Chapter 14 Replacement Decisions

Sunk Costs, Opportunity Costs, and Cash Flows

14.1

(a) Purchase cost = $15,000, market value = $6,000, sunk cost = $15,000 - $6,000
= $9,000

(b) opportunity cost = $6,000

(c)

$$PW(15\%) = -\$6,000 - \$1,500 - \$3,000(P/F,15\%,1)$$
$$-(\$3,500 - \$3,000)(P/F,15\%,2)$$
$$= -\$10,486.77$$
$$AEC(15\%) = \$10,486.77(A/P,15\%,2)$$
$$= \boxed{\$6,450.58}$$

(d)

$$PW(15\%) = -\$7,500 - \$3,000(P/F,15\%,1) - \$3,500(P/F,15\%,2)$$
$$-\$3,800(P/F,15\%,3) - \$4,500(P/F,15\%,4)$$
$$-\$9,800(P/F,15\%,5)$$
$$= -\$22,698.98$$
$$AEC(15\%) = \$22,698.98(A/P,15\%,5)$$
$$= \boxed{\$6,771.46}$$

14.2

(a) opportunity cost = $30,000

(b) Assume that the old machine's operating cost is $30,000 per year. Then the new machine's annual operating cost is zero. The cash flows associated with retaining the defender for two more years are

n	0	1	2
Cash Flows:	-$30,000	-$30,000	-$18,000

$$AEC_D = (\$30,000 - \$12,000)(A/P,12\%,2) + \$12,000(0.12)$$
$$+\$30,000$$
$$= \$42,090.57$$

(c) Cash flows for the challenger: Year 0: -$165,000; Years 1-7: $0; Year 8: $5,000

$$AEC_C = (\$165,000 - \$5,000)(A/P,12\%,8) + \$5,000(0.12)$$
$$= \$32,808$$

(d) Since $AEC_D > AEC_C$, we should replace the defender now.

14.3
(a) initial cash outlay for the new machine = $120,000

(b) Cash flows for the defender: Year 0: -$10,000 Years 1-5: 0

(c)
$$AE(15\%)_D = -\$10,000(A/P,15\%,5) = -\$2,983$$
$$AE(15\%)_C = -\left[(\$120,000 - \$30,000)(A/P,15\%,7) + \$30,000(0.15)\right]$$
$$+\$50,000$$
$$= \$23,868$$

We should purchase the new machine because it has a higher annual equivalent cash flow.

14.4
(a) Cash flows

Year:	0	1	2	3	4	5
Defender	-$10K	0	0	0	0	$5K
Challenger	-$75K	$30K	$30K	$30K	$30K	$30K

(b)
$$PW(15\%_D = -\$10K + \$5K(P/F,15\%,5) = -\$7,514$$
$$PW(15\%_C = -\$75K + \$30K(P/A,15\%,6) = \$25,565$$

∴ Should replace the defender

14.5
(a) and (b) Cash flows:

Year:	0	1	2	3	4	5
Defender	-$5,500	$21,000	$21,100	$21,200		
Challenger	-$36,500	$24,000	$24,000	$24,000	$24,000	$30,300

- Revenue for defender = ($19 - $12) × 3,000 = $21,000 per year
- Revenue for challenger = ($19 - $11) × 3,000 = $24,000 per year

(c)

$$AE_D(12\%) = -\left[(\$5,500-\$1,200)(A/P,12\%,3)+\$1,200(0.12)\right]+\$21,000$$
$$= \$19,065.70$$
$$AE_C(12\%) = -\left[(\$36,500-\$6,300)(A/P,12\%,5)+\$6,300(0.12)\right]+\$24,000$$
$$= \$14,866.23$$

Keep the defender for now.

Economic Service Life

14.6
(a) Interest $i = 12\%$ Defender:

Year	OC	MV	AEC_{OC}	CR(12%)	Total AEC(12%)
0		$7,700			
1	$3,200	$4,300	$3,200	$4,324	$7,524
2	$3,700	$3,300	$3,436	$2,999	$6,435
3	$4,800	$1,100	$3,840	$2,880	$6,720
4	$5,850	0	$4,261	$2,535	$6,796

The remaining useful life for the defender is two years with an AEC value of $6,435, i.e., $N_D^* = 2, AEC_D = \$6,435$.

(b) $N_C = 10$ years

$$AEC_C = \$31,000(A/P,12\%,10)+\$1,000-\$2,500(A/F,12\%,10)$$
$$= \$6,344$$

Since $AEC_D > AEC_C$, the defender should be replaced now.

14.7

(a) Economic service life = 4 years:

Year	OR	MV	AE$_{OR}$	CR(12%)	Total AE
0		$8,000			
1	$4,000	$4,200	$4,000	$4,760	-$760
2	$3,400	$2,940	$3,717	$3,347	$370
3	$2,710	$2,058	$3,419	$2,721	$698
4	$1,917	$1,411	$3,104	$2,332	$772
5	$1,004	$1,008	$2,774	$2,061	$713

When $N = 4$, we have the largest AE value (revenue). The economic service life of the system is 4 years. (Note that we want to maximize our operating revenue.)

(b) The economic service life varies with the interest rate:

Interest rate	Economic service life	Maximum annual revenue
1%	3 years	$1,333
5%	4 years	$1,127
10%	4 years	$876
15%	4 years	$613
20%	4 years	$341
25%	5 years	$77
30%	5 years	-$191
40%	6 years	-$710

- The maximum annual revenue at its economic service life varies inversely with the interest rate.
- The economic service life increases as the interest rate increases in our example. As the interest rate increases, the capital cost will also increase. However, the annual equivalent revenue will decrease. Thus, the net effect is that the marginal increase in the capital cost is less than the decrease in the annual equivalent revenue, resulting in extending the service life.

14.8

(a) Interest $i = 10\%$

n	OC	MV	AEC_{OC}	CR(10%)	AEC(10%)
0		$15,000			
1	$2,500	$12,000	$2,500	$4,500	$7,000
2	$3,200	$8,100	$2,833	$4,786	$7,619
3	$5,300	$5,200	$3,579	$4,461	$8,039
4	$6,500	$3,500	$4,208	$3,978	$8,186
5	$7,800	0	$4,796	$3,957	$8,753

(b) Interest $i = 15\%$

n	OC	MV	AEC_{OC}	CR(10%)	AEC(10%)
0		$15,000			
1	$2,500	$12,000	$2,500	$5,250	$7,750
2	$3,200	$8,100	$2,826	$5,459	$8,285
3	$5,300	$5,200	$3,538	$5,072	$8,610
4	$6,500	$3,500	$4,131	$4,553	$8,684
5	$7,800	0	$4,675	$4,475	$9,150

$\therefore$ In both cases, the economic service life is 1 year.

Replacement Decision with an Infinite Planning Horizon and No Technological Change

14.9

With the infinite planning horizon,

$$AEC_D = \$6,000(A/P,8\%,6) + \$2,000 - \$1,500(A/F,8\%,6)$$
$$= \$3,093.42$$
$$AEC_C = \$21,000(A/P,8\%,12) + \$1,000 - \$500(A/F,8\%,12)$$
$$= \$3,760.25$$

Keep the present machine for now. The economic advantage is $666.83 per year ($3,760.25 - $3,093.42).

14.10 (a) and (b)

n	Defender	Challanger
0	-$4,000	-$6,000
1	-$3,000	-$2,000
2	-$4,500	-$3,000
3	-$5,000	-$2,000

$$AEC_C(15\%) = (\$6,000 + \frac{\$1,000}{1.15^2})(A/P,15\%,3) + \$2,000$$
$$= \$4,959.04$$

$$AEC_D(15\%) = (\$4,000 + \frac{\$3,000}{1.15} + \frac{\$4,500}{1.15^2} + \frac{\$5,000}{1.15^3})(A/P,15\%,3)$$
$$= \$5,824.62$$

∴ Now is the time to replace the defender.

14.11

(a) Opportunity cost = $0

(b) The cash flows are:

Year:	0	1	2	3	4	5
Defender	$0	-$3K	-$3K	-$3K	-$3K	-$3K
Challenger	-$10K	0	0	0	0	0
C - D	-$10K	$3K	$3K	$3K	$3K	$3K

(c)
$$PW(i)_{C-D} = -\$10,000 + \$3,000(P/A,i,5) = 0$$

∴ With $i*_{C-D} = 15.24\% > 10\%$, select the challenger.

14.12

(a)
$$AE_D = -\$2,000(A/P,15\%,5) + \$10,000 - \$7,000$$
$$= \$2,403.37$$
$$AE_C = -\$12,000(A/P,15\%,5) + \$11,500 - \$5,000 + \$2,000(A/F,15\%,5)$$
$$= \$3,216.84$$

∴ Yes, the new machine should be purchased now.

(b)

Let

$$-P(A/P,15\%,5) + \$6,500 + \$2,000(A/P,15\%,5) = \$2,403.37$$

We find $P = \$14,727$.

14.13

Assume that the old system has a current market value of P.

$$AEC_D = P(A/P,14\%,5) + \$20,000$$
$$AEC_C = \$200,000(A/P,14\%,10) + \$5,000 - \$18,000(A/F,14\%,10)$$
$$= \$42,412$$

Let $AEC_D = AEC_C$ and solve for P. We find that $P = \$76,942$. If the resale value of the defender is higher than \$76,942, the installation of the system is justified.

14.14

$$AEC(12\%)_D = \$60,000(A/P,12\%,10) + \$18,000$$
$$= \$28,619$$
$$AEC(12\%)_C = (\$200,000 - \$20,000)(A/P,12\%,10) + \$20,000(0.12) + \$14,000$$
$$= \$48,257$$

∴ Since $AEC_D < AEC_C$, do not replace the defender.

14.15

$$AEC_C = \$53,500(A/P,12\%,5) - \$12,000(A/F,12\%,5)$$
$$+\$4,200 + \$500(A/G,12\%,5)$$
$$= \$18,039.80$$
$$AEC_D = \$8,500(A/P,12\%,5) + \$8,700$$
$$= \$11,057.98$$

∴ Since $AEC_C > AEC_D$, retain the defender for now.

14.16

(a) Economic service life:

n	OR	MV	AE_{OR}	CR(10%)	AE(10%)
0		$20,000			
1	$35,550	$13,000	$35,550	$9,000	$26,550
2	$31,013	$13,000	$33,390	$7,500	$25,890
3	$25,794	$8,450	$31,095	$8,383	$24,712
4	$19,794	$3,570	$28,660	$5,540	$23,120

The economic life of the cab is one year. These cabs should be replaced every year.

(b) Rate of return calculation:

$$PW(i) = -\$20,000 + \frac{\$35,550 + \$13,000}{1+i} = 0$$

Solving for i yields 143%. The internal rate of return with a one-year replacement cycle is 143%.

14.17

For the challenger, we have:

$$AEC_C = \$50,000(A/P,10\%,12) + \$3,000 - \$6,000 - \$3,000(A/F,10\%,12)$$
$$= \$4,198$$

For the defender, we need to find its economic service life. Since the annual operating cost is constant and the salvage value declines as it ages, the annual equivalent cost is a decreasing function of the holding period. This means that the economic life is equal to its physical life, as illustrated in the following table. ($N_D = 5$ years, $AEC_D = \$4,227$). With $i = 10\%$

Year	OC	MV	AEC_{OC}	CR(10%)	AEC(10%)
0		$2,000			
1	$3,800	$1,500	$3,800	$700	$4,500
2	$3,800	$1,200	$3,800	$581	$4,381
3	$3,800	$960	$3,800	$514	$4,314
4	$3,800	$768	$3,800	$465	$4,265
5	$3,800	$614	$3,800	$427	$4,227

$\therefore$ Since $AEC_D > AEC_C$, the new machine should be purchased.

14.18

$$AEC_{\text{Option 1}} = \$15,000 + \$48,000(A/P,12\%,10) + \$12,000 - \$5,000(A/F,12\%,10)$$
$$= \$35,210$$
$$AEC_{\text{Option 2}} = (\$84,000 - \$6,000)(A/P,12\%,10) + \$24,000 - \$9,000(A/F,12\%,10)$$
$$= \$37,291$$

$\therefore$ Since $AEC_{\text{Option 1}} < AEC_{\text{Option 2}}$, Option 1 should be selected.

Replacement Problem with a Finite Planning Horizon

14.19 There are several plausible scenarios. Some of the most feasible scenarios are;

$$(j_0,2),(j,3),(j,3),(j,2):PW(12\%) = \$17,601$$
$$(j_0,1),(j,3),(j,3),(j,3):PW(12\%) = \$18,081$$
$$(j_0,3),(j,3),(j,3),(j,1):PW(12\%) = \$17,597$$
$$(j_0,3),(j,3),(j,4):PW(12\%) = \$17,221$$
$$(j_0,4),(j,3),(j,3):PW(12\%) = \$18,384$$

$\therefore$ It appears that the $(j_0,3),(j,3),(j,4)$ option becomes the best strategy. Keep the defender for 3 years; replace it with challenger j and keep it for 3 years; replace it with another challenger and keep it for 4 years.

14.20 There are several plausible scenarios. Some of the most feasible scenarios are;

$$(j_0,3),(j,3),(j,2):PW(12\%) = \$67,526$$
$$(j_0,2),(j,3),(j,3):PW(12\%) = \$67,390$$
$$(j_0,1),(j,3),(j,3),(j,1):PW(12\%) = \$66,378$$
$$(j_0,4),(j,3),(j,1):PW(12\%) = \$65,695$$
$$(j_0,4),(j,4):PW(12\%) = \$65,958$$

$\therefore$ It appears that the $(j_0,3),(j,3),(j,2)$ option becomes the best strategy. Keep the defender for 3 years; replace it with challenger j and keep it for 3 years; replace it with another challenger and keep it for only 2 years.

14.21

$$PW_D = \$12,000 + \$4,000(P/A,11\%,6) - \$2,000(P/F,11\%,6)$$
$$= \$27,852.86$$

$$PW_C = [\$10,000 + \$2,000(P/A,11\%,3) - \$4,000(P/F,11\%,3)]$$
$$\times [1 + (P/F,11\%,3)]$$
$$= \$20,709.66$$
$$\therefore \text{Since } PW_C < PW_D, \text{ replace the defender now.}$$

14.22
$$AE_D = \$4,000 + \$12,000(A/P,11\%,6) - \$2,000(A/F,11\%,6)$$
$$= \$6,583.77$$

$$AE_C = \$2,000 + \$10,000(A/P,11\%,3) - \$4,000(A/F,11\%,3)$$
$$= \$4,895.28$$

$$\therefore \text{Since } AE_C < AE_D, \text{ replace the defender now.}$$

Replacement Analysis with Tax considerations

14.23
(a) **Comments:** Sunk cost can be defined as either the difference in book value and market value or the cost that has already been expended ($).

(b)
$$\text{book value} = \$15,000 - (\$3,000 + \$4,800 + \$1,440) = \$5,760$$
$$\text{market value} = \$6,000$$

In this example, if the sunk cost is defined as the difference in book value and market value, there would be no sunk cost as the market value exceeds the book value. However, the difference between the purchase cost ($15,000) and the current market value ($6,000) may be viewed as another sunk cost that should not be considered in the replacement analysis.

(c) Opportunity cost of not replacing the truck:

$$\text{book value} = \$15,000 - (\$3,000 + \$4,800 + \$1,440)$$
$$= \$5,760$$

$$\text{market value} = \$6,000$$
$$\text{taxable gain} = \$6,000 - \$5,760 = \boxed{\$240}$$
$$\text{gains tax} = \$240 \times 0.40 = \$96$$
$$\text{net proceeds from sale} = \$6,000 - \$96 = \$5,904$$

The opportunity cost for not replacing the old machine now, which is $5,904, is viewed as an investment required keeping the old machine.

(d) Since the market value is less than the original purchase cost, there would be no capital gains. The taxable gain in the amount of $96 in (b) is an ordinary gain.

(e) Equivalent annual cost of operating the truck for two more years:

Cash Flow	End of Period		
Elements	0	1	2
Investment	-$5,904		
Net proceeds			$2,491
-0.6(O&M) cost	-$900	-$1,800	-$2,100
+ (0.40) D_n		$691	$346
Net cash flow	-$6,804	-$1,109	$737

$$PW(15\%) = -\$7,211$$
$$AEC(15\%) = \$4,436$$

The equivalent annual cost of owning and operating the truck for 5 years:

Cash Flow						
Elements	0	1	2	3	4	5
Investment	-$5,904					
Net proceeds						0
-0.6(O&M)	-$900	-$1,800	-$2,100	-$2,280	-$2,700	-$5,880
+ (0.40) D_n		$691	$691	$346	0	0
Net cash flow	-$6,804	$1,109	-$1,409	-$1,934	-$2,700	-$5,880

$$PW(15\%) = -\$14,573$$
$$AEC(15\%) = \$4,347$$

14.24

(a)

$$\text{book value} = 0$$

$$\text{ordinary gains} = \$30,000 - 0 = \$30,000$$

$$\text{gains tax} = \$30,000 \times 0.4 = \boxed{\$12,000}$$

(b) Opportunity cost $= \$30,000 - \$12,000 = \boxed{\$18,000}$

(c) , (d) and (e): Replace the defender now with the challenger

n	0	1	2
Depreciation	$0	$0	$0
Book value	0	0	0
Market value	$30,000		$12,000

Cash Flow Statement			
+(.4)*(Depreciation)		0	0
Opportunity cost	(18,000)		7,200
Net Cash Flow	($18,000)	$0	$7,200

PW (12%) = ($12,260)   AEC(12%) = $7,254

Option 2: Replace the defender

n	0	1	2	3	4	5	6	7	8
Depreciation		$23,579	$40,409	$28,859	$20,609	$14,735	$14,718	$14,735	$7,359
Book value	$165,000	$141,422	$101,013	$72,155	$51,546	$36,812	$22,094	$7,359	$0
Market value						$0	$0	$0	$0
Savings in O&M cost		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000

Cash Flow Statement									
Investment	(165,000)								
Net proceeds from sale									3,000
+(.4)*(Depreciation)		9,431	16,163	11,543	8,243	5,894	5,887	5,894	2,944
(1 - 0.4)*(Savings)		18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000
Net Cash Flow	($165,000)	$27,431	$34,163	$29,543	$26,243	$23,894	$23,887	$23,894	$23,944

PW (12%) = ($29,428)   AEC(12%) = $5,924

14.25

(a) Based on the opportunity cost approach:

$$\text{Cost basis} = \$120{,}000$$

(b) Gains or losses at the time of disposal:
- Old machine:

$$\text{total depreciation} = \$50{,}000$$
$$\text{book value} = 0$$
$$\text{market value} = 0$$
$$\text{taxable gain} = \$0$$

- New machine:

$$\text{total depreciation} = \$109{,}272$$
$$\text{book value} = \$10{,}728$$
$$\text{salvage value} = \$30{,}000$$
$$\text{taxable gain} = \$19{,}272$$
$$\text{gains tax} = \$7{,}709$$

(c) Cash flow for the old machine:

Cash Flow Elements	0	1	2	3	4	5
Investment	-$26,000					
Net proceeds						0
+ (0.40) D_n		$4,000	$4,000	$4,000	$4,000	$4,000
Net cash flow	-$26,000	$4,000	$4,000	$4,000	$4,000	$4,000

(d) Replacement analysis: Replace the old machine now.

$$PW(15\%)_{old} = -\$26{,}000 + \$4{,}000(P/A,15\%,5)$$
$$= -\$12{,}591$$
$$AE(15\%)_{old} = -\$12{,}591(A/P,15\%,5) = \boxed{-\$3{,}756}$$
$$PW(15\%)_{new} = -\$120{,}000 + \$36{,}859(P/F,15\%,1)$$
$$+ \cdots + \$54{,}432(P/F,15\%,7)$$
$$= \$41{,}787$$
$$AE(15\%)_{new} = \$41{,}787(A/P,15\%,7) = \boxed{\$10{,}044}$$

Financial Data	n	0	1	2	3	4	5	6	7
Depreciation			$17,148	$29,388	$20,988	$14,988	$10,716	$10,716	$5,352
Book value		($120,000)	($137,148)	($166,536)	($187,524)	($202,512)	($213,228)	($223,944)	($229,296)
Salvage value									$30,000
Savings in O&M cost			$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Cash Flow Statement									
Investment		(120,000)							
Net proceeds from sale									22,304
+(.40)*(Depreciation)			6,859	11,755	8,395	5,995	4,286	4,286	2,141
(1 - 0.40)*(Savings)			30,000	30,000	30,000	30,000	30,000	30,000	30,000
Net Cash Flow		($120,000)	$36,859	$41,755	$38,395	$35,995	$34,286	$34,286	$54,445

PW (15%) =	$41,787		AE (15%) =	$10,044

14.26 (a) & (b) Decision: Replace the defender now.

(1) Keep the defender

	n	0	1	2	3	4	5
Depreciation		$9,600	$5,760	$5,760	$2,880	$0	$0
Book value		14,400	8,640	2,880	0	0	0
Market value		$10,000					5,000
Cash Flow Statement							
+(.35)*(Depreciation)			2,016	2,016	1,008	0	0
Opportunity cost		(13,220)					3,250
Net Cash Flow		($13,220)	$2,016	$2,016	$1,008	$0	$3,250

PW (15%) =	($7,664)		AE (15%) =	($2,286)

(2) Replace the defender

	n	0	1	2	3	4	5
Depreciation			$15,000	$24,000	$14,400	$8,640	$4,320
Book value		$75,000	$60,000	$36,000	$21,600	$12,960	$8,640
Market value							$0
Savings in O&M cost			$30,000	$30,000	$30,000	$30,000	$30,000
Cash Flow Statement							
Investment		(75,000)					
Net proceeds from sale							3,024
+(.35)*(Depreciation)			5,250	8,400	5,040	3,024	1,512
(1 - 0.35)*(Savings)			19,500	19,500	19,500	19,500	19,500
Net Cash Flow		($75,000)	$24,750	$27,900	$24,540	$22,524	$24,036

PW (15%) =	$8,582		AE (15%) =	$2,560

14.27 (a), (b) & (c) Decision: Do not replace the defender now.

(1) Keep the defender

n	0	1	2	3
Depreciation				
Book value				
Market value	$5,500			$1,200
Revenue		$21,000	$21,000	$21,000
Cash Flow Statement				
+(1-0.4)*(Revenue)		$12,600	$12,600	$12,600
Opportunity cost	(3,300)			
Net proceeds from sale				720
Net Cash Flow	($3,300)	$12,600	$12,600	$13,320

PW (12%) = $27,476   AE (12%) = $11,439

(2) Replace the defender

n	0	1	2	3	4	5
Depreciation		$7,300	$11,680	$7,008	$4,205	$2,102
Book value	$36,500	$29,200	$17,520	$10,512	$6,307	$4,205
Market value						$6,300
Revenue		$24,000	$24,000	$24,000	$24,000	$24,000
Cash Flow Statement						
Investment	(36,500)					
Net proceeds from sale						5,462
+(.40)*(Depreciation)		2,920	4,672	2,803	1,682	841
(1 - 0.40)*(Savings)		14,400	14,400	14,400	14,400	14,400
Net Cash Flow	($36,500)	$17,320	$19,072	$17,203	$16,082	$20,703

PW (12%) = $28,381   AE (12%) = $7,873

14.28 (a) & (b)

- Defender:

		Investment	$ 8,285		Book Value	$ 7,889
		Tax Rate (%)	35		MARR (%)	12

Holding Period	O&M	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3	4	5	6	7	8						
0															
1	$ 3,200	$ 2,311								$ 2,311	$ 5,578	$ 4,300	$ (1,278)	$ (511)	$ 4,811
2	$ 3,700	$ 2,311	$ 1,116							$ 3,427	$ 4,462	$ 3,300	$ (1,162)	$ (465)	$ 3,765
3	$ 4,800	$ 2,311	$ 2,231	$ 1,116						$ 5,658	$ 2,231	$ 1,100	$ (1,131)	$ (452)	$ 1,552
4	$ 5,850	$ 2,311	$ 2,231	$ 2,231	$ 1,116					$ 7,889	$ -	$ -	$ -	$ -	$ -

								Equivalent Annual Cost if the Challenger is Kept for N More Years			

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum. PV of O&M Cost	Cum. PV of Dep. Credit	Total Operating Cost		Capital Cost	Operating Cost	Total Cost
1	$ 4,811	$4,296	$ 2,080	$1,857	$1,857	$ 722	$1,135		$4,468	$1,271	$5,739
2	$ 3,765	$3,001	$ 2,405	$1,917	$3,774	$ 1,034	$2,741		$3,126	$1,622	$4,748
3	$ 1,552	$1,105	$ 3,120	$2,221	$5,995	$ 1,623	$4,372		$2,989	$1,820	$4,810
4	$ -	$0	$ 3,803	$2,417	$8,412	$ 2,149	$6,263		$2,728	$2,062	$4,790

Note that the cost of retaining the defender on after-tax basis is $8,285, instead of $7,700. The scheduled depreciation amount during the fifth year of ownership is $3,122. However, the asset will be disposed of during the recovery period, the allowed depreciation amount will be (0.5)($3,122) = $1,561. Then, the book value becomes $9,370, instead of $7,809. With the market value of $7,700, there will be a loss of $1,670. The tax credit on this loss will be $1,670(0.35) = $584.50. Finally, the net proceeds from sale of old asset will be $8,285 (= $7,700 + $584.50).

- Challenger:

Tax Rate(%)	35
MARR(%)	12

Financial data

n	0	1	2	3	4	5	6	7	8	9	10
Depreciation		$ 4,429	$ 7,592	$ 5,422	$ 3,872	$ 2,767	$ 2,767	$ 2,768	$ 1,383	$ -	$ -
Book value	$ 31,000	$ 26,571	$ 18,979	$ 13,557	$ 9,685	$ 6,918	$ 4,151	$ 1,383	$ (0)	$ (0)	$ (0)
Salvage value											$2,500
Gains tax											
O&M cost		$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$1,000

Cash Flow Statement

	0	1	2	3	4	5	6	7	8	9	10
Investment	$ (31,000)										
Net proceeds from sale											$1,625
+(.35)*(Depreciation)		$ 1,550	$ 2,657	$ 1,898	$ 1,355	$ 969	$ 969	$ 969	$ 484	$ -	$ -
(0.65)*(O&M cost)		(650)	(650)	(650)	(650)	(650)	(650)	(650)	(650)	(650)	(650)
Net Cash Flow	($31,000)	$900	$2,007	$1,248	$705	$319	$319	$319	($166)	($650)	$975

PW (12%) =	($26,761)
AEC (12%) =	$4,736

(c) Marginal analysis:

- From $n = 1$ to $n = 2$:
$$\$4,811(1.12) - \$3,765 + \$2,741 = \$4,364 < \$4,736$$

- From $n = 2$ to $n = 3$:
$$\$3,765(1.12) - \$1,522 + \$4,372 = \$7,066 > \$4,736$$

Keep the defender for two years, which happens to be the same as the economic service life as calculated before. (In general, you should not expect this to happen all the time.)

14.29

(a) Economic service life = 5 years

Input Data:

Investment	$10,000		Book value	$10,000
Tax Rate(%)	40		MARR (%)	15

Holding Period	O&M	Permitted Annual Depreciation Amounts over the Holding Period						Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3	4	5	6						
1	$1,500	$2,000						$2,000	$8,000	$5,300	($2,700)	($1,080)	$6,380
2	$2,100	$2,000	$1,600					$3,600	$6,400	$3,900	($2,500)	($1,000)	$4,900
3	$2,700	$2,000	$3,200	$960				$6,160	$3,840	$2,800	($1,040)	($416)	$3,216
4	$3,400	$2,000	$3,200	$1,920	$576			$7,696	$2,304	$1,800	($504)	($202)	$2,002
5	$4,200	$2,000	$3,200	$1,920	$1,152	$576		$8,848	$1,152	$1,400	$248	$99	$1,301
6	$4,900	$2,000	$3,200	$1,920	$1,152	$1,152	$576	$10,000	$0	$600	$600	$240	$360

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum.PV of O&M Cost	Cum.PV of Dep. Cost	Total Operating Cost		Equivalent Annual Cost if the Challenger is Kept for N More Years		
									Capital Cost	Operating Cost	Total Cost
1	$6,380	$5,548	$900	$783	$783	$696	$87		$5,120	$100	$5,220
2	$4,900	$305	$1,260	$953	$1,736	$1,180	$556		$3,872	$342	$4,214
3	$3,216	$2,115	$1,620	$1,065	$2,801	$1,916	$885		$3,454	$387	$3,841
4	$2,002	$1,144	$2,040	$1,166	$3,967	$2,300	$1,667		$3,102	$584	$3,686
5	$1,301	$647	$2,520	$1,253	$5,220	$2,547	$2,673		$2,790	$797	$3,587
6	$360	$179	$3,803	$1,462	$6,682	$2,761	$3,921		$2,595	$1,036	$3,631

(b) Economic service life = 5 years

Input Data:
Investment $10,000   Book value $10,000
Tax Rate(%)   40   MARR (%)   10

Holding Period	O&M	Permitted Annual Depreciation Amounts over the Holding Period						Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3	4	5	6						
1	$1,500	$2,000						$2,000	$8,000	$5,300	($2,700)	($1,080)	$6,380
2	$2,100	$2,000	$1,600					$3,600	$6,400	$3,900	($2,500)	($1,000)	$4,900
3	$2,700	$2,000	$3,200	$960				$6,160	$3,840	$2,800	($1,040)	($416)	$3,216
4	$3,400	$2,000	$3,200	$1,920	$576			$7,696	$2,304	$1,800	($504)	($202)	$2,002
5	$4,200	$2,000	$3,200	$1,920	$1,152	$576		$8,848	$1,152	$1,400	$248	$99	$1,301
6	$4,900	$2,000	$3,200	$1,920	$1,152	$1,152	$576	$10,000	$0	$600	$600	$240	$360

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum.PV of O&M Cost	Cum.PV of Dep. Cost	Total Operating Cost	Equivalent Annual Cost if the Challenger is Kept for N More Years		
								Capital Cost	Operating Cost	Total Cost
1	$6,380	$5,548	$900	$818	$818	$727	$91	$4,620	$100	$4,720
2	$4,900	$305	$1,260	$1,041	$1,859	$1,256	$603	$3,429	$348	$3,777
3	$3,216	$2,115	$1,620	$1,217	$3,076	$2,074	$1,002	$3,050	$403	$3,453
4	$2,002	$1,144	$2,040	$1,393	$4,469	$2,520	$1,949	$2,723	$615	$3,338
5	$1,301	$647	$2,520	$1,565	$6,034	$2,820	$3,214	$2,425	$848	$3,273
6	$360	$179	$3,803	$1,826	$7,860	$3,093	$4,767	$2,245	$1,095	$3,340

14.30

(a) At $i = 10\%$, the economic service life = 8 years:

Initial Investment= $20,000

Holding Period	O&M	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3	4	5	6	7	8						
1	$3,000	$2,500								$2,500	$17,500	$10,000	($7,500)	($3,000)	$13,000
2	$4,000	$2,500	$2,500							$5,000	$15,000	$8,000	($7,000)	($2,800)	$10,800
3	$5,000	$2,500	$2,500	$2,500						$7,500	$12,500	$6,000	($6,500)	($2,600)	$8,600
4	$6,000	$2,500	$2,500	$2,500	$2,500					$10,000	$10,000	$4,000	($6,000)	($2,400)	$6,400
5	$7,000	$2,500	$2,500	$2,500	$2,500	$2,500				$12,500	$7,500	$2,000	($5,500)	($2,200)	$4,200
6	$8,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500			$15,000	$5,000	$0	($5,000)	($2,000)	$2,000
7	$9,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500		$17,500	$2,500	$0	($2,500)	($1,000)	$1,000
8	$10,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$20,000	$0	$0	$0	$0	$0
9	$11,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$20,000	$0	$0	$0	$0	$0

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum.PV of O&M Cost	Cum.PV of Dep. Credit	Total Operating Cost		Equivalent Annual Cost if the Challenger is Kept for N More Years		
									Capital Cost	Operating Cost	Total Cost
1	$13,000	$11,818	$1,800	$1,636	$1,636	$909	$727		$9,000	$800	$9,800
2	$10,800	$8,926	$2,400	$1,983	$3,620	$1,736	$1,884		$6,381	$1,086	$7,467
3	$8,600	$6,461	$3,000	$2,254	$5,874	$2,487	$3,387		$5,444	$1,362	$6,806
4	$6,400	$4,371	$3,600	$2,459	$8,333	$3,170	$5,163		$4,930	$1,629	$6,559
5	$4,200	$2,608	$4,200	$2,608	$10,940	$3,791	$7,150		$4,588	$1,886	$6,474
6	$2,000	$1,129	$4,800	$2,709	$13,650	$4,355	$9,295		$4,333	$2,134	$6,467
7	$1,000	$513	$5,400	$2,771	$16,421	$4,868	$11,553		$4,003	$2,373	$6,376
8	$0	$0	$6,000	$2,799	$19,220	$5,335	$13,885		$3,749	$2,603	$6,352	← Economic Service Life
9	$0	$0	$6,600	$2,799	$22,019	$5,335	$16,684		$3,473	$2,897	$6,370

(b) At $i = 25\%$, the economic service life = 9 years

Holding Period	O&M	Permitted Annual Depreciation Amounts over the Holding Period								Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3	4	5	6	7	8						
1	$3,000	$2,500								$2,500	$17,500	$10,000	($7,500)	($3,000)	$13,000
2	$4,000	$2,500	$2,500							$5,000	$15,000	$8,000	($7,000)	($2,800)	$10,800
3	$5,000	$2,500	$2,500	$2,500						$7,500	$12,500	$6,000	($6,500)	($2,600)	$8,600
4	$6,000	$2,500	$2,500	$2,500	$2,500					$10,000	$10,000	$4,000	($6,000)	($2,400)	$6,400
5	$7,000	$2,500	$2,500	$2,500	$2,500	$2,500				$12,500	$7,500	$2,000	($5,500)	($2,200)	$4,200
6	$8,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500			$15,000	$5,000	$0	($5,000)	($2,000)	$2,000
7	$9,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500		$17,500	$2,500	$0	($2,500)	($1,000)	$1,000
8	$10,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$20,000	$0	$0	$0	$0	$0
9	$11,000	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$2,500	$20,000	$0	$0	$0	$0	$0

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum.PV of O&M Cost	Cum.PV of Dep. Cost	Total Operating Cost		Equivalent Annual Cost if the Challenger is Kept for N More Years		
									Capital Cost	Operating Cost	Total Cost
1	$13,000	$10,400	$1,800	$1,440	$1,440	800	$640		$12,000	$800	$12,800
2	$10,800	$6,912	$2,400	$1,536	$2,976	1,440	$1,536		$9,089	$1,067	$10,156
3	$8,600	$4,403	$3,000	$1,536	$4,512	1,952	$2,560		$7,990	$1,311	$9,302
4	$6,400	$2,621	$3,600	$1,475	$5,987	2,362	$3,625		$7,359	$1,535	$8,894
5	$4,200	$1,376	$4,200	$1,376	$7,363	2,689	$4,674		$6,925	$1,738	$8,663
6	$2,000	$524	$4,800	$1,258	$8,621	2,951	$5,670		$6,599	$1,921	$8,520
7	$1,000	$210	$5,400	$1,132	$9,754	3,161	$6,592		$6,260	$2,085	$8,346
8	$0	$0	$6,000	$1,007	$10,760	3,329	$7,431		$6,008	$2,232	$8,240
9	$0	$0	$6,600	$886	$11,646	3,329	$8,317		$5,775	$2,402	$8,177

(c) At $i = 0\%$, the economic service life $= 4$ years:

- Capital recovery cost:

$$\text{gain} = S_n - B_n$$
$$\text{gain tax} = t_m(S_n - B_n)$$
$$\text{net proceeds} = (1-t_m)S_n + t_m B_n$$
$$= (1-0.40)(12,000 - 2000n) + 0.40(20,000 - 2,500n)$$
$$CR = \frac{I - (1-t_m)S_n - t_m B_n}{n}$$
$$= \frac{4,800 - 200n}{n}$$
$$= \frac{4,800}{n} - 200$$

- Equivalent annual O&M cost:

$$\text{A/T O\&M} = (1-t_m)\big[3,000 + 1,000(n-1)\big]$$
$$= 1,200 + 600n$$
$$AE_{O\&M} = \frac{\sum_{n=0}^{n}(1,200 + 600n)}{n}$$
$$= 1,500 + 300n$$

- Depreciation tax credit:

$$AE_D = \frac{\sum_{n=0}^{n}(t_m + D_n)}{n}$$
$$= 1,000$$

- Minimum total annual equivalent cost:

$$AE = \frac{4,800}{n} - 200 + 1,500 + 300n - 1,000$$
$$= \frac{4,800}{n} + 300n + 300$$
$$\frac{dAE}{dn} = \frac{-4,800}{n^2} + 300 = 0$$

$$n = 4 \text{ years}$$

14.31 Economic service life

(a) With $i = 10\%$ and tax rate $= 40\%$: Economic service life $= 1$ year

Input Data:
Investment	$15,000	Book value	$15,000
Tax Rate(%)	40	MARR (%)	10

Holding Period	O&M	Permitted Annual Depreciation Amounts over the Holding Period					Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3	4	5						
1	$2,500	$3,000					$3,000	$12,000	$12,000	$0	$0	$12,000
2	$3,200	$3,000	$2,400				$5,400	$9,600	$8,100	($1,500)	($600)	$8,700
3	$5,300	$3,000	$4,800	$1,440			$9,240	$5,760	$5,200	($560)	($224)	$5,424
4	$6,500	$3,000	$4,800	$2,880	$864		$11,544	$3,456	$3,500	$44	$18	$3,482
5	$7,800	$3,000	$4,800	$2,880	$1,728	$864	$13,272	$1,728	$0	($1,728)	($691)	$691

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum.PV of O&M Cost	Cum.PV of Dep. Credit	Total Operating Cost		Equivalent Annual Cost if the challenger is Kept for N More Years		
									Capital Cost	Operating Cost	Total Cost
1	$12,000	$10,909	$1,500	$1,364	$1,364	$1,091	$273		$4,500	$300	$4,800
2	$8,700	$7,190	$1,920	$1,587	$2,950	$1,884	$1,066		$4,500	$614	$5,114
3	$5,424	$4,075	$3,180	$2,389	$5,340	$3,110	$2,229		$4,393	$896	$5,289
4	$3,482	$2,379	$3,900	$2,664	$8,003	$3,779	$4,224		$3,982	$1,333	$5,314
5	$691	$429	$4,680	$2,906	$10,909	$4,230	$6,679		$3,844	$1,762	$5,606

(b) With $i = 15\%$ and tax rate $= 30\%$: Economic service life = 1 year

Input Data:

Investment	$15,000	Book value	$15,000
Tax Rate(%)	30	MARR (%)	15

Holding Period	O&M	Permitted Annual Depreciation Amounts over the Holding Period					Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3	4	5						
1	$2,500	$3,000					$3,000	$12,000	$12,000	$0	$0	$12,000
2	$3,200	$3,000	$2,400				$5,400	$9,600	$8,100	($1,500)	($450)	$8,550
3	$5,300	$3,000	$4,800	$1,440			$9,240	$5,760	$5,200	($560)	($168)	$5,368
4	$6,500	$3,000	$4,800	$2,880	$864		$11,544	$3,456	$3,500	$44	$13	$3,487
5	$7,800	$3,000	$4,800	$2,880	$1,728	$864	$13,272	$1,728	$0	($1,728)	($518)	$518

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum.PV of O&M Cost	Cum.PV of Dep. Cost	Total Operating Cost	Equivalent Annual Cost if the Challenger is Kept for N More Years		
								Capital Cost	Operating Cost	Total Cost
1	$12,000	$10,435	$1,750	$1,522	$1,522	783	$739	$5,250	$850	$6,100
2	$8,550	$6,465	$2,240	$1,694	$3,216	1,327	$1,888	$5,250	$1,162	$6,412
3	$5,368	$3,530	$3,710	$2,439	$5,655	2,156	$3,499	$5,024	$1,533	$6,556
4	$3,487	$1,994	$4,550	$2,601	$8,256	2,588	$5,669	$4,556	$1,986	$6,541
5	$518	$258	$5,460	$2,715	$10,971	2,865	$8,106	$4,398	$2,418	$6,816

14.32

(a) Challenger

Financial Data	*n*	0	1	2	3	4	5	6	7	8	9-10
Depreciation			$21,435	$36,735	$26,235	$18,735	$13,395	$13,380	$13,395	$6,690	$0
Book value		$150,000	$128,565	$91,830	$65,595	$46,860	$33,465	$20,085	$6,690	$0	$0
Market value		$150,000									
Savings			$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000
Cash Flow Statement											
+(1-0.40)*(Savings)			18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000
+(.4)*(Depreciation)			8,574	14,694	10,494	7,494	5,358	5,352	5,358	2,676	0
Investment		(150,000)									
Net Cash Flow		($150,000)	$26,574	$32,694	$28,494	$25,494	$23,358	$23,352	$23,358	$20,676	$18,000

PW (10%) = $3,889   AE (10%) = $633

(b) Defender

Financial Data	*n*	0	1	2	3	4	5	6	7	8	9
Depreciation			$12,000	$12,000	$12,000	$12,000	$12,000	$12,000			
Book value		$72,000	$60,000	$48,000	$36,000	$24,000	$12,000	$0			
Current market value											
Cash Flow Statement											
+(.4)*(Depreciation)			4,800	4,800	4,800	4,800	4,800	4,800			
Investment		(28,800)									
Net Cash Flow		($28,800)	$4,800	$4,800	$4,800	$4,800	$4,800	$4,800			

PW (10%) = ($7,895)   AE (10%) = ($1,813)

Financial Data	n	0	1	2	3	4	5	6	7	8	9
Depreciation			$12,000	$12,000	$12,000	$12,000	$12,000	$12,000			
Book value		$72,000	$60,000	$48,000	$36,000	$24,000	$12,000	$0			
Current market value		$45,000									
Cash Flow Statement											
+(.4)*(Depreciation)			4,800	4,800	4,800	4,800	4,800	4,800			
Investment		(55,800)									
Net Cash Flow		($55,800)	$4,800	$4,800	$4,800	$4,800	$4,800	$4,800			

PW (10%) = ($34,895)   AEC(10%) = $8,012

(d) Challenger with an extended service life of 12 years

Financial Data	n	0	1	2	3	4	5	6	7	8	9-12
Depreciation			$21,435	$36,735	$26,235	$18,735	$13,395	$13,380	$13,395	$6,690	
Book value		$150,000	$128,565	$91,830	$65,595	$46,860	$33,465	$20,085	$6,690	$0	
Savings			$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Cash Flow Statement											
+(.4)*(Depreciation)			8,574	14,694	10,494	7,494	5,358	5,352	5,358	2,676	0
+(0.60)*(Savings)			9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Investment		(150,000)									
Net Cash Flow		($150,000)	$17,574	$23,694	$19,494	$16,494	$14,358	$14,352	$14,358	$11,676	$9,000

PW (10%) = ($45,390)   AEC(10%) = $6,662

14.33 (a) and (b):

(a) Defender (Model A)

Original Investment = $150,000

n	0	1	2	3	4	5	6
Depreciation		$26,235	$18,735	$13,395	$13,380	$13,395	$6,690
Book value	$91,836	$65,601	$46,866	$33,471	$20,091	$6,696	$6
Current market value	$0						

Cash Flow Statement

+(.4)*(Depreciation)		10,494	7,494	5,358	5,352	5,358	2,676
Investment	(44,081)						
Net Cash Flow	($44,081)	$10,494	$7,494	$5,358	$5,352	$5,358	$2,676

PW (10%) = ($15,829)   AE (10%) = ($3,634)

Decision: Replace Model A with Model B

(b) It is rather difficult to predict what technological advances would be made on typical equipment in the future. If the industrial engineer had expected a more efficient lathe to be available in one or two years, he could defer the replacement decision. Since Model A was already placed in service, the amount of $ 150,000 expended is a sunk cost, and it should not be considered in future replacement decisions.

(b) Challenger (Model B)

n	0	1	2	3	4	5	6	7	8	9	10
Depreciation		$42,870	$73,470	$52,470	$37,470	$26,790	$26,760	$26,790	$13,380		
Book value	$300,000	$257,130	$183,660	$131,190	$93,720	$66,930	$40,170	$13,380	$0		
Savings		$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000

Cash Flow Statement

+(.4)*(Depreciation)		17,148	29,388	20,988	14,988	10,716	10,704	10,716	5,352	0	0
+(0.60)*(Savings)		45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
Investment	(300,000)										
Net Cash Flow	($300,000)	$62,148	$74,388	$65,988	$59,988	$55,716	$55,704	$55,716	$50,352	$45,000	$45,000

PW (10%) = $63,079   AE (10%) = $10,266

14.34 Replacement Analysis

(a) Keep the defender

Financial Data	n	-4	-3	-2	-1	0	1	2	3	4	5	6
Depreciation			$2,858	$4,898	$3,498	$2,498	$1,786	$1,784	$1,786	$892		
Book value		$20,000	$17,142	$12,244	$8,746	$6,248	$4,462	$2,678	$892	$0	$0	$0
Current market value												$1,500
O&M cost							$2,000	$2,000	$2,000	$2,000	$2,000	$2,000
Cash Flow Statement												
(-0.7)*(O&M cost)							(1,400)	(1,400)	(1,400)	(1,400)	(1,400)	(1,400)
+(.3)*(Depreciation)							536	535	536	268	0	0
Investment						(6,449)						
Net proceeds from sale												1,050
Net Cash Flow		$0	$0	$0	$0	($6,449)	($864)	($865)	($864)	($1,132)	($1,400)	($350)

PW (8%) = ($10,682)   AEC(8%) = $2,311

(b) Replace the defender

Financial Data	n		1	2	3	4	5	6	7	8	9	10-11	12
Depreciation			$3,001	$5,143	$3,673	$2,623	$1,875	$1,873	$1,875	$937	$0	$0	$0
Book value		$21,000	$17,999	$12,856	$9,183	$6,560	$4,685	$2,812	$937	($0)	($0)	($0)	($0)
O&M cost			$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	1000
Cash Flow Statement													
+(.3)*(Depreciation)			900	1,543	1,102	787	563	562	563	281	0	0	0
(-0.7)*(O&M cost)			(700)	(700)	(700)	(700)	(700)	(700)	(700)	(700)	(700)	(700)	(700)
Investment		(21,000)											
Net proceeds from sale													350
Net Cash Flow		($21,000)	$200	$843	$402	$87	($137)	($138)	($137)	($419)	($700)	($700)	($350)

PW (8%) = ($21,310)   AEC(8%) = $2,828

14.35 (a) and (b): Replace the defender now

Option 1 : Keep the defender					
	n	0	1	2	3
Depreciation			$0	$0	$0
Book value			$0	$0	$0
Expected Market value		$4,000	$3,000	$2,000	$1,000
O&M cost			$3,000	$4,500	$6,000
Cash Flow Statement					
(-0.6)*(O&M cost)			(1,800)	(2,700)	(3,600)
+(.4)*(Depreciation)			0	0	0
Investment		(2,400)			
Net proceeds from sale					600
Net Cash Flow		($2,400)	($1,800)	($2,700)	($3,000)
PW (15%) =	($7,979)		AEC(15%) =	$3,495	

Option 2 : Replace the defender					
	n	0	1	2	3
Depreciation			$2,000	$2,667	$444
Book value		$6,000	$4,000	$1,333	$889
O&M cost			$2,000	$3,000	$4,000
Cash Flow Statement					
+(.4)*(Depreciation)			800	1,067	178
(0.6)*(O&M cost)			(1,200)	(1,800)	(2,400)
Investment		(6,000)			
Net proceeds from sale					1,556
Net Cash Flow		($6,000)	($400)	($733)	($667)
PW (15%) =	($7,341)		AEC(15%) =	$3,215	

14.36 (a), (b), and (c):

Option 1 : Keep the defender							
Financial Data	*n*	0	1	2	3	4	5
Depreciation			$800	$800	$800	$800	$800
Book value		$4,000	$3,200	$2,400	$1,600	$800	$0
Expected Market value		$0	$0	$0	$0	$0	$0
O&M cost			$0	$0	$0	$0	$0
Cash Flow Statement							
(-0.6)*(O&M cost)			0	0	0	0	0
+(.4)*(Depreciation)			320	320	320	320	320
Investment		(1,600)					
Net proceeds from sale							
Net Cash Flow		($1,600)	$320	$320	$320	$320	$320
PW (10%) =	($387)		AEC(10%) =	$102			

Option 2 : Replace the defender							
Financial Data	*n*	0	1	2	3	4	5
Depreciation			$1,429	$2,449	$1,749	$1,249	$446
Book value		$10,000	$8,571	$6,122	$4,373	$3,124	$2,678
Expected Market value		$0	$0	$0	$0	$0	$0
Savings in O&M cost			$3,000	$3,000	$3,000	$3,000	$3,000
Cash Flow Statement							
+(.4)*(Depreciation)			572	980	700	500	178
(0.6)*(Savings in O&M cost)			1,800	1,800	1,800	1,800	1,800
Investment		(10,000)					
Net proceeds from sale							1,071
Net Cash Flow		($10,000)	$2,372	$2,780	$2,500	$2,300	$3,049
PW (10%) =	($205)		AEC(10%) =	$54			
Incremental cash flow		($8,400)	$2,052	$2,460	$2,180	$1,980	$2,729
IRR=	10.82%	>10%, replace the defender now.					

14.37

(a) Replacement analysis

Option 1 : Keep the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$0	$0	$0	$0	$0
Book value		$0	$0	$0	$0	$0	$0
Expected Market value		$1,000	$0	$0	$0	$0	$0
O&M cost			$7,000	$7,000	$7,000	$7,000	$7,000
Cash Flow Statement							
(-0.6)*(O&M cost)			($4,200)	($4,200)	($4,200)	($4,200)	($4,200)
+(.4)*(Depreciation)			$0	$0	$0	$0	$0
Investment		($600)					
Net proceeds from sale							
Net Cash Flow		($600)	($4,200)	($4,200)	($4,200)	($4,200)	($4,200)

PW (15%) = ($14,679) AEC(15%) = $4,379

Option 2 : Replace the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$1,715	$2,939	$2,099	$1,499	$535
Book value		$12,000	$10,285	$7,346	$5,248	$3,749	$3,214
O&M cost			$5,000	$5,000	$5,000	$5,000	$5,000
Increased Revenue			$1,500	$1,500	$1,500	$1,500	$1,500
Cash Flow Statement							
+(.4)*(Depreciation)			686	1,176	840	600	214
-(0.6)*(O&M cost)			(3,000)	(3,000)	(3,000)	(3,000)	(3,000)
(0.6)*(Revenue)			900	900	900	900	900
Investment		(12,000)					
Net proceeds from sale							2,485
Net Cash Flow		($12,000)	($1,414)	($924)	($1,260)	($1,500)	$600

PW (15%) = ($15,317) AEC(15%) = $4,569

Incremental cash flow ($11,400) $2,786 $3,276 $2,940 $2,700 $4,800

IRR= 12.76%   < 15%, keep the defender.

(b) Breakeven market value: Let X denote the current market value of the old machine. Then, the opportunity cost for not replacing the old machine now is given by

$$X - 0.4X = 0.6X$$

$$PW(15\%)_{defender} = -0.6X - \$4,200(P/A,15\%,5)$$

$$= -0.6X - \$14,074$$

This present value must be the same as the present value of the challenger.

$$-0.6X - \$14,074 = -\$15,317$$

$$X = \boxed{\$2,072}$$

14.38 Replacement analysis: Let X denote the current market value of the old call-switching system:

$$AEC(14\%)_{defender} = \$20,000(0.60) + 0.60X(A/P,14\%,5)$$
$$= \$14,000 + (0.6X)(0.29128)$$
$$= \$14,000 + 0.175X$$
$$AEC(14\%)_{challenger} = \$156,291(A/P,14\%,10)$$
$$= \$29,963$$

To justify the new call-switching system now, we must have

$$AEC(14\%)_{defender} < AEC(14\%)_{challenger}$$
$$\$14,000 + 0.175X < \$29,962$$
$$X > \boxed{\$91,215}$$

- Challenger:

Depreciation		$40,000	$64,000	$38,400	$23,040	$23,040
Book value	$200,000	$160,000	$96,000	$57,600	$34,560	$11,520
Salvage value						
O&M cost		$5,000	$5,000	$5,000	$5,000	$5,000
Cash Flow Statement						
-(0.6)*(O&M cost)		(3,000)	(3,000)	(3,000)	(3,000)	(3,000)
+(.4)*(Depreciation)		16,000	25,600	15,360	9,216	9,216
Investment	(200,000)					
Net proceeds from sale						
Net Cash Flow	($200,000)	$13,000	$22,600	$12,360	$6,216	$6,216

Financial Da	_n_	6	7	8	9	10
Depreciation		$11,520	$0	$0	$0	$0
Book value		$0	$0	$0	$0	$0
Salvage value						
O&M cost		$5,000	$5,000	$5,000	$5,000	$5,000
Cash Flow Statement						
-(0.6)*(Savings in O&M cost)		(3,000)	(3,000)	(3,000)	(3,000)	(3,000)
+(.4)*(Depreciation)		4,608	0	0	0	0
Investment						
Net proceeds from sale						10,800
Net Cash Flow		$1,608	($3,000)	($3,000)	($3,000)	$7,800

PW (14%) =   ($156,292)
AEC(14%) = $29,963

14.39 Defender analysis

Input Data:
Investment $12,725   Book value $15,000
Tax Rate(%)   35   MARR (%)   18

Holding Period	O&M	Permitted Depreciation over Holding Period			Total Depreciation	Book Value	Expected Market Value	Taxable Gains	Gains Tax	Net A/T Salvage Value
		1	2	3						
1	$4,500	$4,000			$4,000	$11,000	$5,200	($5,800)	($2,320)	$7,520
2	$5,300	$4,000	$4,000		$8,000	$7,000	$3,500	($3,500)	($1,400)	$4,900
3	$6,100	$4,000	$4,000	$4,000	$12,000	$3,000	$1,200	($1,800)	($720)	$1,920

Holding Period N	A/T Market Value	PV of Market Value	A/T O&M Cost	PV of O&M Cost	Cum.PV of O&M Cost	Cum.PV of Dep. Credit	Total Operating Cost	Equivalent Annual Cost if the Challenger is Kept for N More Y		
								Capital Cost	Operating Cost	Total Cost
1	$7,520	$6,373	$2,925	$2,479	$2,479	1,186	$1,292	$7,496	$1,525	$9,021
2	$4,900	$3,519	$3,445	$2,474	$4,953	2,192	$2,761	$5,880	$1,764	$7,643
3	$1,920	$1,169	$3,965	$2,413	$7,366	3,044	$4,322	$5,315	$1,988	$7,303

- Challenger analysis

Financial Data	*n*	0	1	2	3	4	5
Depreciation			$6,216	$10,653	$7,608	$5,433	$3,885
Book value		$43,500	$37,284	$26,631	$19,023	$13,589	$9,705
Salvage value							
O&M cost			$1,500	$1,500	$1,500	$1,500	$1,500
Cash Flow Statement							
-(0.65)*(O&M cost)			(975)	(975)	(975)	(975)	(975)
+(.35)*(Depreciation)			2,176	3,729	2,663	1,902	1,360
Investment		(43,500)					
Net proceeds from sale							
Net Cash Flow		($43,500)	$1,201	$2,754	$1,688	$927	$385

Financial Data	*n*		6	7	8	9	10
Depreciation			$3,880	$3,885	$1,940	$0	$0
Book value			$5,825	$1,940	($0)	($0)	($0)
Salvage value							
O&M cost			$1,500	$1,500	$1,500	$1,500	$1,500
Cash Flow Statement							
-(0.65)*(O&M cost)			(975)	(975)	(975)	(975)	(975)
+(.35)*(Depreciation)			1,358	1,360	679	0	0
Investment							
Net proceeds from sale							2,275
Net Cash Flow		$0	$383	$385	($296)	($975)	$1,300

PW (18%) = ($38,619)
AEC(18%) = $8,593

> (b) Optimal time to replace (marginal analysis): Since the remaining
> useful life of 3 years coincides with the physical life, keep the defender
> for 3 years.

14.40 Decision: Do not replace the defender now.

	0	1	2	3	4	5	6	7	8	9	10
Depreciation		$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
Book value	$50,000	$45,000	$40,000	$35,000	$30,000	$25,000	$20,000	$15,000	$10,000	$5,000	$0
Current market value	$60,000										
O&M cost		$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000	$18,000
Cash Flow Statement											
(-0.6)*(O&M cost)		($10,800)	($10,800)	($10,800)	($10,800)	($10,800)	($10,800)	($10,800)	($10,800)	($10,800)	($10,800)
+(.4)*(Depreciation)		$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000
Opportunity cost	($56,000)										
Net proceeds from sale											
Net Cash Flow	($56,000)	($8,800)	($8,800)	($8,800)	($8,800)	($8,800)	($8,800)	($8,800)	($8,800)	($8,800)	($8,800)

PW (12%) = ($105,722)   AEC(12%) = $18,711

(b) Replace the defender

	0	1	2	3	4	5	6	7	8	9	10
Depreciation		$28,580	$48,980	$34,980	$24,980	$17,860	$17,840	$17,860	$8,920	$0	$0
Book value	$200,000	$171,420	$122,440	$87,460	$62,480	$44,620	$26,780	$8,920	$0	$0	$0
O&M cost		$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000
Cash Flow Statement											
+(.4)*(Depreciation)		$11,432	$19,592	$13,992	$9,992	$7,144	$7,136	$7,144	$3,568	$0	$0
(-0.6)*(O&M cost)		($2,400)	($2,400)	($2,400)	($2,400)	($2,400)	($2,400)	($2,400)	($2,400)	($2,400)	($2,400)
Investment	($200,000)										
Net proceeds from sale											$12,000
Net Cash Flow	($200,000)	$9,032	$17,192	$11,592	$7,592	$4,744	$4,736	$4,744	$1,168	($2,400)	$9,600

PW (12%) = ($155,220)   AEC(12%) = $27,472

14.41 Decision: Do not replace the defender now.

Financial Data	n	0	1	2	3	4	5
Depreciation			$0	$0	$0	$0	$0
Book value		$0	$0	$0	$0	$0	$0
Market value		$8,500					
Operation Cost			$8,700	$8,700	$8,700	$8,700	$8,700

Cash Flow Statement							
+(.35)*(Depreciation)			0	0	0	0	0
Opportunity cost		(5,525)					
-(1-0.35)*(Operation cost)			(5,655)	(5,655)	(5,655)	(5,655)	(5,655)
Net Cash Flow		($5,525)	($5,655)	($5,655)	($5,655)	($5,655)	($5,655)

PW (12%) = ($25,910)   AEC(12%) = $7,188

Replace the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$7,645	$13,102	$9,357	$6,682	$2,386
Book value		$53,500	$45,855	$32,753	$23,396	$16,713	$14,327
Market value		$53,500					$12,000
Operation Cost			$4,200	$4,700	$5,200	$5,700	$6,200

Cash Flow Statement							
Investment		(53,500)					
Net proceeds from sale							12,815
+(.35)*(Depreciation)			2,676	4,586	3,275	2,339	835
-(1-0.35)*(Operation cost)			(2,730)	(3,055)	(3,380)	(3,705)	(4,030)
Net Cash Flow		($53,500)	($54)	$1,531	($105)	($1,366)	$9,620

PW (12%) = ($47,813)   AEC(12%) = $13,264

14.42

- Defender analysis

n	0	1	2	3	4	5	6
Depreciation	$2,873	$2,054	$2,052	$2,054	$1,026	$0	$0
Book value	$7,185	$5,131	$3,080	$1,026	($0)	($0)	($0)
Market value	$2,000	$1,500					
O&M cost		$3,800	$3,800	$3,800	$3,800	$3,800	$3,800
Cash Flow Statement							
-(0.6)*(O&M cost)		($2,280)	($2,280)	($2,280)	($2,280)	($2,280)	($2,280)
+(.40)*(Depreciation)		$822	$821	$822	$410	$0	$0
Opportunity cost	($4,649)						
Net proceeds from sale							$600
Net Cash Flow	($4,649)	($1,458)	($1,459)	($1,458)	($1,870)	($2,280)	($1,680)

PW (10%) =   ($11,917)   AEC(10%) = $2,736

Note: Opportunity cost of keeping the defender is calculated as follows:

- Book value (if sold now with the half-year convention) = $3,286+$5,633+$4,023 + (0.5)($2,874) = $8,622
- Taxable gain (loss) = $2,000 -$8,622 = ($6,622)
- Tax credit (savings) = $6,622(0.40) = $2,649
- Net proceeds from sale = $2,000 + $2,649 = $4,649

- Challenger analysis

Financial Data	0	1	2	3	4	5	6
Depreciation		$7,145	$12,245	$8,745	$6,245	$4,465	$4,465
Book value	$50,000	$42,855	$30,610	$21,865	$15,620	$11,155	$6,690
Savings		$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
O&M cost		$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Cash Flow Statement							
-(0.6)*(O&M cost)		($1,800)	($1,800)	($1,800)	($1,800)	($1,800)	($1,800)
(0.6)*(Savings)		$3,600	$3,600	$3,600	$3,600	$3,600	$3,600
+(.4)*(Depreciation)		$2,858	$4,898	$3,498	$2,498	$1,786	$1,786
Investment	($50,000)						
Net proceeds from sale							
Net Cash Flow	($50,000)	$4,658	$6,698	$5,298	$4,298	$3,586	$3,586

Financial Data		7	8	9	10	11	12
Depreciation		$4,460	$2,230	$0	$0	$0	$0
Book value		$2,230	$0	$0	$0	$0	$0
Savings		$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
O&M cost		$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
Cash Flow Statement							
-(0.6)*(O&M cost)		($1,800)	($1,800)	($1,800)	($1,800)	($1,800)	($1,800)
(0.6)*(Savings)		$3,600	$3,600	$3,600	$3,600	$3,600	$3,600
+(.4)*(Depreciation)		$1,784	$892	$0	$0	$0	$0
Investment							
Net proceeds from sale							$1,800
Net Cash Flow	$0	$3,584	$2,692	$1,800	$1,800	$1,800	$3,600

PW (10%) = ($22,733)   AEC(10%) = $3,336

14.43 Option 1:

Depreciation		$6,859	$11,755	$8,395	$5,995	$4,286
Book value	$48,000	$41,141	$29,386	$20,990	$14,995	$10,709
Current Market value	$6,000					
O&M cost		$27,000	$27,000	$27,000	$27,000	$27,000

Cash Flow Statement						
(-0.60)*(O&M cost)		(16,200)	(16,200)	(16,200)	(16,200)	(16,200)
+(.40)*(Depreciation)		2,744	4,702	3,358	2,398	1,715
Opportunity cost	(3,600)					
Investment	(48,000)					
Net proceeds from sale						
Net Cash Flow	($51,600)	($13,456)	($11,498)	($12,842)	($13,802)	($14,485)

Financial Data	n	6	7	8	9	10
Depreciation		$4,282	$4,286	$2,141	$0	$0
Book value		$6,427	$2,141	$0	$0	$0
Salvage value						$5,000
O&M cost		$27,000	$27,000	$27,000	$27,000	$27,000

Cash Flow Statement						
-(0.40)*(O&M cost)		(16,200)	(16,200)	(16,200)	(16,200)	(16,200)
+(.40)*(Depreciation)		1,713	1,715	856	0	0
Investment						
Net proceeds from sale						3,000
Net Cash Flow		($14,487)	($14,485)	($15,344)	($16,200)	($13,200)

PW (12%) = ($129,093)   AEC (12%) = $22,847

Option 2:

Depreciation		$12,004	$20,572	$14,692	$10,492	$7,501
Book value	$84,000	$71,996	$51,425	$36,733	$26,242	$18,740
O&M cost		$24,000	$24,000	$24,000	$24,000	$24,000

Cash Flow Statement

(-0.60)*(O&M cost)		(14,400)	(14,400)	(14,400)	(14,400)	(14,400)
+(.40)*(Depreciation)		4,801	8,229	5,877	4,197	3,000
Investment	(84,000)					
Net proceeds from sale						
Net Cash Flow	($84,000)	($9,599)	($6,171)	($8,523)	($10,203)	($11,400)

Financial Data	*n*	6	7	8	9	10
Depreciation		$7,493	$7,501	$3,746	$0	$0
Book value		$11,248	$3,746	($0)	($0)	($0)
Salvage value						$9,000
O&M cost		$24,000	$24,000	$24,000	$24,000	$24,000

Cash Flow Statement

-(0.40)*(O&M cost)		(14,400)	(14,400)	(14,400)	(14,400)	(14,400)
+(.40)*(Depreciation)		2,997	3,000	1,499	0	0
Investment						
Net proceeds from sale						5,400
Net Cash Flow		($11,403)	($11,400)	($12,901)	($14,400)	($9,000)

PW (12%) = ($140,744)   AEC(12%) = $24,910

14.44 The remaining useful life of the defender is 1 year. Its annual equivalent cost is $1,666. When the defender is replaced now by the challenger, its equivalent annual cost is $2,191, indicating that the defender should be kept for now.

Holding Period N	A/T Market Value	PV of Market Value	A/T Operating Cost	PV of Operating Cost	Cum.PV Operating Cost	Equivalent Annual Cost if the Challenger is Kept for N More Years		
						Capital Cost	Operating Cost	Total Cost
1	840	$750	$1,330	$1,188	$1,188	$336	$1,330	$1,666
2	700	$558	$1,610	$1,283	$2,471	$291	$1,462	1,753
3	350	$249	$1,890	$1,345	$3,816	$333	$1,589	1,922
4	0	$0	$2,170	$1,379	$5,195	$346	$1,710	2,056
5	0	$0	$2,380	$1,350	$6,546	$291	$1,816	2,107

(b) Replace the defender

Financial Data	n	0	1	2	3	4	5
Depreciation			$1,200	$1,920	$1,152	$691	$346
Book value		$6,000	$4,800	$2,880	$1,728	$1,037	$691
Salvage value							$1,000
Operation Cost			$1,100	$1,300	$1,500	$1,700	$1,800

Cash Flow Statement							
Investment		(6,000)					
Net proceeds from sale							907
+(.30)*(Depreciation)			360	576	346	207	104
-(1-0.30)*(Operation cost)			(770)	(910)	(1,050)	(1,190)	(1,260)
Net Cash Flow		($6,000)	($410)	($334)	($704)	($983)	($249)

PW (12%) = ($7,899) AEC(12%) = $2,191

14.45 (a) & (b)

Option 1 : Keep the defender

n	0	1	2	3	4	5	6
Depreciation	$5,120	$3,072	$1,843	$1,843	$922	$0	$0
Book value	$7,680	$4,608	$2,765	$922	$0	$0	$0
Market value	$12,000						$2,000
Operating cost		$4,000	$4,000	$4,000	$4,000	$4,000	$4,000
Cash Flow Statement							
+(.3)*(Depreciation)		$922	$553	$553	$276	$0	$0
-(1-0.30)*(Operating cost)		($2,800)	($2,800)	($2,800)	($2,800)	($2,800)	($2,800)
Opportunity cost	($11,472)						
Net proceeds from sale							$1,400
Net Cash Flow	($11,472)	($1,878)	($2,247)	($2,247)	($2,524)	($2,800)	($1,400)

PW (11%) =   ($20,703)   AEC(11%) = $4,894

Option 2 : Replace the defender

n	0	1	2	3	4	5	6
Depreciation (First Cycle)		$2,000	$3,200	$960			
Book value (First Cycle)	$10,000	$8,000	$4,800	$3,840			
Depreciation (Second Cycle)					$2,000	$3,200	$960
Book value (Second Cycle)				$10,000	$8,000	$4,800	$3,840
Salvage value				$4,000			$4,000
Operating cost		$2,000	$2,000	$2,000	$2,000	$2,000	$2,000
Cash Flow Statement							
+(.3)*(Depreciation)		$600	$960	$288	$600	$960	$288
-(1-0.30)*(Operating cost)		($1,400)	($1,400)	($1,400)	($1,400)	($1,400)	($1,400)
Investment	($10,000)			($10,000)			
Net proceeds from sale				$3,952			$3,952
Net Cash Flow	($10,000)	($800)	($440)	($7,160)	($800)	($440)	$2,840

PW (11%) =   ($15,583)   AEC(11%) = $3,683

∴ Decision: Replace the defender now with the current challenger. Then, replace the current challenger at the end of 3 years with a similar challenger.

Short Case Studies

ST 14.1

(a) The following assumptions were made: (1) Depreciable life for the challenger = 12 years (2) the challenger will be obsolete after 10 years with zero salvage value. (3) Kazakhstan's tax rate = 40%. (5) No market value for a leaky oil system (defender)). With these assumptions, the defender wins. Do not replace the defender.

Financial Data	n	0	1	2	3	4	5-9	10
Depreciation			$10,400	$10,400	$10,400	$10,400	$10,400	$10,400
Book value		$104,000	$93,600	$83,200	$72,800	$62,400	$52,000	$0
Market value								
Operating cost			$41,000	$41,000	$41,000	$41,000	$41,000	$41,000

Cash Flow Statement								
+(.4)*(Depreciation)			4,160	4,160	4,160	4,160	4,160	4,160
Opportunity cost		(104,000)						
Net proceeds from sale			(24,600)	(24,600)	(24,600)	(24,600)	(24,600)	(24,600)
Net Cash Flow		($104,000)	($20,440)	($20,440)	($20,440)	($20,440)	($20,440)	($20,440)

PW (20%) = ($189,694)   AEC(20%) = $45,246

Option 2 : Replace the defender

Financial Data	n	0	1	2	3	4	5-9	10
Depreciation			$27,083	$27,083	$27,083	$27,083	$27,083	$27,083
Book value		$325,000	$297,917	$270,833	$243,750	$216,667	$189,583	$54,167
Salvage value								$0
Operating cost			$12,000	$12,000	$12,000	$12,000	$12,000	$12,000

Cash Flow Statement								
Investment		(325,000)						
Net proceeds from sale								21,667
+(.4)*(Depreciation)			10,833	10,833	10,833	10,833	10,833	10,833
-(1-0.40)*(Operating cost)			(7,200)	(7,200)	(7,200)	(7,200)	(7,200)	(7,200)
Net Cash Flow		($325,000)	$3,633	$3,633	$3,633	$3,633	$3,633	$25,300

PW (20%) = ($306,268)   AEC(20%) = $73,052

(b) If environmental impact is taken into account, it might be better to install the new facility. It is also quite possible that the government of Kazakhstan would impose some huge fines upon discovering the environmental damage caused by the defending facility. This type of issues needs to be addressed before making any final decision.

ST 14.2

(a) It is assumed that the current FMS manufacturing technology would prevail for several years with no major cost and productivity improvement. Therefore, if the present system is kept for the remaining useful life, it will be replaced by the current FMS technology with the same investment and O&M costs.

(b) Decision: The challenger should be adopted

Option1: Keep the defender

n	0	1	2	3	4	5
Operating cost		$105,000	$115,000	$125,000	$135,000	$145,000
Current market value	$140,000					

Cash Flow Statement

n	0	1	2	3	4	5
-(.6)*(O&M)		($63,000)	($69,000)	($75,000)	($81,000)	($87,000)
Opportunity cost	($84,000)					
Net Cash Flow	($84,000)	($63,000)	($69,000)	($75,000)	($81,000)	($87,000)

PW (15%) =   ($329,837)   AE (15%) =   ($98,395)

Option 2: Replace the defender

n	0	1	2	3	4	5	6	7	8	9	10
Depreciation		$185,770	$318,370	$227,370	$162,370	$116,090	$115,960	$116,090	$57,980		
Book value	$1,300,000	$1,114,230	$795,860	$568,490	$406,120	$290,030	$174,070	$57,980			
Savings		$664,243	$664,243	$664,243	$664,243	$664,243	$664,243	$664,243	$664,243	$664,243	$664,243
Operating cost		$45,000	$47,000	$49,000	$51,000	$53,000	$55,000	$57,000	$59,000	$61,000	$63,000

Cash Flow Statement

n	0	1	2	3	4	5	6	7	8	9	10
+(.4)*(Depreciation)		$74,308	$127,348	$90,948	$64,948	$46,436	$46,384	$46,436	$23,192		
+(0.60)*(Savings)		$398,546	$398,546	$398,546	$398,546	$398,546	$398,546	$398,546	$398,546	$398,546	$398,546
-(.6)*(O&M)		($27,000)	($28,200)	($29,400)	($30,600)	($31,800)	($33,000)	($34,200)	($35,400)	($36,600)	($37,800)
Investment	($1,300,000)										
Net proceeds											$72,000
Net Cash Flow	($1,300,000)	$445,854	$497,694	$460,094	$432,894	$413,182	$411,930	$410,782	$386,338	$361,946	$432,746

PW (15%) = $888,146   AE (15%) = $176,965

ST 14.3

(a) Decision: Replace the defender now.

(b) The optimal time to replace the defender is "now." If the AE cost for the defender is smaller than that of the challenger, we need to perform the marginal analysis, i.e., calculating the incremental cost of operating the defender for just 1 more year.

n	0	1	2	3	4	5
Operating cost		$65,000	$65,000	$65,000	$65,000	$65,000
Maintenance		$2,500	$2,875	$3,306	$3,802	$4,373

Cash Flow Statement

n	0	1	2	3	4	5
-(.6)*(O&M)		($40,500)	($40,725)	($40,984)	($41,281)	($41,624)
Opportunity cost						
Net Cash Flow		($40,500)	($40,725)	($40,984)	($41,281)	($41,624)

PW (16%) = ($134,052)   AE C(16%) = $40,941

Option 2: Replace the defender

n	0	1	2	3	4	5	6	7	8	9	10
Depreciation(Building)		$1,160	$1,210	$1,210	$1,210	$1,210	$1,210	$1,210	$1,210	$1,210	$1,160
Book value (Building)	$47,200	$46,040	$44,830	$43,620	$42,410	$41,200	$39,990	$38,780	$37,570	$36,360	$35,200
Depreciation(Equipment)		$18,777	$32,180	$22,982	$16,412	$11,734	$11,721	$11,734	$5,860		
Book value (Equipment)	$131,400	$112,623	$80,443	$57,461	$41,049	$29,315	$17,594	$5,860			
Savings		$57,895	$57,895	$57,895	$57,895	$57,895	$57,895	$57,895	$57,895	$57,895	$57,895
O&M cost		$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000	$35,000

Cash Flow Statement

n	0	1	2	3	4	5	6	7	8	9	10
+(.4)*(Depreciation)		$7,975	$13,356	$9,677	$7,049	$5,178	$5,172	$5,178	$2,828	$484	$464
+(0.60)*(Savings)		$34,737	$34,737	$34,737	$34,737	$34,737	$34,737	$34,737	$34,737	$34,737	$34,737
-(.6)*(O&M)		($21,000)	($21,000)	($21,000)	($21,000)	($21,000)	($21,000)	($21,000)	($21,000)	($21,000)	($21,000)
Investment	($178,600)										
Net proceeds											$21,964
Net Cash Flow	($178,600)	$21,712	$27,093	$23,414	$20,786	$18,915	$18,909	$18,915	$16,565	$14,221	$36,165

PW (16%) = ($72,819)   AEC(16%) = $15,066

ST 14.4 Option 1: Keep the defender

Depreciation		$8,930	$8,920	$4,460						
Book value		13,387	4,467							
Market value		40,000								
Setup cost			$16,000	$16,000	$16,000	$16,000	$16,000	$16,000	$16,000	$16,000
Operating cost			$15,986	$16,785	$17,663	$18,630	$19,692	$20,861	$22,147	$23,562

Cash Flow Statement

+(.4)*(Depreciation)			3,568	1,784						
Opportunity cost	(31,141)									
-(1-0.40)*(Setup)			(9,600)	(9,600)	(9,600)	(9,600)	(9,600)	(9,600)	(9,600)	(9,600)
-(1-0.40)*(Operating cost)			(9,592)	(10,071)	(10,598)	(11,178)	(11,815)	(12,517)	(13,288)	(14,137)
Net Cash Flow	($31,141)	($15,624)	($17,887)	($20,198)	($20,778)	($21,415)	($22,117)	($22,888)	($23,737)	

PW (12%) =   ($130,228)
AEC(12%) = $26,215

Option 2: Purchase a used machine

Depreciation		$21,178	$36,294	$25,920	$18,510	$13,234	$13,219	$13,234	$6,610
Book value	$148,200	$127,022	$90,728	$64,808	$46,298	$33,063	$19,844	$6,610	$0
Salvage value								$0	$0
Setup cost		$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000
Operating cost		$11,500	$11,950	$12,445	$12,990	$13,590	$14,245	$14,950	$15,745
Savings		36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000

Cash Flow Statement

+(1-0.40)*(Savings)		21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600
+(.4)*(Depreciation)		8,471	14,518	10,368	7,404	5,294	5,288	5,294	2,644
Investment	(148,200)								
-(1-0.40)*(Setup)		(9,000)	(9,000)	(9,000)	(9,000)	(9,000)	(9,000)	(9,000)	(9,000)
-(1-0.40)*(Operating cost)		(6,900)	(7,170)	(7,467)	(7,794)	(8,154)	(8,547)	(8,970)	(9,447)
Net Cash Flow	($148,200)	$14,171	$19,948	$15,501	$12,210	$9,740	$9,341	$8,924	$5,797

PW (12%) =   ($84,215)
AEC(12%) = $16,953

Option 3: Keep the defender on year and switch to a brand new machine

Financial Data	n	0	1	2	3	4	5	6	7	
Depreciation		$8,930	$4,460							
Book value		$4,462								
Market value		$30,000							$0	
Setup cost			$16,000	$16,000	$16,000	$16,000	$16,000	$16,000	$16,000	
Operating cost			$16,785	$17,663	$18,630	$19,692	$20,861	$22,147	$23,562	
Cash Flow Statement										
+(.4)*(Depreciation)			1,784	0						
Opportunity cost		(21,571)								
-(1-0.40)*(Setup)			(9,600)	(9,600)	(9,600)	(9,600)	(9,600)	(9,600)	(9,600)	
-(1-0.40)*(Operating cost)			(10,071)	(10,598)	(11,178)	(11,815)	(12,517)	(13,288)	(14,137)	
Net Cash Flow		($21,571)	($17,887)	($20,198)	($20,778)	($21,415)	($22,117)	($22,888)	($23,737)	
PW (12%) =	($116,925)		AE (12%) =	($25,620)						

Option 3 : Purchase a new after 1 year

Financial Data	n	0	1	2	3	4	5	6	7	8
Depreciation			$28,644	$49,090	$35,059	$25,036	$17,900	$17,880	$17,900	$8,940
Book value		$200,450	$171,806	$122,715	$87,657	$62,621	$44,720	$26,840	$8,940	$0
Market value		$200,450							$0	$0
Setup cost			$13,500	$13,500	$13,500	$13,500	$13,500	$13,500	$13,500	$13,500
Operating cost			$10,350	$10,755	$11,200	$11,691	$12,231	$12,821	$13,455	$14,171
Savings			$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000
Cash Flow Statement										
+(1-0.40)*(Savings)			21,600	21,600	21,600	21,600	21,600	21,600	21,600	21,600
+(.4)*(Depreciation)			11,458	19,636	14,023	10,014	7,160	7,152	7,160	3,576
Investment		(200,450)								
-(1-0.40)*(Setup)			(8,100)	(8,100)	(8,100)	(8,100)	(8,100)	(8,100)	(8,100)	(8,100)
-(1-0.40)*(Operating cost)			(6,210)	(6,453)	(6,720)	(7,015)	(7,339)	(7,693)	(8,073)	(8,503)
Net Cash Flow		($200,450)	$18,748	$26,683	$20,803	$16,500	$13,321	$12,959	$12,587	$8,573
PW (12%) =	($113,865)		AE (12%) =	($22,921)						

ST 14.5
(a) Development of a combined productivity index:

| *n* | Operating hours | | Ratio | Combined productivity index |
	Defender	Challenger		
1	1,800	2,500	1.389	1.667
2	1,800	2,400	1.333	1.600
3	1,700	2,300	1.353	1.624
4	1,700	2,100	1.235	1.482
5	1,600	2,000	1.250	1.500

(b)
• Adjusted annual O&M costs for Defender

n	Operating HR	Maintenance	Labor	Fuel	Total
1	1,800	$46,800	$42,120	$24,408	$115,128
2	1,800	$46,800	$42,120	$24,408	$115,128
3	1,700	$46,800	$39,780	$23,052	$111,332
4	1,700	$46,800	$39,780	$23,052	$111,332
5	1,600	$46,800	$37,440	$21,696	$107,536

• Adjusted annual O&M costs for Challenger

| *n* | Operating HR | M | L | F | Combined Productivity index | Adjusted | | | |
						M	L	F	Total
1	2,500	$35,000	$58,500	$48,000	1.667	$21,000	$35,100	$28,800	$84,900
2	2,400	$38,400	$56,160	$46,080	1.600	$24,000	$35,100	$28,800	$87,900
3	2,300	$43,700	$53,820	$44,160	1.624	$26,917	$33,150	$27,200	$87,267
4	2,100	$48,300	$49,140	$40,320	1.482	$32,583	$33,150	$27,200	$92,933
5	2,000	$58,000	$46,800	$38,400	1.500	$38,667	$31,200	$25,600	$95,467

(c) Replacement analysis
• Defender analysis

n	Market value	Depreciation	O&M Cost	After tax Salvage	Dep. Tax credit	A/T O&M cost
0	$75,000					
1	$60,000	0	$113,328	$36,000	0	$67,997
2	$50,000	0	$113,328	$30,000	0	$67,997
3	$30,000	0	$109,632	$18,000	0	$65,779
4	$30,000	0	$109,632	$18,000	0	$65,779
5	$10,000	0	$105,936	$6,000	0	$63,562

n	Net O&M cost	Cumulative O&M cost	Net Investment	Equivalent Annual Cost		
				Capital cost	Operating cost	Total
0						
1	$67,997	$59,128	$13,696	$15,750	$67,997	$83,747
2	$67,997	$110,543	$22,316	$13,726	$67,995	$81,721
3	$65,779	$153,794	$33,165	$14,526	$67,362	$81,888
4	$65,779	$191,403	$34,708	$12,158	$67,049	$79,207
5	$63,562	$223,005	$42,017	$12,534	$66,522	$79,056

• Defender analysis

n	Market value	Depreciation	O&M Cost	After tax Salvage	Dep. Tax credit	A/T O&M cost
0	$400,000					
1	$300,000	$80,000	$84,900	$308,000	$32,000	$50,940
2	$240,000	$128,000	$87,900	$220,800	$51,200	$52,740
3	$190,000	$76,800	$87,267	$160,080	$30,720	$52,360
4	$150,000	$46,080	$92,933	$117,648	$18,432	$55,760
5	$115,000	$46,080	$95,467	$78,216	$18,432	$57,280

n	Net O&M cost	Cumulative O&M cost	Net Investment	Equivalent Annual Cost		
				Capital cost	Operating cost	Total
0						
1	$18,940	$16,470	$132,174	$152,000	$18,940	$170,940
2	$1,540	$17,634	$233,043	$143,345	$10,847	$154,192
3	$21,640	$31,863	$294,745	$129,098	$13,956	$143,054
4	$37,328	$53,205	$332,734	$116,557	$18,638	$135,195
5	$38,848	$72,519	$361,113	$107,720	$21,633	$129,352

∴ Decision: The economic service life for the defender is 5 years with AEC(15%) = $79,060. On the other hand, the economic service life for the challenger is also 5 years with AEC(15%) = $129,352. Even though the challenger is a better machine in terms of operating efficiency, its initial cost is too high to justify its purchase at this point.

(d) Replacement analysis under inflation

- Adjusted operating and maintenance cost by inflation: Sample calculation for fuel cost – Defender for Year 2:

    Fuel cost before inflation = $24,408
    Price index for fuel for year 2 = 120
    Fuel cost after inflation = $24,408(1.2) = $29,290

Other inflation-adjusted operating and maintenance cost elements can be calculated similarly. The following table summarizes these calculations. All cost figures are in actual dollars.

Defender

n	Maintenance	Labor	Fuel	Total
1	$50,544	$48,438	$26,849	$125,831
2	$54,288	$52,650	$29,290	$136,228
3	$58,032	$51,714	$29,968	$139,714
4	$58,968	$53,703	$32,273	$144,944
5	$59,904	$52,416	$32,544	$144,864

Challenger

n	Maintenance	Labor	Fuel	Total
1	$22,680	$40,365	$31,680	$94,725
2	$27,840	$43,875	$34,560	$106,275
3	$33,377	$43,095	$35,360	$111,832
4	$41,055	$44,753	$38,080	$123,888
5	$49,493	$43,680	$38,400	$131,573

- Replacement analysis: Keep the defender for now

Defender

n	Market value	Depreciation	O&M Cost	After tax Salvage	Dep. Tax credit	A/T O&M cost
0	$75,000					
1	$60,000	$0	$125,831	$36,000	$0	$75,498
2	$50,000	$0	$136,228	$30,000	$0	$81,737
3	$30,000	$0	$139,714	$18,000	$0	$83,828
4	$30,000	$0	$144,944	$18,000	$0	$86,966
5	$10,000	$0	$144,864	$6,000	$0	$86,918

n	Net O&M cost	Cumulative O&M cost	Net Investment	Equivalent Annual Cost		
				Capital cost	Operating cost	Total
0						
1	$75,498	$65,651	$13,696	$15,750	$75,498	$91,248
2	$81,737	$127,455	$22,316	$13,726	$78,398	$92,124
3	$83,828	$182,574	$33,165	$14,526	$79,967	$94,493
4	$86,966	$232,297	$34,708	$12,158	$81,374	$93,532
5	$86,918	$275,511	$42,017	$12,534	$82,185	$94,719

- **Challenger**

n	Market value	Depreciation	O&M Cost	After tax Salvage	Dep. Tax credit	A/T O&M cost
0	$400,000					
1	$300,000	$80,000	$94,725	$308,000	$32,000	$56,835
2	$240,000	$128,000	$106,275	$220,800	$51,200	$63,765
3	$190,000	$76,800	$111,832	$160,080	$30,720	$67,099
4	$150,000	$46,080	$123,888	$117,648	$18,432	$74,333
5	$115,000	$46,080	$131,573	$78,216	$18,432	$78,944

n	Net O&M cost	Cumulative O&M cost	Net Investment	Equivalent Annual Cost		
				Capital cost	Operating cost	Total
0						
1	$24,835	$21,596	$132,174	$152,000	$24,835	$176,835
2	$12,565	$31,097	$233,043	$143,345	$19,128	$162,473
3	$36,379	$55,016	$294,745	$129,098	$24,097	$153,195
4	$55,901	$86,978	$332,734	$116,557	$30,468	$147,025
5	$60,512	$117,063	$361,113	$107,720	$34,920	$142,640