

Development of Automated Aquatic Taxi for Sri Lanka using Kansei Engineering Concept

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Abstract: Transport is essential because it allows for contact, trade, and other types of people-to-people exchange. Transport plays a crucial role in economic development and civilization. When it comes to transportation media mainly, we are using air, water, and ground. As Sri Lankan people, very commonly, we are using ground roads to travel between cities. Most of the time, we apply waterways only to export and import between counties. We rarely use waterways within the country as our transport service. Now ground roads are too much busy because the number of vehicles is growing daily. So, we are introducing this new technology “Automated Aquatic Taxi (AAT)” service to use our natural waterways to transport in Sri Lanka. Our main aim is to reduce the ground road traffic and save the time of passengers with a new experience. As AAT authors are introducing a small or medium size, an enclosed boat is designed to automatically ferry passengers between and around cities. We are planning this to have also automated the manual control system. Automate allows “autonomous identification” and safe navigation around stationary objects in the water, swimmers, and any other obstacles. As Sri Lankan, we have a great history of waterways experiences. Our ancient people used boats and small barges to transport. So, this new step of AAT service will be a good experience in future aquatic transportation.

Keywords: Kansei Engineering, Aquatic Taxi, Transportation.

Introduction

The Automated Aquatic Taxi (AAT) is a small enclosed boat designed automatically ferry the passengers around the city by using waterways in Sri Lanka (Anon., 2020). It has been the best alternative mode of transport, which offers better connectivity with roads and railways as it is congestion and pollution-free. Sri Lanka is a country which is enriched with numerous numbers of waterways all over the country by connecting one city to another. So, this AAT helps citizens of Sri Lanka to complete their daily necessities by travelling along with waterways by avoiding the usual traffic and it helps to increase the tourist attraction towards the country.

Figure 1 below represents all the state of waterways that are available in Sri Lanka and it shows how our country is rich with waterways. There are many rivers, lakes, reservoirs, and coastal water in the country.

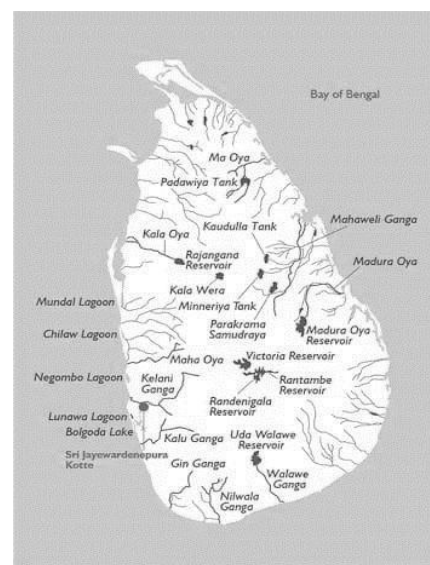


Figure1. State of Water Ways in Sri Lanka (Asia, n.d.)

Early Sri Lankans travelled across the rivers or waterways to fulfil their daily necessities by using boats or ferries. Considering the vast amount of literature pieces of evidence, it could be concluded that a well-established inland transport system has prevailed in the country from ancient times. However, AAT provides a significant influence on taking the inland transportation system of Sri Lanka to a different era. According to the latest WHO data published in 2017 road Traffic Accidents Deaths in Sri Lanka reached 3,554 or 2.80% of total deaths (SOMASUNDARASWARAN, 2006). So, this automatic aquatic taxi provides a great opportunity to reduce the rate of road accidents happens due to the heavy traffic as well. This AAT offers many benefits for its passengers, such as reduction of traffic, fewer crashes, and also it helps to reach the destination quicker than city roads. AAT becomes a major part of smart transportation as it reduces road traffic and road accidents (HKSK Hettikankanama, 2019). Smart transportation is a vital role of the smart city concept which is a popular concept among the city authorities all over the world. In the present number of international organizations consider the development of low carbon society (Sugeeswari Lekamge, 2013). This will be a solution as there is less pollution. AAT helps to increase the income of the government by increasing the tourist attraction for the cities

The development of our AAT is done primarily done by using Kansei Engineering concepts. Kansei Engineering is a branch of Ergonomics and it aims to produce a new product or to improve the social system based on the human emotional approach (Lévy, n.d.).

For the part of this AAT development, the focus is on the function of comfortable, safety, and attraction.

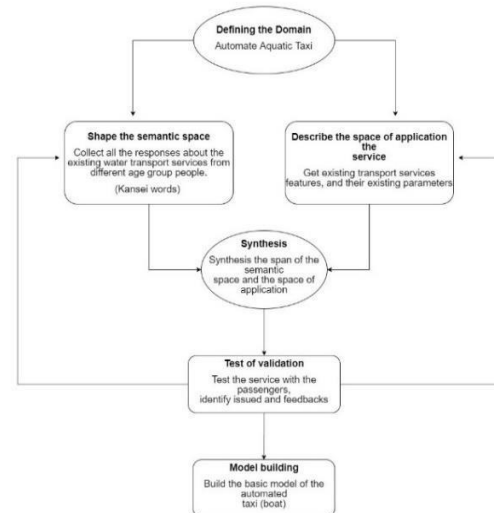


Figure 2. Kansei Engineering Methodology

The authors implemented this taxi according to the Kansei Engineering methodology. Figure 2 describes the process according to Kansei Engineering methodology.

The Kansei Engineering procedure applied in this research is the followings; (Schütte, 2002)

- (1) Draw images of the upcoming automated aquatic taxi,
- (2) Evaluate these designs based on KE method,
- (3) The evaluated data is analyzed by statistical analysis,
- (4) Using the results of design specifications derived from statistical analysis, the manufacturing of the basic model of the taxi is done.
- (5) Selected passengers/clients on different age levels and experiences evaluate the product. These data are analyzed again using statistical methods,
- (6) the designer group develops automated aquatic Taxi (AAT)

1.1 Features of the Product

- AAT is designed with automated controls, there is an option to manually control the taxi as well.

- Providing comfortable sailing for 8 people
- During the sail, this AAT rises above the water waves which minimizes pitching and gives passengers an absolute sense of comfort.
- The engine does not pollute the environment and runs almost silently.
- In addition to driving performances and comfort, the taxi impresses with an innovative steering wheel with a display, satellite navigation system and sonar which saves from underwater dangers
- Interior space can be transformed; furniture folds, side windows extend which creates a feeling of maximum spaciousness

1.2 Existing Systems

The need for accessible waterborne transit is likely to grow with the demand for tourist attractions, business travel and other development around bodies of water [1]. As a result, we thought to introduce the product Automated Aquatic taxi (AAT) with Kansei engineering concepts. The AAT is a small, enclosed boat designed to automatically ferry passengers around the city.

The AAT has planned to design with a unique look and colour schemes. While AAT is designed with automated controls, there is an option to manually control the craft. This has been added to open up the craft to tourists who might want to explore the city waterways on their own and for the Urbanities who needs to travel for their working places across the city without any traffic (Anon., n.d.) .

There are many existing systems for this product from the type of small to luxury aquatic vehicles. Following are some of them.

1.2.1 Capsule water taxi

Capsule water Taxies have been introduced for several years. The production has been begun by an Italian company the 2015 Jet Taxi is a new design from the company Jet

Capsule (Anon., n.d.) . Jet Taxis is weighing nearly 3.5 tons and it's powered by two diesel-fuelled engines, The special feature is the ecofriendliness of this craft (Anon., n.d.). To provide a quality travelling time for passengers it has designed in such a way that passengers protected from external temperatures, being protected against humidity, rain or sun, in any weather conditions. So, it's clear that this is a new way to conceive the "Water Mobility" (Anon., n.d.)

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1.2.2 Futuristic hybrid boats

Most common travelling methods are cars, buses, trains and another land vehicle. But it is very rare to have water travelling experience. Futuristic hybrid boats are one of the best ways that a passenger can have such an experience. futuristic exterior that is completely a modern one, it also addresses the issue of environmental pollution by way of its hybrid capabilities (Anon., n.d.).

1.2.3 VT36 Speed Yacht is Luxury Aqua

The yacht was firstly invented by Dutch of the 14th century Since then yachts have been popular among people as an aquatic taxi, which provides a luxurious experience to passengers. There are many types of yachts available to make a lot of sense. The VT36 Speed Yacht isn't just a normal boat; it has a luxurious design with hardwood.

The types below are put into these categories: [8]

1. Express, Express Cruiser, Cruiser, Sports Cruiser
2. Flybridge, Sedan, Sedan Bridge, Sport Bridge
3. Motor Yacht, Pilothouse Motor Yacht, Cockpit Motor Yacht, Sky lounge
4. Tri-Deck, Mega Yacht
5. Sportfish, Express Sportfish, Flybridge Sportfish, Convertible

1.2.4 NYC Water Taxi

This water taxi is a New York Water Taxi and it is 12 feet high. It offers passengers to wonderful sightseeing through the East River and Hudson River (Anon., n.d.) .

Methodology

2.1 Materials and Methods

Kansei Engineering method includes a list of steps. Based on the statistical procedure, the first step is to select suitable Kansei words, usually gained through literature. The second step is the Kansei evaluation experiment, where participants will rate the design samples using the Kansei words, which obtained from the first stage with a Semantic Differential (SD) scale. The last step or simply the third step is about the statistical procedure which analyses the relationship between Kansei words and the product design elements

2.2. Collection of Kansei words

Table 1 shows the 20 words that have been collected and gathered to form a new database for an automated aquatic taxi.

Table 1: Selected Kansei words

Modern	Comfortable	Stylish	Creative
Strong	Convenient	Simple	Complex
Elegant	Functional	Cheap	Durable
Friendly	Impressive	Neat	Attractive
Average	Expensive	Safety	Exclusive

It was necessary to collect some of the words (Kansei words) that might reflect the needs of the customer and that relate to the product which will help us in thinking about the proposals for a new product suitable to the needs of the customer.

2.3. Semantic Differential (SD) scale The semantic differential can be known as a kind of a rating scale which is designed to measure the connotative meaning of objects, concepts, and events. The connotations can be used to determine the attitude towards the given object, concept or event or is a standard visual analogue scale and a 7-grade-Likert scale. Authors have used 7-grade-Likert rather than 5- grade-likert as it is more accurate and easy to use. And also we can get a better idea of the respondent's preference. To ensure that the word was properly understood, the extremes on the opposite sides of the scales were symbolized by (very much) and (not at all).

We weight every word to determine its importance, then select the most important words to be used in the questionnaire. Thirty-five participants were interviewed and asked to answer the SD scale questionnaire

2.4. Importance weighting

In this study, authors use SD scale to measure the importance of each word and choose the most important words which have high grades, also we calculate the weight of each word to determine the importance of the word.

The weight = (the total grades of the word) / (7*no of participant).

Table 2 represents the grade of Kansei words and importance weighting.

After selecting the words that have the highest degrees and the highest weights. We collect all selected words in a table. Table 3 shows that the six words that have the highest grade are comfortable, convenient, attractive, functional, safety, and durable.

Table 2: Grade and weighting of Kansei words

Kansei Word	Grade	Weight
Modern	144	0.58775
Strong	129	0.52653
Expensive	102	0.41632
Attractive	181	0.73877
Complex	82	0.33469
Convenient	173	0.70612
Friendly	60	0.24489
Functional	177	0.72244
Comfortable	190	0.77551
Exclusive	132	0.53877
Simple	100	0.40816
Stylish	151	0.61632
Durable	167	0.68163
Neat	78	0.31836
Safety	189	0.77142
Impressive	92	0.37551
Creative	113	0.46122
Elegant	120	0.48979
Cheap	103	0.42040

Table 3: The meaning table

Kansei Words	Meaning
Comfortable	Providing physical well-being or relief
Convenient	Fitting in well with a person's needs
Attractive	Pleasing or appealing to the senses
Durable	Able to withstand wear, pressure or damage hardwearing
Functional	Relating to how something works or operates
Safety	Condition of being protected from or unlikely to cause danger, risk, or injury

The chosen elements (characteristics) related to the most appropriate word of Kansei words by brainstorming. These words & elements are combined in a questionnaire. Each question must be involved some requirements of the product related to Kansei words which must be suitable for this requirement

In this study, the questionnaire includes three sections, two sections (functional and dysfunctional) to check the AAT design (Taxi shape, Taxi material, Taxi mechanism). The number of questions is thirty-two divided to sixteen functional questions and sixteen dysfunctional questions.

Analysis of Questionnaire Results

3.1 AAT shape analysis

The participants were asked to choose among (capsule, hexagonal, and squared). Due to the result of the total satisfaction factor, it's clear that (Capsule-shape) is the most satisfactory. So, the new design should consider the shape to be a capsule shape. Capsule-shape of the taxi helps to reduce the resistance that occurred by the water by helping taxi to move faster by using less power.

3.2 AAT material analysis

Authors have asked whether it is better aluminium, carbon fibre or steel. Due to the result of the total satisfaction factor, it's clear that carbon fibre is the most satisfactory. So, the new design should consider the taxi material to be made of carbon fibre material. Carbon fibre is the ideal material for manufacture the body of the taxi since carbon fibre is stronger, stiffer and lighter than steel and aluminium.

3.3. AAT mechanism analysis

In this section, the participants were asked to comment on the taxi's engine, windows, seats, lighting and electrical systems, security systems and navigation systems.

2.5. Relating KE with engineering characteristics

Respondents have to select the following facts.

- Single engine or dual engine
- Transparent side window or transparent roof window
- Limo seat or single seat
- Set door locks automatically or set door manually
- Autopilot navigation or manual navigation

We have gathered data about the general idea about the aquatic taxi, how it affects to Sri Lanka, preference of the community to new technology, benefits, drawbacks and many other things also.

From this survey authors, the main aim is not only implementing this taxi but also introduce this new technology to Sri Lanka and give this marvellous experience to the Sri Lankan. So, they have asked several questions to get to know their likes and dislikes.

3.4 Pairwise comparison of opinion about AAT

Each respondent in the questionnaire is allowed to make their general opinion about aquatic taxi technology whether it is “Strongly Agree”, “Agree”, “Somewhat Agree”, “neutral”, “Somewhat Disagree”, “Disagree” or “Strongly Disagree”. Most of the respondent have a positive attitude towards this.

According to data, we gathered “Agree” and “Somewhat Agree” are the factors rated highly with generalized weights of 50.6%, 30.9% respectively.

3.5 Factors considered implementing AAT

According to the survey results, we found out that 84.9% of the people like that taxi would implement that can operate manually.

A small amount of number 15.1% people like fully automate. They like AAT which can process manually also.

We can clearly say according to the data we gather many people think attractiveness and comfortable of this aquatic taxi. According to our knowledge, the reason is as it is a new experience to Sri Lankan People. When some people highly accept the safety of the taxi some people don't care about safety

An average amount of respondents believe comfortability, safety and attractiveness of this new proposed system are sufficient to start this project.

3.6 Design

After following the procedure described above, we created the following design according to the ethical facts and the respondents' suggestions and government project in 2017 (Megapolis, April 2017). Figure 3 shows the sketch of the design of AAT. We wish to build it with more features as shown in figure 4 as in a way it increases the safety of passengers, travelling speed, reliability, comfortability and the outer appearance as well.

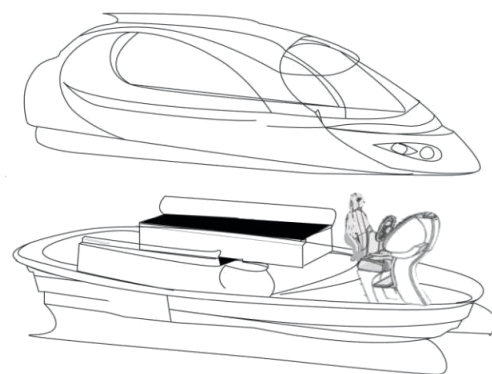


Figure 3: Sketch of the designed AAT

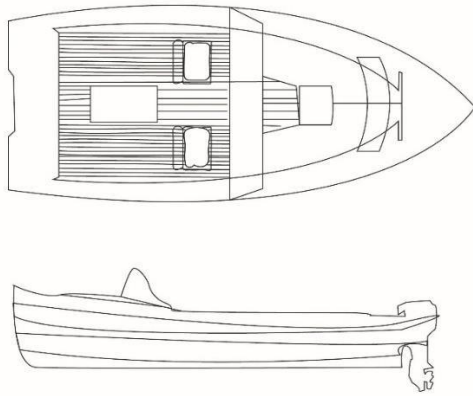


Figure 4: The new automated aquatic taxi design

It is a capsule shape which is easy to go through the water. It is fully covered design to improve the safety of passengers. Though it is automated there is a separate section where a person can manually control the boat in an emergency case. This is a medium-size boat which is designed for 4-6 passengers. So there are two separate seats. Basic parts like lights, front window wipers are included. To get the attraction transparent glass have been added end to the bottom.

3.7 Major obstacles in implementing AAT

Lack of infrastructure and high initial cost are two major problems we have to face when implementing such kind of project in Sri Lanka. The investors must discuss these issues with relevant government authorities. Only 34.8% of people who contributed to this survey believe that the government having positive feedback towards such kind of projects.

56.3% of respondents do not have an idea or previous knowledge about how they can use aquatic taxi for their travelling purposes. So, awareness programs like advertisements on media must be conducted before launching this project.

39.8% of people do not live near any waterway or else pass any waterway in daily

travelling. For these kinds of people cannot use this transportation method. Only 60.2% of people are living near or else pass any waterway in daily travelling.

Another problem we have identified is backwardness in adapting to new trends. Only 52.6% of people think it will suit. 6.4% of people do not even like to test it. This is not a good situation.

Abnormal fear for water is also a problem. 24.1% nearly (1/4) of people fear for water and 14.5% does not have confidence. Only 61.4% have the confidence to travel through this system. Another point is whether the people who use these water inlets as their livelihood and the people who live adjoining with these water inlets will allow making this project happen. Another thing that this project should be done without harming the natural environment.

3.8 Benefits of AAT

An excellent number of respondents believe that the Reduction of traffic results in fewer crashes. Moreover, AAT helps to reach the relevant destination quicker than city roads by avoiding traffic. AAT provides the main source of income for the government of Sri Lanka by increasing tourist attraction towards the country (Lévy, n.d.). AAT provides safe rides for the riders who want to handle the taxi manually as well as automatically. This vehicle provides super luxury comfortable sailing for about 8 members. AAT is a super environmentally friendly vehicle which does not cause air pollution like ordinary vehicles in the city roads. AAT is fast and it gives a unique experience for its riders.

Discussion and Conclusion

There are many automated vehicles on the roads and in the sky. What about the water? Is it impossible in the water?

Actually No. AAT will be the new trend in the transport system. Already using ships, boats

for export, import and fishing. But when it comes to Sri Lanka, we rarely use our natural waterways for transport service. Sri Lanka has a wide range of rivers and waterways. The number of vehicles in the world as well as Sri Lanka, has increased within a short period. Because of that government must increase the facilities of the roads and they have to build more roads like highways. When it comes to building new roads, it is a big process and it needs more money. Sometimes they may have to remove hundreds of trees. When to consider the design of the taxi; the main shape of the taxi is based on capsule shape since capsule shape helps taxi to move faster by consuming less power. The material used to manufacture the body of the taxi was carbon fibre since carbon fibre is stronger, stiffer and lighter than steel or aluminium. Authors are introducing this new technology AAT to use the existing waterways of Sri Lanka. Furthermore, we can distribute this service as the government and private sectors. This will be a good opportunity to get the attraction of foreigners to our country. Automate can work day and night in all types of weather. With the latest technologies, automated water taxis may have the ability to “see in the dark”. Onboard cameras and lidar sensors spot and avoid other boats and floating debris. Near future, we can improve these automated aquatic taxis into cargo boat service. When it comes to a new idea, there are both pros and cons. So, this service may not be able to apply all over the country. Because we may not find suitable waterways all over the cities. When it comes to a new idea, there are both pros and cons. Less cost of maintenance is a major benefit of water transportation when it comes to rail and road transport the maintenance cost is quite high but the maintenance cost of water transport is quite less. AAT will be beneficial during natural calamities like flood and rains when rail and road transport is disrupted, relief operations can be operated through water

transport. AAT will be a major source of tourist attraction in the next few years (Mehta, n.d.).

Slow speed is one of the disadvantages in aquatic taxis, it is a slow means of transport. Failure of monsoon results into fall in the water level of rivers making navigation difficult. At the same time, water transport is riskier as compared to other means because there is always a danger of sinking. Waterways and canals can't be worked for transportation during the time as water may freeze during winter or water level may go particularly down during summer.

Also, there is a small percentage of passengers who have aquaphobia (abnormally afraid of water) (Anon., n.d.) Like all computer systems, automated water taxis would programme to run and use manual control system also. So, it will help to avoid these issues.

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