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Article

Design of a High Performance Hybrid Tricycle (THAR) to assist people with motor disabilities

Diseño de un Triciclo Híbrido de Alto Rendimiento (THAR) de asistencia para personas con discapacidad motora

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Abstract

In Mexico, there is a delay in the mobility process of people with motor disabilities. At the same time, in our country there are nearly 3 million people with motor disabilities according to what INEGI reports in its 2020 census. Therefore, a virtual prototype is being proposed as a result of the first stage of its own methodology for the design of a hybrid tricycle to transport people with motor disabilities, which offers versatility in terms of transport configurations in the facilities of the Polytechnic University of Guanajuato (UPG). In a second stage, it is proposed to build a scale prototype using additive manufacturing to identify areas of opportunity before building the final prototype and carrying out its real physical tests in order to obtain sufficient data to implement a commercial model that can be reproduced. reliable way.

Goals	Method	Contribution
* Conceptual design of a hybrid tricycle. * Comply with the required technical conditions. * Meet economic requirements.	* Needs detection. * Development and selection of the conceptual solution proposal. * Virtual prototypes in CAD.	* Development of a hybrid assistance vehicle for people with motor disabilities.

People with motor disabilities, hybrid tricycle, design methodology

Resumen

Existe en México un rezago en el proceso de movilidad de las personas con discapacidad motriz. Al mismo tiempo en nuestro país se presenta cerca de 3 millones de personas con discapacidad motriz de acuerdo a lo que informa INEGI en su censo 2020. Por lo anterior se está proponiendo un prototipo virtual como resultado de la primera etapa de una metodología propia para el diseño de un triciclo híbrido para transportar a personas con discapacidad motriz, que ofrezca una versatilidad en cuanto a las configuraciones de transporte en las instalaciones de la Universidad Politécnica de Guanajuato (UPG). En una segunda etapa se propone construir un prototipo a escala empleando la manufactura aditiva para lograr identificar áreas de oportunidad antes de construir el prototipo final y realizar sus pruebas físicas reales para poder obtener la data suficiente para implantar un modelo comercial y que pueda ser reproducido de manera confiable.

Objetivos	Metodología	Contribución
* Diseño conceptual de un triciclo híbrido. * Cumplir con las condiciones técnicas requeridas. * Satisfacer los requerimientos económicos.	* Detección de necesidades. * Desarrollo y selección de la propuesta conceptual de solución. * Prototipos virtuales en CAD.	* Desarrollo de vehículo híbrido de asistencia para personas con discapacidad motriz.

Personas con discapacidad motriz, triciclo híbrido, metodología de diseño

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Introduction

Currently the world's population depends excessively on the energy produced from hydrocarbons, in Mexico in 2019 there was a shortage of gasoline in the central states of the Mexican Republic.

One of the motives behind this project is the search for environmentally friendly and economical mobility alternatives, so that an ecological and economical means of transport is available, which can be acquired and used by the sector of the population that suffers from motor disabilities, to transport themselves in a safe, fast and economical way. Another important aspect is that in Mexico the national market is dominated by distribution companies and only one manufacturer, Vetelia, located in Guanajuato [5].

According to the 2020 Population and Housing Census, there are 6,179,890 people with some kind of disability in Mexico, which represents 4.9% of the country's total population. Of these, 53 % are women and 47 % are men [7].

Box 1

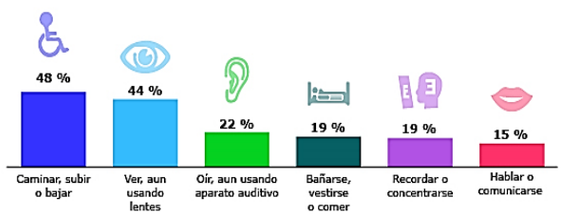

Figure 1

Percentage of the population with disabilities according to difficulty in activity 2020
Source: INEGI. Population and Housing Census 2020

Specifically within the Polytechnic University of Guanajuato (UPG) we are pursuing the development and manufacture of a hybrid tricycle of our own design as a means of transport within the campus, whose purpose is:

- Transport the driver.
- Transport a person with a motor disability in a back seat or transport people who do not have a disability (assistant person).
- To tow a person in a wheelchair with the person on board.

Figure 2 shows the infrastructure and the routes between the different buildings within the UPG.

Box 2

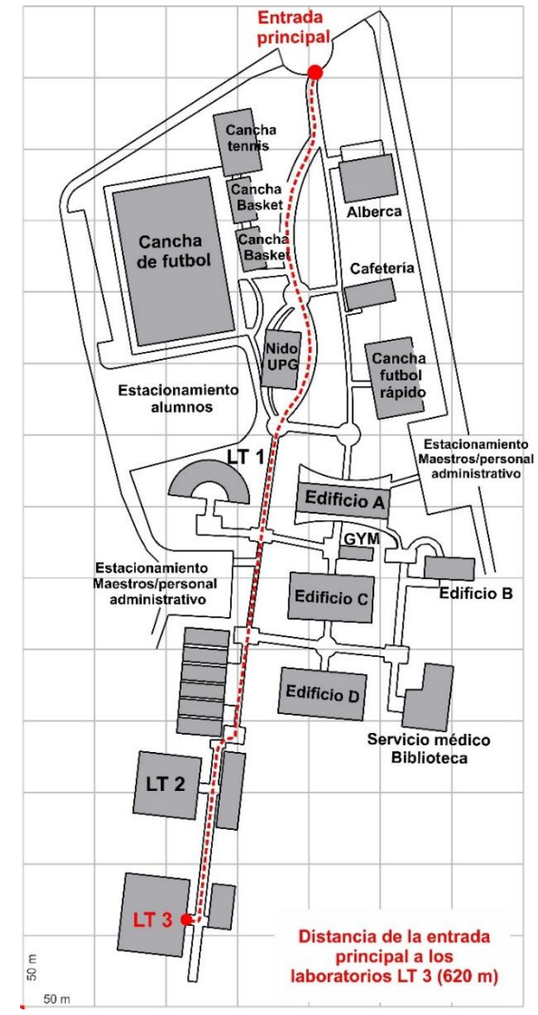

Figure 2

Layout of the Polytechnic University of Guanajuato with example of a longer route. [3]Design of an electric vehicle for people with handicap

Methodology

The project will be developed by converting a bicycle into a hybrid tricycle based on a Mercurio Victoria R700 bicycle as shown in figure 3.

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Box 3

Figure 3
Base bike for conversion to electric tricycle
Source: Own authorship

The development of the hybrid tricycle design was based on the methodology proposed in Figure 4, which is based on descriptive methods and design processes.

Box 4

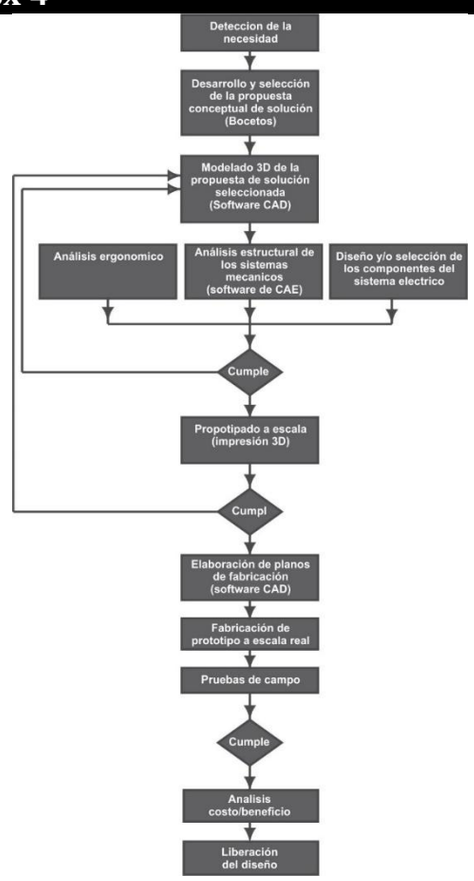

Figure 4
Design methodology
Source: Own authorship

In order to detect the needs, first of all, a survey was carried out through a digital platform, which was sent to potential users, giving the following results as shown in Figure 5.

Box 5

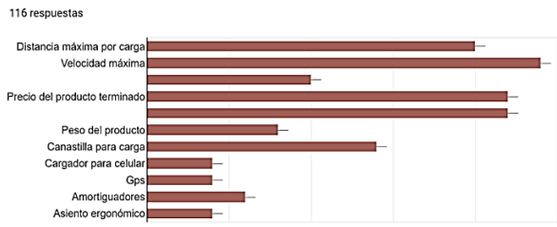

Figure 5
Detection of needs
Source: Own authorship

List of requirements

In order to establish the limits according to the requirements, a list of requirements will be made. Among the most important limits are cost, size or weight of the tricycle, performance, legal or safety requirements, among others. The following table 1 shows the detailed requirements and specifications of the proposed hybrid tricycle.

Box 6

Table 1
Identifying needs

Requirements	W o D
1. Ergonomics	
- Comfortable seating.	W
- People with mobility problems should have easy access to the rear seat.	W
- Supportive supports with locks.	W
1. Functional features	
- Easy coupling.	W
- Ability to tow a wheelchair.	W
- Stability while driving.	W
- Auxiliary accessories for mobile phone.	D
- Adjustable arms for towing any type of wheelchair.	W
1. Control system	
- Reliable when operating the hybrid tricycle.	W
- Simple configuration.	D
Mode of operation	
- Manual.	W
- Electric, electronic.	W
4. Power generation	
- Human propulsion.	W
- Battery charging system.	W
- Battery electric system.	W
5. Power transmission	
- Pedal, gear and chain system.	W
- Propulsion by electric motor.	W
1. Working conditions	
- Frequent use.	D
- Reliable.	W
4. Weight	
- Gross vehicle weight 300 kg.	D
- Towing capacity 120 kg.	W
4. Dimensions	
- 4000 mm x 1200 mm x 1100 mm	D
3. Maintenance	
- According to hours of use.	D
- Easy to replace commercially available parts.	W

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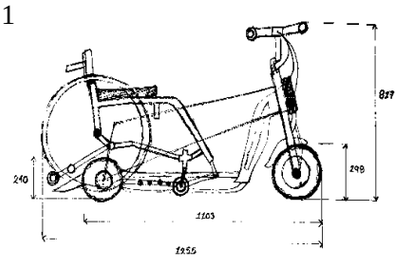
Generation of alternatives

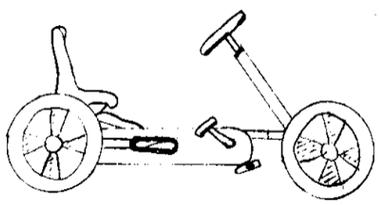
For the conceptual design of the hybrid tricycle proposal, sketches were made of the configurations to solve the needs detected, these sketches are shown in figure 6.

Box 7

Proposal 1



Proposal 2



Proposal 3

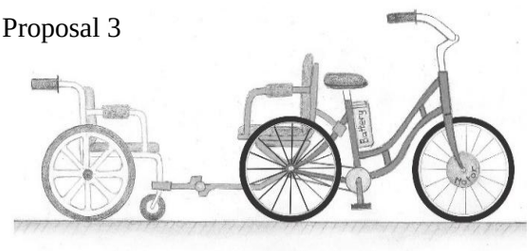


Figure 6
Proposals for conceptual designs.
Source: Own authorship

Technical and economic evaluation of proposals

Identifying the essential criteria to meet the specifications obtained in the survey, the economic aspect, easy manufacturing, easy maintenance and with arms adaptable to any wheelchair, are the most influential factors in the definition of the design of the hybrid tricycle since it is required to have sufficient pulling power combined with the autonomy by battery charge, one of the difficulties is that the electric motors and batteries that are capable of achieving these characteristics require a higher electrical voltage and amperage, which influences the cost of the hybrid tricycle.

Consequently, the proposals are evaluated on a scale of 1 to 10, where 10 is satisfactory compliance with the criteria to be evaluated; in addition to applying a three-level weighting known as the influence factor, where 1 is important, 2 is very important and 3 is essential. See tables 2 and 3.

Box 8

Table 2
Technical assessment

			Score (Pi)			
	Evaluation criteria	**Weighting (Wi)**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Ideal option**
1	Ergonomics	3	7	5	8	10
2	Functionality features	2	7	6	10	10
3	Control system	3	8	8	8	10
4	Mode of operation	3	9	7	9	10
5	Power generation	3	8	8	7	10
6	Power transmission	3	9	9	9	10
7	Operating conditions	2	9	7	7	10
8	Weight	3	8	8	9	10
9	Dimensions	1	8	7	9	10
10	Maintenance	2	6	8	8	10
	TOTAL = Σ (Wi X Pi)		**199**	**184**	**209**	**250**
	Technical coefficient = Total score / Perfect score		**0.796**	**0.736**	**0.836**	

Source: Own authorship

Box 9

Table 3
Economic evaluation

			Score (Pi)			
	Evaluation of alternatives	**Weighting (Wi)**	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Ideal option**
1	Operation	3	6	7	8	10
2	Manufacturing	2	7	6	7	10
3	Materials	3	8	8	8	10
4	Maintenance	2	7	7	9	10
5	Power generation	3	8	8	8	10
	TOTAL =Σ (Wi X Pi)		**94**	**95**	**104**	**130**
	Coeficiente económico = Puntaje total / Puntaje perfecto		**0.723**	**0.731**	**0.8**	

Source: Own authorship

The best choice is one that not only has the most appropriate technical and economic factors, but also maintains a balance between the two. Therefore, the indicated project will be developed based on the first option as shown in the graph (see figure 7).

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Box 10

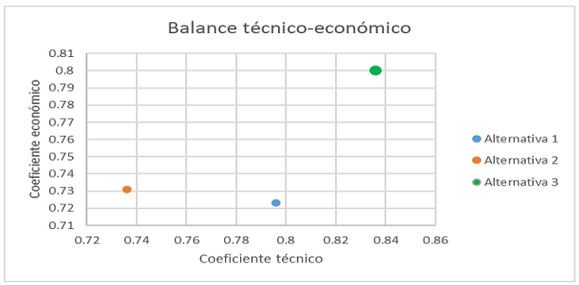

Figure 7
Technical and economic balance
Source: Own authorship

Results

By applying the design methodology it was possible to obtain the virtual prototype of a hybrid tricycle based on the choice of one of the proposals put forward. The selected vehicle seeks to integrate the necessary elements to meet the technical and economic requirements of the project versus the comparison of the other proposals that were not selected. Using CAD design as a tool, a virtual model was designed, as shown in figure 8.

Box 11

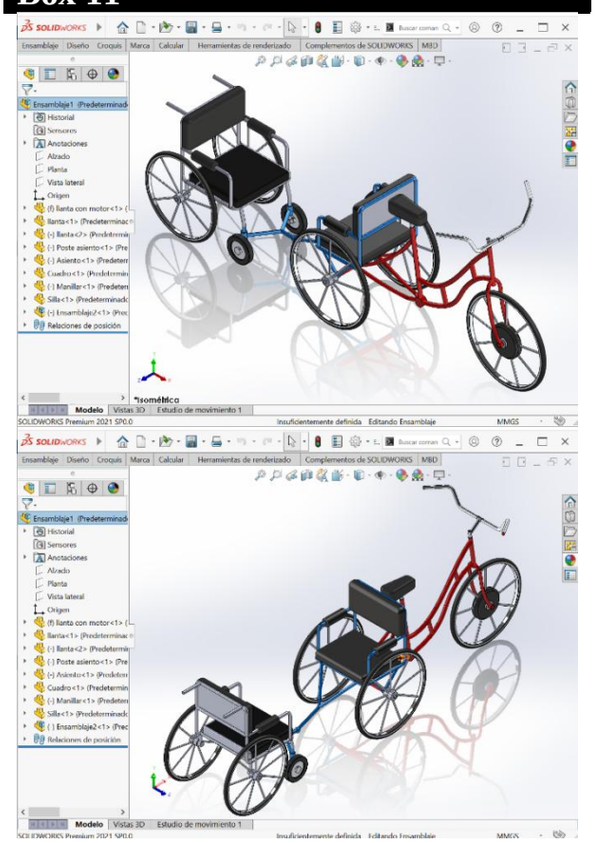

Figure 8
Design of virtual model of proposal 3 in CAD software
Source: Own authorship

This prototype has basically three sections, the first one is for the driver, the second one can be used to transport a person with motor disabilities or a carer and the third one is a coupling system to attach a wheelchair and transport a third person occupying the attached wheelchair as shown in figure 9. This can be used in two modes, either by human propulsion or in electric mode, both using chain and sprocket for power transmission. This is in order for the hybrid tricycle to behave efficiently and effectively as shown in figure 10.

Box 12

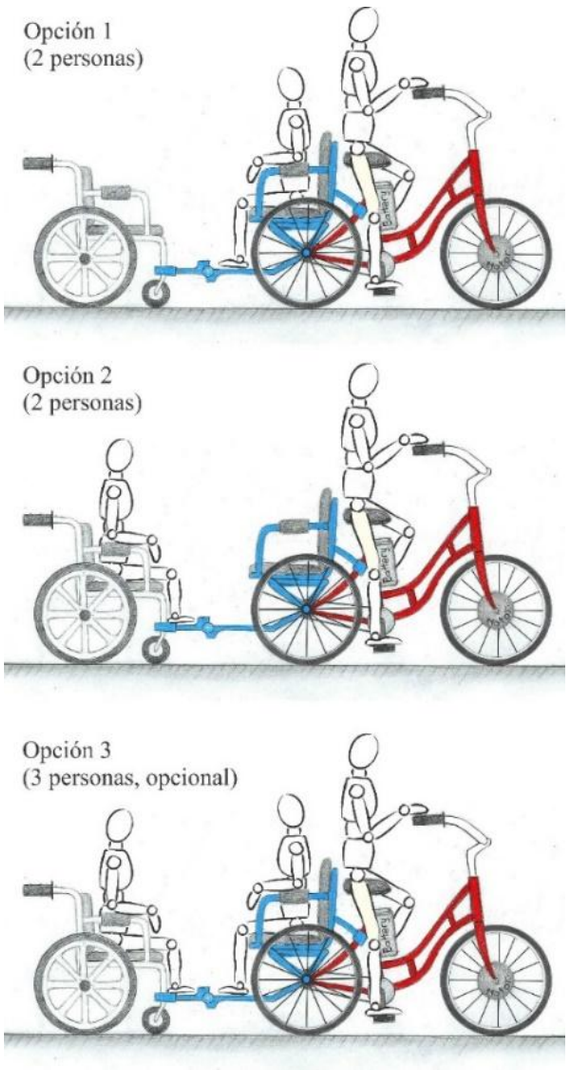

Figure 9
Options for use of the hybrid tricycle
Source: Own authorship

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Box 14

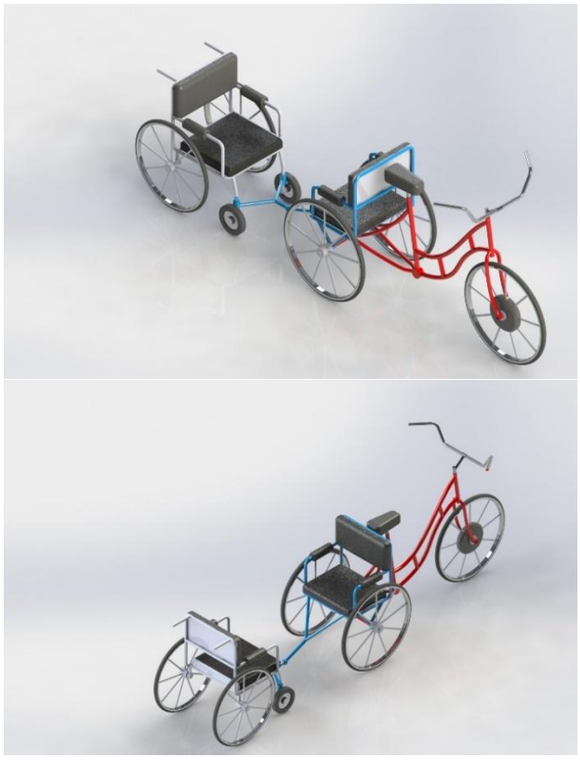

Figure 10
Rendering of virtual model of proposal 3 in CAD software
Source: Own authorship

Conclusions

The development of the virtual prototype proposed in this work seeks to optimise with a passenger configuration that adapts to the needs of two possible general scenarios that people with motor disabilities may present, where one of these scenarios is when the person with motor disabilities can have control of their body structure (from the waist up), i.e. can maintain a stable composure, the second scenario is when a person who has motor disabilities but does not have control of their body structure and therefore requires a person to accompany them with the function of taking care of their transfer when using this transport system.

The selected proposal is in its design phase; subsequent work will include the development of a physical prototype to scale using additive manufacturing, in order to identify areas of opportunity in the actual manufacture of this proposal. It is very satisfying to contribute with this type of alternative solutions to be applied for the benefit of our society with motor disabilities, thus contributing to a better quality of life in terms of mobility.

It was decided to work on this type of vehicle because of the importance and the impact it has on people with motor disabilities because it represents a great satisfaction for the authors. More work will be done in terms of future manufacturing and assembly, and better integration with the ramp to achieve the main objective and offer more functional alternatives with the ramp.

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