IMPLEMENTATION OF ANALYTICAL ACCOUNTING MODELS AND MANAGEMENT INDICATORS AND DEVELOPMENT OF BUSINESS INTELLIGENCE AND BUSINESS ANALYTICS TOOLS IN URBAN AND METROPOLITAN COLLECTIVE TRANSPORT OPERATORS. A CASE STUDY

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ABSTRACT

Purpose: The study aims to conceptualize and describe tools for improving the strategic definition of business models and facilitating decision-making in urban transport. It focuses on integrating Information and Communication Technologies (ICT), Artificial Intelligence (AI) and Business Intelligence (BI) tools to address sustainability concerns and enhance operational efficiency.

Method: The research explores the evolution of management tools in urban transport, and use the case study of Transportes Interurbanos de Tenerife S.A.U. (TITSA) in order to illustrate practical application.

Result and Conclusion: The implementation of analytical accounting models and BI tools result in significant improvements in decision-making and operational efficiency. It allowed for better cost calculation, revenue analysis, and margin identification.

Keywords: Urban Transport, Business Intelligence (BI), Cost Accounting, Artificial Intelligence (AI), Information And Communication Technologies (ICT).

IMPLEMENTAÇÃO DE MODELOS DE CONTABILIDADE ANALÍTICA E INDICADORES DE GESTÃO E DESENVOLVIMENTO DE INTELIGÊNCIA EMPRESARIAL E FERRAMENTAS DE ANÁLISE EMPRESARIAL EM OPERADORES DE TRANSPORTE COLETIVO URBANO E METROPOLITANO. UM ESTUDO DE CASO

RESUMO

Objetivo: O estudo visa conceituar e descrever ferramentas para melhorar a definição estratégica de modelos de negócios e facilitar a tomada de decisões no transporte urbano. Ele se concentra na integração de Tecnologias da Informação e Comunicação (TIC), Inteligência Artificial (IA) e ferramentas de Business Intelligence (BI) para abordar preocupações com a sustentabilidade e melhorar a eficiência operacional.

Método: A pesquisa explora a evolução das ferramentas de gestão no transporte urbano e utiliza o estudo de caso da Transportes Interurbanos de Tenerife S.A.U. (TITSA) para ilustrar a aplicação prática.

Resultado e Conclusão: A implementação de modelos de contabilidade analítica e ferramentas de BI resultou em melhorias significativas na tomada de decisões e eficiência operacional. Isso permite uma melhor calculação de custos, análise de receitas e identificação de margens.

Palavras-chave: Transporte Urbano, Business Intelligence (BI), Contabilidade de Custos, Inteligência Artificial (IA), Tecnologias da Informação E Comunicação (TIC).

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IMPLEMENTACIÓN DE MODELOS DE CONTABILIDAD ANALÍTICA E INDICADORES DE GESTIÓN Y DESARROLLO DE HERRAMIENTAS DE INTELIGENCIA EMPRESARIAL Y ANÁLISIS EMPRESARIAL EN OPERADORES DE TRANSPORTE COLECTIVO URBANO Y METROPOLITANO. UN ESTUDIO DE CASO

RESUMEN

Objetivo: El estudio tiene como objetivo conceptualizar y describir herramientas para mejorar la definición estratégica de los modelos de negocio y facilitar la toma de decisiones en el transporte urbano. Se centra en la integración de las tecnologías de la información y la comunicación (TIC), la inteligencia artificial (IA) y las herramientas de inteligencia empresarial (BI) para abordar los problemas de sostenibilidad y mejorar la eficiencia operativa.

Método: La investigación explora la evolución de las herramientas de gestión en el transporte urbano, y utiliza el estudio de caso de Transportes Interurbanos de Tenerife S.A.U. (TITSA) para ilustrar la aplicación práctica.

Resultado y conclusión: La implementación de modelos de contabilidad analítica y herramientas de BI resultan en mejoras significativas en la toma de decisiones y la eficiencia operativa. Permitió un mejor cálculo de costos, análisis de ingresos e identificación de márgenes.

Palabras clave: Transporte Urbano, Inteligencia de Negocio (BI), Contabilidad de Costos, Inteligencia Artificial (AI), Tecnologías de la Información y la Comunicación (TIC).

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1 INTRODUCTION

In today's reality, transportation and mobility management face increasing challenges linked to demographic evolution, population concentration in large urban and metropolitan areas, environmental and energy sustainability, etc., which must be addressed through imaginative solutions and determined policies that promote clean and efficient transportation modes, smart city development, and measures to ensure system sustainability.

One of the key players in this field are the Municipalities, responsible for the collective urban transportation service in our cities, which must organize it, regardless of the chosen management modality, through the previously mentioned parameters. In this context, providing service management entities and concessionaire companies with tools that facilitate the strategic definition of their business model, the development of their operations, the organization of their personnel, the management of their assets, the configuration of their products and services, and customer service becomes relevant. These are the main dimensional axes that shape their management matrix and define their success or failure.

There are many issues that must be addressed when addressing the aforementioned problems: on the one hand, those related to the orientation of strategies and innovation models,
R&D&I and sustainability, in its multiple aspects (environmental, financial, and social, etc.); on the other hand, those related to the concretization of these strategies into specific investment, quality, marketing and sales, logistics and supply chain policies, financial management, risk management, and control.

Furthermore, organizations operate today in a technological ecosystem that requires them to articulate policies to develop their activities through ICT (Information and Communication Technologies) and Artificial Intelligence tools, also addressing their cybersecurity, as a critical element for operating safely and protecting their external and internal agents.

However, although much of the debate is focusing on the technological level, we cannot forget that at the heart of the matter are people, as they are not only the ultimate reason for the existence of any organization but also the key element that, at all levels, determines its success or failure.

Therefore, we cannot overlook key aspects such as change management and knowledge management or the ethical codes and good governance, as well as transparency, as key elements of the Entity's Social Contract with its internal agents and with the Community. Thus, the aforementioned scenario contains an entire organizational universe that defines a broad field of interest for both the professional manager and the social researcher, as previously stated.

Our proposal for study is framed within this framework of ideas, focused on the global analysis of management dimensions, from the perspective of research related to disciplines linked to the analysis of information systems and data exploitation, to improve the management of urban and metropolitan collective transport operators.

With this purpose, we seek to conceptualize and describe the main tools linked to this purpose through the study of a real case application.

From cost calculation, revenues, and margins at all levels and for the entire global dimensional matrix of the organization (cost of consumption, centers, agents, activities and process, products, etc.) to the definition of management indicators and dashboards, through the development and implementation of Business Intelligence or Institutional Intelligence tools, as the first aspect of the phenomenon.

Indeed, the first step is to generate adequate information to understand the reality of the organization and support decision-making processes at its different levels of responsibility (senior management, middle management, operational management) and meet the accountability requirements of Society.
But there is a second aspect linked to this reality that begins from the first. Once we have the information and the appropriate database architecture to support it, it is necessary to analyze its content and exploit it to generate knowledge and improve organizational dysfunctions and inefficiencies. That is, it is about optimizing the information available to managers to guide and improve the decisions they make, by having a documented and rigorous rationality based on data rather than intuitions.

In this context, techniques related to Data Mining, Big Data, and predictive analytics take center stage, allowing the detection and reduction of hidden costs and the identification of business opportunities, as well as the subsequent organizational reengineering processes that enable the overcoming of dysfunctions, the enhancement of revenues, and the exploitation of strengths, and consequently, the promotion of competitiveness, continuous improvement, and business and organizational success.

Examples of improvements introduced by such tools include the implementation of policies for fuel savings, planning preventive vehicle maintenance, determining the optimal fleet renewal point, reviewing the vehicle acquisition policy based on comparative analysis of brands and models, or reviewing human factor management to improve employee absenteeism.

2 PERSPECTIVES AND EVOLUTION OF MANAGEMENT TOOLS IN ICT ENVIRONMENTS IN THE COLLECTIVE TRANSPORT SECTOR

According to the approach outlined in the previous lines, it is necessary to address the conceptualization and description of the theoretical framework described above and propose a sectoral case study that illustrates an example of application of the reference theoretical framework.

In this context, we have chosen the case of urban and metropolitan collective transport and the public or private companies that operate as concessionaires of this service. Our choice is motivated by the fact that within this framework, there is great potential for the application of the techniques described above, especially due to the growth and importance of the sector and the significant technological development it is experiencing: vehicle geolocation, smart transportation networks, smart city development, multimodality development, concern for sustainable mobility... This circumstance, combined with our experience in implementing analytical management systems in the sector, justifies its choice as a case study.
Within our theoretical framework and, from the perspective of disciplines related to analytical accounting information systems and management, there has been a significant evolution from the early practices existing in pre-industrial revolution stages and, especially, from then on, guided by a mechanistic and Taylorist vision of business management, to the present day, anticipated by the existential crisis experienced in the discipline due to the social and economic changes of the last decades of the 20th century (mass consumption economies, internationalization of markets, increase in uncertainty, quality segmentation as a competitive advantage, people and team management, etc.) and materialized in the early days of our century with a technological, social, and industrial revolution that places us in a radically different environment.

Aspects such as globalization, micro-segmentation of customers and markets, the proliferation of uncertain environments, the explosion and development of Information and Communication Technologies (ICT), the Internet of Things (IoT), Industry 4.0, virtual reality, or Artificial Intelligence (AI) have highlighted the need to develop new tools and a new language in the field of organizational management.

We are currently at a critical juncture in the human relationship with business activity, as evidenced by enlightening data such as those formulated by the McKinsey report (Chinn, 2020), which predicts that, in the European Union alone, 59 million jobs (26% of the total) are at risk of disappearing, or the conclusions of the 2019 Davos Forum, which estimate that 65% of today's children will work in professions that do not yet exist. These predictions are necessarily linked to a reconsideration of educational systems and employee training processes in companies, as well as their alignment with management systems.

From the perspective of our analysis, we are experiencing an evolution that can be summarized in four main areas:

2.1 FORMULATION OF MODELS AND TOOLS FOR ACCOUNTING AND ECONOMIC-FINANCIAL MANAGEMENT

The classic development of the discipline has allowed the formulation of various management tools: standards, inventory valuation, cost/volume/profit analysis, program budgets, zero-based budgets, performance measurement systems, incentive models, etc., widely used by managers of organizations and extensively discussed in academic literature.
2.2 DEVELOPMENT OF INTEGRATES INFORMATION SYSTEMS

The classic development of the discipline has allowed the formulation of various management tools: standards, inventory valuation, cost/volume/profit analysis, program budgets, zero-based budgets, performance measurement systems, incentive models, etc., widely used by managers of organizations and extensively discussed in academic literature.

2.3 IMPLEMENTATION OF BUSINESS INTELLIGENCE (BI) TOOLS

The aforementioned proliferation of ERPs and ICTs has enabled and compelled the implementation of Discovery Data tools, facilitating the exploitation of the increasing volumes of generated information and its articulation along multiple dimensional axes oriented towards decision-making.

2.4 DEVELOPMENT AND IMPLEMENTATION OF BUSINESS ANALYTICS (BA) SOLUTIONS AND TECHNIQUES.

The next stage in the described process is the exploitation of information for data-driven management, through the widespread use of algorithms, data mining techniques, predictive analytics, and big data.

2.5 DEVELOPMENT OF ARTIFICIAL INTELLIGENCE (AI) TOOLS

The next stage is linked to the advancement of autonomous systems that introduce capabilities for rational thought and action, techniques that are already being developed and applied to varying degrees in multiple fields of activity (medicine, engineering, economics, transportation, etc.).

In fact, regarding the scope of our case study, there are highly advanced developments in different fields such as the design of intelligent transportation networks or the advancement of autonomous vehicles.
3 IMPLEMENTATION OF AN ANALYTICAL ACCOUNTING MODEL AND BUSINESS INTELLIGENCE TOOLS IN A PUBLIC TRANSPORT COMPANY

Currently, urban and metropolitan transportation plays an essential role in the economic and social structure of cities and population centers worldwide. The organization of models that ensure adequate frameworks guaranteeing the fluidity, economy, universality, and sustainability of inhabitants' movements, through a suitable combination of various public and private transportation means, is critically relevant.

For public authorities, it is essential to organize mechanisms for the provision of such services in any of its management forms, aiming to achieve adequate levels of efficiency and sustainability, determined and conditioned by factors such as population density, topography, urban planning, spatial disposition, etc. Therefore, transportation operators' managers must develop tools that promote these objectives. Autonomous vehicles, geolocation, Smart-cities, sensorization, intelligent transportation networks, alternative fuels, user support apps (transfers, lines, schedules, etc.), mobile phone payments, are examples of the many advances being applied to improve a service of nuclear importance, to maintain our economic and social model, and its sustainability in the face of challenges such as climate change.

We present a case of implementing an analytical accounting model and Business Intelligence for a public collective transportation company.

Transportes Interurbanos de Tenerife S.A.U. (TITSA) is a public limited company of the Insular Council of Tenerife that, over its 30 years of evolution and history, has become a benchmark in public collective passenger transportation nationally. The main activity carried out by TITSA is the provision of collective public passenger transportation services by bus on the island of Tenerife, which is part of the Canary Islands archipelago.

TITSA is the main public transportation operator in Tenerife and manages the bus stations of La Laguna, La Orotava, Puerto de la Cruz, Buenavista del Norte, Guía de Isora, Adeje, Granadilla de Abona, Güímar, Candelaria, and the Santa Cruz interchange, in addition to workshops and garages in La Orotava, La Laguna, Santa María del Mar, among others. It offers urban services in the Tenerife capital, Santa Cruz, La Laguna, Los Realejos, and Guía Isora, La Orotava, Los Realejos, and Arona, as well as interurban, school, and discretionary transportation services. TITSA buses operate 365 days a year, 24 hours a day, with a network of approximately 3,700 stops distributed throughout the island territory, serving with a network of 160 lines, over 500 vehicles, more than 33 million passengers, and more than 35 million
kilometers traveled per year, with a staff of 1,724 professionals, of which 1,381 employees are drivers.

The company decided to undertake this project to ensure compliance with legality and reporting obligations, as well as to modernize and improve its management on multiple fronts: generating quality information for decision-making, improving base information for setting prices and tariffs, increasing the transparency of the entity, promoting both internal and external benchmarking, contributing to improving the financial sustainability of the service, etc.

To achieve this, an analysis and diagnosis of its information systems were first addressed, defining the appropriate data integration strategy for the project's scope, after which it was possible to define the analytical model, the set of dashboards and selected management indicators, and the implementation and integration of the computer system, with a project timeframe of 10 months.

**Figure 1**

*Integration of management systems*

To construct the dashboard structure that configured the BI tool, the following groups of tools were used:

- Pivot tables for numerical analysis of the different dimensional variables defined in the model (cost elements, centers, vehicles (make-model, fuel type, ...), lines, service kilometers, passengers transported, workshop hours, driver hours, etc.) (see example of cost table by line type in figure 2);
- Bar charts for schematic analysis of the different dimensional variables defined in the model (cost elements, centers, vehicles (make-model, fuel type, ...), lines, service kilometers, passengers transported, workshop hours, driver hours, etc.) (see figure 2);
- Percentage distribution charts of the different dimensional variables defined in the model (cost elements, centers, vehicles (make-model, fuel type, ...), lines, service kilometers, passengers transported, workshop hours, driver hours, etc.) (see figure 2);
- Scatter plots of the different dimensional variables defined in the model (cost elements, centers, vehicles (make-model, fuel type, ...), lines, service kilometers, passengers transported, workshop hours, driver hours, etc.) (see figure 2);
- Information exploitation charts for identifying entities that exceed certain levels of dispersion in relation to the different dimensional variables defined in the model (cost elements, centers, vehicles (make-model, fuel type, ...), lines, service kilometers, passengers transported, workshop hours, driver hours, etc.) (see example of cost/km dispersion table by vehicle model type –outliers- in figure 4);
- Sets of key performance indicators (KPIs) for the basic analytical axes of management (personnel costs, service lines, passengers transported, kilometers traveled, etc.) (see example of KPI table of costs, revenues, and margins per passenger and kilometer in figure 5).

**Figure 2**

*Cost Dashboard by Line Type*

![Cost Dashboard by Line Type](image_url)

Source: Own elaboration
In conclusion, this represents a successful case, highly appreciated by the company's management as it constitutes a project that has enabled the generation of valuable information to guide decision-making and improve the management of the operator. Furthermore, it
represents a critical first step towards the development of predictive analytics, big data, and data mining models that facilitate the identification of trends, anomalies, hidden costs, etc., enabling continuous improvement of the public service in multiple facets: fuel savings and containment of polluting and greenhouse gas emissions, improvement of traffic congestion, fleet renewal and maintenance policy through the determination of the optimal fleet renewal point or preventive maintenance interventions, etc.

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