Logistics analysis in the oil exploration activities based on Project Management and System Dynamics approach

Melkyn Ricardo Saavedra Marroquin
Federal University of Bahia, Doctoral student of Industrial Engineering, Salvador, Brazil
Corresponding author: ricardo.saavedra1@gmail.com
Cristiano Hora de Oliveira Fontes
Federal University of Bahia, Dept. of Chemical Engineering, Salvador, Brazil
Francisco Gaudêncio M. Freires
Federal University of Bahia, Dept. of Mechanical Engineering, Salvador, Brazil
Leonardo José González Rodríguez
University of La Sabana, Faculty of Engineering, Chia, Colombia

Abstract
This paper presents a logistics planning methodology which integrates three conceptual tools: logistics, project management and system dynamics. This methodology is used to make an integral analysis of the activities carried out in the oil exploration activities across the logistics cycle during in a particular project.

Keywords: Logistics, Project Management, System Dynamics

INTRODUCTION

Project Management in the oil and gas industry defines the analytical structure and processes in an organized and sequential way for efficient project planning and management in exploratory field projects. It uses concepts of PMBok® to ensure the correct implementation of the activities of the project. Due to the complexity and high risk of such projects, the industry has introduced concepts about the use of languages and programs for projects to be analyzed, managed and executed.

The idea of this approach is based on a systems method. It considers that project management is based on a dynamic control process that takes place within a project system and interacts with the external environment. This system is a functional organization with a sub-system for materials, equipment and facilities, which is integrated with the project work and organizational structure (Rodrigues et al. 1994).

Due to business sustainability over time, logistic planning plays an important role in industry. It is applied in different segments of the oil business which focuses on the exploration and production of hydrocarbons. The process related to drilling focuses on logistical support for operation, which includes activities such as topography, soil studies and engineering, construction and materials, and support during the early stages of construction, drilling, and abandoned area need to be studied.

In this paper, a methodology for logistics operations management limited to exploratory well operations, from the final well location coordinates to the drilling completion including demobilization is presented. The main objective of this study is to develop a methodology to articulate project management and system dynamics in order to support the decision making process for a comprehensive analysis within exploratory well management. A dynamic model will be developed, identifying the different elements required to improve the coordination and management activities for the appropriate allocation of resources and the identification of the economic impact on project monitoring and control.

THEORETICAL FRAMEWORK

Applications in Project Management

Rodrigues and Bowers (1996) noted that traditional models support the project manager in operational problems within processes, while dynamic models provides more understanding of the strategic issue of the effectiveness of different management policies. Both approaches, consider project management as a dynamic planning, implementation and control process, as illustrated in Figure 1.

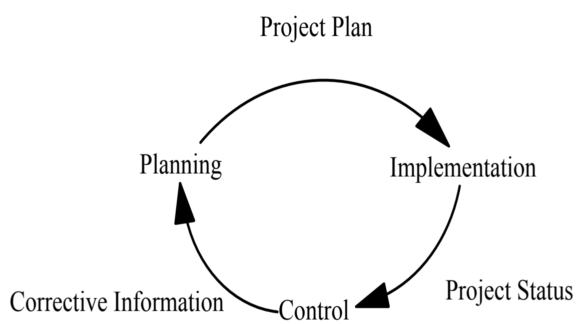

Figure 1 - The generic project management. Adapted from Rodrigues and Bowers (1996)

The project management process is put into a wider context, which includes many soft factors which are often external to the project work. However, there is a strong focus on human factors considered dominant in the feedback structures. In Figure 2, a human resource management process is presented.

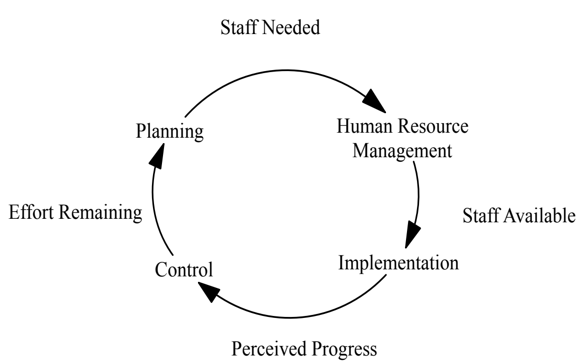

Figure 2 – The human resource management process. Adapted from Rodrigues and Bowers (1996)

The traditional approach to project management is based on the definition of Work Breakdown Structure (WBS), scheduling and budgeting activities, monitoring and controlling, and evaluating and reporting project status along the project life cycle.

The system dynamics approach to project management is based on a holistic view of the project management process and focuses on the feedback processes that take place within the project system. Figure 3 illustrates the main features of an influence diagram, the core of the system dynamics model (Rodrigues and Bowers, 1996).

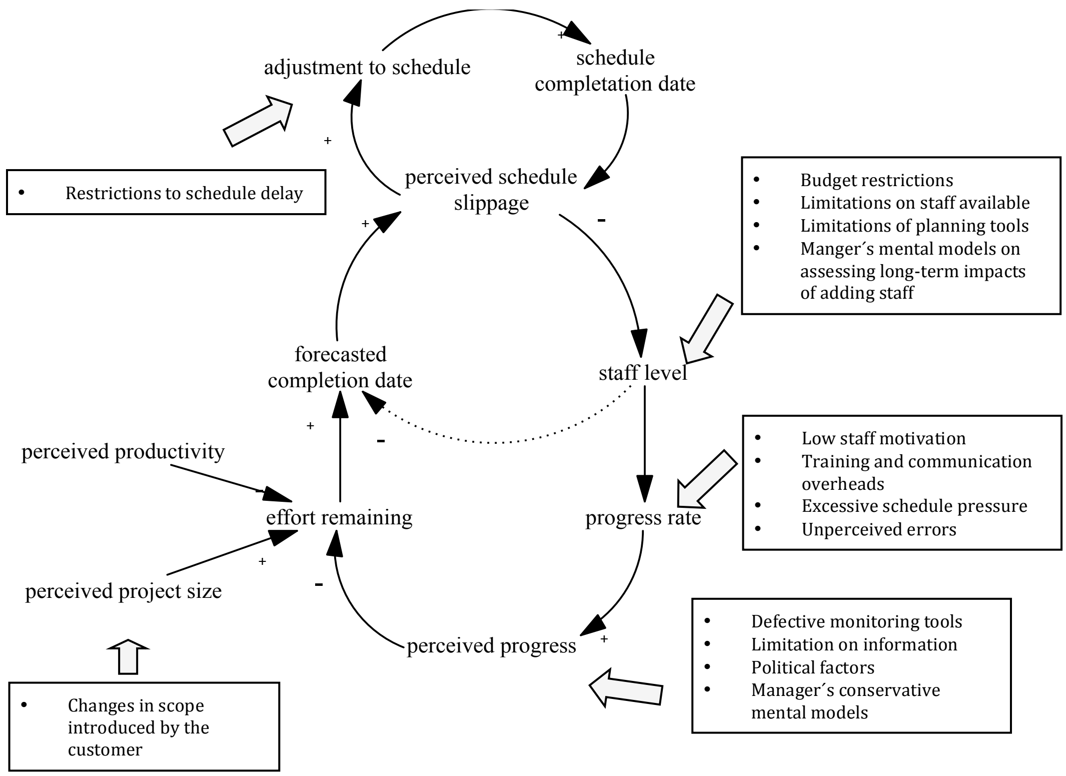

Figure 3 – The project control cycle. Adapted from Rodrigues and Bowers (1996)

Rodrigues and Bowers (1996) noted that the application of system dynamics to project management has been motivated by various factors:

- An interest in considering the whole project rather than a sum of individual elements (the holistic approach);
- The need to examine major non-linear aspects typically described by balancing or reinforcing feedback loops;
- A need for a flexible project model which offers a laboratory for experiments with management´s options, and;
- The failure of traditional analytic tools to solve all project management problems and the desire to experiment with something new.

Rodrigues (2000) proposed an integral method that can be used by any organization to develop system dynamics models in order to support the management of an individual project.

Furthermore, Mancera et al. (2011) proposed a method that uses four conceptual tools: service management, logistics, project management, and system dynamics, providing a comprehensive analysis of the activities done by companies providing services. All of this occurs through the logistic cycle with the purpose of improving coordination between activities and resource allocation, reducing delays, and improving customer perception about service quality.

The decisions in projects often include strategic, tactical and operational issues. The use of system dynamics in most cases are at the end of the strategic / tactical spectrum. Strategic project management covers decisions that are taken in designing the project and then the management provides operational decisions that consider the long-term impact of these decisions on the project.

Project Management of Exploratory Wells

The mission of systematic project management in this paper seeks to establish clear, organized and sequential procedures and activities to be developed in the planning and implementation process of investment projects for exploratory wells using the concepts of PMBok and FEL (*Front-End Loading*) method. This is to ensure compliance of installation of well operations with best practices of the system and industry (Project Management in Exploratory Wells, Oil Company Confidential Document, 2014).

Throughout life cycle of the project there are several steps that must be met progressive and successively called phases. A project is divided into five phases, namely: data identification, selection, definition (well program), execution (contracts), and operation and critical analysis, each with their activities according to the scope of the project as shown in Table 1.

Table 1 – Basic structure of exploratory wells project (phases)

Data identification	Selection	Definition	Execution	Operation and critical analysis
Define equipment, management, and preliminary objectives	Generate alternatives and analyze it technique and economically	Elaborate Drilling and Evaluation Program	Civil works	Well drilling
Scouting	Elaborate Logistics Plan	Obtain licenses	Support base installation	Evaluation and critical analysis
Identify critical resources	Select Rig, materials and critical equipment	Begin with contractual processes	Equipment (drilling) mobilization	Close contracts and support base

At the end of each phase there are decision gates. For the first three phases: Data, Selection and Definition which are the project planning, each gate is associated with four options: pursue, recycle, postpone or recommend cancellation. In subsequent phases: Execution, and Operation and critical analysis, the gates consider only two options; the first defines the start of the postponement of the phase, while the next defines the project closure.

According to the above, this model is integrated through the project management cycle, contemplating the five macro processes: initiation, planning, execution, control and monitoring, and closure. Each decision is supported by documents which are compiled and presented to the committee to be analyzed and validated for decision-making.

Logistics System and Cycle

The logistics system is a set of support systems that interact with the central system and the environment of the organization in order to support operations and generate advantage through exchanges of matter, energy and information. These will be made between internal, local, regional or global issues, throughout logistic cycle.

The logistics system develops a set of structured activities known as a logistics cycle, defined as operation or implementation in logistics companies and it comprises five levels (Kalenatic et al. 2009):

- First level, *Determination of needs or requirements*, is defined as positive and responsible for calculating and precise logistics needs (material, personnel and equipment).
- Second level, *Obtaining the necessary resources* to meet these requirements.
- Third level, *Provision and delivery of proceeds*, consists of getting the customer or applicant system, system, resources, product or service required in the right place, in the right amounts, at the right time, with the required quality and at a fair price.
- Fourth level, *Maintenance*, which is to ensure the continuity of the good, service or integrated system.
- Finally, *reverse logistics*, responsible for determining and operating the means to return to the system and its processes, sub-products, media management or unwanted outputs generated by the central system and support systems.

Each of these systems has a series of activities which are identified using Work Breakdown Structure (WBS). Every activity required renewable and non-renewable resources where the WBS is analyzed for identification. The execution of the activities of the WBS is affected by controllable and uncontrollable variables, and an analysis is performed for their identification in each project phases using traditional methods.

METHODOLOGY

Conceptual Analysis System

The proposed methodology consists of four phases: system characterization, structure analysis, and simulation and policy review. Each phase integrates concepts of project management of exploratory wells, system dynamics and planning in the development of projects.

The first phase, *system characterization* identifies and classifies the systems of the project from the logistics cycle definition, and the activities carried out in each system and the resources associated with them are identified (Feres 2002).

The second phase, *structure analysis*, is performed using dynamic systems whose main goal is to understand how the system works and what its behavior is (Sterman 2000).

The third phase, *simulation*, integrates system dynamics, logistics cycle and project scheduling using a dynamic model that identifies the delays caused by an inadequate allocation.

The last phase, *validation and policy review*, applies a dynamic and integral method in terms of project management based on the results obtained from the outputs of the simulation with the purpose of establishing priorities in the implementation of policies, and to gradually improve activity coordination of the project management system in exploratory wells.

According to the contextualization of the work and from a methodological point of view, the project is analyzed from the definition of coordinates to the final drilling of the well, including demobilization, and includes a total of fourteen (14) activities with its duration as shown in Table 2.

Table 2 – Summary of project activities

Item	***Activities***	***Duration (Days)***
A	Definition of Coordinates	45
B	Environmental Management Transact	119
C	Logistics Recruitment	90
D	Land Negotiation	90
E	Preliminary Studies	75
F	Environmental Management Plan	60
G	Well Design and Program	130
H	Drilling Contracts	120
I	Civil Works Contracts	120
J	Civil Works Execution	100
K	Equipment and Materials Mobilization	30
L	Maintenance	95
M	Drilling Operation	65
N	Equipment and Materials Demobilization	30
	Drilling Project Total Days	**397**

Figure 4 shows the proposed method in detail and activities for each phase defined based on the project scope and the minimum exploratory program, and the exploration schedule to drill one well. According to this, the WBS (*Work Breakdown Structure*) is established, identifying the activities to be developed by the central and support systems based on the logistics cycle.

On the other hand, and according to the definition of Logistics and Life Cycle Project, and the investigation presented, in Table 3 the relation between these two aspects is presented. Thus, the 14 activities of the analyzed project through logistics cycle are presented.

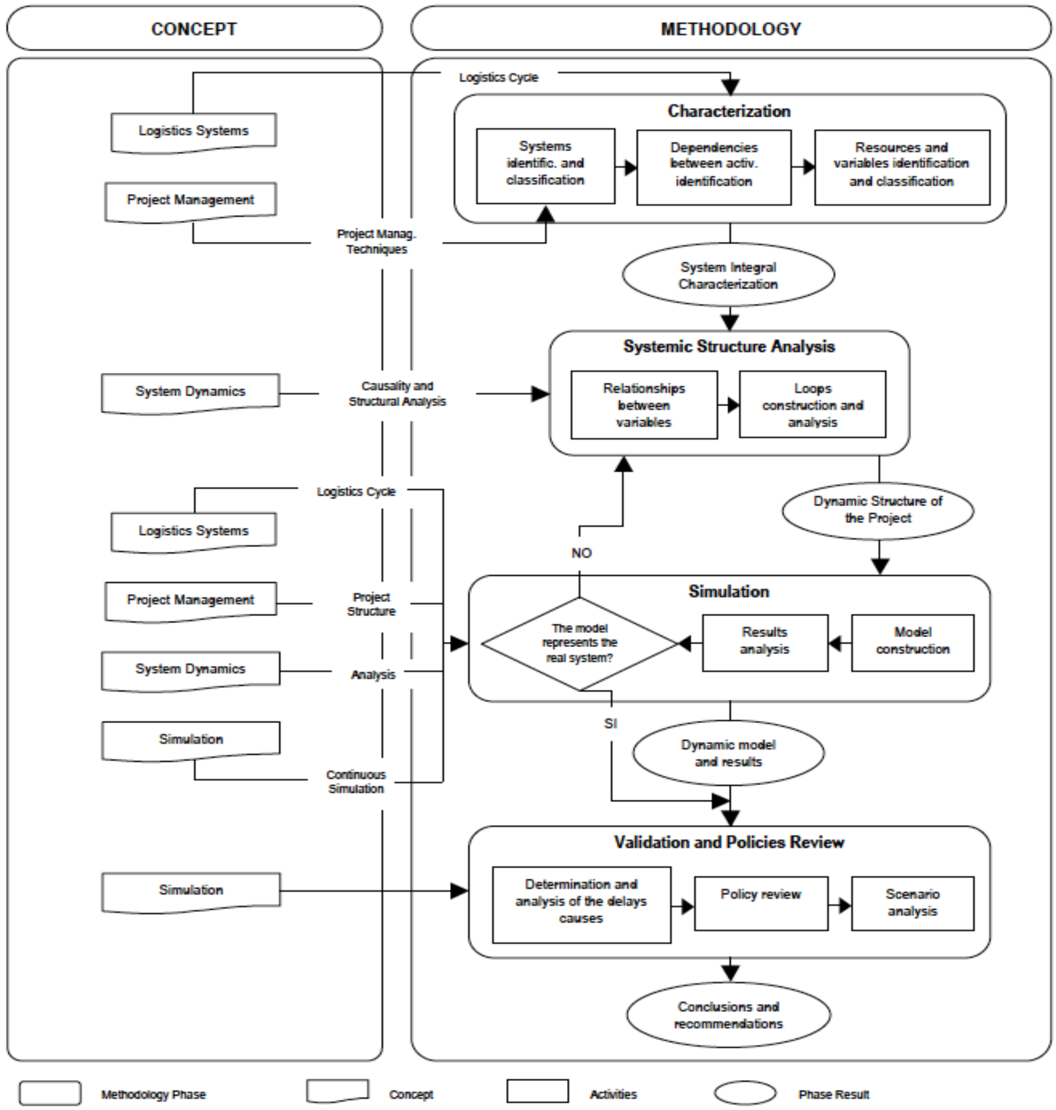

Figure 4 – Dynamic planning methodology

Table 3 – Relationship between Logistics Activity Cycle and Project Life Cycle

Logistics Cycle	***Project Management Cycle of Exploratory Wells***				
STAGE	***PHASE 1***	***PHASE 2***	***PHASE 3***	***PHASE 4***	***PHASE 5***
	Initiation	***Planning***	***Execution***	***Monitoring and Control***	***Closure***
Determination of Needs	*A, B*	*G*		***Note:*** *System does not involve activities performed throughout the Project Cycle Management*	
Provision of Resources	*D*	*C, E, F, H, I*			
Delivery of Resources			*J, K, M*		
Maintenance			*L*		
Reverse Logistics					*N*

The aim of methodology is to establish the relationship and correspondence between the theory and the proposed planning model, where the logistic cycle represents the starting point for the analysis of the project structure of exploratory wells, shown in Figure 5.

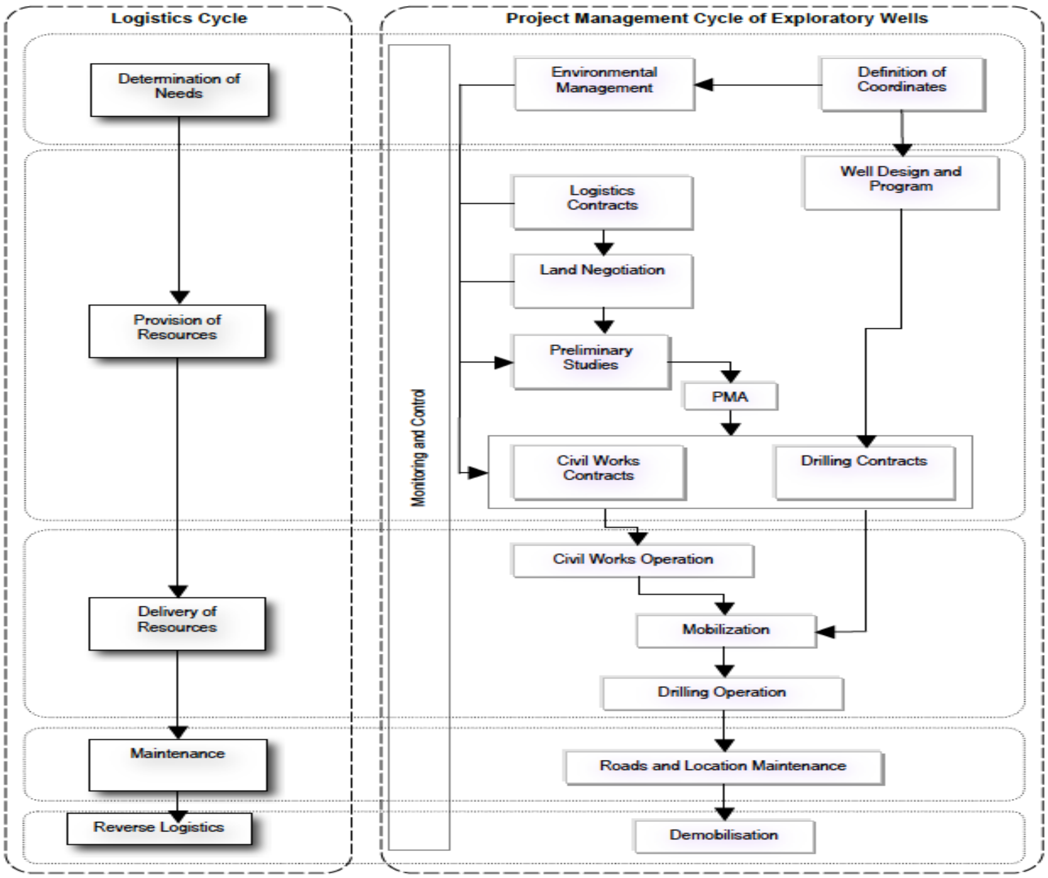

Figure 5 – Relationship between logistics cycle and project management cycle

Structure Systemic Analysis and Simulation

Figure 6 shows the conceptual structure of the project management system between activities A, B, C, D and E (causal diagram) in VENSIM software.

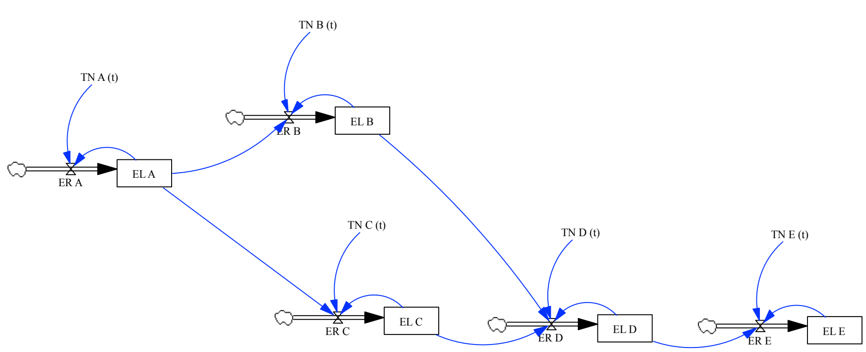

Figure 6 – Dynamic Model Structure

According to the dynamic model, the activities are represented by level variables (activity execution level or EL), which are defined as an activity execution percentage in function of execution rate (activity execution rate or ER, and activity output rate or OR). The activity execution rate depends on the activity technical norm (TN) which is the standard duration for the activity execution. Equation (1) shows the relation, in particular, for the activity A.

$$ELA_K = ELA_J + \left(ERA_{JK} + ORA_{JK}\right) \times \partial t \tag{1}$$

On the other hand, and according to the simulation processes, an analysis is developed to identify activities as well as its possible causes which are delayed. This processes is realized in the VENSIM software which lets establish priorities to the policies review based on the delay for each activity.

CONCLUSIONS

The methodology was validated in a petroleum company. According to this, the integration of project management and system dynamics during the logistics cycle let to identify that the planning process needs to start with one month before due to the resources allocation.

Furthermore, considering that the project requires some approval of the government entities, the logistics activities related with the project represents the critical path of the project. That is, is necessary to assign more resources to the activities B, C, D and E, with the objective to have all contracts ready before the drilling operation.

Due to the budget represents an important issue in all projects; a budgetary assignation must be identified in the monitoring and control phase intersect with the delivery of resources and maintenance stage. This is because the main activities of the project are focused in the execution phase and requires more attention by the managerial staff.

The logistic cycle plays an important role in the project management. This is because of the application of the five levels let to establish a better assignation of the resources for each activity, for example, in personal assignation and land transportation. This is an important tool to apply in the oil industry for better decision-making, maybe in Production and/or Drilling with more detail in a particular phase of the project management cycle.

The application of system dynamics in project management and supply chain management has emerged in the last decade due to the development of new methods and theories in a dynamic system characterized by interactions and feedbacks in and among organizations. Sterman et al. 2015 shows some perspectives and opportunities for the application of the system dynamics and relevant developments in operations management with mutual benefit in new research.

Bibliography

Project Management Institute. 2013. *A Guide to the Project Management Body of Knowledge (PMBOK Guide).* 5th edn. PMI Publishing, Newtown Square, PA.

Rodrigues, A. G. 1994. The role of system dynamics in project management: A comparative analysis with traditional models. *Proceedings International System Dynamics Conference* Lincoln, MA, 214-225.

Rodrigues, A. G. and Bowers, J. 1996. System Dynamics in Project Management: A comparative analysis with traditional methods. *System Dynamics Review*, 12(2): 121-139.

Rodrigues, A. and Bowers, J. 1996. The role of system dynamics in project management. *International Journal of Project Management* 14(4): 213-220.

Rodrigues, A. 2000. The Application of System Dynamics to Project Management: An Integrated Methodology (SYDPIM). *PhD Dissertation Thesis*. Department of Management Science, University of Strathclyde.

Mancera, L. H., Gonzalez, L., Kalenatic, D. and Moreno, K. 2011. Metodología de planeación logística basada en gestión de proyectos y dinámica de sistemas en empresas prestadoras de servicios. *Revista Facultad de Ingeniería Universidad de Antioquia*, 58: 208-218.

Confidential Document. 2014. Exploratory Project Management. *Integrated Management System. Petroleum Industry*, Colombia.

Feres, S. 2002. *Logística pura: más allá de un proceso logístico*. Editorial Corporación John F. Kennedy, Bogotá, Colombia.

Lyneis, J., Ford, D. 2007. System dynamics applied to project management: a survey, assessment, and directions for future research. *System Dynamics Review*, 23(2/3): 157-189.

Sterman, J. D. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin/McGraw Hill: Chicago, IL.

Sterman, J. D., et al. 2015. System dynamics perspectives and modeling opportunities for research in operations management. *Journal of Operations Management*, 39-40: 1-5.