Mobile Virtual Reality Laboratory for Industrial Maintenance Training: A Technical and Economic Feasibility Study

Laboratório Móvel de Realidade Virtual para Treinamento em Manutenção Industrial: Um Estudo de Viabilidade Técnica e Econômica

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ABSTRACT

Virtual reality is an enabling technology that is already being used in industrial training, the next step is to make this application as customized as possible for each customer. The innovation discussed in this article is a mobile virtual reality maintenance lab with the primary goal of providing training services. This innovation will be developed using a 3D model of the equipment, and a virtual environment will be created and applied to the customer's location using a mobile office. So, this study presents a model to evaluate the technical and financial feasibility of using a mobile maintenance office for training equipment while taking the metaverse into account. The proposed model relies on InCaS - Intellectual Capital Statement. Intellectual Capital can can prove particularly useful in the development, production, and sales of an organization's products and services. The proposed model was applied in a Brazilian market context. We observed that there are still technical, economical, effective, and efficient options for using mobile offices for training equipment to disseminate knowledge, test newly acquired knowledge, and improve currently used maintenance techniques. This opens the door to innovate, to reduce the costs associated with continuous improvement processes, and to introduce new scientific research and development by taking into account the potential to test these improvements in a virtual environment.

Keywords: Virtual Reality; Industrial Training; Model Feasibility; Intellectual Capital Statement; Business Case

RESUMO

A realidade virtual é uma tecnologia que já está sendo utilizada em treinamentos industriais, o próximo passo é tornar esta aplicação o mais personalizada possível para cada cliente. A inovação discutida neste trabalho é um laboratório móvel de manutenção de realidade virtual com o objetivo principal de fornecer serviços de treinamento. Esta inovação será desenvolvida utilizando um modelo 3D do equipamento, e um ambiente virtual será criado e aplicado na localização do cliente utilizando um escritório móvel. Portanto, este estudo apresenta um modelo para avaliar a viabilidade técnica e financeira do uso de um escritório de manutenção móvel para treinamento de equipamentos, levando em conta o metaverso. O modelo proposto se baseia no InCaS - Intellectual Capital Statement. O Capital Intelectual pode se mostrar particularmente útil no desenvolvimento, produção e venda de produtos e serviços de uma organização. O modelo proposto foi aplicado em um contexto de mercado brasileiro. Observamos que ainda existem opções técnicas, econômicas, eficazes e eficientes para o uso de escritórios móveis para treinamento de equipamentos para disseminar conhecimentos, testar conhecimentos recém-adquiridos e melhorar as técnicas de manutenção utilizadas atualmente. Isto abre a porta para inovar, para reduzir os custos associados aos processos de melhoria contínua e para introduzir novas pesquisas e desenvolvimento científico, levando em conta o potencial de testar estas melhorias em um ambiente virtual.

Palavras-chave: Realidade Virtual, Treinamento Industrial; Viabilidade do Modelo; Declaração de Capital Intelectual; Caso de Negócios.

INTRODUCTION

It is well known that virtual reality (VR), along with other digital tools, is already used in industrial training; nevertheless, the next innovation is to make this application as customized as possible for each customer. In addition, even digital tools still require a physical location to be used, which makes it difficult for businesses and industries to use them outside of areas with a higher level of technological development where these services are often provided. In this way, a mobile laboratory will be created to spread virtual reality technology throughout more regions of the country to construct this innovative service. The innovation described in this paper relates to a mobile virtual reality maintenance workshop with the primary goal of providing training services to businesses from a wide range of industry sectors.

The modernization of industrial companies requires the use of labor with a higher degree of specialization since it frequently entails the use of increasingly sophisticated and modern equipment and machinery (Netto et al., 1998). There are several studies on the use of virtual reality for training and education, some of which even claim that the outcomes of training using virtual reality are unquestionably better than those obtained using real-world systems (Netto et al., 1998).

Businesses like Nabisco Food of Foods (East Hanover, New Jersey) use solutions in virtual reality to train their personnel in maintenance and service for their production lines. Since 1994, Motorola, a manufacturer of electronic components such as semiconductors, has used virtual reality to train its most recent employees on-site, saving the company a significant amount on travel and training expenses. Using a virtual simulation environment, which allows for the training of a large number of people and allows for error tolerating and correction without affecting the service, the use of virtual reality seeks to meet this requirement. The end effect is more assertive real-world maintenance that has no bearing on the scheduled paralysis time (Netto et al., 1998).

The following data on the use of virtual reality in training teams to use specific equipment are presented in a 2018 article (Revista M&T, 2018). The characteristic most important to this image is the difference in values between training formats, with no comparison to the values presented in this work being justified given that these values can vary greatly depending on the number of people being trained, the size of the virtual world, the number of elements to be created to make up the meals, the duration of the training, and the distance from the company's headquarters to the client.

Considering this scenario, this study presents a model to evaluate the technical and financial feasibility of using a mobile maintenance office for training equipment while taking the metaverse into account. The proposed model is applied in a Brazilian market scenario.

This document is organized as follows to describe virtual reality and metaverse as well as InCas – Intellectual Capital Statement (Zickgraf, 2009). The next section presents a proposed model to analyze the technical and economic feasibility for implementing a mobile virtual reality laboratory for industrial maintenance training with proposed models for technical and economic feasibility. it concludes by presenting conclusions and suggestions for future research.

VIRTUAL REALITY AND METAVERSE

Virtual reality is a computer-generated digital environment that can be experienced and interacted with as if it were real. VR and other digital development have changed how companies executes daily routines (Dias Junior; Ferreira; Winkler, 2023). Besides, virtual reality has helped organizations to achieve several Sustainable Development Goals (SGD) (Chamusca et al., 2023).

At the same time, due to recent changes in people life, most people have become accustomed to making things online. In this context, a concept that has emerged is the metaverse. Metaverse is “a massive scaled and interoperable network of real-time rendered 3D virtual words that can be experienced synchronously and persistently by an effectively unlimited number of users, such as identity, history, entitlements, objects, communications, and payments (Ball, 2022).

The metaverse is a collective virtual shared space, including the collection of virtual worlds, expanding reality and the Internet (Rong et al., 2021),(Ruxi; Anling, 2021). It uses a variety of new generation information technologies to achieve the multi-dimensional and deep integration of technology, individual, organization, production, culture, social interaction, entertainment, economy, and constructs a new immersive network social form, which is parallel and intermingled with human society, and can be shared continuously.

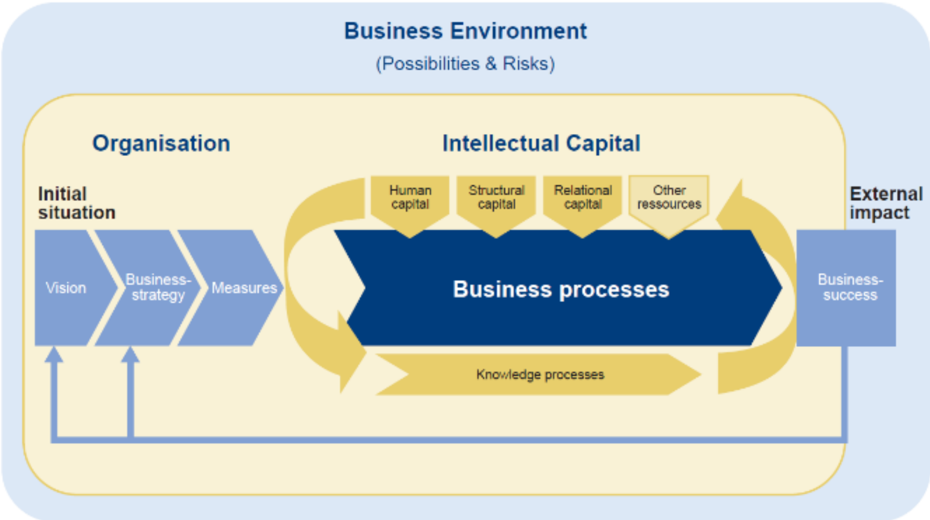
The metaverse is still facing many challenges, such as: i) inadequate policy planning; ii) immature technology development; iii) standard system in not perfect; iv) difficulties in legal supervision; v) economic rules are difficult to determine; and vi) Moral ethics are impacted. Based on topics (ii) and (v), this study presents a model to examine the technical and financial feasibility of using a mobile maintenance office for training equipment (Wang; Yan; Zhou, 2021).

InCaS – INTELLECTUAL CAPITAL STATEMENT

The InCaS - Intellectual Capital Statement – is a methodology developed by a Research Consortium in Europe in 2006. The intellectual capital' (IC) becomes increasingly important for future-oriented organizations. IC can prove particularly useful in the development, production and selling of a company's products and services. It covers a diversified knowledge area, ranging, for instance, from staff qualification and motivation, leadership and management structures, to organizational capacities or relations to the market. Overall, IC is a crucial resource in gaining an advantage over competition, and in ensuring the future success of a business. However, such a powerful resource naturally requires an appropriate operating instrument. (Zickgraf, 2009).

Intellectual Capital Statement (Wang; Reiterer, 2018) is a strategic management instrument for assessing and developing the Intellectual Capital (IC) of an organization. It shows how Intellectual Capital is linked to corporate goals, business processes and the business success of an organization using indicators to measure these elements. The structural model, presented in Figure 1, describes the main elements of the ICS as well as their interrelations:

Figure 1 - Intellectual Capital Statement structure.



Fonte: (Robert; Piotrowski, 2009)

The organization is embedded in the business environment. The BP are chains of activities within an organization and their network-like contexts. They provide the output of the organization which is useful to the customers. BP describe the interaction of people, operating resources, knowledge and information in cohesive step. (Wang; Reiterer, 2018).

The intellectual capital (IC) is divided into three categories:

30 Human Capital (HC) is defined as "what the single employee brings into the value adding processes".

31 Structural Capital (SC) is defined as "what happens between people, how people are connected within the company, and what remains when the employee leaves the company"

32 Relational Capital (RC) is defined as "the relations of the company to external stakeholders".

The human capital (HC) considers the professional competences, social competences, employee motivation and leadership ability. The structural capital considers the cooperate culture, internal cooperation and knowledge transfer and management instruments. And, the relational capital (RC) considers the customer and investor relationship.

PROPOSED MODEL TO ANALYSE THE TECHNICAL AND ECONOMIC FEASIBILITY TO IMPLEMENT A MOBILE VIRTUAL REALITY LABORATORY FOR INDUSTRIAL MAINTENANCE TRAINING

The proposed model is based on the challenges presented by (Wang; Yan; Zhou, 2021) and InCas (Zickgraf, 2009).

1- Immature technology development;

2- Economic rules are difficult to determine

Considering the InCaS can be developed for a business process, it is important to consider that the “training industrial maintenance process using a mobile virtual reality laboratory” will be analyzed. The main idea is to create value for the customers and the following questions help to describe the value creating model of the company.

Question 1 - What product or service does the business offer?

Question 2 - How can customers benefi t from this product or service?

Question 3 - Which market segments / groups of customers are targeted?

Question 4 - To whom will the proposition be appealing?

Question 5 - From whom will resources be received?

Question 6 - How are the products or services created?

Question 7 - How are they going to be delivered to the customers?

Question 8 - How will the customer pay for the product or service?

Question 9 - What is the price/margin for the product or service offered to the customer?

The answers are the base for the value creating model that is the kernel for any strategic considerations. And the IC (people, structural and relationship) are the bases to offer value for the customers.

The answers for questions (1), (2) and (3) must be positive to develop the mobile virtual reality laboratory, i.e, the developers must have answers for these question and answers must create value for the customers.

TECHNICAL VIABILITY – PROPOSED MODEL

Maintenance is a procedure that keeps equipment and machinery in excellent operating order and safety. The knowledge and experience of the teams of employees are the foundation of effective maintenance, and the knowledge and experience of the workers are acquired via their learning experiences and work experiences. In the face of an increasingly dynamic activity like maintenance, commonly utilized techniques like training manuals, work shadowing, evaluation, and certification processes are out of date, less effective, and take too much time.

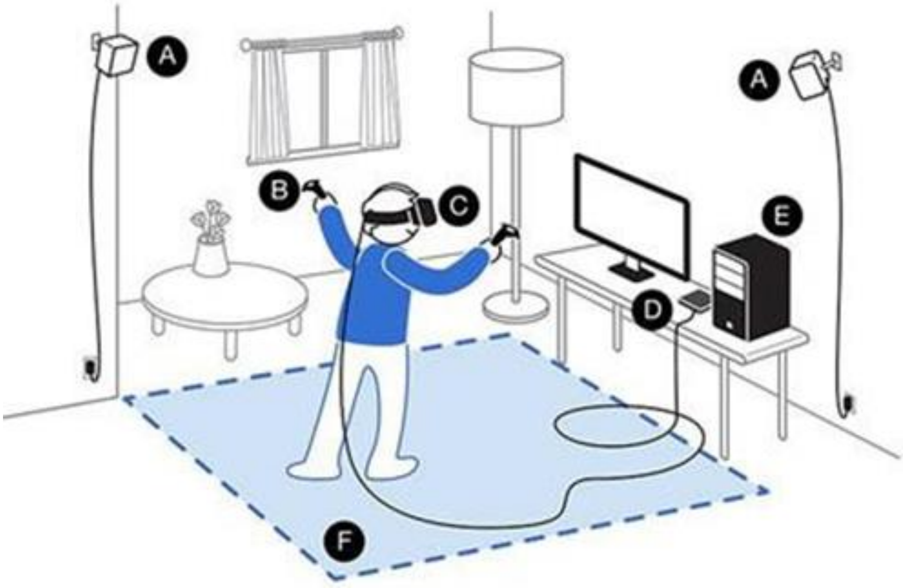
Additionally, the necessity to accommodate various learning styles, including verbal, auditory, and visual, is not addressed by these techniques. Additionally, given the rapid nature of the sector, workers do not have much time for on-the-job training because the actual work scenario and atmosphere does not support them (Numfu; Riel; Noel, 2019).

There are several ways to build a mobile workshop, from modifying trailers to placing a container on the wheels of a truck to facilitate easy delivery to the customer, as seen in Figures 2, 3, and 4:

Figure 2 - A rendering of the interior of a large, well-rounded travel trailer, an example of a mobile space that can be modified to accommodate the facilities needed to run the machines.

Fonte: (Blendspace, 2019)

Figure 3 - Instructions for organizing a space to use the virtual reality glasses, through the illustration it is possible to see that the minimum required size can be supported by the space provided in a trailer



Fonte: (Tim, 2016)

The mobile lab solution does not rule out the possibility of using virtual reality in larger spaces, with the equipment transfer to a client-provided space at the company's location being viable. This makes it possible to do workouts that include a larger group of individuals or call for a wider range of movement. Once the application has been completed in virtual reality, the client will be given access to all documents created throughout the development process as well as the virtual world's blueprint for their use as they see fit. If a client needs to conduct the same training session with a different group of people, the portion of the service fee related to the costs associated with the development of the virtual world will be waived, and the tools used in previous training sessions may be reused in projects for other clients who use the same machine.

Pertinent information regarding this innovative service is that the use of the home office work format during the development of 3D and virtual world programming, enabling developers to work from anywhere in the nation. In this instance, the employees in charge of testing and supporting virtual reality will work from a mobile unit, taking the training facility to the clients. It is intended that more of these mobile units will be developed over time to operate with a focus in various regions and states of the country, eventually taking on a franchise-like shape, which will save transportation costs. It is important to conclude the description of the proposed service by stating that it has the potential to provide training in a variety of other areas, not only maintenance, and that this represents one of the best opportunities for business growth.

Figure 4 - Use of a container as an office, an example that proves the possibility of using this space to build the laboratory

Fonte: (Totti Equipamentos, 2012)

The innovation proposed differs in that a 3D model of the equipment will be developed and a virtual environment will be created and applied on-site at the customer using a mobile workshop. Supporting businesses in various locations enables access to this technology to be democratized, independent of an organization's proximity to major centers or even the team's relocation for training at these locations.

The requirement to move away from a traditional training strategy, based on paper and video instructions, to a more engaging and effective model is brought on by the significant increase in the usage of new technologies in the manufacturing sector (Blendspace, 2019). Modern head-mounted displays (HMDs) provide full separation of touch and visual awareness, as well as total immersion. This enables the modeling of a variety of environments during maintenance task training without sacrificing actual touch sensitivity. Tracking actual objects and synchronizing the location and current states of moveable parts via IoTP are essential steps in building a functional and acceptable virtual environment. The virtual environment is customizable and enables the modeling of many scenarios, including stress during operations, for teaching the maintenance chores (Tim, 2016).

To evaluate the technical feasibility, it is necessary analyze the process necessary to develop the customized solutions for the clients. And it involves the evaluation the following IC:

1- Human Capital (HC) – Professional Competence – The expertise gained within the organization or in the employee's career: professional training, higher education, training courses and seminars, as well as practical work experiences gained on-the-job. (Wang; Reiterer, 2018).

2- Strututural Capital (SC) - Internal Co-operation and Knowledge Transfer - The manner how employees, organizational units and different hierarchy levels exchange information and co-operate together (e.g. conjoint projects). The focused knowledge transfer among employees. Furthermore, the focused knowledge transfer between generations is noticeable. (Wang; Reiterer, 2018).

3- Structural Capital (SC) – The process to develop the customized solution for the client, considering the following steps:

4- Relational Capital (RC) – Customer relationship – Customer must be involved into the company process.

Based on this, the following points must be evaluated in the technical point of view:

5- Reality, and a smaller space will be used to house the machines that will be used to process it. These devices will primarily be computers and monitors to which virtual reality goggles will be connected, with the option to also include other devices capable of enhancing the possibilities for interaction with the virtual world, such as 3D printers for quick prototyping.

6- Implement the Solution – In this stage must be evaluate the feasibility in implement the results of virtual reality into the laboratory for training people.

7- Develop the World´s Model - The world's model consists of a scene, 3D objects, and 3D characters, as well as the wide range of interactions that may be had with these elements, requires a wide range of technical knowledge, including 3D modeling and programming that is focused on animation. The client will already be involved in the process during this stage of the development of this virtual world, providing the team with information about their company and their processes so that they may faithfully reproduce their descriptions. The same procedure will be carried out using the same machines that these companies' employees would use for training; in other words, all of these equipment's processes and functionalities will be researched in order to be programmed in virtual reality.

8- Select the Movel Laboratory - In this stage, it's crucial to define this "laboratory" properly because it will simultaneously have many possibilities and some limitations due to the adjustments required to make it both functional and portable. The idea is to create a vehicle akin to a domestic trailer, but instead of being made up of moving parts, the majority of the space will be left empty to accommodate the movement of people immersed in virtual

In this moment, the design team must be able to answer the following questions, that are related to the HC, SC and RC, according to the table 1.

Table 1. Questions to analyze the technical feasibility.

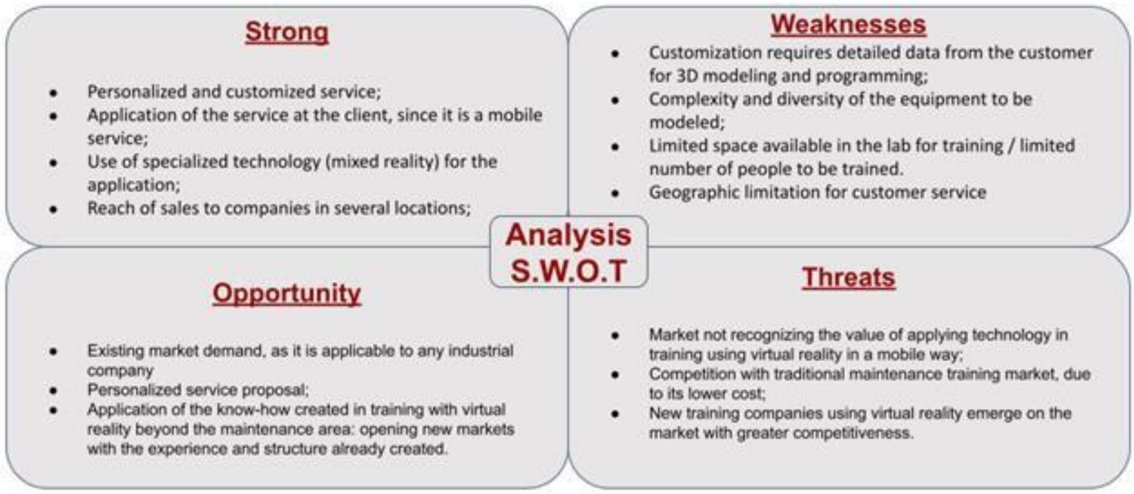
Question 4 - To whom will the proposition be appealing? (RC)	The target audience for the training must be defined, including not only the participants but also all stakeholders involved in the activity.
Question 5 - From whom will resources be received? (HC / SC)	It is crucial to determine the scope of training delivery. This definition serves as the basis for determining which resources will be modeled in a virtual environment. Consideration must be given to the skills and knowledge of those who will develop the activity.
Question 6 - How are the products or services created? (HC / SC)	It entails defining the technologies and tools that will be used to generate virtual environments, as well as the tools that will be employed. Consideration must be given to the skills and knowledge of those who will develop the activity.
Question 7 - How are they going to be delivered to the customers (RC)?	Considers the definition of the environment's delivery format in which the work will be developed. It corresponds to the purview definition and the technologies that will be utilized in the laborator

Fonte: Elaborated by the authors, 2022.

The service being offered has great strength because it has specialized staff who can provide a service that is tailored to the client's business's needs and is applied locally, according to the questions answered and the analysis that covered all internal organizational aspects. This sets it apart from its rivals because it is a mobile service that can reach businesses in a variety of locations. However, given that each client will have very specific equipment and that this customization requires a detachment of data from the client to develop the tridimensional project and create the virtual environment, a weakness could be found in the variety and complexity of the application. Additionally, there is a restriction on how the training is applied, reflecting in a cap on the number of people trained every session based on the size of the mobile laboratory. A weakness might be the inability to provide service to clients who are located far from one of the company's units due to the difficulty of transportation.

There is already a market need for industrial maintenance training in general, so the company's service is customized and extends geographically to other regions. This is relevant to the analysis of the external environment. The main threat is that the market will not recognize the value of using virtual reality in mobile training exercises, which would hinder the company's growth and could result from competition with the market for traditional training exercises in maintenance. Additionally, it is seen as a threat to the entry of new training companies using virtual reality that are more competitive. Figure (Fig. 5) presents an overview of the market analysis based on the S.W.O.T. matrix (Cunha, 2022).

Figure 5 - Analysis S.W.O.T matrix



Fonte: (Cunha, 2022)

ECONOMIC VIABILITY – PROPOSED MODEL

The main competency to be developed for the implementation of innovation is understanding the market and the customer to provide the service in a personalized manner both during the 3D project phase and the creation of the virtual environment as well as during the implementation phase, to meet the customer's need for maintenance training. Considering the analysis of the competitive forces in the business environment performed in the previous sections, it was planned that an internal team with expertise in the acquisition of hardware and software with already-established marketability would develop the innovative solution. The unique selling point of the service will be the creation of client-specific virtual reality projects and their use in on-site maintenance training. The construction of the contextualization of the technologies that will be created and acquired for innovation (Brunzini et al., 2021) is aided by the Table 2 gest (Appendix A).

The demand was projected considering the number of companies that could use the industrial maintenance training services using virtual reality in the region.

Table 2 - Demand projection

Year	Quantity
1	14
2	16
3	18
4	24
5	25

Fonte: Elaborated by the authors, 2022

The product is in fact a service to be provided, as already explained in the previous sections.

The steps of the technical design of the service consist of:

Data collection at the customer (Equipment data, required functionality, virtual environment).

3D modeling and programming

3D virtual reality application / calibration

Sales via Web site / trade shows / technical visit

Service provided via mobile lab at customer site

Based on the needs identified for carrying out the innovative project, considering the resources necessary for launching the project and executing the services, the necessary items were listed and the respective costs for the preparation of the first budget were identified, as shown in the table below (Table 3). This budget comprises expenses from the beginning of the first year and initial investments from year zero.

Table 3 - Total Cost

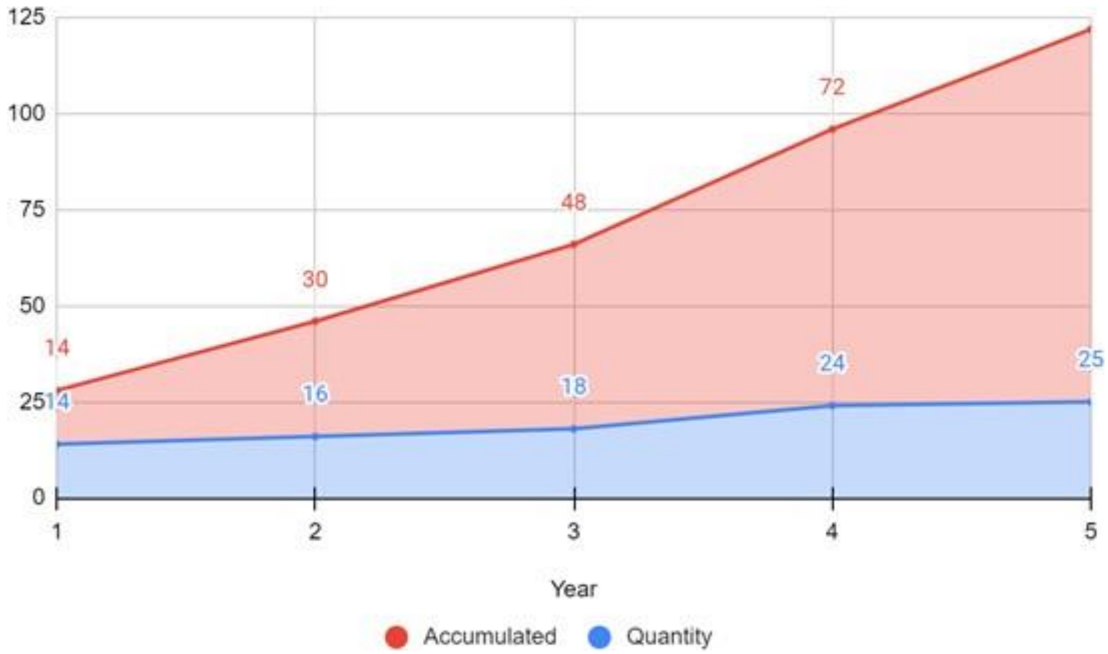
	Budgeted Items	Quantity	Total Cost
	Equipments		
1	Computer (advanced processor and video card)	3	R$ 60.000,00
2	Virtual Reality Kit (glasses and joysticks)	4	R$ 12.000,00
3	Smart TV	1	R$ 3.000,00
	Laboratory Utensils		
1	Battery Case	1	R$ 1.500,00
2	Stationery Kit	1	R$ 500,00
3	Tools Kit	1	R$ 3.000,00
	Digital Resources		
1	Site Development	1	R$ 10.000,00
2	Lifetime Modeling Software License	1	R$ 900,00
3	Virtual Reality Software Annual License	1	R$ 2.500,00
4	Website Expenses	N/A	R$ 373,00
	Adapted Vehicle	1	R$ 175.000,00
	Working Capital	N/A	R$ 20.000,00
	Administrative Expenses	N/A	R$ 18.400,00
	TOTAL		**R$ 307.173,00**

Fonte: Elaborated by the authors, 2022

Over a 5-year horizon, it was estimated that there would be an increase of 2 projects each year until the fourth year (Fig. 6). There would then be an increase in the number of employees, allowing for the expansion of the project's service capacity and an increase in the number of services provided. Based on previous market research in Brazil and considering that the market for virtual reality services lacks a well-defined price list and depends on the complexity of each service, an average fixed price per service of R$ 50,000.00 was established.

For fixed costs, annual expenses with the company's website were considered, taking into account maintenance, the annual value of the domain and hosting costs. The value of the annual license for the virtual reality software and the vehicle maintenance review were also considered, in addition to the monthly rent of the garage for the mobile laboratory and the internet for the laboratory, as shown in Table 4. Marketing expenses were considered as a fixed cost annual, as they were made for a market with very specialized communication channels (event fairs, exhibitions, workshops, technical visits, etc.).

Figure 6 - Market Demand Forecast



Fonte: Elaborated by the authors, 2022

Table 4: Fixed Costs

FIXED COSTS	Custo (R$)				
	ANO1	ANO 2	ANO 3	ANO 4	ANO 5
License (RV Software Annuity)	2.500,00	2.500,00	2.500,00	2.500,00	2.500,00
Garage/shed rental	1.200,00	1.200,00	1.200,00	1.200,00	1.200,00
Website (Domain annual fee, hosting and maintenance)	373,00	373,00	373,00	373,00	373,00
Marketing	15.000,00	15.000,00	15.000,00	15.000,00	15.000,00
Vehicle Maintenance	1.000,00	1.000,00	1.000,00	1.000,00	1.000,00
Internet	1.200,00	1.200,00	1.200,00	1.200,00	1.200,00
Depreciation	25.500,00	25.500,00	25.500,00	25.500,00	25.500,00

Fonte: Elaborated by the authors, 2022

All the functional group, including both fixed and temporary employees, was taken into consideration for the variable costs. The cost of fuel, office supplies, and laboratory equipment that become obsolete over time are expenses that are also influenced by the demand for services at any given time (Table 5). The cost of food and lodging were also considered because a 14-day (2-week) average training period will require technicians and drivers to remain in the client's area until the end of the service. Additionally, depending on the chosen business model, the services might be provided throughout the entire country of Brazil, meaning that in cases where they are more remote, the employees will also need accommodations and support with food during the execution of the workouts.

Table 5 - Variable Cost

VARIABLE COSTS	Custo (R$)				
	ANO1	ANO 2	ANO 3	ANO 4	ANO 5
Consumables (Gasoline)	2.100,00	2.400,00	2.700,00	3.600,00	3.750,00
Secondary Materials (laboratory and homeoffice consumables)	2.000,00	2.000,00	2.000,00	2.000,00	2.000,00
Manpower - Programmer - Coordinator - 3D Modeler - Computer Technician - Drivers;	77.850,00	86.500,00	141.350,00	158.900,00	186.325,00
Accommodation and Catering Costs	64.680,00	73.920,00	83.160,00	110.880,00	115.500,00

Fonte: Elaborated by the authors, 2022

Due to the nature of the project, which is entirely focused on the acquisition of already-developed hardware and software with well-established technologies, costs associated with development were not included. This limits initial investment in the acquisition of goods. Installations were not included because the chosen business model operates from a home office. Regarding vehicles, it was deemed appropriate during this time to purchase just one vehicle for the fleet of mobile laboratories. This vehicle will be purchased with all necessary modifications, such as adjustable space, feature, and moving parts, to function as a virtual reality lab. The vehicle's estimated value was R$ 175.000,00.

Initial equipment, furniture, and appliance investment was estimated at R$ 90.900,00 and distributed as shown in the below table (Table 6). The estimated value of the initial round of money was added to the values assessed for investment in fixed assets (R$ 265.900,00), bringing the total initial investment in the innovation project up to R$ 285.900,00. The initial money was deemed necessary to cover the costs associated with labor in the first three months, allowing time to prospect for the first sales opportunities.

Table 6: Total Cost

	Budgeted Items	Quantity	Total Cost
	Equipments		
1	Computer (advanced processor and video card)	3	R$ 60.000,00
2	Virtual Reality Kit (glasses and joysticks)	4	R$ 12.000,00
3	Smart TV	1	R$ 3.000,00
	Laboratory Utensils		
1	Battery Case	1	R$ 1.500,00
2	Stationery Kit	1	R$ 500,00
3	Tools Kit	1	R$ 3.000,00
	Digital Resources		
1	Site Development	1	R$ 10.000,00
2	Lifetime Modeling Software License	1	R$ 900,00
	TOTAL		**R$ 90.900,00**

Fonte: Elaborated by the authors, 2022

Value of initial capital necessary to be considered is R$20.00,000. Based on the aspects raised, the cash flow of the innovation project was prepared, presented in the following table. For the development of the cash flow, taxes on gross revenue were taxed at 27% (being 17% of ICMS and 10% of IPI). As for depreciation, we considered higher order values related to more critical fixed assets and higher value, such as the vehicle and electronic equipment (10% depreciation, as is indicated for these types of assets). (Appendix B) The obtained graph reveals the location of the Payback for the innovation project, which is situated in the start of the third year, in accordance with the projected and considered. The graph shows the project's growth behavior without dips in relation to cash flow and increasing accumulated value as highlighted in figure 7.

Figure 7 - Cash Flow Analysi

Fonte: Elaborated by the authors, 2022

This projection considered a "Year 0" of four months, during which just the company's acquisitions and organization for the start of immediate operations—without the need for technological development— would be carried out. The following table lists the feasibility indicators that were used as the basis for the investment decision made for the proposed innovation project. The analysis carried out identified a payback of about 25 months and 23 days, which indicates that the initial investment would be repaid at the beginning of the third year, within the anticipated life cycle of innovation.

The equilibrium point (Q0) of the first obtained was 8.25%, which is considerably good for the project, indicating that the company can begin to balance expenses with 8.25% of active operational capacity, which is justified by the "production" of services totally dependent on demand, and that at the beginning of a service project not the entire company team needs to be mobilized, only the coordinator and the modeler.

Regarding the Net Present Value (NPV), it was positive, which indicates that the future flows brought and added to the present value equals about 2 times the initial investment, which adds value to the investment. The Index of Profitability (IR) obtained fulfilled the requirement of being greater than 1 and was in the order of 2.46 times the amount invested. The internal rate of return (IRR) was 43.70%, a somewhat high value, justified mainly by the dependence on service demand and by annual flows with values close to the value of the total initial investment. The ratio of fixed costs over variable costs, or Cf/Cv, was found to be 31.90 percent in the first year, indicating higher variable costs, a common service profile, and the effects of concentrated labor costs. The relatively low value indicates a degree of security and stability with respect to market fluctuations.

The Return on Investment (ROI) for the first year was 111,09 percent, meaning that every investment generated profit greater than twice its original value. This may be justified by the fact that there were just a few investments made in fixed activities during the project's first year.

The Ebitda to gross sales ratio obtained for the first year was 31.43%, indicating an interesting profitability potential in relation to the sales made in the year. It tends to increase over the years. As for the Ebitda per total investment ratio for the first year, a value of 76.94% was found, indicating the potential to turn the total investment into profit (profitability) of about 77%, as described in table 7.

One last indicator was disregarded by the innovation project, being the PDE/Net revenue, referring to spending on research, development and engineering. This indicator was not disregarded due to the fact that the project in question has no development needs, requiring only the acquisition of already established and known technologies, as well as in this project the acquisition of the adapted vehicle will occur by outsourcing the production of the adapted vehicle (without the need to develop it on its own).

Table 7: Indicator of Economic Viability

Economic Feasibility Indicators		
Indicator	**Value**	**Acceptance condition**
Q0 (Break-even point) 1st year	8,45%	The smaller the better (< 50%)
VPL (net present value) ($)	446.120,13	Be positive (> 0)
IR (Profitability index)	2,49	Greater than one (> 1)
TIR (Internal rate of return)	43,70%	Higher than the market (> 0.05)
Payback (in months)	25,78	The smaller the better
Cf/CV ratio (Fixed/variable cost) 1st year	31,90%	Low ratio denotes greater security, it is less susceptible to variations in demand.
ROI (Return on investment) 1st year	111,09%	About assets.
Ebitda per gross sales 1st year	31,43%	Profitability potential in relation to sales
Ebitda per total investment 1st year	76,94%	Potential to turn total investment into profit (almost 77% profitability)
PDE / Net revenue	N/A	Criterion not applicable to the project

Fonte: Elaborated by the authors, 2022

So, given the factors discussed and the developed analyses regarding profitability and sustainability, it is possible to infer that the proposed innovation project has technical, economic, and commercial feasibility and can be realized with the necessary investments and proper management during annual sales flows.

CONCLUSION

Given the dynamic nature of the industrial sector and its continuous advancements, maintenance teams must always be in a training and qualification environment. These trainings demand the use of a team of qualified facilitators to transfer knowledge and experiences to the learners, as well as physical space for the training to take place, as well as the use of methodologies that allow the testing of acquired knowledge. Along with the costs directly related to training, there are other expenses such as the time spent mobilizing and demobilizing the training team and the equipment required for practical exercises. In this context, the use of virtual reality as a training tool has already shown effective in addressing the prerequisites required for knowledge transmission and, in certain cases, in reducing the number of resources mobilized.

This work sought to examine the technical and economic feasibility of using a mobile maintenance workshop for training teams. Innovation in this project was highlighted due to its uniqueness, commercial feasibility, and advancement in the fields of qualification and training of maintenance teams. Another topic covered in this paper is the technical plausibility of using a mobile training lab with virtual reality. The economic feasibility of this type of project in comparison to the Brazilian market, particularly the market in which it intends to be launched and implemented, was similarly demonstrated through a case study using management tools.

There are still technical, economic, efficient, and effective options for adopting a mobile workshop for training teams that use virtual reality as tools for spreading knowledge, testing newly acquired knowledge, and applying improvements to currently employed maintenance techniques. Including the potential for testing these improvements in a virtual environment, this opens the door for innovation, a reduction in costs for ongoing improvement processes, as well as the introduction of new scientific research and development.

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APPENDICES

A - Table of Burgelman and Rosenbloom (Burgelman; Christensen; Wheelwright, 2013)

DECISES ↦ ANALYSES ↧	ACQUIRE EXTERNAL TECHNOLOGY	GENERATE ITS OWN TECHNOLOGY	DEVELOP NEW/MODIFIED PRODUCT	DEVELOP NEW/MODIFIED PROCESS	PROVIDE CUSTOMER SUPPORT
Competitive forces of the business environment	Acquisition of virtual and/or augmented reality hardware and software licenses	Customized Virtual Systems	Development of customized models and systems	Service developed on site	Remote (software) and on-site (hardware) technical assistance
Value added areas in the company	Operations: Engineering team	Inbound Logistics, Operations, and Outbound Logistics: Hiring a specialized team (programming and modeling), PD&I	Inbound Logistics, Operations, and Outbound Logistics: Using know-how from the customer's maintenance team and hiring a coordinator with maintenance expertise	Inbound Logistics, Operations, and Outbound Logistics: Logistics Department	Outbound Logistics, Sales and Service: Software, Sales, and IT Department
Required technologies (essential/auxiliary)	Virtual reality equipment, rugged hardware, adapted vehicle, electronic lab supplies	Virtual system modeling and management software	Virtual system modeling and management software	Mobile lab management	Systems integrated into the company's platform, for remote management
Commitment of resources (% sales)	21%	N/A	N/A	N/A	N/A