

# Selecting a Wearable GPS Device for Children

Course Title:	Decision Making
Course Number:	ETM 530/630
Instructor:	Dr. Tugrul Daim
Term:	Winter 2017
Author(s):	Bhawinee Banchongraksa
	Jessie Truong
	Lu Chuan Chieh
	Mufeed Yacoub
	Papit Meteekotchadet

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Report No.: Type: Note:	Student Project		

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#### **1. Executive Summary**

A missing child is a parent's worst nightmares. When a child is missing, even for a very short time frame, it is hard for a parent not to entertain a variety of horrifying scenarios and outcomes. In recent years, GPS technology has offered a practical solution to this dilemma in the form of smartphones and wearable tracking devices. For younger children, who are ten years old and under, many schools do not permit them to have phones on hand due to its distractive nature. So, wearable tracking devices become the only option for parents who want to keep track of their young children by default. Moreover, without missing a beat, the wearable industry has made this observation and has consequently introduced many wearable devices to the market. The quantity and variety of these wearable devices may certainly be for the consumer's benefit as manufacturers compete, but it puts the consumers in a moderately overwhelming position as they attempt to browse through the options of an unfamiliar sector of technology.

This paper will address the decision-making process of selecting a wearable tracking device for young children by using the hierarchical decision model (HDM). Through literature review, we will identify relevant features with which we construct the model, and identify the top options for the model to choose from.

#### 2. Introduction

From the variety smartwatches, and fitness trackers out in the market today, we see that there are more wearable devices out there today than ever before. Also, since wearable devices are used in a range of applications, including healthcare, sports and fitness, and there are continuous innovations in the industry, we can safely presume that wearable devices will be around for some time to come. One of the trends that can be observed in this growing industry is the level of integration of these devices with people of all ages, including children.

All parents want to keep their children safe, but choosing parenting styles used to keep them safe is still a heated topic. Safety is defined differently for every parent. Freerange parents would never leash their child, while helicopter parents would never let their child out of their sight. However, when it comes to crowded events, theme parks, or giving the children the independence to venture out into the world alone, will the latest trend in child safety be common ground? Wearable technology with GPS tracking capabilities the newest approach to help protect our children. The device allows parents to pinpoint the exact position of the child using a map on their smartphone or tablet. They come in many colors with different designs and different features, choosing one could be a hair pulling decision for some parents. We conducted a study through reviewing articles regarding wearable devices for children to narrow down the device list in helping parents decide which device is right for their need and financial status.

#### 2.1 Technology Definition

Wearable technology is a category of technology that is designed to be worn on the person's body and to track information mostly related to the fields of health, fitness, location, and biofeedback. The devices have communication capability which allows the user to access data in real-time by using another connected device [15]. A Wearable Global Positioning System (GPS) tracker is a wearable device used to track a person. The main function is GPS tracking system providing exact location and information of a person being tracked. The location data can be stored within the GPS tracking device or can be sent to a central database [1]. Thus the devices can display location either in real-time or when analyzing later.

#### 2.2 What do they do? What are they used for?

The wearable GPS tracking device is used to monitor a child's locations and activities. The device allows parents to track their children when they are outside or away from parents' sight so that the parents have peace of mind and are ensured that the children are where they're supposed to be. The tracking device connects the child to the parents via an application on a smartphone or internet-enabled computer which can directly show a route and location of the child.

The capabilities of each brand of the tracking devices are different; such as GPS range, battery life, real- time tracking, and monthly service fee. These are some criteria that the parents have to take into account. Likewise, the child also considers the products in term of physical attributes such as weight, materials, and colors. The wearable tracking device can have several additional features besides tracking system. For example, some manufacturers provide communication either one way or 2-way communication such as calling and texting, and some devices can send an emergency alert.

#### **3. Problem Definition**

According to the National Center for Missing and Exploited Children, roughly 800,000 children are reported missing each year in the United States [5]. The causes behind this estimated 2,000 missing children per day vary; some children are kidnapped by strangers or family members, so, some drown, and some wonder of and are lost.

About 203,900 children are abducted by family members, about 58,200 children by family acquaintances, and about 115 children by strangers [6]. National Center for Missing Children reports that 20 percent of the children abducted by nonfamily members are found dead [7].

Other situations, such as drowning and getting lost, typically occur with young children when they wander away their parents in public. Also, Children having mental disabilities or behavioral issues such as Attention Deficit Disorder and autism appear to wander out of the guardian's sight whenever they are distracted [8]. Even though smartphones could be a choice, it's functions seem to be too complicated for young children to use. Moreover, there are great numbers of studies that illustrate that children should not be allowed to use smartphones for reasons related to learning and behavior development. Currently, the average age for children getting a first smartphone is at 10.3 years mark [9]. Consequently, with those concerns discussed above and with the age limitations of owning a smartphone, the wearable tracking devices could be the best suited alternative for parents of young children. However, there are many brands in the market today providing these type of

devices with a variety of different features. Therefore, in this paper, we adopt the Hierarchical Decision Model (HDM) to assist parents in selecting the wearable tracking device best suited for them and their children.

## 4. Literature Review

Currently, there are many GPS tracking devices out there on the market [2], by understanding their limitations and focus on what is most important to the parents, we can get a great tracking device that works well for them. The goal in this segment is to analyze top ten GPS tracking devices for children in the market by reviewing online articles.

We start out with a list of top 15 devices reviewed the articles. The list also includes all the features each device offers. To meet our goal, we need to narrow down to top 10 devices. In helping us making the cut, we interviewed technology experts to help defined technical features. Also, we interview existing and non-existing users for a list of features from the GPS tracking device that are important to them. The feature lists are combined for the final list of devices that match only to those features. We listed the devices side by side to show the differences so that parents can use as a quick reference. Device rating is also included to help parents in making their decision.

From the articles [2], we feel as a kid-friendly product the device needs to have a compact size letting them fit neatly in backpacks or on smaller wrists. With real-time GPS signal allows parents to know where the child helps put parents' minds at ease. Capabilities such as panic alert send a signal alerting parents when the device is taking off the child's wrist, or allowing the child to send an SOS text message are also necessary to consider. Below are the criteria we firmly feel parents need to consider when purchasing one.

#### Price

Having a GPS tracker, you do not only pay for the device but also need to pay monthly service fees. The monthly fee could consider whether you sign for the service contract or not. On the other hand, different devices have different marketing for convincing their customers to buy it such as free for couple month at the beginning [4].

#### **Battery Life**

Battery life is always a critical feature for any technology product, but it is even more critical for use on a tracking device. It is impacts the performance of the product. It could cause bad signals to the receiver device. We believe parents should only consider devices that have a battery life of at least 24 hours.

#### Waterproof

Kids meant to be clumsy. Owning a waterproof device is necessary for them. This will protect the life of the device.

#### **Range of Service**

Tracking network the device offers. Since this product is a tracking device, GPS should be a must. The range of this signal should be strong. 3G, wifi are considered as additional.

#### Communication

For children in Kindergarten and First Grade, this might not be a necessary feature to consider. For older children, we feel text feature is more necessary than call. This is because in a case of dangerous where they cannot talk where texting is the only option to communicate for help.

#### Compatibility

This is important as parents have different network providers. A device that is compatible with more than one platforms is a winner in this competitive market.

#### **Real Time**

This is the most important feature in the device. Being able to know where your children are at real time is like being there with your children.

#### **Distraction-free**

This feature is nice to have because it doesn't distract the children from their school work while they are in class.

#### **Monthly Service Fee**

Majority of these tracking device require monthly service fee and this feel like a drawback for the parents who are on budget.

#### **Panic Alert**

This feature is good for children with special need. In the case of the device get remove from the child's wrist, an alert signal gets sent to the parents. We recommend this feature to parents who have kids with autism.

#### Easy to Use

The device needs to be easy enough for the child to navigate, as well as for the parents to set it up and monitor it. We can put it to two different criteria part. Anything goes with hardware; we define it be a sub-criteria under the criteria. On the other hand, the device works with software; we define it be a sub-criteria under the technical performance criteria. More detail will discuss in the model section.

#### **Child Appealing**

A child's product needs to be child appealing. These devices come in different colors, different shapes for the little ones.

The Table I, II are the summary of devices with the features we filtered and collected from our articles review. These devices are highly recommended to parents who are planning to purchase one.

	HereO	AmbyGear	Filip 2	Caref GPS	Wherecom K3
Price	\$199	\$99	\$149.99	\$67.95	\$129.99
Battery Life	Up to 60 hours	7 Days	Up to 2 days	1 Day	Up to 2 days
Water Proof	Splash-proof	Yes	Water-resistant (IP63)	Yes	
Range of Service	GSM, GPS, WiFi	GPS, WiFi, bluetooth	GPS, 3G/GSM, Wi-Fi	GPS	3G, GPS, WiFi
Screen	Yes/EPD	yes/4 colors LED	Yes	Yes	Yes/LCD
Communication	Text	Text	Text/Call	Text/Call	Call
Compatibility	iOS, Android	iOS, Android	iOS, Android	iOS, Android	iOS, Android, Windows
Real Time	Yes	Yes	Yes	Yes	Yes
Distraction-free	N/A	Yes			
Monthly Fee	\$4.95/month	no	\$10/month	\$9.99/month	
Panic Alert	Yes	Yes	Yes	Yes	Yes
Others		1.Send text/alert without service			
		2.Games			
		3.Find me apps			
Amazon Rating	2.5/5		2/5	2.5/5	

 Table I
 Final Lists of Children GPS Tracking Devices from the Articles Reviews

#### Table II Final Lists of Children GPS Tracking Devices from the Articles Reviews [18-22]

1					
	PocketFinder	Tinitell	My Buddy Tag	Lineable	Paxie Band
Price	\$129.95	\$149.00	\$40.00	\$5.00	\$175.00
Battery Life	2~3 Days	1~3 Days	1 Year	1 Year	Up to 36 hours
Water Proof	Yes	Yes	Yes	Yes	Yes
Range of Service	GPS, 3G/GSM Cell ID, Wi-Fi	GSM, GPS	Bluetooth/Limit Range	Bluetooth/Limit Range	GPS
Screen	No	No	No	No	NO
Communication	Email	Call	NO	NO	NO
Compatibility	iOS, Android	iOS, Android	iOS, Android	iOS, Android	N/A
Real Time	Yes	Yes			Yes
Distraction-free		N/A	NO	NO	
Monthly Fee	\$12.95/month	\$12/month	NO	NO	\$9.99/month
Panic Alert	Yes	N/A	Yes		Yes
Others	For Pet/ Elderly User		out of range alert	Group package	
Amazon Rating	3/5		2.5/5	3/5	

These tracking devices are meant to help keep the children safe while parents are busy keeping up with their daily chores. Our goal is to help parents feel at ease when deciding which device fits their need and financial status. We recognized the list of devices above can be overwhelming for some parents. Later in this report, we will re-assess these devices to limit the scope to 5 devices; in addition we will use HDM model to help narrow down the best device based on the experts' evaluation.

### 5. Relevant Brands

In our process of selecting the best wearable tracking devices, we decided to select relevant brands and how many of them would be considered as our alternatives. First, we conducted a literature review on the top brands of the devices and collected some suggestions from the users. Even though we focused specifically on the wearable ones, there were up to ten brands found in the market today having the minimum features desired. However, we picked five out of those ten brands based on their comparable level of technology used and competencies. With the quantity of 5 alternatives, the model and analysis would not be too complex but they would still be various enough between each one of them to proceed in the model. The relevant brands considered as our alternatives are HereO GPS Watch, AmbyGear Smartwatch, Filip 2, Caref GPS, and Omate Wherecom K3. None of these brands is well-known in high-tech industry. So, the brand would not be considered in our analysis.

#### Here O

HereO was founded in 2011. It is GPS Watch was officially unveiled in 2015. HereO claimed that its GPS watch is small enough to fit a kid's wrist ages three and up [10]. Its design appears in colorful and attractive for kids, and it is available with popular cartoon characters printed such as Hello Kitty. Also, HereO GPS watch intendedly provides only simple features which would be easy for children to use. However, its price seems to be highest among alternatives selected.



Fig. 1. Here O

#### AmbyGear

AmbyGear smartwatch was developed under Ambit Networks company founded in 2013. AmbyGear was released in 2015 [11]. As it focuses mostly on children six years old and above, it appears in more complex features and functions, including games and apps, compared to the majority of the alternatives. Also, its price is much lower than HereO even though it provides more services as it clearly emphasizes itself as the internet of kids. However, some customers see many features provided as distractions for their children.



Fig. 2. AmbyGear

### Filip 2

Filip 2 was released in 2014 by Filip company founded in 2012 [12]. Filip 2 typically focus on tracking and communicating functions similar to HereO. Unlike AmberGear, it does not provide additional services such as games or apps. Filip introduced its product that was inspired by real situation happening in founder's life. The author's three years old son, Filip once wandered off his sight among the crowd and they were separated for 30 minutes [12]. This inspired the author to come up with Filip 2 based on this inspiration; it emphasizes its objective as keeping parents and kids stay connected. Filip 2 could also make and receive calls and its price only a little above average.



Fig. 3. Filip 2

#### **Caref GPS**

Caref GPS watch was released in 2014. The company was founded in 2012 [13]. Product's features and functions are very similar to Filip 2. Interestingly, Caref also introduces the same pattern kind of story as Filip did about the inspiration. However, its price is much lower than Filip 2 and even cheapest among our alternatives.



Fig. 4. Caref GPS

#### **Omate Wherecom K3**

Omate Wherecom K3 was released in 2016. The company, Omate was founded in 2013 [14]. Omate Wherecom K3 focuses on children six years old and above. It features and functions are more complex than other alternatives. Its additional functions are mostly about entertainment. It could also make and receive calls, and its price is about average.



Fig. 5. Omate Wherecom K3

## 6. Methodology - Hierarchical Decision Model (HDM)

### 6.1 The HDM

The Hierarchical Decision Model (HDM) is a decision making method for analyzing complex and multi-criteria decisions[16][17]. HDM was originally developed by Dr. Kocaoglu in 1979 with the same fundamental concepts as the Analytical Hierarchy Process (AHP), but using a different pairwise comparison scale and judgment quantification technique [23]. Later on, in 1981, the general form of the HDM was developed by Dr. Cleland and Dr. Kocaoglu. This model consists of five levels of decision elements namely Mission, Objectives, Goals, Strategies and Actions (MOGSA) [24]. These levels are flexible to undergo appropriate changes to accommodate a vast variety of cases and structures. The number of levels may also increase or decrease depending on the complexity or simplicity of the subject accordingly.

The fundamental advantage of HDM is its ability to decompose problems into a hierarchy of more easily comprehended sub-problems to be evaluated independently. Using pairwise comparison, subject experts provide values for the priorities of the items in the model at each level. In simpler terms, experts choose in a series of one to one comparisons which item is more important than the other. HDM gives decision makers the ability to organize feelings, intuition, and logical thinking in the decision making process [25].

### 6.2 Criteria Selection and Model Building

To address the research objective, a HDM was developed as shown in Fig. 6. The model structure content is derived from a literature review and a team brainstorming session of the different factors that should be considered as it relates to children's wearable tracking devices. The model is composed of four levels.

**Level 1** – Mission: This level represents the mission we are set out to achieve, assist parents in selecting a GPS tracking device for children from the age of 5 to 10.

**Level 2** – Criteria: This level includes the main categories for consideration. As all team members have technical background, we acted as the technical experts and selecting these criteria. For any technology, we feel there are at least 3 important criteria buyer should consider before make their purchase. These important criteria are the technical performance of the device, the design of the device, and the financing capability from the buyer, anything else are additional.

Level 3 – Sub-Criteria: This level includes a more specific features for consideration. We sat down and interviewed several existing product owners to get the list of features/functionalities that are important to them. The final list was generated in combining this list to the list that we collected from our literature/articles reviewed.

**Level 4** – Alternatives: This level presents the options available. The 5 products finalized in relevant brand section from literature/articles reviewed result will be used as our alternatives. The detail of our research model can see in Appendix B



Fig. 6. HDM Model

In this model, we have 7 experts from our social circle doing pairwise comparison for our project. According to the table below, there is information about our experts showing their ages, gender, jobs, marital status, and number of children they have. Essentially, we also consider whether they owned the products or they were potential buyers.

Before they do the pairwise comparison, we sent them information and specifications of the 5 alternatives that we chose. By doing this, it could insured that, at least, all of them would have knowledge for all of those five devices although they were sort of familiar with this kind of technology as some of them have already owned a device and some of them are looking to have it.

Moreover, we also made sure that our experts were enable to understand the model and can proceed the pairwise comparison correctly. Therefore, we sent them the link of the model with instructions and followed them up whether they exactly knew how to do it. Then we let the ones who ensured that they really understood how to do it do by themselve. On the other hand, for the ones who were not clearly sure how to do the pairwise in the model, we met them in person and assisted them while they were doing the pairwise in the model. This could ensured that we would get the correct results as all of them proceeded the pairwise comparison in the model correctly. The following Table III is the overall of our experts:

	Gender	Age	Occupation	Number of Children/Grandchildren	Current Product Owner	Potential Buyer
Expert 1	Female	31	Retailed Manager	1	Yes	
Expert 2	Female	35	Dental Assistant	2	No	Yes
Expert 3	Female	60	Interpreter	2	Yes	
Expert 4	Male	55	Teacher	1	No	Yes
Expert 5	Female	48	Business Owner	0	No	Yes
Expert 6	Female	32	Piano Teacher	0	Yes	
Expert 7	Female	46	Business Owner	2	Yes	

Table III Lists of the Experts

## 7. Data Analysis and Results

After choosing the right expert, we decided to collect the pairwise comparison scores by sitting with, and interviewing the experts to ensure they understand the scoring process and answer their questions as they come up. Prior to our meeting with the experts, we provided an information sheet containing the specifications and features of each device. The goal of this step was to bring our experts up to par and to for them to have a leveled knowledge of the basics.

After the scores were entered, we received our results from the HDM software. Table IV below shows the criteria level results. The numbers highlighted in yellow below show the top rated criteria for each expert. According to Table IV, we observe that most of our experts feel that technical performance is really important for them, which include current product owner and potential buyer. On the other hand, we can see that expert 2 valued design over technical performance. Meanwhile, financial is her second priority for the criteria because her sons always lose something such as a lunchbox or a pencil box, so she will not buy an expensive device for it.

	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Expert7	Mean
Technical Performance	0.43	0.10	0.33	0.43	0.42	0.32	0.42	0.35
Design	0.17	0.40	0.27	0.17	0.15	0.22	0.13	0.22
Financial	0.12	0.30	0.22	0.12	0.38	0.32	0.37	0.26
Additional Features	0.28	0.20	0.18	0.28	0.05	0.14	0.08	0.17
Inconsistency	0	0	0	0	0.01	0	0.01	

Table IV Criteria Importance - Consolidated

Fig. 7 shows the experts' rating percentages at the criteria level. As we can see, technical performance has the highest rate at this criteria level. Due to the safety concerns that is tied with the selection objective, it is not surprising that technical performance is considered to be the most important aspect for the experts at 35%. The financial aspect fell in second place, as it received 26%. Next, the design received 22% here because the design of easy to use is also the criteria that parents are understandably concerned with. Meanwhile, we can see that additional features are the lowest one in criteria level because our expert feels less necessary for an additional feature at this level when they are scoring. At this second level of the HDM, the inconsistency is well within the allowed range at 0-0.01.



Fig. 7. Criteria Importance Consolidated Chart

After getting the result at the criteria level, we analyze the results at the sub-criteria level of our HDM model, which is represented in Table V. Every expert has compared each sub-criteria relative to its particular criteria group. Table V shows the consolidated data from the seven experts with regards to the sub-criteria level. Also, the results for each expert concerning the sub-criteria level are found in Appendix A. The numbers highlighted in yellow below show the top rated sub-criteria for each expert. from the results we can see that the expert's priorities are different. Also, 'Criteria Importance' column contains the values in the criteria evaluation. For example, price is the sub-criteria under the financial, so the criteria importance of price will be 0.26.

Next, it is important to Call attention that we have two 'Easy to Use' sub-criteria. One for the Technical Performance, and one for the Design criteria. Another important explanation to make is that the 'Sub-Criteria weight' values come from the multiplication of the 'Mean' value by the 'Criteria Importance' value. For example, the price's weight originates 0.54, which multiplied by 0.26 gives us 0.14 for the sub-criteria weight.

	Expert1	Expert2	Expert3	Expert4	Expert5	Expert6	Expert7	Mean	Criteria Importance	Sub-criteria Weight
Price	0.5	0.42	0.52	0.45	0.8	0.5	0.6	0.54	0.26	0.14
Battery Life	0.33	0.44	0.27	0.3	0.6	0.24	0.63	0.40	0.22	0.09
Water Proof	0.5	0.73	0.48	0.65	0.3	0.48	0.3	0.49	0.17	0.08
Service Range	0.18	0.16	0.2	0.22	0.26	0.2	0.36	0.22	0.35	0.08
Communication	0.16	0.13	0.2	0.27	0.26	0.2	0.22	0.20	0.35	0.07
Compatibility	0.18	0.12	0.05	0.07	0.07	0.05	0.14	0.09	0.35	0.03
Real Time	0.21	0.19	0.26	0.24	0.25	0.23	0.17	0.22	0.35	0.08
Distraction-free	0.08	0.1	0.06	0.09	0.08	0.06	0.05	0.07	0.35	0.03
Monthly Fee	0.5	0.58	0.48	0.55	0.2	0.5	0.4	0.45	0.26	0.12
Panic Alert	0.5	0.27	0.52	0.35	0.7	0.52	0.7	0.51	0.17	0.09
Easy to Use(T)	0.18	0.3	0.23	0.11	0.09	0.26	0.07	0.18	0.35	0.06
Easy to Use(D)	0.33	0.31	0.56	0.44	0.2	0.6	0.21	0.38	0.22	0.08
Child Appealing	0.33	0.25	0.17	0.26	0.2	0.16	0.16	0.22	0.22	0.05

Table V Sub-Criteria Evaluation Data - Consolidated

The Table VI below is our sub-criteria weights from high to low.

Sub-Criteria	Weight
Price	14%
Monthly Fee	12%
Panic Alert	9%
Battery Life	9%
Easy to Use(D)	8%
Waterproof	8%

Table VI Weights of Each Sub-Criteria

Service Range	8%
Real Time	8%
Communication	7%
Easy to Use(T)	6%
Child Appealing	5%
Compatibility	3%
Distraction-free	3%

From Table VI, we can see that top four sub-criteria are price, monthly fee, panic alert and battery life. We notice that Financial is critical for our experts because price and monthly fee are the sub-criteria for the Financial. This result makes since children between 5~10 years old may easily lose their wearable device. For this reason, parents will understandably be reluctant to buy a device that is too expensive. Distraction-free is the lowest weight because our experts feel that this doesn't matter when considering the safety of their children. Compatibility is the least weighted sub-criteria, but it does not mean it doesn't matter to the experts because all devices can be paired with the Android and iOS system. The pie chart of our sub-criteria, you can see at the Fig. 8.



Fig. 8. Sub-Criteria Evaluation Data - Consolidated Chart

After the sub-criteria level, we will move to the last level, which is alternatives, shown in Table VII and Fig.9. At this level, we will score our devices relative to the sub-criteria. Table VII is the result of the alternatives level. We can see from the pie chart at Fig.9, AmbyGear is the best choice for a wearable tracking device for children.

The numbers highlighted in yellow below show the top rated device for each expert. We notice that Experts 1,3,6,7, who own this type of devices, are in agreement in choosing AmbyGear as their top choice. On the other hand, Experts 2, 4, 5, who do not own these type of devices, scores were not as consistent. It is safe to conclude that these results correlate to the experts' level of experience with these products.

The last critical area of HDM model analysis is inconsistency. The importance of low inconsistency is a gauge of how well an expert can move through the pair-wise comparisons and not become lost and hence inconsistent. The additional statistical information about the HDM model's results is in Appendix C.

	Here O GPS Watch	AmbyGear Smartwatch	Filip 2	Caref GPS	Wherecpm K3	Inconsistency
Expert1	0.19	0.21	0.2	0.2	0.2	0.01
Expert2	0.25	0.3	0.15	0.17	0.13	0.03
Expert3	0.22	0.22	0.19	0.21	0.16	0
Expert4	0.22	0.2	0.18	0.19	0.21	0.01
Expert5	0.15	0.22	0.15	0.3	0.18	0.01
Expert6	0.17	0.27	0.18	0.23	0.15	0
Expert7	0.19	0.22	0.18	0.2	0.21	0.01
Mean	0.2	0.23	0.18	0.21	0.18	
Minimum	0.15	0.2	0.15	0.17	0.13	
Maximum	0.25	0.3	0.2	0.3	0.21	
Std. Deviation	0.03	0.03	0.02	0.04	0.03	
Disagreement						0.028

Table VII Overall Results



Fig. 9. Overall Results Chart

Fig. 10 is the overall result of HDM, all the number here we just mention before level by level, so we can the value here for the whole model.



Fig. 10. Overall Results of HDM

## 8. Limitations and Future Research

In our project, selecting a GPS tracking device for children, the limitation can be considered as the selection of the experts. Based on their jobs, majority of them are not professional in the technical areas or specialized in wearable devices. In the future, we should also have some experts specialized in specific areas: electronic, design, and marketing. This will be for three steps: selection of criteria, selection of sub-criteria, and pairwise comparison. We can even have them evaluate particularly in the areas they are expertized in. For example, experts who have background in the electronic area will be professional in technical features. Experts who have background in design or marketing will be professional in design on hardware features. Then, we can see whether there will be significant changes in the result or not.

We selected a variety of models of the product that are available to the market, but still there are a considerable number of different options that could have been chosen (perhaps yielding different results). Therefore, future research works could apply the same model to a different set of alternatives, or yet to the same ones, but only adding more criteria.

#### 9. Conclusion

The goal of this study was to help parents select the best children GPS tracking device at an affordable price. By using the Hierarchical Decision Model that is built with criteria collected through literature review and interviewing the experts we achieved our goal. The result from the HDM pairwise comparison indicated that AmbyGear is the winner with 23% overall score. First, the runner-up is Caref GPS with 21% overall rating, and our second runner-up is HereO GPS watch with an overall score of 20%. The other two alternatives are tight with 18% overall score. The margin between these devices is very small. The overall inconsistency and disagreement are very low thus we did not perform validation nor sensitivity test for our model. We feel our result might be personally biased because some of our experts are product owners, and they might be in favorite one over the other. Another area we realize might impact our model is the Additional Features criteria. The features from this criteria were not available for all product. This shows our lack of expertise in selecting criteria for the model. Also, our naming convention for the subcriteria easy-to-use was not clear enough. We used the same name as the child node for criteria Performance and Design. This caused some confusion to the experts when they made the pairwise comparison.

In conclusion, we feel our model could be improved in multiple ways. Perhaps we can start with improving the selection of criteria for evaluating the alternatives. Our HDM's experts can be selected on people who have not own the product to avoid bias opinion. Last, naming convention in the model need to be clear and precise to keep off the confusion for our experts.

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Expert1	Technical Performance	Design	Financial	Additional Features
Price			0.5	
Battery Life		0.33		
Water Proof				0.5
Service Range	0.18			
Communication	0.16			
Compatibility	0.18			
Post Time	0.10			
Distriction from	0.21			
Distraction-free	0.08		0.5	
Monthly Fee			0.5	0.5
Panic Alert				0.5
Easy to Use	0.18	0.33		
Child Appealing		0.33		
Inconsistency	0.01	0	0	0
Expert 2	Technical Performance	Design	Financial	Additional Features
Price			0.42	
Battery Life		0.44		
Water Proof				0.73
Service Range	0.16			
Communication	0.10		+	
Commetil	0.13		+	
Compatibility	0.12		+	
Real I ime	0.19			
Distraction-free	0.1			
Monthly Fee			0.58	
Panic Alert				0.27
Easy to Use	0.3	0.31		
Child Appealing		0.25		
Inconsistency	0.01	0	0	0
Expert 3	Technical Performance	Design	Financial	Additional Features
Price			0.52	
Battery Life		0.27		
Water Proof				0.48
Service Range	0.2			0.10
Communication	0.2			
Communication	0.2			
Compatibility	0.05			
Real Lime	0.26			
Distraction-free	0.06			
Monthly Fee			0.48	
Panic Alert				0.52
Easy to Use	0.23	0.56		
Child Appealing		0.17		
Inconsistency	0	0	0	0
Expert 4	Technical Performance	Design	Financial	Additional Features
Price			0.45	
Battery Life		0.3	0.10	
Water Droof		0.0		0.65
				0.05
	0.22			
Service Range	0.22			
Communication	0.22 0.27			
Communication Compatibility	0.22 0.27 0.07			
Communication Compatibility Real Time	0.22 0.27 0.07 0.24			
Communication Compatibility Real Time Distraction-free	0.22 0.27 0.07 0.24 0.09			
Communication Compatibility Real Time Distraction-free Monthly Fee	0.22 0.27 0.07 0.24 0.09		0.55	
Communication Compatibility Real Time Distraction-free Monthly Fee Panic Alert	0.22 0.27 0.07 0.24 0.09		0.55	0.35
Communication Compatibility Real Time Distraction-free Monthly Fee Panic Alert Easy to Use	0.22 0.27 0.07 0.24 0.09 0.11	0.44	0.55	0.35
Communication Compatibility Real Time Distraction-free Monthly Fee Panic Alert Easy to Use Child Appealing	0.22 0.27 0.07 0.24 0.09 0.11	0.44	0.55	0.35
Service Range Communication Compatibility Real Time Distraction-free Monthly Fee Panic Alert Easy to Use Child Appealing Inconsistency	0.22 0.27 0.07 0.24 0.09 0.11	0.44	0.55	0.35

## Appendix A - Experts Individual Results of Sub-Criteria

Expert 5	Technical Performance	Design	Financial	Additional Features
Price			0.8	
Battery Life		0.6		
Water Proof				0.3
Service Range	0.26			
Communication	0.26			
Compatibility	0.07			
Real Time	0.25			
Distraction-free	0.08			
Monthly Fee			0.2	
Panic Alert				0.7
Easy to Use	0.09	0.2		
Child Appealing	0.00	0.2		
Inconsistency	0	0	0	0
Inconsistency	v	v	v	v
Expert 6	Technical Performance	Design	Financial	Additional Features
Price	recument renormance	Design	0.5	r assidonal r catales
Battery Life		0.24	0.5	
Water Droof		0.24		0.48
Service Penge	0.2			0.40
Communication	0.2			
Communication	0.2			
Compatibility	0.05			
Real Lime	0.23			
Distraction-free	0.06			
Monthly Fee			0.5	
Panic Alert				0.52
Easy to Use	0.26	0.6		
Child Appealing		0.16		
Inconsistency	0	0	0	0
Expert 7	Technical Performance	Design	Financial	Additional Features
Price			0.6	
Battery Life		0.63		
Water Proof				0.3
Service Range	0.36			
Communication	0.22			
Compatibility	0.14			
Real Time	0.17			
Distraction free	0.05			
Monthly For	0.05		0.4	
Denie Aleri			0.4	0.7
Panic Alert	0.07	0.01		0.7
Easy to Use	0.07	0.21		
Child Appealing		0.16		
Inconsistency	0	0	0	0

## **Appendix B - Research Model**



## **Appendix C - Model Statistical Results**

<b>Source of Variation</b>	Sum of Square	Deg. of freedom	Mean Square	F-test value			
Between Subjects:	0.02	4	.005	3.28			
Between Conditions:	0.00	6	0.000				
Residual:	0.03	24	0.001				
Total:	0.05	34					
Critical F-value with degrees of freedom 4 & 24 at 0.01 level:							
Critical F-value with	3.38						
Critical F-value with degrees of freedom 4 & 24 at 0.05 level:							
Critical F-value with	2.19						