A System Dynamics Model For Replacement and Overhaul Policies On Capital Asset Subject To Technological Change

Farid Mardin
fmardin@tiunhas.net
Takeshi Arai
tarai@rs.noda.tus.ac.jp
Department of Industrial Administration, Faculty of Science and Technology
Tokyo University of Science
2641 Yamazaki, Noda City, Chiba 278-8510, Japan

Abstract

Capital asset replacement has a significant effect on company cash flow, since the investment on new asset is expensive. Overhaul policy can extend the optimal service life of an asset, and results in lower total life cycle cost of an asset. Technological change also affects the life cycle cost and optimal service life of an asset. In this paper we examine the replacement/renewal and overhaul/refurbish policies in a combination under technological change. We used System Dynamics model and simulate hypothetical data for 4 cases, and the output is in line with some previous studies using analytical models.

Keywords : Capital Asset, Replacement, Technological Change, System Dynamics

Introduction

Due to deteriorate, Operating and Maintenance costs (OMC) of running equipment increase with time, thus the older the age of running equipment, the higher the OMC. On the other hand, the older the asset, the acquiring cost can be spread out for longer periods, and as a result, the acquiring cost per unit period will decrease. In replacement theory, the acquiring cost known as Capital Costs (CC), which is consists of purchasing plus installation costs and book value or salvage value of the asset at the time when it replaced by the new asset.

Replacement or renewal of an asset has a very significant effect on OMC since right after renewal, the OMC cost decreases to its initial value. However, replacement action is expensive and too frequent replacement is inefficient. Major examination and repair, known as overhaul, of the running asset can reduce its OMC and extend its economic life. Overhaul of a running asset less expensive compare to replacement, but its effect on OMC reduction is less than the effect of replacement.

As an implication of technological change, the costs structure and the characteristic new assets with newer technological level are different from asset with older technological level, therefore the optimal service life of every asset is different. It is reasonable to postpone asset replacement until new asset with higher level of technology is introduced an available. But to extend the service life of running asset beyond its economic life results in higher OMC cost.

Many studies have been conducted concerning asset replacement under two types of technological change: continuous technological change and discontinuous technological change or technology breakthroughs [1]. In this paper, we use continuous technological change, where the new asset with newer technological level is released in every period.

The objective of this paper is to examine the combined effect of replacement and overhaul policy of capital asset under continuous technological change during planning horizon. A System Dynamics (SD) simulation model is used as a tool to evaluate the behavior of the system under some scenarios. There are previous studies in capital asset renewal, maintenance and overhaul problems using SD [2],[3],[4].Compare to analytical model, SD model more suitable for the systems containing complex structures and can be used for qualitative analysis and can be used as a tool for forecasting and decision making by comparing all possible simulation scenarios. Capital asset replacement problem under technological change is a hard problem.

This paper is organized as follows. First, we review the basic replacement theory and the effect of overhaul on asset service life and also we explain the effect of technological change on optimal replacement interval. Then, we formulate the model and explain the structure and logic of the model. The next section is numerical example and the output of simulation run using this assumption numerical variables and parameters for all scenarios. The last section is a conclusion and discussion about the simulation outputs.

Replacement, Overhaul and Technological Change on Capital Asset

Determining the optimal replacement time of running asset in replacement problem is a trade-off process between OMC and CC. In the classical replacement problem, there are two famous calculation methods, Economic Life (EL) method and Challenger-Defender (CD) method [5].

In EL method, the calculation of economic life of an asset only consider costs associated with this asset, regardless the costs associated with its newer available asset as a challenger. The economic life of is determined based on Equivalent Annual Cost (EAC) of OMC and CC, which is the time when the total EAC of OMC and CC reaches its minimum value. This method results in optimal solution if there is no technological change or the rate of technological change is relatively low, thus the properties of current asset and the properties of next asset for replacement are identical. In this situation, the optimal service life of every asset in serial replacement is equal.

Figure 1 shows the EAC curve associated with Total Costs, OMC, and CC. The figure shows that EAC of OMC increases with time, meanwhile EAC of CC decreases in time, therefore the EAC curve for total costs forms U-shaped curve, with one minimum point. The time associated with this minimum point is the economic life of the asset.

When there is a property difference between running asset and new asset available for replacement, one use the second method called CD method. In this method, the replacement time of running asset is determined by comparing marginal cost of keeping running asset (defender) for one more period and the minimum EAC of challenger, which is reached at its economic life. Therefore, in deciding replacement time of running asset, one has to consider the future cost of available challenger. However, it is counterintuitive since the solution from EL method outperforms CD method [6].

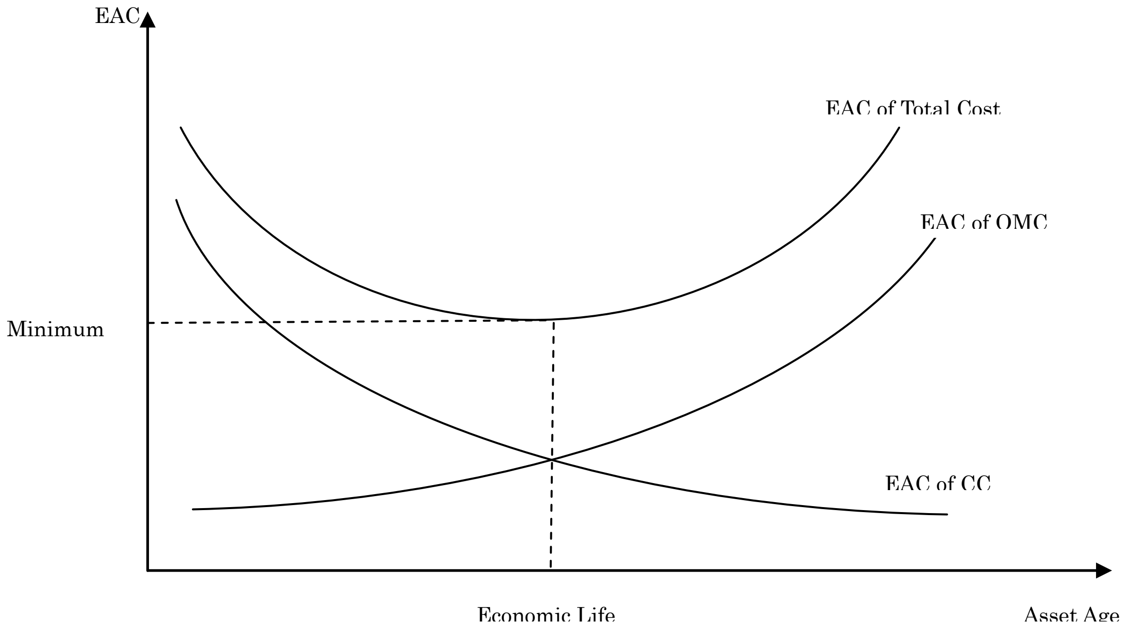

Figure 1.

Equivalent Annual Cost (EAC) of an Asset Vs Asset Age

OMC of a running asset can be reduced by overhaul action. The cost of overhaul is relatively cheaper compare to cost of replacement or renewal, but the effect on the OMC reduction is relatively small compare to the effect of renewal on reduction of OMC. The effect of overhaul on an aging asset only shifted downward its current OMC. Meanwhile, replacement of an asset with the new asset will reduce the OMC to OMC initial value of new asset with newer technology level, but it need more investment cost for purchase a new asset, which is relatively expensive compare to overhaul cost.

In practice, replacement policy can be used in a combination with overhaul policy. Overhaul action will improve performance of running asset and will reduce its current OMC. The improvement caused by an overhaul when the asset age is relatively new is relatively small compare to the improvement brought by an overhaul action when the age of the asset is relatively older [7]. If the OMC of running asset decreases, its economic life can be extended.

Figure 2 shows the pattern of replacement cycle of an asset with and without overhaul policy. The pattern shows that the replacement intervals are constant for both policies, but the replacement interval for asset with overhaul policy (dashed line) is longer compare to replacement interval for the asset without overhaul policy (continues line). The constant but different replacement interval for both policies shows that predecessor, current, and successor assets have a similar cost characteristics and performance because there are no technological changes.

As a consequence of technological change, predecessor, current and the successor assets have different costs characteristics and performances. New asset with newer technological level will have better performance, higher reliability, higher efficiency, lower energy consumption, lower initial OMC, and lower OMC increasing rate compare to new asset with older technological level. These variables have significant effect on OMC of the asset.

Figure 3 shows a typical OMC of asset with different technological level. For the asset with newer the technological level, the lower the initial OMC, deterioration rate and operating cost increasing rate. Therefore, the asset with the newer technological level can be used for a longer time to reach the same total OMC of the asset with previous technological level.

Purchasing price of new asset with newer technological level can be lower or higher compares to the older technological level asset. In general, for mechanical equipment, the purchasing price of new asset with newer technological level is more expensive compare to asset with previous level of technology. Figure 4 shows a typical purchasing price of asset with different technological level. There is also a situation where the purchasing price of asset with newer technological level is cheaper than the purchasing price of asset with older technological level, particularly for electronic equipments.

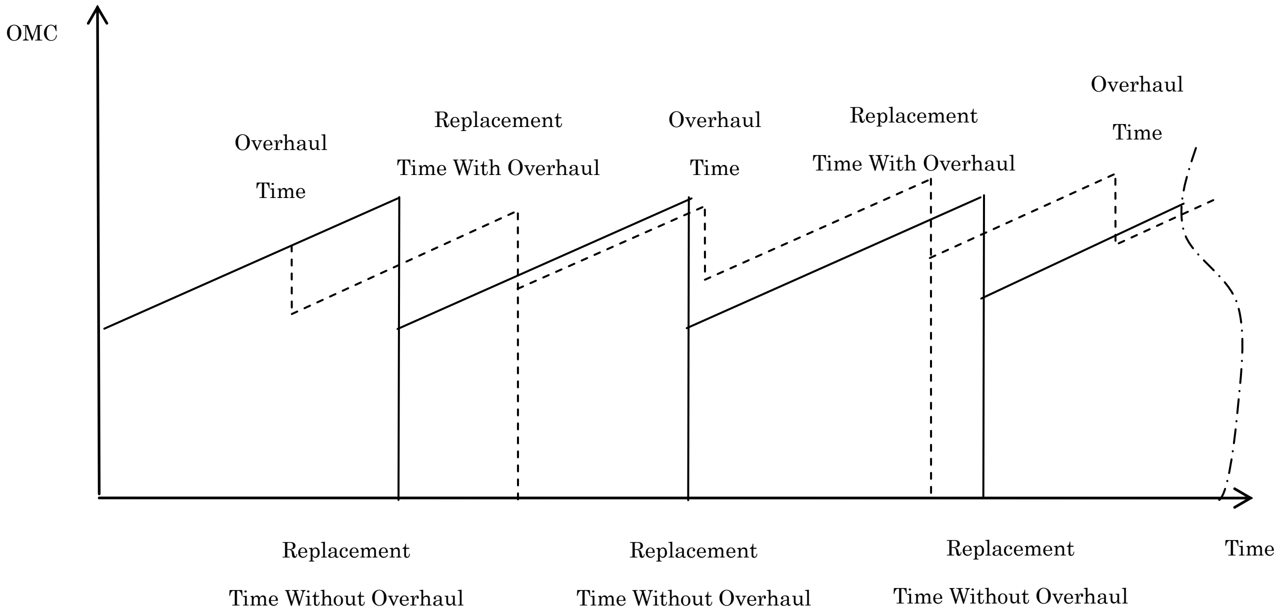

Figure 2.
Typical Replacement Cycle For Asset With Overhaul and Without Overhaul Policies (Without Technological Change)

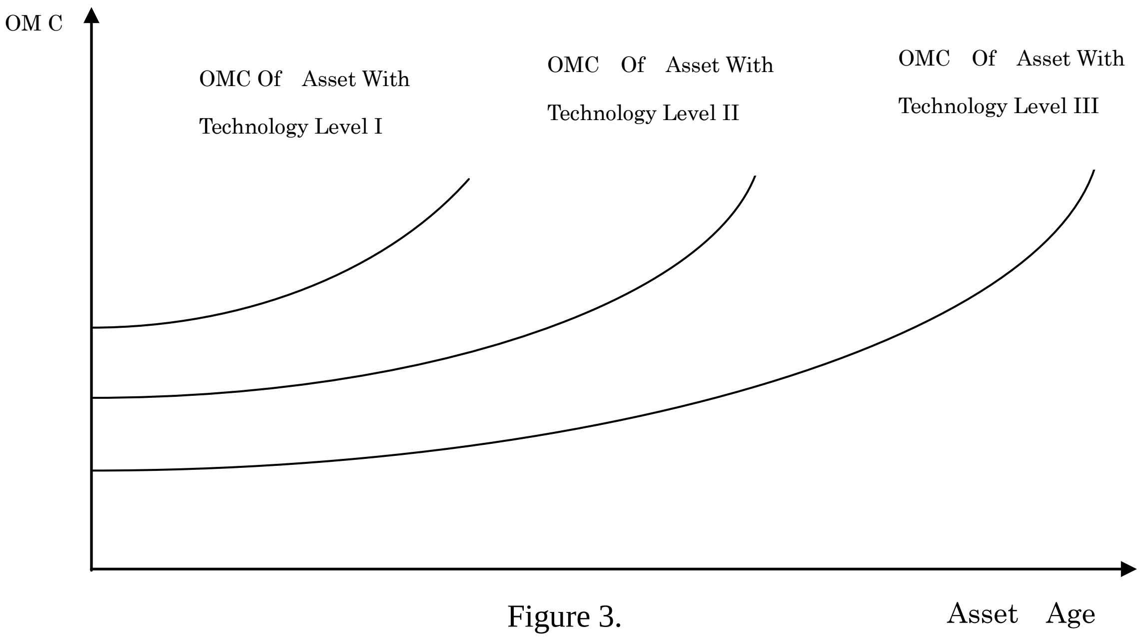

Figure 3.
Initial OMC and OMC Increasing Rate For Asset With Different Technological Level

Under this technological change circumstance, when the technological change rate relatively high, theoretically, the EL method yields sub-optimal solution, because the calculation of running asset economic life does not take into account the costs of new asset with newer technology level as available challenger. In this situation, logically, it is better to consider the costs of running asset (defender) and costs the newer asset available as a challenger to determine optimal service life of every asset. Therefore, the optimal life time of current asset depends on the optimal service life of previous asset and optimal service life of next asset. This problem can be described by quotation below [8]

"Not only does the replacement of machine n by machine n + 1 depend on the time when machine n replaced machine n – 1; it also depends on the time when machine n + 2 will replace machine n + 1."

Technological change provides new asset with newer technology level with a relatively higher reliability, more efficient, lower initial OMC, and lower OMC increasing rate. If the replacement interval relatively longer, the service life of running equipment becomes longer, therefore, its total life cycle cost increases. On contrary, the longer the replacement interval, the lower initial OMC and OMC increasing rate of the newer equipment available for replacement. The purchasing price increases as well, thus there will be a trade-off process to find the optimum time to replace running asset with the new asset.

For running asset, the total costs can be reduced by overhaul policy. Overhaul action reduces the current OMC level right after overhaul. There is a trade-off to find the optimum overhaul time. On the one hand, the more frequent overhaul, the higher the overhaul cost, but on the other hand, it reduces the running asset OMC and extends its optimal service life.

Technological change will affect the optimal replacement interval. There are two possibilities of replacement interval. The first is one is increasing optimal replacement interval, the optimal service time of current asset is longer than the optimal service life of its predecessor, and shorter than optimal service life of its successor occurs when the technological change rate in the purchasing cost is less intense than the technological change rate in the initial OMC and OMC increasing rate. The second one is decreasing optimal replacement interval, the optimal service time of current asset is shorter than the optimal service life of its predecessor, and longer than optimal service life of its successor occurs when the effect of technological change rate on the purchasing cost is equal to or greater than the technological change rate on the OMC [1].

Figure 5 shows a typical increasing optimal replacement interval with overhaul policy (dashed line) and without overhaul policy (continues line). The initial OMC and OMC increasing rate of new asset with newer technology level are lower than those of new asset with older technological level. Therefore, it takes longer time for the asset with newer technological level to reach the same OMC of asset with older technological level.

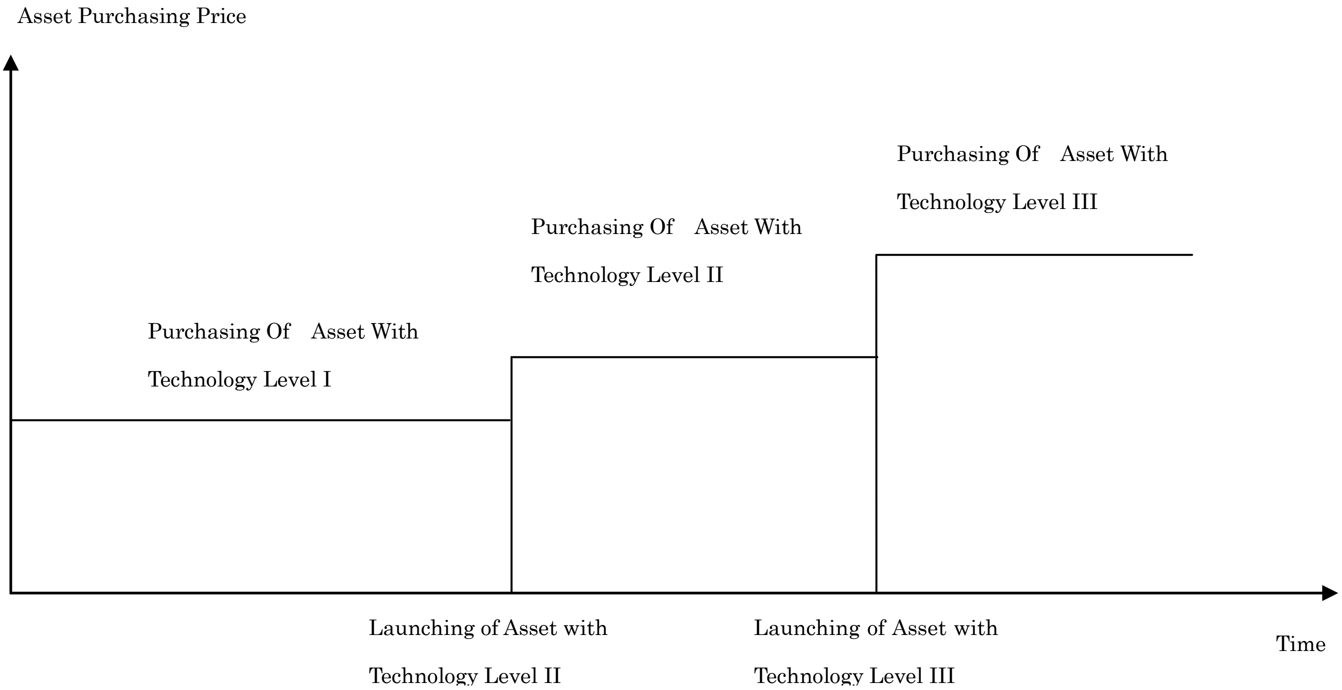

Figure 4.

Typical Purchasing Price of New Equipment With Different Technological Level

Model Formulation and Description

In this paper, we use Stella Software to model this problem. For convenience, we make two sectors, the first is New Asset Innovation sector, and the second is Running Asset and Cost Accumulation sector

Figure 6 shows the New Asset Innovation Sector. At the beginning of simulation, Purchasing Price, Initial OMC, Initial OMC Increasing Rate are set to Purchasing Price Base, Initial OMC Base, Initial OMC Increasing Rate Base, respectively. Throughout the simulation, Initial OMC and OMC Increasing Rate decrease and Purchasing Cost increases according to Technological Change Rate of Initial OMC Per Period, Technological Change Rate of OMC Increasing Rate Per Period, and Technological Change Rate of Purchasing Price Per Period, respectively.

Figure 7 shows the sector of Running Asset and The Cost Accumulation from all assets used during the simulation length. In every Replacement Time, the running asset is replaced by new asset. For this new replacement asset, the values of Initial OMC, OMC Increasing Rate and Purchasing Cost are set to the values of new asset with newest technological level which is available at this replacement time. OMC of running asset increases due to aging according to its OMC Increasing Rate Per Period. Salvage value of running asset decreases by its Depreciation Rate Per Period, thus the capital cost increases as the asset getting older. When OMC of running asset is relatively high, it is more economical to purchase a new asset to replace the running asset. OMC of running asset can be reduced by overhaul action. Just after overhaul, OMC of running asset decreases, but not as low as its initial value. The reduction of OMC after overhaul is depend on OMC decreasing rate per overhaul, which is function of age of the asset being overhauled, the older the running asset age, the higher the OMC reduction. Overhaul action incurs Overhaul Cost and this cost is a function of Overhaul Cost Base per overhaul, Overhaul Cost Increasing Rate, and Age of Running Asset which is overhauled

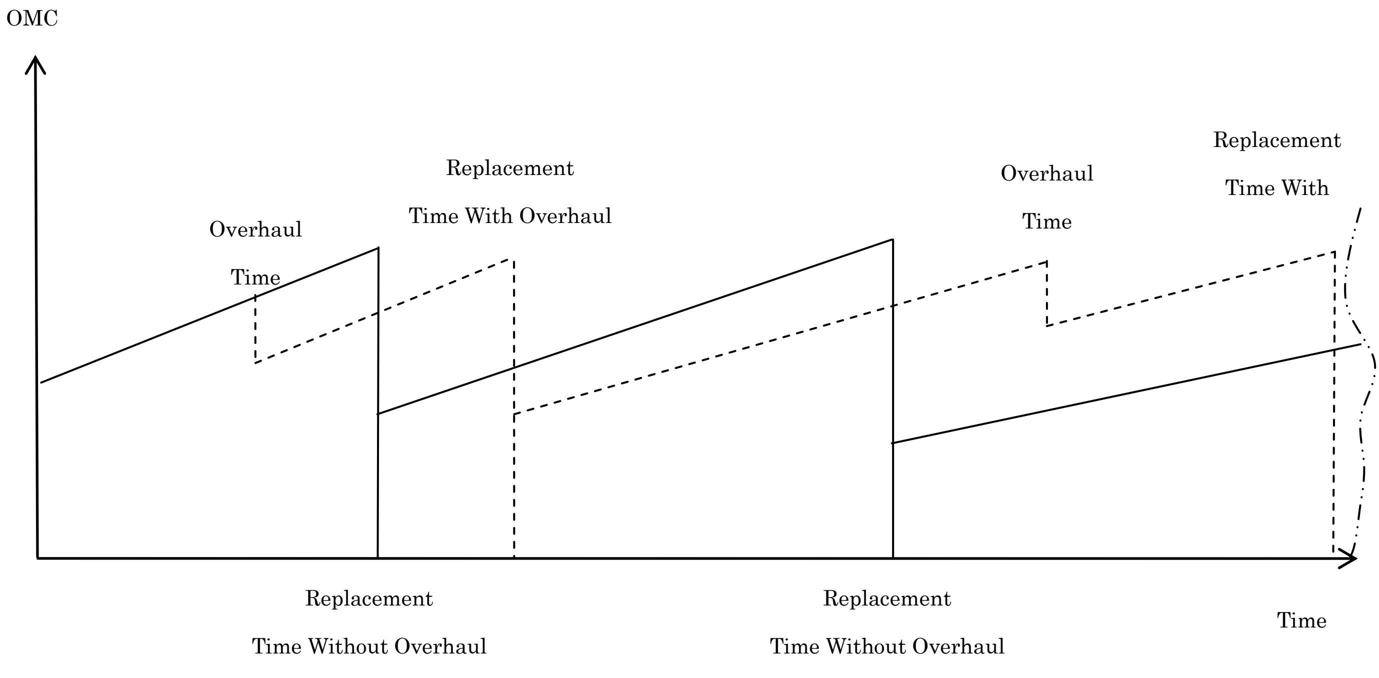

Figure 5.
Typical Replacement Cycle For Asset With Overhaul and Without Overhaul Policies
(With Technological Change)

Capital Cost, OMC, and Overhaul Cost for all assets use during Simulation Length (planning horizon) are accumulated as total costs and discounted at its Discount Rate Period to get NPV of total cost.

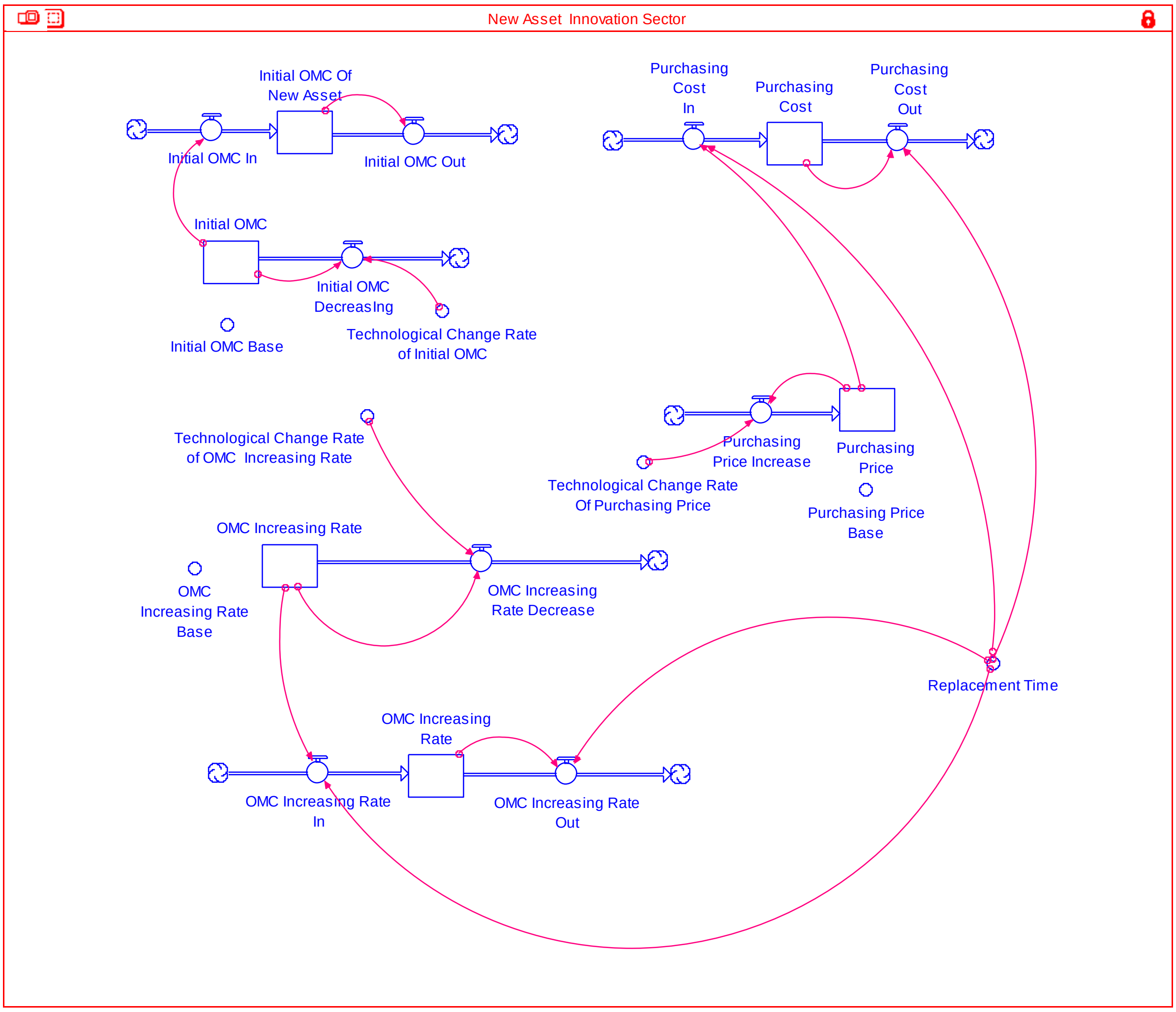

Figure 6

New Asset Innovation Sector

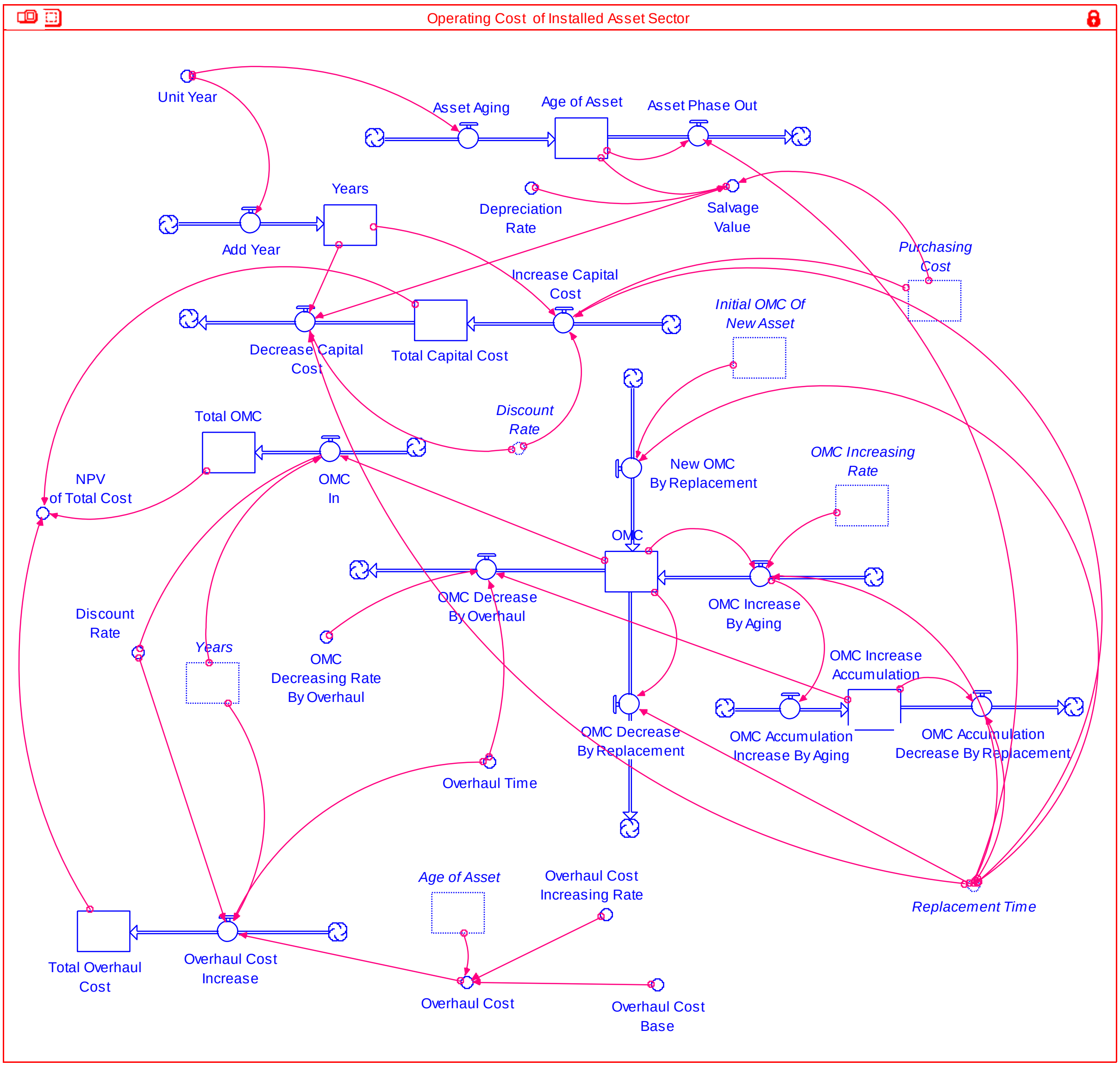

Figure 7

Running Asset and Cost Accumulation Sector

Numerical Example and Results

Since there is no real technological change rates data, we use values 0.01 which are the minimum values of technological change rates used in [6]. The data we use in this simulation are as follows.

Purchasing Price Base	: 100.000
Initial OMC Base	: 3000
OMC Increasing Rate Base	: 0.30
Discount Rate Per Period	: 0.10
Depreciation Rate Per Period	: 0.15

Overhaul Cost Base	: 1000
Overhaul Cost Increasing Rate Per Period	: 0.10
OMC Decreasing Rate Due To Overhaul	: 0.50
Technological Change Rate Of Purchasing Price Per Period	: 0.01
Technological Change Rate Of Initial OMC Per Period	: 0.01
Technological Change Rate of OMC Increasing Rate Per Period	: 0.01
Simulation Length (Periods)	: 50

We use 4 cases as follows

1. Replacement problem without overhaul policy and no technological change
2. Replacement problem with overhaul policy and no technological change
3. Replacement problem without overhaul under technological change
4. Replacement problem with overhaul policy under technological change

The optimal policy for case 1 is to replace the running asset in every 7 periods and the NPV of total cost is 238,702. The effect of overhaul can be seen in case 2, the total NPV of total cost is lower, only 232,095. In this case, the optimal replacement times are 8, 16, 24, 32, 40 and 48 and overhaul times are 4, 12, 20, 28, 36, and 44. The replacement interval is constant in every 8 periods, and overhaul interval also constant every 8 periods.

For case 3, the effect of technological change is taking into consideration. Effect of technology change on asset replacement, not only reduce the total costs, but change the optimal replacement interval as well. In case 3, the replacement interval is increasing. Assets service life is 6, 7, 8, 9, and 10 periods. The NPV of total cost for case 3 is 234,636, lower than case 1 when there is no technological change. And the asset service life of successor asset is always longer than its predecessor because both initial OMC and OMC increasing rate of newer asset are lower than those of previous asset.

In case 4, we examine the effect of overhaul policy and technological change on asset replacement problem. For case 4, the NPV of total cost is 228,450 which is the lowest among all cases. The replacement interval increases as in 3 due to technological change and overhaul interval increases as well. The optimal replacement times are 8, 18, 30, and 44, and the optimal overhaul times are 4, 13, 24, and 37.

Figures 8, 9, 10 and 11 present the simulation results of NPV of Total Capital Costs, NPV of Total OMC , NPV of Total Overhaul Costs , and NPV of Total Cost, for all cases, respectively. The summary of NPV of all total costs, replacement interval and overhaul interval for all cases is shown in Table 1.

First, comparing case 1 and case 2 when there is no technological change, it is shown in case 1, there is no overhaul cost, but the OMC is higher than the OMC for case 2, however, overhaul action insignificantly reduce the OMC. In case 1, NPV of

Total OMC is lower compare to the sum of NPV of total OMC and NPV of Total Overhaul Cost in Case 2, meaning there is no benefit from overhaul action on OMC. The benefit of overhaul action is gained from the reduction of NPV of Total Capital Cost. The effect of overhaul in case 2 is significantly reduce NPV of Total Capital Cost because the optimal life of every asset use during planning horizon is relatively high compare to optimal life of every asset in case 1.

For replacement problem under technological change cases, as in cases 3 and 4, the overhaul action, unexpectedly, does not reduce NPV of OMC, the OMC increases, instead.. As in no technological change, the benefit of overhaul action is gained from the reduction of NPV of Capital Cost, but the reduction of in case 4 is higher than the reduction in case 2.

Table 1.

Summary Of Simulation Results For All Cases

Case	**Replacement Time**	**Overhaul Time**	**NPV of Total Capital Cost**	**NPV of Total OMC**	**NPV of Total Overhaul Cost**	**NPV of Total Cost**
Case 1	7, 14, 21, 28, 35, 42, 49	No Overhaul	170.943	67.758	0	238.702
Case 2	8, 16, 24, 32, 40, 48	4, 12, 20, 28, 36, 44	162.960	67.279	1.855	232.095
Case 3	6, 13, 21, 30, 40	No Overhaul	175.056	59.580	0	234.636
Case 4	8, 18, 30, 44	4, 13, 24, 37	157.285	69.446	1.718	228.450

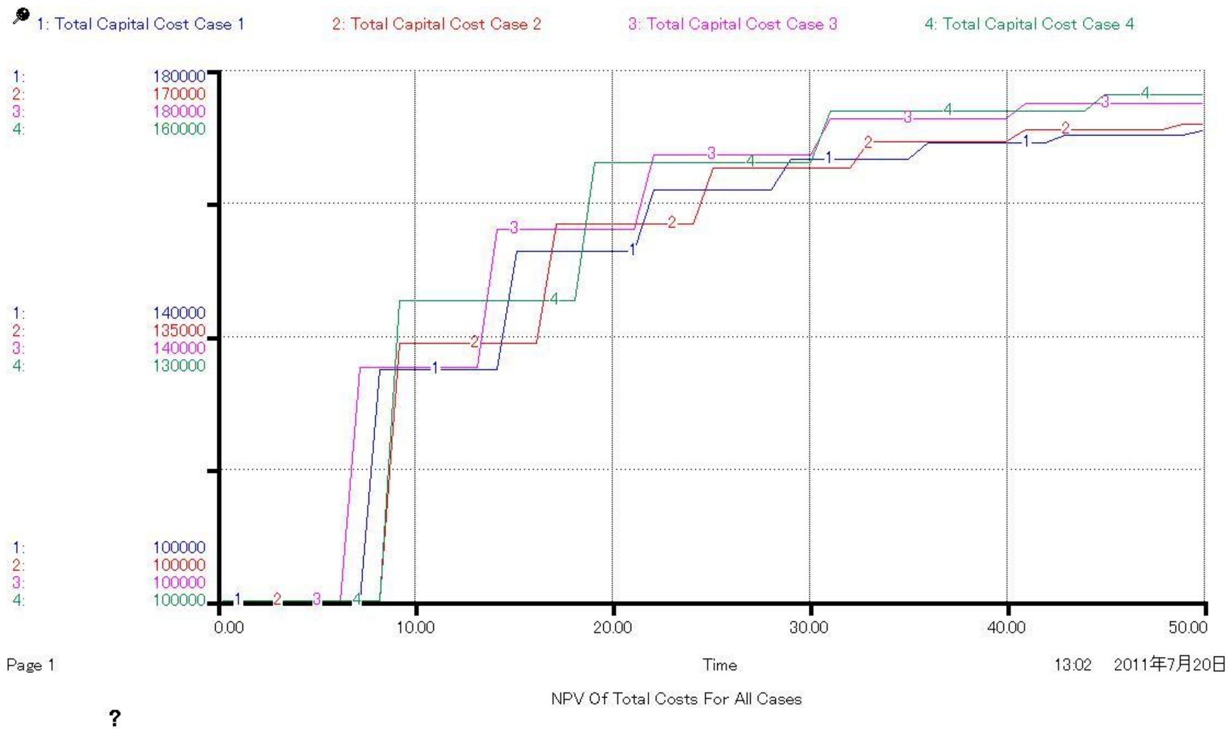

Figure 8
NPV of Total Capital Costs for all cases

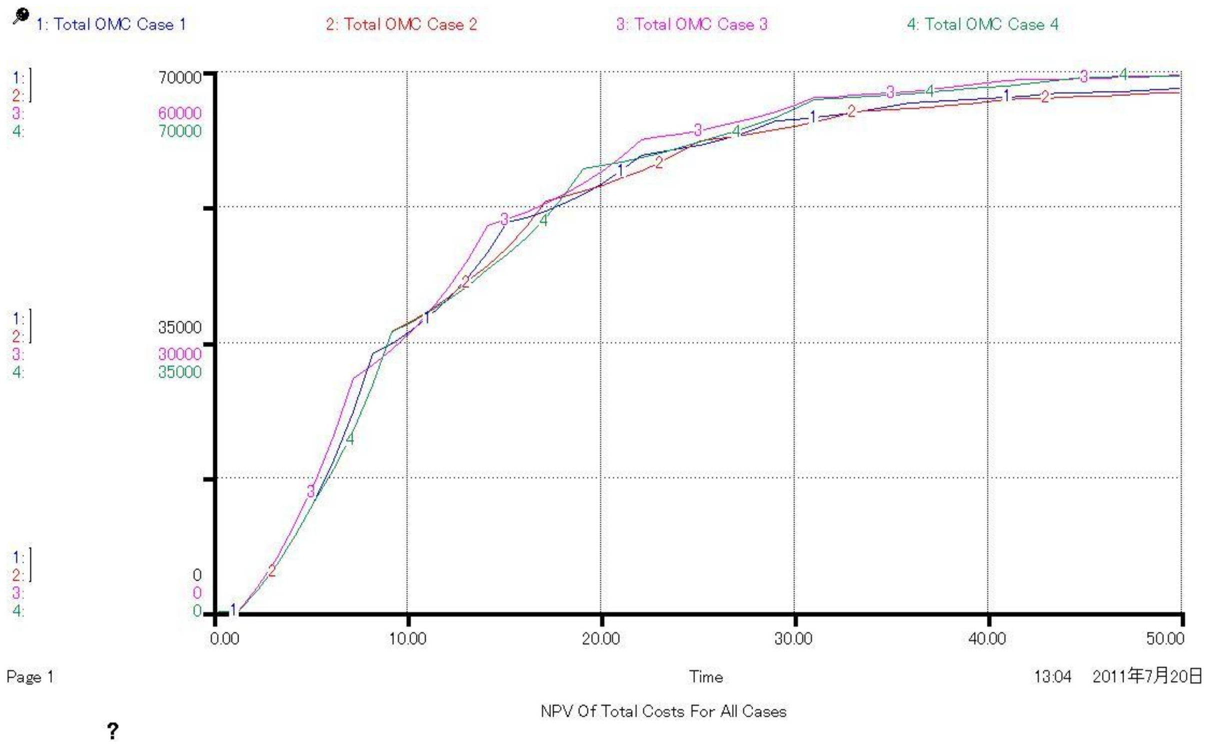

Figure 9
NPV of Total OMC for all cases

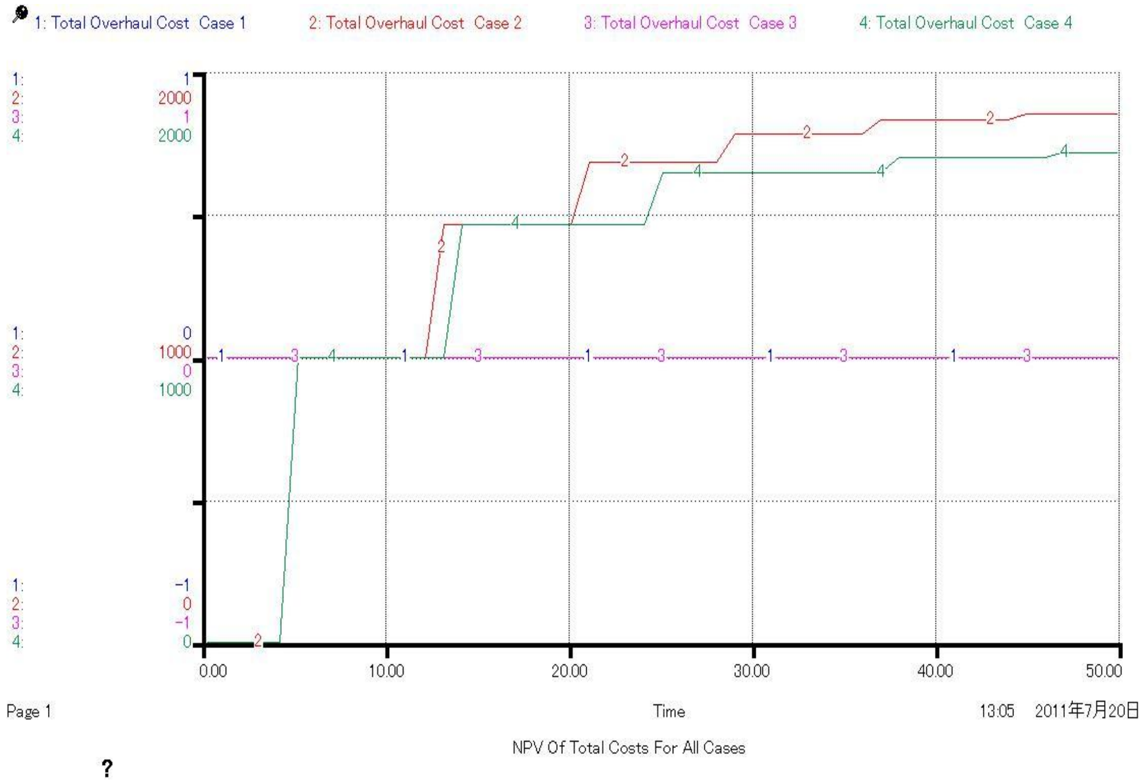

Figure 10

NPV of Total Overhaul Cost for all cases

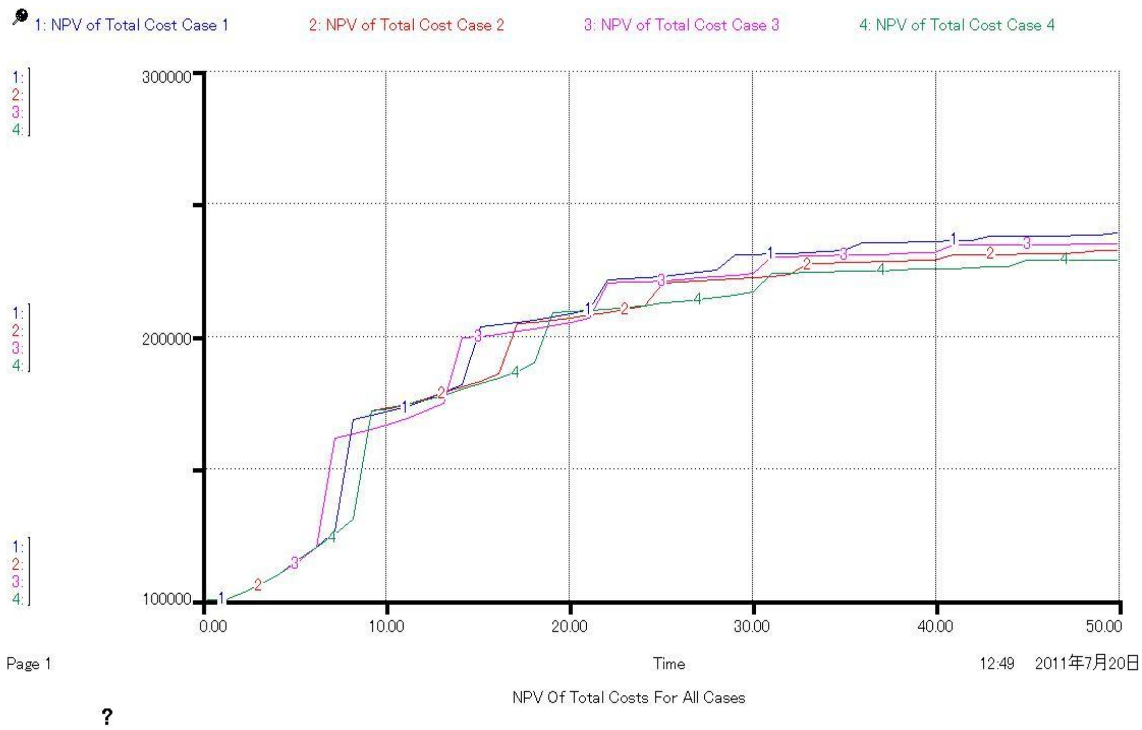

Figure 11

NPV of Total Cost for all cases

Conclusions

In this paper we used SD model to examine the behavior of optimal replacement time of capital asset. Since we could not have any real data to simulate, hypothetical data are used to evaluate the model. The behavior of the model is in line with several previous analytical models in replacement and overhaul problems. Overhaul action can extend the economic life of capital asset and reduce NPV of total costs during planning horizon as shown by case 1 and case 2. Technological change provides a new asset with newer technological level with lower initial OMC and OMC increasing rate, thus the interval of serial replacement is increasing, also the NPV of total cost for all asset use during planning horizon is lower as shown by case 1 and case 3.The combination of replacement and overhaul policies results the lowest NPV of total cost as shown by case 4.

The lack of real data, especially for technological change rate on Purchasing Price, Initial OMC, and OMC increasing rate is a primary constraint to validate the model. In the future, we have to collect the real data in order to further validate this developed SD model.

References

[1] Yatsenko,Y. and Hritonenko, N. "Technological Breakthroughs And Asset Replacement." The Engineering Economist, Vol. 54 (2009) : 81-100.

[2] Bivona, E.and Montemaggiore, G.B."Understanding Short and Long-Term Implications Of "Myopic" Fleet Maintenance Policies : A System Dynamics Application to A City Bus Company." System Dynamics Review, Vol. 26, No 3 (2010) : 195-215

[3] Killingsworth, W.R., Speciale, S.M., Martin, N.T. "The Role Of Overhaul In Reducing Lifecycle Costs and Maximizing The Return on Investment to Improve Reliability" (paper presented at The 28th International Conference Of The System Dynamics Society, Seoul, South Korea, July 25-29, 2010)

[4] Caicedo, S. and Diaz, F.A. "Too Early, Too Quickly : Impact Of Short Term Decision In Fleet Renewal Programs" (paper presented at The 27th International Conference Of The System Dynamics Society, Albuquerque, New Mexico, USA, July 26-30, 2009)

[5] Fraser, N.M et al., *Global Engineering Economics : Financial Decision Making For Engineers 4th Edition*. Toronto : Pearson Education Canada, 2008

[6] Regnier, E., Sharp, G., Tovey, C. "Replacement Under Ongoing Technological Progress." IIE Transcation, 36 (2004) : 497-508

[7] Roll, Y. and Sachish, A. "Combined Overhaul And Replacement Policies For

Deteriorating Equipment.” Journal Of The Operations Research Society Of Japan, Vol 21, No 2 (1978) : 274-286.
[8] Masse,P., *Optimal Investment Decisions*. Englewood Cliffs, NJ: Prentice Hall, 1962.

Annex 1. Equations Of The Model

Age_of_Asset(t) = Age_of_Asset(t - dt) + (Asset_Aging - Asset_Phase_Out) * dt
INIT Age_of_Asset = 0
INFLOWS:
Asset_Aging = Unit_Year
OUTFLOWS:
Asset_Phase_Out = IF(Replacement_Time=0) THEN (Age_of_Asset*0) ELSE (Age_of_Asset*1)
Initial_OMC(t) = Initial_OMC(t - dt) + (- Initial_OMC__DecreasIng) * dt
INIT Initial_OMC = Initial_OMC_Base
OUTFLOWS:
Initial_OMC__DecreasIng = Initial_OMC*Technological_Change_Rate_of_Initial_OMC
Initial_OMC_Of_New_Asset(t) = Initial_OMC_Of_New_Asset(t - dt) + (Initial_OMC_In - Initial_OMC_Out) * dt
INIT Initial_OMC_Of_New_Asset = Initial_OMC
INFLOWS:
Initial_OMC_In = Initial_OMC
OUTFLOWS:
Initial_OMC_Out = Initial_OMC_Of_New_Asset
OMC(t) = OMC(t - dt) + (OMC_Increase_By_Aging + New_OMC__By_Replacement - OMC_Decrease__By_Overhaul - OMC_Decrease_By_Replacement) * dt
INIT OMC = 0
INFLOWS:
OMC_Increase_By_Aging = IF(Replacement_Time=0) THEN (OMC_Increasing__Rate*OMC) ELSE (0)
New_OMC__By_Replacement = IF(Replacement_Time=0) THEN (Initial_OMC_Of_New_Asset*0) ELSE (Initial_OMC_Of_New_Asset*1)
OUTFLOWS:
OMC_Decrease__By_Overhaul = IF(Overhaul_Time=0) THEN (0) ELSE (OMC_Increase_Accumulation*OMC_Decreasing_Rate_By_Overhaul)

OMC_Decrease_By_Replacement = IF(Replacement_Time=0) THEN (OMC*0) ELSE (OMC*1)

OMC_Increase_Accumulation(t) = OMC_Increase_Accumulation(t - dt) + (OMC_Accumulation_Increase_By_Aging - OMC_Accumulation_Decrease_By_Replacement) * dt

INIT OMC_Increase_Accumulation = 0

INFLOWS:

OMC_Accumulation_Increase_By_Aging = OMC_Increase_By_Aging

OUTFLOWS:

OMC_Accumulation_Decrease_By_Replacement = IF(Replacement_Time=0) THEN (OMC_Increase_Accumulation*0) ELSE (OMC_Increase_Accumulation)

OMC_Increasing_Rate(t) = OMC_Increasing_Rate(t - dt) + (-OMC_Increasing__Rate_Decrease) * dt

INIT OMC_Increasing_Rate = OMC__Increasing_Rate_Base

OUTFLOWS:

OMC_Increasing__Rate_Decrease = OMC_Increasing_Rate*Technological_Change_Rate__of_OMC__Increasing_Rate

OMC_Increasing__Rate(t) = OMC_Increasing__Rate(t - dt) + (OMC_Increasing_Rate_In - OMC_Increasing_Rate_Out) * dt

INIT OMC_Increasing__Rate = OMC_Increasing_Rate

INFLOWS:

OMC_Increasing_Rate_In = IF(Replacement_Time=0) THEN (OMC_Increasing_Rate*0) ELSE (OMC_Increasing_Rate*1)

OUTFLOWS:

OMC_Increasing_Rate_Out = IF(Replacement_Time=0) THEN (OMC_Increasing__Rate*0) ELSE (OMC_Increasing__Rate*1)

Purchasing__Cost(t) = Purchasing__Cost(t - dt) + (Purchasing_Cost_In - Purchasing__Cost_Out) * dt

INIT Purchasing__Cost = Purchasing_Price_Base

INFLOWS:

Purchasing_Cost_In = IF(Replacement_Time=0) THEN (Purchasing__Price*0) ELSE (Purchasing__Price*1)

OUTFLOWS:

Purchasing__Cost_Out = IF(Replacement_Time=0) THEN (Purchasing__Cost*0) ELSE (Purchasing__Cost*1)

Purchasing__Price(t) = Purchasing__Price(t - dt) + (Purchasing__Price_Increase) * dt

INIT Purchasing__Price = Purchasing_Price_Base

INFLOWS:
Purchasing__Price_Increase = Purchasing__Price*Technological_Change_Rate_Of_Purchasing_Price
Total_Capital_Cost(t) = Total_Capital_Cost(t - dt) + (Increase_Capital__Cost - Decrease_Capital__Cost) * dt
INIT Total_Capital_Cost = Purchasing__Cost
INFLOWS:
Increase_Capital__Cost = IF(Replacement_Time=0) THEN (Purchasing__Cost*0) ELSE (Purchasing__Cost/(1+Discount__Rate)^Years)
OUTFLOWS:
Decrease_Capital__Cost = IF(Replacement_Time=0) THEN (Salvage_Value*0) ELSE (Salvage_Value/(1+Discount__Rate)^Years)
Total_OMC(t) = Total_OMC(t - dt) + (OMC_In) * dt
INIT Total_OMC = 0
INFLOWS:
OMC_In = OMC/(1+Discount__Rate)^Years
Total_Overhaul_Cost(t) = Total_Overhaul_Cost(t - dt) + (Overhaul_Cost__Increase) * dt
INIT Total_Overhaul_Cost = 0
INFLOWS:
Overhaul_Cost__Increase = IF(Overhaul_Time=0) THEN (0) ELSE ((Overhaul_Cost)/(1+Discount__Rate)^Years)
Years(t) = Years(t - dt) + (Add_Year) * dt
INIT Years = 0
INFLOWS:
Add_Year = Unit_Year
Depreciation__Rate = 0.15
Discount__Rate = 0.15
Initial_OMC_Base = 300
NPV_of_Total_Cost = Total_Capital_Cost+Total_OMC+Total_Overhaul_Cost
OMC_Decreasing_Rate_By_Overhaul = 0.5
OMC__Increasing_Rate_Base = 0.3
Overhaul_Cost = Overhaul_Cost__Base*(1+Overhaul_Cost_Increasing_Rate)^Age_of_Asset
Overhaul_Cost_Increasing_Rate = 0.1
Overhaul_Cost__Base = 100
Purchasing_Price_Base = 10000

Salvage_Value = Purchasing__Cost*(1-Depreciation__Rate)^(Age_of_Asset)
Technological_Change_Rate_of_Initial_OMC = 0.01
Technological_Change_Rate_Of_Purchasing_Price = 0.01
Technological_Change_Rate__of_OMC__Increasing_Rate = 0.01
Unit_Year = 1
Overhaul_Time = GRAPH(TIME)
Replacement_Time = GRAPH(TIME)