Replacement Decisions

1 Introduction

- Aging assets may not provide sufficient quality, functionality or their costs may have become excessive
- What factors should be considered in an economic decision of when to replace?

2 Reasons for Replacement

- When there is a cheaper way to get the service:
  - Old assets often have high operating and/or maintenance costs (e.g., 1970s gas-guzzling cars)
  - Technological or organizational change (e.g., change from drafting boards to CAD systems)
- When the current asset is inadequate and has to be replaced, i.e., for insufficient capacity, poor quality, or doesn't meet environmental standards

3 Capacity Costs

- **Capital cost:** the depreciation expense incurred because the asset loses value over time
- **Installation cost:** cost of installing the asset (labour, lost output due to shutdown for installation and learning)
  - Installation costs occur at installation time, and are *not reversible*
- The incremental cost of keeping an installed asset is typically low.
- This gives the existing asset (called the **defender**) a built-in advantage over a potential replacement (called the **challenger**).

4 Operating and Maintenance Costs

- To use the asset, **operating and maintenance costs** will be incurred**.**
- In contrast to capital costs, operating and maintenance costs typically increase as the asset ages.
- To make a replacement decision, we must include both the capital and operating and maintenance costs.
- This is traditionally done with **equivalent annual cost (EAC)** computations.

5 Types of Replacements

- Is Challenger the same as or different from Defender?

1) Challenger is the same as Defender
   - e.g., a worn-out industrial air compressor is replaced *periodically* with a similar unit: how frequently should it be replaced?

2) Challenger is different than Defender: Succeeding Challengers are the same as the first Challenger
   - e.g., an old furnace can be replaced with a high-efficiency furnace; later replacements will also be high-efficiency. When should we replace the old one: now, next year, the year after ... ?

3) Challenger is different than Defender: Succeeding Challengers are different from first Challenger
   - e.g., an office computer is replaced with a more advanced one, and later, it is replaced by an even more advanced computer

6 Challenger is the Same as Defender: Economic Life

- If technology is not changing, if prices and interest rates are not changing, and if we will need this type of service "forever," then an asset will always be replaced with the same type of asset.
- This results in **cyclic replacement**; the length of the cycle is the **economic life**, defined as the lifetime that minimizes:

(*EAC of capital cost*)+ (*EAC of operating & maintenance costs*)

[EAC = Equivalent Annual Cost]

- EAC of capital cost decreases as the asset is kept longer.
- EAC of operating and maintenance costs increases as the asset is kept longer.
- Therefore, a minimum-EAC lifetime should exist.

Example 1 : A new bottle capping machine costs $40 000, plus $5000 for installation. The machine is expected to have a useful life of 8 years with no salvage value at that time (assume straight line depreciation). Operating and maintenance costs are expected to be $3000 for the first year, increasing by $1000 each year thereafter. Interest is 12%. What is the economic life of the bottle capper?

7 Challenger is Different from Defender

- When we replace an asset by another with a different technology, two cases can be examined:

Case 1: All succeeding challengers are the same as the current challenger

Case 2: The challengers after the current challenger will be different — most likely better

For Case 1, the general idea of the problem to solve:

eventually, we'll be in the era of the Challenger, which costs us the EAC of the Challenger, in $ per year; can we have a temporarily lower cost by keeping the Defender for a while?

Case 1: Sequence of Identical Challengers

1) Find EAC at the economic life of the challenger.

2) Find the cost of keeping the defender one more year.

3a) **IF** EAC(defender, one more year) $\leq$ EAC(challenger),

$\Rightarrow$ Keep the defender at least one more year

3b) **ELSE:** i.e.,

EAC(defender, one more year) > EAC(challenger),

IF there is a "life" for the defender that will give an EAC less than EAC(challenger),

$\Rightarrow$ Keep the defender for that "life" and then replace

ELSE

$\Rightarrow$ Replace the defender immediately

Example 2: Brockville Brackets (BB) has a 3 year old robot.

	Defender	Challenger
Purchase price	$300 000	$175 000
Installation	$50 000	$10 000
Useful life	12 years	9 years
Depreciation (per year)	20%	20%

The annual maintenance costs for the replacement robot are $40 000 the first year and will increase by 10% per year thereafter. The current robot's maintenance costs are expected to be $50 000 next year, also increasing at 10% per year. MARR is 15%. Should BB replace the robot? When?

Assumptions made in the solution of Example 2:

- The challenger will be replaced by a stream of robots with identical technology — that is what allowed us to compute the economic life of the challenger
- the installation cost of the Defender is irrelevant because we cannot change the past: it is a “sunk cost”
- the “first cost” of keeping the Defender is its salvage value *now*, i.e. the revenue that we would receive if we sold it now: this is the “opportunity cost” of keeping it

Case 2: Sequence of Different Challengers

- Normally we may expect the future challegers to be better than the current challenger.
- Then, do we skip over the current challenger and wait for the next “new and improved” challenger?
- Do we wait even longer for the anticipated next-generation “new and improved” challenger?
- We would have to enumerate all possible combinations of decisions and evaluate all to make a choice.

A variation of Example 2:

- BB may use the current robot for up to 9 years, and then replace it with a stream of new robots, or
- BB may, as an intermediate measure, replace the current robot with an upgraded used robot, to be kept for up to 9 years, followed by a stream of new robots.

- BB can list all the possible options as Mutually Exclusive projects.
- The possible projects might be listed as:

Project #	Keep Current Robot for	Keep Upgrade Robot for	Start stream of New Robots in
1	0 Years	0 Years	0 Years
2	1 Years	0 Years	1 Years
3	2 Years	0 Years	2 Years
...	...	...	...
10	9 Years	0 Years	9 Years
11	0 Years	1 Years	1 Years
12	1 Years	1 Years	2 Years
13	2 Years	1 Years	3 Years
...	...	...	...
20	9 Years	1 Years	10 Years
...	...	...	...
100	9 Years	9 Years	18 Years

- The EAC for each project would have to be calculated (quite a bit of work!).
- The list would increase geometrically if we expect that each Challenger was different from the preceding one.
- Typically, we shall have very little information about the costs and benefits of new challengers.
- It is often reasonable to assume that all challengers in the future will be approximately the same as the current challenger.

- **A last note:** How do we make a replacement decision when we need the asset for a **finite period** of time (e.g., for a contract of specified length)?

Example 3: How would the solution to Brockville Brackets (Example 2) change if BB only needed the services of the robot for an additional 5 years?