Reengineering the Locomotive Operation Management Process in the Railways of Iran (RAI)

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Abstract

This article is the result of a project performed in the Iranian Railways (RAI) with the purpose of radical process improvement to optimize the utilization of fixed assets. To carry out this project, a BPR methodology is customized. In this project, after completing preliminary studies and documentation and analysis stages, the locomotive distribution process was selected among all the other processes in the operations functional area as the most critical process, in regard of the situations of RAI, to be reengineered. According to the deployed methodology, after putting behind all necessary studies and documentations on the current performance of the locomotive distribution process, its problems were analyzed and improvement objectives set. Three alternatives have been presented for the new process and the proposed process is introduced in further detail.

Keywords: business process reengineering; process redesign; locomotive operation management; locomotive distribution; iranian railways

1. Introduction

Because of the importance of transportation and communication as a prerequisite in economic

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development of each country, Iranian government has paid considerable attention to investment and development in them. In addition, because of its special strategic location, Iran has had special importance for traveling passengers and transporting freights as it is a bridge between East and West. In general, there is an increasing growth and development in rail services in Iran for both passenger and freight which reveal the successful achievements in this field.

Locomotives are one of the most significant fixed assets in railways, which play critical direct and indirect roles in productivity of the railway. Due to high price of this asset, exclusivity of this technology to a limited number of companies and countries, and limitations in foreign affair procurements for the Iranian government, and some others, it is to utmost importance for the administrators of RAI to make the most out of their in-hand assets. Therefore, locomotive operation management is one of the most critical processes in railway operations in RAI. Statistics indicate a low locomotive productivity. Rail operations managers of RAI believe the available number of locomotives and the current procedure of locomotive operation management will not satisfy the growing demand of freight transportation.

BPR is regarded as process-oriented which is trying to overcome some problems raised by hierarchical structures. According to Michael Hammer and James Champy, the BPR gurus and founders of the term itself, BPR is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed (Hammer and Champy 2001).

Despite the number of definitions in the literature, they seem to have a shared understanding of the key elements of BPR. The following key characteristics are typical to BPR projects: radical change, dramatic performance improvements, high potential business benefits, process-based organizations, customer orientation, information technology as an enabler, rapid pace of change, and high risks (Hammer and Champy 2001, Kallio et al. 1999).

Hammer and Champy (2001) consider information technology (IT) as the key enabler of BPR (Hammer and Champy 2001). They believe a company that cannot change the way it thinks about IT cannot reengineer; a company that equates IT with automation cannot reengineer; a company that looks for problems first and then seeks technology solutions for them cannot reengineer (Malhota 1998). The existence of a high level of risk in large BPR projects may also explain the reason that many firms choose to implement only portions of enterprise-wide systems, such as Enterprise Resource Planning (ERP) that usually provides a means to do BPR (Ozcelik 2010, Wang 2008).

The contemporary definition of BPR, therefore, encompasses a continuum of approaches to process transformation that may include both radical and incremental improvements, depending on the nature of the problem (Ozcelik 2010).

The objective of this paper is to investigate the locomotive operation management process as the most critical process in the functional area of railway operation in the Railways of Iran and redesign it a way that significant, radical improvements are achieved in the performance of locomotives, resulting in higher revenue for RAI.

This paper is organized in the following sections. Section 2 describes the BPR implementation framework. Section 3 presents an introduction to RAI following the current situation of the locomotive distribution process. Sections 4 cover the current process problem analysis. Finally, sections 5 and 6 relate to alternatives for the new process and the proposed process for locomotive distribution. Conclusions and discussions could be reached in section 7.

2. BPR implementation framework

There are no facts and rules to applying BPR. Every company has its own unique situation.
Different situations require different tools, and the tools used may depend on personal judgement and ideas. As a result, there are many ways to go about BPR. In order to develop a suitable framework for this project based on the business characteristics of RAI, several different frameworks and methodologies such as IMPROVERAIL (2003), IBM (1995), Kettinger and Teng (1997), Covert (1997), Prosci (2003) and GAO (1997) were reviewed.

Among all, a composite Process Regeneration Method Framework designed by Kettinger and Teng, based on the descriptions and analysis of 25 BPR methodologies (Kettinger and Teng 2000), was considered the basis to draw upon in this project's framework. Kettinger and Teng's composite methodology consists of seven main phases. Each phase includes steps for which certain tasks must be accomplished to complete the steps. The designers for each step have suggested useful techniques and tools. The Overall steps of the implemented BPR framework devised based on Kettinger and Teng's Methodology is presented in Fig 1. This framework is organised in 8 main steps and each step consists of several tasks.

3. Locomotive distribution process

The Iranian Railways (RAI) is the national state-owned railway system of Iran. The Iranian Ministry of Roads and Transportation (R&T) is the state agency that oversees the RAI. In 2008, Iran with an area of 1,648,195 km² and about 70 million populations, RAI operated 11,106 km of rail network over 15 districts (RAI, 2008). The railway network expands by about 500 km per year according to the Ministry of R&T. In 2006, RAI reported its facilities as follows (RAI 2008):

- Locomotives (diesel-electric, electric and shunting), numbering 565;
• Fright cars, numbering 16,330;
• Different kind of passenger coaches, numbering 1,192;
• Main Stations, numbering 429;
• Bogie change installation at Jolfa and Sarakhs international border stations which changes about 200 bogies each 24 hours based on two working shifts;
• Free Trade International stations, numbering 16.

To carry out its mission and functions and as regard of its wide operational area, RAI is composed of a hierarchical structure. In this hierarchy structure, 15 districts operate under the supervision of a central headquarters, and each region is in charge of affairs of a number of stations.

The General Departments of Districts have corresponding units to the General Department of Centre, which carry out the related services in districts. These Departments are in tight interaction with the Centre and take orders from it in high-level activities. There are stations at the lowest level of this hierarchy. Stations are sources of basic data for planning and control, and they work under supervision of the General Departments of Districts.

Fig. 2. Current daily locomotive planning and control process
The current locomotive distribution process in RAI is performed according to the flowchart presented in Fig. 2. This process starts with daily collection of information on ready to be carried freight and locomotives in service. Locomotives are assigned to freights based on freight priorities. If freight amount surpasses available locomotives, extra locomotives from the closest district are dedicated. If districts are short in locomotives themselves, the possibility of receiving them from repair and maintenance workshops is investigated. It happens sometimes that some freight is left over. In this case, freight priorities are re-examined to see whether locomotive assignment must be revised or the freight could be handed over to the next day. All these steps shape up the daily planning and control of locomotive operation management process. Once the operation has been performed, their must be short term and intermediate control over the project. Daily reports on the location and situation of locomotives and the daily average locomotive productivity are presented to managers as well as monthly and ad hoc reports to middle and top level managers.

Process documentation in this project involved application of several techniques such as Data Flow Diagram (DFD), Function Decomposition Diagram (FDD) and Activity Diagram. Figure 3 shows DFD Level0, illustrating external agent’s relationship with the process under study. DFD Level0 was broken down in advance into 2 levels, shaping 3 DFDs in Level1 and a total of 6 DFDs in Level 2.

The Locomotive Operation Management Process is found to consist of 3 main sub-processed: Locomotive Distribution Daily Planning, Locomotive Distribution Daily Supervision and Control, and Locomotive Distribution High Level Supervision. Locomotive Distribution Daily Planning breaks down to four sub-processes as follows: Locomotive Stock Information Collection, Freight Stock Information Collection, Priority Examination and Determination, and Assigning Available Locomotives to Prior Freights. Locomotive Distribution Daily Supervision and Control process is fulfilled based on the fulfillment of two lower level processes: Control and Follow-up of Daily Plan Execution, and Preparation of Daily Reports. Locomotive Distribution High Level Supervision involves the preparation of monthly and ad hoc reports related to locomotive distribution on RAI’s railway network to middle and top-level managers.

Fig.3. DFD level0 of locomotive distribution process
4. Problems analysis and defining improvement objectives

Analyzing the current process, applied information systems and existing communication platforms, resulted in the identification of several problems and shortfall. By the application of fishbone model, all problems and shortfall were root cause analyzed. Four main problems identified in the process of problem analysis are as follows:

- Long duration of the planning sub-process,
- Low accuracy of the devised plan,
- Low accuracy of monitoring and control over the whole process,
- Lengthy reporting time.

The main sources of these problems are human errors, lack of proper information systems, improper communication platforms, and low specialization in this field, while others are stemmed from more comprehensive deficiencies in the Transportation Functional Area, such as:

- Lack of long term vision on freight planning and assets planning,
- Lack of unity in commanding,
- Repetitiveness in task performance,
- Multiplicity of involved parties in the process.

Productivity indexes are meant to show how well fixed assets have being managed and in this project the locomotive productivity index was chosen as the indicator of how well locomotive capacities have been utilized. Regarding the relevantly low amount of this index in RAI in compared to other countries based on the statistics presented by UIC (2009) and in spite of the high amount of freight transportation demand in RAI, this index needs considerable improvement. This improvement could be achieved in several ways, ranging from investment and development aspects to procedural aspects, and even combinations of both could be considered. This project concentrates on procedural aspects improvement of the process. Therefore improvement objectives could be determined as:

- Increase in planning precision,
- Increase in monitoring and control accuracy,
- Decline in planning time,
- Reduction in reporting time.

5. Alternatives for the process designs

Based on the framework introduced in section 3, a number of alternatives must be produced before finalizing the locomotive operation management process. These alternatives have been established mainly on the ideas achieved by benchmarking other railways and brainstorming sessions with rail transportation experts. Combination and analysis of these innovative ideas resulted in three main alternatives presented in Table 2. This table compares these alternatives based on structure, centralization, and geographical distribution of the sub-processes.

In Alternative 1, the process is fully concentrated in this way that all locomotive distribution authorities are fully centralized at the Central Control Centre (CCC). CCC extracts locomotive and freight information straight form the stations, without any involvement of RAI’s districts. All sorts of planning (both mid-term and operational) along with high level and daily monitoring and control task place from CCC.

In Alternative 2 the process is performed in a way that majority of the authorities are centralized in the CCC and RAI’s districts are involved in parts of the process with limited authority. Information gathering takes place at stations; it will reach CCC after districts gather and sum them up.
Planning at all levels will be performed at CCC. RAI districts will be involved in daily monitoring and control, but high level monitoring will only take place at CCC.

In Alternative 3, there exists a new concept referred to as zone. A zone is determined as a part of the railway network regardless of the existing districts. These zones are mostly designated based on origin and destination of trains, which could turn out to be smaller or greater than existing districts. As mentioned in Table 1, these zones are authorized necessary authorities to have the process performed within their boundaries. The CCC will hardly interfere with the process in compared to the other two alternatives. Stations supply the Zones Control Centre (ZCC) with necessary information to organize daily locomotive distribution plans based on the mid-term plan devised by CCC. ZCC in each zone itself carries out daily monitoring and controls while CCC gets involved with ZCC only in high level monitoring.

One of the great debates in the railway industry has been over whether management should be highly centralized or decentralized. Over the years, both concepts have been in vogue. More recently, technology allowed railways to build huge centralized dispatching centres (Kaufman 2000). Some railways have tendency toward centralization and some other are managed decentralized, while railways exist which are a combination of both.

To decide between centralization and decentralization, three aspects are to be studied (Kaufman, 2000):

- Who are the customers (such as crew assignment, locomotive dispatching, human resources, etc.) and where that process can best be administered;
- Where managerial effectiveness and standardization of approach can occur;
- Where resource control and optimize in terms of managerial effectiveness would take place.

Railways experiences show policies, definition of standards, support, and general planning must be made centrally, while such as tactical decision-making, personnel s, execution and such affairs require decentralized performance.

According to further analysis and consulting railway transportation experts, opting the third alternative among those described in this section, could lead to a process which achieves dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed. The promise of the finders of BPR will be realized once the process has been well designed.

6. Reengineered locomotive distribution process

In this section, the reengineered locomotive operation management process is briefly introduced in five subsections as follows. Section 8.1 introduces the process objectives. Section 8.2 describes how locomotive productivity is measured because of the performance of the newly designed process. Section 8.3 concentrates on zone determination and the number of locomotives, which must be considered for each. Section 8.4 relates to composing sub processes, their distribution over the organizational units and information systems requirements. Finally, in section 8.5 expected benefits of the new process is described based on summing up feed-backs from experts during the design phase and the designers experience.

The objective of this process is to distribute locomotives over the railway network according to the amount of freight in origins, geographical condition of the districts, as well as the financial benefits of carrying freights and their priority to their final destination. The new process must guarantee incremental reduction in freight settlement at freight origins, maximum increase in locomotive capacity usage, and financial advantages for RAI.
Table 1. Nominated alternatives for the locomotive distribution process

| Alternative 1: Full Centralized by a Central Control Centre | Alternative 2: At District by a Central Control Centre | Alternative 3: Zonular by Zones Control Centre |
|-----------------------------------------------------------|------------------------------------------------------|-----------------------------------------------|
| Total Centralization                                      | Majority of authorities in the Centre and districts with limited authorities | Majority of authorities in zones and the Centre with limited authorities |
| Data Gathering                                             | Stations, District Control Centre                    | Stations, Zone Control Centre                 |
| Mid-term Planning                                          | Central Control Centre                               | Central Control Centre                        |
| Operational Planning                                      | Central Control Centre                               | Central Control Centre                        |
| High Level Monitoring                                     | Central Control Centre                               | Central Control Centre & Zone Control Centre  |
| Daily Monitoring                                           | Central Control Centre                               | Central Control Centre                        |
| Daily Control                                              | Central Control Centre                               | Zone Control Centre                           |
|                                                           | District Control Centre                              |                                               |

In the new design, regardless of its current regional hierarchy, the railway network is divided into individual zones. These individual zones will be given a defined number of locomotives for each technical plan period to serve the freight transportation demand in each zone. The zone's performance will be assessed by the following productivity index:

\[
P = \frac{L}{H \times N_R}
\]

where,
- \( P \): Loco Productivity;
- \( L \): Gross Transported Load;
- \( H \): Locomotive Availability Hours;
- \( N_R \): Locomotive Normalization Rate.

Gross transported load is calculated as: total load carried and force produced by sever gradient in each track sections. Iran has a variety of geographical conditions; therefore, some parts of RAI’s network have been laid on mountaneous areas while others on plains. Locomotives can carry long heavy trains on these plains, but the same traction power is capable of lugging a much lighter (consequently a shorter) one in mountaneous areas, which slopes reach up to 30 per-thousand in some parts. Therefore, this is an important to consider in productivity calculation.

Locomotives are not available 24 hours a day. Some time must be considered for inspections, scheduled maintenance and repairs. Locomotive Availability Hours is the sum of hours each locomotive has been ready for operations.

Since these rolling stocks have different traction powers based on the product model, in order to calculate productivity, a conversion factor must be used to transform it to a unite locomotive. This factor is referred to as Locomotive Normalization Rate. This factor can be read off a table with the same title currently applied in RAI for each locomotive in operation in Iran’s national railways.

After calculating the productivity of each locomotive, the average of all would be considered the locomotive productivity for each railway zone.

Moreover, receiving revenue based on productivity, zones will also be rewarded a defined percentage of the total annual revenue RAI has achieved by carrying freight. Defining such reward could encourage zones to cooperate with Head Quarters (HQ) to increase the overall railway income.
When zones have surplus locomotive or their freight is less prior at times in compare to other zones during each tactical plan period, they may rent their locomotives out to demanding zones by an agreed rent. Some times locomotives are assigned to freight trains which their final destination is somewhere outside the owner's zone. In such cases, the train may complete its journey. A specific period must be appointed for the ZCC to plan the locomotive to get back to its owner’s zone; otherwise the owner may acclaim financial penalization for such delay.

Fig. 4. Defined locomotive operation management zone

Table 2. Number of dedicated locomotives* to each zone

| Zone | 1  | 2  | 3  | 4   |
|------|----|----|----|-----|
| Number of Locomotives | 24 | 47 | 89 | 335 |

* The average number of unit main locomotives available for service per day has been considered for the calculation. Unit main locomotive is the number of locomotives times the locomotive normalization rate.

According to freight train’s traffic on RAI’s network, zones must be defined in a way that there would be the least traffic among zones and the internal traffic within each zone. For this purpose, the carried car statistics from origin to destination in 2008 was analyzed. Figure 4 illustrates the result of locomotive operation management zones determination.

The number of locomotives in each zone is calculated based on the share of each zone in:

(1) RAI’s tone-kilometre in 2008,
(2) Number of loaded cars ready to be carried,
(3) Freight demand for the tactical plan period.

The total number of locomotives is the average of the 3 figures calculating. Table 2 holds the final result of the number of locomotives allocated to each zone.

The new locomotive operation management process consists of four main sub-processes:
- Locomotive Distribution Operational Planning (involved with daily planning of locomotives assignment to freight ready to be carried),
- Locomotive Distribution Tactical Planning (which determines the number of locomotives for each zone based on considerations of section 8.3 for each tactical period),
- Locomotive Distribution Operational Supervision and Control (control on performance of daily plans in each zone),
- Locomotive Distribution High Level Supervision (performs high level control over the process performance by HQ).

To document the candidate process, different techniques such as Data Flow Diagram (DFD), Functional Decomposition Diagram (FDD), Information Systems Architecture, and Organizational Unit-Process Matrix were applied. Fig 5 holds the Organizational Unit-Process Matrix as examples of numerous documentations prepared in the design phase.

Figure 5 matrix concentrates on the distribution of the four sub-processes of the new locomotive operation management process in organizational units. This matrix illustrates how and at what level each sub-process is performed. The Zone Central Control and Zone Traction Service are similar to those at RAI districts, but at zonular level. All sub-processes are cross-functional, while Locomotive Distribution Tactical Planning is the only one performed at solely one organization unit which is the highest among those involved in locomotive management.

| Organizational Unit                          | Central control centre | Zone central control | Zone traction service | Research & planning dept | Make-up Stations |
|----------------------------------------------|------------------------|----------------------|-----------------------|--------------------------|-----------------|
| Locomotive distribution operational planning | *                      | *                    | *                     |                          | *               |
| Locomotive distribution tactical planning    | *                      |                      |                       |                          |                 |
| Locomotive distribution operational supervision and control | * |                      | *                     |                          |                 |
| Locomotive distribution high level supervision | * |                      | *                     |                          |                 |

Fig. 5. Organizational unit - locomotive distribution sub processes matrix

One of the main s highly affecting the incremental outcomes of the process being reengineered is to apply IT in redesigning the process. From all aspects of IT which include hardware, information systems (IS), data storage, platforms, network and communication, studies have only been concentrated on information systems; other aspects have been considered constant as inputs to IT related studies, namely systems have been designed on current platforms, applying mainly existing hardware, data storage and communicating facilities. Information systems determined to support the new process are categorized in three main categories of ISs: Transaction Processing Systems (TPS), Management Information Systems (MIS), and Decision Support Systems (DSS).

The newly designed process, as believed by rail transport experts and the process designers experience in the field, is quite believed to embody the following benefits:
- Reduction in planning time and re-planning in case of occurrence of unpredicted events,
- Increase in monitoring and control accuracy;
• Reduction in the involvement of the Centre in detailed, daily, and massive s;
• Getting the Centre involve in long term planning, and general accurate monitoring while those involved in daily panning and control are involved in their own affair;
• Increase in planning accuracy;
• Increase in locomotive productivity;
• Development of a competitive environment in achieving total benefit for RAI;
• Getting managers and planners of the area they manage or plan, close to the related operations;
• Reduction in the number of middle managers and personnel;
• Reduction in current costs;
• Reduction in the number of involved parties in the process.

7. Conclusions

Locomotives are one of the most critical fixed assets in RAI and considered an operation bottleneck. Problems such as long duration of planning, low accuracy of the devised plan, low accuracy of monitoring and control over the whole process, lengthy reporting time, as well as lack of long term vision on freight planning and assets planning, lack of unity in commanding, repetitiveness in task performance, multiplicity of involved parties in the process within this functional area add up to improper management of this asset.

In order to overcome the consequences of the problems, the locomotive operation management process has been reengineered. To redesign the aforementioned process, three alternatives were developed, analysed and the suitable option entered detailed design.

The objective of the reengineered process is to distribute locomotives over the railway network according to the amount of freight in origins, geographical condition of the districts, as well as the financial benefits of carrying freights and their priority to their final destination. To attain this objective the process has been redesigned and some of the major items have been presented in the paper:

The design phase does not end at this level. A popular trend in recent BPR projects is applying simulation in order to predict major results of applying the design; therefore, simulating the process before performance accounts necessary.

Since the entire Transportation Operations and Movement function is the most vital ones for RAI, it's crucial for it to be performed as optimum as possible. In order to reach its required efficiency, considering this function as an integrated process and reengineering it with the zonular structure mentioned in this article, is advantageous. By applying such radical change in RAI, its organizational structure will change fundamentally and the number of organizational levels and middle managers would decrease considerably. An important factor, which must also be considered in the determination of the zones and the number of locomotives for each, is considering the network growth, new districts and line extension, as well as new origin-destinations for freights and international transportation.

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