

Problem 12

Defender and Challenger

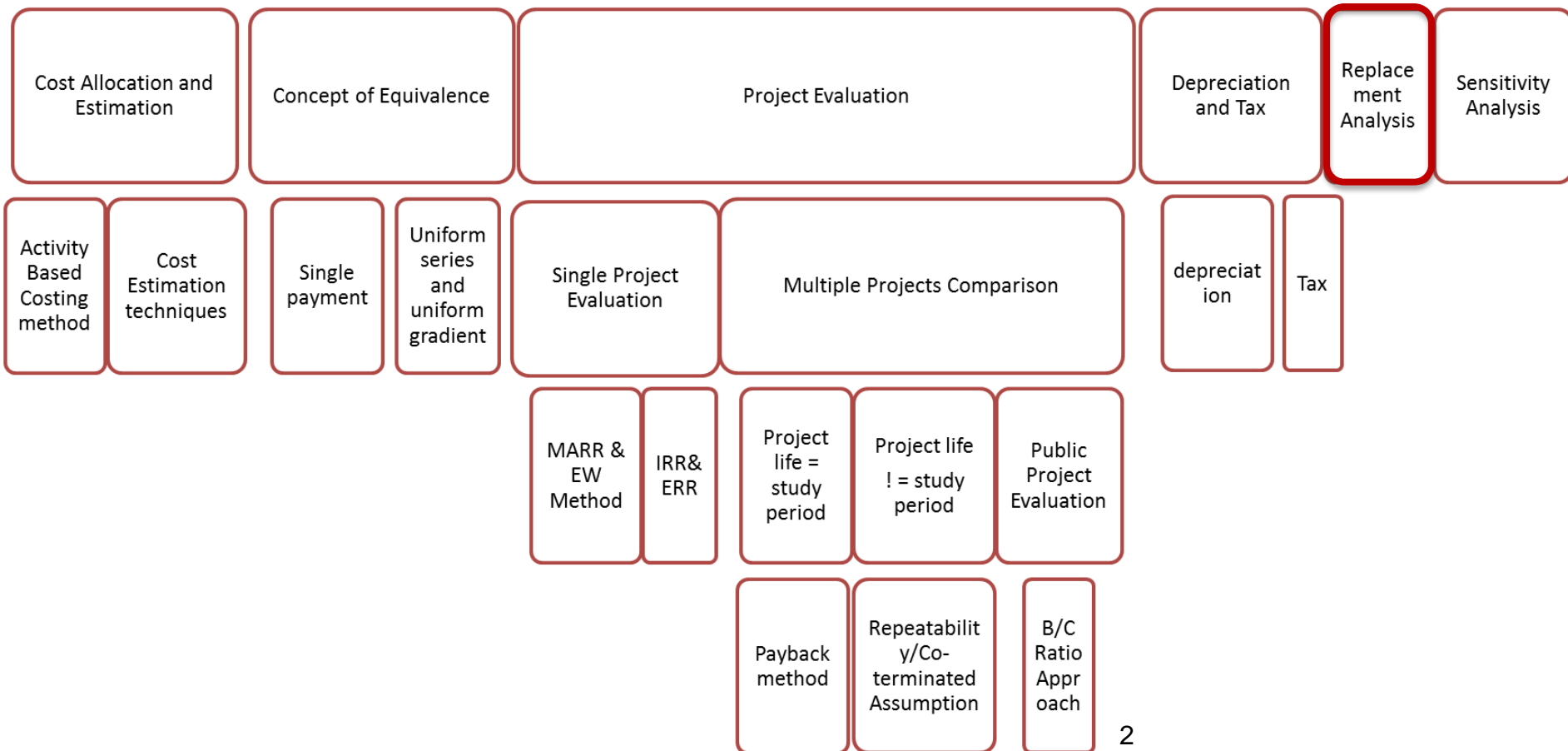
E213 – Engineering Cost Decisions

SCHOOL OF
ENGINEERING

Module Coverage: Topic Tree



E213 – Engineering Cost Decisions



Recap...



- Previous studies:
 - Use of PW/FW/AW, IRR/ERR, Payback period
 - Repeatability and co-terminated assumptions for unequal lives
 - Depreciation and Taxes
 - All alternatives are ***NEW***

Replacement Study



- An asset is currently in use and its function is needed in the future, it will be replaced at some time
- Replacement study answers the question of ‘when’ (not ‘if’) to replace.

Reasons for Replacement Analysis

- Equipment deteriorates due to aging
- Obsolescence, e.g. new technology has emerged, requirements have changed
- Leasing has become more attractive than owning the asset

Terminology



- Defender – Asset currently owned
- Challenger – Asset that is going to replace defender
- Book Value/Market Value
- Sunk Cost are any pass cost and investment that cannot be recovered
- Equivalent Uniform Annual Cost (EUAC)

Considerations



- Sunk Cost is ignored
- Remaining life of defender = life of challenger, can apply AW, PW or FW analysis.
- Remaining life of defender \neq life of challenger, need to apply repeatability assumption or co-terminated assumption.
- The initial capital cost (in year zero) and current book value of the defender is irrelevant in replacement analysis.⁶

Equivalent Uniform Annual Cost (EUAC)

- A special name for AW when there is no revenues in the cash flow diagram (**Cost alternative**)
- Calculate the annual worth (AW) for Defender and Challenger
- Recall:
- $AW(i\%) = R - E - CR(i\%)$
 - where $CR(i\%) = I(A|P, i\%, n) - S(A|F, i\%, n)$
 - CR is the equivalent uniform annual cost of the capital invested.
- The name is Equivalent Uniform Annual ⁷Cost (EUAC)

Economic Service Life (ESL)



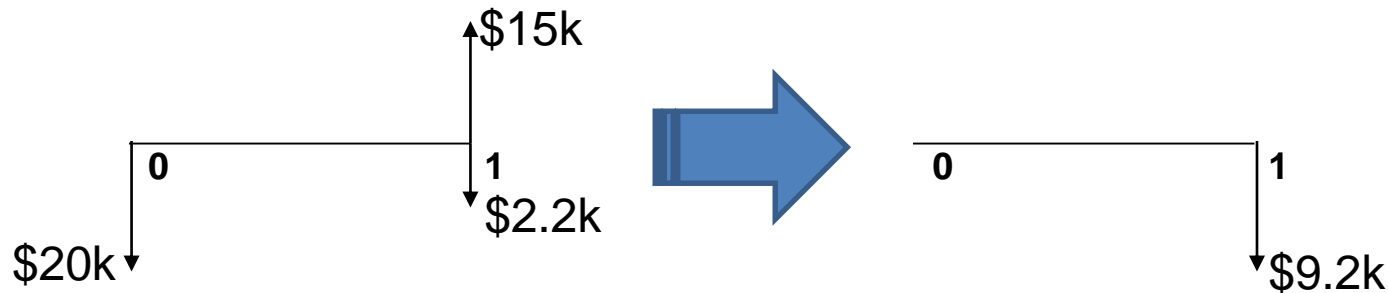
- ESL is the life of the equipment that has the minimum Equivalent Uniform Annual Cost (EUAC).
- ESL is also referred to as Minimum Cost Life.
- E.g. A lorry's market value decreases but its operating cost increases as the years go by. MARR = 10%

| Year | Market Value | Operating Cost |
|------|--------------|----------------|
| 0 | \$20,000 | - |
| 1 | \$15,000 | \$2,200 |
| 2 | \$10,000 | \$2,500 |
| 3 | \$5,000 | \$3,500 |

Economic Service Life (ESL)



- If we use the lorry for 1 more year, cash flow diagram:

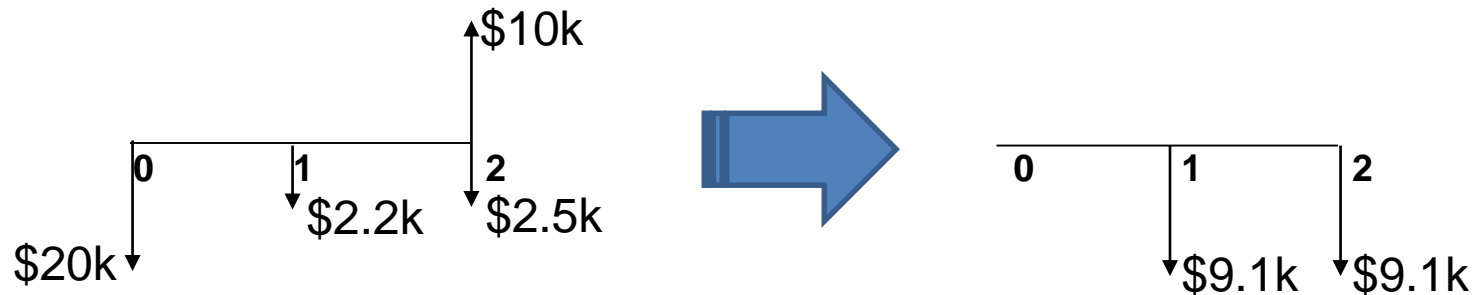


- Present worth of cash flow
 $= -20,000 + (15,000 - 2,200)(P|F, 10\%, 1)$
 $= -\$8,363.64$
- $EUAC_1$
 $= 8,363.64(A|P, 10\%, 1) = \$9,200$

Economic Service Life (ESL)



- If we use the lorry for 2 more years, cash flow diagram:



- Present worth of cash flow
$$= -20,000 - 2,200(P|F, 10\%, 1) + (10,000 - 2,500)(P|F, 10\%, 2)$$
$$= -\$15,801.70$$
- $EUAC_2$
$$= 15,801.70(A|P, 10\%, 2) = \$9,104$$

Economic Service Life (ESL)



- $EUAC_2 < EUAC_1$
- Continue to calculate $EUAC_3$
- $ESL = 'n'$ years, where $EUAC_n$ is the minimum.
- We get the best value (i.e. the lowest annual cost) from the lorry if we use it until the 2nd year.

| Year k | Market Value | Operating Cost | Present Worth of total cost | EUAC |
|--------|--------------|----------------|-----------------------------|---------|
| 0 | \$20,000 | - | | |
| 1 | \$15,000 | \$2,200 | \$8,364 | \$9,200 |
| 2 | \$10,000 | \$2,500 | \$15,802 | \$9,104 |
| 3 | \$5,000 | \$3,500 | \$22,939 | \$9,224 |

P12 Suggested Solution

Problem Statement



- Defender: existing car
- Challenger: new car
- Recommend whether Paul should continue using the existing car or replace it with the new car.
- Determine the Economic Service Life of the new bus if Paul were to proceed with buying the new car.

Opportunity Cost Approach



- Current market value (offered by potential buyer) of the defender is used as the initial cost of defender.
- Need to consider only the present and future cash flows in replacement studies. Sunk cost need not be considered.

| | Defender | Challenger |
|---------------------|--|--|
| First cost | \$79,000 | \$170,000 |
| Annual Maintenance | \$5,800 (year 6), to increase 30% yearly | \$3,800 (year 1), to increase 23% yearly |
| Salvage/Book Value | \$23,640 (9 th year) | \$108,000 (4 th year) |
| Annual Depreciation | \$13,840 | \$15,500 |
| Useful Life | 10 (5 years left) | 10 years |

$$(79,000 - 9,800)/5 = 13,840$$

$$170,000 - 15,500 \times 4 = 108,000$$

$$(170,000 - 15,000)/10 = 15,500$$

Opportunity Cost Approach



| | Current car (Defender) | New car (Challenger) |
|---------------------------------------|--|---|
| Cash Flows Diagram (Opportunity Cost) | <p>Defender</p> | <p>Challenger</p> |
| PW (8%) | $= -79,000 - 5,800(P/F, 8\%, 1) - 7,540(P/F, 8\%, 2) - 9,802(P/F, 8\%, 3) + (-12,742.60 + 23,640)(P/F, 8\%, 4)$ $= -\$90,605.50$ | $= -170,000 - 3,800(P/F, 8\%, 1) - 4,674(P/F, 8\%, 2) - 5,749.02(P/F, 8\%, 3) + (-7,071.29 + 108,000)(P/F, 13\%, 4)$ $= -\$107,906$ |
| EUAC (8%) | $= \$90,605.50 \times (A/P, 8\%, 4)$ $= \$27,353.80$ | $= \$107,906 \times (A/P, 8\%, 4)$ $= \$32,576.90$ |

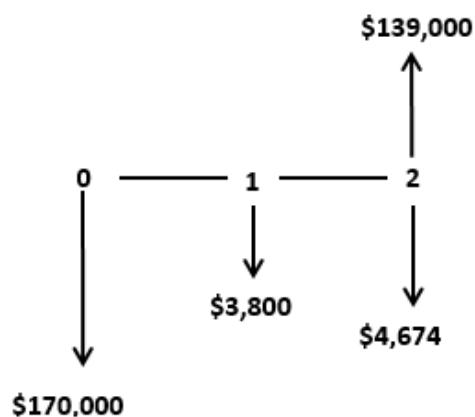
$$EUAC_{\text{defender}} < EUAC_{\text{challenger}}$$

Conclusion: **Paul should NOT switch to the new car now**

Economic Service Life (new car)



| End of Year | Initial Investment | Market Value (\$) | Operating Cost (\$) | Present Worth | Equivalent Uniform Annual Cost |
|-------------|--------------------|-------------------|---------------------|---------------|--------------------------------|
| 0 | \$170,000.00 | | | | |
| 1 | | \$154,500.00 | \$3,800.00 | -\$30,462.96 | \$32,900.00 |
| 2 | | \$139,000.00 | \$4,674.00 | -\$58,355.62 | \$32,724.04 |
| 3 | | \$123,500.00 | \$5,749.02 | -\$84,051.20 | \$32,614.68 |
| 4 | | \$108,000.00 | \$7,071.29 | -\$107,903.87 | \$32,578.42 |
| 5 | | \$92,500.00 | \$8,697.69 | -\$130,252.65 | \$32,622.62 |
| 6 | | \$77,000.00 | \$10,698.16 | -\$151,425.19 | \$32,755.60 |
| 7 | | \$61,500.00 | \$13,158.74 | -\$171,741.59 | \$32,986.82 |
| 8 | | \$46,000.00 | \$16,185.25 | -\$191,518.27 | \$33,327.01 |
| 9 | | \$30,500.00 | \$19,907.86 | -\$211,071.92 | \$33,788.33 |
| 10 | | \$15,000.00 | \$24,486.66 | -\$230,723.68 | \$34,384.63 |



Based on the cash flow diagram when you use the new car for two years, you can calculate:

$$PW = -170,000 - 3,800*(P/F,8\%,1) - 4,674*(P/F,8\%,2) + 139,000(P/F,8\%,2)$$

$$= -\$58,360.70$$

$$EUAC = 58,360.70*(A/P,8\%,2) = \$32,728.70$$

Minimum EUAC = \$32,578.42 at the end of year 4, so ESL = 4 years

If Paul decides to buy the new car, he should use it for 4 years to enjoy the lowest EUAC.

Learning Objectives



- Explain the reasons for replacement
- Apply the terminology of replacement analysis
- Perform replacement study between Defender and Challenger using EUAC (Equivalent Uniform Annual Cost) criterion
- Interpret the concept of economic service life
- Apply EUAC to determine economic service life

E213 Engineering Cost Decisions (Topic Flow)

