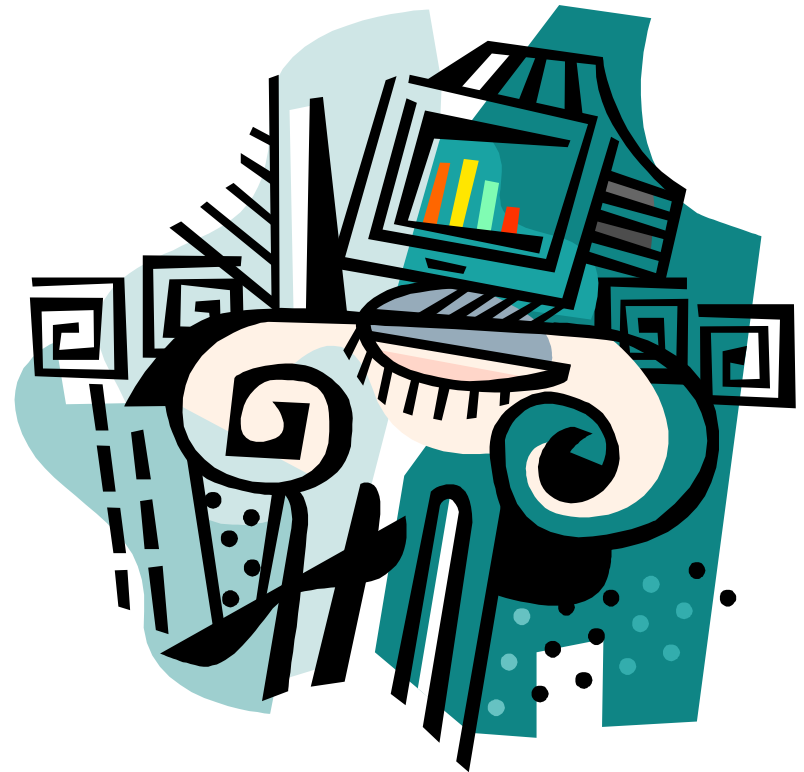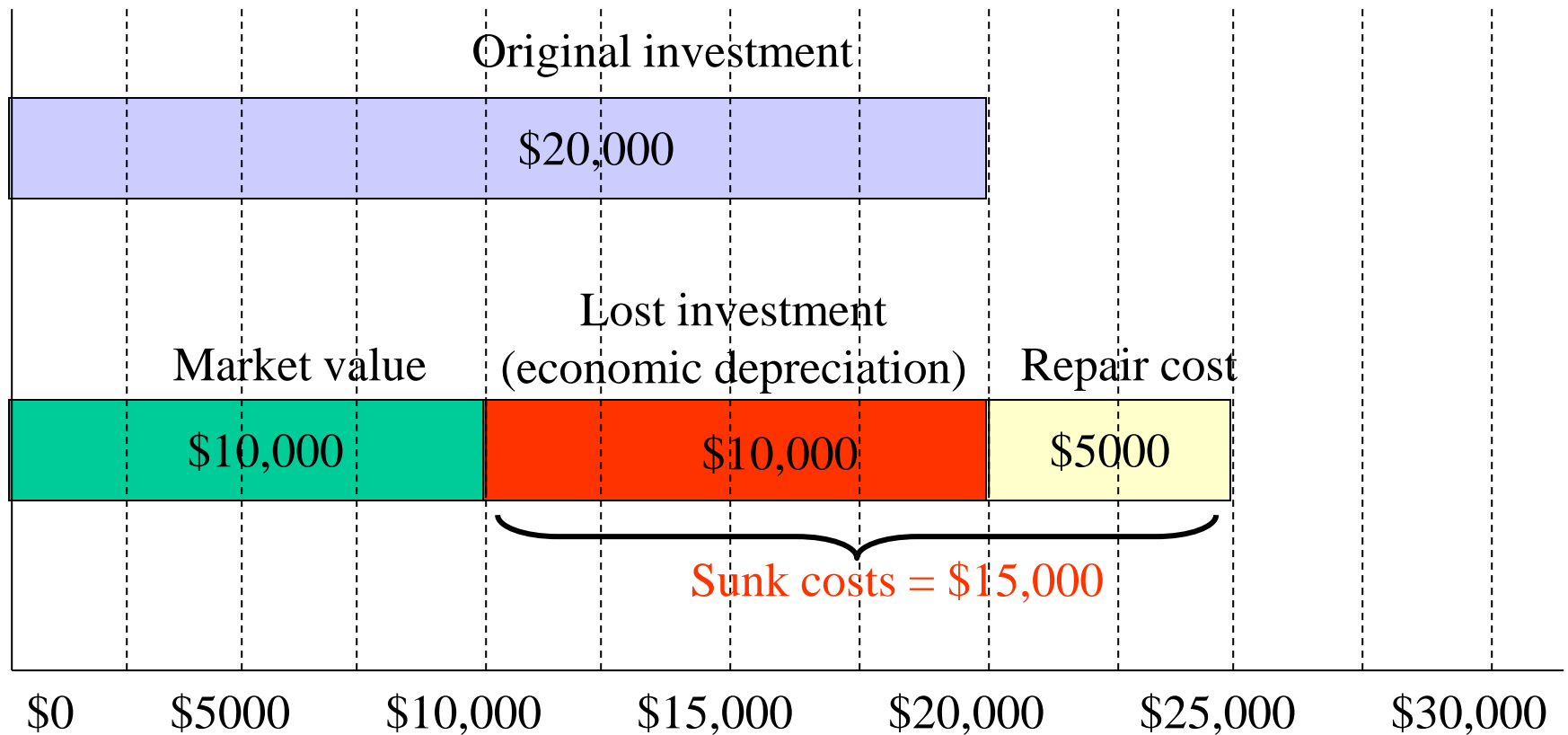# Chapter 15
Replacement Decisions

- Replacement Analysis Fundamentals

- Economic Service Life

- Replacement Analysis When Required Service is Long

- Replacement Analysis with Tax Consideration

Replacement Terminology

- **Defender**: an old machine

- **Challenger**: new machine

- **Current market value**: selling price of the defender in the market place

- **Sunk cost**: any past cost unaffected by any future decisions

- **Trade-in allowance**: value offered by the vendor to reduce the price of a new equipment
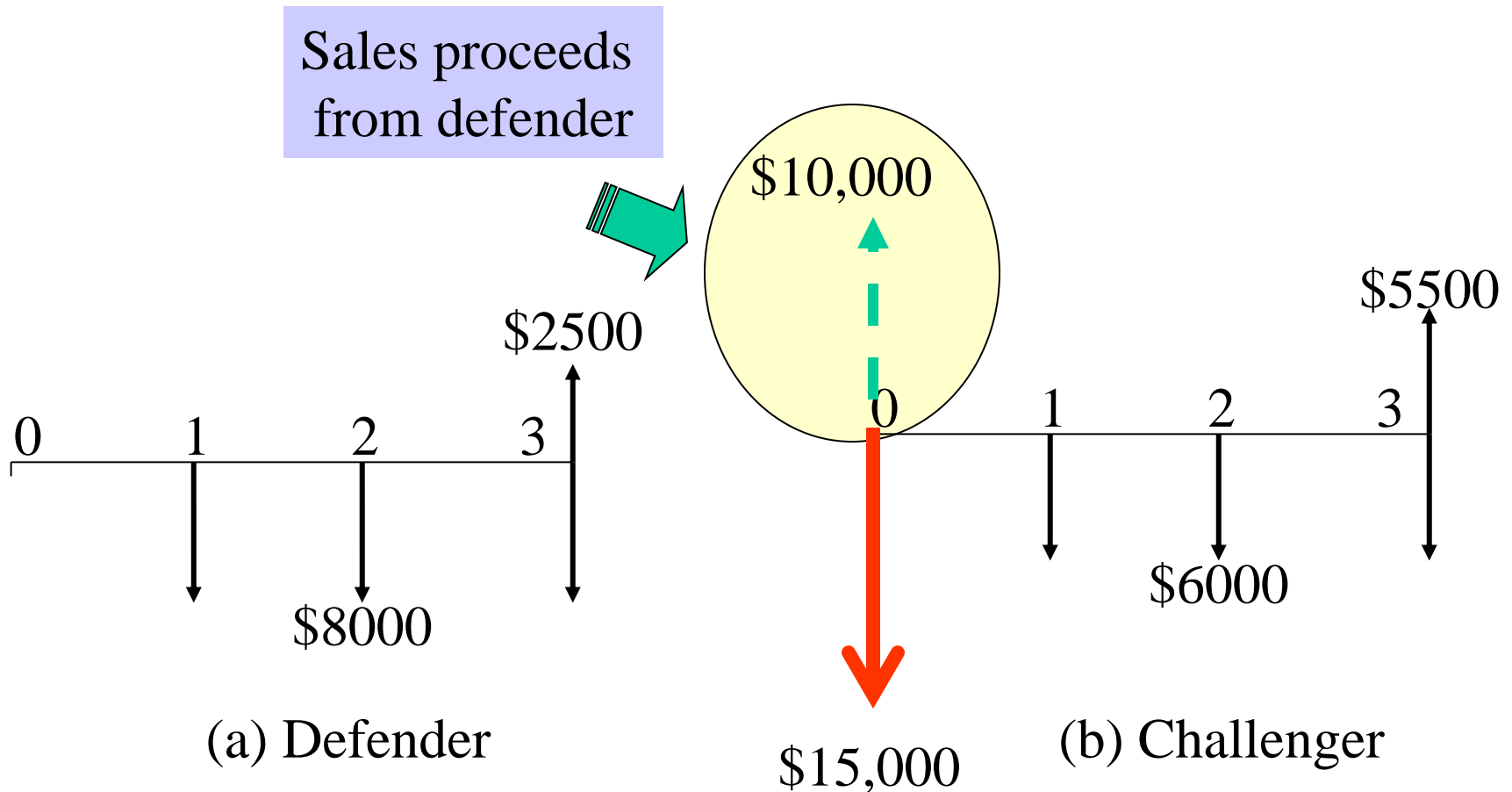
- **Operating Cost**

Sunk Cost associated with an Asset's Disposal

Original investment

$20,000

Market value

Lost investment (economic depreciation)

Repair cost

$10,000

$10,000

$5000

Sunk costs = $15,000

$0 $5000 $10,000 $15,000 $20,000 $25,000 $30,000

Replacement Decisions

- **Cash Flow Approach**

  - Treat the proceeds from sale of the old machine as <u>down payment</u> toward purchasing the new machine.

  - Can be used if the analysis period is same for all alternatives.

  - Use NPW or AE analysis to decide

- **Opportunity Cost Approach**

  - Treat the proceeds from sale of the old machine as the <u>investment required</u> to keep the old machine.

Replacement Analysis – Cash Flow Approach

Sales proceeds from defender

$10,000

$2500

$8000

0   1   2   3

(a) Defender

$15,000

$5500

$6000

0   1   2   3

(b) Challenger

Annual Equivalent Cost - Cash Flow Approach

- Defender:

$$PW(12\%)_D = \$2,500 \, (P/F, 12\%, 3) - \$8,000 \, (P/A, 12\%, 3)$$
$$= \underline{- \$17,434.90}$$
$$AE(12\%)_D = PW(12\%)_D(A/P, 12\%, 3)$$
$$= -\$7,259.10$$

- Challenger:

$$PW(12\%)_C = \$5,500 \, (P/F, 12\%, 3) - \$5,000$$
$$- \$6,000 \, (P/A, 12\%, 3)$$
$$= \underline{-\$15,495.90}$$
$$AE(12\%)_C = PW(12\%)_C(A/P, 12\%, 3)$$
$$= -\$6,451.79$$
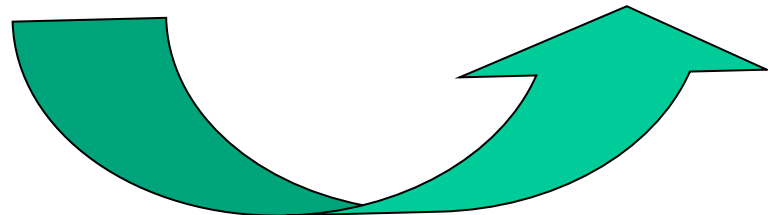
Replace the defender now!

Opportunity Cost Approach

Defender

$2500

0   1   2   3

$8000

$10,000

Proceeds from sale viewed as an opportunity cost of keeping the asset

Challenger

$5500

0   1   2   3
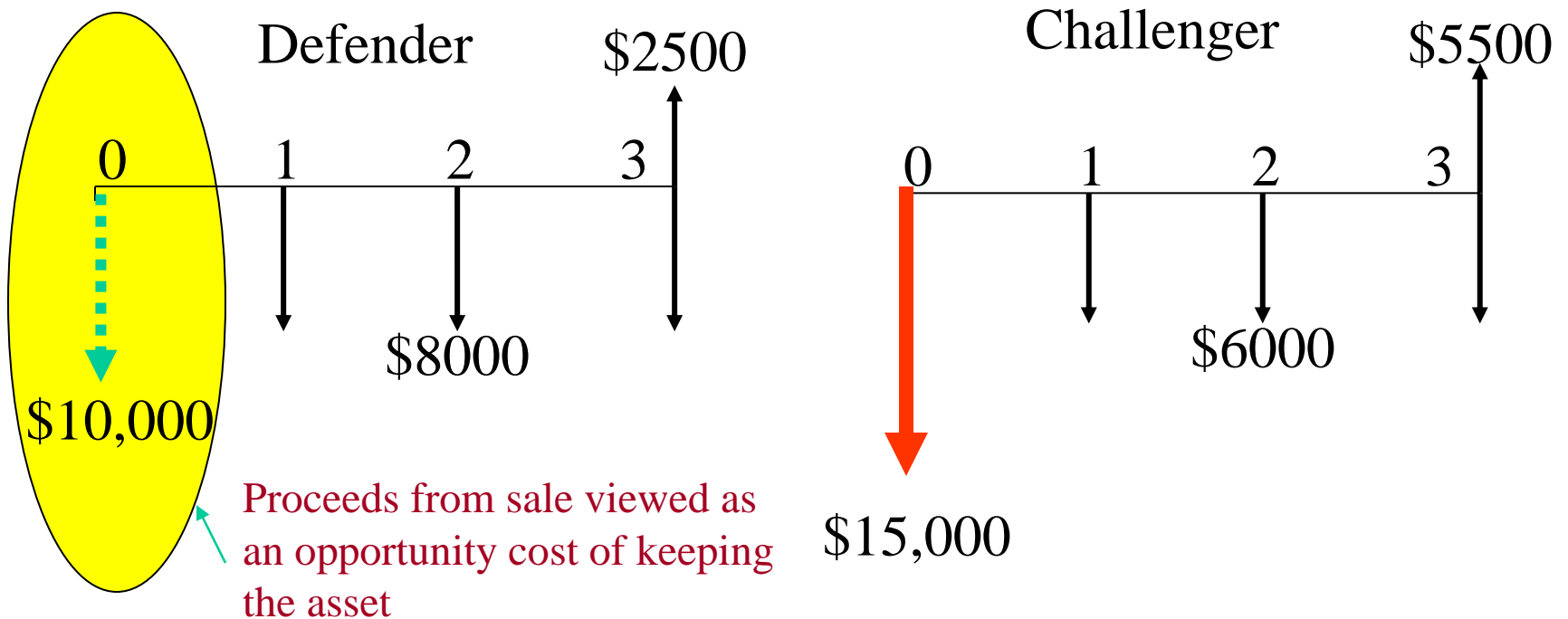
$6000

$15,000

Opportunity Cost Approach

● Defender:

$$PW(12\%)_D = -\$10{,}000 - \$8{,}000(P/A, 12\%, 3) + \$2{,}500(P/F, 12\%, 3)$$

$$= -\$27{,}434.90$$

$$AE(12\%)_D = PW(12\%)_D(A/P, 12\%, 3)$$

$$= -\$11{,}422.64$$

● Challenger:

$$PW(12\%)_C = -\$15{,}000 - \$6{,}000(P/A, 12\%, 3) + \$5{,}500(P/F, 12\%, 3)$$

$$= -\$25{,}495.90$$

$$AE(12\%)_C = PW(12\%)_C(A/P, 12\%, 3)$$

$$= -\$10{,}615.33$$

Replace the defender now!

Economic Service Life

- Def:**Economic service life** is the <u>useful life</u> of a defender, *or* a challenger, that results in the minimum equivalent annual cost

- Why do we need it?: We should use the respective economic service lives of the defender and the challenger when conducting a replacement analysis.

Minimize

Ownership (Capital) Cost (init.+salvg.)

+

Operating cost
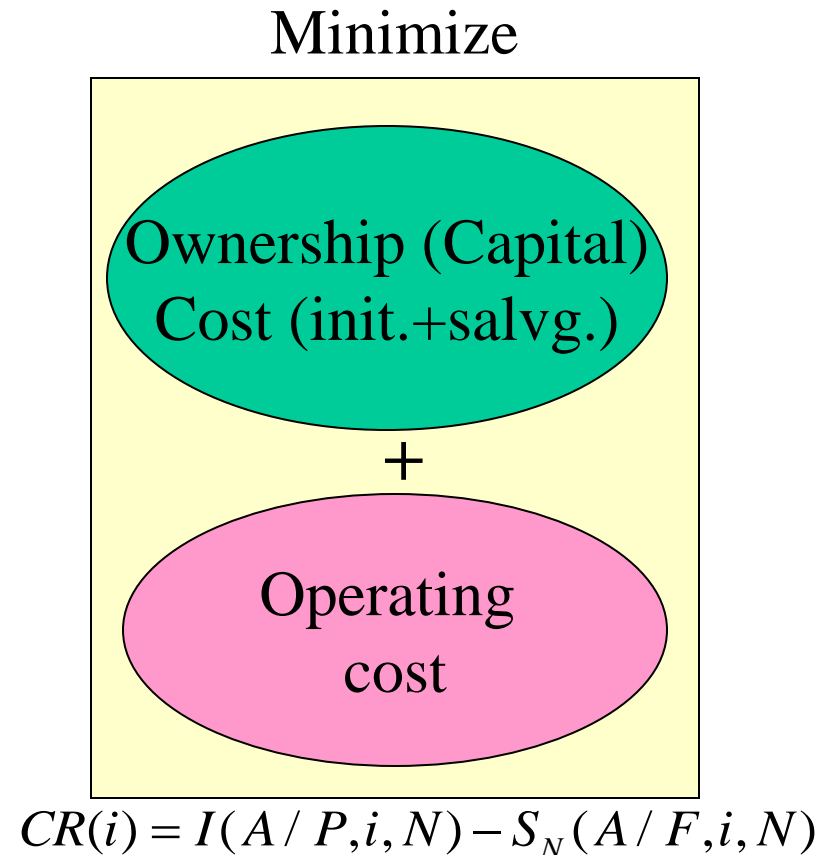
$$CR(i) = I(A/P, i, N) - S_N(A/F, i, N)$$

Mathematical Relationship

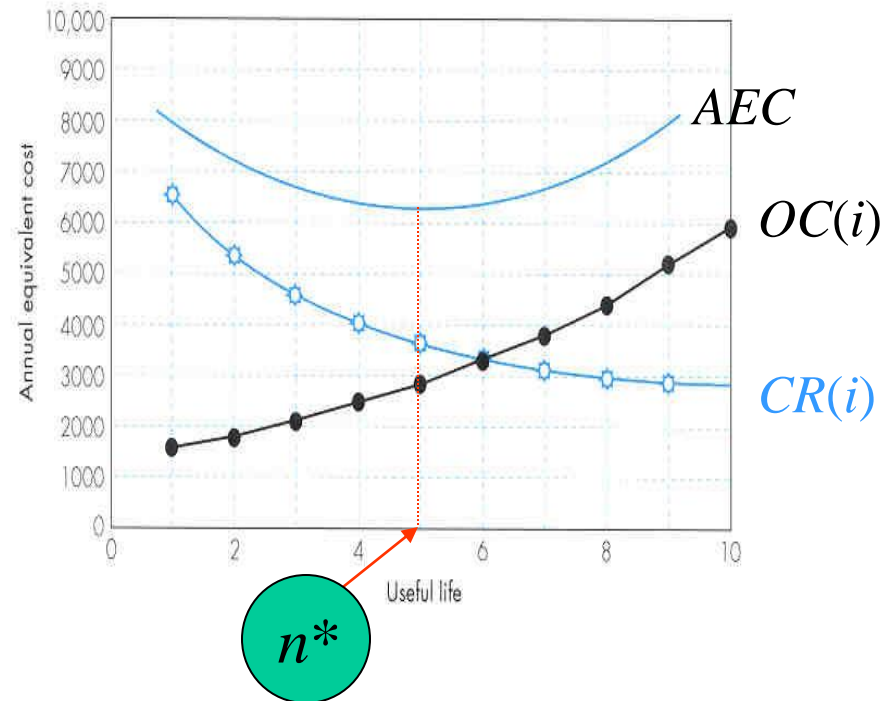- Capital Recov. Cost.

$$CR(i) = I(A/P, i, N) - S_N(A/F, i, N)$$

- Operating Cost:

$$OC(i) = \boxed{\sum_{n=1}^{N} OC_n(P/F, i, n)}(A/P, i, N)$$

- Total Cost:

$$AEC = CR(i) + OC(i)$$

- Objective: Find n^* that minimizes AEC

n^*

Required Assumptions and Decision Frameworks

- Planning horizon (study period)
- Technology
- Relevant cash flow information
- Decision Frameworks

Replacement Strategies under the Infinite Planning Horizon

1. **Replace the defender now**: The cash flows of the challenger will be used from today and will be repeated because an <u>identical challenger</u> will be used if replacement becomes necessary again in the future. This stream of cash flows is equivalent to a cash flow of AE_{C*} each year for an infinite number of years.

2. **Replace the defender, say, *x* years later**: The cash flows of the defender will be used in the first *x* years. Starting in year x+1,the cash flows of the challenger will be used indefinitely.

Example 15.5

- Defender: Find the remaining useful (economic) service life.

$$N_{D^*} = 2\, years$$
$$AE_{D^*} = \$5,116$$

$$N = 1: AE(15\%) = \$5,130$$
$$\boxed{N = 2: AE(15\%) = \$5,116}$$
$$N = 3: AE(15\%) = \$5,500$$
$$N = 4: AE(15\%) = \$5,961$$
$$N = 5: AE(15\%) = \$6,434$$

- **Challenger**: find the economic service life.

$N = 1$ year: $AE(15\%) = \$7,500$
$N = 2$ years: $AE(15\%) = \$6,151$
$N = 3$ years: $AE(15\%) = \$5,847$
$N = 4$ years: $AE(15\%) = \$5,826$
$N = 5$ years: $AE(15\%) = \$5,897$

$N_{C*} = 4$ years

$AE_{C*} = \$5,826$

Replacement Decisions

$$N_{D^*} = 2 \text{ years}$$

$$AE_{D^*} = \$5,116$$

$N_{C^*} = 4$ years

$AE_{C^*} = \$5,826$

- Should replace the defender now? No, because $AE_D < AE_C$

- If not, when is the best time to replace the defender? Need to conduct marginal analysis.

Summary

- In replacement analysis, the **defender** is an existing asset; the **challenger** is the best available replacement candidate.

- The **current market value** is the value to use in preparing a defender's economic analysis. **Sunk costs**—past costs that cannot be changed by any future investment decision—should not be considered in a defender's economic analysis.

- Two basic approaches to analyzing replacement problems are the **cash flow approach** and the **opportunity cost approach**.

  - The cash flow approach explicitly considers the actual cash flow consequences for each replacement alternative as they occur.

  - The opportunity cost approach views the net proceeds from sale of the defender as an opportunity cost of keeping the defender.

- **Economic service life** is the <u>remaining useful life</u> of a defender, *or* a challenger, that results in the minimum equivalent annual cost or maximum annual equivalent revenue. We should use the respective economic service lives of the defender and the challenger when conducting a replacement analysis.

- Ultimately, in replacement analysis, the question is not *whether* to replace the defender, but *when* to do so.

- The AE method provides a <u>marginal basis</u> on which to make a year-by-year decision about the best time to replace the defender.

- As a general decision criterion, the PW method provides a more direct solution to a variety of replacement problems, with either an infinite or a finite planning horizon, or a technological change in a future challenger.

- The role of **technological change** in asset improvement should be weighed in making long-term replacement plans
- Whenever possible, all replacement decisions should be based on the cash flows after taxes.