THE LIFE CYCLE COST MANAGEMENT (LCCM) ASPECTS OF MAINTENANCE IN URBAN PUBLIC TRANSPORT (UPT) SYSTEMS, ARGUMENTS FOR A GUIDE OF TRAMS MODERNIZATION

CSUZI I
Oradea Transport Local SA
dir.gen@otl.ro

Abstract: Planned life cycle is determined by how deep operating and maintaining the infrastructure and public transport vehicles, reducing costs is optimized by adapting appropriate strategies. Reliability and availability of transport systems mandatory minimum cost criteria must respect and maximum safety criteria. The paper contains findings and recommendations at both general and specific to the study.

Keywords: planned life cycle, reliability, maintenance, assessments of obsolescence, cost optimization, public transport system management

1. THE URBAN PUBLIC TRANSPORT SYSTEM

Community Service designed to meet the requirement of population mobility is the public passenger transport service named Urban Public Transport (UPT), organized on various territorial levels (national, county, regional and local) and ways (scheduled, special, occasional), road vehicles diverse (buses, trams, subway). UPT material related infrastructure is characterized by:

a.) stations with appropriate furniture, equipment, travel information kiosk or ticket vending machines, etc...

b.) tram tracks, contact wires supporting pillars, filling stations (rectifiers) cables...

c.) transport vehicles with the necessary degree of comfort amenities offered (E-Card and printed ticket validating, information systems and air conditioning equipment fleet management GPS, Wi-Fi router, etc ...)

d.) to maintain infrastructure and vehicles (workshops, equipment, gauges and control tools and measurement instruments, trucks with various facilities)

e.) to transport persons organizing exploitation, sale of travel tickets and control, legal and compliance framework program transport, public relations, internet web platforms, apps ...

All the system, its features, both material and operational can be designed in the classical idea of marketing as product concept, namely the definition covers product / service / system (PSS), valid rules and economic laws that describe the life cycle of the product. Quantification of public transport can be made by various indicators of process evaluation is viewed in terms of three major criteria:

a.) refers to the movement of vehicle traffic, with definitions of vehicle-kilometers, vehicle-trips, the average operating speed, while non-conformity with execution schedules and operating costs;

b.) mobility passengers sums during their movement being driven by the need movement. The measure is its passenger-kilometer (the average length of a trip), person-trip travel speed average cost per trip. It involves many aspects of analysis, such as interconnectivity modes effectiveness relative to the travel destination, etc ... that are very difficult to quantify;

c.) Accessibility refers to the conditions of use, the ease of use of UPT. It is a requirement of passenger transportation in particular, quantifiable through discomfort, cost and time, distance traveled to and from the first station of the UPT connection. The measurement it is relatively difficult or impossible when traveling without prescription charts (planning).

As a case study are data from OTL SA [3]:

Table 1. Quantitative characterization of the urban transport system OTL SA

INDICATOR	THE UPT SYSTEM					
	BUSES (C)			TRAMVAY (EE)		
	YEAR					
	2012	2013	2014	2012	2013	2014
Passenger numbers (N_{CL})	14.502.279	13.027.829	13.572.209	40.622.135	39.184.778	39.716.901
Total distance (D) [x1000 km]	2.989	2.843	3.558	2.219	2.117	2.036
Cost for EE & C (C_E) [x1000 lei]	5.304	5.067	6.216	2.868	3.453	2.479

Energy cost pass/km [lei/pass/km]	0,37	0,39	0,46	0,07	0,09	0,06
Operational cost (C_O) [x1000 lei]	20.075	19.321	22.199	26.195	27.774	27.262
Total cost (C_T) [x1000 lei]	20.811	19.944	22.501	27.447	29.045	28.148
Total Income (V_T real) [x1000 lei]	14.120	14.399	16.418	34.284	35.052	34.604
Profit indicator: $I_P = V_T/C_T$	0,68	0,72	0,73	1,25	1,21	1,23

Note: C - Fuel consumption for buses

EE - Electric energy consumed by trams

Distance for trams is for KT4D & ULF, or complete of T4D+B4D. Total average distance for last year (all tram) are in the next table:

The distance traveled by trams (KT4, ULF, T4D+B4D)

Year	2012	2013	2014
Distance for trams [x1000 km]	3.560	3.493	3.404

2. MAINTENANCE IN UPT

Transport systems in terms of maintenance behaves like any complex product is a aggregation strategy applied procedures on each item [3], [6]. In the PSS analysis, we identify some optimization methods for evaluating and predicting maintainability. By analogy with the reliability and maintainability case, we distinguish three steps:

a.) estimate of maintainability;

b.) maintainability improvement on the targets;

c.) compliance of conformity.

We can identify several methods to assess the repair times for analyzed items [12]:

a.) the experimental method presents disadvantage of a lengthy determinations that have influence on the cost and promote the industrial circuit does not allow optimizing the intervening further human factors;

b.) Technical Document review method (method Bazovszky) requires a team of specialists in maintenance, the disadvantage of uncertainty on the duration of the repair, and does not lend itself to a maintenance contract proofs objectives;

c.) tree maintenance method eliminates the disadvantages of the above, the most commonly used. Tree maintenance is a graphical representation of a logic operation maintenance, providing qualitative and quantitative procedures necessary for this operation.

According to this method of analysis of maintenance operations stand three steps:

I. Phase fault location - contains a sequence of measurements made in a logical and efficient to locate the fault as quickly as possible, the establishment and nature thereof;

II. Repair phase - which is to replace the defective system effectively;

III. Calibration and phase control - which involves checking and repair system for determining compliance with the original characteristics after the fault.

3. THE LIFE CYCLE OF PSS

The concept of life cycle of a PSS is borrowed from demography. Careful observation of the performance of products led to the finding of five stages (phases) with distinct characteristics, size of economic indicators being correlated with the phases of the life cycle of PSS. These steps can be grouped into two broad sub cycles: one innovation (including technical development of the product) and one economic development (between launch of the product and its commercial decline).

a.) Create product starts when the firm identify and exploit new product idea, devise, technically and commercially, future product. During creating PSS sales are zero, and the costs are high, which also includes the supply for research and development.

b.) The introduction (launch) is the period when the new product is launched, and the pace of sales growth is slow. Profits are negative or low due to low sales and high distribution and promotion expenses. Introducing a new product on the market requires the adoption of best possible marketing strategies depending on: the nature of the product, market structure and the concrete conditions in which the release. The adoption of high prices and low promotion can lead to high profits, only if the lack of competition in the market in terms of product knowledge by potential clients. Introducing a new PSS in a low price, with strong promotion allows rapid penetration of the market and achieving high market shares in the hope of profit.

c.) The increase is between massive acceptance by the market (ex. profits increasing). At this stage the question of choosing between a high market share, with moderate profits, but longer-term and lower market share, but big profits in the short term. Investments in improving the product, promoting sustained and broad distribution can lead to the conquest of a dominant market position, but are detrimental to current profits.

d.) Maturity is the time to limit or even decrease of sales, PSS has been accepted by most buyers/users of potential market collapses slow or fast. Most products are in this stage of their life cycle. The success depends on continuous innovation, leading either to market development (finding new market segments, brand repositioning, etc.), development of PSS (quality improvement, its characteristics and its attractiveness default) or change marketing strategies .

e.) The decline is the period when sales and profits decline in a steady pace (due to technical progress, changes in consumer preferences, increasing competition, etc.). At this stage you can make efforts to maintain product (or brand) market by cutting prices in the hope of increasing sales or waived product.

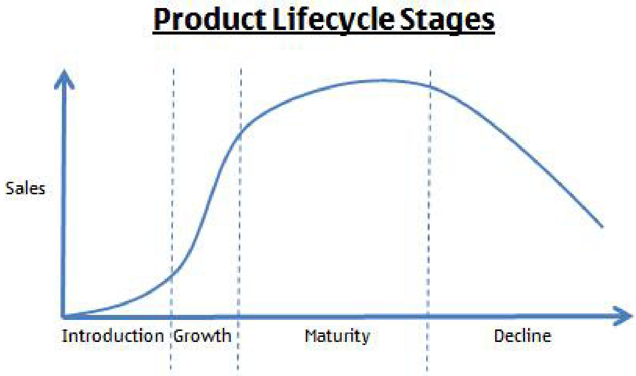

Fig. 1. Sales development lifecycle stages

Not all PSS follows the curve of the "S" cycle of life, some can record rapid fall after introduction phase, others remain a long time in the mature stage or declining stage, can learn new growth phase as a result of its repositioning or sustained promotion. The concept of "product life cycle" can refer to an entire class of products or services, the life cycle of a trade mark can change rapidly due to competition action. Prior to launch on the market a new product to determine "life expectancy" of it using a number of methods for forecasting (ex. extrapolation method phenomenological employing the product in a particular class, category or group whose evolution-driven cycle and its life-form curve is known from previous experience); can be used for comparison, bowing from the premise that the development of a product in a new market could be similar to that which he had in another market, which was released first, I can use intuitive methods of forecasting and simulation techniques. Determining the stage of the life cycle that is at a time PSS and especially predicting its evolution future market is a difficult (because of the multitude of information on developments in products on the market, the difficulty of a correct symptoms they present a particular product, lack of purpose 'information system, etc.). In this regard you can use a number of indicators such as:

a.) the spreading of the product on the market (as determined by the number of users thereof);

b.) the degree of penetration of consumer product (expressed in volume and value of your shopping volume and frequency specific purchase);

c.) the delivery speed of the product on the market (calculated as a ratio between the geographical area covered by the distribution of the product and the time it is done);

d.) the number of potential suppliers who have respectively PSS.

The tender age and diagnosis research phase in the life cycle that is at a time can use the qualitative parameters such as image that has a certain degree PSS consumers or loyalty shown by customers for it.

Basically lifecycle simplified PSS can be defined generally by the five stages of life demographics listed are: birth (creation and prototype), childhood (first steps on the market), adolescence (initial evolutions of PSS), maturity (only if viable products reach this stage) and decline ("slow death" by obsolescence). Analysis of each stage of the life cycle must be made multi-criteria, in terms of marketing commercial, technical or/and economical efficiency, including efficiency-optimizing energy effects on the environment by hazards emanate ecological quality of the product/system/service, satisfaction of users etc....

International Organization for Standardization (ISO) in Geneva defined as standard ISO15686 standard approach for regulating general concept of Life Cycle Cost (LCC), applicable in various fields (for particular constructs, services, activities planned cyclical, etc ...) [9], [10]. By definition LCC is "economic assessment taking into account all flows significant costs and relevant agreed on a period of analysis, expressed in monetary value. The estimated costs are necessary to achieve the performance levels set out, including reliability, safety and availability. In the context of sustainable procurement, use LCC is essential to demonstrate that the public procurement processes and decisions should be taken not only by the criterion of minimum price, but in terms of LCC, taking into account the evolution of all costs during the life cycle, including environmental impacts and other indirect effects.

4. QUALITY OF PSS. LIFE CYCLE ASSESSMENT

Properties, parameters of a PSS can be numerous, among which the most important and significant as quality characteristics [11]:

a) Functional characteristics - which are directly related to the use of a particular product such as tensile strength, energy indicators, precision processing, nutritional value of a food;

b) The characteristics of material - which relate to the structure of the materials used, the state of surface treatment, geo-metric dimensions, volume, weight;

c) Sensory characteristics and psycho-social - which refers to the aesthetics of the product (appearance, elegant color, etc.), organoleptic issues (taste, smell), as well as aspects of its operation (noise, comfort, etc.);

d) Characteristics of reliability, maintainability and availability which refers to the product properties to be fit for use at any time of his life.

Each product goes through different stages in time, after a spiral own related qualitative properties, which presents significant 13 points (see Figure 2):

1 - Scientific research;

2 - Concept;

3 - Prototype design and execution;

4- Prototype approval and finalization of technical documentation;

5 - Set the manufacturing process, equipment insurance, instruments and qualifications of people;

6 - Supply of raw materials;

7 - Provision of equipment and instrumentation;

8 - The production process itself;

9 - Control the production process;

10 - Conducting tests and trials;

11 - Product delivery to the recipient;

12 - Product confrontation with market requirements;

13=> 1*- Scientific research to a higher level.

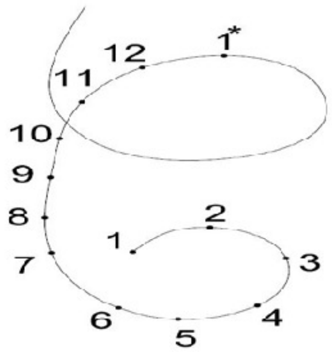

Fig. 2. Spiral quality of PSS

We note that spiral finest quality is a defining life cycle stages, even involves a clear repeatability, a higher level of PSS cycle. Study quality cycle completes PSS study life cycles by highlighting each step costs by summing defining characteristic life cycle cost. Since the birth of the idea of defining its initial PSS are specific costs, whose sizing depends on feasibility studies that establish the amounts of investment needed to design, development, launch. After entering the market PSS will appear receipts hope is that revenue to cover the initial investment and the production / cumulative operating with a profit hoped. Shortening the period of growth, longer maturity goals before saturation are solved, as if the decline PSS revitalization and trying to avoid "neutral sales" when PSS becomes unprofitable.

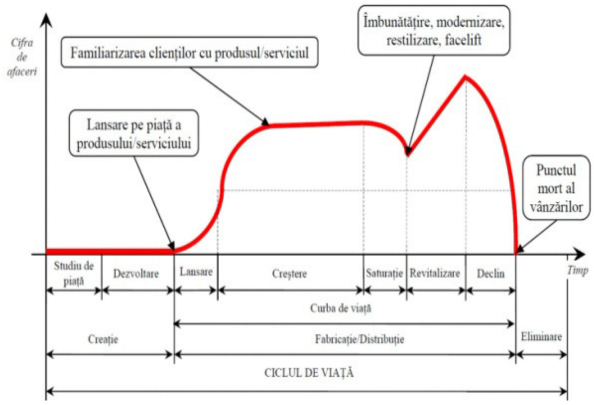

Fig. 3. And the definition of a PSS lifecycle

Chronology appearance LCC concept dates back to the early 1960's, when the electronics revolution, the "explosion" of the technologies, space exploration change human civilization. Mastering these developments requires recognizing the importance of organization of production, control costs over the life of the product. The model called by initiators "TEROTECHNOLOGY", it was a first approximation of the potential costs of a lifecycle. Base decisions are expected only in dependence of capital: investing in technology even larger amounts may produce lower long-term costs, the effect is not a single product but a whole family of that series, such as low maintenance costs for a series of vehicles. In the 1970's, studies focus was already operating costs, the theory appears "cost-in-use", the focus is on operating, maintenance but have a deficiency in the lack of assessment of costs throughout the product life. This deficiency has been eliminated by the emergence of a theory of the concept Life Cycle Cost to start 1980's - 2000's brought the concept completion Whole Life Cycle Cost (WLCC) that is treated throughout the life of the product, and the one after disappearance by scrapping costs and environmental obligations.

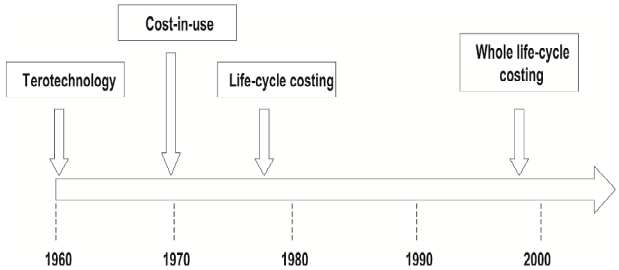

Fig. 4. Chronology LCC evaluation methods

If "TEROTECHNOLOGY" was more characteristic of the British, the Americans were the ones who introduced Procurement Conditions the LCC. Japan adopted an ambivalent approach of the concept of Total Productive Maintenance (TPM), regarding both from the perspective of the producer and the user of the product life. Germany kept the LCC American practices and developing a emphasized that birth and growth stage of the life cycle cost is the deciding during maturity and decline. Since 1990 "Lebenszykluskostenrechnung" (invoice lifecycle costs) imposes a severe treatment on accounting rules and financial marketing [14].

5. RISKS LCC

The purpose of life cycle cost analysis (Life Cycle Cost Analysis - LCCA) method is to calculate the total cost of the project alternatives and select a design which ensures that the system will provide the lowest total cost of ownership / operation. The first and most challenging task of a LCCA is to determine the economic effects of PSS, to argue alternatives and to quantify these effects in terms of economic aspect. LCCA calculates the costs of a PSS its entire life cycle, including planning, design, procurement, installation, operation, maintenance, replacement redesign, removal and disposal. The input numbers are not all clear, some are estimates, and others are dependent on many parameters or internal/external factors. In such interpretations lack of certainty is treated through risk management, which has two basic elements risk analysis and monitoring stages [1].

Risk analysis consists of:

a.) the identification of possible risks (based on previous experience, similar projects...)

b.) a risk assessment, quantification breakage and undesirable effects (statistical calculations, extrapolations)

c.) qualitative and quantitative assessment of the risks and their likelihood

d.) the risk response actions (after identification of risks, measures can diminish)

Responses to the risk may be different:

a.) to accept risk

b.) Actual transfer risk to third parties (ex. insurance policy)

c.) reduce risk through design

d.) avoiding risk by minimizing the probability of occurrence

e.) risks creating reserves necessary treatment (time, resources and manpower...)

These actions each have a cost that will include life cycle cost of PSS. Because we have costs in various stages influencing reduce the cost of being different, falling to the stages of maturity, with similar observation on increasing the accuracy of cost estimates cycle of life and advance the timeline lifecycle PSS [9].

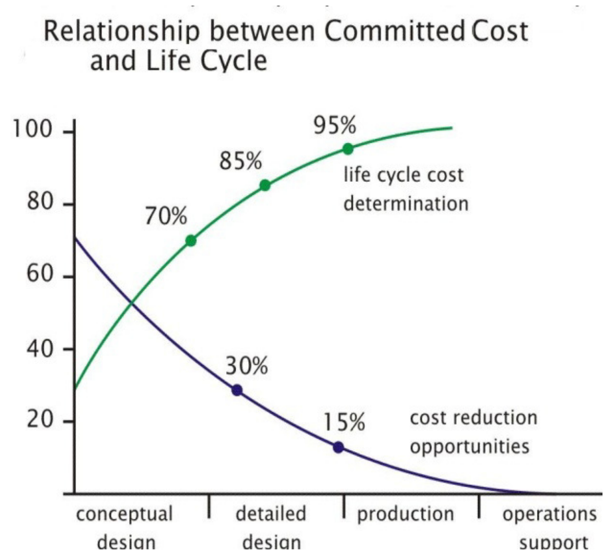

Fig. 5. Influencing the value and accuracy of defining the various stages LCC costs

6. LIFE CYCLE ANALYSIS ON ENVIRONMENTAL CRITERIA

LCA (Life Cycle Assessment - LCA) of the product is an environmental management technique that identifies flows of materials, energy and waste of a product during the life cycle of the product and its environmental impact. A developed and comprehensive dictionary definition [13]: "Life cycle assessment of a product is to assess and analyze the product's environmental consequences; product evaluation aims at extracting and processing raw materials, through all stages of its production, transport and distribution, utilization efficiency enhancement, maintenance and recycling. going to final disposal or until his reinstatement into the environment. "As defined refers only to the environmental impacts of the product and does not address the system-financial factors, political, social etc. (ex. impacts of costs). The full life cycle stages must be included and the necessary transport or due to the existence product that is virtually unacceptable in this time of economic crisis.

Standards define the general principles and the framework for the management and reporting of studies LCA (SR EN ISO 14040: 2007 and ISO 14040: 2006) provides guidance on the requirements and guidelines for life cycle assessment (SR EN ISO 14044: 2007 and ISO 14044 : 2006) [7].

7. TOTAL COST OF PSS

Total cost analysis throughout life (Whole Life Cycle Cost - WLCC) is based on the consideration of highlighting all costs stages, such as:

a.) the purchase prices, the costs incurred included (delivery, installation, insurance, commission levels, etc...)

b.) Total operating costs (energy, maintenance, insurance, human resources, etc...)

c.) neutralization costs (costs of recycling, reuse, disposal, destruction, etc...)

d.) Costs related to guarantees given

The first two elements of the total cost over the life WLCC constitute the "total cost of the owner" (Total Cost of Ownership-TCO) of PSS [5].

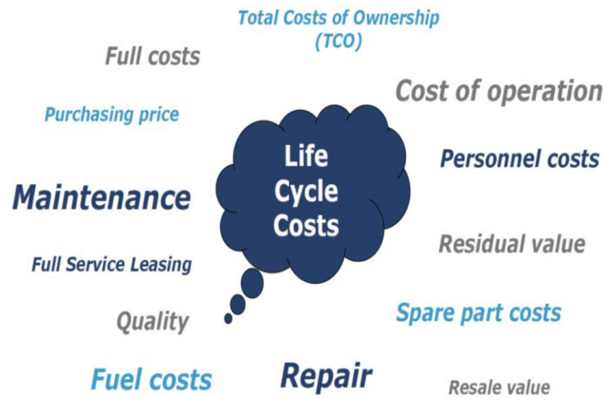

Fig. 6. Evaluation of total lifetime costs of a PSS

If we analyze its components TCO TPU is observed large percentage of the initial investment (acquisition costs) and maintenance with spare parts included and the operation (energy, human resources…).

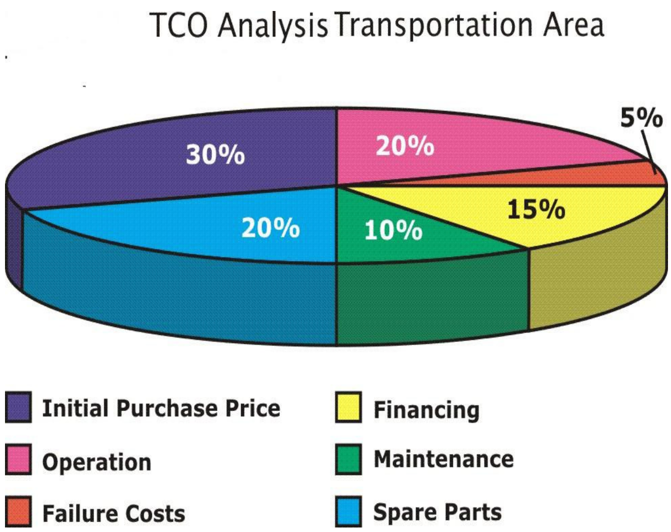

Fig. 7. Average components of costs for the UPT

Maintenance of transport vehicles is a challenge eternal strategies to address are different depending on the type of transport (buses, trolleybuses, Trams, metro and suburban trains). Common priority is to ensure maximum security of all UPT. Maintenance related costs can be calculated by summing each of the materials and manipulations of operations at planned intervals and multiplying them by frequency of application. Repairs as part of corrective maintenance is similarly quantified [5]:

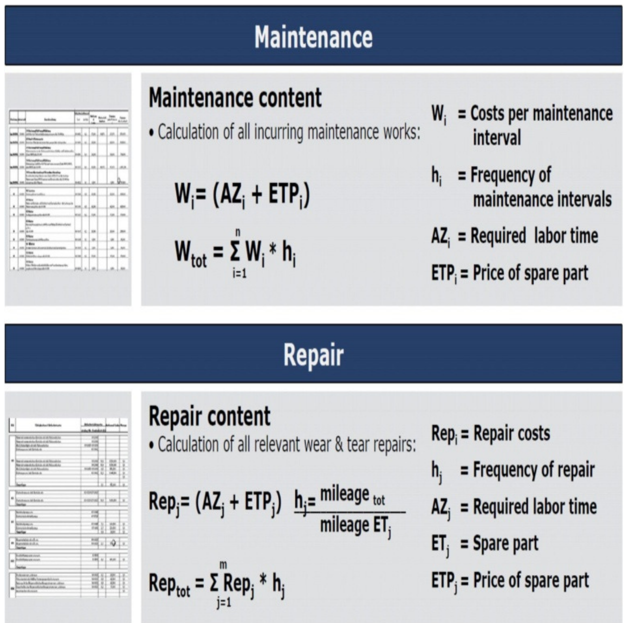

Fig. 8. Calculations maintenance costs of UPT vehicles

Life Cycle Costs can be represented in a three dimensional matrix:

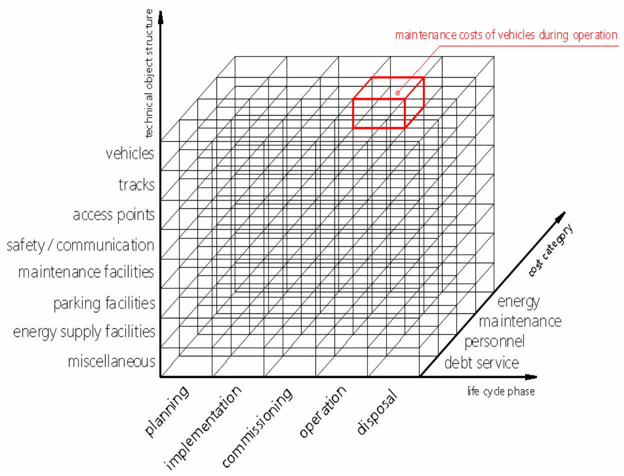

Fig. 9. Life Cycle Costs Matrix of UPT

The size is done by analyzing the various cost components of UPT (vehicles, equipment, signaling, safety, passenger information, infrastructure, etc ..), in terms of TCO (operating costs such as energy, maintenance, human resources) and their aggregation can be done in stages predefined life of PSS.

Matrix costs through detailed graphical representation in Fig. 10, where distinguished initial costs and operating costs. In turn are direct operational costs (maintenance and energy- electric or fuel) and indirect (human resource costs, insurance, etc...):

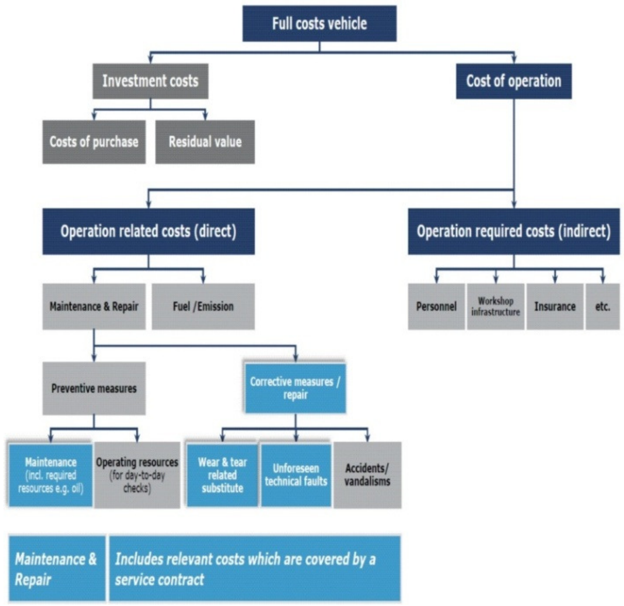

Fig. 10. Total costs and its elements UPT vehicles

Correct and timely assessment of the effects of the cost of LCC and can reduce their effective treatment. The earlier valuation calculations are done we can speak of a preliminary determination, control costs, while delaying the process, costs will be generated along the way will be aggregated and treated or compensated later.

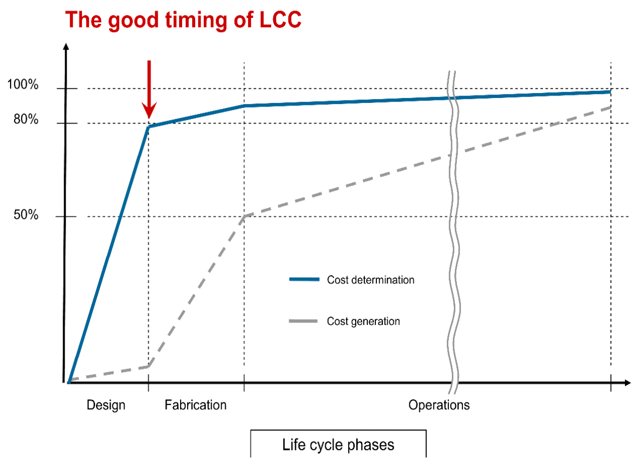

Fig. 11. Determining the optimum time and generation of lifecycle costs

8. MODERNIZATION, RECONSTRUCTION, INFRASTRUCTURE, OPTIMIZATION OF UPT

Specific case studies UPT requires a separate analysis on the different transport modes, for this paper we chose transport trams with traction. Being composed of infrastructure (rail, fuel-rectifiers, contact wires = U_+ and power of "return" = U- and vehicles) [3]:

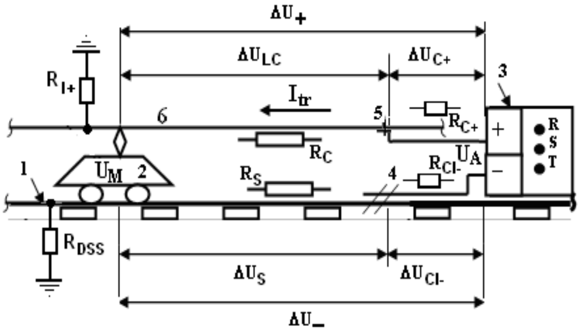

Fig. 12. Simplified and schematic representation of an electric tram system

One modernization, reconstruction and expansion of infrastructure is a major investment of a local authority that you have to be preceded by feasibility and opportunity studies, detailed design and implementation itself. Observe the design phases on the tram network (define routes and termini, schedules, performance charts based on commercial speeds and travel times).

Mandatory traveled phases will be:

a.) Analysis of the tram network:

- PU review the objectives and priorities of the city assessment of transport corridors and the number of passengers future
- Impact assessment and related services
- Comparisons of technologies applicable
- Route elements, operational features of transport
- Cost-benefit analysis and investment justifications

b.) Feasibility Study:

- Advertising and public consultation
-Define financing strategies and fundraising necessary
-Defining requirements and special needs of the beneficiaries
- Analysis of the legislative and legal provisions

c.) The design of the tram network:

- Design team (architects, Rail specialist-AFER, structure and roads specialists ...)
- Drafting effective rail routes
- Designing utilities (drainage, signage, tram ...)
- Design-recovery substations
- Assessment of maintenance facilities, choice of optimal execution solutions
-Obtaining permits and approvals necessary for construction

d.) The construction of the tram network:

- Obtaining the investment budgeting
- Public procurement procedure for choosing the builder and project supervisor, purchasing materials and services needed
- Contracting, documenting activities of construction / modernization
- Testing, evaluation, approval by competent authorities
- Final approval and commissioning

The activities listed are mandatory step of the way with other upgrades, such as rolling stock, in this case the old tram fleet of equipment. The estimated and centralization of steps required to go in modernizing tram system is as follows [2]:

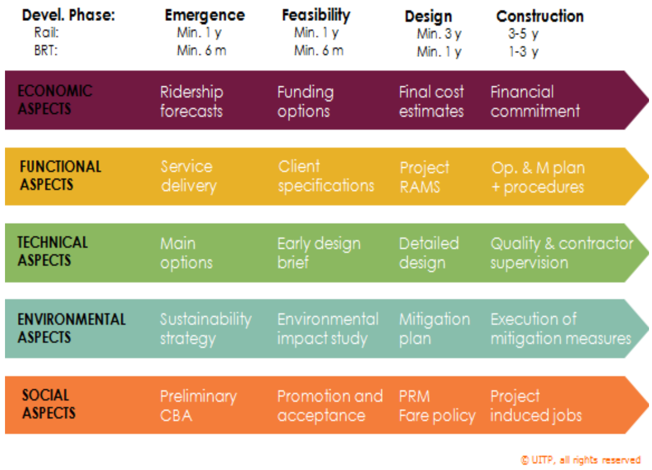

Fig. 13. Optimizing the planning modernization of UPT

9. OPTIMIZE MAINTENANCE AND MODERNIZATION OF TRANSPORT VEHICLES

Optimizing a vehicle modernization depends heavily on cost-benefit analyzes or the determination of service life is based on the technical condition assessed. If the bus is relatively easy to decide the profitability of construction changes or upgrades by various major facilities reported versus the purchase price can't be justified sufficiently argued. Major changes (ex. Motor or gearbox otherwise not economically justified!) Are not recommended, but improvements are possible comfort (passenger information systems facilities with audio and visual, wireless internet access, etc...).

It looked like an exercise in effective investment if electric buses. If we consider only TCO, return of investments (ROI) clearly negatively affected, the high cost of batteries enormous increase in the medium term maintenance cost, what makes it not suitable for operation in UPT. A study in Singapore shows that the electric bus will be viable only on the emergence of new technologies that cheaper costs of batteries [4].

If the situation is different trams, new price of these trams is somewhere between 1.2 and 2.5 million, depending on equipment and technical features or other events.

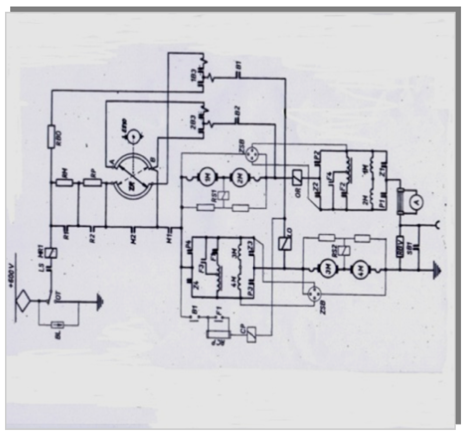

Fig. 14. TATRA trams drive circuitry

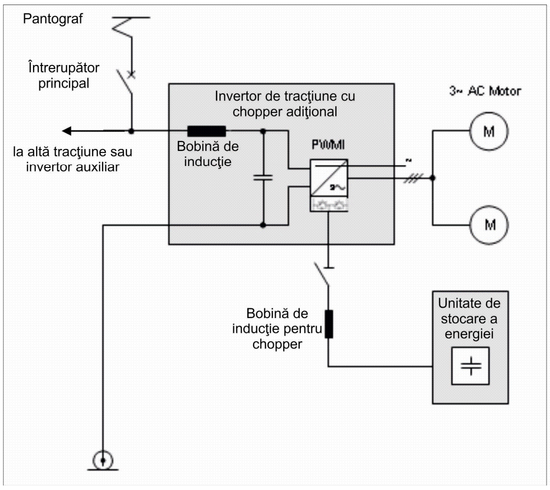

Fig. 15. SIEMENS trams drive circuitry

Analyzing the technical parameters of the tram park of OTL notes key differences between trams TATRA T4D and SIEMENS ULF 151, wiring diagrams drive indicates the essential difference of engines (DC and AC). Power losses acceleration and braking TATRA are meant higher than SIEMENS has the inverters and braking energy recovery [15]. By dialing the values of balance electricity (BEE) we find a higher yield when operating asynchronous motors:

Table 2. - The average values of power load of trams

Nr. Crt.	Type of Trams	Nr. of the Tram	P_0 [kW]	P_{0m} [kW]	P_{ae} [kW]
1	ULF	55	17.1	16,99	92,11
2		58	16,87		
3	kT4D – I (DC generator)	202	32,76	31,72	106,84
4		204	29,18		
5	kT4D – I (static generator)	217	28,61		
6		227	36.32		
7	T4D – G	10/110	35,27	33,06	108,18
8		28/128	31,59		
9	T4D – I	38/138	29,93		
10		43/143	35,53		

SANKEY diagram for an electrically operated tram system is the basic equation with the following energy components [6], [15]:

W_{aMT} - energy absorbed (measured on the MV - MT transformer)

W_A - auxiliary power consumption (own technology) power stations (STR)

ΔW_{RD} - loss of energy rectifiers (RD);

ΔW_T - energy losses in transformers STR structure;

ΔW_L - energy losses on the network of transmission lines (LA) with three components:

→ **ΔW_{LS}** - energy losses shortly Street;

→ **ΔW_{LI}** - energy losses at LA injection;

→ **ΔW_{LC}** - energy losses at LA contact (contact wires);

ΔW_M - energy losses engines tram structure;

ΔW_{RG} - losses and own consumption of energy control equipment operating parameters of the tram;

ΔW_{mec} - mechanical energy losses in transmission mechanisms of the tram;

W_U - useful energy has known significant traction processes (power) power, the energy that produces effectiveness (tram movement).

Table 3. - BEE components of power for trams in OTL

Type of Tramway / Component of Power	ULF	kT4D	T4D – B4D
P_A [kW]	92,11	106,84	108,18
ΔP_M [kW]	6,44	13,89	14,06
ΔPRG [kW]	3,88	4,6	5,72
ΔPAT [kW]	2,32	2,04	2,54
ΔP_{mec} [kW]	8,06	14,97	14,63
ΔP [kW]	20,7	35,5	36,95
P_U [kW]	71,41	71,34	71,23
η [%]	77,5	66,8	65,8

Useful energy forms and energy absorbed accumulated losses:

$$W_{aT} = W_U + \Delta W$$

Energy losses accumulated is expressed by:

$$\Delta W = W_A + \Delta W_T + \Delta W_{RD} + \Delta W_L + \Delta W_M + \Delta W_{RG} + \Delta W_{mec} + \Delta W_{AT}$$

Rating losses are made on each component under specified characteristics transformer, rectifier, wires and cables, engines and transmissions, contact and insulation are quantifiable loss.

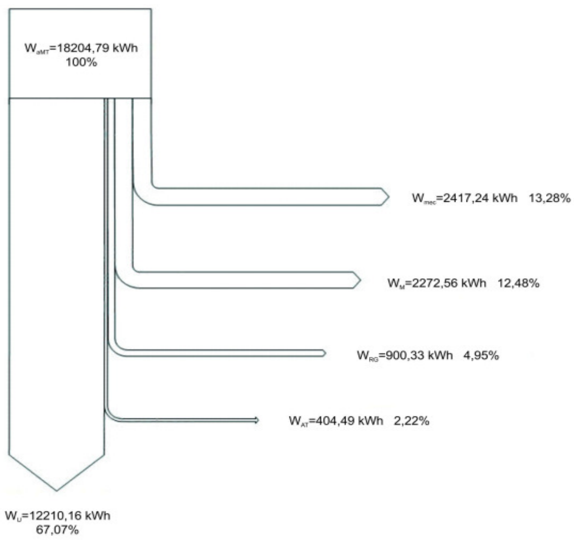

Fig. 16. SANKEY diagram of the contour of the OTL trams

As shown in Tables 2 and 3, by comparison with SANKEY diagram of a tram drive motors with brake energy recovery, it easily the parameters TATRA trams operated with DC motors are below that asynchronous motors with brake energy recovery:

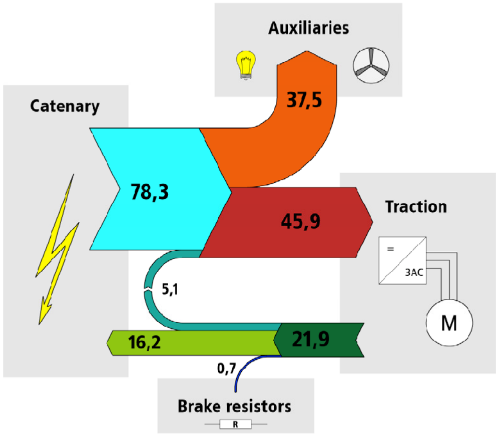

Fig. 17. SANKEY diagram of a tram theoretical braking energy recovery

It is proven that the first intervention to modernize electric drive will be changing or keeping the chopper DC motors (less efficient in operation!), recommend AC motors and invertors for recovering braking energy.

Besides this change is obligatory challenge the body and improvements, relative to passenger comfort. It recommends changing doors type harmonica with automatic door plate, it redraws the interior with ergonomic chairs, to provide air conditioning, performed information systems for passenger, LED lighting, and many other possibilities facelift like yet more "saucy". Examples of good practice in Europe to modernize trams we TATRA Czech Republic, Germany, Estonia and Russia.

Foto 1. TATRA T3 modernized in Brno-CZECH Rep.

Foto 2. TATRA KT4 adapted to Low-Floor in TALLIN-Estonia

Foto 3. Russian concept for TATRA T3 upgrade

Foto 4. Modernized GT8 named ARMONIA in Timişoara

10. CONCLUSIONS

In the UPT Safety Laboratory "MECHATRONICS" of OTL SA, as a result of a project carried out on EU funds of over 4 million Euro (excluding VAT), has the overall objective of increasing safety TPU and five specific objectives, such as:

a) Increasing the level of training of human resources to find solutions for continuous performance increase trams;

b) Material supplies in the research and development laboratory dedicated instrumentation equipment and next-generation, structured on the following directions:

- Measuring, monitoring, analyzing and identifying vibration reduction solutions primarily for SSTA;
- Measuring, monitoring, analyzing and finding solutions to maintain within the allowable electrical parameters of operation of trams;
- Test van and SDV for fixes and electrical measurements on the ground;

Analysis of the data presented, the context TPU, availability of parks TATRA trams transport companies in Romania (from a total of approx. 1350 TATRA trams are over 600 pc are older than 30 - 45 years!). Although not neglect the possibility of acquisition of new trams through development funds (POR) deemed essential and mandatory development of a "Guide to modernize trams TATRA" which is the first step in renewing fleets trams obsolete, being the stage of life after maturity, life cycle cost calculations will demonstrate the viability action as appropriate.

The results of many example of modernization give us values inside 250 - 500.000 Euro for each tram conditioned by the deep consistency of changing.

REFERENCES:

[1] MARSCHING S., HANSMAN F.: *Life-cycle costs determine asset management policy*, revue Railway Gazette International, Brussels, January 2015

[2] DAUBY L.: *Planning, Design and Construction of Urban Rail System*, UITP papers, Brussels, 2014

[3] CSUZI I.: *Contribuţii la evaluarea şi optimizarea performanţelor energetice şi de disponibilitate ale sistemului de tracţiune electrică urbană,* Teza de Doctorat, 2011, Universitatea din Oradea

[4] WONG Y.S., WENG-FENG L., WANG Z.: *Life Cycle Cost Analysis of different vehicle technologies in Singapore*, World Electric Vehicle Journal Vol.4, ISSN 2032-6653, p.912-920, SHENZEN, Nov.2010

[5] DREYER Ph.: *Maintenance & Repair Contracts as part of a LCC consideration,* 1-st UITP Bus Seminar papers, Bologna, Oct. 2013

[6] FELEA I.: *Audit electroenergetic la Regia de Transport Local*, Oradea, 2009

[7] ***: *SR EN ISO 14040:2002- Management de mediu. Evaluarea ciclului de viaţă. Principii şi cadru de lucru.*

[8] ***: *Guidelines for Life-Cycle Assessment*., SETAC: "Code of Practice", Brussels, 1993

[9] ***: *Life Cycle Assessment. What it is and How to do it.*, UNEP-DTIE, Paris, 1996, ISBN 92-807-1546-1

[10] ***: *Towards a Global Use of LCA.* , UNEP, Paris, 1999, ISBN 92-807-1740-5

[11] OPREAN C., ŢÎŢU M.: *Managementul calităţii în economia şi organizaţia bazate pe cunoştinţe.*, Editura AGIR, Bucureşti, 2009, ISBN 978-973-720-167-6

[12] MUNTEANU T., GURGUIATU G., BĂLĂNUŢĂ C.: *Fiabilitate şi calitate în ingineria electrică,* notiţe de curs, Universitatea „Dunărea de Jos", Galaţi, 2009

[13] PÂRVU M.: *Dicţionar de mediu*, Editura RA Monitor Oficial, Bucureşti, 2005

[14] OKANO K.: *Life Cycle Costing- An approach to life cycle cost management, consideration for historical development*, Asian Pacific Management Review, Tokyo, 2001, p.317-341

[15] CSUZI I.: *Sisteme de acţionare electrică (SAE)*, notiţe de curs, Universitatea Oradea, 2014