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Team 503: Technology to Disrupt Human Trafficking

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Abstract

The abstract is a concise statement of the significant contents of your project. The abstract should be one paragraph of between 150 and 500 words. The abstract is not indents.

Keywords: list 3 to 5 keywords that describe your project.

Disclaimer

Your sponsor may require a disclaimer on the report. Especially if it is a government sponsored project or confidential project. If a disclaimer is not required delete this section.

Acknowledgement

These remarks thanks those that helped you complete your senior design project. Especially those who have sponsored the project, provided mentorship advice, and materials. 4

- Paragraph 1 thank sponsor!
- Paragraph 2 thank advisors.
- Paragraph 3 thank those that provided you materials and resources.
- Paragraph 4 thank anyone else who helped you.

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A17	Steering Column Angle
A27	Pan Angle
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AAA	American Automobile Association
AARP	American Association of Retired Persons
AHP	Accelerator Heel Point
ANOVA	Analysis of Variance
AOTA	American Occupational Therapy Association
ASA	American Society on Aging
BA	Back Angle
BOF	Ball of Foot
BOFRP	Ball of Foot Reference Point
CAD	Computer Aided Design
CDC	Centers for Disease Control and Prevention
CU-ICAR	Clemson University - International Center for Automotive Research
DDI	Driver Death per Involvement Ratio
DIT	Driver Involvement per Vehicle Mile Traveled
Difference	Difference between the calculated and measured BOFRP to H-point

DRR	Death Rate Ratio
DRS	Driving Rehabilitation Specialist
EMM	Estimated Marginal Means
FARS	Fatality Analysis Reporting System
FMVSS	Federal Motor Vehicle Safety Standard
GES	General Estimates System
GHS	Greenville Health System
H13	Steering Wheel Thigh Clearance
H17	Wheel Center to Heel Pont
H30	H-point to accelerator heel point
HPD	H-point Design Tool
HPM	H-point Machine
HPM-II	H-point Machine II
HT	H-point Travel
HX	H-point to Accelerator Heel Point
HZ	H-point to Accelerator Heel Point
IIHS	Insurance Institute for Highway Safety
L6	BFRP to Steering Wheel Center

Chapter One: EML 4551C

1.1 Project Scope

1.1.1 Project Description

The objective of this project is to design a technology allowing human trafficking victims to discretely call for help and relay their location to be rescued by authorities . In 2023, over 2,100 cases of human trafficking were reported in Florida, ranking third amongst U.S. states (CBS 2024). Florida is a hotspot for all types of human trafficking, which mainly includes sex trafficking, labor trafficking, and domestic minor trafficking (Uitts 2023). It is estimated that under two percent of minor trafficking victims are rescued (Miller 2023). The current efforts to rescue human trafficking victims is not sustainable, hence a large market for a product to cause prevention is present.

1.1.2 Key Goals

The primary goal of this project is to design a device that would enable operators to discreetly gather actionable intelligence on potential human trafficers. The device may or may not require human interaction but will not allow traffickers to notice the signal it is relaying.

Additionally, this device should involve a tracking method so that those being trafficked can be rescued. A signal will be relayed to any outside sources that can locate the signal and its location.

The signal should be capable of following the individual to different locations and relaying a position. The device should have a either a continuous beacon or send out discrete signals while being transported or stationary.

This device should be capable of operating in typical environmental conditions in the state of Florida so that it can maintain performance year-round in the major cities throughout the state. The device will be installed in a vehicle interior and therefore will need resistance to higher than ambient temperatures in the summer.

1.1.3 Market

The primary market for this project is the CIA (Central Intelligence Agency) who will be overseeing the creation of the product. Other primary markets for this project are federal law enforcement agencies including the FBI (Federal Bureau of Investigations), DEA (Drug Enforcement Agency), and the U.S. Department of Homeland Security who may also want to use the product or access the designs. The secondary markets for this project include local law enforcement agencies such as county sheriff departments, city police stations, and local first responders who will be using the technology to help rescue human trafficking victims. Another secondary market is legal guardians of minors or residents of Florida who may need to access the product. A further secondary market is private business owners who want to help prevent human trafficking from occurring on their properties. Finally, public transportation hubs, such as bus stops, train stations, shipyards/docks, and airports are a valid market due to the high volume of human trafficking that passes through these areas (Migration Data Portal, 2024).

1.1.4 Assumptions

Each of the assumptions for this project are generally devoted to one of three categories. Firstly, the intersection points at which the developed technology will integrate with existing systems. Secondly, which parties can be expected to understand how to

operate the technology before, during, or after it is needed. Finally, some assumptions must be made to define the expected operating conditions.

Defining integration points with existing systems allows the maximum amount of time to be spent on the aspects of this project that will improve upon current technologies and meet the key goals. For this purpose, it is assumed that first responders have the necessary technology to receive and interpret the devices signals and data.

The developed technology requires user interaction; however, it is not reasonable to expect all users will have the time or ability to train in its use so it is assumed that victims will not have prior training or experience operating the technology. Public knowledge of how the technology operates would make it more likely for traffickers to become aware of it and avoid it so it must be assumed that only first responders and essential personnel will have prior knowledge of how the device operates.

Assumptions related to the technology's operating conditions are based on the potential environmental factors it will face. The device will have a primary operational area covering the state of Florida. As such, it must be assumed that the temperature range that it will face extends from 0 to 50 degrees Celsius. It must also be assumed that the technology will be in dusty and/or humid conditions. Finally, the team assumes the technology will be tested in environments that are the same or very similar to those in which high rates of human trafficking occur.

The device is designed to be deployed as technology either implanted into a vehicle's rear-view mirror, or as a self-contained unit that will replace the rear-view

mirror. Given these factors, it is assumed that up to a week of uninterrupted vehicle access can be obtained for installation.

Finally, the device will be deployed in situations where the people that interact with it may be inherently hostile to its presence, and where its detection can reduce or undermine its effectiveness. Therefore, the device must be able to remain undetected under intense scrutinity.

1.1.5 Stakeholders

The primary stakeholder in this project is the Central Intelligence Agency (CIA), who is contacting us through Joe. Dr. McConomy is our secondary stakeholder, which will assist with advising, communication, and guidance. State Troopers from the Florida Highway Patrol will act as an additional stakeholder, as we will be in contact with Troopers who have experience with cases involving human trafficking. All other areas of law enforcement will be in contact about potential product testing and information. Victims of human trafficking and anyone located in the Florida region have interest in this product. The machine shop and any other parties involved with overseeing the construction of our prototype have an interest in seeing that it is not delayed during manufacturing. Team 503 is interested in that the product created meets all the key goals and customer needs.

1.2 Customer Needs

1.2.1 Interpretation of Needs

The CIA has partnered with the FAMU-FSU College of Engineering to develop a device to discretely relay the location of human traffickers. Joe, a government employee and point of contact, is responsible for answering any questions that are present. The customer for the device is anyone who will be using the device firsthand to locate human traffickers. It is our responsibility to design the device to our best ability under the standards and regulations that our customers require.

The questions that were proposed and answered are listed below, as well as the interpretation for each answer.

Question	Customer Response	Interpretation
Is there a specific size/weight requirement?	"No dimensions are on hand but will be researched, the smaller the better, battery size is typically the largest issue, will double check to make sure no specific dimensions"	The smaller the device, the more reliable it will be.
Is there a budget for this device?	"No one has discussed budget but would shoot for a practical, practicality is more of a driving factor than price"	Practicality, when making decisions about the device, takes priority over budget.
Should the device be tailored to any specific demographic (age or gender)?	"No particular demographic, think about how the device will be used, won't hand it directly to a trafficker"	All demographics will be considered.
Where do current human trafficking deterrents fall short?	"Battery life is one of the biggest issues, look at something that transmits in lower frequencies, could store GPS coordinates for later retrieval, depends on the target and where they are going, recent technology has	A longer battery life and lower frequencies compared to existing technologies.

	looked into Apple find my location"	
Should the device be tailored to a specific type of trafficking (Sex, labor, etc.)?	"All trafficking should be considered, big target on child and sex trafficking"	All types of human trafficking will be taken into consideration.
Should the device work without user activation?	"It can be up for discretion but would consider it being interactive because something may need to be customized later on, we love to have some control over our technology"	Control over technology is a large positive and is more reliable than no interaction.
What existing systems may we be able to utilize?	"Laura is the biggest technology right now, outside of that its mostly GPS coordinates, accelerometers are used after GPS signal is lost"	Research Laura, GPS, and accelerometers.
Should the device be designed for sale to the general public?	"I will leave that up to your discretion, one company I work with has both a commercial version and a private version"	Sales to the general public is up for discretion.
Are there specific battery requirements for the device?	"Battery life is the most important aspect of the device"	Battery life will be of very high importance in the design.
Are there any specific materials that should be used?	"As long as the materials have a wide temperature range"	Consider materials that withstand a wide range of temperature.
What type of signal should we be transmitting to reveal the victim's location?	"No specific signals, discretion can be used to decide method"	All types of signals will be considered when designing the device.
Are there any CIA regulations or codes that we should follow?	"Technically there are no codes besides they can't kill anyone"	Device is free from any specific codes or regulations.
Can we assume the user will not know how to operate the device?	"Victims will have zero interaction"	User interface will be catered towards front line human trafficking correspondents.
What temperatures should we account for?	"A wide range of temperatures is needed"	Account for all temperatures found in Florida.
Any recommendations for where to look for research?	"In particular no, we usually go to individual components"	Research individual parts, ex) gps trackers, tracking frequencies, etc.

Table 1: Interpretation of Sponsor's Answers

1.2.2 Explanation of Results

The purpose of the project is different than what Team 503 had first anticipated. The device will be used to help rescue human trafficking victims, but it is to be focused on catching the actual traffickers themselves. The victim will have no interaction with the device, meaning the interface will be catered towards the agent. Changes to the project scope will need to be made to adjust to the new circumstances.

The Central Intelligence Agency (CIA) wants to develop a device to help front line human trafficking correspondents discretely locate traffickers. There are not many explicit technical requirements, however, our sponsor emphasized the need for the device to be as compact as possible, dust and water resistant, and have ample battery life. Battery life is the most prominent issue in today's human trafficking technology and the most prioritized need. The device can utilize existing technologies but is not beholden to any certain one. Overall, the customer's priorities are battery life, tracking capabilities, and environmental resistance.

1.3 Functional Decomposition

1.3.1 Introduction

Using a functional decomposition analysis, the complex overall system of the device can be broken into subsystems and individual functions. Firstly, the customer needs are gathered and analyzed so that the required functionalities of the device can be determined. These functionalities are then categorized into separate sub systems that are required to achieve the targeted operation of the device. Performing this functional decomposition analysis organizes the function and establishes a hierarchal representation

of the operational components necessary to accomplish the project goals. The following functional decomposition was developed based on the customer needs interpreted from a conversation with the project sponsor.

1.3.2 Hierarchy Introduction and Data Generation

The customer needs, key goals, and assumptions were used to collect the data to organize the functions of the device into systems based on complexity. Every action of the device was listed in the lowest level of sub-sections, followed by consecutive sub-sections that are organized based on relationships. Figure 1 shows how each action of the device is connected to make the final product.

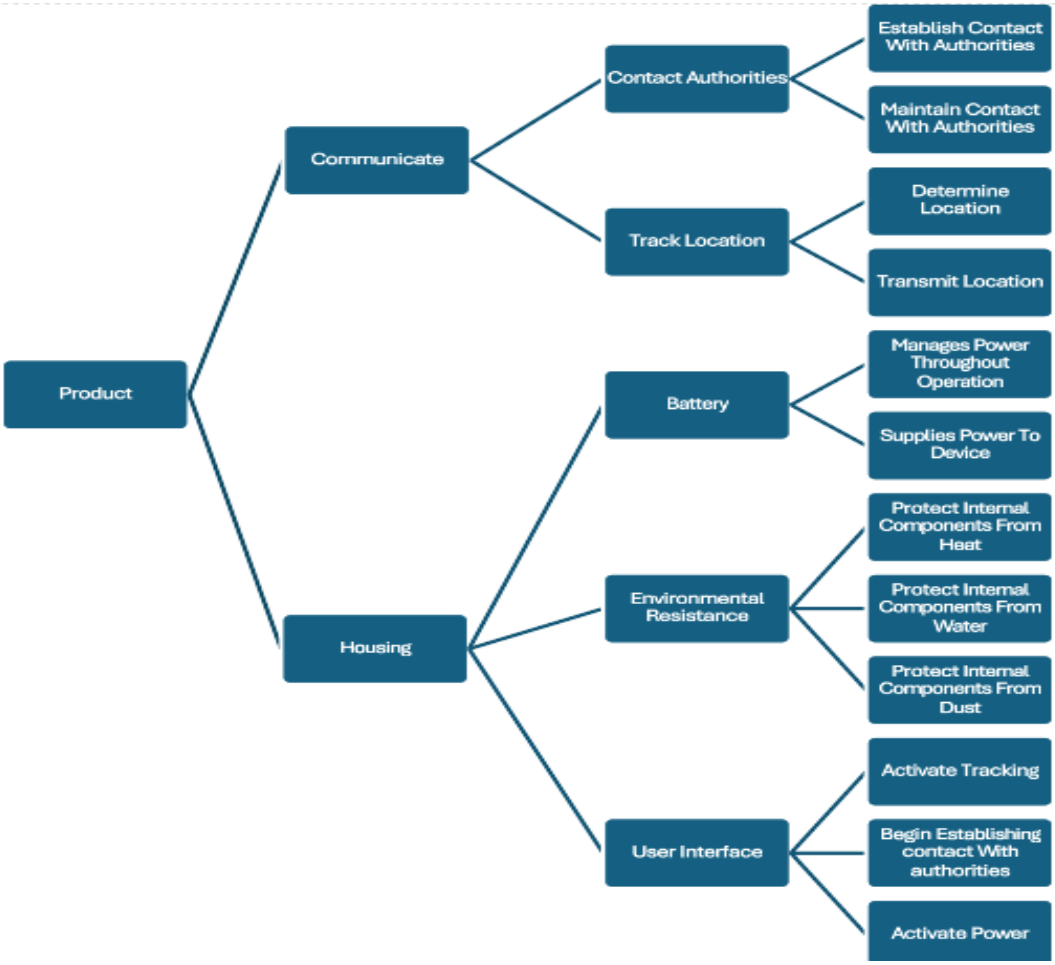


Figure 1: Hierarchy Chart

1.3.3 Explanation of Hierarchy Chart

The highest level of the hierarchy chart is the product. This includes everything in the key goals that the product is trying to accomplish.

The second level is made up of housing and communication. The device will work to transmit location to outside parties which will involve setting up a line of communication. The authorities will need to be contacted when the device has a location and is ready to transmit. Housing describes all of the components that will be enclosed within the physical structure of the device.

The third and fourth level are made up of the main components of the device, as well as the actions to be completed. The lowest level describes what the device will be doing to the lowest degree.

1.3.4 Connection to Systems

Viewing Table 2, we ended up with the following sub-systems: Contact Authorities, Track Location, Battery, Environmental Resistance, and User Interface. Each section below will discuss the priority ranks of the system and function relationships.

Contact Authorities

The sub-system of Contact Authorities has the function of establishing and maintaining contact with the authorities that have ownership over the device. It is important to establish contact with the correct signal and at the right time as time is crucial when activating the device. Contact must be maintained throughout the entire operation once the connection is established with authorities, as any location data is crucial to the operation.

Track Location

The location must be determined and transmitted as a function of the Track Location sub-system. An accurate location is vital to accurate data collected by the device; Authorities will be depending on an accurate location. The transmission of the location needs to be consistent along with the accuracy to have maximum effectiveness of the device.

Battery

The battery must supply power throughout the device and be able maintain the device's efficiency during the entire operation. Battery life should be targeted to be as long as possible due to the variations of time this device may be out in the unknown. The battery will provide adequate power to function and perform its tasks but should be conserved where it is necessary.

Environmental Resistance

The device will be exposed to all sorts of environments whether it is in use or not. It is important that the device is built to withstand any environmental conditions such as water, dust, and heat. The material may experience one or all of these conditions at once, requiring it to be able to adapt to its environment and be serviceable in any condition.

User Interface

The device may need to be activated when it is deployed, requiring the power source to turn on or increase intensity. This also includes the device activating its tracking method as well as sending out an initial connection to authorities.

1.3.5 Smart Integration

The following figure is the cross reference table which was created from the hierarchy chart. A cross reference table connects each of the lowest level actions to however many higher level systems that they interact with. The purpose of the table is to show the interactions between each action of the product.

Sub-System	Contact Authorities	Track Location	Battery	Environmental Resistance	User Interface	Total
Establish Contact with Authorities	X	X			X	3
Maintain Contact with Authorities	X	X	X			3
Determine Location		X				1
Transmit Location	X	X				2
Manages Power Throughout Operation			X			1
Supplies Power to Device			X			1
Protect Internal Components From Heat				X		1
Protect Internal Components From Water				X		1
Protect Internal Components From Dust				X		

Activate Tracking		X			X	
Begin Establishing Contact With Authorities	X				X	
Activate Power			X		X	

Table 2: Cross Reference Table

1.3.6 Actions and Outcomes

This device is intended to be deployed by law enforcement agents to track the location of potential suspected traffickers and send a signal containing that information back to the agent. The aim of this device is to help disrupt the human trafficking process by capturing location data of the suspects and relaying this data to law enforcement. The device is expected to be discreate, provide a reliable signal, and have long lasting battery compared to similar devices.

The device itself must be designed to track the location of suspects even when moving between different destinations. Therefore, the device must be relatively compact to ensure it will not be identified by the suspect. Further, the device must be durable enough to withstand a wide range of environmental conditions and maintain operation. The housing of the device should be moisture, dust, and wind resistant to prevent damage to interior components when exposed to different environmental conditions. It must also be capable of operating at high speeds in the case that it is attached or placed within moving vehicles.

1.3.7 Function Resolution

The device primarily operates based on two essential functions: activation and transmission. Its purpose is to aid in locating trafficking activities once triggered. The activation process is similar to existing technologies, enabling the device to transmit a signal to the relevant authorities. This transmission includes the location where the device was activated, as well as a tracking system that monitors the device's movement. The information is then relayed to the authorities, allowing them to track the device's location and take appropriate action to intercept the trafficking operation.

1.4 Target Summary

1.4.1 Introduction

After the functions of our device were determined, the targets and metrics were taken from the functional decomposition and the hierarchy chart. The target represents the value that each function is required to satisfy while the metric is how each of the targets will be measured. The critical targets for our device were decided based on which targets are most important to satisfy the key goals of our product. A full list of the targets and metrics for this project can be found in Appendix C: Target Catalog.

1.4.2 Derivation of Critical Targets

Targets were first determined with no priority given to importance or criticality. Then, the primary functions of the device were considered, namely, tracking and transmitting. The goals most directly related to these are considered mission critical.

Determine Location

To satisfy the need to determine location, our device will need to be within a fifty-meter range of its exact location. Determining a correct location is crucial to the device as incorrect or inconsistent readings will throw off the tracking route. A buffer to the exact

location was given as pinpointing the exact location without error may be challenging if the device is hidden away and obstructed from a strong signal. To test the method of determining location, we will take our device out into areas with different environments and obstructed by different materials. We will then attempt to track the location of the device multiple times and determine how close are readings are. If the device fails these tests, steps to improve the signal from our device will be taken. This target is beneficial as it helps meet additional needs such as the need for a variety of signals to be considered, the need for different environmental conditions to considered, and the need for different materials that can withstand different temperatures to be considered.

Transmit Location

Transmitting the device's location involves data communication between the user and the device’s geographical position. The transmission must be a discrete signal that is secure enough not to be intercepted by the targeted suspects. It is critical that the transmission of location data is both accurate and secure for operational success. To validate this function, the device must be able to be located entirely through communication between the user and the device; and the device must also be immune to reasonable attempts of signal interception and counter-tracking. Testing these functions will be done in a similar manner to the determine location function. The device will be challenged in various environments and conditions, and it must still be able to meet the above requirements in these locations. Therefore, this target also helps meet the needs to allow the operator to have control over the device, considering a variety of signals for tracking, and considering different existing systems to build off of.

Manage Power Throughout Operation

For the battery to last as long as needed, it will need to manage its power usage throughout operation. If the battery stays on for the entire course of operation at a max power setting, the battery life will not be sustainable. The amount of power the device needs to operate should be supplied at all times, but no more than that. A method of charging the battery may be implemented into the device such as solar power or wind power. By managing the power of the battery, the needs for a long battery life, a reliable signal, and maintaining discretion by allowing for a smaller casing of the tracking components due to a reduced battery size. The process for testing battery life will be to record how long the battery can withstand certain levels of output charge. In between recording those values, the battery will be recharged to full power. The charge life after consecutive recharges will be recorded to measure the fall off of the battery life after usage.

Activate Power

When the user is ready to activate the device and begin tracking location, the device may need to be turned on from a large or small proximity. The device will need to readily respond to activation when it is needed. Failure to activate when needed may cause a loss of data results and incorrectly track the suspect. This target will depend on the method of activation chosen. To test distance activation, we will attempt to activate the device from a range of distances. If the device does respond to activation in an immediate manner, we will take steps to increase the device's response time. This target additionally satisfies the needs for the operator to have some control over the technology, for the user interface to be catered to front line human trafficking correspondents, and for different types of signals to be considered

1.4.3 Critical Targets and Metrics Table

System	Function	Target	Metric
Track Location	Determine Location	Less than or equal to 50 m	Error in Transmitted Location
Transmit Location	Transmit Location	Span of less than five seconds to less than an hour	Transmission Time
Battery	Manage Power Throughout Operation	1-12 months of recharging	Potential Recharges
User Interface	Activate Power	<1 percent failure rate	Failure Rate

1.5 Concept Generation

1.5.1 Introduction

Team 503 collaborated to generate concepts to accomplish the goals of the project. The team met as a group to ideate designs while considering all of the parameters including customer needs, targets, and functions. Different tools were used to create ideas which are discussed below. The full list of generated concepts can be found in Appendix B: Figures and Tables.

1.5.2 Concept Generation Tools

To aid with the team generating one-hundred concepts, Team 503 used a handful of concept generation methods to influence creativity.

The first method that was used was rapid ideation. The team completed this method individually to set some groundwork for the concept generation. Each member

allotted themselves a short period of time and came up with as many ideas as possible. After ideating, all of the ideas were added to the table.

The second method that was used was brainstorming. This method was completed after rapid ideation and was also individual. Each team member read through the concepts that were generated in the first method to inspire creativity. After everyone had read through the concepts, each team member took some time to brainstorm ideas using research and thought process. This involved team members using the research document and doing research on their own to brainstorm ideas and lead to potential concepts. The concepts were then added to the table.

The third method that was used was round robin. After completing two individual team concept generation tactics, Team 503 gathered to finish the list of concepts. The team started with one group member listing a potential concept, and then circulating the group to list off as many ideas as possible. This method was used to get the team to talk amongst themselves to spark creativity off of one another. The team used this method to complete the list and get to one-hundred concepts.

1.5.3 Medium Fidelity Concepts

The five medium fidelity concepts were chosen based on how well they aligned with the customer needs and the targets of our project. The medium fidelity were not upgraded to high fidelity for two main reasons; they aren't believed to satisfy the key goals completely or they are too far out of the range of the team's capabilities.

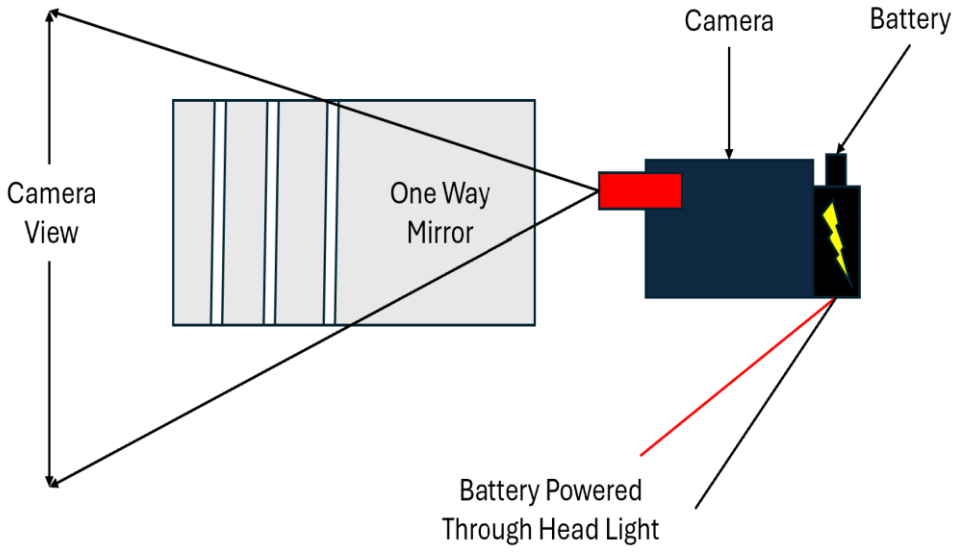
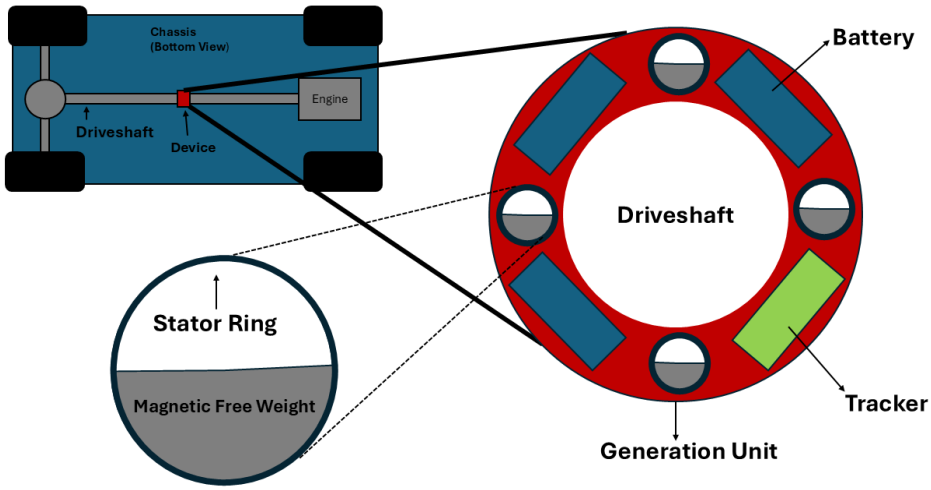
Concept	Description

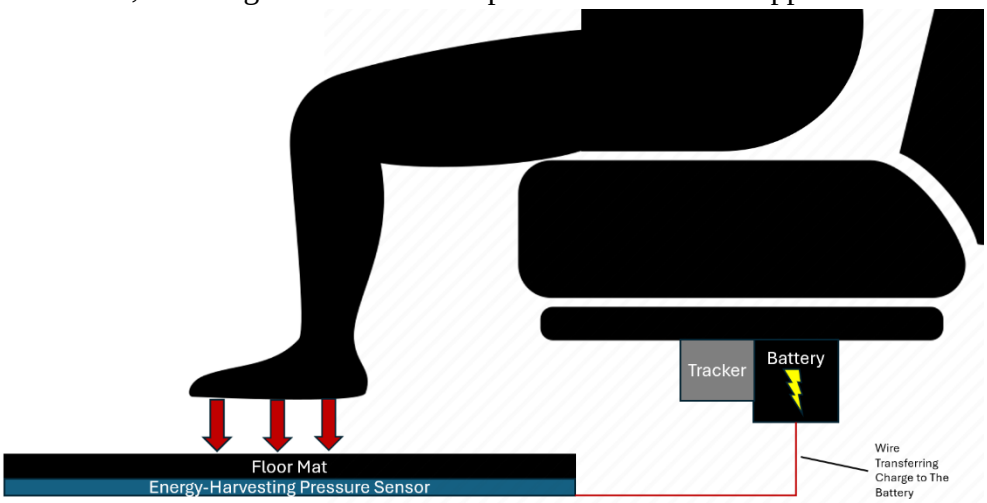
33	A SIM card scanner would be hidden on a suspected trafficker's vehicle and would develop a list of SIM numbers for every phone that enters the vehicle. This information would later be used to trace the location of where the phones end up.
38	Something is placed onto the battery of the car after being discreetly installed. When the traffickers are using the vehicle and it is suspected that victims are present, a remote control can activate the device. The device will cut the power from the engine and take away the functions of the vehicle, causing it to come to a stop.
39	A hotel keycard would be used as a tracking device and given to suspected traffickers checking in.
34	Geo fencing would be used to monitor the suspected trafficking building or location to observe the activity of phones entering and exiting the area.
67	A GPS is stored inside a license plate and tracks the location of the vehicle. The battery will plug into license plate lights or have solar panels to recharge. The GPS will send out a signal if it has been tampered with.

1.5.4 High Fidelity Concepts

The three high fidelity concepts were chosen due to the satisfaction of the key goals of the project. The team feels that these three concepts are best at satisfying all of the constraints of the project such as the customer needs, targets, and main functions of the device. The team also feels that these three designs are within range of the capabilities of the team's abilities.

Concept	Description
25	Most rear-view mirrors in cars contain some sort of metal within the mirror itself. This could be a protective layer or an anti-glare layer, containing some sort of metal. A user would discreetly replace the mirror in the rear-view with a one-way glass that replicates a normal mirror. Behind the mirror would be a camera and a battery connected to the inputs to the rear-view mirror light. This allows the battery to draw power for the camera. The camera or scanner

	will take a picture when the car is turned on and use facial recognition to track certain passengers. 
10	A battery and sensor would be hooked up to the axle of a car. When the car begins to move, the battery will rotate at an increasing speed. The battery will use a power generation system similar to watches that uses the movement to generate power. The battery will recharge itself while in use and transmit the location. 

63	When someone enters a car, they apply pressure to the wells of the floor where they are sitting. This pressure can be harnessed into power to charge the battery of the tracker. The sensor is stored inside of the floormats of the car, allowing it to measure the pressure when it is stepped on. 

1.6 Concept Selection

After generating concepts and selecting eight designs that were considered medium and high fidelity, concept selection tools were used to narrow down which design best fit the project. Tools such as the Binary Pairwise Comparison (BPC), House of Quality (HOQ), Pugh Chart, and the Analytical Hierarchy Process (AHP), were used to help grade the potential designs.

1.6.1 Binary Pairwise Comparison (BPC)

The first tool used was the Binary Pairwise Comparison. The customer needs were ranked to determine which needs are the most important to the project. This comparison helps to weigh the needs when they are used in the House of Quality later. Incorporating

tracking ranked the highest with a total score of eight while protecting from environmental conditions ranked last with a total score of zero.

Customer Needs	1	2	3	4	5	6	7	8	9	Total
1: The Smaller The Better		0	1	1	0	0	0	0	1	3
2: Long Battery Life	1		1	1	0	0	1	1	1	6
3: Considers All Traficking	0	0		0	0	0	0	0	1	1
4: Control Over Technology	0	0	1		0	0	1	1	1	4
5: Incorporate Tracking	1	1	1	1		1	1	1	1	8
6: Supplies Power to Device	1	1	1	1	0		1	0	1	6
7: Handle Range of Temperatures	1	0	1	0	0	0		1	1	4
8: No Victim Interaction	1	0	1	0	0	1	0		1	4
9: Protect From Environmental Conditions	0	0	0	0	0	0	0	0		0
Total	5	2	7	4	0	2	4	4	8	

Figure 2: Binary Pairwise Comparison

1.6.2 House of Quality (HOQ)

The next tool used was the House of Quality which scores the customer needs with their respective weights to important engineering characteristics. The HOQ takes the scores for each characteristic against the weight of the need and puts the totals into percentages. The completed HOQ is shown below.

Customer Requirements	IWF	Size	Discreteness	Battery Life	Tracking	Durability	Cost	Autonomous	Storage	
1: The Smaller The Better	3	9	9	3	9	3	9	3	1	
2: Long Battery Life	6	3	3	9	1	3	9	9	9	
3: Considers All Traficking	1	0	9	1	0	0	1	0	0	
4: Control Over Technology	4	1	0	3	0	1	3	9	3	
5: Incorporate Tracking	8	3	1	1	1	1	1	9	9	
6: Supplies Power to Device	6	3	0	9	0	1	3	9	1	
7: Handle Range of Temperatures	4	3	0	3	0	9	3	9	1	
8: No Victim Interaction	4	0	9	1	0	0	0	9	0	
9: Protect From Environmental Conditions	0	1	0	0	3	9	3	9	0	Total
Raw Score		103	98	154	41	81	132	297	151	1057
Reletive Weight %		10%	9%	15%	4%	8%	12%	28%	14%	
Rank Order		5	6	2	8	7	4	1	3	

Figure 3: House of Quality

After completing the House of Quality, autonomous ranked the highest for engineering characteristics. Making sure the device runs on its own and can operate in some way without constant user control is crucial to our design. Ranking second was the battery life of the device. The CIA emphasized battery life being a critical constraint that most current technology falls short of. Ranking third was storage of the device. Being able to store the device somewhere

where it can operate without sacrificing its quality is crucial. Ranking last is the tracking of the device. Although the device is meant to track suspects, picking a tracking signal is not of high importance to our project.

1.6.3 Pugh Chart

The next tool used is the Pugh Chart which compares each concept to a datum concept. The datum concept that was used was an Apple Air Tag. Each concept was scored compared to how well it was at each engineering characteristic, compared to the datum. If the concept was better than the datum, it received a "+". If the concept was the same as the datum, it received a "S". If the concept was worse than the datum, it received a "-".

Engineering Chars	Datum	Concept 25	Concept 63	Concept 10
Size		-	-	-
Discreteness		+	+	S
Battery Life		+	+	+
Tracking		+	+	+
Durability		+	-	+
Cost		-	-	-
Autonomous		+	+	+
Storage		+	-	S
Pluses		6	4	4
Minuses		2	4	2

Figure 4: Pugh Chart 1

Engineering Chars	Datum(63)	25	10
Size		+	+
Discreteness		+	S
Battery Life		+	+
Tracking		S	S
Durability		+	S
Autonomous		S	S
Storage		+	-
Pluses		5	2
Minuses		0	1

Figure 5: Pugh Chart 2

For the first Pugh Chart, only the top three designs were evaluated as the CIA informed the team that those three were of higher importance and relevance to the project. Concept 25 ranked the highest with six plus marks while concepts 63 and 10 ranked second with four each. Concept 63 had a higher number of minus marks than concept 10, so concept 63 became the new datum for the second Pugh Chart. For the second Pugh Chart, concept 25 ranked the highest with five plus marks, compared to only two plus marks for concept 10.

1.6.4 Analytical Hierarchy Process (AHP)

The final tool that was used was the Analytical Hierarchy Process.

	Size	Discreteness	Battery Life	Tracking	Durability	Cost	Autonomous	Storage
Size	1.00	1.00	5.00	3.00	7.00	0.14	1.00	5.00
Discreteness	1.00	1.00	1.00	3.00	0.14	0.11	0.11	1.00
Battery Life	0.20	1.00	1.00	9.00	0.33	0.11	0.33	1.00
Tracking	0.33	0.33	0.11	1.00	0.20	0.11	0.14	0.14
Durability	0.14	7.00	3.00	5.00	1.00	7.00	7.00	0.33
Cost	7.00	9.00	9.00	9.00	0.14	1.00	5.00	0.33
Autonomous	1.00	9.00	3.00	7.00	0.14	0.20	1.00	3.00
Storage	0.20	1.00	1.00	7.00	3.00	3.00	0.33	1.00
Sum	10.88	29.33	23.11	44.00	11.96	11.68	14.92	11.81

Figure 6: Analytical Hierarchy Process

	Size	Discretene	Battery Life	Tracking	Durability	Cost	Autonomous	Storage	Criteria Weights
Size	0.091944	0.034091	0.216346	0.068182	0.585191	0.012235	0.067021277	0.423387	0.187299651
Discreteness	0.091944	0.034091	0.043269	0.068182	0.011943	0.009516	0.007446809	0.084677	0.043883608
Battery Life	0.018389	0.034091	0.043269	0.204545	0.027866	0.009516	0.022340426	0.084677	0.055586814
Tracking	0.030648	0.011364	0.004808	0.022727	0.01672	0.009516	0.009574468	0.012097	0.014681702
Durability	0.013135	0.238636	0.129808	0.113636	0.083599	0.599511	0.469148936	0.028226	0.209462418
Cost	0.643608	0.306818	0.389423	0.204545	0.011943	0.085644	0.335106383	0.028226	0.250664207
Autonomous	0.091944	0.306818	0.129808	0.159091	0.011943	0.017129	0.067021277	0.254032	0.129723228
Storage	0.018389	0.034091	0.043269	0.159091	0.250796	0.256933	0.022340426	0.084677	0.108698372
Sum	1	1	1	1	1	1	1	1	1

Figure 7: Normalized Analytical Hierarchy Process

Concept	Alternative Value	Rank
25	0.633341	1
63	0.216784	2
10	0.149875	3

Figure 8: Final Decision Matrix

After completing the analytical hierarchy process, concept 25 had the highest alternative value in the final decision matrix. The AHP compared the engineering characteristics to each other and gave them values based off of their percentage of importance. These values were then used to assess each concept based off of how well they satisfied each engineering characteristic. The values were then used to create a final decision matrix which scored the three remaining concepts based on how well they compared to each other. Concept 25 ranked the highest with a score of 0.63 while concept 63 was the next highest with a score of 21. Concept 10 ranked the lowest with a score of 0.14. The final decision matrix reveals that concept 25 is the best solution towards the problem based off of the characteristics that are important and the concepts that were provided.

1.6.5 Final Selection

The final concept for our design is concept 25. The design features a camera that is hidden behind the rear-view mirror of a car. The glass of the mirror would be replaced with one-way glass, only acting as a mirror for people sitting in the car. A camera would be placed in the hollow compartment behind the glass of the mirror, viewing the entire interior of the vehicle. The battery connected to the camera is then connected to the lighting system on the rear view mirror compartment, allowing it to draw power when the car is turned on. The photo that is taken will be use facial recognition to identify the people inside the vehicle, further using that data to locate suspects. The final design is pictured below.

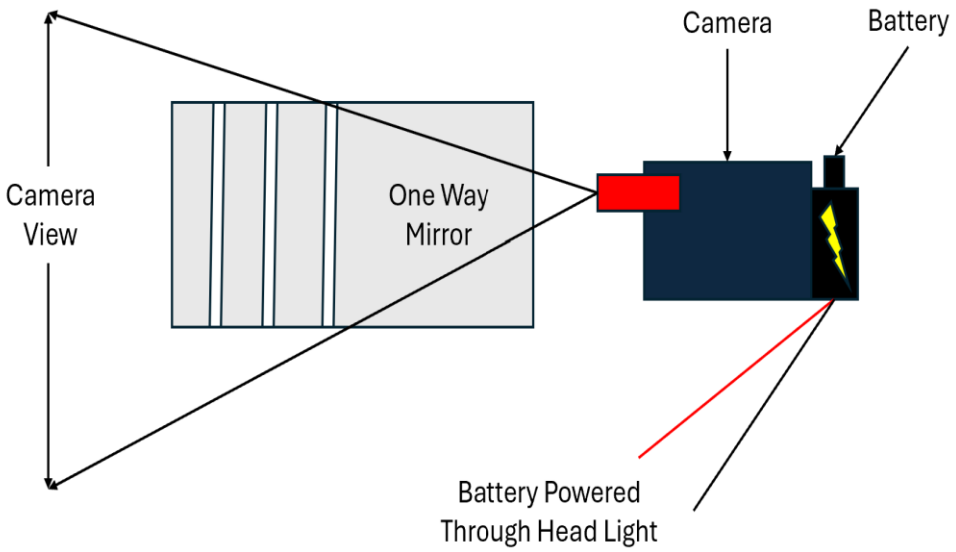


Figure 9: Final Concept Selection

Not only did concept 25 rank the highest in the final decision matrix, but it was the concept that the sponsor heavily recommended during the last meeting. After presenting the medium and high fidelity concepts to the sponsor, he showed much interest in concept 25. It was determined that the sponsor wanted the team to use concept 25 as the final design for the project. It was mentioned that the CIA may have previously investigated something similar to this concept in previous years. The sponsor recommended that concept 25 should be further pursued.

1.8 Spring Project Plan

Chapter Two: EML 4552C

2.1 Spring Plan

Project Plan.

Build Plan.

Appendices

Appendix A: Code of Conduct

Mission Statement

The team intends to use the skills and experience they have obtained throughout their time as mechanical engineering students to develop a technology that disrupts human trafficking, without disclosing personal details and maintaining secrecy.

Outside Obligations

Team Member	Obligations
Timothy Chlaupek	No outside obligations
Rashad Cohen	Part-Time Intern, Student-Athlete, Club President
Jose Fernandez	Part-time Internship
Jackson Gunnels	Marching Chiefs (Equipment Staff), Part-Time Job (Spring)
Reid Pitts	SAE, Monthly Volunteer Obligation

Team Roles

The following roles have been assigned by all of the group members based on personal preference and academic strengths. The roles are subject to change throughout the course of the project if needed.

Team Member	Role
Timothy Chlaupek	Software Engineer
Rashad Cohen	Design Engineer
Jose Fernandez	Thermal Engineer
Jackson Gunnels	Fabrication Engineer
Reid Pitts	Electrical Engineer

Communication

The primary method of group communication will be carried out through text messages. The primary way to share files, call the group, or discuss virtually with our sponsor or advisor is Microsoft Teams. To contact Dr. McConomy, email is the preferred method of communication. If an email does not receive a response from either our sponsor or advisor within 2 business days, a follow-up email will be sent. An additional 2 business days of no response to the follow-up email will result in an in-person meeting with McConomy either by appointment or after class.

All group members must inform the group if they are planning on sending an email to either the sponsor or advisor so that multiple emails are not sent.

Dress Code

Group Meetings:

Informal attire is allowed at any group meetings not involving any outside parties, as long as it is appropriate.

Advisor Meetings:

All group members must wear business casual at advisor meetings whether in person or virtual. This includes pants, a collared shirt, and a belt. A tie is not necessary for advisor meetings.

Sponsor Meetings:

All group members must wear business casual at sponsor meetings whether in person or virtual. This includes pants, a collared shirt, and a belt. A tie is not necessary for advisor meetings.

Presentations/Design Reviews:

All group members are required to wear formal business attire during any presentations or design reviews. This includes khaki pants, dress shoes, a polo shirt (tucked in), and a belt.

Attendance Policy

All group members are expected to be present during all meetings unless an outside obligation prevents them. If someone is unable to attend a meeting for any reason, a notification at least the day before is required to be excused from that meeting. If a group member doesn't notify the group of an absence at a meeting, one pass will be given, but a repeated offense will call for a group discussion. If further absences continue, Dr. McConomy will be notified about the situation.

In the event of an emergency of a group member, that group member will notify the group and details to alter the work structure will be discussed.

Weekends

All group members will make an effort to complete their portion of the work before the weekend. Extra effort is expected to help other group members finish their portion of the assignment if it is Thursday and the assignment is not completed.

A group meeting will be held to discuss if work needs to be done over the weekend if a vacation day is not needed.

Vacation Days

If an assignment is not completed by 12:00 P.M., on the Friday that an assignment is due, a discussion will be held to determine if the team will be able to complete the assignment by the required deadline. If all team members decide that the workload is too heavy, a vacation day will be used by each team member to extend the deadline.

If a group member is planning on using a vacation day for an individual assignment, they must notify the group that they have used it immediately.

At least one vacation day must be saved for group assignments. If a group member needs to use their second vacation day, a team meeting will be held to discuss if it is acceptable.

Assignment Submission

A confirmation of submission will be presented via text by a group member before the assignment's due date. A message to confirm that the group member has successfully submitted the assignment is also required via text message.

Contact with Dr. McConomy

All team members will contact Dr. McConomy via email if clarification or answers to questions are needed about anything related to the project. All group members will be CC'd with every email. Efforts to send emails during business hours will be made, although emails may be sent at any time of the day if needed.

Group Discussion (Problems Among Group Members):

Before Dr. McConomy is contacted, any problem within the group will be brought to attention at a team meeting and discussed. If a resolution is unreachable, Dr. McConomy will be contacted to help resolve the issue. At this point, Dr. McConomy will listen to all sides of the issue and come up with a resolution or a strategy to help the group resolve it.

Advising/Sponsor Meeting:

Emails to meet with our sponsor or advisor will be sent with at least a 48-hour notice. Emails will use professional language and provide multiple times to meet depending on group availability.

How to Amend

In order for the code of conduct to be amended, a unanimous vote must be conducted after the changes have been proposed. If the vote is not unanimous, the code of conduct will remain the same and the issue(s) must be resolved with a team meeting. All group members are required to sign the new code of conduct if it has been amended.

Decorum Statement

The team recognizes that the content of this project deals with human lives that may have experienced tragedy. Therefore, an appropriate level of respect, privacy and decorum is expected when dealing with issues of this nature.

Statement of Understanding

By signing this document, you acknowledge that you have read and agree to the terms listed above for the following semesters of senior design.

Date: September 9, 2024

Signature:

Appendix B: Functional Decomposition

Sub-System	Contact Authorities	Track Location	Battery	Environmental Resistance	User Interface	Total
Establish Contact with Authorities	X	X			X	3
Maintain Contact with Authorities	X	X	X			3
Determine Location		X				1
Transmit Location	X	X				2
Manages Power Throughout Operation			X			1
Supplies Power to Device			X			1
Protect Internal Components From Heat				X		1
Protect Internal Components From Water				X		1
Protect Internal Components From Dust				X		
Activate Tracking		X			X	
Begin Establishing Contact With Authorities	X				X	
Activate Power			X		X	

Table 2: Cross Reference Table

Appendix C: Target Catalog

System	Function	Target	Metric
Contact Authorities	Establish Contact with Authorities	Connects in less than 10 seconds	Connection Time
Contact Authorities	Maintain Contact with Authorities	Connection loss <1 percent	Connection Loss Rate
Track Location	Determine Location	Less than or equal to 50 m	Error in Transmitted Location
Track Location	Transmit Location	Span of less than five seconds to less than an hour	Transmission Time
Battery	Manage Power Throughout Operation	1-12 months of recharging	Potential Recharges
Battery	Supply Power to Device	1 – 12 months depending on operation mode	Battery Life
Environmental Resistance	Protect Internal Components from Heat	Withstand up to 120 degrees Fahrenheit	Heat Resistance
Environmental Resistance	Protect Internal Components for Water	IPX7 rating – 30 minutes 1 meter underwater (Saugat, 2024)	Submersion
Environmental Resistance	Protect Internal Components from Dust	IPX7 rating – water resistance suggests dust resistance (Saugat, 2024)	Submersion
User Interface	Activate Tracking	<1 percent failure rate	Failure Rate
User Interface	Begin Establishing Contact with Authorities	<1 percent failure rate	Failure Rate
User Interface	Activate Power	<1 percent failure rate	Failure Rate
Form	Remain Covert	pass/fail	Sponsor agreement that

			device is acceptably covert

Appendix A: APA Headings (delete)

Heading 1 is Centered, Boldface, Uppercase and Lowercase Heading

Heading 2 is Flush Left, Boldface, Uppercase and Lowercase Heading

Heading 3 is indented, boldface lowercase paragraph heading ending with a period.

Heading 4 is indented, boldface, italicized, lowercase paragraph heading ending with a period.

Heading 5 is indented, italicized, lowercase paragraph heading ending with a period.

See publication manual of the American Psychological Association page 62

Appendix B Figures and Tables

Table 1: 100 Concepts

Design Number	Design Description	Process to Create
1	Tracker connected to tires, can monitor speed of rotation	Rapid Ideation
2	Magnet tracker on tire	Rapid Ideation
3	Tracker connected to driveshaft	Rapid Ideation
4	Tracker connected to bulb of headlight for charge	Rapid Ideation
5	Tracker connected to blinker bulb, charges when blinkers are activated	Rapid Ideation
6	Tracker connected to cigarette lighter	Rapid Ideation
7	Tracker hidden in fluid tanks; gas powered	Rapid Ideation
8	Tracker hidden in windshield wiper tank, close to engine for power	Rapid Ideation
9	Tourbillon generation battery (watches) mounted axially	Rapid Ideation
10	Tourbillon generation battery (watches) mounted to rotating component	Rapid Ideation
11	Small turbine in fluid lines to generate power	Rapid Ideation
12	Tracker in relay	Rapid Ideation
13	Peltier generation	Rapid Ideation
14	Piezoelectric generation	Rapid Ideation
15	Tracker in trunk, discrete location	Rapid Ideation
16	Dead reckoning	Rapid Ideation
17	Wire splice	Rapid Ideation
18	Car antenna beacon	Rapid Ideation
19	Magnetic mounting of tracker to bottom side of car	Rapid Ideation
20	SIM scanner to monitor activity	Rapid Ideation
21	Infrared wheel locator	Rapid Ideation

22	Geofencing locator and tracker	Rapid Ideation
23	Solar Powered wheel hub tracker	Rapid Ideation
24	Powered through taillights	Rapid Ideation
25	One way glass rearview mirror	Rapid Ideation
26	One way glass car door mirrors	Rapid Ideation
27	Gas door hinge sensor, runs on fuel, can deploy when suspect is getting gas	Rapid Ideation
28	Bugged rental cars	Rapid Ideation
29	Battery connected to gas pedal tracker	Rapid Ideation
30	Battery connected to air conditioning	Rapid Ideation
31	Battery connected to heating system	Rapid Ideation
32	Tracker that only is powered by internal car system, will turn off when car is off so it will be harder to find, do not need to track location when stationary	Rapid Ideation
33	Tracker that is placed on car that collects SIM data of occupant's cell phones in car	Rapid Ideation
34	Geofencing suspected trafficking sites	Rapid Ideation
35	Using SIM data along with DOT roadway markers to track travel	Rapid Ideation
36	Internal organ generation	Brainstorming
37	One way car mirror camera	Brainstorming
38	Remote Deactivation	Brainstorming
39	Hotel Keycard Tracker	Brainstorming
40	Tracker placed on spare tire	Brainstorming
41	Tracker that uses pressure from floor mats to draw power	Brainstorming
42	Tracker that uses force from steering wheel to generate power	Brainstorming

43	Tracker that draws power from radio battery	Brainstorming
44	Tracker that collects date from charging ports of car to identify passengers	Brainstorming
45	Tracker that highlights mile markers to track distance	Brainstorming
46	Tracker that locates exit signs and position to locate what exit is taken	Brainstorming
47	Beacons at highway rest stops to mark long distance travel	Brainstorming
48	Bus station scanners to track entering and leaving stations	Brainstorming
49	Bus station facial recognition	Brainstorming
50	Battery powered by light in overhead mirror	Brainstorming
51	Undetectable film on bus seats, stick to traffickers, harmless, disintegrates fast, can be spotted using special technology	Brainstorming
52	Volume knob tracker using rotational energy from turning of knob	Brainstorming
53	Tracker in nut of the tire	Brainstorming
54	Tracker in headrests that charges using the body heat.	Brainstorming
55	Bluetooth-enabled tracker hidden inside seatbelt mechanism	Round Robin
56	Heat-sensitive adhesive patches on door handles	Round Robin
57	Facial recognition cameras embedded in public highway billboards to identify suspected traffickers or victims	Round Robin
58	Biometric sensors in vehicle seats to detect the presence and identity of passengers	Round Robin
59	RFID tags sewn into vehicle upholstery	Round Robin

60	Motion-activated cameras placed at gas stations that track repeat visits by suspected vehicles	Round Robin
61	Smart parking meters with vehicle scanning capability, checking license plates for trafficking patterns	Round Robin
62	Voice recognition software in smart car voice assistants	Round Robin
63	Vehicle entry/exit pressure sensors in footwells, tracking occupant movements over time	Round Robin
64	UV light-responsive vehicle paints, embedded with microscopic QR codes, scannable only with specialized equipment	Round Robin
65	Mobile app linked to ride-share services	Round Robin
66	Proximity detection system that alerts nearby phones if a vehicle linked to trafficking is within a specified range	Round Robin
67	Smart license plates with built-in GPS that send an alert if tampered with or removed from the registered vehicle	Round Robin
68	Automated surveillance drones that scan vehicle license plates in high-risk areas, relaying data to law enforcement	Round Robin
69	Motion detectors in highway medians that track erratic or suspicious driving behaviors over long distances	Round Robin
70	Pressure-sensitive back seats in taxis or rideshares, alerting authorities if they detect abnormal activity or prolonged weight presence	Round Robin
71	Emergency apps with disguised user interfaces,	Round Robin

	allowing victims to send out distress signals to nearby devices	
72	Vehicle-inspection checkpoints with infrared body heat scanners, detecting hidden passengers or concealed compartments	Round Robin
73	Silent panic button integrated into the vehicle's dashboard that automatically alerts authorities to a possible trafficking scenario	Round Robin
74	Traffic light camera systems with AI-driven pattern recognition to flag frequent late-night traffic in high-risk trafficking areas	Round Robin
75	Drones with infrared sensors patrolling highways to detect hidden people inside vehicles, especially in isolated areas	Round Robin
76	Thermal cameras on highway toll booths, identifying hidden heat sources within vehicles, like concealed passengers	Round Robin
77	Tire tread pressure sensors, which can identify abnormal weight in vehicles indicating hidden compartments or passengers	Round Robin
78	Smart traffic signs with motion-sensing radar, flagging vehicles that consistently take evasive routes or drive irregularly in known trafficking zones	Round Robin
79	Burdock style tracker that sticks to clothes/ shoelaces and harnesses energy like a watch when suspect swings their legs.	Biomimicry
80	Windshield wipers with built in trackers tapping into the	Brainstorming

	power supplied to swing the wiper.	
81	Tracker stuck under the car with miniature wind turbine for capturing wind power as car drives at higher speeds.	Brainstorming
82	Tracker on undersurface of car that extends a leg with a wheel to drag on the road and help generate power	Brainstorming
83	Tire patch that puts a tracker on the inside of the tire and uses the rotation to generate power	Brainstorming
84	Tracker in the emblem of the vehicle that uses solar power	Brainstorming
85	Tracker in the exhaust that uses the heat from exhaust to generate power	Brainstorming
86	Tracker replacing the button of a jacket	Brainstorming
87	Outlet in USB port that taps into any phone plugged into it	
88	Tracker in the fuse box of the car	Brainstorming
89	Tracker placed inside of the car key that charges off the key battery	Brainstorming
90	Tracker that uses color changing tech to remain discreet	Brainstorming
91	Tracker using earth's natural magnetic fields for positioning where GPS is lacking	Brainstorming
92	Tracker in oil filter that can be input during oil change and captures heat from the oil	Brainstorming
93	OBD port tracker on interior cables of OBD	Brainstorming
94	Brake pad magnetic tracker that uses the friction to generate power	Brainstorming

95	Hubcap with tracker built in that makes use of rotational energy	Brainstorming
96	Fuel cap tracker that recharges using tightening and loosening of the cap	Brainstorming
97	Tracker attached to speakers	Brainstorming
98	Tracker in base of cup holder that harnesses the pressure drinks	Brainstorming
99	Tire valve cap tracker that uses the tire pressure to help generate power	Brainstorming
100	Dashboard vent tracker that generates solar power	Brainstorming

Table 1

The Word Table and the Table Number are Normal Font and Flush Left. The Caption is Flush Left, Italicized, Uppercase and Lowercase

Level of heading	Format
1	**Centered, Boldface, Uppercase and Lowercase Heading**
2	**Flush Left, Boldface, Uppercase and Lowercase**
3	***Indented, boldface lowercase paragraph heading ending with a period***
4	***Indented, boldface, italicized, lowercase paragraph heading ending with a period.***
5	*Indented, italicized, lowercase paragraph heading ending with a period.*

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There are no sources in the current document.

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