (fix, repair, modify).
- The economic life is measured from the point of purchase until the point at which we save money by replacing the asset.
- Thus, the physical life is always greater than or equal to the economic life.

Terminology

- **Defender:** the existing equipment, building or decision that was previously implemented.
- **Challenger:** the proposed replacement that is currently under consideration.

The most common question asked in industry is:
When should the existing asset(s) be replaced?

Some Issues to Consider

- If a unit fails, must it be removed permanently from service, or can it be repaired?
- Are standby units available if the system fails?
- Do components or units fail independently of the failure of other components?
- Is there a budget constraint?
- Is the planning horizon finite or infinite?
- Are consequences other than economic effects considered (ie. sociotechnical issues)?
- Are income tax consequences considered?

More Issues to Consider…

- If the unit can be repaired after failure, is there a constraint on the capacity of the repair facility?
- Is preventative maintenance included in the model?
- Is only one replacement allowed over the planning horizon?
- Is there more than one replacement unit (price and quality combination) available at a given point in time?
- Do future replacement units differ over time? Are technological improvements considered?
- Are periodic operating and maintenance costs constant or variable over time?

What is the basic comparison?

- Analysis is based on the “most economical alternative” over its respective life.

The decision criterion leads to one of the following:
- ➢ if the defender is more economical, it should be retained;
- ➢ if the challenger is more economical, it should be installed.

- Identify the defender and the best challenger:
  - Product
  - Machine
  - Process
  - Personnel
  - Mix

Minimum Cost Life

The most effective way to think about replacement is to consider the equivalent uniform annual cost of the asset over its life, taking various different durations for its life. The EUAC is usually made up of two factors: the initial cost of the asset, spread out over its life; and the annual cost of repairs and maintenance. (The capital recovery should include a deduction for the salvage value of the asset).

The first factor will go down as we consider longer lifetimes, while the second will usually go up. The sum of the two will therefore (usually) have a minimum value. This is the minimum EUAC, and the number of years corresponding to the min EUAC is the minimum cost life (which is often shorter than the physical or useful life of the asset).

Simple Example

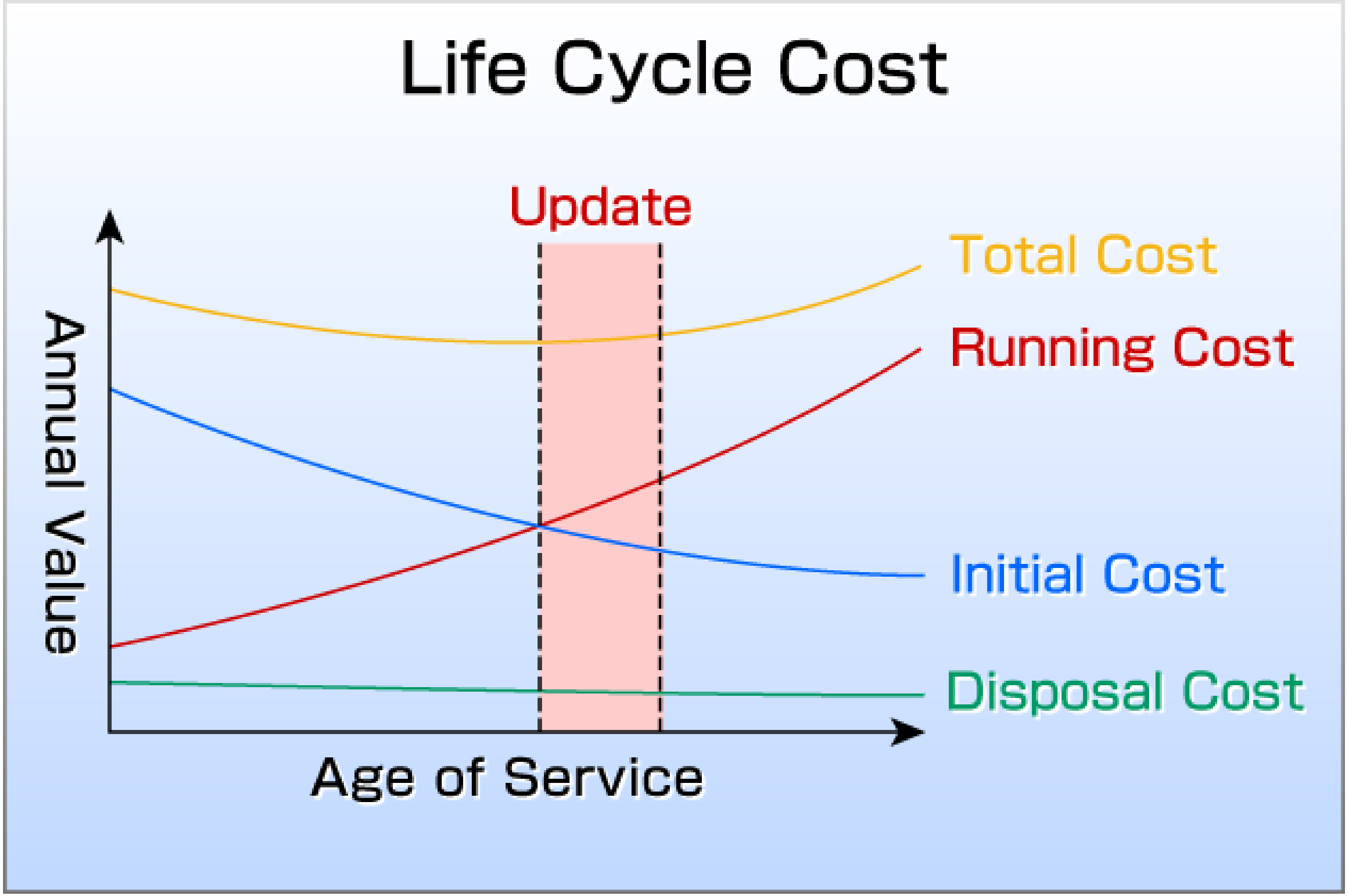
- Piece of Machinery costs $15,000 to purchase and install.
- Annual maintenance costs are $1000 in the first year, increasing $500 per year.

Initial Cost	$15,000			
Lifetime	Annualized Initial Costs	Operating Costs	Annualized Operating Costs	Total Annual Costs
1	$15,000	$1,000	$1,000	$16,000
2	$7,500	$1,500	$1,250	$8,750
3	$5,000	$2,000	$1,500	$6,500
4	$3,750	$2,500	$1,750	$5,500
5	$3,000	$3,000	$2,000	$5,000
6	$2,500	$3,500	$2,250	$4,750
7	$2,143	$4,000	$2,500	$4,643
8	$1,875	$4,500	$2,750	$4,625
9	$1,667	$5,000	$3,000	$4,667
10	$1,500	$5,500	$3,250	$4,750

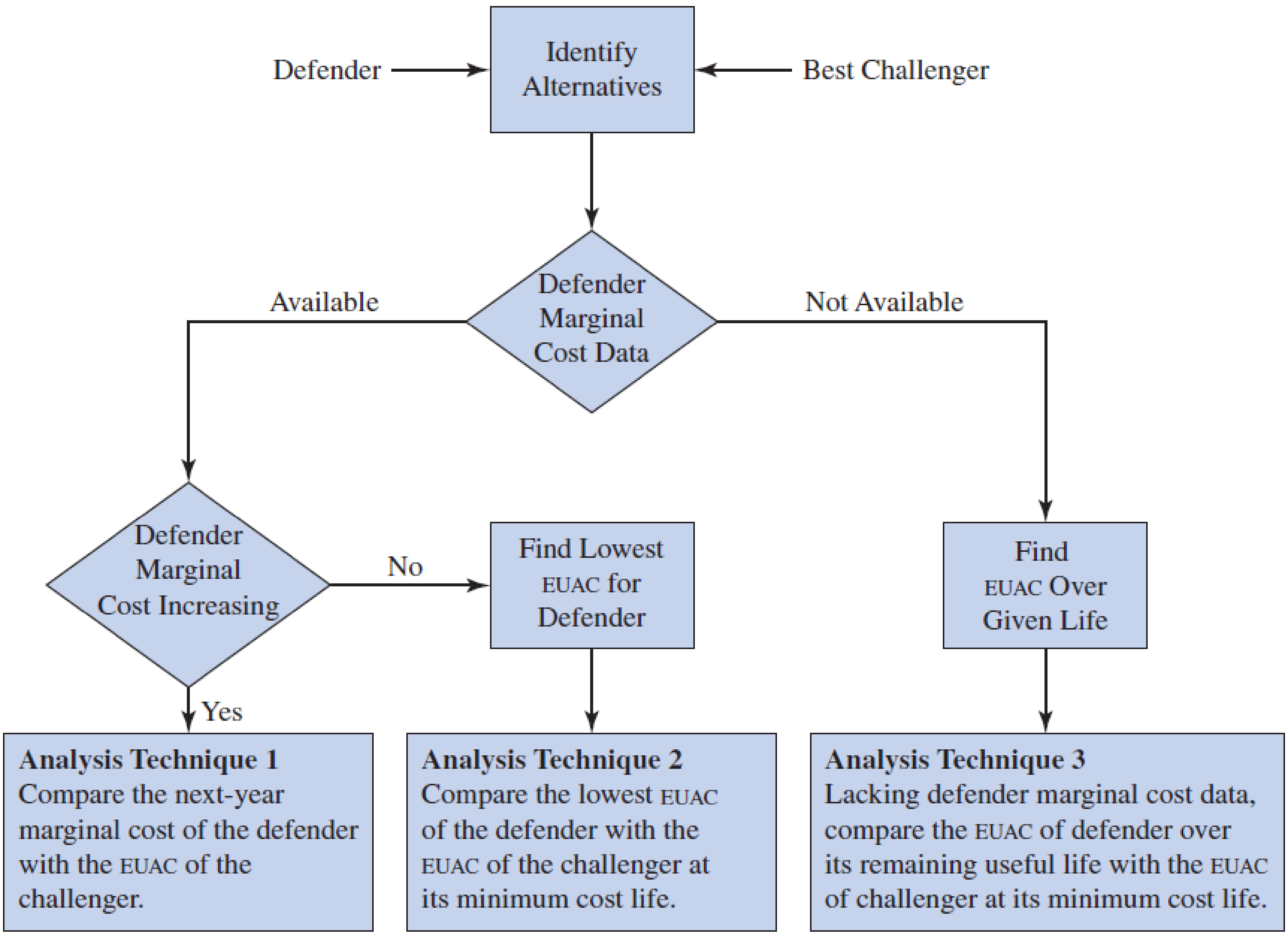
Minimum annualized costs

- Note – these are nominal costs, not EAUCs

Minimum Cost Life



Replacement Analysis Decision Map



Replacement Analysis Decision Table

	Where	Compare	
	Defender's marginal cost is	Defender's	Best challenger's
1	Available and increasing	Next year's marginal cost	EACF at minimum cost life
2	Available and not increasing	EACF at minimum cost life	EACF at minimum cost life
3	Not available	EACF over useful life remaining	EACF at minimum cost life

Pause: What is marginal cost in this context?

- The year-by-year costs of keeping an asset.
- The period of any yearly marginal cost of ownership is always one year, calculated as end-of-year cash flow.
- The marginal cost of ownership for any year in the life of an asset is the cost for that year only, including:
  - Capital recovery costs (loss in market value and lost interest for the year)

    -Estimates of an asset's market value on a year-to-year basis is required
  - Yearly operating and maintenance costs
  - Yearly taxes and insurance

Replacement Analysis Technique #1:

- Defender Marginal Costs are Increasing
  - Retain the defender if its marginal cost for the next year are < the minimum EACF of the challenger.
  - When the marginal cost of the defender becomes > the minimum EACF of the challenger, replace the defender.
- Technique #1 is appropriate when the replacement repeatability assumptions hold:
  - The best challenger will continue to be available in all later years at the same economic cost.
  - The period of needed service is infinite.

Replacement Analysis Technique #2:

- The defender's marginal costs are not increasing initially; this is usually the case when the defender is at an early point in its useful life.
  - Retain the defender if its minimum EACF is less than the minimum EACF of the challenger.
  - If the defender is retained, replace it with the challenger when its marginal cost becomes > the minimum EACF of the challenger.
- The replacement repeatability assumptions must hold to justify using this technique.

Replacement Analysis Technique #3:

- The defender's marginal costs are not known; this can occur when the defender is based on aging technology with a shrinking market.
- Compare the EACF of the defender over its remaining stated useful life against the minimum EACF of the challenger.
- Choose the asset that yields the more positive EACF in this comparison.

Complications in Replacement Analysis

- The salvage value of replacing a defender may affect the conclusion if not handled correctly.
- Opportunity Cost Perspective
  - Is the value of the opportunity lost (salvage of defender) applied to the defender for not replacing now?
- This is in contrast to subtracting it from the cost of the challenger (cash flow perspective)
  - Subtracting from the challenger yields incorrect results if the remaining life of the defender differs from the life of the challenger.

Replacement Analysis: Problem 1

For a study period of 10 years, perform a replacement analysis on the following two alternatives at an interest rate of 11% per year

	Current ($)	Proposed ($)
Purchase Price	100,000	50,000
Current Value	30,000	———
Estimated Value in 10 Years	2000	12,000
Operating Costs/Year	6000	2000

Replacement Analysis: Solution 1

Determine EUAW over the 10-year study period

$$\begin{aligned}\text{EUAW}_{\text{current}} &= -30{,}000(A/P,\ 11\%,\ 10) + 2000(A/F,\ 11\%,\ 10) - 6{,}000 \\ &= -30{,}000(0.16980) + 2000(0.05980) - 6000 \\ &= \$-10{,}974.40\end{aligned}$$

$$\begin{aligned}\text{EUAW}_{\text{proposed}} &= -50{,}000(A/P,\ 11\%,\ 10) + 12{,}000(A/F,\ 11\%,\ 10) - 2000 \\ &= -50{,}000(0.16980) + 12{,}000(0.05980) - 2000 \\ &= \$-13{,}772.40\end{aligned}$$

Keep the current alternative.

Problem 2

EXAMPLE 13-6

A five-year-old machine, whose current market value is $5,000, is being analyzed to determine its minimum EUAC at a 10% interest rate. Salvage value and maintenance estimates and the corresponding marginal costs are given in the following table.

Data			Calculating Marginal Costs		
Year	Salvage Value	O&M Cost	$S_{t-1}(1+i)$	$-S_t$	Marginal Cost
0	$5,000				
1	4,000	$ 0	$5,500	−$4,000	$1,500
2	3,500	100	4,400	−3,500	1,000
3	3,000	200	3,850	−3,000	1,050
4	2,500	300	3,300	−2,500	1,100
5	2,000	400	2,750	−2,000	1,150
6	2,000	500	2,200	−2,000	700
7	2,000	600	2,200	−2,000	800
8	2,000	700	2,200	−2,000	900
9	2,000	800	2,200	−2,000	1,000
10	2,000	900	2,200	−2,000	1,100
11	2,000	1,000	2,200	−2,000	1,200

Continued

Solution 2

SOLUTION

Because the marginal costs have a complex, non-increasing pattern, we must calculate the minimum EUAC of the defender.

			If Retired at End of Year n		
Years Kept, n	Salvage Value (S) at End of Year n	Maintenance Cost for Year	EUAC of Capital Recovery $(P - S) \times (A/P, 10\%, n) + Si$	EUAC of Maintenance $100(A/G, 10\%, n)$	Total EUAC
0	$P = \$5{,}000$				
1	4,000	\$ 0	\$1,100 + 400	\$ 0	\$1,500
2	3,500	100	864 + 350	48	1,262
3	3,000	200	804 + 300	94	1,198
4	2,500	300	789 + 250	138	1,177
5	2,000	400	791 + 200	181	1,172
6	2,000	500	689 + 200	222	1,111
7	2,000	600	616 + 200	262	1,078
8	2,000	700	562 + 200	300	1,062
9	2,000	800	521 + 200	337	1,058 ←
10	2,000	900	488 + 200	372	1,060
11	2,000	1,000	462 + 200	406	1,068

Solution 2 (cont’d)

- If the best challenger to the above machine has a cost of \$7000 and an expected lifetime of 15 years and \$300 annual operating costs, should it replace the existing machine, and when?

- EAUCc = \$7000 (A/P, 10%, 15) + \$145 = \$7000(.1315) + \$145 = \$1065.50

8	2,000	700	562 + 200	300	1,062
9	2,000	800	521 + 200	337	1,058←
10	2,000	900	488 + 200	372	1,060
11	2,000	1,000	462 + 200	406	1,068