

Chapter 11

Replacement and Retention Decisions

Solutions to Problems

- 11.1 Specific assumptions about the challenger are:
1. Challenger is best alternative to defender now and it will be the best for all succeeding life cycles.
 2. Cost of challenger will be same in all future life cycles.
- 11.2 The defender's value of P is its fair market value. If the asset must be updated or augmented, this cost is added to the first cost. Obtain market value estimates from expert appraisers, resellers or others familiar with the asset being evaluated.
- 11.3 The consultant's (external or outsider's) viewpoint is important to provide an unbiased analysis for both the defender and challenger, without owning or using either one.
- 11.4 (a) Defender first cost = blue book value = $10,000 - 3,000 = \$7000$

(b) Since the trade-in is inflated by \$3000 over market value (blue book value)

$$\begin{aligned}\text{Challenger first cost} &= \text{sales price} - (\text{trade-in value} - \text{market value}) \\ &= P - (\text{TIV} - \text{MV}) \\ &= 28,000 - (10,000 - 7000) \\ &= \$25,000\end{aligned}$$

- 11.5 $P = \text{market value} = \$350,000$
 $\text{AOC} = \$125,000 \text{ per year}$
 $n = 2 \text{ years}$
 $S = \$5,000$

- 11.6 (a) Now, $k = 2$, $n = 3$ years more. Let $MV_k = \text{market value } k \text{ years after purchase}$

$$\begin{aligned}P &= MV_2 = 400,000 - 50,000(2)^{1.4} = \$268,050 \\ S &= MV_5 = 400,000 - 50,000(5)^{1.4} = \$-75,913 \\ \text{AOC} &= 10,000 + 100(k)^3 \text{ for } k = \text{year } 3, 4, \text{ and } 5\end{aligned}$$

k	3	4	5
Study period year, t	1	2	3
AOC	\$12,700	16,400	22,500

(b) In 2 years, $k = 4$, $n = 1$ since it had an expected life of 5 years. more.

$$\begin{aligned} P &= MV_4 = 400,000 - 50,000(4)^{1.4} = \$51,780 \\ S &= MV_5 = 400,000 - 50,000(5)^{1.4} = \$-75,913 \\ AOC &= 10,000 + 100(5)^3 = \$22,500 \text{ for year 5 only} \end{aligned}$$

$$\begin{aligned} 11.7 \quad P &= MV = 85,000 - 10,000(1) = \$75,000 \\ AOC &= \$36,500 + 1,500k \quad (k = 1 \text{ to } 5) \\ n &= 5 \text{ years} \\ S &= 85,000 - 10,000(6) = \$25,000 \end{aligned}$$

11.8 Set up AW equations for 1 through 5 years and solve by hand.

$$\begin{aligned} \text{For } n=1: \text{ Total } AW_1 &= -70,000(A/P, 10\%, 1) - 20,000 + 10,000(A/F, 10\%, 1) \\ &= -70,000(1.10) - 20,000 + 10,000(1.0) \\ &= \$-87,000 \end{aligned}$$

$$\begin{aligned} \text{For } n=2: \text{ Total } AW_2 &= -70,000(A/P, 10\%, 2) - 20,000 + 10,000(A/F, 10\%, 2) \\ &= \$-55,571 \end{aligned}$$

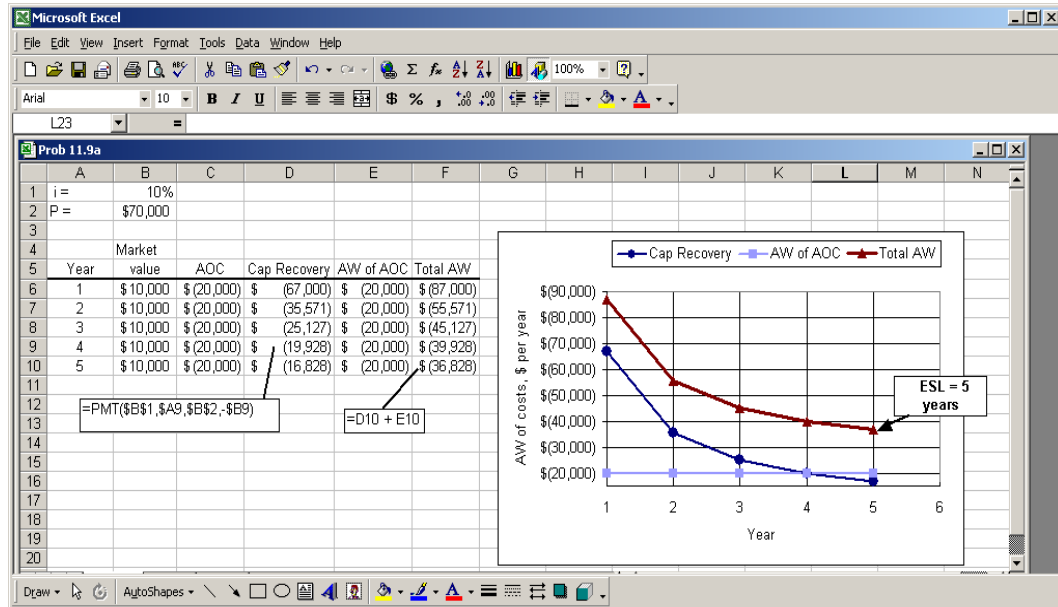
$$\text{For } n=3: \text{ Total } AW_3 = \$-45,127$$

$$\text{For } n=4: \text{ Total } AW_4 = \$-39,928$$

$$\text{For } n=5: \text{ Total } AW_5 = \$-36,828$$

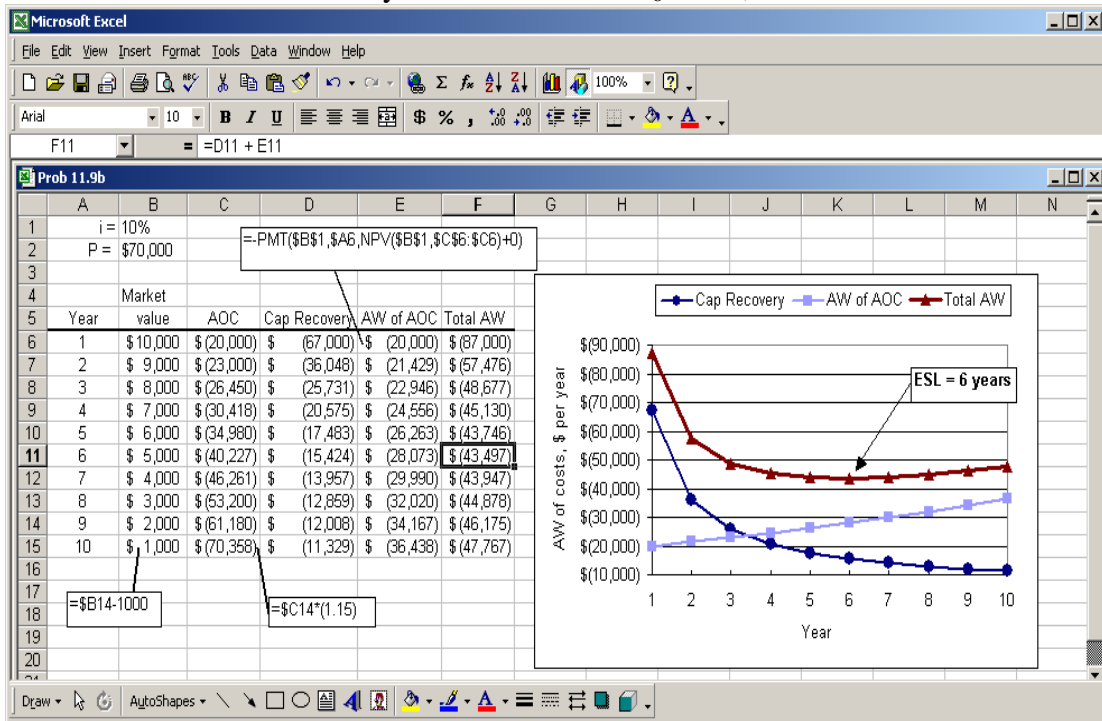
Economic service life is 5 years with Total $AW_5 = \$-36,828$

- 11.9 (a) Set up the spreadsheet using Figure 11-2 as a template and develop the cell formulas indicated in Figure 11-2 (a). The ESL is 5 years, as in Problem 11.8.



- (b) On the same spreadsheet, decrease salvage by \$1000 each year, and increase AOC by 15% per year. Extend the years to 10. The ESL is relatively insensitive between years 5 and 7, but the conclusion is:

ESL = 6 years with Total $AW_6 = \$43,497$



11.10 (a) Set up AW relations for each year.

$$\text{For } n = 1: AW_1 = -250,000(A/P, 4\%, 1) - 25,000 + 225,000(A/F, 4\%, 1) \\ = \$-60,000$$

$$\text{For } n = 2: AW_2 = -250,000(A/P, 4\%, 2) - 25,000 + 200,000(A/F, 4\%, 2) \\ = \$-59,510$$

$$\text{For } n = 3: AW_3 = -250,000(A/P, 4\%, 3) - 25,000 + 175,000(A/F, 4\%, 3) \\ = \$-59,029$$

$$\text{For } n = 4: AW_4 = -250,000(A/P, 4\%, 4) - 25,000 + 150,000(A/F, 4\%, 4) \\ = \$-58,549$$

$$\text{For } n = 5: AW_5 = -250,000(A/P, 4\%, 5) - 25,000 + 125,000(A/F, 4\%, 5) \\ = \$-58,079$$

$$\text{For } n = 6: AW_6 = -250,000(A/P, 4\%, 6) - [25,000(P/A, 4\%, 5) + \\ 25,000(1.25)(P/F, 4\%, 6)](A/P, 4\%, 6) + 100,000(A/F, 4\%, 6) \\ = \$-58,556$$

AW values will increase, so ESL = 5 years with $AW_5 = \$-58,079$.

No, the ESL is not sensitive since AW values are within a percent or two of each other for values of n close to the ESL.

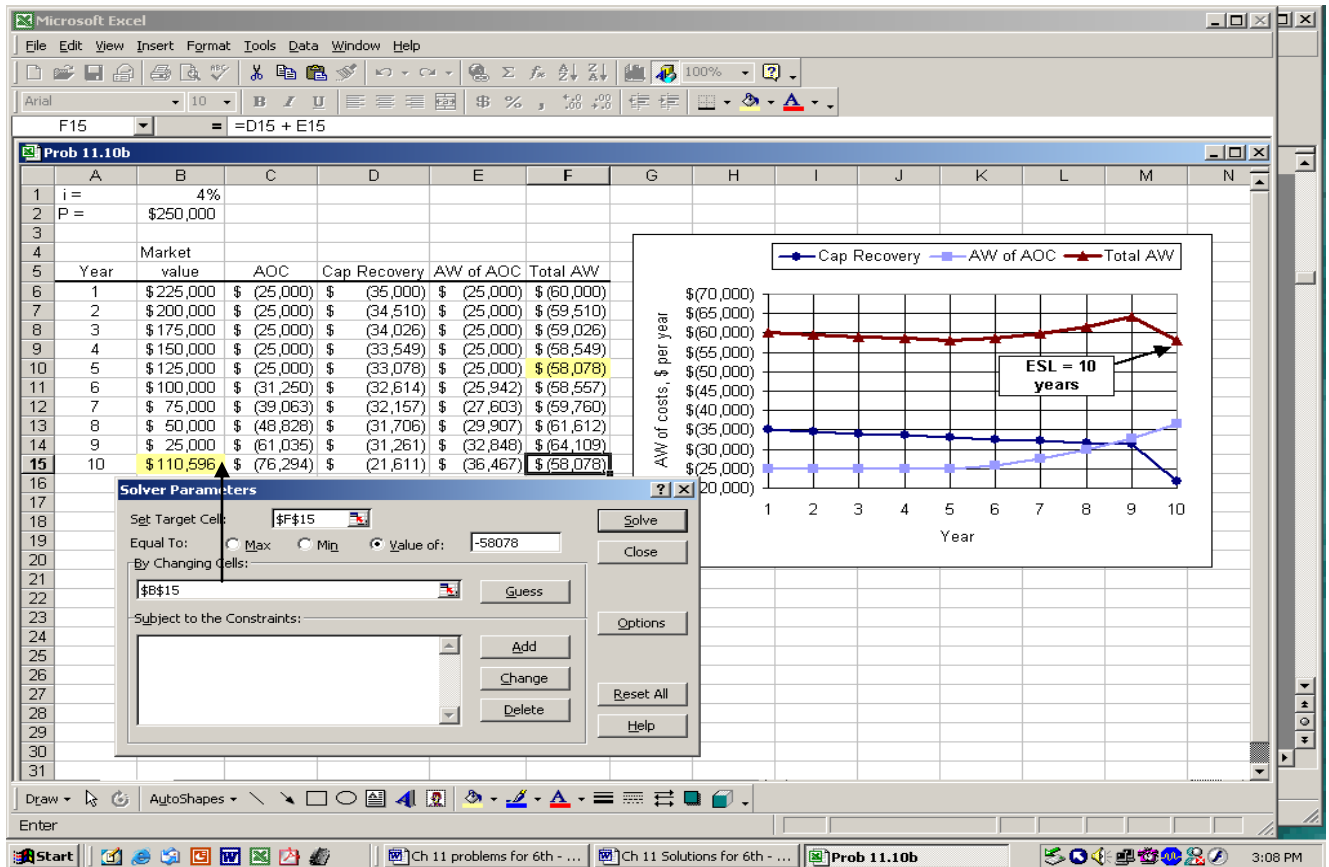
(b) For hand solution, set up the AW_{10} relation equal to $AW_5 = \$-58,079$ and an unknown MV_{10} value. The solution is $MV_{10} = \$110,596$.

$$AW_{10} = -250,000(A/P, 4\%, 10) - [25,000(P/A, 4\%, 5) + 31,250(P/F, 4\%, 6) + \dots \\ + 76,294(P/F, 3\%, 10)](A/P, 4\%, 10) + MV_{10}(A/P, 4\%, 10) \\ = \$-58,079$$

A fast solution is also to set up a spreadsheet and use SOLVER to find MV_{10} with $AW_{10} = AW_5 = \$-58,079$. Currently, $AW_{10} = \$-67,290$. The spreadsheet below shows the setup and chart. Target cell is F15 and changing cell is B15. Result is

Market value in year 10 must be at least \$110,596 to obtain $ESL = 10$ years.

11.10 (cont)



- 11.11 (a) Set up AW equations for years 1 to 6 and solve by hand (or PMT function for spreadsheet solution) with $P = \$100,000$. Use the A/G factor for the gradient in the AOC series.

$$\text{For } n = 1: AW_1 = -100,000(A/P, 18\%, 1) - 75,000 + 100,000(0.85)^1(A/F, 18\%, 1) \\ = \$ -108,000$$

$$\text{For } n = 2: AW_2 = -100,000(A/P, 18\%, 2) - 75,000 - 10,000(A/G, 18\%, 2) \\ + 100,000(0.85)^2(A/F, 18\%, 2) \\ = \$ -110,316$$

$$\text{For } n = 3: AW_3 = -100,000(A/P, 18\%, 3) - 75,000 - 10,000(A/G, 18\%, 3) \\ + 100,000(0.85)^3(A/F, 18\%, 3) \\ = \$ -112,703$$

$$\text{For } n = 4: AW_4 = \$ -115,112$$

$$\text{For } n = 5: AW_5 = \$ -117,504$$

$$\text{For } n = 6: AW_6 = -100,000(A/P, 18\%, 6) - 75,000 - 10,000(A/G, 18\%, 6) \\ + 100,000(0.85)^6(A/F, 18\%, 6) \\ = \$ -119,849$$

ESL is 1 year with $AW_1 = \$-108,000$.

- (b) Set the AW relation for year 6 equal to $AW_1 = \$-108,000$ and solve for P, the required lower first cost.

$$AW_6 = -108,000 = -P(A/P, 18\%, 6) - 75,000 - 10,000(A/G, 18\%, 6) \\ + P(0.85)^6(A/F, 18\%, 6)$$

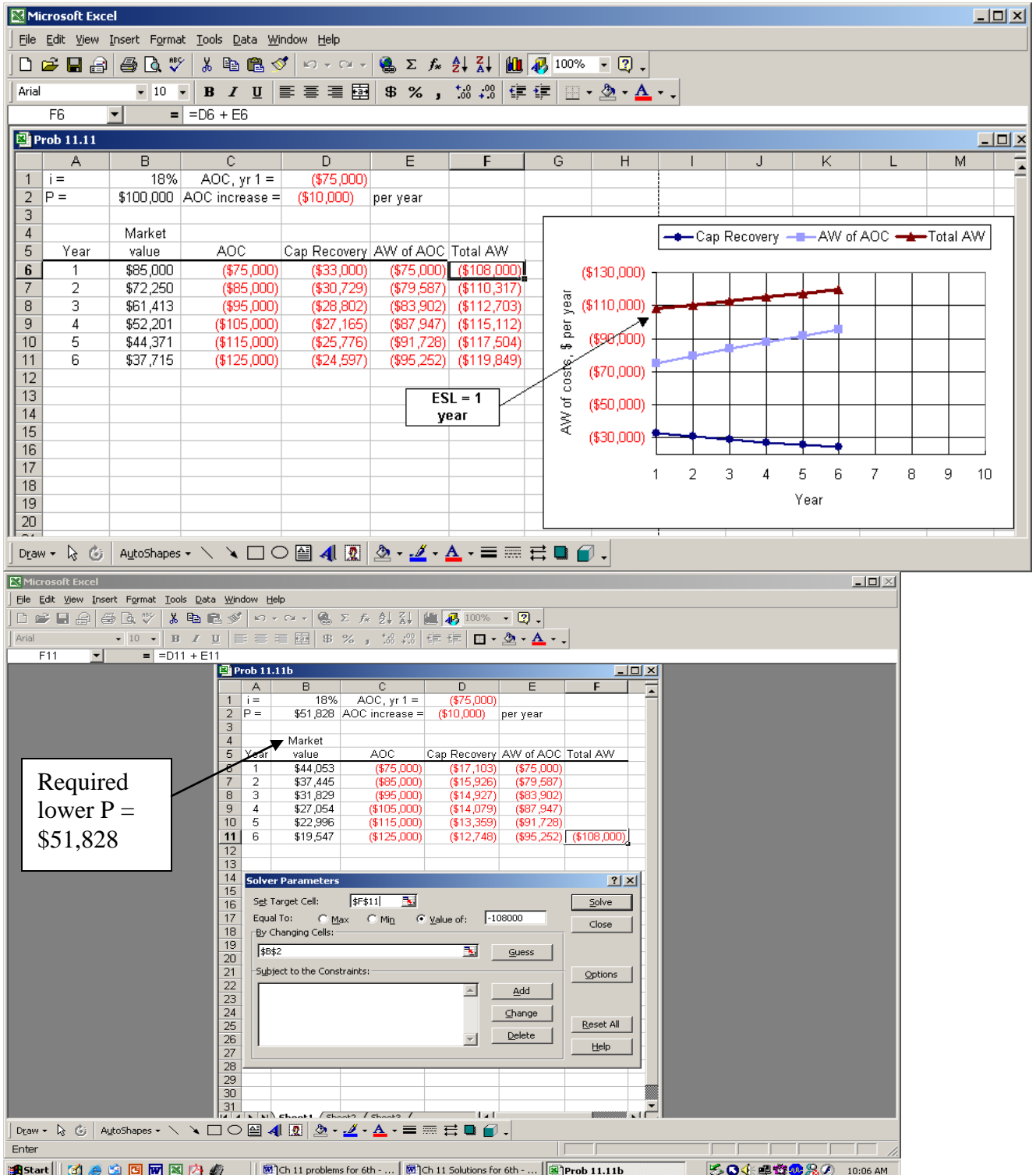
$$-108,000 = -P(0.28591) - 75,000 - 10,000(2.0252) + P(0.37715)(0.10591)$$

$$0.24597P = -95,252 + 108,000$$

$$P = \$51,828$$

The first cost would have to be reduced from \$100,000 to \$51,828. This is a quite large reduction.

11.11 (cont) (a) and (b) Spreadsheets are shown below for (a) $ESL = 1$ year and $AW_1 = \$-108,000$, and (b) using SOLVER to find $P = \$51,828$.



11.12 (a) Develop the cell relation for AW using the PMT function for the capital recovery component and AOC component. A general template may be:

	A	B	C	D
1	i =			
2				
3		Market		
4	Year	Value	AOC	AW value Excel function
5	0			=PMT(\$B\$1,\$A6,\$B\$5,-\$B6)+PMT(\$B\$1,\$A6,-NPV(\$B\$1,\$C\$6:\$C6))
6	1			=PMT(\$B\$1,\$A7,\$B\$5,-\$B7)+PMT(\$B\$1,\$A7,-NPV(\$B\$1,\$C\$6:\$C7))
7	2			=PMT(\$B\$1,\$A8,\$B\$5,-\$B8)+PMT(\$B\$1,\$A8,-NPV(\$B\$1,\$C\$6:\$C8))
8	3			=PMT(\$B\$1,\$A9,\$B\$5,-\$B9)+PMT(\$B\$1,\$A9,-NPV(\$B\$1,\$C\$6:\$C9))
9	4			=PMT(\$B\$1,\$A10,\$B\$5,-\$B10)+PMT(\$B\$1,\$A10,-NPV(\$B\$1,\$C\$6:\$C10))
10	5			=PMT(\$B\$1,\$A11,\$B\$5,-\$B11)+PMT(\$B\$1,\$A11,-NPV(\$B\$1,\$C\$6:\$C11))
11	6			=PMT(\$B\$1,\$A12,\$B\$5,-\$B12)+PMT(\$B\$1,\$A12,-NPV(\$B\$1,\$C\$6:\$C12))
12	7			=PMT(\$B\$1,\$A13,\$B\$5,-\$B13)+PMT(\$B\$1,\$A13,-NPV(\$B\$1,\$C\$6:\$C13))
13	8			=PMT(\$B\$1,\$A14,\$B\$5,-\$B14)+PMT(\$B\$1,\$A14,-NPV(\$B\$1,\$C\$6:\$C14))
14	9			=PMT(\$B\$1,\$A15,\$B\$5,-\$B15)+PMT(\$B\$1,\$A15,-NPV(\$B\$1,\$C\$6:\$C15))
15	10			

(b) Insert the MV and AOC series and $i = 10\%$ to obtain the answer $ESL = 2$ years with $AW_2 = \$-84,667$.

	A	B	C	D
1	i =	10%		
2				
3		Market		
4	Year	Value	AOC	AW value
5	0	\$80,000		
6	1	\$60,000	(\$60,000)	(\$88,000)
7	2	\$50,000	(\$65,000)	(\$84,667)
8	3	\$40,000	(\$70,000)	(\$84,767)
9	4	\$30,000	(\$75,000)	(\$85,679)
10	5	\$20,000	(\$80,000)	(\$86,878)
11	6			
12	7			

For hand solution, the AW relation for $n = 2$ years is:

$$AW_2 = \$-80,000(A/P, 10\%, 2) - 60,000 - 5000(A/G, 10\%, 2) + 50,000(A/F, 10\%, 2) = \$-84,667$$

11.13 (a) Solution by hand using regular AW computations.

Year	Salvage Value, \$	AOC, \$
1	100,000	70,000
2	80,000	80,000
3	60,000	90,000
4	40,000	100,000
5	20,000	110,000
6	0	120,000
7	0	130,000

$$AW_1 = -150,000(A/P, 15\%, 1) - 70,000 + 100,000(A/F, 15\%, 1) \\ = \$-142,500$$

$$AW_2 = -150,000(A/P, 15\%, 2) - [70,000 + 100,000(A/G, 15\%, 2)] \\ + 80,000(A/F, 15\%, 2) \\ = \$-129,709$$

$$AW_3 = \$-127,489$$

$$AW_4 = \$-127,792$$

$$AW_5 = \$-129,009$$

$$AW_6 = \$-130,608$$

$$AW_7 = \$-130,552$$

ESL = 3 years with $AW_3 = \$-127,489$.

(b) Spreadsheet below utilizes the annual marginal costs to determine that ESL is 3 years with $AW = \$-127,489$.

Year	Market value	Loss in MV for year	Lost interest MV for year	AOC	MC for year	AW of marginal cost
0	\$150,000					
1	\$100,000	\$ 50,000	\$ 22,500	\$ 70,000	\$142,500	\$ (142,500)
2	\$ 80,000	\$ 20,000	\$ 15,000	\$ 80,000	\$115,000	\$ (129,709)
3	\$ 60,000	\$ 20,000	\$ 12,000	\$ 90,000	\$122,000	\$ (127,489)
4	\$ 40,000	\$ 20,000	\$ 9,000	\$100,000	\$129,000	\$ (127,792)
5	\$ 20,000	\$ 20,000	\$ 6,000	\$110,000	\$136,000	\$ (129,009)
6	\$ -	\$ 20,000	\$ 3,000	\$120,000	\$143,000	\$ (130,607)
7	\$ -	\$ -	\$ -	\$130,000	\$130,000	\$ (130,553)

11.14 Set up AW equations for $n = 1$ through 7 and solve by hand.

$$\text{For } n = 1: AW_1 = -100,000(A/P, 14\%, 1) - 28,000 + 75,000(A/F, 14\%, 1) = \$-67,000$$

$$\text{For } n = 2: AW_2 = -100,000(A/P, 14\%, 2) - [28,000(P/F, 14\%, 1) + 31,000(P/F, 14\%, 2)] (A/P, 14\%, 2) + 60,000(A/F, 14\%, 2) = \$-62,093$$

$$\text{For } n = 3: AW_3 = \$-59,275$$

$$\text{For } n = 4: AW_4 = \$-57,594$$

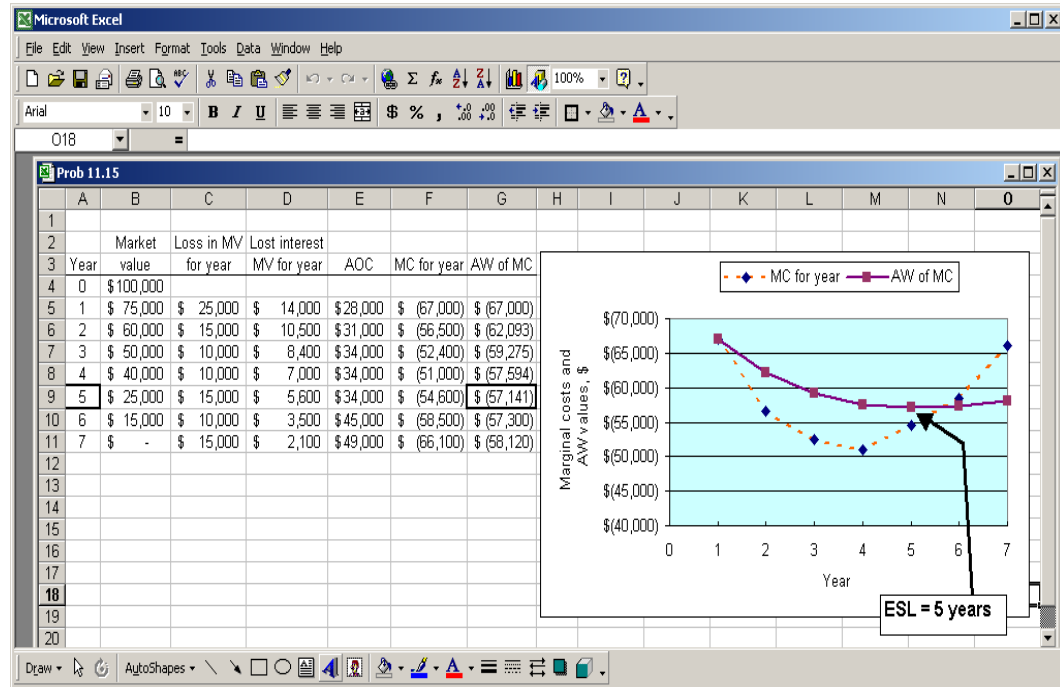
$$\text{For } n = 5: AW_5 = \$-57,141$$

$$\text{For } n = 6: AW_6 = \$-57,300$$

$$\text{For } n = 7: AW_7 = \$-58,120$$

Economic service life is 5 years with $AW = \$-57,141$.

11.15 Spreadsheet and marginal costs used to find the ESL of 5 years with $AW = \$-57,141$.



- 11.16 (a) Year 200X: Select defender for 3 year retention at $AW_D = \$-10,000$
 Year 200X+1: Select defender for 1 year retention at $AW_D = \$-14,000$
 Year 200X+2: Select challenger 2 for 3 year retention at $AW_{C2} = \$-9,000$
- (b) Changes during year 200X+1: Defender estimates changed to reduce ESL and increase AW_D
 Changes during year 200X+2: New challenger C2 has lower AW and shorter ESL than C1.

- 11.17 Defender: ESL = 3 years with $AW_D = \$-47,000$
 Challenger: ESL = 2 years with $AW_C = \$-49,000$

Recommendation now is to retain the defender for 3 years, then replace.

- 11.18 Step 2 is applied (section 11.3, which leads to step 3. Use the estimates to determine the ESL and AW for the new challenger. If defender estimates changed, calculate their new ESL and AW values. Select the better of D or C (step 1).

$$\begin{aligned} 11.19 \quad AW_D &= -(50,000 + 200,000) (A/P, 12\%, 3) + 40,000(A/F, 12\%, 3) \\ &= -250,000(0.41635) + 40,000(0.29635) \\ &= \$-92,234 \end{aligned}$$

$$\begin{aligned} AW_C &= -300,000(A/P, 12\%, 10) + 50,000(A/F, 12\%, 10) \\ &= -300,000(0.17698) + 50,000(0.05698) \\ &= \$-50,245 \end{aligned}$$

Purchase the challenger and plan to keep then for 10 years, unless a better challenger is evaluated in the future.

- 11.20 Set up the spreadsheet and use SOLVER to find the breakeven defender cost of \$149,154. With the appraised market value of \$50,000, the upgrade maximum to select the defender is:

$$\text{Upgrade first cost to break even} = 149,154 - 50,000 = \$99,154$$

This is a maximum; any amount less than \$99,154 will indicate selection of the upgraded current system.

Prob 11.20

	A	B	C	D	E	F	G	H	I	J
1		i = 12%								
2										
3										
4		Defender	Challenger							
5		P and S	P and S							
6	Year	estimates	estimates							
7	0	-\$149,154	-\$300,000							
8	1									
9	2									
10	3	\$40,000								
11	4									
12	5									
13	6									
14	7									
15	8									
16	9									
17	10		\$50,000							
18	AW value	-\$50,246	-\$50,246							

Solver Parameters

Set Target Cell:

Equal To: ☐ Max ☐ Min ☒ Value of:

By Changing Cells:

Subject to the Constraints:

11.21 (a) The n values are set; calculate the AW values directly and select D or C.

$$\begin{aligned}AW_D &= -50,000(A/P, 10\%, 5) - 160,000 \\&= -50,000(0.26380) - 160,000 \\&= \$-173,190\end{aligned}$$

$$\begin{aligned}AW_C &= -700,000(A/P, 10\%, 10) - 150,000 + 50,000(A/F, 10\%, 10) \\&= -700,000(0.16275) - 150,000 + 50,000(0.06275) \\&= \$-260,788\end{aligned}$$

Retain the current bleaching system for 5 more years.

(b) Find the replacement value for the current process.

$$-RV(A/P, 10\%, 5) - 160,000 = AW_C = -260,788$$

$$-0.26380 RV = -100,788$$

$$RV = \$382,060$$

This is 85% of the first cost 7 years ago; way too high for a trade-in value now.

11.22 (a) Find the ESL for a current vehicle. Subscripts are D1 and D2.

$$\begin{aligned}\text{For } n = 1: AW_D &= -(8000 + 50,000)(A/P, 10\%, 1) - 10,000 \\&= -58,000(1.10) - 10,000 \\&= \$-73,800\end{aligned}$$

$$\begin{aligned}\text{For } n = 2: AW_D &= -(8000 + 50,000)(A/P, 10\%, 2) - 10,000 - 5000(A/F, 10\%, 2) \\&= -58,000(0.57619) - 10,000 - 5000(0.47619) \\&= \$-45,800\end{aligned}$$

The defender ESL is 2 years with $AW_D = \$-45,800$.

$$AW_C = \$-55,540$$

Spend the \$50,000 and keep the current vehicles for 2 more years.

(b) Add a salvage value term to $AW_C = \$-55,540$, set equal to AW_D and find S.

$$AW_D = -45,800 = -55,540 + S(A/F, 10\%, 7)$$

$$S = -9740/0.10541 = \$92,401$$

Any $S \geq \$92,401$ will indicate replacement now.

11.23 **Life-based** conclusions with associated AW value (in \$1000 units) based on estimated n value.

Study conducted this many years ago	Alternative selected	
	Defender AW value	Challenger AW value
6		Selected \$-130
4		Selected \$-120
2		Selected \$-130
Now		Selected \$- 80

ESL-based conclusions with associated AW value (in \$1000 units) based on ESL

Study conducted this many years ago	Alternative selected	
	Defender AW value	Challenger AW value
6		Selected \$- 80
4	Selected \$- 80	
2	Selected \$- 80	
Now		Selected \$- 80

The decisions are different in that the defender is selected 4 and 2 years ago. Also, the AW values are significantly lower for the ESL-based analysis. In conclusion, the AW values for the ESLs should have been used to perform all the replacement studies.

11.24 (a) By hand: Find ESL of the defender; compare with AW_C over 5 years.

$$\begin{aligned}\text{For } n = 1: AW_D &= -8000(A/P, 15\%, 1) - 50,000 + 6000(A/F, 15\%, 1) \\ &= -8000(1.15) - 44,000 \\ &= \$-53,200\end{aligned}$$

$$\begin{aligned}\text{For } n = 2: AW_D &= -8000(A/P, 15\%, 2) - 50,000 + (-3000 + 4000)(A/F, 15\%, 2) \\ &= -8000(0.61512) - 50,000 + 1000(0.46512) \\ &= \$-54,456\end{aligned}$$

$$\begin{aligned}\text{For } n = 3: AW_D &= -8000(A/P, 15\%, 3) - [50,000(P/F, 15\%, 1) + \\ &\quad 53,000(P/F, 15\%, 2)](A/P, 15\%, 3) + (-60,000 + \\ &\quad 1000)(A/F, 15\%, 3) \\ &= -8000(0.43798) - [50,000(0.8696) + 53,000(0.7561)] \\ &\quad (0.43798) - 59,000(0.28798) \\ &= \$-57,089\end{aligned}$$

The ESL is now 1 year with $AW_D = \$-53,200$

$$\begin{aligned}AW_C &= -125,000(A/P, 15\%, 5) - 31,000 + 10,000(A/F, 15\%, 5) \\ &= -125,000(0.29832) - 31,000 + 10,000(0.14832) \\ &= \$-66,807\end{aligned}$$

Since the ESL AW value is lower than the challenger AW , Richter should keep the defender now and replace it after 1 year.

11.24 (b) By spreadsheet: In order to obtain the defender ESL of 1 year, first enter market values for each year in column B and AOC estimates in column C. Columns D determines annual CR using the PMT function, and AW of AOC values are calculated in column E using the PMT function with an imbedded NPV function. To make the decision, compare AW values.

$$AW_D = \$-53,200$$

$$AW_C = \$-66,806$$

Select the defender now and replaced after one year.

Defender Analysis

Year	Market value	AOC	Cap Recovery	AW of AOC	Total AW
1	\$ 6,000	\$ (50,000)	\$ (3,200)	\$ (50,000)	(53,200) ESL
2	\$ 4,000	\$ (53,000)	\$ (3,060)	\$ (51,395)	\$ (54,456)
3	\$ 1,000	\$ (60,000)	\$ (3,216)	\$ (53,873)	\$ (57,089)

Challenger Analysis

Year	P and S value	AOC	Cash flow
0	\$ (125,000)		\$ (125,000)
1		\$ (31,000)	\$ (31,000)
2		\$ (31,000)	\$ (31,000)
3		\$ (31,000)	\$ (31,000)
4		\$ (31,000)	\$ (31,000)
5	\$ 10,000	\$ (31,000)	\$ (21,000)

AW of C: (\$66,806)

11.25 The opportunity cost refers to the recognition that the trade in value of the defender is foregone when this asset is retained in a replacement study.

11.26 The cash flow approach will only yield the proper decision when the defender and challenger have the same lives. Also, the cash flow approach does not properly reflect the amount needed to recover the initial investment, because the value used for the first cost of the challenger, $P_C = \text{first cost} - \text{market value of defender}$, is lower than it should be from a capital recovery perspective.

11.27 (a) By hand: Find the replacement value (RV) for the in-place system.

$$-RV(A/P, 12\%, 7) - 75,000 + 50,000(A/F, 12\%, 7) = -400,000(A/P, 12\%, 12) - 50,000 + 35,000(A/F, 12\%, 12)$$

$$-RV(0.21912) - 75,000 + 50,000(0.09912) = -400,000(0.16144) - 50,000 + 35,000(0.04144)$$

$$\begin{aligned} -0.21912 \text{ RV} - 75,000 + 50,000(0.09912) &= -113,126 \\ -0.21912 \text{ RV} &= -43,082 \\ \text{RV} &= \$196,612 \end{aligned}$$

(b) By hand: Solve the AW_D relation for different n values until it equals $AW_C = -\$113,126$

$$\text{For } n = 3: -150,000(A/P, 12\%, 3) - 75,000 + 50,000(A/F, 12\%, 3) = -\$122,635$$

$$\text{For } n = 4: -150,000(A/P, 12\%, 4) - 75,000 + 50,000(A/F, 12\%, 4) = -\$113,923$$

$$\text{For } n = 5: -150,000(A/P, 12\%, 5) - 75,000 + 50,000(A/F, 12\%, 5) = -\$108,741$$

Retain the defender just over 4 years.

By spreadsheet: One approach is to set up the defender cash flows for increasing n values and use the PMT function to find AW . Just over 4 years will give the same AW values.

Prob 11.27						
	A	B	C	D	E	F
1	i = 12%					
2		Challenger	Defender cash flows if retained n years			
3	Year	Cash flow	n = 3 years	n = 4 years	n = 5 years	n = 6 years
4	0	\$ (400,000)	\$ (150,000)	\$ (150,000)	\$ (150,000)	\$ (150,000)
5	1	\$ (50,000)	\$ (75,000)	\$ (75,000)	\$ (75,000)	\$ (75,000)
6	2	\$ (50,000)	\$ (75,000)	\$ (75,000)	\$ (75,000)	\$ (75,000)
7	3	\$ (50,000)	\$ (25,000)	\$ (75,000)	\$ (75,000)	\$ (75,000)
8	4	\$ (50,000)		\$ (25,000)	\$ (75,000)	\$ (75,000)
9	5	\$ (50,000)			\$ (25,000)	\$ (75,000)
10	6	\$ (50,000)				\$ (25,000)
11	7	\$ (50,000)				
12	8	\$ (50,000)				
13	9	\$ (50,000)				
14	10	\$ (50,000)				
15	11	\$ (50,000)				
16	12	\$ (15,000)				
17	AW value	(113,124)	(122,635)	(113,923)	(108,741)	(105,323)

- 11.28 Determine ESL of defender and challenger and then decide how long to keep defender.

Defender ESL analysis for 1, 2 and 3 years:

$$\begin{aligned}\text{For } n = 1: AW_D &= -20,000(A/P, 15\%, 1) - 50,000 + 10,000 \\ &= -20,000(1.15) - 40,000 \\ &= \$-63,000\end{aligned}$$

$$\begin{aligned}\text{For } n = 2: AW_D &= -20,000(A/P, 15\%, 2) - 50,000 - 10,000(A/G, 15\%, 2) \\ &\quad + 6000(A/F, 15\%, 2) \\ &= -20,000(0.61512) - 50,000 - 10,000(0.4651) + 6,000(0.46512) \\ &= \$-64,163\end{aligned}$$

$$\begin{aligned}\text{For } n = 3: AW_D &= -20,000(A/P, 15\%, 3) - 50,000 - 10,000(A/G, 15\%, 3) \\ &\quad + 2000(A/F, 15\%, 3) \\ &= -20,000(0.43798) - 50,000 - 10,000(0.9071) + 2,000(0.28798) \\ &= \$-67,255\end{aligned}$$

Defender ESL is 1 year with $AW_D = \$-63,000$

Challenger ESL analysis for 1 through 6 years:

$$\begin{aligned}\text{For } n = 1: AW_C &= -150,000(A/P, 15\%, 1) - 10,000 + 65,000 \\ &= -150,000(1.15) + 55,000 \\ &= \$-117,500\end{aligned}$$

$$\begin{aligned}\text{For } n = 2: AW_C &= -150,000(A/P, 15\%, 2) - 10,000 - 4,000(A/G, 15\%, 2) \\ &\quad + 45,000(A/F, 15\%, 2) \\ &= \$-83,198\end{aligned}$$

$$\begin{aligned}\text{For } n = 3: AW_C &= -150,000(A/P, 15\%, 3) - 10,000 - 4,000(A/G, 15\%, 3) \\ &\quad + 25,000(A/F, 15\%, 3) \\ &= \$-72,126\end{aligned}$$

$$\begin{aligned}\text{For } n = 4: AW_C &= -150,000(A/P, 15\%, 4) - 10,000 - 4,000(A/G, 15\%, 4) \\ &\quad + 5,000(A/F, 15\%, 4) \\ &= \$-66,844\end{aligned}$$

$$\begin{aligned}\text{For } n = 5: AW_C &= -[150,000 + 10,000(P/A, 15\%, 5) + 4,000(P/G, 15\%, 5) \\ &\quad + 40,000(P/F, 15\%, 5)](A/P, 15\%, 5) \\ &= \$-67,573\end{aligned}$$

$$\begin{aligned}\text{For } n = 6: AW_C &= -[150,000 + 10,000(P/A, 15\%, 6) + 4,000(P/G, 15\%, 6) \\ &\quad + 40,000[(P/F, 15\%, 5) + (P/F, 15\%, 6)](A/P, 15\%, 6) \\ &= \$-67,849\end{aligned}$$

11.28 (cont)

Challenger ESL is 4 years with $AW_C = \$-66,844$

Conclusion: Keep the defender 1 more year at $AW_D = \$-63,000$, then replace for 4 years at $AW_C = \$-66,844$, provided there are no changes in the challenger's estimates during the year the defender is retained.

- 11.29 (a) Set up a spreadsheet (like that in Example 11.2) to find both ESL and their AW values.

Microsoft Excel

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Arial 10 B I

F18 =D18 + E18

Prob 11.29a

	A	B	C	D	E	F	G
1	i = 15%						
2	P = \$20,000						
3							
4		Market					
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW	
6	1	\$ 10,000	\$ (50,000)	\$ (13,000)	\$ (50,000)	(63,000)	ESL
7	2	\$ 6,000	\$ (60,000)	\$ (9,512)	\$ (54,651)	\$ (64,163)	
8	3	\$ 2,000	\$ (70,000)	\$ (8,184)	\$ (59,071)	\$ (67,255)	
9							
10							
11	P = \$ 150,000						
12	Market		AOC +				
13	Year	value	Rework	Cap Recovery	AW of AOC	Total AW	
14	1	\$ 65,000	\$ (10,000)	\$ (107,500)	\$ (10,000)	(117,500)	
15	2	\$ 45,000	\$ (14,000)	\$ (71,337)	\$ (11,860)	(83,198)	
16	3	\$ 25,000	\$ (18,000)	\$ (58,497)	\$ (13,629)	(72,126)	
17	4	\$ 5,000	\$ (22,000)	\$ (51,538)	\$ (15,305)	(66,844)	ESL
18	5	\$ -	\$ (66,000)	\$ (44,747)	\$ (22,824)	(67,571)	
19	6	\$ -	\$ (70,000)	\$ (39,636)	\$ (28,213)	(67,849)	
20							

Draw AutoShapes

- 11.29 (cont) (b) Develop separate columns for AOC and rework costs of \$40,000 in years 5 and 6. Use SOLVER to force AW_C to equal \$-63,000 in year 6 (target cell is H19). Rework cost allowed is \$20,259 (changing cell is D18), which is about half of the projected \$40,000 estimate.

Impact: For all values of rework less than \$20,259, the replacement study will indicate selection of the challenger for the next 6 years and disposal of the defender this year.

Defender Analysis

Year	Market value	AOC	Capital Recovery	AW of AOC	Total AW
1	\$ 10,000	\$ (50,000)	\$ (13,000)	\$ (50,000)	(63,000)
2	\$ 6,000	\$ (60,000)	\$ (9,512)	\$ (54,651)	(64,163)
3	\$ 2,000	\$ (70,000)	\$ (8,184)	\$ (59,071)	(67,255)

Challenger Analysis

Year	Market value	AOC	Rework	Capital Recovery	Rework	AW of AOC	Total AW
1	\$ 65,000	\$ (10,000)	\$ -	\$ (107,500)	\$ -	\$ (10,000)	(117,500)
2	\$ 45,000	\$ (14,000)	\$ -	\$ (71,337)	\$ -	\$ (11,860)	(83,198)
3	\$ 25,000	\$ (18,000)	\$ -	\$ (58,487)	\$ -	\$ (13,629)	(72,126)
4	\$ 5,000	\$ (22,000)	\$ -	\$ (51,538)	\$ -	\$ (15,305)	(66,844)
5	\$ -	\$ (26,000)	\$ (20,259)	\$ (44,747)	\$ (3,005)	\$ (16,891)	(64,643)
6	\$ -	\$ (30,000)	\$ (20,259)	\$ (39,636)	\$ (4,976)	\$ (18,389)	(63,000)

Solver Parameters

Set Target Cell: $H\$19$

Equal To: ☐ Max ☐ Min ☒ Value of: -63000

By Changing Cells: $D\$18$

Subject to the Constraints:

Buttons: Add, Change, Delete, Guess

- 11.30 (a) If no study period is specified, the three replacement study assumptions in Section 11.1 hold. So, the services of the defender and challenger can be obtained (it is assumed) at their AW values. When a study period is specified these assumptions are not made and repeatability of either D or C alternatives is not a consideration.
- (b) If a study period is specified, all viable options must be evaluated. Without a study period, the ESL analysis or the AW values at set n values determine the AW values for D and C. Selection of the best option concludes the study.

- 11.31 (a) Develop the options first. Challenger can be purchased for up to 6 years. The defender can be retained for 0 through 3 years only. For 5 years the four options are:

Options	Defender	Challenger
A	0 years	5 years
B	1	4
C	2	3
D	3	2

Defender and challenger AW values (as taken from Problem 11.28 or 11.29(a) spreadsheet).

Years in service	Defender AW value	Challenger AW value
1	\$-63,000	\$-117,500
2	-64,163	-83,198
3	-67,255	-72,126
4	-	-66,844
5	-	-67,571

Determine the equivalent cash flows for 5 years for each option and calculate PW values.

Option	Years in service		Equivalent Cash Flow, AW \$ per year					PW, \$
	D	C	1	2	3	4	5	
A	0	5	-67,571	-67,571	-67,571	-67,571	-67,571	-226,508
B	1	4	-63,000	-66,844	-66,844	-66,844	-66,844	-220,729
C	2	3	-64,163	-64,163	-72,126	-72,126	-72,126	-228,832
D	3	2	-67,255	-67,255	-67,255	-83,198	-83,198	-242,491

Select option B (smaller PW of costs); retain defender for 1 year then replace with the challenger for 4 years.

- (b) There are four options since the defender can be retained up to three years.

Options	Defender	Challenger Contract
E	0 years	5 years
F	1	4
G	2	3
H	3	2

Determine the equivalent cash flows for 5 years for each option and calculate PW values

Option	Years		Equivalent Cash Flow, AW \$ per year					PW, \$
	D	C	1	2	3	4	5	
A	0	5	-85,000	- 85,000	- 85,000	- 85,000	- 85,000	-284,933
B	1	4	-63,000	- 85,000	- 85,000	- 85,000	- 85,000	-265,803
C	2	3	-64,163	- 64,163	-100,000	-100,000	-100,000	-276,955
D	3	2	-67,255	- 67,255	- 67,255	-100,000	-100,000	-260,451

Select option D (smaller PW of costs); retain defender for 3 years then replace with the full-service contract for 2 years.

- 11.32 Study period is 3 years. Three options are viable: defender for 2 more years, challenger for 1; defender 1 year, challenger for 2 years; and, challenger for 3 years. Find the AW values and select the best option.

1. Defender 2 years, challenger 1 year:

$$AW = -200,000 - (300,000 - 200,000)(A/F, 18\%, 3)$$

$$= -200,000 - 100,000 (0.27992)$$

$$= \$-227,992$$

2. Defender 1 year, challenger 2 years

$$AW = [-200,000(P/F, 18\%, 1) + 225,000(P/A, 18\%, 2)(P/F, 18\%, 1)](A/P, 18\%, 3)$$

$$=[-200,000(0.8475) + 225,000(1.5656)(0.8475)](0.45992)$$

$$= \$-215,261$$

3. Challenger for 3 years

$$AW = \$-275,000$$

Decision: Replace the defender after 1 year.

11.33 (a)	Option	Defender	Challenger
	1	0	5
	2	0	6
	3	0	7
	4	0	8
	5	3	2
	6	3	3
	7	3	4
	8	3	5

Prob 11.33													
i = 10%													
			Cash flow for different study period lengths, \$ per year										
	Option	D	C	1	2	3	4	5	6	7	8	PW	AW
4	1	0	5	-90,000	-90,000	-90,000	-90,000	-90,000				(\$341,171)	(\$90,000)
5	2	0	6	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000			(\$479,079)	(\$110,000)
6	3	0	7	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000		(\$535,526)	(\$110,000)
7	4	0	8	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000	-110,000	(\$586,842)	(\$110,000)
8	5	3	2	-90,000	-90,000	-90,000	-90,000	-90,000				(\$341,171)	(\$90,000)
9	6	3	3	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000			(\$391,973)	(\$90,000)
10	7	3	4	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000		(\$438,158)	(\$90,000)
11	8	3	5	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	(\$480,143)	(\$90,000)
12													
13													
14													

Formula bar: `=PMT(B1,$B11+$C11,L11)`

A total of 5 options have $AW = \$-90,000$. Several ways to go; defender can be replaced now or after 3 years and challenger can be used from 2 to 5 years, depending on the option chosen.

- (b) PW values cannot be used to select best options since the equal-service assumption is violated due to study periods of different lengths. Must use AW values.

- 11.34 (a) There are 6 options. Spreadsheet shows the AW of the current system (defender, D) for its retention period with close-down cost in last year followed by annual contract cost for years in effect. The most economic is:

Select option 5; retain current system for 4 years; purchase contract for the 5th year only at \$5,500,000, assuming the contract cost remains as quoted now. Estimated AW = \$-3.61 million per year

	A	B	C	D	E	F	G	H	I	J	K	L
1	i = 8%											(b)
2	Cash flow for different study period lengths, \$ per year											% change
3	Option	D	C	0	1	2	3	4	5	PW	AW	in AW
4	1	0	5	-3,000	-5,000	-5,000	-5,000	-5,000	-5,000	(\$22,964)	(\$5,751)	-
5	2	1	4	-	-4,800	-5,000	-5,000	-5,000	-5,000	(\$19,778)	(\$4,954)	-13.9%
6	3	2	3	-	-2,300	-4,300	-5500	-5500	-5500	(\$17,968)	(\$4,500)	-9.2%
7	4	3	2	-	-3,000	-3,000	-4,000	-5500	-5500	(\$16,311)	(\$4,085)	-9.2%
8	5	4	1	-	-3,000	-3,000	-3,000	-4,000	-5500	(\$14,415)	(\$3,610)	-11.6%
9	6	5	0	-	-3,700	-3,700	-3,700	-3,700	-4,200	(\$15,113)	(\$3,785)	4.8%
10												
11					Includes close-down expense					=-3700-500	=PMT(\$B\$1,5,J9)	
12												

- (b) Percentage change (column L) is negative for increasing years of defender retention until 5 years, where percentage turns positive (cell L9).

If option 6 is selected over the better option 5, the economic disadvantage is
 $3,785,000 - 3,610,000 = \$175,000$ equivalent per year for the 5 years.

- 11.35 There are only two options: defender for 3, challenger for 2 years; defender for 0, challenger for 5. Defender has a market value of \$40,000 now

Defender

$$\begin{aligned}
 \text{For } n = 3: \text{AW}_D &= -(70,000 + 40,000)(A/P, 20\%, 3) - 85,000 \\
 &= -110,000(0.47473) - 85,000 \\
 &= \$-137,220
 \end{aligned}$$

Challenger

$$\begin{aligned}\text{For } n = 2: AW_C &= -220,000(A/P, 20\%, 2) - 65,000 + 50,000(A/F, 20\%, 2) \\ &= -220,000(0.65455) - 65,000 + 50,000(0.45455) \\ &= \$-186,274\end{aligned}$$

$$\text{For } n = 3: AW_C = \$-155,703$$

$$\text{For } n = 4: AW_C = \$-140,669$$

$$\begin{aligned}\text{For } n = 5: AW_C &= -220,000(A/P, 20\%, 5) - 65,000 + 50,000(A/F, 20\%, 5) \\ &= -220,000(0.33438) - 65,000 + 50,000(0.13438) \\ &= \$-131,845\end{aligned}$$

The challenger $AW = \$-131,845$ for 5 years of service is lower than that of the defender. By inspection, the defender should be replaced now. The AW for each option can be calculated to confirm this.

Option 1: defender 3 years, challenger 2 years

$$\begin{aligned}AW &= [-137,220(P/A, 20\%, 3) - 186,274(P/A, 20\%, 2)(P/F, 20\%, 3)](A/P, 20\%, 5) \\ &= \$-151,726\end{aligned}$$

Option 2: defender replaced now, challenger for 5 years

$$AW = \$-131,845$$

Again, replace the defender with the challenger now.

FE Review Solutions

11.36 Answer is (a)

11.37 Answer is (d)

11.38 Answer is (c)

11.39 Answer is (c)

11.40 Answer is (b)

Extended Exercise Solution

The three spreadsheets below answer the three questions.

1. The ESL is 13 years.

Microsoft Excel - C11- ext exer soln

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A22 =

	A	B	C	D	E	F	G	H	I	J	K
1	Ext Exercise Solution - #1. Find the ESL										
2									Operating	Cumulative	
3								Year	hours	hours	
4		First cost &		Capital	AW of AOC	Total		1	500	500	
5	Year	rebuild cost	AOC	recovery	and rebuild	AW		2	1500	2000	
6	0	\$ (800,000)						3	2000	4000	
7	1	\$ -	\$ (25,000)	\$ (880,000)	\$ (25,000)	\$ (905,000)		4	2000	6000	Rebuild
8	2	\$ -	\$ (25,000)	\$ (460,952)	\$ (25,000)	\$ (485,952)		5	2000	8000	
9	3	\$ -	\$ (25,000)	\$ (321,692)	\$ (25,000)	\$ (346,692)		6	2000	10000	
10	4	\$ (150,000)	\$ (25,000)	\$ (252,377)	\$ (57,321)	\$ (309,697)		7	2000	12000	Rebuild
11	5	\$ -	\$ (40,000)	\$ (211,038)	\$ (54,484)	\$ (265,522)		8	2000	14000	
12	6	\$ -	\$ (46,000)	\$ (183,686)	\$ (53,384)	\$ (237,070)		9	2000	16000	
13	7	\$ (180,000)	\$ (52,900)	\$ (164,324)	\$ (72,306)	\$ (236,630)		10	2000	18000	Rebuild
14	8	\$ -	\$ (60,835)	\$ (149,955)	\$ (71,303)	\$ (221,258)		11	2000	20000	
15	9	\$ -	\$ (69,960)	\$ (138,912)	\$ (71,204)	\$ (210,116)		12	2000	22000	
16	10	\$ (216,000)	\$ (80,454)	\$ (130,196)	\$ (85,337)	\$ (215,534)		13	2000	24000	Replace
17	11	\$ -	\$ (92,522)	\$ (123,171)	\$ (85,725)	\$ (208,896)					
18	12	\$ -	\$ (106,401)	\$ (117,411)	\$ (86,692)	\$ (204,103)					
19	13	\$ -	\$ (122,361)	\$ (112,623)	\$ (88,147)	\$ (200,769)	ESL				
20											
21	Answer: ESL is 13 years with AW = \$-200,769										
22											

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Draw AutoShapes

Ready

2. Required MV = \$1,420,983 found using SOLVER with F12 the target cell and B12 the changing cell.

Microsoft Excel - C11- ext exer soln

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10 B I

A24 =

	A	B	C	D	E	F	G	H	I	J	K	L
1	Ext Exercise Solution #2. Find required market value at end of year 6 to make ESL be n = 6 years											
2									Operating	Cumulative		
3								Year	hours	hours		
4		First cost &		Capital	AW of AOC	Total		1	500	500		
5	Year	rebuild cost	AOC	recovery	and rebuild	AW		2	1500	2000		
6	0	\$ (800,000)						3	2000	4000		
7	1	\$ -	\$ (25,000)	\$ (880,000)	\$ (25,000)	\$ (905,000)		4	2000	6000	Rebuild	
8	2	\$ -	\$ (25,000)	\$ (460,952)	\$ (25,000)	\$ (485,952)		5	2000	8000		
9	3	\$ -	\$ (25,000)	\$ (321,692)	\$ (25,000)	\$ (346,692)		6	2000	10000		
10	4	\$ (150,000)	\$ (25,000)	\$ (252,377)	\$ (57,321)	\$ (309,697)		7	2000	12000	Rebuild	
11	5	\$ -	\$ (40,000)	\$ (211,038)	\$ (54,484)	\$ (265,522)		8	2000	14000		
12	6	\$ 1,420,983	\$ (46,000)	\$ (183,686)	\$ 130,786	\$ (52,900)	ESL	9	2000	16000		
13	7	\$ -	\$ (52,900)	\$ (164,324)	\$ 111,424	\$ (52,900)		10	2000	18000	Rebuild	
14	8	\$ -	\$ (60,835)	\$ (149,955)	\$ 96,361	\$ (53,594)		11	2000	20000		
15	9	\$ -	\$ (69,960)	\$ (138,912)	\$ 84,113	\$ (54,799)		12	2000	22000		
16	10	\$ -	\$ (80,454)	\$ (130,196)	\$ 73,787	\$ (56,409)		13	2000	24000	Replace	
17	11	\$ -	\$ (92,522)	\$ (123,171)	\$ 64,813	\$ (58,358)						
18	12	\$ -	\$ (106,401)	\$ (117,411)	\$ 56,806	\$ (60,604)						
19	13	\$ -	\$ (122,361)	\$ (112,623)	\$ 49,500	\$ (63,123)						
20												
21	Answer: The market value would be extremely high at \$1.42 million to make ESL be 6 years.											
22	This is substantially more than the pump cost new at \$800,000.											
23	SOLVER was used.											
24												

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Draw AutoShapes

Ready NUM

3. SOLVER yields the base AOC = \$-201,983 in year 1 with increases of 15% per year. The rebuild cost in year 4 (after 6000 hours) is \$150,000. Also this AOC series is huge compared to the estimated AOC of \$25,000 (years 1 – 4).

Microsoft Excel - C11- ext exer soln

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A21 =

	A	B	C	D	E	F	G	H	I	J	K
1	Ext Exercise #3. Find the base AOC to make ESL be n = 6 years; no rebuild done										
2									Operating	Cumulative	
3		AOC, \$/year	-\$201,982.83					Year	hours	hours	
4		First cost &		Capital	AW of AOC	Total		1	500	500	
5	Year	rebuild cost	AOC	recovery	and rebuild	AW		2	1500	2000	
6	0	\$ (800,000)						3	2000	4000	
7	1	\$ -	\$ (201,983)	\$ (880,000)	\$ (201,983)	\$ (1,081,983)		4	2000	6000	
8	2	\$ -	\$ (232,280)	\$ (460,952)	\$ (216,410)	\$ (677,363)		5	2000	8000	
9	3	\$ -	\$ (267,122)	\$ (321,692)	\$ (496,520)	\$ (818,212)		6	2000	10000	Sell
10	4	\$ -	\$ (307,191)	\$ (252,377)	\$ (247,990)	\$ (500,367)					
11	5	\$ -	\$ (353,269)	\$ (211,038)	\$ (265,235)	\$ (476,273)					
12	6	\$ -	\$ (406,260)	\$ (183,686)	\$ (283,513)	\$ (467,199)	ESL				
13	7		\$ (467,199)	\$ (164,324)	\$ (302,874)	\$ (467,199)					
14											
15	Answer: This is also not very reasonable. The AOC base in year 1 would have to be very large										
16	at \$201,982 per year to force ESL to be 6 years.										
17											
18											
19											
20											
21											

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Draw AutoShapes

Ready NUM

Neither suggestion in #2 or #3 are good options.

Case Study Solution

1. Plan 1 – Current system augmented with conveyor

$$\begin{aligned}
 AW_{\text{current}} &= -15,000(A/P, 12\%, 7) + 5000(A/F, 12\%, 7) - 180,000(2.4)(0.01) \\
 &= -15,000(0.21912) + 5000(0.09912) - 4320 \\
 &= \$-7111
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{new}} &= -70,000(A/P, 12\%, 10) + 8000(A/F, 12\%, 10) - 240,000(2.4)(0.01) \\
 &= -70,000(0.17698) + 8000(0.05698) - 5760 \\
 &= \$-17,693
 \end{aligned}$$

$$\begin{aligned}\text{Plan 1 AW} &= \text{AW}_{\text{current}} + \text{AW}_{\text{new}} \\ &= \$-24,804\end{aligned}$$

Plan 2 – Conveyor plus old mover

$$\begin{aligned}\text{AW}_{\text{conveyor}} &= -115,000(\text{A/P}, 12\%, 15) - 400,000(0.0075) \\ &= -115,000(0.14682) - 3000 \\ &= \$-19,884\end{aligned}$$

$$\begin{aligned}\text{AW}_{\text{old}} &= -15,000(\text{A/P}, 12\%, 7) + 5000(\text{A/F}, 12\%, 7) - 400,000(0.75)(0.01) \\ &= -15,000(0.21912) + 5000(0.09912) - 3000 \\ &= \$-5791\end{aligned}$$

$$\begin{aligned}\text{Plan 2 AW} &= \text{AW}_{\text{conveyor}} + \text{AW}_{\text{old}} \\ &= \$-25,675\end{aligned}$$

Plan 2 – Conveyor plus new mover

$$\text{AW}_{\text{conveyor}} = \$-19,884$$

$$\begin{aligned}\text{AW}_{\text{new}} &= -40,000(\text{A/P}, 12\%, 12) + 3500(\text{A/F}, 12\%, 12) - 400,000(0.75)(0.01) \\ &= -40,000(0.16144) + 3500(0.04144) - 3000 \\ &= \$-9312\end{aligned}$$

$$\begin{aligned}\text{Plan 3 AW} &= \text{AW}_{\text{conveyor}} + \text{AW}_{\text{new}} \\ &= \$-29,196\end{aligned}$$

Conclusion: Select plan 1 (Current system augmented with conveyor) at \$-24,804.

$$\begin{aligned}2. \text{AW}_{\text{contractor}} &= -21,000 - 380,000(0.01) \\ &= \$-24,800\end{aligned}$$

The AW is just about identical to plan 1 (\$-24,804), so the decision is up to the management of the company.