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Reengineering of Road Maintenance System

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Abstract: As we know that maintenance is very critical activity, in each and every fields, it is not only critical but also very risky as well as costly. Therefore, reengineering is good choice for this purpose. The objective of this paper is to identify different type of factor that helps in reengineering of road management system. The research plan is to conduct survey, to generate case studies and build a framework i.e based on spatial database and attributes of the system. That uses dynamic segmentation to link road, geographic information and attribute information. Framework is designed in such a way that help us during reengineering of road maintenance system, to allocate resources according to need of plans, requirements, type of road network and help road manager to determine which type of maintenance is used when and to determine how much time, cost & resources are required to generating an optimal maintenance plan for a road. Optimal means, minimizing net present value of maintenance cost. The aim of this paper is developed such kind of framework, which can measure the overall efficiency of road maintenance operation. The framework is designed to consider the effect of environment (such as climate, location etc.) and operation (traffic load) factor on such efficiency.

Keywords: Reengineering, Reengineering Economics, type of maintenance, Framework of Road Maintenance

I. INTRODUCTION

A road is a route, or way on land between two places, which typically has been paved or otherwise improved to allow travel by some conveyance, including a horse, cart, or motor vehicle. Roads can be one way or two way each with one or more lanes and also any associated side lanes and tree lawns. Roads that are available for use by the public may be referred to as public roads or highways.

Road construction requires the creation of a continuous right-of-way, overcoming geographic obstacles and having grades low enough to permit vehicle or foot travel [1] and may be required to meet standards set by law [2] or official guidelines [3] . The process is often begun with the removal of earth and rock by digging or blasting, construction of embankments, bridges and tunnels, and removal of vegetation (this may involve deforestation) and followed by the laying of pavement material. A variety of road building equipment is employed in road building [4, 5].

After design, approval, planning, legal and environmental considerations have been addressed; alignment of the road is set out by a surveyor [6].

Like all structures, roads deteriorate over time. Deterioration is primarily due to accumulated damage from vehicles, however environmental effects such as frost heaves, thermal cracking and oxidation often contributes [7] to it.

According to a series of experiments carried out in the late 1950s, called the AASHO Road Test, it was empirically determined that the effective damages done to the road is roughly proportional to the Fourth power of axle weight [8]. A typical tractor-trailer weighing 80,000 pounds (36.287 t) with 8,000 pounds (3.629 t) on the steer axle and 36,000 pounds (16.329 t) on both of the tandem axle groups is expected to do 7,800 times more damage than a passenger vehicle with 2,000 pounds (0.907 t) on each axle. Potholes on roads are caused by rain damage and vehicle braking or related construction works.

Virtually all roads require some form of maintenance before they come to the end of their service life. Pro-active agencies continually monitor road conditions and apply preventive maintenance treatments as needed to prolong the lifespan of their roads. Technically advanced agencies monitor the road network surface condition with sophisticated equipment such as laser/inertial Profilometers. These measurements include road curvature, cross slope, asperity, roughness, rutting and texture (roads).

However, maintenance is very costly and time consuming, therefore, reengineering is good choice rather then maintenance. Reengineering is helpful to reduce not only risk associated with maintenance of the system but also helps to:

a. improves one's understanding of existing system,
b. prepares or improves the existing system itself, usually for increased maintainability, reusability.

Reengineering can help reduce an organization's evolution risk. It is not uncommon for the only source of information regarding why a existing system does what it does to be the existing system itself. Reengineering hence can help an organization recoup its investment in existing system. Reengineering can make existing system easier to change and improve its reusability. Incorporation of new design and implementation techniques can create a more modular and compos able system, accommodating not only future modifications more effectively but also the re-composition of a system into a new approach for a new system.

Hence reengineering is a catalyst for automating system maintenance, providing a cusp through which an organization (private/public that is responsible for road maintenance) can take a fresh direction in its development and support of the organization's system portfolio, as well as acting as a potential agent for enabling reuse within the organization.

In this paper reengineering apply on road maintenance system that help us to analyze, understand and determine how reengineering reduces the cost of maintenance not only in software system but also reduces the cost of any physical system. Here, we have apply reengineering on road maintenance system, and develop a framework that reduces the overall complexity of maintenance, reduces maintenance cost, resources required during maintenance of different type of road maintenance.

II. REENGINEERING ECONOMICS

The decision to reengineer is usually fiscal, rather than technical. Systems become increasingly expensive to maintain as they age and 'bit rot' sets in – the increasing occurrence of errors are induced through miscomprehension of increasingly contorted code. However, the criteria from which arises the decision to redevelop or reengineer a system are diverse and extremely fuzzy. Sneed (Sneed 1991) lays out a simple framework for judging the derived benefit. Management is typically first concerned with the cost of reengineering relative to the cost of redevelopment and the cost of maintenance. The choice between redevelopment and reengineering is principally one involving the difference in value attached to the old and new system, balanced by the risks associated with the anticipated costs of (in)action:

Reengineering Benefit = [Old_Value – (Reeng_Cost * Reeng_Risk)] – [New_Value – (Dev_Cost * Dev_Risk)]

The life-expectancy of the existing system relative to the time required to reengineer it and the time required to redevelop it should appear as weights in the risk terms. Note that it is quite possible to derive negative benefit if the cost or risk of reengineering the system is sufficiently high compared to the costs of just starting over from scratch.

The choice between continued maintenance and reengineering is structured similarly:

Reengineering Benefit = [Old_Maint_Cost – Reeng_Maint_Cost] + [Old_Value – (Reeng_Cost * Reeng_Risk)] – [New_Value – (Dev_Cost * Dev_Risk)]

factoring in an additional term addressing the expected difference in maintaining the old versus reengineered system. The *added* value of reengineering a new system must be balanced against the *current* value of the present system. This is also risky to reengineer relative to the risk of a new development and the risk of doing nothing.

III. REENGINEERING RISKS

In order to factor risk into an economic decision model such as the one above, it is first necessary to understand just where risks lie, and the form that they might take. Arnold elaborates the following framework for categorizing risk in the reengineering of software (Arnold 1993):

- ***a.*** Process risks
- ***b.*** Personnel risks
- ***c.*** Application risks
- ***d.*** Technology risks
- ***e.*** Tool risks
- ***f.*** Strategy risks

IV. REVIEW OF THE LITERATURE

Like all structures, roads deteriorate over time. Deterioration is primarily due to accumulated damage from vehicles, however environmental effects such as frost heaves, thermal cracking and oxidation often contribute [9]. According to a series of experiments carried out in the late 1950s, called the AASHO Road Test, it was empirically determined that the effective damage done to the road is roughly proportional to the Fourth power of axle weight [10]. A typical tractor-trailer weighing 80,000 pounds (36.287 t) with 8,000 pounds (3.629 t) on the steer axle and 36,000 pounds (16.329 t) on both of the tandem axle groups is expected to do 7,800 times more damage than a passenger vehicle with 2,000 pounds (0.907 t) on each axle. Potholes on roads are caused by rain damage and vehicle braking or related construction works.

Pavements are designed for an expected service life or design life. In some UK countries the standard design life is 40 years for new bitumen and concrete pavement. Maintenance is considered in the whole life cost of the road with service at 10, 20 and 30 year milestones [11]. Roads can be and are designed for a variety of lives (8-, 15-, 30-, and 60-year designs). When pavement lasts longer than its intended life, it may have been overbuilt, and the original costs may have been too high. When a pavement fails before its intended design life, the owner may have excessive repair and rehabilitation costs. Many concrete pavements built since the 1950s have significantly outlived their intended design lives [12]. Some roads like Chicago, Illinois's "Wacker Drive", a major two-level viaduct in downtown area are being rebuilt with a designed service life of 100 years [13].

Virtually all roads require some form of maintenance before they come to the end of their service life. Pro-active agencies continually monitor road conditions and apply preventive maintenance treatments as needed to prolong the lifespan of their roads. Technically advanced agencies monitor the road network surface condition with sophisticated equipment such as laser/inertial Profilometers. These measurements include road curvature, cross slope, asperity, roughness, rutting and texture (roads). This data is fed into a pavement management system, which recommends the best maintenance or construction treatment to correct the damage that has occurred.

Maintenance treatments for asphalt concrete generally include crack sealing, surface rejuvenating, fog sealing, micro-milling and surface treatments. Thin surfacing preserves, protects and improves the functional condition of the road while reducing the need for routing maintenance, leading to extended service life without increasing structural capacity [14].

Failure to maintain roads properly can create significant costs to society, in a 2009 report released by the American Association of State Highway and Transportation Officials (USA) about 50% of the roads in the USA are in bad condition with urban areas worse. The report estimates that urban drivers pay an average of $746/year on vehicle repairs while the average US motorist pays about $335/year. In contrast, the

average motorist pays about $171/year in road maintenance taxes (based on 600 gallons/year and $0.285/gallon tax).

Greitzer defines the highway maintenance as "the act of preserving and keeping a highway, including all of its elements, in condition as close as is practical to its originally constructed condition, or its subsequently improved condition; and the operation of a highway facility and services incidental thereto, to provide safe, convenient, and economical highway transportation." Greitzer 1976, p. 59. Greitzer divided the road maintenance into two main activities as physical maintenance and traffic services/ operations Greitzer 1976.

V. PROBLEM DESCRIPTION

Today, the significant changes of road networks are maintained & this has reflected broader political and economic development, which has occurred. The tradition manual method of measuring cracking in road pavement is slow and unreliable. There are many type maintenance [15] that takes place to maintenance the road:

- ***A. Routine Maintenance:*** are on going maintenance work, which involves both maintenances of pavement and off carriage way items. It is normally funded out of the recurrent budget, carried out at interval of less than one year and includes such items as road sign, repair, vegetation, control, drainge maintenance, pothole repair and crack sealing.
- ***B. Periodic Maintenance:*** it is carried out at intervals of several years and is funded from either recurrent or capital budget. It usually refers to resurfacing works, such as thin aspheric overlays and sprayed bitumen surfacing dressing. Sometimes, it also refers to thick asphattic and granular overlays, which improves the structural integrity of road, but these are more often referred to as pavement reconstruction or rehabilitation.
- ***C. Emergency And Winter Maintenance:*** these works cannot be estimated with certainty in advanced funding typical comes from special or contingency funds or sometimes the recurrent budget. E.g repair of washout, clearance of debris, salting and gritting and snow removal.
- ***D. Preventive Maintenance:*** this type of maintenance consists of activities that are performed to extend the life of newly constructed asset items. Such activities are performed in a planned fashion and in advance of a need for repairs and in advance of substantial deterioration of the asset items to be able to avoid such occurrences, to decrease the deterioration rate of such asset items, to increase the time in which they become defective, and to maintain or improve the overall functional condition of the road system without enhancing its structural capacity. Preventive maintenance is planned, cyclical, not condition based and not performed to add structural capacity (where applicable, e.g., pavement)
- ***E. Restorative Or Reactive Maintenance***: this type of maintenance consists of activities that are performed to return an asset item as close as possible to its original condition. This requires minor repairs and replacement of certain components. Such maintenance is performed on asset items that are still functioning and structurally sound but which have minor defects such as section loss, cracking, etc.
- ***F. Rehabilitative Maintenance:*** this type of maintenance consists of major repairs and replacements. Such efforts are regarded as reconstructions which are much more expensive than the aforementioned two types of maintenance. It is important to note that rehabilitative maintenance is disregarded within this research as it is more like construction rather than maintenance.

VI. DESIGNED OF FRAMEWORK

Reengineering of road maintenance system is a fundamental relationship between the maintenance level and the budget requirement (i.e. Efficiency of road maintenance) need more investigation [17].

Road maintenance is a process that is greatly affected by the uncontrolled factors such as climatic condition, traffic volume, geographic location n, road surrounding environment, road design (type of material and thickness), road construction (quality of material and workmanship), condition during construction phase, subsurface condition, amount of snow and ice treatment applied to road.

There are two group of uncontrolled factor :

a. uncontrolled factor that effect the preventive and reactive maintenance effort
b. uncontrolled factor that effect the deterioration

Considering the effect of such uncontrolled factors is very important in any maintenance performance measurement system, especially for the instance performance measurement system, and for the instance in which comparative analysis is to make.

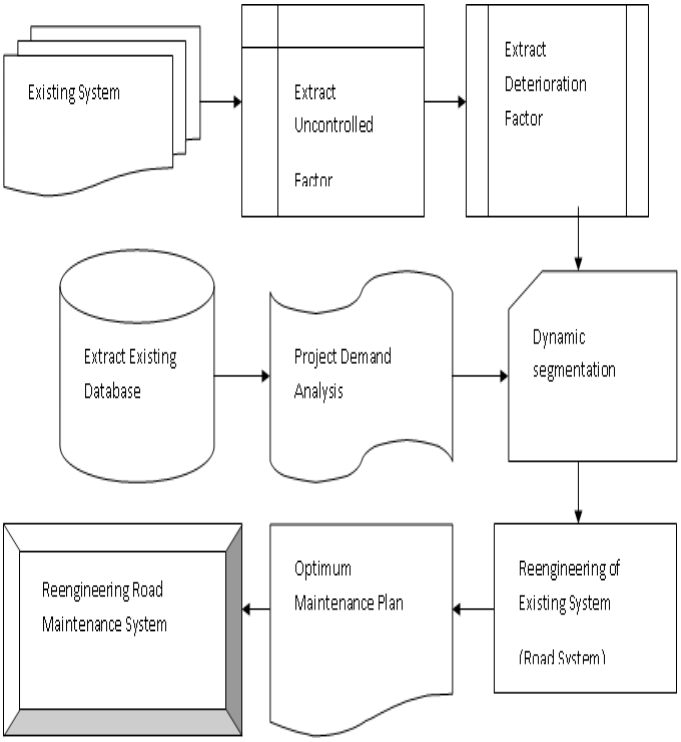

Figure: 1Framework of Road Maintenance System'

In reengineering of road maintenance, planning is one of very important activity, that helps road manager or road authority to determine which type of maintenance is to be used when and how much time, cost and resource are required to reengineering of existing system and to generating an optimal maintenance plan for a road. It minimizing over all net present value of maintenance cost.

There are certain kind of approaches that are very beneficial to reduce the cost of maintenance, during reengineering of road system:

A. Event map histories, which shows consistently poor sections of road requiring rehabilitation
B. More effective utilization of existing road maintenance assets: rapid response to identified road defect
C. Reduced capital expenditure on road maintenance assets: expanding road network can be effectively maintained with less equipment
D. Immediate recognition of haul road condition, visual inspection for each change of hauler route unnecessary
E. Help in extract uncontrolled and deterioration factor
F. The increased utilization of existing computer based information and transport management system to provide stream-lined and integrated data management and information.

VII. SCOPE OF WORK

A. Identify the key findings regarding maintenance requirements for different categories of roads, weather conditions and pavement material (asphalt, concrete, etc.);
B. Examine the existing working arrangements between the committee of roads, road administrations, and contractors;
C. Review budget allocations that is approved by central government or state government during the last three years and the budget planned under future experience.
D. Acquire information and account of labor, equipment and resources for road maintenance operations, identifying the equipment supplied by government authorities or private supplier and costs involved for maintenance and upkeep.
E. Road fund and private sector involvement in road operations.
F. Analyze the reasons for unsuccessful efforts previously launched to involve private sector in the routine maintenance operations
G. Examine all maintenance operations (existing and planned) ongoing, on the main roads and the percentage of roads where no routine maintenance has been performed within the recent years;
H. Estimate the road maintenance requirements of each type of road network and identify the road maintenance funding gap between the budget and the requirements;
I. Assess the construction authorities and its potential to perform road maintenance works; and
J. Review the legislation and documentation for the establishment and assess the capability and capacity of authorities (that may private agency or government agencies) at all levels, including: skilled labor, technicians and skilled/ unskilled human resources required during reengineering of road maintenance system.
K. Measure performance indicators for different types of pavements (concrete, asphalt) and road categories and standard unit cost for routine maintenance;
L. Develop or build profile of resource deficiencies to overcome the existing huge backlog in the network and future requirements for the road maintenance;
M. Develop proposals for the establishment of a skills development and training program; and
N. A strategy and plan for future road maintenance or suggest if another such organization could be given the responsibility wholly or partly.
O. For making strategy for road maintenance funding and private sector involvement in the operation of the investment program road if feasible.
P. For reducing overall maintenance cost, resources, effort as well as time required during future maintenance of existing system

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